energy harbor

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January 3, 2022
L-21-187

10 CFR 50.90

ATTN: Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT:
Davis-Besse Nuclear Power Station, Unit No. 1
Docket No. 50-346, License No. NPF-3
Request for an Amendment to Change the Design Basis Methodology for the Shield Building Containment Structure

Pursuant to 10 CFR 50.90, Energy Harbor Nuclear Corp. is submitting a request to amend the Renewed Facility Operating License No. NPF-3 for the Davis-Besse Nuclear Power Station, Unit No. 1.

Energy Harbor Nuclear Corp. proposes a change in the design basis that would accept laminar concrete cracking of a limited width in the outer reinforcement layer of the shield building containment structure as discussed in the updated final safety analysis report.

The enclosure provides a description and assessment of the proposed change. The enclosure includes a report that establishes the technical justification supporting the proposed change and a markup of the updated final safety analysis report.

Energy Harbor Nuclear Corp. requests approval of the proposed amendment by January 31, 2023. Once approved, the amendment shall be implemented within 60 days.

There are no regulatory commitments contained in this submittal. If there are any questions or if additional information is required, please contact Mr. Phil H. Lashley, Manager - Fleet Licensing, at (330) 696-7208.

I declare under penalty of perjury that the foregoing is true and correct. Executed on January 3, 2022.

Sincerely,

Terry J. Brown

Enclosure:
Evaluation of the Proposed Change

cc: NRC Region III Administrator
NRC Resident Inspector
NRC Project Manager
Executive Director, Ohio Emergency Management Agency,
State of Ohio (NRC Liaison)
Utility Radiological Safety Board

Enclosure
L-21-187

Evaluation of the Proposed Change
(1405 pages follow)

Subject: Request for an Amendment to Change the Design Basis Methodology for the Shield Building Containment Structure

ATTACHMENTS

1. Bechtel Power Corporation Technical Report, 25884-000-30R-C01R-00002, Revision 0, “Incorporating Laminar Cracks of up to 0.050 Inch in the Design Basis of the Davis-Besse Shield Building.”

2. Updated Final Safety Analysis Report Markup.

1.0 SUMMARY DESCRIPTION

In accordance with 10 CFR 50.90, Energy Harbor Nuclear Corp. is providing this evaluation in support of amending Renewed Facility Operating License No. NPF-3 for the Davis-Besse Nuclear Power Station, Unit No. 1 (DBNPS). The proposed change in the design basis would accept laminar concrete cracking of a limited width in the outer reinforcement layer of the shield building containment structure as discussed in the updated final safety analysis report (UFSAR). The proposed changes to the DBNPS UFSAR require prior Nuclear Regulatory Commission (NRC) approval.

2.0 DETAILED DESCRIPTION

2.1 System Design and Operation

As described in Section 1.2.10 of the UFSAR, the containment system consists of two structures: a steel containment vessel and a reinforced concrete shield building, and their associated systems. The containment system provides protection for the public from the radiological consequences of a hypothetical accident discussed in Chapter 15 of the UFSAR.

The containment vessel, including all its penetrations, is a low-leakage steel structure designed to withstand a postulated loss-of-coolant accident and to confine a postulated release of radioactive material. It is a cylindrical pressure vessel with hemispherical dome and ellipsoidal bottom. It houses the reactor vessel, reactor coolant piping, pressurizer, pressurizer quench tank and coolers, reactor coolant pumps, steam generators, core flooding tanks, letdown coolers, and containment air cooling and recirculating systems.

The containment vessel is completely enclosed by a reinforced concrete shield building having a cylindrical shape with a shallow dome roof. An annular space is provided between the wall of the containment vessel and the shield building, and clearance is also provided between the containment vessel and the dome of the shield building. With the exception of the concrete under the containment vessel there are no structural ties between the containment vessel and the shield building above the foundation slab. Above this there is freedom for differential movement between the containment vessel and the shield building

The shield building is designed to provide biological shielding during normal operation and from hypothetical accident conditions. The building provides a means for collection and filtration of fission product leakage from the containment vessel following a hypothetical accident through the emergency ventilation system, an engineered safety feature designed for that purpose. In addition, the building provides environmental protection for the containment vessel from adverse atmospheric conditions and external missiles. The shield building is a nuclear safety-related, seismic Class 1 structure important to safety and designed to remain functional in the event of a maximum possible earthquake and design basis events.

The reinforced concrete shield building was designed in accordance with American Concrete Institute (ACI) 307-69, “Specification for the Design and Construction of Reinforced Concrete Chimneys,” and checked by the ultimate strength design method in accordance with ACI 318-63, “Building Code Requirements for Reinforced Concrete.” Load combinations specified in ACI 307-69 provide the design basis of the shield building. Further details of the shield building design and design bases are provided in Section 3.8.2.2 of the UFSAR.

2.2 Current Requirements

As described above, UFSAR Section 3.8.2.2 specifies that the design of the shield building structure conforms to ACI 318-63 and ACI 307-69. In accordance with ACI, the shield building design includes adequate reinforcing in the concrete walls, dome, and foundation to resist design forces and control cracking due to concrete shrinkage and temperature gradients. However, the ACI codes do not specify allowable limits or discuss the acceptability of laminar concrete cracking in regards to structural behavior or capacity of the shield building.

2.3 Reason for the Proposed Change

Laminar concrete cracking in the plane of the outer reinforcement mat of the shield building was observed in 2011 while creating a temporary opening for the reactor pressure vessel head replacement. The Shield Building Monitoring Program described in Section 18.1.43 of the UFSAR supplements the Structures Monitoring Program and monitors for extent and width of concrete cracking, as well as visible change of material properties and loss of material for both concrete and rebar in areas of laminar concrete cracking.

The intent of Energy Harbor is to repair areas of laminar cracking. However, some areas where laminar cracking has been observed have limited access for repair. Laminar cracks in these areas, less than or equal to 0.050 inches, would not be immediately repaired; however, these areas would continue to be part of the monitoring program described above. The proposed change would be to the shield building design basis to specify that cracks less than or equal to 0.050 inches are acceptable and do not affect the structural behavior or capacity of the shield building.

2.4 Description of the Proposed Change

As indicated above, the shield building design includes adequate reinforcing in the concrete walls to resist design forces and control cracking due to concrete shrinkage and temperature gradient. The original structural analysis did not include allowance for laminar concrete cracking. Recent analysis, discussed below, determined a laminar concrete crack width that has a negligible effect on the overall stiffness, dynamic characteristics and performance of the shield building and is therefore deemed acceptable.

The proposed change will update the UFSAR with a statement that laminar concrete cracks with widths less than or equal to 0.050 inches in the outer reinforcement layer of the shield building are acceptable in the design bases without explicit consideration in the analysis. Laminar concrete cracks with a width greater than 0.050 inches would be repaired.

3.0 TECHNICAL EVALUATION

In order to support the proposed change, conservative experimental tests and analyses have been performed and are presented in Attachment 1, Bechtel Power Corporation Technical Report, 25884-000-30R-C01R-00002. The report concludes that crack widths of up to 0.050 inches have no adverse impact on the capacity of the reinforcing bars to perform their intended function, ensuring shield building structural adequacy. Also, composite action of the shell, overall structural response, and serviceability and durability of the shield building are not adversely impacted with laminar concrete cracking up to 0.050 inches. The monitoring program ensures that any exceedance in cracking is adequately identified and addressed.

The test results show that the outer circumferential reinforcement bars maintain their full design capacity with the presence of laminar concrete cracks with widths up to 0.050 inches. Additionally, review of the load-deflection behavior of the specimens in the test programs does not indicate any significant change in the reloading stiffness of specimens after introduction of the laminar concrete cracks with widths exceeding 0.050 inches.

The shield building is designed for all applicable loads and load combinations in accordance with UFSAR Section 3.8.2.2.4, including dead and live loads, wind and tornado loads, and operating basis and safe shutdown earthquakes. The controlling load combinations for the design of the shield building involve the design basis safe shutdown earthquake, for which the shield building will behave like a cantilever where most of the forces are transferred through in-plane shear and axial membrane forces and very little through out-of-plane bending of the shell. The laminar concrete cracking has no impact on in-plane stiffness of the cylindrical shell, which will resist most of the applicable seismic loads. For thermal and tornado loads that produce hoop tension and moment, the existence of laminar concrete cracking does not change the concrete section behavior since the concrete shell is already assumed to be cracked through-thickness. The applicable tension forces are primarily resisted by the hoop reinforcement, which were demonstrated in testing to maintain their design function with crack widths up to 0.050 inches. Therefore, it is concluded that no changes need to be made to the analytical model in order to account for the effect of the limited laminar concrete cracking on shield building stiffness.

Therefore, the effect of laminar concrete cracking on the overall stiffness, dynamic characteristics, and performance of the shield building is negligible.

Finally, the ability of the shield building to perform its other UFSAR-described design functions of biological shielding and a boundary for the emergency ventilation system are not affected by the laminar concrete cracking. Laminar concrete cracking does not reduce the concrete thickness required for adequate biological shielding. Also, the laminar concrete cracking in the outer reinforcement mat of the shield building will not degrade the shield building pressure boundary since it does not penetrate through-wall.

4.0 REGULATORY EVALUATION

4.1 Applicable Regulatory Requirements / Criteria

The following regulatory requirements and guidance are applicable to this license amendment request.

- As reflected in Section 3 of the UFSAR, the following General Design Criteria are applicable to this proposed change. Appendix A to 10 CFR Part 50 - General Design Criteria for Nuclear Power Plants:

  Criterion 1 - Quality Standards and Records. Structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function. A quality assurance program shall be established and implemented to provide adequate assurance that these structures, systems, and components will satisfactorily perform their safety functions. Appropriate records of the design, fabrication, erection, and testing of structures, systems, and components important to safety shall be maintained by or under the control of the nuclear power unit licensee throughout the life of the unit.

  Criterion 2 - Design Bases for Protection Against Natural Phenomena. Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect: (1) appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena and (3) the importance of the safety functions to be performed.

Criterion 4 - Environmental and Dynamic Effects Design Bases. Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents, including loss-of-coolant accidents. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit. However, dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping.

Criterion 16 - Containment Design. Reactor containment and associated systems shall be provided to establish an essentially leak-tight barrier against the uncontrolled release of radioactivity to the environment and to assure that the containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.

Criterion 50 - Containment Design Basis. The reactor containment structure, including access openings, penetrations, and the containment heat removal system shall be designed so that the containment structure and its internal compartments can accommodate, without exceeding the design leakage rate and, with sufficient margin, the calculated pressure and temperature conditions resulting from any loss-of-coolant accident. This margin shall reflect consideration of (1) the effects of potential energy sources which have not been included in the determination of the peak conditions, such as energy in steam generators and energy from metal-water and other chemical reactions that may result from degradation but not total failure of emergency core cooling functioning, (2) the limited experience and experimental data available for defining accident phenomena and containment responses, and (3) the conservatism of the calculational model and input parameters.

- Codes and Standards:

  American Concrete Institute (ACI) 307-69, “Specification for the Design and Construction of Reinforced Concrete Chimneys,”

  ACI 318-63, “Building Code Requirements for Reinforced Concrete.”

The test results in Attachment 1 show that the outer circumferential rebars maintain their full design capacity with the presence of laminar concrete cracks with widths up to 0.050 inches. Therefore, laminar concrete cracking up to this width has no effect on the structural behavior or capacity of the shield building considering reinforcement engagement, composite action of the shell, overall structural response, and serviceability/long term durability of the structure. In conclusion, the effect of laminar concrete cracking up to this width on the overall stiffness, dynamic characteristics and performance of the shield building is negligible.

The proposed change does not affect compliance with the specified regulations or guidance and will ensure that the lowest functional capabilities or performance levels of equipment required for safe operation are met.

4.2 No Significant Hazards Consideration Analysis

Pursuant to 10 CFR 50.90, Energy Harbor Nuclear Corp. is submitting a request to amend the Renewed Facility Operating License No. NPF-3 for the Davis-Besse Nuclear Power Station, Unit No. 1. The proposed change would accept a limited width of laminar concrete cracking along the outer reinforcement layer in the design basis of the shield building containment structure as discussed in the updated final safety analysis report.

Energy Harbor Nuclear Corp. has evaluated whether or not a significant hazards consideration is involved with the proposed amendment by focusing on the three standards set forth in 10 CFR 50.92, "Issuance of amendment," as discussed below:

1. Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

   Response: No

   The shield building functions to protect against and mitigate potential accidents. The proposed change of laminar concrete cracking in the outer reinforcement layer up to the width of 0.050 inches has been evaluated with a conclusion that the effect on the overall stiffness, dynamic characteristics, and performance of the shield building is negligible. Based on this, the shield building capability to perform its specified design function is maintained. The proposed change does not involve a significant increase in the probability of an accident previously evaluated.

   The effect of the proposed change on the overall shield building integrity and structural capability have been determined to be negligible. Also, the ability of the shield building to perform its other UFSAR-described design functions of biological shielding and a boundary for the emergency ventilation system are not affected. Since the shield building function is maintained, there will not be a significant increase in the consequences of a previously evaluated accident.

   Therefore, the proposed amendment does not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

   Response: No

   The proposed change of laminar concrete cracking in the outer reinforcement layer up to the width of 0.050 inches has been evaluated with a conclusion that the effect on the overall stiffness, dynamic characteristics, and performance of the shield building is negligible. The proposed change does not affect the design function or operation of the shield building or any other plant system, structure or component. Laminar concrete cracks up to 0.050 inches are shown to be negligible with cracks greater than 0.050 inches requiring repair. Based on this, there are no new failure mechanisms or accident initiators created by this proposed change.

   Therefore, the proposed amendment does not create the possibility of a new or different kind of accident from any previously evaluated.

3. Does the proposed amendment involve a significant reduction in a margin of safety?

   Response: No

   The proposed amendment is requesting approval of changes to the UFSAR and shield building design basis to allow a limited width of laminar concrete cracking along the outer concrete reinforcement layer of the shield building. The current licensing and design basis does not provide an explicit acceptance value for laminar concrete cracking, this change specifies a value of 0.050 inches.

   Experimental test results have shown that the outer circumferential reinforcement bars maintain their full design capacity with the presence of laminar concrete cracks with widths up to 0.050 inches. Conservatisms included in the tests included concrete strength differences between tested and as-built, not including the effect of staggering of spliced reinforcement bars in the tests, and not including the curvature of the shield building in the tests. It is concluded that the effect of laminar concrete cracking up to this width on the shield building design is negligible and the margin of safety is maintained.

   Therefore, the proposed amendment does not involve a significant reduction in a margin of safety.

Based on the above, Energy Harbor Nuclear Corp. concludes that the proposed amendment does not involve a significant hazards consideration under the standards set forth in 10 CFR 50.92(c), and, accordingly, a finding of "no significant hazards consideration" is justified.

4.3 Conclusions

In conclusion, based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the Commission's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

5.0 ENVIRONMENTAL CONSIDERATION

A review has determined that the proposed amendment would change a requirement with respect to installation or use of a facility component located within the restricted area, as defined in 10 CFR 20, or would change an inspection or surveillance requirement. However, the proposed amendment does not involve (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluents that may be released offsite, or (iii) a significant increase in individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, pursuant to 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

6.0 REFERENCES

1. American Concrete Institute (ACI) Standard 307-69, "Specification for the Design and Construction of Reinforced Concrete Chimneys."

2. American Concrete Institute (ACI) Standard 318-63, "Building Code Requirements for Reinforced Concrete."

Attachment 1

Bechtel Power Corporation Technical Report, 25884-000-30R-C01R-00002, Revision 0, “Incorporating Laminar Cracks of up to 0.050 Inch in the Design Basis of the Davis-Besse Shield Building”

(1391 pages follow)

TECHNICAL REPORT

Energy Harbor Nuclear Corporation

INCORPORATING LAMINAR CRACKS OF UP TO 0.050 INCH IN THE DESIGN BASIS OF THE DAVIS-BESSE SHIELD BUILDING

25884-000-30R-C01R-00002, Rev. 000

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1.0 Objective

The objective of this report is to provide a description of the testing and analysis work performed that establishes the technical justification for including laminar cracks of up to 0.050 inch (unit denoted as ” throughout this report) in the design basis of the Davis-Besse Shield Building.

This report addresses the impact of laminar cracking on reinforcement capacity, composite action of the shell, overall structural response, and serviceability and long-term durability to provide the technical justification that laminar cracking up to 0.050” does not adversely impact the structural capacity and performance of the Shield Building.

It should be noted that a repair program has been instituted to completely repair shoulders where laminar cracking exists. This repair program provides general repair to the entire shoulder using ACI codes and guidelines under safety-related work restrictions to eliminate the laminar cracking condition. This repair program restores the Shield Building to the design/licensing basis. However, there are some isolated regions where the cracking is not greater than 0.050” and repair would be difficult due to significant interferences. Thus, this Technical Report supports the repair program by providing the technical justification for incorporation of 0.050” as the acceptance limit for laminar crack width, where cracking less than 0.050” has no effect on the structural capacity and performance and would be incorporated into the design/licensing basis.

General references throughout this report include the USAR as the licensing basis (Ref. 4a), the DCM as the design basis (Ref. 4b), and ACI 318-63 and ACI 307-69 as the design codes of record (Refs. 5a & 5b).

2.0 Background

During the creation of the temporary opening in the cylindrical wall of the Shield Building for the Reactor Pressure Vessel Head (RPVH) replacement at the Davis-Besse nuclear power plant, a laminar crack was observed on October 10, 2011 in the architectural flute shoulder area in the vicinity of the opening. The crack was located in the plane of the main outer reinforcing bar mat. During the original investigation, crack widths were determined using core bore samples. The cracks were established to be tight with crack widths of less than 0.010” in most cases. Since the original investigation, some of these cracks have propagated and/or widened as observed through the Shield Building monitoring program.

2.1 Shield Building Description

The Shield Building at the Davis-Besse nuclear power plant is a safety-related freestanding cylindrical reinforced concrete structure capped with a shallow spherical dome. The structure configuration can be found in References 3a-3c and is shown in Figure 1. The cylindrical wall and dome are 30” and 24” thick, respectively, and the inner radii to the inner surfaces of the wall and dome are 69.5 feet (unit denoted as ’ throughout this report) and ~123.3’, respectively. There are eight (8) architectural flute areas on the outer periphery of the cylindrical wall, with each area comprised of two built-up or thickened shoulders. The original Shield Building design considers the flute shoulders as purely architectural features providing no structural capacity beyond that provided by the cylindrical wall.

The Shield Building cylindrical wall is reinforced by meridional (vertical) and circumferential (hoop) reinforcing bars forming a grid near both faces of the wall, with the hoop reinforcement located outside the vertical reinforcement. The reinforcing arrangements for both vertical and hoop rebar varies along the height of the Shield Building. Reinforcing for the shoulders consists of vertical bars and horizontal ties conforming to the profile of the shoulder and intersecting the main reinforcing.

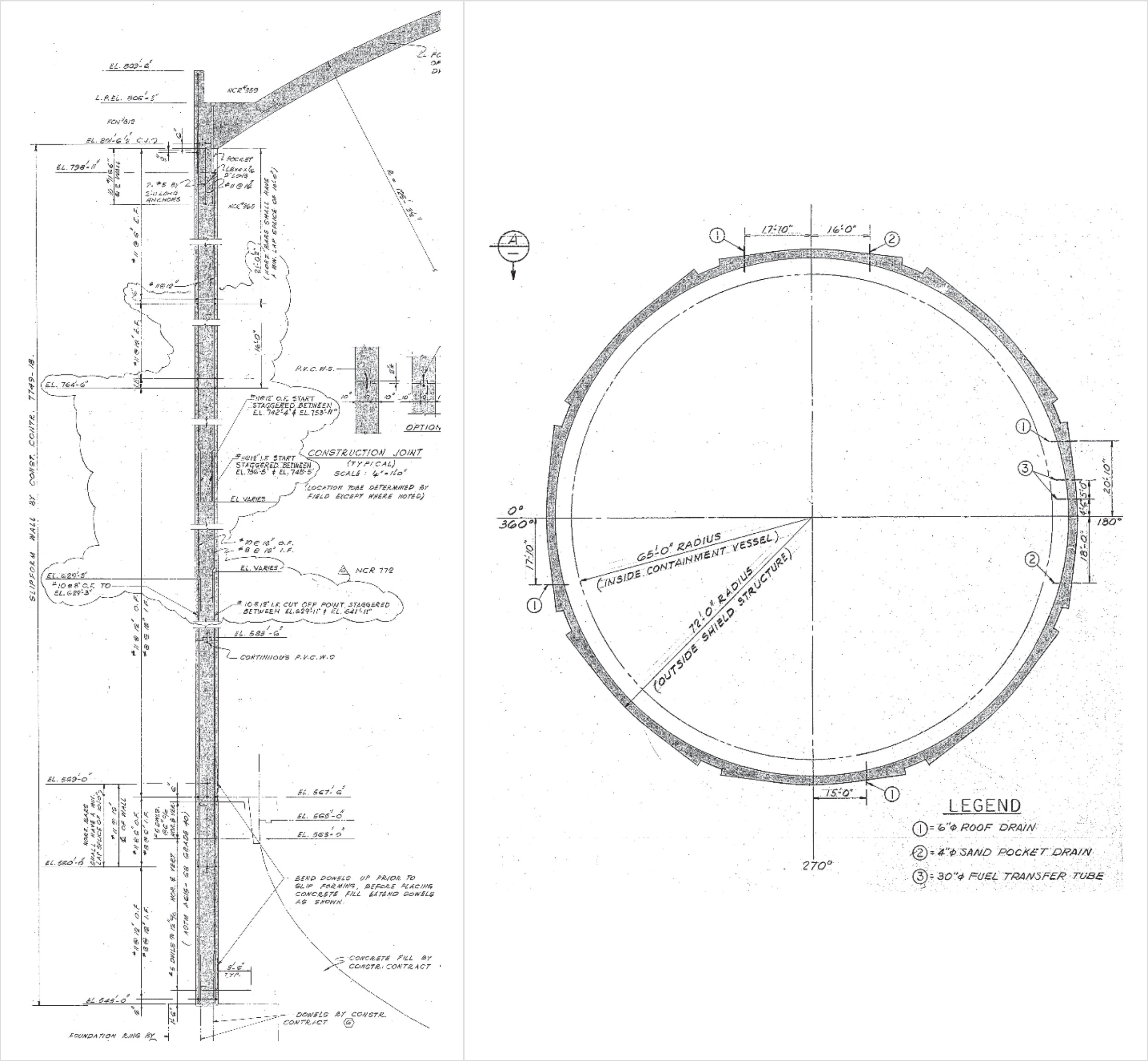


Figure 1: Shield Building Plan and Section

During the original construction of the Shield Building, a temporary opening was provided in the cylindrical wall, which was subsequently closed at the end of construction activities. In 2002, a temporary opening was created and then restored to allow removal and replacement of the RPVH. Subsequently, a temporary opening was created and then restored to allow the removal and replacement of the RPVH in 2011 (a temporary opening with the same profile and location as the 2011 opening was also used for the Steam Generator (SG) replacement in 2014). The arrangement of the original and subsequent temporary openings is depicted in Figure 2.

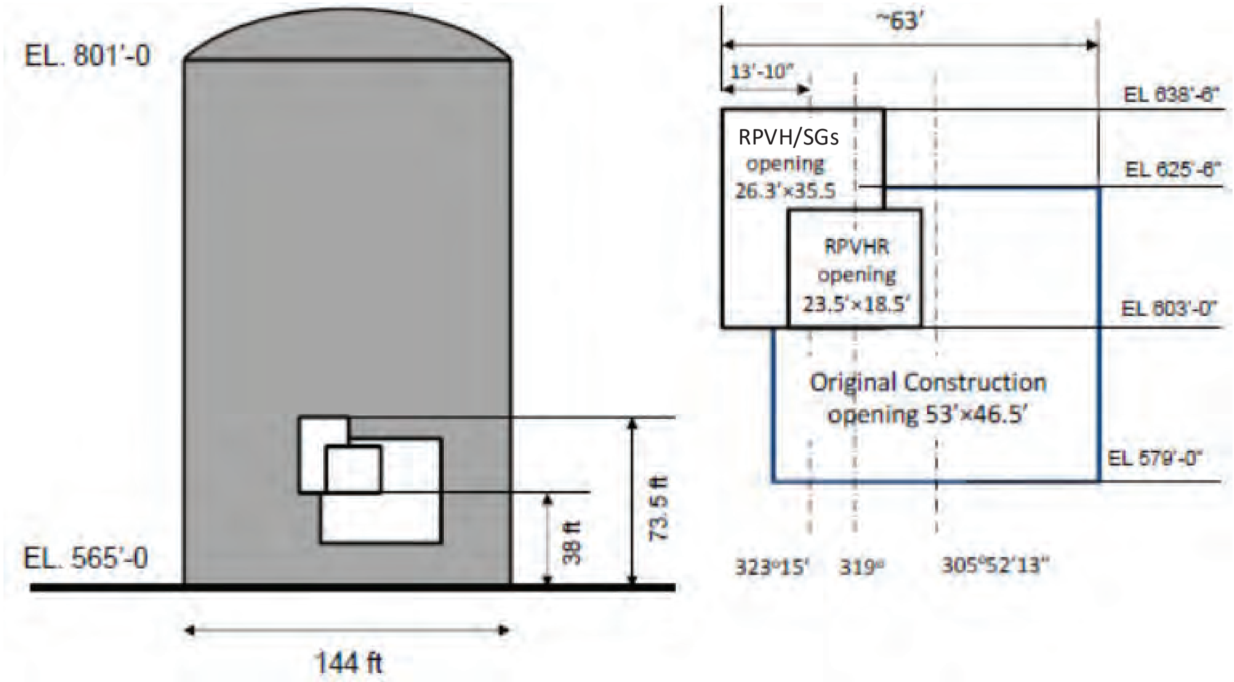


Figure 2: Shield Building Temporary Openings

2.2 History of Laminar Cracking Condition

During the creation of the 2011 temporary opening for the RPVH replacement, a crack was observed on October 10, 2011 in the architectural flute shoulder area at the edge of the opening (see Figure 3). The crack was found on the left vertical side of the opening (looking from the outside) and identified to be in the plane of the outer main reinforcing bar grid. The crack indication disappeared after some minor manual chipping along the edges of the opening and the crack was established to be a circumferential laminar crack with no indication in the radial (through-thickness) direction.

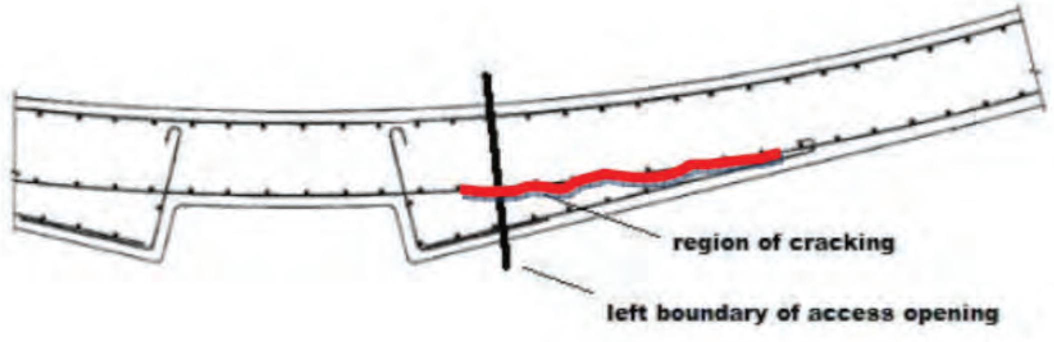


Figure 3: Cracking in Flute Shoulder Region on Left Edge of Temporary Openings

Further investigations and examinations were carried out, including impulse response (IR) scanning by Construction Technology Laboratories (CTL) of the accessible areas around the circumference of the Shield Building. IR scanning could not be performed on inaccessible areas including the exterior Shield Building wall areas covered by the ladder and vent stack as well as the interior Shield Building wall areas within the Auxiliary Building envelope that were covered by a double wall or equipment. The IR scanning indicated that the laminar cracking was not just limited to the shoulder where the temporary openings were located, but rather was also present in the other shoulders. These scans also revealed that similar cracking was present outside the shoulder areas in the top 20’ of the cylindrical wall (approximately between El. 780’ and 801’) and that local cracking was present near main steam Penetrations 39 and 40. The observations from IR scanning were corroborated by core bores taken from the areas with laminar crack indications. Laminar cracking was not identified in the Shield Building dome.

In general, the observations indicated that the laminar cracking is in line with the outer mat of the main cylindrical reinforcing. The IR maps and core bores in these regions, along-with the chipping conducted on the left edge of the temporary opening, show that in general the cracks terminate when approaching the location where the shoulder reinforcing intercepts the outer mat of the main cylindrical reinforcing.

The widths of the cracks observed in 2011 were measured using a crack comparator from core bores taken at as many locations as possible. These indications of laminar cracking were observed to be tight, with most cracks with widths less than 0.010” (one reading of 0.013”).

Since the cracks were tight and there was no evidence of carbonation on the cracked surfaces or of any rebar corrosion, the age of the cracks could not be accurately established. The root cause analysis of the condition concluded that these cracks had been present in the Shield Building for a long time with no adverse impact on its structural integrity and safety function.

During the initial technical acceptance of the Shield Building, industry experts Prof. Mete Sozen of Purdue University and Prof. David Darwin of the University of Kansas were consulted for an independent assessment of the structural integrity of the Shield Building. As part of their review, they recommended that the potential impact of the laminar crack on the bond capacity of rebar should be investigated at the splice locations by performing additional experimental testing. The details of the testing process and results is outlined in subsequent sections.

Also, as part of initial technical acceptance of the Shield Building, a crack monitoring program was instituted (Ref. 6a). This periodic monitoring program utilizes the combination of IR scanning and core bores to evaluate the condition of the building and to identify any changes in the crack configuration within the building. As committed to in USAR Section 18.1.43, implementation of this monitoring program is per site procedure to identify concrete condition, crack width/extents, and rebar condition (if exposed within the core bores). Inspection is per industry standards and inspectors are qualified as described in Chapter 7 of ACI 349.3R (Ref. 5c). The monitoring program covers the circumference of the Shield Building using a sampling that provides a representative sample for the regions with laminar cracking and incorporates the knowledge gained from previously collected crack data to help track any potential crack growth and/or propagation. The data from the crack monitoring program is documented in References 3d and 3e.

The data from the crack monitoring program in 2013 and 2014 indicated no significant change in crack widths and no indications of any crack propagation from the initial observations.

The data from the crack monitoring program in 2015 indicated that there was an increase in the crack widths at some core bore locations, with the maximum crack width of approximately 0.016” at one location; however, there was no indication of any propagation of cracks beyond the initially identified areas.

The crack monitoring program observations from 2016 indicated that crack widths at most locations were higher than the corresponding 2015 readings, with the maximum crack width exceeding 0.050”. The monitoring also observed cracking in previously uncracked bores. Since these observations were significantly different from those in previous monitoring programs, an independent verification of the plant crack measuring procedure was carried out by CTL (Ref. 6b). A comparison of the data collected by plant personnel with that from CTL for the same crack locations and using similar techniques generally produced comparable results, with some exceptions where CTL results indicated higher crack widths at some locations. In summary, the independent review by CTL verified the plant procedure for crack width measurements and confirmed that cracks exceeded 0.050” at some locations. The 2016 monitoring program also indicated the first evidence of rebar corrosion in the areas with laminar cracking.

The crack monitoring program observations from 2017 to current indicate a continued trend of propagation in both crack width and extent of cracking. Each year’s findings are documented and evaluated to establish continued operability.

As noted in Section 1.0, a repair program has been instituted to perform bulk concrete repair of the shoulders where laminar cracking exceeds 0.050”. In the subsequent sections, this Technical Report provides the basis for incorporation of the 0.050" acceptance limit into the design/licensing basis.

3.0 Rebar Capacity

The initial technical evaluation identified that the bond strength of the lap splices for the reinforcement in the region of laminar cracking was the main item that needed further investigation. Since the laminar cracking is located along the plane of the reinforcement, the capacity of the reinforcing bars has the greatest potential to be affected by the laminar cracking. The limiting component of this effect was determined to be at the lap splices, where the laminar cracking had the potential to cause slippage and prevent the reinforcing bar from developing its full capacity.

To establish the structural adequacy of the Shield Building with the initially observed laminar cracking with crack widths of up to 0.013", an experimental test program (Phase I) was conducted at Purdue University and the University of Kansas in 2012 with the main objective of investigating the effect of laminar cracks (with widths approaching those observed in the Shield Building) on the bond capacity of the reinforcement at the lap splice locations (Ref. 1a). The observations and conclusions from the Phase I test program were used to perform the initial structural design evaluation of the Shield Building and demonstrate compliance with applicable codes of record and regulatory requirements.

Subsequently, a Phase II test program was conducted at Purdue University in 2016 to establish the maximum width of laminar cracks that will not affect the load carrying capacity of the reinforcement at the lap splice locations (Ref. 1b). The main goal of the Phase II test program was to help establish the structural adequacy of the Shield Building for any crack widths observed during the plant periodic monitoring that may not be covered by the conclusions from the Phase I test program.

As noted earlier, the 2016 crack monitoring program identified significant widening and propagation of the laminar cracks compared to those observed in previous periodic crack monitoring. Some of the laminar crack observations exceeded the bounding crack width limit recommended by the Phase II test program. Therefore, a Phase III test program was designed and conducted at Purdue University in 2017 to investigate the effectiveness of post-installed adhesive anchors on the load carrying capacity of reinforcement at the lap splice locations (Ref. 1c), as a potential repair mechanism for the Shield Building. The experimental setup for the Phase III test program was different from that used in the Phase I and II test programs, but it did include reference specimens without anchors to benchmark the results. Although the use of post-installed anchors was not adopted as the repair mechanism for the Shield Building, the observations from the Phase III reference specimens without anchors provided additional data that can be used to supplement and confirm the conclusions on maximum crack widths from the earlier test programs.

The details of these three test programs are provided below. It is noted that this technical report is based on the Phase I, II and III testing at Purdue University only. Although the results from the Phase I testing at the University of Kansas were utilized in the initial structural adequacy evaluation of the Shield Building and produced similar results as the testing at Purdue University, they are not included in this report because the testing was not continued at the University of Kansas beyond Phase I (i.e., did not evaluate the effect of laminar cracking on the rebar splices for widths in the range relevant to this technical report).

For all the testing phases, it was not possible to exactly match the concrete properties given the age of the concrete. Therefore, every effort was made in the test programs to test at relatively lower (conservative) compressive strength and tensile strength values to produce conservative bond capacity values. The average 28-day compressive strength from original construction of the Shield Building was 5,836 psi; the average compressive strength of in-place concrete obtained from cores taken during the Shield Building evaluation in 2011 was 7,571 psi, with a corresponding tensile strength of 918 psi. The material properties used for the Phase I, II, and III test programs are described in Sections 3.1.2, 3.2.2, and 3.3.2, respectively. All reinforcing bars used in testing conformed to ASTM A615, which is the same as for the original construction of the Shield Building.

3.1 Phase I Test Program

The objective of the Phase I test program in 2012 was to evaluate the effect of laminar cracking with crack widths on the order of 0.010”, on the load carrying capacity of reinforcing bar (Ref. 1a). Based on a review of Shield Building reinforcement details, the 79” lap splices for vertical rebar and hoop rebar below EL 780’ and 120” lap splices for hoop rebar above EL 780’ were postulated to be within the regions of laminar cracking. The vertical bars are confined by the hoop bars and concrete cover, so the splices for vertical bars are less critical than the splices for the hoop bars. The reinforcement is comprised of both #10 and #11 bars. The #10 reinforcing bar requires less development length and is therefore less critical than the #11 reinforcing bar.

The Phase I test program was established and conducted at Purdue University, testing 12 specimens of 79” and 120” lap splices for #11 bars. The specimen configuration in the Phase I test program used 6” spacing between bars (matching the minimum spacing of rebar for the Shield Building) and was prepared with lap splices placed side by side, as compared to the actual construction of the Shield Building where the splices are staggered. These conservatisms maximized the effect of the rebar/splices on each other. Also, the specimen configuration was conservative in that the splices in the Shield Building conform to the curvature of the building, which would provide an additional confinement effect, but this curvature was not included in the straight beam tests.

The test specimens were large-scale girders with rectangular sections, as typically used for testing splices. The specimens were 4-point girders, simply supported at two points equidistant to the center and loaded at two points, outside the supports, also equidistant to the center. A total of 12 specimens were tested under static loading, with six (Series A) having 120-in splices (nominally 85 bar diameters) and the remaining six (Series B) having 79-in splices (nominally 56 bar diameters). In both Series A and B, loading was applied monotonically in two test girders. In the remaining four test girders, an initial load was applied to or beyond yield to cause initial cracking, then the specimens were unloaded then reloaded.

In addition to load and deflection measurements, crack patterns and widths as well as longitudinal and transverse deformations of the test girders were recorded. The observed behavior of the test girders is described in terms of measured load-deflection relationships, recorded crack-width developments, and calculated reinforcement stresses. Detailed information on those topics is provided in Appendix A.

3.1.1 Experimental Outline

The test setup for the 120” and 79” splices is shown in Figures 4 and 5, respectively. Each girder in Series A had a total length of 39’, with the ends of the 120” splice at 3’ from the closer support. The cantilevered portions of the girder were 11’-6” long. Loads were applied on each cantilever segment at 10’ from the support. Each girder in Series B had a total length of 34’-4”, with the ends of the 79” splice at 3’ from the closer support. The cantilevered segments of the girder were 10’-10 ½” long. Loads were applied on each cantilever segment at 9’-8 ½” from the supports.

The test specimen configuration was based on the following considerations:

- Include more than one lap splice to simulate the interaction of adjacent lap splices (two splices were used).
- Use a minimum cover of 3” that translated to a clear distance of 6” between the two splices and led to a cross-sectional width of (4x3+4x1.41)”. The width of the girder section was set at 17 5/8” (Figure 6).
- Produce a splitting crack in the horizontal plane that would intersect both splices. To increase the probability of a splitting crack in the horizontal plane, given that cracking tends to occur in the direction in which cover is smallest, a side cover of 3” was used and a top cover of 5” was used.

The loads were generally applied in increments of 6 kips up to 36 kips, and above 36 kips, load increments were determined by measured displacement. Four of the specimens in Series A were subjected to loading in increments of 6 kips to yield and then to a mid-span deflection of 0.9”, unloaded, and reloaded. In Series B, the four specimens were loaded to 36 kips in 6-kip increments, unloaded, and then reloaded.

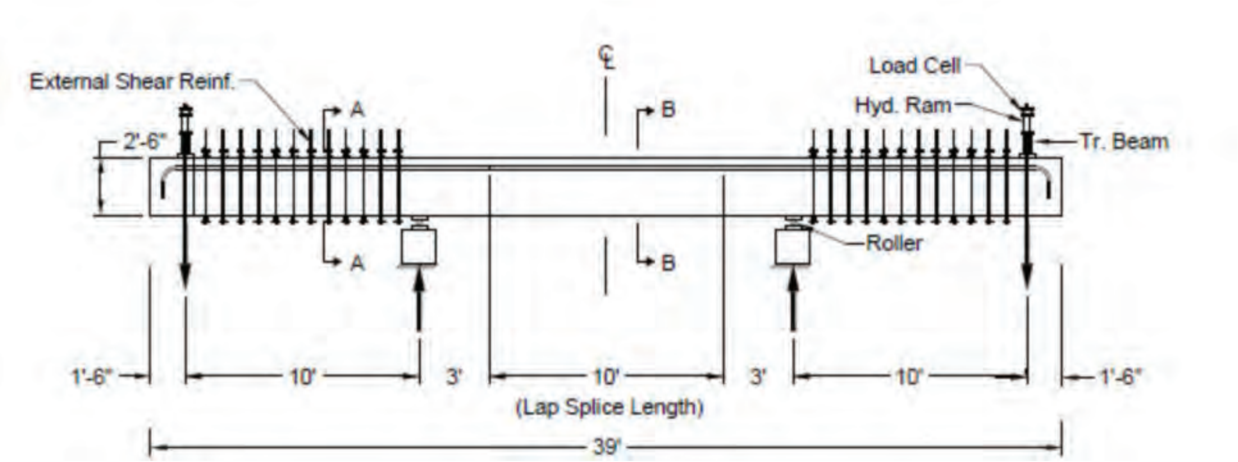


Figure 4: Series A Test Girder (From Appendix A)

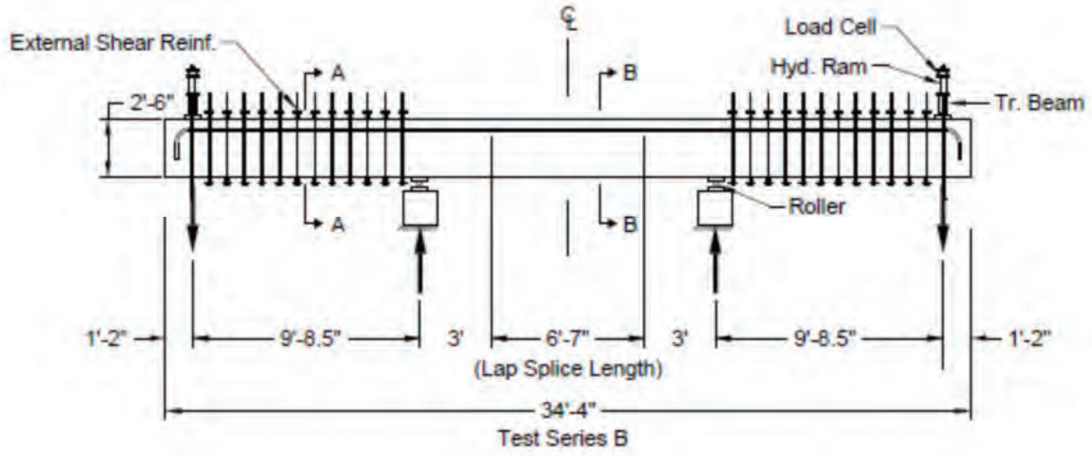


Figure 5: Series B Test Girder (From Appendix A)

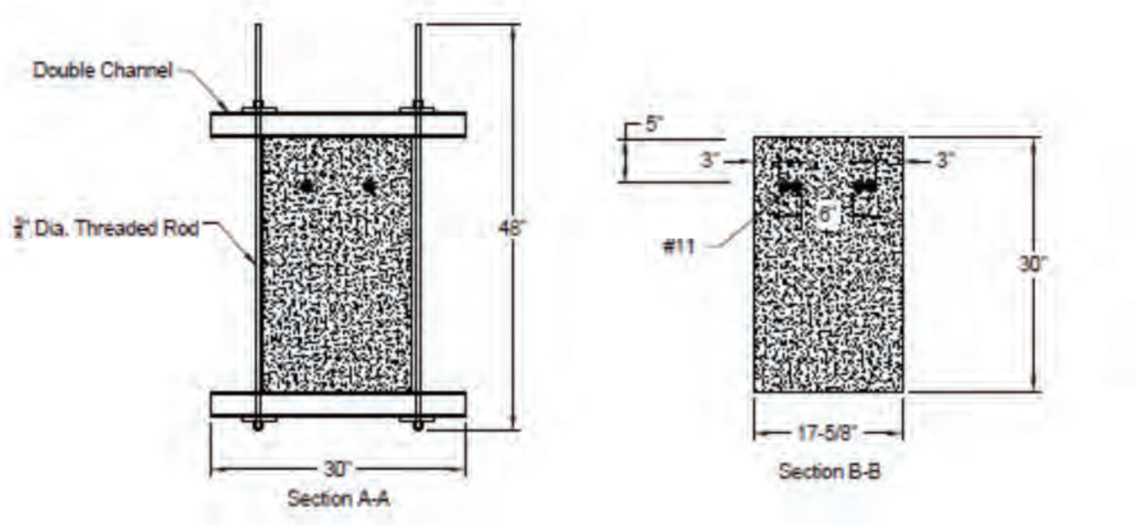


Figure 6: Cross-Sectional Dimensions of Series A and B Girders (From Appendix A)

Load and deflection measurements were obtained continuously and crack patterns and widths were recorded at different load steps in each test.

3.1.2 Materials

The opening of splitting cracks depends on the relationship between the tensile strength of the concrete and the intensity of bond stress that creates the splitting stresses. Since the compressive strength of the in-place concrete for the Shield Building exceeded 6,000 psi, the tests were conservatively designed to have a concrete strength at time of tests not exceeding 6,000 psi.

Concrete used in the specimens was mixed and delivered to the laboratory by Irving Materials Inc. of West Lafayette, IN. Each girder and its related cylinders were cast using concrete from a single truck. The mix proportions by weight were:

Component	Weight of Component / Weight of Cement
Cement	1
Fine Aggregate	2.4
Coarse Aggregate (max. size = 1¼ in.)	2.6
Water	0.55

Target air entrainment was 5%, similar to the in-situ Shield Building. As concrete was being placed, temperature, air content, and slump of the mix were measured. Air temperature was also recorded. Target moist curing was 7 days but the curing period was reduced for some specimens as a result of early cylinder tests that indicated high strength. Table 1 shows the concrete strength data and detailed information for each casting is included in Appendix A.

All reinforcing bars came from the same heat and the actual material yield and tensile strengths of rebar were 66 ksi and 103 ksi, respectively (Table 2). Stress-strain properties of the bars are included in Appendix A.

Table 1: Concrete for Phase I Test Program

Test Girder Designation	Cast	Tested	Concrete Compressive Strength [psi]	Concrete Splitting Cylinder Strength [psi]	Lap Length [in.]
A1	17 April 2012	4 June 2012	5270	480	120
A2	17 April 2012	1 June 2012	6030	500	120
A3	17 April 2012	30 May 2012	5890	480	120
A4	24 April 2012	8 June 2012	5110	440	120
A5	24 April 2012	7 June 2012	5240	440	120
A6	24 April 2012	5 June 2012	5490	450	120
B1	10 April 2012	10 May 2012	4460	450	79
B2	10 April 2012	23 May 2012	4800	480	79
B3	10 April 2012	21 May 2012	4780	420	79
B4	30 April 2012	14 May 2012	5460	490	79
B5	30 April 2012	17 May 2012	5260	480	79
B6	30 April 2012	25 May 2012	5230	450	79

Table 2: Reinforcement for Phase I Test Program

Bar Designation	#11
Nominal Diameter, in.	1.41
Nominal Area, in^2	1.56
Nominal Perimeter, in.	4.43
Unit Weight, lbf/ft	5.31
Yield Stress*, ksi	66
Strength*, ksi	103
Limiting Strain in 8 in., %	14,18,19

**Note: mean from tests of three coupons*

3.1.3 Load-Deflection Relationships

Figures 7 and 8 contain the measured load-deflection relationships of the Series A and B girders, respectively. The reported deflection is the relative movement (deflection up considered to be positive) of girder mid-span with respect to the supports. The reported load is the averaged load applied near the end of the cantilever section.

All load-deflection curves measured had two common characteristics: (1) Yield moment of the section was developed after appearance of laminar cracks at low loads and at zero load in the case of the reloaded girders, and (2) all girders tested demonstrated a definite capability to maintain strength with increase in deflection beyond the yield.

It is of interest to note that the overall behavior of test girders A1, A4, A5, and A6 that were loaded, unloaded, and reloaded differed very little from those of A2 and A3 that were only loaded once, even though the specimen failures were initiated by the splice bond. In-fact, all the specimens had similar shapes to the envelope curves. All girders in Series A had the same yield deflection (approx. 0.5”) and similar maximum mid-span deflections (ranging from 1.4”-1.8”). Similar conclusions can be made for the responses of girders of Series B. For this series, the yield deflection was approximately 0.3” and the maximum deflection ranged from a little below 0.5” (Girder B1) to above 0.6” (Girder B6).

The range in concrete strength from 4460 to 5460 psi did not have a significant influence on the yield deflection. The three test girders with relatively low concrete strengths (Girders B1, B2, and B3) did have slightly lower maximum deflections; but the maximum recorded value for B1 (0.47”) with a concrete compressive strength of 4460 psi was not significantly lower than that of B5 (0.55”) which had a concrete compressive strength of 5260 psi.

Maximum applied loads ranged from 42.0 kips to 44.1 kips for Series A and from 39.7 kips to 40.6 kips for Series B. Based on the maximum applied load alone, it is hard to differentiate the results for Series B compared to those of Series A. It is also worth noting that results of both Series A and Series B tests showed repeatability and consistency of results as shown in Figure 9 which is reassuring in terms of expected performance.

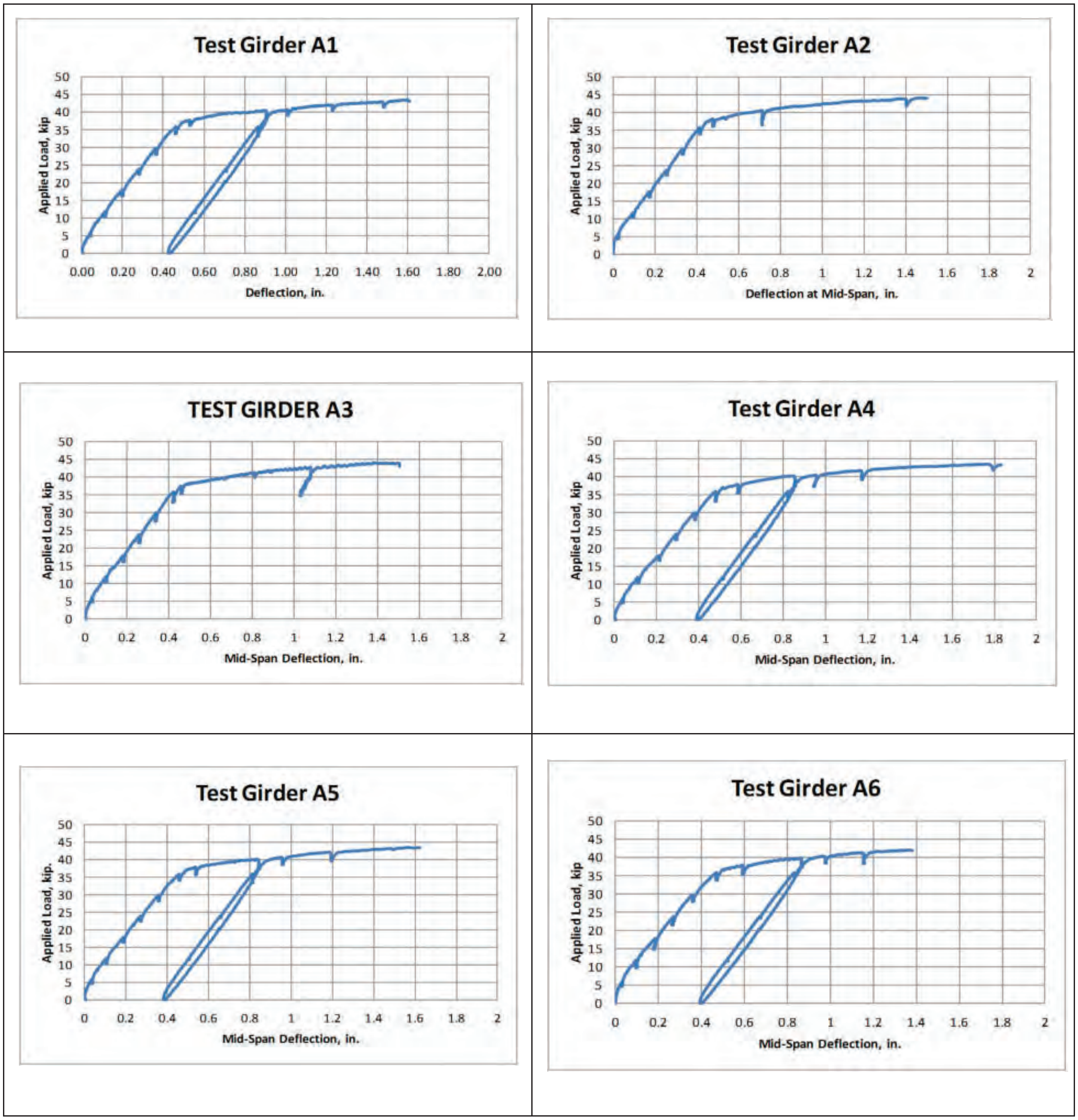


Figure 7: Force Deflection Behavior of Series A Specimens (From Appendix A)

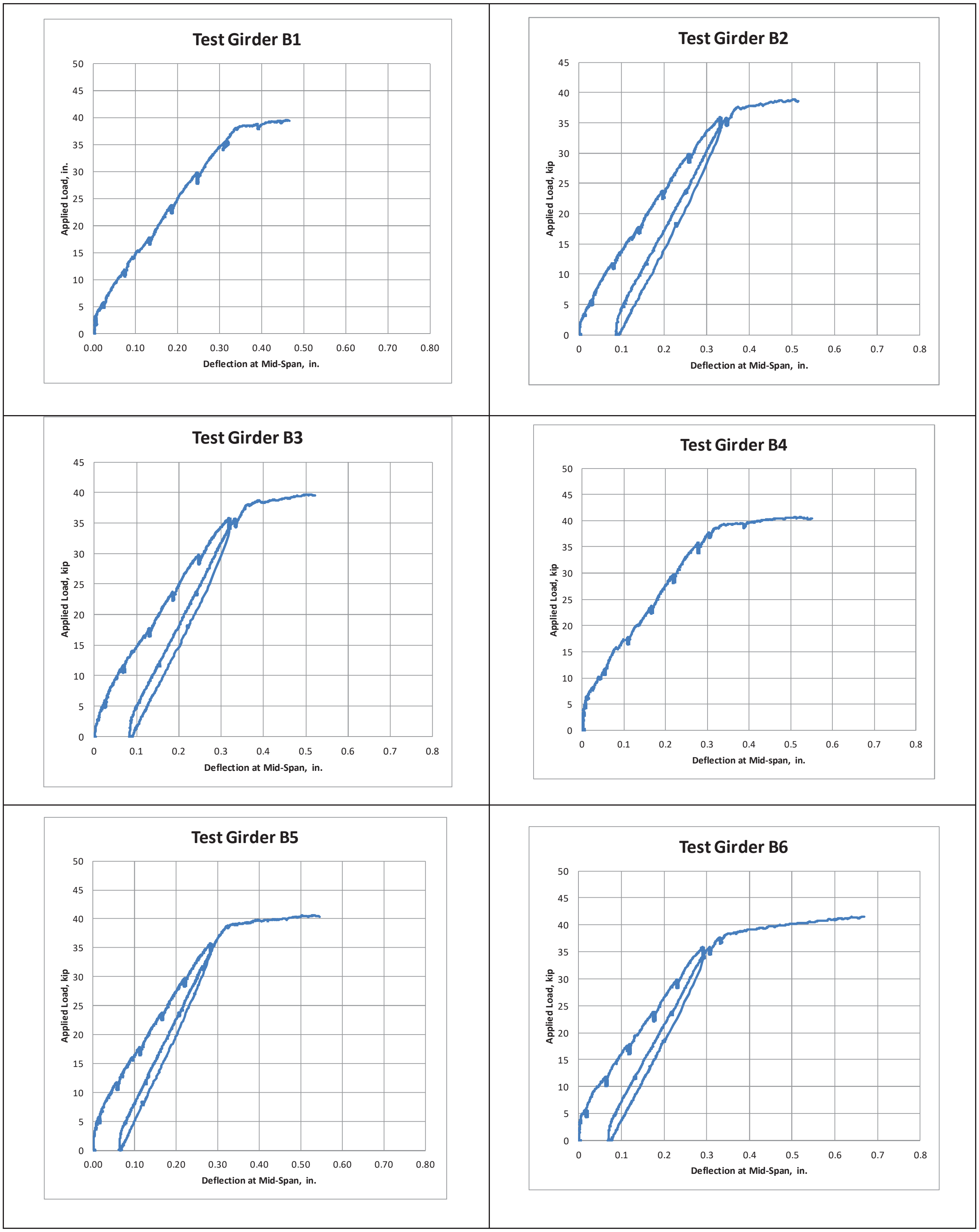


Figure 8: Force Deflection Behavior of Series B Specimens (From Appendix A)

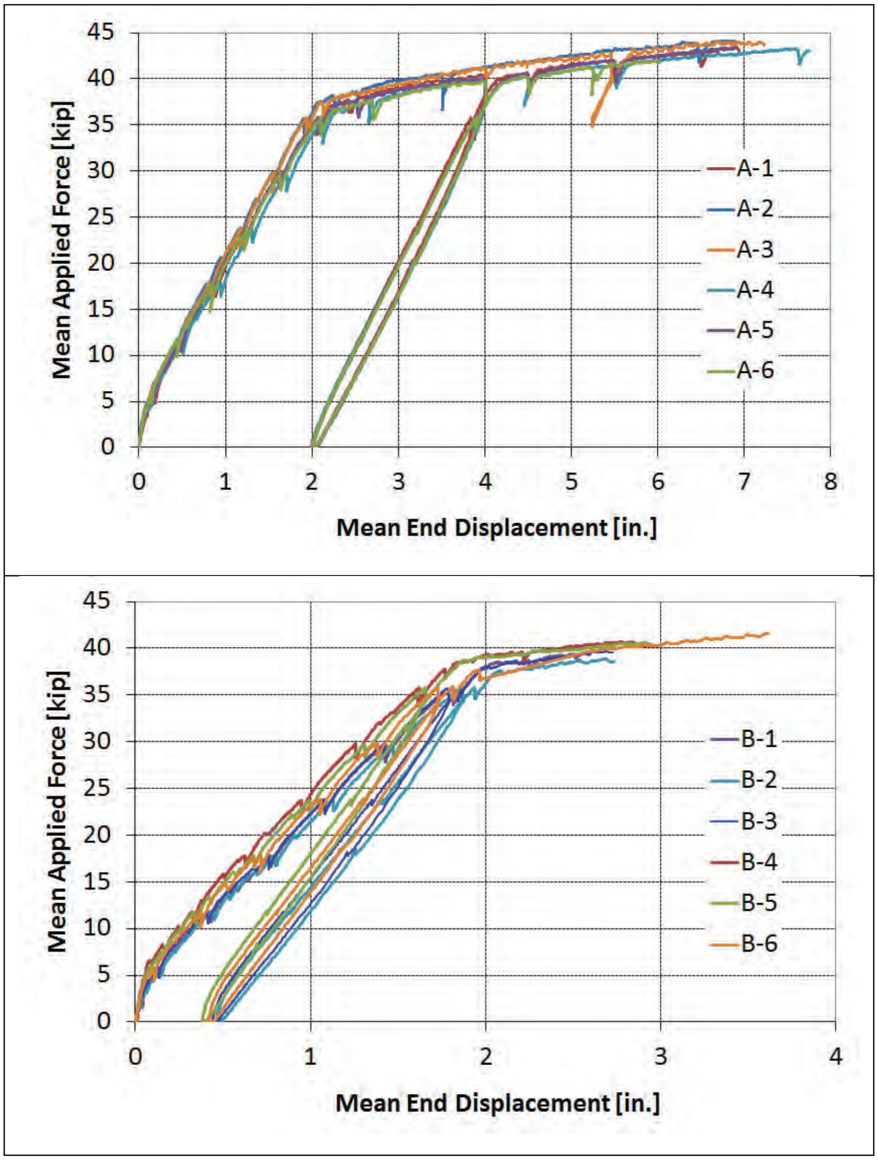


Figure 9: Consistency of Results for Phase I Test Program

3.1.4 Crack Measurements

Changes in crack patterns and widths were recorded in detail and are reported completely in Appendix A. Observed development of flexural crack patterns and thicknesses were consistent with what is normally expected in reinforced concrete beams responding primarily to flexure. Figure 10 shows a typical pattern of observed cracking. The flexural cracks occurred at a spacing of approximately twice the top cover or ~10". It is also seen that the cracks near mid-span did not reach as far towards the compressed edge of the girder as the ones near the support. This was an indication that the lap splice was effective, and all four bars resisted the load.

Figure 10 also shows the typical pattern of the horizontal crack at or near the level of the reinforcement in the test specimens (highlighted in red and representative of the laminar crack). A descriptive metaphor for their formation is provided by visualizing the bars as thin-walled pressurized tubes embedded in concrete. The internal pressure causes circumferential tensile stresses in the concrete around the tube that decrease with distance. The crack is initiated in the weakest plane which corresponds to the plane resulting in the minimum cover. The crack is initiated in the immediate surface of the tube and progresses out as the pressure in the tube increases. It is also relevant to note that a splitting crack can exist next to the reinforcement but not be visible on the surface of the girder.

Figure 10: Typical Pattern of Cracks – Phase I (From Appendix A)

The projection of this metaphor to the test girders suggests that the splitting crack would occur on a horizontal plane intersecting the reinforcement and that the surface width of the crack is likely to be smaller than its width next to the spliced bars. The force transfer mechanism in the splice is best understood by the following measurements: (1) longitudinal strain distribution at reinforcement level, (2) vertical deformation of the girder surface, and (3) distribution of widths of the splitting cracks. These are presented in detail in Appendix A.

The longitudinal-strain data show that there was a dominant pattern in strain distribution along the splice. In the first loadings, rapid change in strain occurred primarily in the outer 20” segments of the splice, indicating the region where most of the force transfer from bar to bar took place. The test results confirm that the regions of relatively large vertical deformation occurred in the outer 20” of the splices for both the 79” and 120” splices.

The crack-width observations documented that measurable (0.005” or more in thickness) laminar cracks of limited length (6”-12”) occurred at low loads on the order of one fourth of the maximum load resisted. Cracks reached levels in excess of 0.100” at loads approaching the maximum load. At such levels of load, laminar cracks meandering along the level of the reinforcement covered virtually the entire test span. In fact, for specimens that were loaded, unloaded, and reloaded, the maximum crack widths reached 0.100” for Series A and 0.030” for Series B specimens during the initial loading.

Figures 11 and 12 show the magnitude of the recorded maximum crack width and vertical deformation along the splice lengths of Series A and B, respectively. The results show good correlation between the crack width and the vertical surface deformation. The results also show that cracks well exceeded the initial crack widths observed in the Shield Building, which were generally less than 0.010”, with one crack of 0.013”.

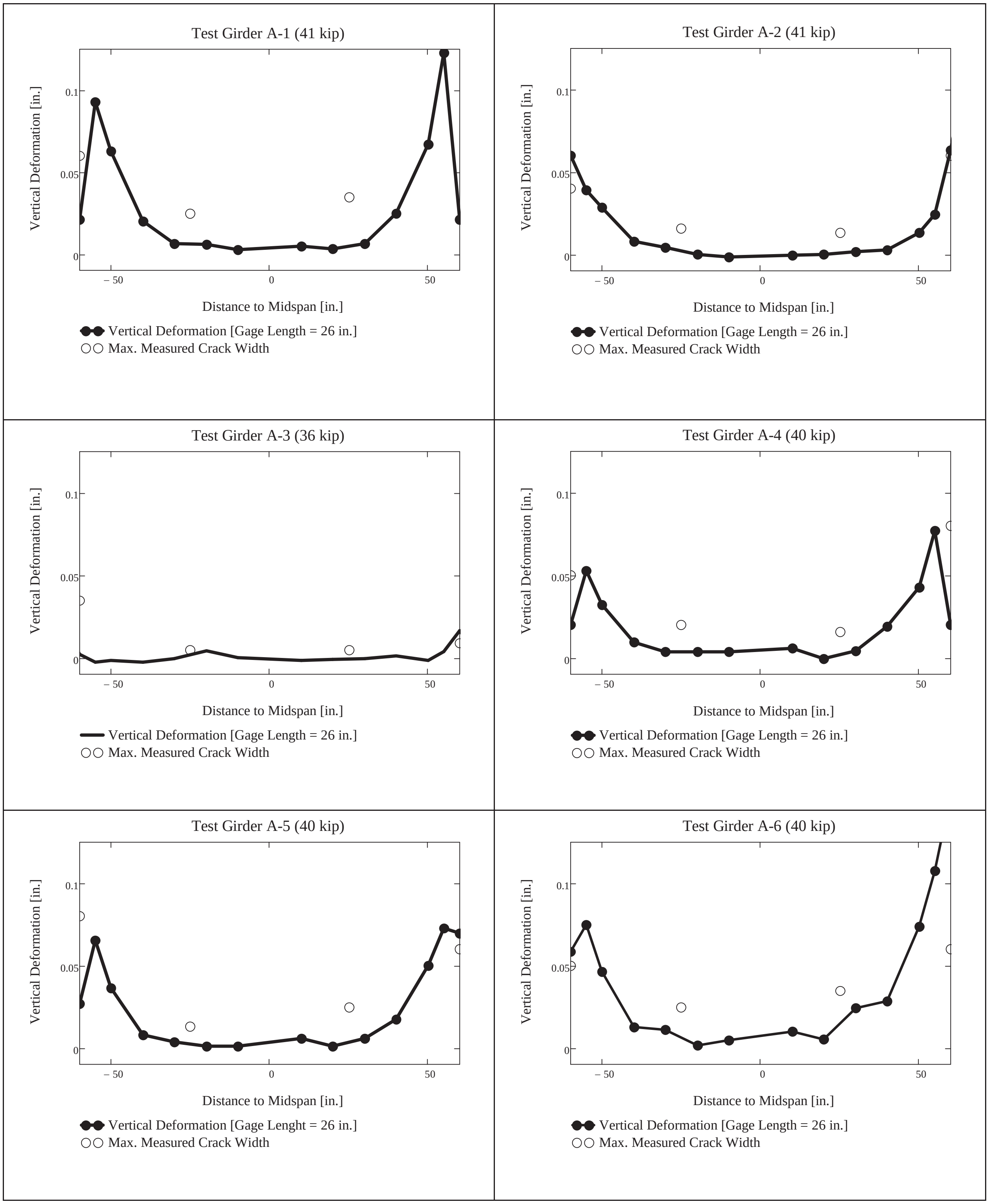
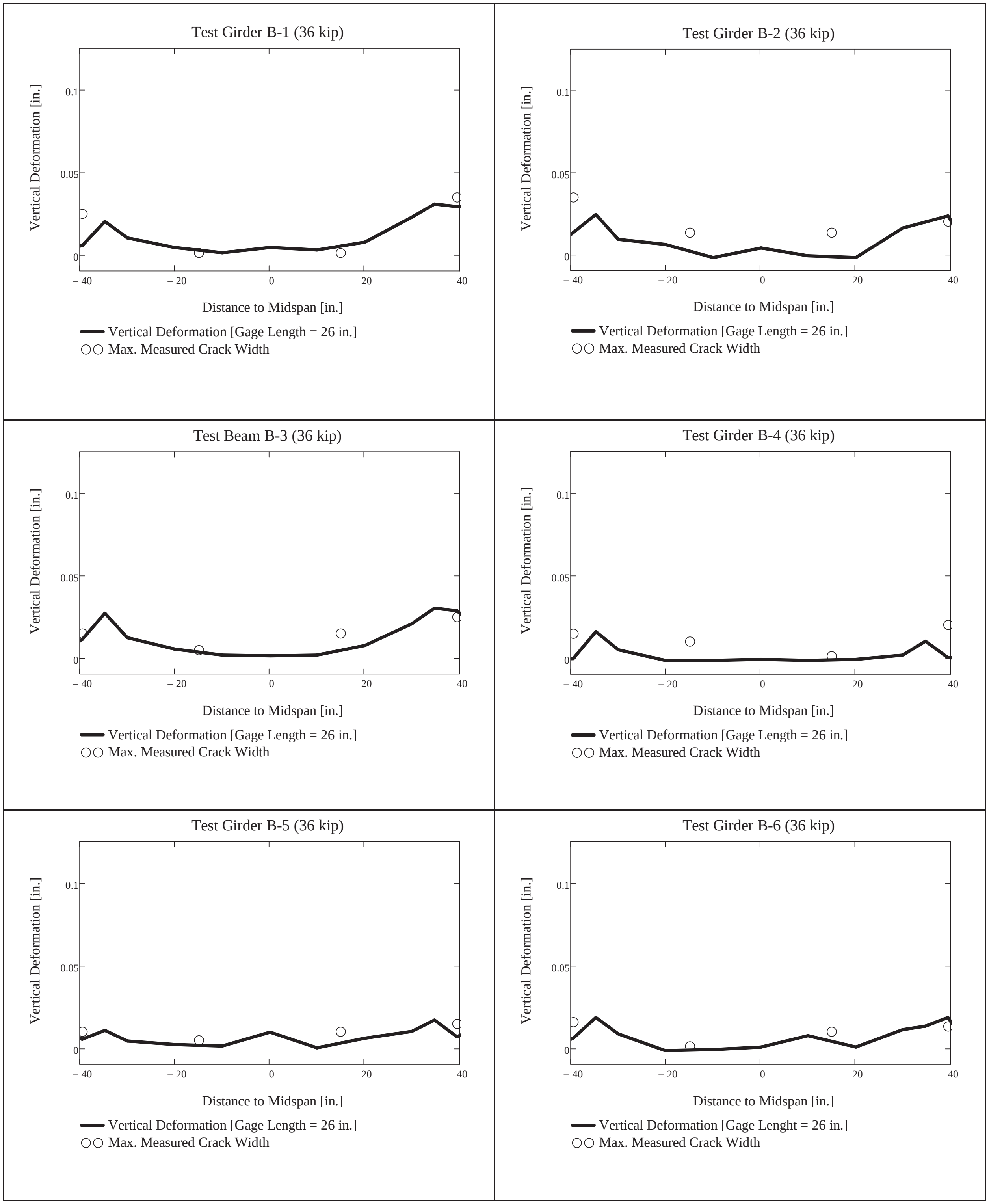


Figure 11: Correlation of Vertical Deformation with Crack Width for Series A



Test Girder B-1 (36 kip)

Test Girder B-2 (36 kip)

Test Beam B-3 (36 kip)

Test Girder B-4 (36 kip)

Test Girder B-5 (36 kip)

Test Girder B-6 (36 kip)

Figure 12: Correlation of Vertical Deformation with Crack Width for Series B

3.1.5 Maximum Reinforcement Stresses Attained

As documented in detail in Appendix A, maximum tensile stresses achieved at the ends of the splice were computed based on the moment at the end of the splice and cross-sectional properties of the test girder. The calculated stresses are shown in Table 3. The minimum tensile stress attained in the reinforcement at the end of the splice was 69 ksi (Test Girder B2) and the maximum was 80 ksi (Test Girders A2 and A3).

Table 3: Summary of Results for Phase I

Test Girder Designation	Concrete Splitting Strength (Tensile) [psi]	Concrete Compressive Strength [psi]	Lap Length [in.]	Maximum Applied Load [kip]	Maximum Moment at Support [kip*ft]	Maximum Moment at Splice End [kip*ft]	Calc. Reinf. Stress at Support [ksi]	Calc. Reinf. Stress at Splice End [ksi]
A1	480	5270	120	43.5	481	470	81	79
A2	500	6030	120	44.1	487	476	82	80
A3	480	5890	120	44.1	487	476	82	80
A4	440	5110	120	43.3	479	468	81	79
A5	440	5240	120	43.4	480	469	81	79
A6	450	5490	120	42.0	466	455	78	77
B1	450	4460	79	39.5	425	417	72	71
B2	480	4800	79	38.9	419	419	71	69
B3	420	4780	79	39.7	427	419	72	70
B4	490	5460	79	39.7	427	419	71	70
B5	480	5260	79	40.6	436	428	73	72
B6	450	5230	79	40.6	436	428	73	72

3.1.6 Key Observations

Based on a review of the Phase I test results and the details presented in Appendix A, the following important observations can be made:

- Strain measurements and observed distribution of laminar cracks created during the tests confirmed that most, if not all, of the force transfer from one bar to another occurred in the end of the splice over a length of approximately 20” (~15 bar diameters). In the four specimens that were unloaded and reloaded, the measured maximum widths of these cracks during the initial loading exceeded 0.100” for Series A and 0.030” for Series B, with the maximum widths of the cracks at zero load before reloading being 0.080” for Series A and 0.015” for Series B.
- In both series, laminar cracks formed at a fraction of the yield load in all test girders. The difference between the strength and behavior of the girders loaded monotonically and those unloaded after reaching or exceeding yield and reloaded was negligible.

The existence of laminar cracks at the beginning of loading did not change the strength of the splices. The ratio of the limiting deflection to the yield deflection was approximately 3:1 in Series A with 120” splices and 2 in Series B with 79” splices.

- The yield strength of the rebar was 66 ksi, and for Series A and B test girders, the tensile stresses of 69 ksi to 80 ksi were attained in the reinforcement at the end of the splice (i.e., the rebar achieved more than its yield strength). The maximum reinforcement stresses in the test girders loaded to develop laminar cracks and reloaded differed negligibly from those in girders loaded monotonically. Each test specimen included two splices placed next to each other without stagger and with 6” spacing. This was a conservative test condition compared to that of the Shield building where splices are staggered and typically have a 12” spacing.

The tests indicated that despite the conservative test conditions, the effect of laminar cracking with crack widths larger than 0.015” (conservatively considering the minimum crack widths at zero load before reloading) is inconsequential to the bond or force transfer capacity of both 79” and 120” lap splices, and full yield capacity could be used for design basis calculations.

3.2 Phase II Test Program

A total of 6 specimens were tested as part of the Phase II test program at Purdue University in 2016 to estimate the maximum width of laminar cracks that would not affect the load carrying capacity of the rebar splices (Ref. 1b). Because the first cracks observed in the Shield Building were narrow, Phase I focused on the effects of laminar cracks on the strength of lap splices without specific attention to establishing a plausible limit to the width of those cracks. Therefore, the goal of Phase II testing was to estimate such a bounding maximum crack width that can be used to help establish the structural adequacy of the Shield Building with the crack widths approaching those observed under the plant monitoring program. Based on the results of the Phase I testing, #11 rebar with 79” lap splices were used as the bounding configuration in the Phase II test program (see Appendix B).

3.2.1 Experimental Outline and Loading Protocol

The Phase II test program specimens were labeled as Series C to supplement the Series A and B Phase I specimens at Purdue University. The Series C test girders had the same geometry and configuration as the Series B test girders shown in Figure 5. Similar to the approach used for the Series B tests, the specimens were tested by applying an initial loading and unloading to initiate laminar cracks in the plane of the spliced rebar, and then reloading, with the loads applied in increments during the loading and reloading cycles. However, the loading for Series C girders was applied using a different loading protocol discussed below than that used for Series B girders. Unless noted otherwise, the term “deflection” below refers to the mid-span deflection for Phase II tests.

From the Phase I test results for Series B specimens, it was observed that most of the specimens yielded at a deflection of approximately 0.30” to 0.35”. The magnitudes of crack widths are directly correlated to the applied loads and corresponding deflections. The unloading for the Series B girders was initiated before or just at yielding (i.e., at a deflection less than 0.35” at the maximum applied load during the initial loading and unloading). To develop cracks wider than those observed for Series B girders, the initial loading for Series C girders was applied, in stages, to a total deflection of at least 0.4” before starting to unload the specimen. Four (4) girders (C-1 to C-3 and C-5) were loaded to a deflection of 0.4” during the initial loading and two (2) girders (C-4 and C-6) were loaded to a deflection of 0.5” during the initial loading.

Similar to Phase I tests, load and deflection measurements were obtained continuously and crack patterns and widths were recorded at different load steps in each test.

3.2.2 Materials

The concrete mix design for the Series C tests was kept the same as that used in the Phase I tests at Purdue University. Concrete used in the specimens was mixed and delivered to the laboratory by Irving Materials, Inc. of West Lafayette, IN. Each test girder and its associated cylinders were cast using concrete from a single truck.

Similar to Phase I, target air entrainment for the concrete mix was 5%. As concrete was being placed, air and concrete temperatures, air content, and slump of the mix were measured. The specimens were cured for a week in accordance with the approved Purdue test procedure. The compressive strength of concrete for the Series C specimens is summarized in Table 4 and shows that the mix used for the test girders was of uniform quality and strength. Detailed information and records for each casting are included in Appendix B.

Table 4: Concrete for Phase II Test Program

Test Girder	Cast Date	Test Date	Concrete Compressive Strength* [psi]	Concrete Splitting Cylinder Strength [psi]	Age of Specimen [days]
C1	2/2/2016	3/21/2016	5300	500	48
C2		3/28/2016	5200	450	55
C3		4/4/2016	5900	500	62
C4		4/11/2016	5700	500	69
C5		4/12/2016	5600	500	70
C6		4/14/2016	5300	400	72

**mean of six cylinder tests*

All reinforcing bars came from the same heat. Stress-strain properties of the bars are included in Appendix B. The properties of the reinforcing bars are presented in Table 5. The actual material yield strength of the rebar used for Phase II tests was 65 ksi.

Table 5: Reinforcement for Phase II Test Program

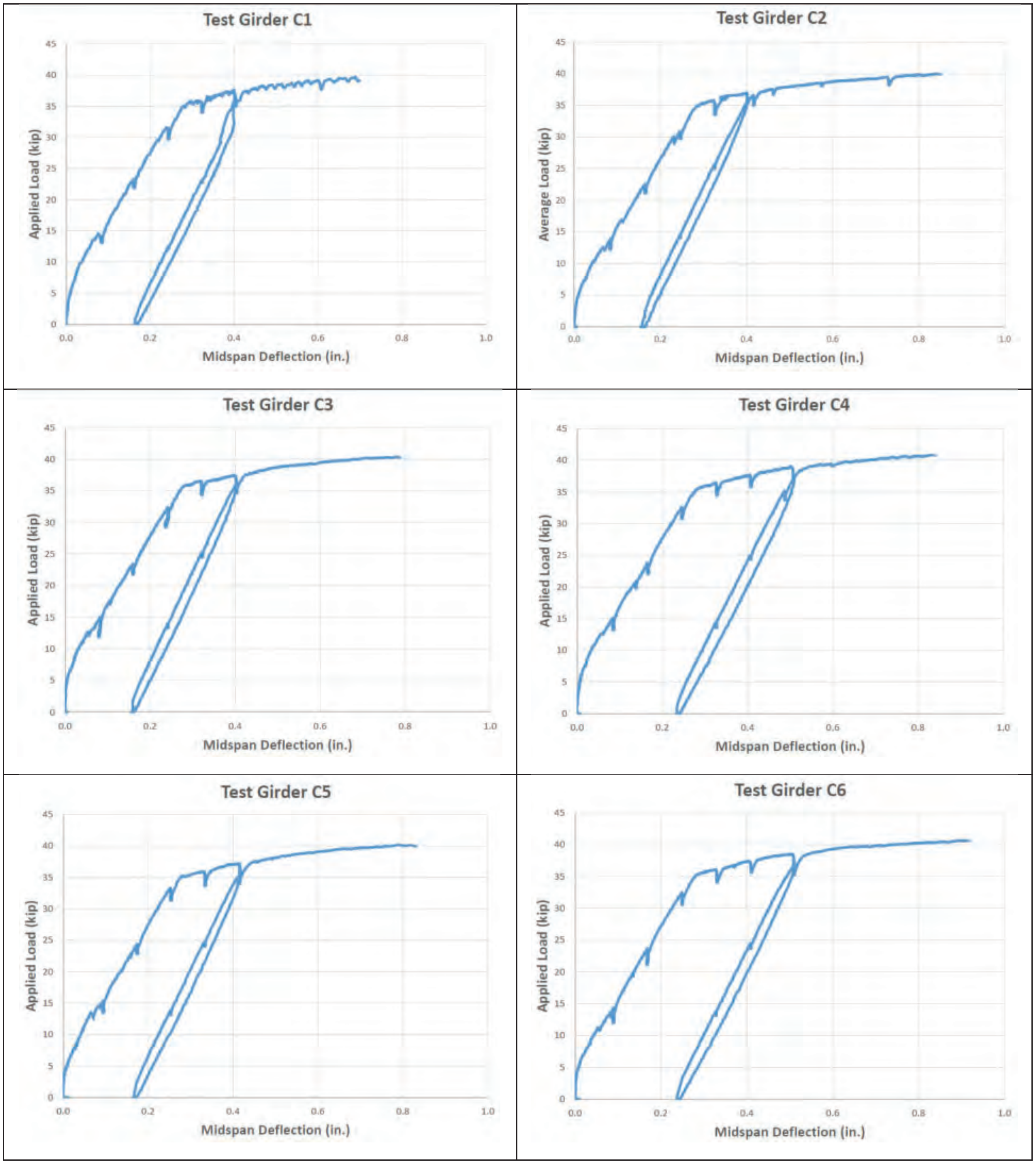
Bar Designation	#11
Nominal Diameter, in	1.41
Nominal Area, in^2	1.56
Nominal Perimeter, in	4.43
Unit Weight, lbf/ft	5.31
Yield Stress*, ksi	65

**mean from tests of three coupons*

3.2.3 Load-Deflection Relationships

Figure 13 depicts the measured load-deflection relationships separately for each of the six (6) test girders and Figure 14 shows the results superimposed in one plot. The reported load is the averaged load applied near the end of the overhang segments and the reported deflection is the mid-span deflection (deflection upward considered to be positive). From Figures 13 and 14, the results of Series C tests showed repeatability and consistency, which provides assurance for the acceptability of the tests (including test results) and expected performance.

The test girders showed yield deflection of approximately 0.28” and maximum deflection ranging from 0.70” to 0.92”. The ultimate load ranged from 39.7 kips to 40.9 kips for the Series C girders. All test girders demonstrated a definite capability to maintain strength with increase in deflection beyond yield, irrespective of the point of unloading.



Test Girder C1

Test Girder C2

Test Girder C3

Test Girder C4

Test Girder C5

Test Girder C6

Figure 13: Measured Load-Deflection Relationships for Phase II (Appendix B)

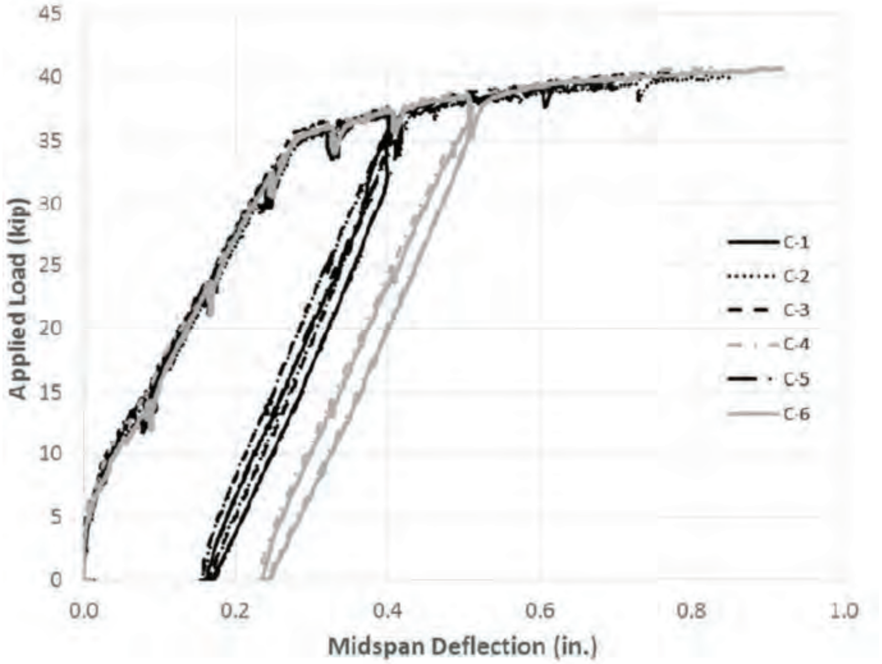


Figure 14: Consistency of Test Results – Phase II

3.2.4 Crack Measurements

Figure 15 shows the vertical deformation plot during the initial loading and unloading for each girder in the middle 80” of the specimen, which approximately corresponds to the length of the splice. The vertical deformation plot for girder C3 contains the data for the South end only, due to a sensor malfunction in the North end.

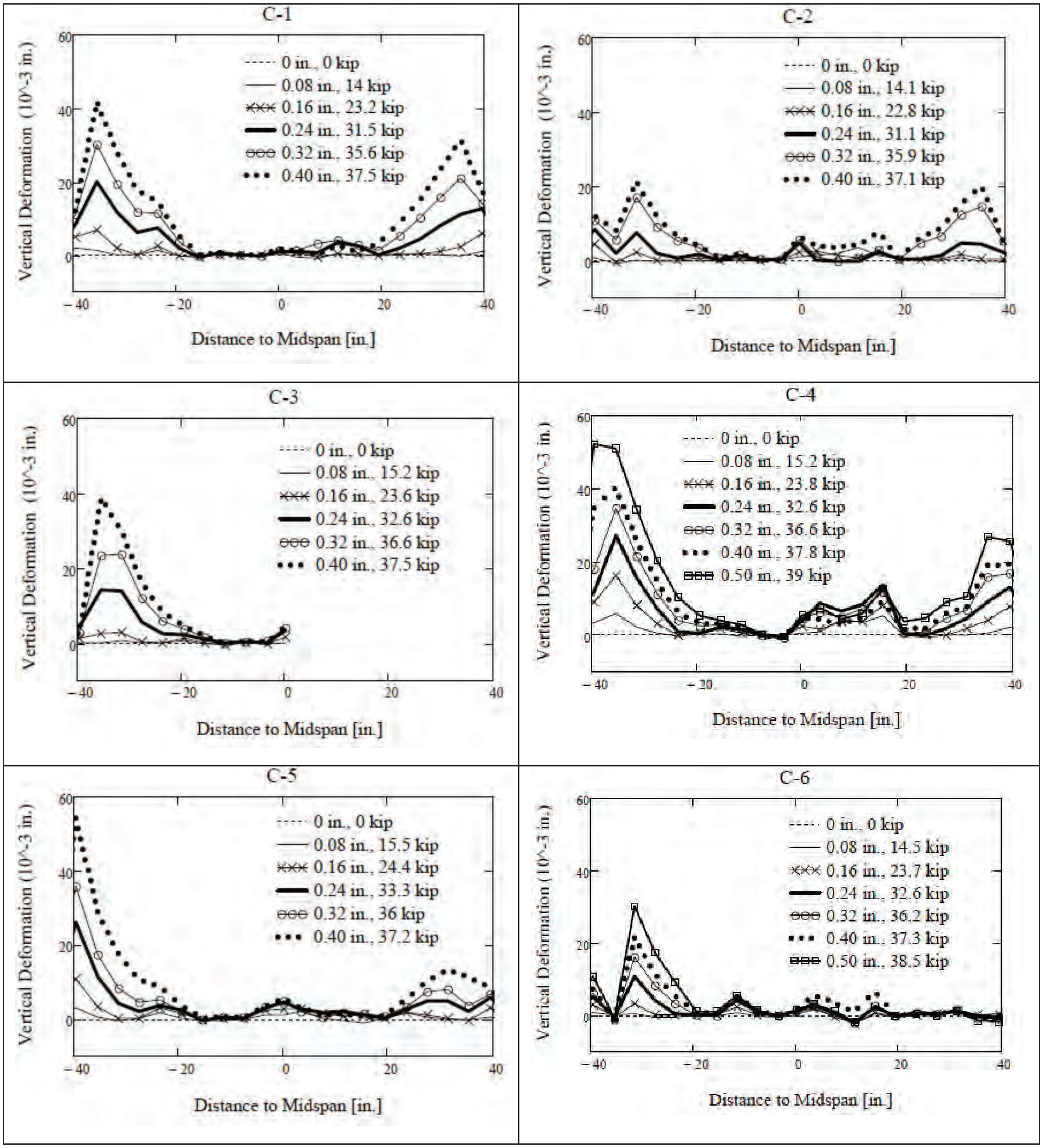


Figure 15: Vertical Deformations for Series C Test Girders during Initial Loading (from Appendix B)

Consistent with the Series B test girders, the results showed that most of the force transfer occurs at the ends of splice over lengths of approximately 15-bar diameters (i.e., approximately 20”). The calculated crack widths at the surface of specimens and the length of cracks are listed in Table 6.

Table 6: Crack Measurements for Phase II (from Appendix B)

Test Girder	Max. Mid-span deflection at Initial Loading [in]	Max. Crack Width reached during Initial Loading [10^{-3} in]	Mid-span Deflection at last reading during reload [in]	Max. Crack Width at last reading during reload [10^{-3} in]	Max. Crack Length at South Splice End [in]	Max. Crack Length at North Splice End [in]
C1	0.42	42	0.70	90	27	23
C2	0.40	21	0.41	25	22	27
C3	0.41	39	0.41	42	23	11
C4	0.52	52	0.50	53	28	24
C5	0.43	54	0.42	57	24	18
C6	0.52	30	0.52	33	22	0

3.2.5 Maximum Reinforcement Stresses Achieved

The maximum stresses in reinforcement at the support and splice end were calculated using the same approach as that in the Phase I test program. The stresses correspond to the moments at the respective locations that are primarily due to applied load, but also include contributions from other loads such as self-weight. The rebar stress calculations are reported in Appendix B and are summarized in Table 7. The tensile stresses attained in the reinforcement were well beyond the rebar yield strength, ranging from 73 ksi to 75 ksi.

Table 7: Summary of Test Results for Phase II (from Appendix B)

Test Girder	Concrete Comp. Strength [psi]	Concrete Splitting Tensile Strength [psi]	Max. Applied Loads [kips]	Max. Midspan Deflection [in]	Max. Moment at Support [ft-kip]	Max. Moment at Splice End [ft-kip]	Calc. Rebar Stress at Support [ksi]	Calc. Rebar Stress at Splice End [ksi]
C1	5300	500	39.7	0.70	427	419	74	73
C2	5200	450	40.0	0.85	430	422	75	74
C3	5900	500	40.4	0.79	434	426	76	74
C4	5700	500	40.9	0.83	439	431	76	75
C5	5600	500	40.2	0.82	432	424	75	74
C6	5300	400	40.7	0.92	437	429	76	75

3.2.6 Key Observations

Based on a review of the Phase II test results and the details presented in Appendix B, the following important observations can be made:

- The strength and ductility response of the test girders did not vary significantly with the maximum load applied during the initial loading. This means that the strength and ductility behavior of the test girders are independent of the maximum crack widths generated in the initial loading and unloading. The ductility ratio for the Series C test girders was approximately 3.
- The maximum crack widths at the surface of the specimens at the maximum load applied in the initial loading cycle ranged from 0.021” to 0.054”.
- Laminar cracks parallel to the spliced reinforcing bar opened at low loads. Widths of the laminar cracks varied along the length of the spliced region, with maximum widths typically in regions close to the ends of the splice.
- Most of the force transfer from one rebar to another occurred in the end of the splice over a length of approximately 15-bar diameters (approximately 20”).
- The yield strength of the rebar was 65 ksi, and for all test girders, the tensile stresses of 73 ksi to 75 ksi were attained in the reinforcement at the end of the splice (i.e., the rebar achieved more than its yield strength).

The intent of the Phase II test program was to estimate the maximum crack width that would not have an effect on the load carrying capacity of the lap splices. Table 6 shows that the maximum crack width during initial loading reached 0.054” for Series C test specimens, demonstrating that the load carrying capacity of the lap splices is not impacted for crack widths up to 0.054”.

The repeatability and consistency of the test results shows that the results are reliable. Also, the results are conservative and have a built-in safety margin for the following reasons, similar to those for the Phase I test program:

- The Series C test girders had an conservative configuration, since the pair of spliced rebar was placed closely next to each other and without stagger, specimen concrete compressive strength was lower than the average compressive strength of the in-place concrete in the Shield Building, and confinement effects due to the curvature of Shield Building and the extra concrete thickness of the Shield Building shoulders were neglected. Therefore, the Series C test results are conservative when compared to the behavior of the spliced rebar in the Shield Building.
- For a deformed rebar embedded in concrete and subjected to pullout force, the splitting stresses are highest next to the rebar and decrease away from the rebar. Therefore, the widths of laminar cracks are expected to be higher next to the rebar compared to those at the surface of the specimen. Therefore, the crack widths reported in Table 6 that are measured at the surface of the specimen are conservative.
- The maximum deflection limit of 0.50” during the initial loading was chosen based on considerations of personnel and equipment safety. Irrespective of the maximum load applied during the initial loading prior to unloading, the Series C test girders had similar strength and ductility response. If safety during testing was not a consideration, it is possible that a higher deflection limit could be achievable which would result in larger crack widths and, thus, potentially showing that crack widths larger than those reported in Table 6 may have no adverse impact on the load carrying capacity of the reinforcement.

Phase II tests showed that crack widths of up to 0.054” did not have an adverse impact on the load carrying capacity of the reinforcing bar lap splices. Reference 1b recommended using a safe bounding crack width limit of 0.050” for the purpose of assessing the acceptance of the observed cracking in the Davis-Besse Shield Building. Appendix D includes a technical memo from Purdue University concluding that laminar cracks with widths up to 0.050” have no adverse effect on the load carrying capacity of the rebar lap splices.

3.3 Phase III Test Program

The purpose of the Phase III test program at Purdue University in 2017 was to investigate the effect of post-installed anchors on the load carrying capacity of the rebar lap splices (Ref. 1c). This main intent was to evaluate the adequacy of the anchor system as a potential repair mechanism for the Shield Building at locations where the laminar crack width exceeded the recommended threshold limit of 0.050” based on Phase II test results. Similar to the Phase II test program, the Phase III investigation focused on the #11 rebar with 79” lap splices, which is the critical configuration.

It should be noted that the anchor system tested during Phase III did not ultimately end up being implemented. However, this testing program did utilize reference samples without anchors, which provided additional data to supplement the Phase I and II testing. Also, as will be discussed below, a different test configuration and protocol were utilized for Phase III; however, the results were similar to Phase I and II, thus providing confirmation of the conclusions reached during Phase I and II.

3.3.1 Experimental Outline and Loading Protocol

Because of the large number of specimens for the Phase III test program and the potential necessity of significantly more tests that would need to be conducted, a simpler test configuration and loading protocol was utilized compared to those used for the Phase I and II test programs at Purdue University. As discussed earlier, Phase I and II test programs used long test girders subjected to 4-point transverse loading that produced constant flexure over the test span and subjected the #11 rebar with lap splice to tensile loading. For the Phase III test program, a simplified test configuration was used, wherein shorter (6’-8” long) specimens were used, but having the same cross-section (17-5/8”×30”) as that for the test girders used in the previous test programs (see Figures 16 and 17). The specimen length was dictated by the 79” lap splice length. The test specimens were subjected to tensile loading applied directly to the spliced #11 rebar to produce similar effects as in the test girder specimens used in the previous test programs. The tensile force to the rebar was applied through a “self-reacting” loading frame (see Figures 16 and 17). Refer to Appendix C for details.

Specimens were tested both without any anchors and with different anchor configurations (depth of embedment, spacing, etc.) as transverse reinforcement. Since the use of anchors is not the subject of this Technical Report, only the six (6) specimens without anchors will be discussed.

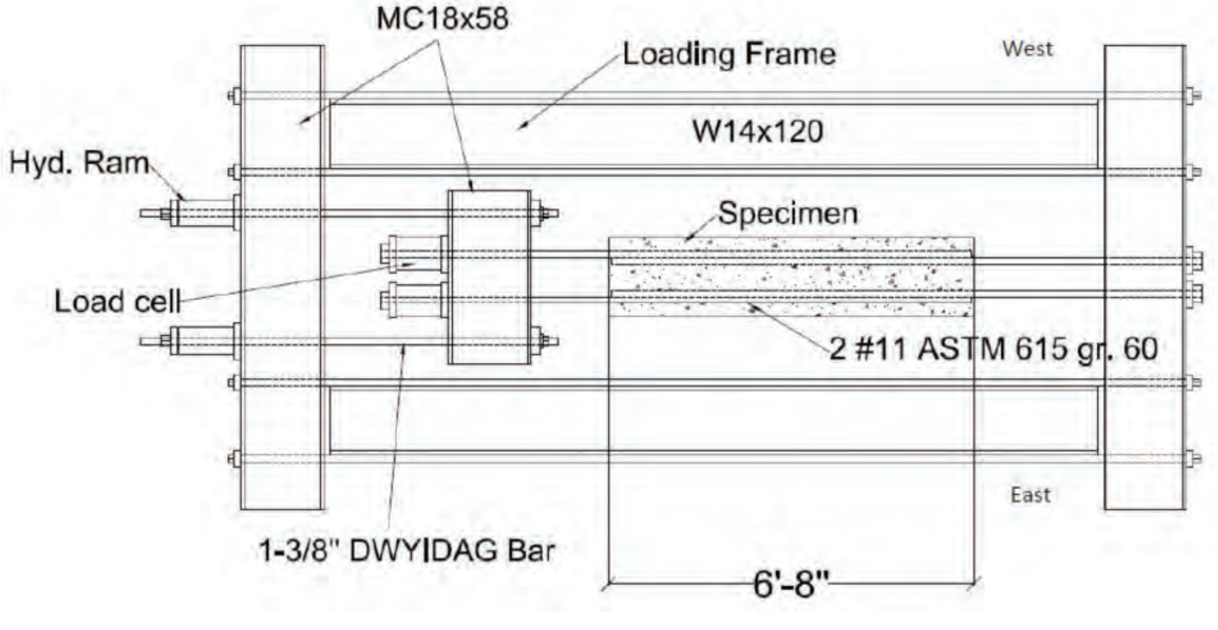


Figure 16: Series D Test Loading Frame Setup (From Appendix C)

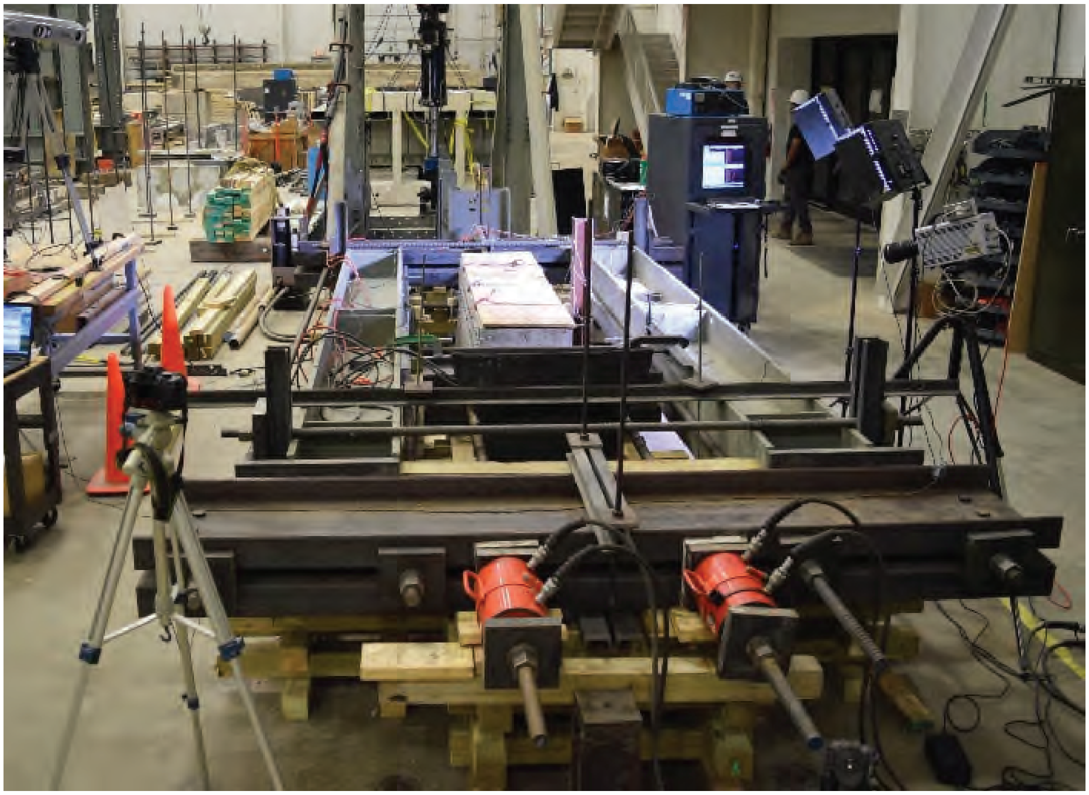


Figure 17: Series D Test Setup and Loading Arrangement (From Ref. 1c)

Table 8: Phase III Test Program Matrix (from Appendix C)

Test Series	Test Specimen	Anchor Details			Bearing Plate
		No. of Anchors	Spacing, s (in)	Embedment depth, d_e (in)	
1	D1	0	N/A	N/A	N/A
	D2				
	D3				
	D9				
	D11				
	D17				

The loading scheme for the tests involved (a) initial loading cycle to create laminar cracks in the specimen, (b) unloading completely, (c) installation of anchors (not covered in this report), and (d) reloading, with loads applied in small increments during the initial loading and reloading cycles. Additionally, during the initial loading cycle, loading was applied to the specimen to create maximum crack widths exceeding the recommended bounding limit of 0.050” from the Phase II program.

During the test, the forces in reinforcing bar, vertical and horizontal deformations, and crack widths were measured and the crack maps were recorded (see Appendix C).

3.3.2 Materials

The concrete mix design for the Series D tests was kept the same as that used in the Phase I and II tests at Purdue University. Concrete used in the specimens was mixed and delivered to the laboratory by Irving Materials, Inc. of West Lafayette, IN. The first set of specimens was cast on January 11, 2017 and the second set of specimens was cast on April 27, 2017.

Similar to Phases I and II, target air entrainment for the concrete mix was 5%. As concrete was being placed, air and concrete temperatures, air content, and slump of the mix were measured. The specimens were cured for a week. The compressive strength of concrete for the Series D specimens is summarized in Table 9 and shows that the mix used for the test girders was of uniform quality and strength. Detailed information and records for each casting are included in Appendix C.

Table 9: Compressive Strength of Concrete – Phase III Program

Test Specimen	Cast Date	Test Date	Concrete Compressive Strength*	Concrete Splitting Cylinder	Age of Specimen (days)
D1	1/11/2017	2/13/2017	3900	450	33
D2	1/11/2017	2/15/2017	3900	450	35
D3	1/11/2017	2/15/2017	3900	450	35
D9	1/11/2017	3/10/2017	4100	400	58
D11	1/11/2017	3/17/2017	4300	400	65
D17	4/27/2017	7/5/2017	4400	450	69

**mean of three tests*

All reinforcing bars came from the same heat. Stress-strain properties of the bars are included in Appendix C. The nominal properties of the reinforcing bars are presented in Table 10. The actual material yield strength of rebar used for Phase III tests was 67 ksi.

Table 10: Reinforcement Properties – Phase III Program

Bar Designation	#11
Nominal Diameter, in	1.41
Nominal Area, in^2	1.56
Nominal Perimeter, in	4.43
Unit Weight, lbf/ft	5.31
Yield Stress*, ksi	67

**mean from tests of twelve coupons*

3.3.3 Test Results and Key Observations

Figure 18 shows the load vs. crack width plots for the specimens without anchors. Appendix C also provides the plots of variations of vertical and horizontal deformations along the length of specimens and the load vs. specimen elongation plots. Table 11 lists the results, including the maximum crack width and maximum rebar stresses during initial loading cycle and at failure.

In general, Figure 18, along with the test results for the specimens with anchors (Appendix C), shows consistency of results and provides assurance for the acceptability of the tests (including test results) and expected performance. The results for Series D specimens without anchors confirmed that the rebar lap splices can maintain full load carrying capacity with laminar cracks of widths exceeding 0.050”.

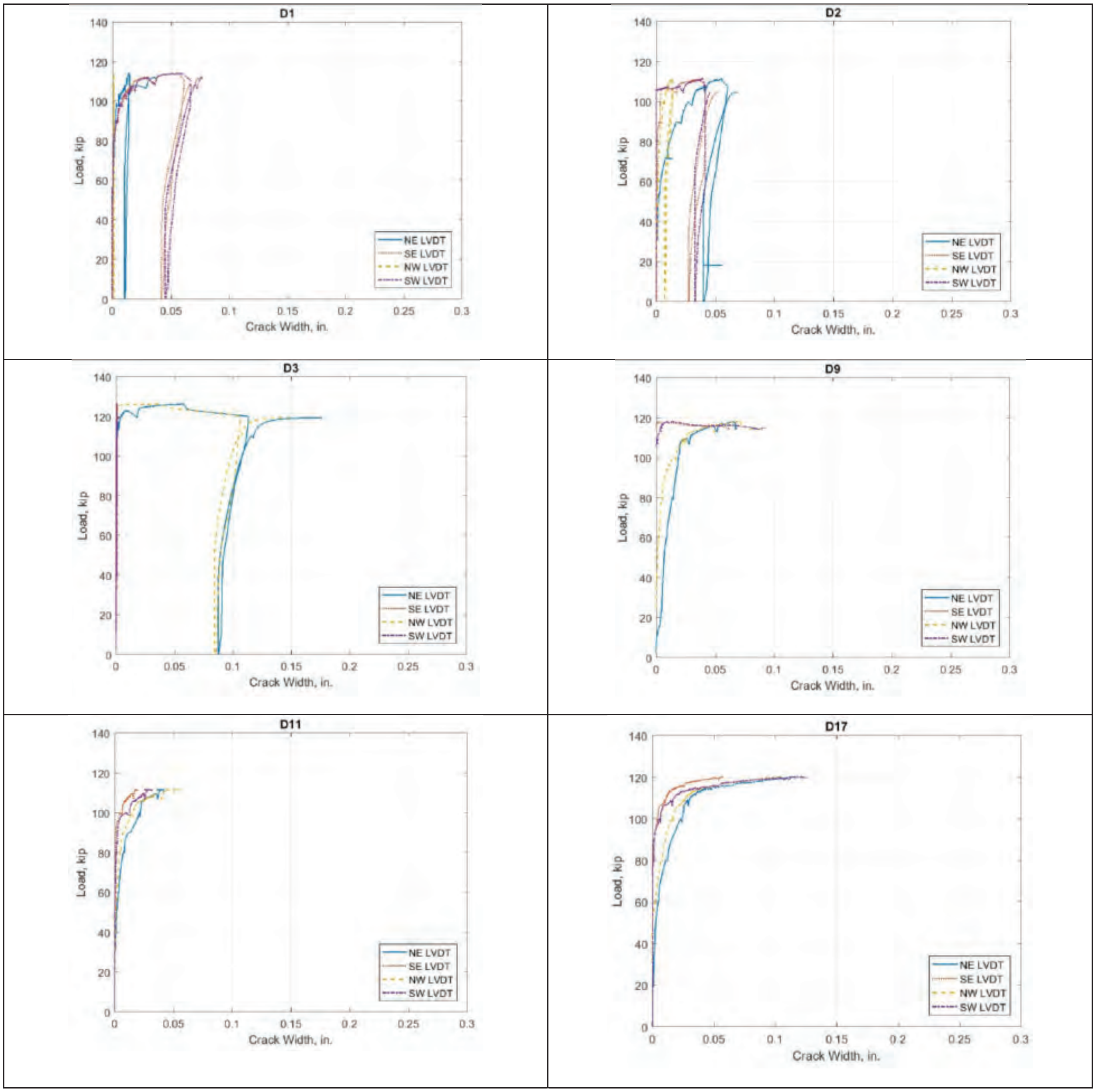


Figure 18: Load vs Crack Width for Phase III Specimens without Anchors (from Appendix C)

Table 11: Crack Widths and Rebar Stresses (from Appendix C)

Test Specimen	Max. Rebar Stress at Splice End (ksi)		Max. Laminar Crack Width (in.)	
	Initial Loading	Failure	Initial Loading	Failure
D1	72	73	0.07	0.08
D2	71	71	0.06	0.07
D3	80	81	0.11	0.18
D9	76	76	0.09	0.09
D11	71	71	0.06	0.06
D17	77	77	0.13	0.13

The behavior of the specimens without anchors generally shows predictable response with specimen failure occurring at crack widths exceeding 0.060”.

The conservatisms noted for Phase I and II test programs are also applicable to Phase III. These include the conservative test configuration with lap splices located side by side in a straight specimen and the measurement of cracks at the surface of the specimen instead of at the rebar location.

3.4 Summary of Phase I, II, and III Purdue Test Results

A total of 24 specimens were tested at Purdue University during the Phase I, II, and III test programs (excluding the specimens tested with post-installed anchors). The testing utilized a conservative test configuration to determine the limiting condition.

Phase I was conducted to test lap splices in the presence of existing laminar cracks without specific attention to initial crack width. In Phase II, laminar cracks were observed to have no detrimental effect on splice strength and deformability for cracks widths reaching up to nearly 0.050” during initial loading. In Phase III, the threshold of 0.050” was confirmed by specimens that were able to attain their full strengths after forming splitting cracks with widths ranging from 0.060” to 0.130" during initial loading. Table 12 provides the maximum reinforcement stress at failure and crack widths for the Phase I, II, and III specimens (without anchors) and Figures 19 and 20 shows the maximum reinforcement stress at failure.

Table 12: Compiled Summary of Phase I, II, and III Test Results

Test Program	Test Girder Designation	Concrete Compressive Strength [psi]	Lap Length [in]	Max. Crack Width at Initial Loading [in]	Max. Crack Width at last reading during reload [in]	Calculated Reinf. Stress [ksi]
Phase I	A1	5270	120	(a)	(a)	79
	A2	6030	120			80
	A3	5890	120			80
	A4	5110	120			79
	A5	5240	120			79
	A6	5490	120			77
	B1	4460	79			71
	B2	4800	79			69
	B3	4780	79			70
	B4	5460	79			70
	B5	5260	79			72
	B6	5230	79			72
Phase II	C1	5300	79	0.042	0.090	73
	C2	5300	79	0.021	0.025	74
	C3	5900	79	0.039	0.042	74
	C4	5700	79	0.052	0.053	75
	C5	5600	79	0.054	0.057	74
	C6	5300	79	0.030	0.033	75
Phase III	D1	3900	79	0.070	0.080	73
	D2	3900	79	0.060	0.070	71
	D3	3900	79	0.110	0.180	81
	D9	4100	79	0.090	0.090	76
	D11	4300	79	0.060	0.060	71
	D17	4400	79	0.130	0.130	77

(a) *Crack widths not reported because Phase I focused on the effects of laminar cracks on the strength of lap splices without specific attention to establishing a plausible limit to the width of those cracks. See Appendix A.*

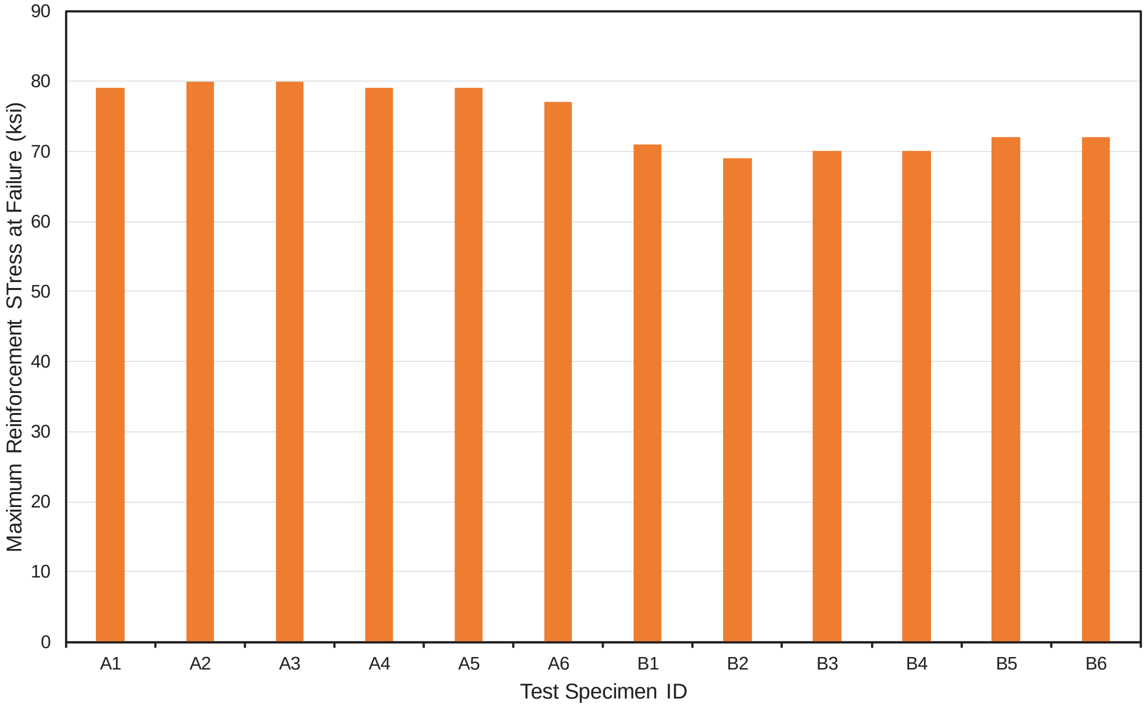


Figure 19: Maximum Reinforcement Stress at Failure for Phase I

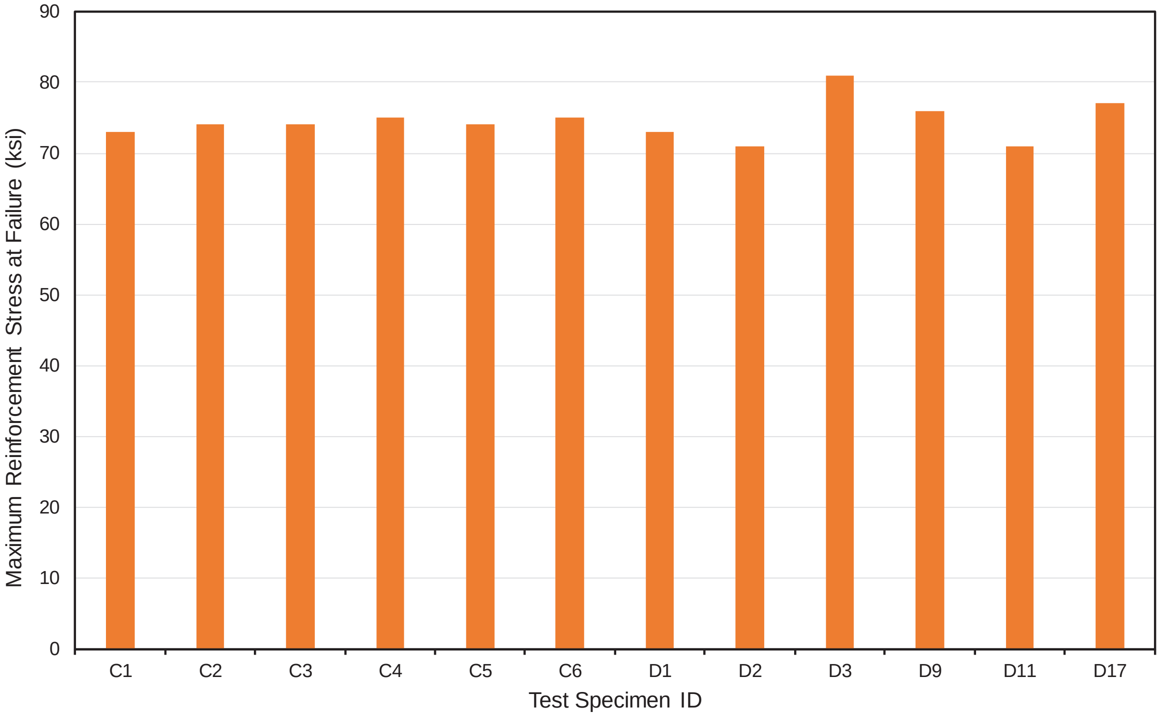


Figure 20: Maximum Reinforcement Stress at Failure for Phases II and III

From the Phase II and III results only, it is evident that the lap splices maintained their full load carrying capacity, with maximum reinforcement stresses ranging from 73 ksi to 81 ksi, with pre-existing crack widths up to 0.130”. The average stress in reinforcement at failure was 74.5 ksi with coefficient of variation of 3.6%.

As discussed earlier, the Phase I tests were conducted with smaller widths of pre-existing laminar cracks to establish the structural adequacy of Shield Building with the laminar crack characteristics prevalent at that time. However, the load-deformation relationships of the Phase I specimens are similar to those of the Phase II and III specimens. Additionally, as noted for Phase I tests, the load deformation relationships of the specimens that were loaded, unloaded, and reloaded are almost identical to the response of specimens that were loaded monotonically. Besides demonstrating the repeatability of the test performance, this shows that the response of Phase I test specimens would lead to the same conclusions even if pre-existing cracks with crack widths approaching those in Phase II and III test programs were created. Considering all test results from all Phases, the maximum reinforcement stress ranged from 69 ksi to 81 ksi with an average stress of 73.2 ksi and a coefficient of variation of 4.0%.

Based on the summary of results presented above, it is concluded that the Shield Building rebar lap splices will safely maintain its full load carrying capacity with laminar cracks widths of up to 0.050”.

3.5 Quality Assurance

It is noted that the Phase I and II test programs were deemed equivalent to an “augmented quality”, with associated QA/QC oversight, the results thereof, are considered appropriate as input to safety-related design. Although the Phase III test program was characterized as “exploratory” and thus, “non-safety”, with an intent to establish a suitable anchor system layout, a similar degree of engineering and management oversight was also provided for the Phase III tests. Additionally, as noted above, the results across the three phases are reproducible and consistent. Therefore, the conclusions established in Section 3.4 are considered applicable for safety-related design of the Shield Building.

The QA/QC records from Phase I and II programs are not repeated here, but are available in References 1a and 1b, respectively.

4.0 Composite Action of Shell

The composite action of the section for the out-of-plane bending effects can be evaluated by the magnitude of in-plane shear transfer capacity across cracked concrete.

Shear force can be transmitted across a crack if the crack faces are moving in opposite directions. This shear transfer capacity can come from three mechanisms: 1) aggregate interlock; 2) dowel action; and 3) axial steel force (see Figure 21).

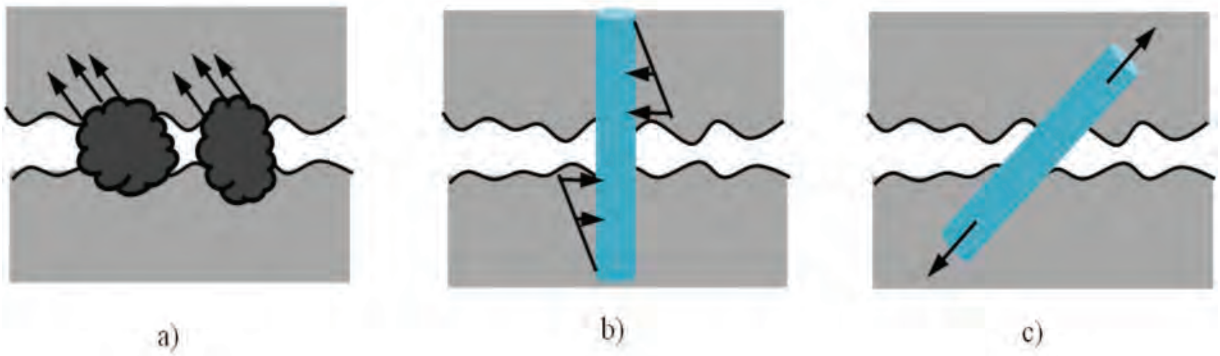


Figure 21: a) Aggregate interlock; b) Dowel action; c) Axial steel force

For a crack without reinforcement across it, shear transfer comes exclusively from the aggregate interlock. The parameters, which affect the aggregate interlock capacity, τ, are identified by different researchers (Walraven, 1980, 1981 (Refs. 7d-7e); Bazant and Gambarova, 1980 (Ref. 7a); Gambarova, 1981 (Ref. 7b); Gambarova and Valente, 1990 (Ref. 7c)) as the crack width, w, the shear displacement, Δ, the concrete crushing strength, $\mathrm{f_{cc}}'$, and the maximum aggregate particle diameter, $\mathrm{D_{max}}$. See Figure 22 for illustration.

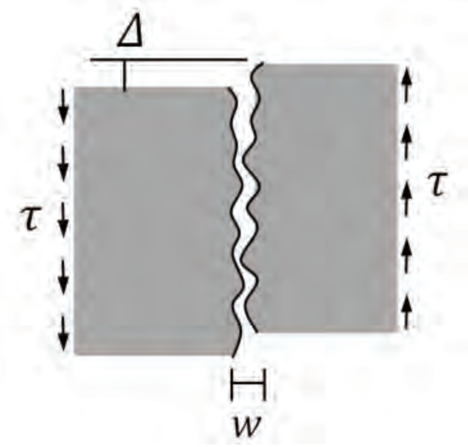


Figure 22: Shear transmission across an un-reinforced crack

Walraven (1980) reported numerous experimental results with the range of $\mathrm{D_{max}} = 16 \sim 32$ mm (0.63” – 1.25”) and $\mathrm{f_{cc}}' = 13.4 \sim 59.1$ N/mm^2 (1944 psi – 8572 psi), covering different cases of crack width ranging from 0.1 to 1.0 mm (0.004” – 0.039”). Based on theoretical analysis and the aforementioned experimental results, Walraven proposed the following equation for the shear transmission across an un-reinforced crack (Refs. 7d-7e):

$$\tau = -\frac{f_{cc}'}{30} + (1.8\, w^{-0.8} + (0.234\, w^{-0.707} - 0.20) f_{cc}')\Delta \qquad (1)$$

In which:

τ : shear transmission across an un-reinforced crack, N/mm^2

f_{cc}' : concrete crushing strength, N/mm^2

w : crack width, mm

Δ : shear displacement, mm

Using principles of fracture mechanics, alternative solutions of the shear transfer mechanism across an un-reinforced crack are proposed by Bazant, Gambarova, and Valente (Refs. 7a-7c).

A comparison of various methodologies mentioned above indicate that significant shear capacity can develop across the plane to develop a composite action as shown in Figure 23.

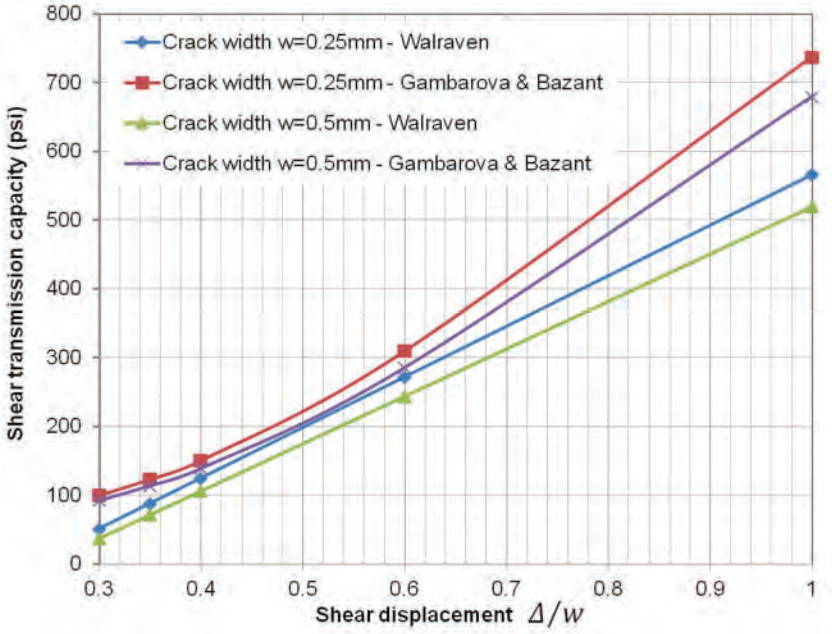


Figure 23: Shear transmission capacity across an un-reinforced crack

Furthermore, in Section 2505 of ACI 318-63, which is used for the ultimate strength design of the Shield Building, the shear transfer along the concrete contact surface without mechanical anchorage (reinforcement) is permitted to be 40 psi for service loads and 76 psi (1.9 × 40 =76 psi) for ultimate loads. These values are comparable to results discussed above.

Note that per the design calculations, the magnitude of shear across the laminar crack is very small compared to the capacity values discussed above, given the relatively nominal out-of-plane bending effects on the shell due to seismic, wind or tornado effects. It is, therefore, concluded that laminar cracking of 0.050” (1.25 mm width) in the outer rebar mat will not impact the expected composite behavior of the shell for the design loads.

5.0 Overall Structural Response

The test results show that the outer circumferential rebar maintains its full design capacity with the presence of laminar cracks with widths up to 0.050”. Additionally, review of the load-deflection behavior of the specimens in all three test programs does not indicate any significant change in the reloading stiffness of specimens after introduction of the laminar cracks with widths exceeding 0.050”.

The Shield Building is designed for all applicable loads and load combinations in accordance with USAR Section 3.8.2.2.4 and DCM Section II.G, including dead and live loads, wind and tornado loads, and operating basis and safe shutdown earthquakes. The controlling load combinations for the design of the Shield Building involve the design basis safe shutdown earthquake, for which the Shield Building will behave like a cantilever where most of the forces are transferred through in-plane shear and axial membrane forces and very little through out-of-plane bending of the shell. The laminar cracking has no impact on in-plane stiffness of the cylindrical shell, which will resist most of the applicable seismic loads. For thermal and tornado loads that produce hoop tension and moment, the existence of laminar cracking does not change the concrete section behavior since the concrete shell is already assumed to be cracked through-thickness. The applicable tension forces are primarily resisted by the hoop reinforcement, which are able to maintain their design function with crack widths up to 0.050” per the testing. Therefore, it is concluded that no changes need to be made to the analytical model in order to account for the effect of laminar cracking on stiffness of the Shield Building.

Based on above discussion, it can be safely concluded that the effect of laminar cracking on the overall stiffness, dynamic characteristics and performance of the Shield Building is negligible.

6.0 Serviceability and Long-Term Durability

Per applicable codes of record for the Shield Building (ACI 318-63 and ACI 307-69) serviceability essentially relates to crack control under service load conditions (not faulted load conditions). Service life of the structure can be affected by the nature, extent and width of cracking present on the surface of the structure that may provide a path for moisture penetration resulting in reinforcement corrosion. For cracking induced by applied loads such as flexure or hoop tension, the primary objective is to limit the crack width (at the surface) to 0.010” per the ACI Standard Building Code, as noted in USAR Section 3.8.2.2.5, in order to limit potential moisture paths that could lead to corrosion of reinforcing steel. The initial detailed condition assessment (supplemented by continued periodic monitoring) did not indicate any unusual surface cracking due to either shrinkage or flexure, with observed surface cracks much tighter than 0.010”.

The monitoring program has subsequently indicated rebar corrosion at the locations of maximum laminar crack widths. To address this, a repair program has been implemented and requires removal and replacement of concrete in areas of cracking exceeding 0.050” with/without any signs of corrosion. The repair program involves chipping of concrete and rebar removal/replacement (as required) to a larger extent than depicted in the latest IR scans. Additionally, a passive cathodic protection program is implemented to mitigate and prevent rebar corrosion after the repair is completed. The periodic monitoring program will continue to verify that the implemented measures are effective in ensuring there is no further rebar corrosion and there are no pathways for moisture infiltration.

Therefore, it is concluded that the long-term durability of the Shield Building is not adversely affected with laminar crack widths of up to 0.050” within the thickness of the cylindrical wall.

7.0 Conclusions

Based on a detailed review of all the relevant technical documents and test reports, it is concluded that crack widths of up to 0.050” have no adverse impact on capacity of reinforcing bars to perform their intended function to ensure the structural adequacy of the Shield Building. Moreover, there are several additional layers of conservatisms that add margin to the design capacity. These conservatisms include a higher strength of the in-place concrete versus the strength of test specimens, not including the effect of staggering of spliced rebars in the test specimens, and not including the curvature of the Shield Building in the test specimen.

It is also concluded that the composite action of the shell, overall structural response and serviceability and durability of the Shield Building are not adversely impacted with laminar cracking of 0.050”. The monitoring program in place will ensure that any exceedance in cracking or evidence of corrosion are adequately identified and addressed.

Appendix E contains a memorandum from Prof. Santiago Pujol, who was responsible for the experimental testing at Purdue University, supporting these conclusions.

8.0 References

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    a. 25593-000-G83-GEG-00016, Rev. 0, Effects of Laminar Cracks on Splice Capacity of No. 11 Bars based on Testing Conducted at Purdue University and University of Kansas for Davis-Besse Shield Building, 2012
    b. 25884-000-30R-C01G-00001, Rev. 0, Effect of Crack Width on the Load Carrying Capacity of No. 11 Bars with 79-inch Lap Splices based on Phase II Testing Conducted at Purdue University for Davis-Besse Shield Building, 2016
    c. 25884-000-30R-C01G-00005, Rev. 0, Effect of Post-Installed Anchors on Load Carrying Capacity of No. 11 Bars with 79-inch Lap Splices for Specimens with Pre-existing Laminar Cracks based on Phase III Testing Conducted at Purdue University, 2018
2. NOT USED.
3. Drawings
    a. C-109, Rev. 6, Shield Building Roof Plan and Details, Sh. 1
    b. C-110, Rev. 8, Shield Building Roof Plan Wall Section and Details

   c. C-111, Rev. 13, Shield Building Wall Development
   d. C-111A, Rev. 10, Shield Building Exterior Developed Elevation
   e. C-111B, Rev. 6, Shield Building Data for Core Bore Inspections
4. Davis Besse Nuclear Power Station Design Basis Documents
   a. Chapters 3 and 18, Updated Safety Analysis Report, Rev. 33
   b. Design Criteria Manual, Rev. 45
5. Codes and Standards & NRC Regulatory Documents
   a. ACI 318-63, Building Code Requirements for Reinforced Concrete
   b. ACI 307-69, Specification for Design and Construction of Reinforced Concrete Chimneys
   c. ACI 349.3R-02, Evaluation of Existing Nuclear Safety-Related Concrete Structures
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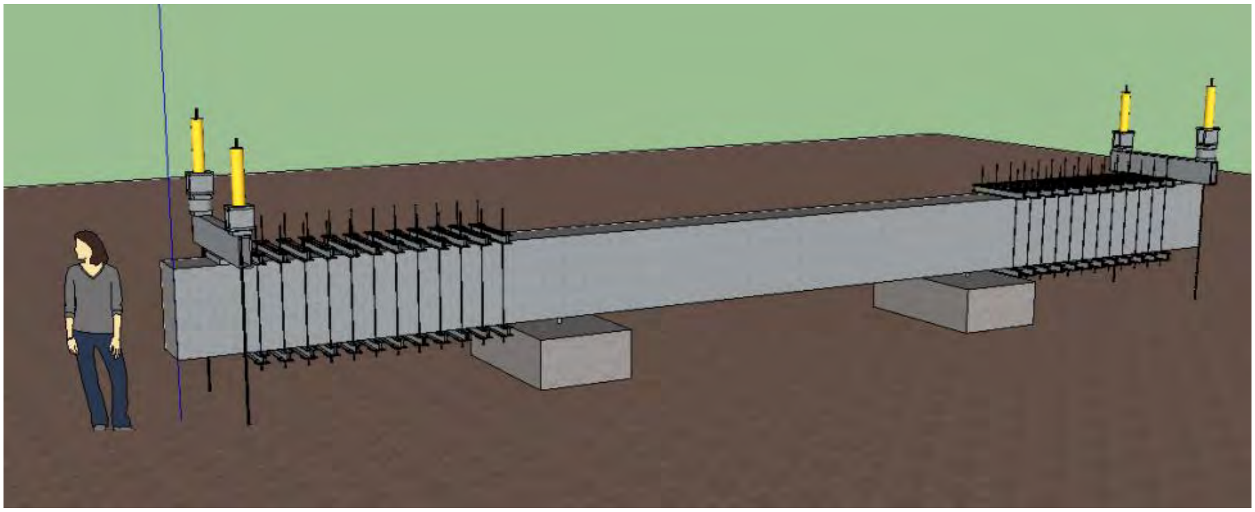
25884-000-30R-C01R-00002, Rev. 000

APPENDIX A

“Purdue Phase I Test Report”



AN INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED LAP SPLICES OF#11 REINFORCING BARS

A Report Submitted to

First Energy Nuclear Operating Company
Oak Harbor, Ohio

by
Mete A. Sozen

Mete A Sozen

and
Santiago Pujol

S Pujol.

12 July 2012
Bowen Laboratory
West Lafayette, IN

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SUMMARY

The object of the experimental investigation reported was to study the effect of laminar cracks on the strength of unconfined lap splices of #11 Grade-60 reinforcing bars embedded in concrete. The study focused on the influence of pre-existing laminar cracks on the strength of lap splices for #11 bars. The planned variables for the study were the length of the splice and the loading program. Twelve girders with lap splices were tested in two series, A and B, of six. Series A had 120-in long splices and series B had 79-in. splices. Concrete strength was not a planned variable. Concrete mixes were selected to produce a concrete strength at 28 days not exceeding 6000 psi. Measured concrete strength at time of test varied from approximately 4500 to 6000 psi. Yield stress of the reinforcing bars was 66 ksi.

In each series, two girders were loaded monotonically to failure. The two series A girders (A-2 and A-3) reached their yield capacities and then failed in flexure to resist a maximum moment of 487 k-ft. The two series B girders also reached their yield capacities and had splice failure at maximum moments of 425 k-ft (Girder B1) and 427 k-ft (Girder B4).

In series A, the remaining four girders were loaded to a deflection beyond yield, unloaded, and then loaded, with pre-existing laminar cracks, to failure. Maximum moments resisted were 481 k-ft(Girder A1), 479 k-ft (Girder A4), 480 k-ft (Girder A5), and 466 k-ft (Girder A6).

In series B, the four were loaded to yield, unloaded, and then loaded, with pre-existing laminar cracks, to failure. Maximum moments resisted were 418 k-ft (Girder B2), 426 k-ft (Girder B3), 435 k-ft (Girder B5), and 435 k-ft (Girder B6).

Load-deflection relationships recorded for the 12 girders are presented in Fig. 13 through 24. Reinforcement stresses developed at splice ends are listed in Table 3. For girders with 120-in splices maximum reinforcement stress attained at ends of splice ranged from 77 to 80 ksi. For girders with 79-in. splices, the range was 69 to 72 ksi.

Differences between the load-deflection responses of initially uncracked and pre-cracked girders were found to be negligible.

Strain measurements and observed distribution of bursting (laminar) cracks confirmed that most , if not all, of the force transfer from one bar to another occurred in the end of the splice over a length of approximately 20 in.(<15 bar diameters). In this region of high bond-stress demand, cracks paralleling the spliced bars opened at as low as one fourth of the maximum load in all girders tested. In the four specimens that were unloaded and reloaded, the measured maximum residual widths of these cracks at zero applied load were 0.08 in for series A and 0.015 for series B.

All load-deflection curves measured had two common characteristics: (1) Yield moment of the section was developed after appearance of laminar bursting cracks at low loads and at zero load in the case of the reloaded girders, and (2) all girders tested demonstrated a definite capability to maintain strength

with increase in deflection beyond yield. The latter characteristic satisfies the traditional demand of professional consensus documents for cases where the loads may be dynamic and/or not known closely.

1. Introductory Remarks

Since the publication of Abrams's monumental study of bond between concrete and steel[1] the engineering profession has been aware of the fact that, in transferring stress to concrete, deformed bars tend to cause bursting stresses in the concrete. The cracks caused by bursting stresses reach the surface of the concrete in which a deformed bar is embedded in a random pattern and tend to parallel the bar causing the stress. Their appearance on the surface of the concrete is a cause for concern.

What if such cracks develop without the influence of bursting stresses related to bond? How much bond stress can a reinforcing bar develop in cracked concrete with the cracks approximating the trajectory of the bar? The experimental investigation described in this report was undertaken to answer this question within a limited domain of variables: "If lap splices of #11 Grade 60 bars with three-in. cover happen to be in concrete having laminar cracks along the plane of the splices, what is the limit to the tensile force that can be transferred from one bar to the other?"

The investigation was carried out at Bowen Laboratory for Large-Scale Civil Engineering Research, West Lafayette, IN. to address this question.

2. Object and Scope

The object of the investigation reported was to study the effect of cracks on the strength of lapped splices of #11 Grade-60 reinforcing bars embedded in concrete. The cracks in question are laminar cracks, or cracks that lie in a plane that coincides with or is parallel and close to the axis of the spliced bars. The fundamental question for the investigation was to determine what level of tensile stress spliced #11 bars could develop if the surrounding concrete already has such cracks.

The test specimens were of a type used usually for testing splices (Fig. 1). They were large-scale girders with rectangular sections. They were simply supported at two points equidistant to the center of the specimen and loaded at two points, outside the reactions, also equidistant to the center of the specimen. A total of 12 specimens were tested under static loading, test durations ranging from three to six hours. Six of these (Series A) had 120-in splices (nominally 85 bar diameters) and the remaining six (Series B) had 79-in splices (nominally 56 bar diameters)..

In each of series A and B, loading was applied continually to failure in two test girders. In the remaining four, loading was first carried to or beyond yielding. Then the load was reduced to zero to be increased again until failure occurred.

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[1] Abrams, Duff A., "Tests of Bond between Concrete and Steel," Bulletin #71, Engineering Experiment Station, University of Illinois, Urbana, 1913, 245 pp.

Concrete strength was not a planned variable in the program. For the test girders with the 120-in splices concrete strength, determined using standard 6x12-in. cylinders, varied from approximately 5000 to 6000 psi. For those with 79-in. splices, it varied from approximately 4500 to 5500 psi (Table 1). Appendix 1 includes details about the tests of concrete samples.

Yield stress and strength of the #11 bars were determined to be 66 ksi and 103 ksi, respectively. Limiting strain, measured over a gage length including the part of the bar that fractured, ranged from 14 to 19 % (Table 2).

In addition to load and deflection measurements, crack patterns and widths as well as longitudinal and transverse deformations of the test girders were recorded. Failure characteristics of the test girders were captured by a high-speed camera operating at 5,000 frames per second.

Following sections contain brief descriptions of the materials, construction and instrumentation of the test girders. Detailed information on those topics is provided in the appendices of this report. The observed behavior of the test girders is described in terms of measured load-deflection relationships, recorded crack-width developments, and calculated reinforcement stresses.

2.1 Experimental Outline

As mentioned in the preceding section, two series of six tests were conducted, one with 120-in. splices and the other with 79-in. splices. Specimens A were cast in groups of three on 17 April 2012 and on 24 April 2012. Specimens B were also cast in groups of three, the first cast being on 10 April 2012 and the second on 30 April.

Because of the concern resulting from early cylinder tests that the concrete strength might surpass 6,000 psi at the intended time of test, specimens of Series B were tested first, during the period 10 through 25 May 2012. Specimens of Series A were tested afterwards during the period 30 May through 8 June 2012. Test dates are listed in Table 1.

The planned variables in the tests were the length of the splice (79 or 120 in.) and the loading program. Two specimens in each series were subjected to increasing applied loads at each loading stage of 6, 12, 18, 24, 30, and 36 kips. Above 36 kips, load increments were determined by measured displacement. Four of the specimens in series A were subjected to loading in increments of 6 kips to yield and then to a mid-span deflection of 0.9 in, unloading, and reloading to failure. In series B, the four specimens were loaded to 36 kip in 6-kip increments, unloaded, and then loaded to failure.

Load and deflection measurements were obtained continuously in each test. Deflections were also measured by dial gages whenever loading was stopped. An Optotrak tracking system was used to measure deformations of the girder after each load increment until there was a threat of failure. Crack patterns and widths were recorded up to a loading stage which was considered to be safe for those making the measurements. This limit, stated in terms of applied load, varied from 30 to 41 kip. Still photographs of the test specimen were taken at all loading stages.

Profile dimensions of the specimen in Series A and B are shown in Fig. 2 and 3

Properties of the girder cross section were based on four considerations.

The first was to have more than one lap splice to simulate the interaction of adjacent lap splices. Two splices were used.

The second was to have a minimum cover of 3 in. that translated to a clear distance of 6 in. between the two splices and led to a cross-sectional width of (4x3+4x1.41) in. The width of the girder section was made 17 5/8 in.

The third was to produce a bursting crack in the horizontal plane that would intersect both splices. To increase the probability of a bursting crack in the horizontal plane and given that cracking tends to occur in the direction in which cover is smaller, the desired minimum side cover of 3 in. was used on the outside bars of the splices and a cover of 5 in. was used on top.

The fourth condition was to make sure that with four #11 bars the section would have a moderate reinforcement ratio not exceeding 1.5 %. An overall depth of 30 in. satisfied that requirement.

The resulting cross-section is shown in Fig.4. Girders of Series A and B had the same-cross sectional dimensions and the same reinforcement. Each girder in series A had a total length of 39 ft .The lap splice length was 120 in. as indicated in Fig. 2. Ends of the splice were each at three ft from the closer support. The cantilevered portions of the girder measured 11 ft 6 in. in length. Loads were applied on each cantilever segment at 10 ft from the support.

Each girder in series B had a total length of 34 ft 4 in. Length of the lap splice was 79 in. and was located as shown in Fig. 3. The ends of the splice were each at three ft from the closer support. The cantilevered segments of the girder were 10 ft 10 ½ in. long. Loads were applied on each cantilever segment at 9 ft 8 ½ in. from the supports.

To make certain that shear or bond problems did not occur in the cantilevered segments of the girder, they were equipped with post-tensioned external stirrups comprising pairs of 3-in. channels at each end and two 5/8in-diameter rods. Figure 4 shows the external stirrups. There were 12 of them on each cantilevered segment placed at equal spacing. Post-tensioning forces in the external stirrups were not measured.

Measured dimensions of test specimens and test setup, obtained before testing, are listed in Appendix 2.

Load was applied through the use of two 60-kip hydraulic center-hole rams near each end of the girder. The rams were supported by a custom-built steel channel. One of the rams on each side was in series with a load cell. A 10x4-in. tube supported the two rams.

3. Materials

(a) Concrete

Concrete used in the specimens was mixed and delivered to the laboratory by Irving Materials Inc. of West Lafayette, IN. Each girder and related cylinders were cast using concrete from a single truck. The mix proportions by weight were

Component	Weight of Component / Weight of Cement
Cement	1
Fine Aggregate	2.4
Coarse Aggregate (max. size = 1¼ in.)	2.6
Water	0.55

Target air entrainment was 5%. As concrete was being placed, temperature, air content, and slump of the mix were measured. Air temperature was recorded. Target moist curing was seven days but the curing period was reduced for some specimens as a result of early cylinder tests that indicated high strength . Detailed information for each casting is included in Appendix 2. Information about curing is given in Appendix 3.

(b) Steel

All #11 reinforcing bars came from the same heat. Stress-strain properties of the bars are included in Appendix 4.

4. Observed Relationships between Applied Load and Deflection

Figures 13 through 24 contain the measured load-deflection relationships of the 12 test girders. The reported deflection is the relative movement (deflection up considered to be positive) of girder mid-span with respect to the supports. The reported load is the load applied near the end of the cantilever section.

It is important to note that a direct comparison of the measured load-deflection curves of girders in series A and B is not justified because of (1) the difference in middle spans (16 ft for girders A and 12 ft 7 in. for girders B), (2) the slight difference in the lever arms of the applied loads (10 ft for girders A and 9 ft 8 ½ in. for girders B) and (3) the difference in the initial selfweight moment (45.8 kip-ft for girders A and 41.7 kip-ft for girders B).

All load-deflection curves measured had two common characteristics: (1) Yield moment of the section was developed after appearance of laminar bursting cracks at low loads and at zero load in the case of the reloaded girders, and (2) all girders tested demonstrated a definite capability to maintain strength with increase in deflection beyond yield. The latter characteristic satisfies the traditional demand of professional consensus documents for cases where the loads may be dynamic and/or not known closely. Considering the Series A girders only, the similar behavior of A2 and A3 is not unexpected. These girders had similar reinforcement, similar concrete strength (6030 and 5890 psi), similar spans and they were loaded to failure similarly. In both cases failure was initiated by failure of concrete in flexural compression after yielding of reinforcement at the supports. It is of interest to note that the overall behavior of test girders A1, A4, A5, and A6 that were loaded, unloaded, and reloaded to failure differed very little from those of A2 and A3 even though the failures of these four girders were initiated by bond. In fact one could not identify easily the ones that were reloaded by studying the shapes of the envelope curves. Girders in series A all had the same yield deflection (approx. ½ in.) and similar maximum mid-span deflections (ranging from 1.4 to 1.8 in.).

Inspection of Fig. 19 through 24 yields similar conclusions for the responses of girders of series B. For this series, the yield deflection was approximately 1/3 in. and maximum deflection ranged from a little below 0.5 in. (Girder B1) to above 0.6 in. (Girder B6). The range in concrete strength from 4460 to 5460 psi would not be expected to have a perceptible influence on the yield deflection. The three test girders with relatively low concrete strengths (Girders B1, B2, and B3) did have the lower maximum deflections but the maximum recorded value of ~0.47 in. for B1 with a concrete compressive strength of 4460 psi was not that much lower than that of B5 that had a concrete compressive strength of 5260 psi (0.55 in.)

Maximum applied loads for series A ranged from 42 to 44.1 kip. This range was from 39.7 to 40.6 for series B. In fact, on the basis of maximum applied load alone, it is hard to discriminate the results for series B vis-à-vis those of series A.

The narrow ranges of measured peak loads indicate consistency and that the sample size (6 repetitions) was proper.

5. Crack Development

Changes in crack patterns and widths were recorded in detail and are reported completely in Appendix 7. Observed development of flexural crack patterns and thicknesses was consistent with what is normally expected in reinforced concrete beams responding primarily to flexure. As seen in Fig. 6, flexural cracks occurred at a spacing of approximately twice the top cover or ~10 in. It is also seen that the cracks near mid-span did not reach as far towards the compressed edge of the girder as the ones near the support. This was an indication that the lap splice was effective, with most of the force transfer occurring near its ends as discussed later. All four bars were participating in load resistance. In the range of linear response to flexure, the neutral axis depth increases with increase in the reinforcement ratio. Even though the total tensile force in the reinforcement at mid-span was comparable to that at the support, the amount of reinforcement was twice as much. This was reflected in the relative lengths of the flexural cracks at mid-span and at the support.

Examples of crack patterns observed are shown in Fig.7 through 12 and Appendix 11.

Cracks of primary interest in this study are those caused by the bursting stresses related to high bond demand. Appendix 7 contains records of their development in detail for every one of the 12 girders tested.

Figure 6 that shows typical flexural cracks also shows the bursting cracks that traverse the beam surface horizontally at or near the level of the reinforcement. A descriptive metaphor for their formation is provided by visualizing the bars as thin walled pressurized tubes embedded in concrete as illustrated in Fig. 25 The internal pressure causes circumferential tensile stresses in the concrete around the tube that decrease with distance as shown ideally in the figure. The crack is initiated in the weakest plane which corresponds to the plane resulting in the minimum cover. The crack is initiated in the immediate surface of the tube and progresses out as the pressure in the tube increases. It is also relevant to note that a bursting crack can exist next to the reinforcement but not be visible on the surface of the girder.

The projection of this metaphor to the test girders suggests that the bursting crack would occur on a horizontal plane intersecting the reinforcement and that the surface width of the crack is likely to be smaller than its width next to the spliced bars. It also provides an introduction to develop an understanding of the bond phenomena observed in the test girders by combining three sets of measurements: (1) Longitudinal strain distribution at reinforcement level, (2) vertical deformation of the girder, and (3) distribution of widths of the bursting cracks.

The first two sets of data were obtained from movements of targets attached to the test girder and monitored using the Optotrak, an optical system for determining the coordinates of the targets in three dimensions. The locations of the targets in specimens of series A and B are shown in Fig. 26 and 27.

The distributions of measured strain along the splices are shown in Fig. 30 through 33. Figures 30 and 31 contain the data from the initial loadings. Figures 32 and 33 include the data from reloadings of four of the girders in each of series A and B.

Despite the inherent scatter, the longitudinal-strain data show that there was a dominant pattern in strain distribution along the splice. In the first loadings, rapid change in strain occurred primarily in the outer 20-in. segments of the splice as indicated by the slopes of the plotted curves in Fig. 30 and 31. Recognizing that the bars within the splice remain in the linear range of response, the slope of the strain distribution becomes a measure of the rate of stress change. Optotrak measurements identify that the critical segments of the splice where most of the force transfer from bar to bar took place were the outer 20-in. lengths.

Because four girders in each series were unloaded and reloaded, Fig. 32 and 33 contain four plots. These sets of data confirm that, in general, the middle 80 in. of the 120-in. splices and the middle ~40 in. of the 79-in. splices were essentially inert.

Measured vertical deformations of the test girders are shown in Fig. 34 and 35. The results included in these figures confirm that the regions of relatively large vertical deformation occurred in the outer 20 in. of the splices for both the 79 and 120-in. splices. An aspect of these vertical-deformation measurements is of special interest. Normalweight-aggregate concrete is expected to have a short-time tensile-strain capacity not exceeding 0.0002. The vertical deformation measurements were made over a gage length of 26 in. Any reliable measurement of tensile extension exceeding 0.005 may be interpreted to indicate the presence of cracks. It is plausible to infer from Fig. 34 and 35 that bursting cracks did exist in the outer 20-in. segments of the splices. Most of the tensile force transfer between the spliced bars occurred in splice segments with bursting cracks.

In the following paragraphs, measured widths of bursting cracks are discussed with perspectives provided by the horizontal strain and vertical deformation measurements made.

Lacking a generally accepted index value such as the intensity scale used for earthquake damage to organize and define data susceptible to scatter, the main generalization that can be made about crack-width observations made in this study is that measurable (0.005 in. or more in thickness) bursting cracks of limited length (six to 12 in.) occurred at low loads on the order of one fourth of the maximum load resisted. Bursting cracks reached levels in excess of 0.1 in. at loads approaching the maximum load. At such levels of load, bursting cracks meandering along the level of the reinforcement covered virtually the entire test span. Representative bursting cracks are shown in Fig. 38 and 39.

To organize the observed bursting-crack widths for discussion, it was decided to divide the middle span into six regions A through F as shown in Fig. 28 and 29. The selection of the lengths of the regions was influenced by the arrangement of the Optotrak targets (Fig. 26 & 27). Selected lengths of regions A through F are shown in Fig. 28 for series A and in Fig. 29 for series B.

Maximum widths of the horizontal cracks in the selected regions at selected values of the applied load are shown in Fig. 40 through 51. The horizontal-axis legend shows the distance from mid-span to the center of the region in inches. The legend on the right-hand side of the plot indicates the applied load at which the readings were recorded. The numbers at the peaks of the “cones” indicate the maximum crack width in thousandths of an inch.

Given the randomness of the tensile strength of concrete and the tensile-stress demands set up by bond, one does not expect uniform results in the charts shown in Fig. 40 through 51. Nevertheless, certain trends may be inferred from the charts. Again, the bursting cracks were wider at the splice ends and at the supports. These trends are confirmed by the vertical deformations shown in Fig. 34 and 35. Comparisons of measured vertical deformations and measured cracks widths are shown in Fig. 52 and 53. At the maximum loads shown in Fig. 40 through 51, the maximum crack width reached 0.15 in. (Fig. 40).

Bringing together the observed data from measurements of longitudinal strain, vertical deformation, and crack-width distribution, it becomes clear that most if not all of the force transfer in the splice took place in regions with bursting cracks. With that knowledge, the mean unit bond strength evaluation on the basis of assuming the bond stress to be distributed uniformly along the splice would seem irrelevant. However, to place the results obtained in the realm of common practice, unit bond stresses were calculated. The mean unit bond strength obtained from the tests was $3.1\sqrt{f'_c}$ for the 120-in splices and $4.4\sqrt{f_c}$ for the 79-in splices. The decrease in mean bond strength with increase in length of splice is consistent with the observation that most of the stress transfer through bond occurred within approximately 15 bar diameters from each splice end. It is of interest to note that the ratio of the observed mean bond strengths, 0.70, is close to the ratio of the splice lengths, 0.66.

6. Maximum Reinforcement Stresses Attained

As documented in detail in Appendices 5 and 6 maximum tensile stresses achieved at the ends of the splice were computed based on the moment at the end of the splice and cross-sectional properties of the test girder. Fig. 54 shows the distribution of bending moments. The calculated stresses are shown in Table 3.

The minimum tensile stress attained in the reinforcement at the end of the splice was 69 ksi (Test Girder B2) and the maximum was 80 ksi (Test Girders A2 and A3)

7. Conclusions

Two girders in each of Series A and B were loaded monotonically to failure.

Four girders of series A were loaded to a deflection of 0.9 in. (approximately twice the yield deflection) and the unloaded to be reloaded to failure. Four girders of series B were loaded to yield, unloaded and reloaded to failure.

At the start of reloading, lengths of approximately 15 bar diameters at each end of each splice were populated with bursting cracks along the splices. Most of the force transfer between spliced bars occurred within these lengths.

The two series of tests conducted were designed to address the question: what is the limit to the tensile force that can be resisted by lap splices of #11 Grade 60 bars with three-in. cover and in concrete having laminar cracks near the plane of the splices? In both series, laminar bursting cracks formed at a fraction of the yield load in all test girders. The difference between the strength and behavior of the girders loaded directly to failure and those unloaded after reaching or exceeding yield and reloaded was negligible. The existence of laminar cracks at the beginning of loading did not change the strength of the splices. The ratio of the limiting deflection to the yield deflection was approximately three in Series A with 120-in. splices and two in Series B with 79-in. splices.

As listed below and illustrated in Fig. 55, maximum reinforcement stresses in the test girders loaded to failure after having been loaded to develop bursting (laminar) cracks and reloaded differed negligibly from those in girders loaded monotonically to failure.

Test Girder	Type of Loading	Maximum Reinforcement Stress at Splice End
A2	Monotonic	79 ksi
A3	Monotonic	80 ksi
B1	Monotonic	71 ksi
B4	Monotonic	70 ksi
A1	Reloaded after Laminar Cracking	79 ksi
A4	Reloaded after Laminar Cracking	79 ksi
A5	Reloaded after Laminar Cracking	79 ksi
A6	Reloaded after Laminar Cracking	77 ksi
B2	Reloaded after Laminar Cracking	69 ksi
B3	Reloaded after Laminar Cracking	70 ksi
B5	Reloaded after Laminar Cracking	72 ksi
B6	Reloaded after Laminar Cracking	72 ksi

TABLES

Table 1 Concrete

Test Girder Designation	Cast	Tested	Concrete Compressive Strength psi	Concrete Splitting Cylinder Strength psi	Lap Length in.
A1	17 April 2012	4 June 2012	5270	480	120
A2	17 April 2012	1 June 2012	6030	500	120
A3	17 April 2012	30 May 2012	5890	480	120
A4	24 April 2012	8 June 2012	5110	440	120
A5	24 April 2012	7 June 2012	5240	440	120
A6	24 April 2012	5 June 2012	5490	450	120
B1	10 April 2012	10 May 21012	4460	450	79
B2	10 April 2012	23 May 2012	4800	480	79
B3	10 April 2012	21 May 2012	4780	420	79
B4	30 April 2012	14 May 2012	5460	490	79
B5	30 April 2012	17 May 2012	5260	480	79
B6	30 April 2012	25 May 2012	5230	450	79

Table 2 Reinforcement

Bar Designation	#11
Nominal Diameter, in.	1.41
Nominal Area, in^2	1.56
Nominal Perimeter, in.	4.43
Unit Weight, lbf/ft	5.31
Yield Stress*, ksi	66
Strength*, ksi	103
Limiting Strain in 8 in., %	14,18,19

*Note: means from tests of three coupons

Table 3 Summary of Results

Test Girder Designation	Concrete Splitting Strength (Tensile) psi	Concrete Compressive Strength psi	Lap Length in.	Maximum Applied Load kip	Maximum Moment at Support kip*ft	Maximum Moment at Splice End kip*ft	Calc. Reinf. Stress at Support ksi	Calc. Reinf. Stress at Splice End ksi
A1	480	5270	120	43.5	481	470	81	79
A2	500	6030	120	44.1	487	476	82	80
A3	480	5890	120	44.1	487	476	82	80
A4	440	5110	120	43.3	479	468	81	79
A5	440	5240	120	43.4	480	469	81	79
A6	450	5490	120	42.0	466	455	78	77
B1	450	4460	79	39.5	425	417	72	71
B2	480	4800	79	38.9	419	419	71	69
B3	420	4780	79	39.7	427	419	72	70
B4	490	5460	79	39.7	427	419	71	70
B5	480	5260	79	40.6	436	428	73	72
B6	450	5230	79	40.6	436	428	73	72

FIGURES

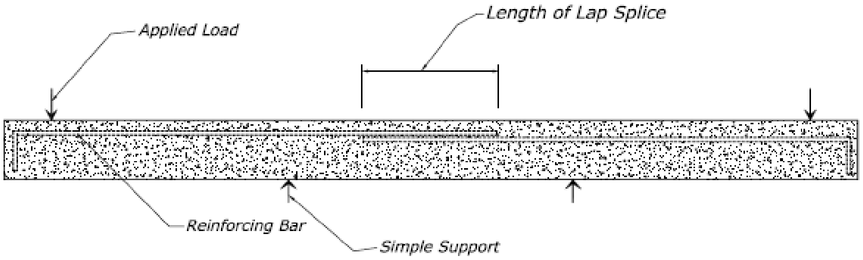


Figure 1 Overall Properties of The Test Girders

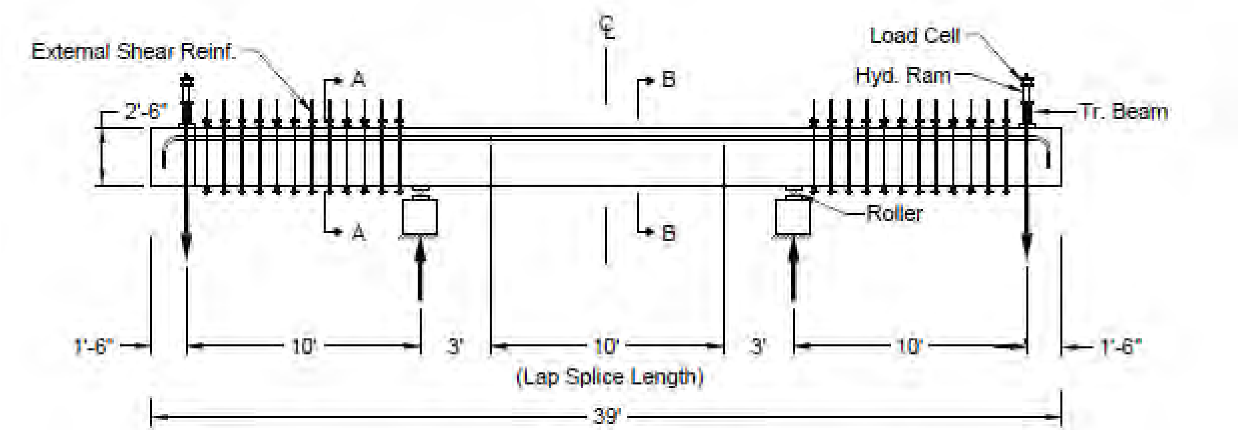


Figure 2 Test Girder, Series A

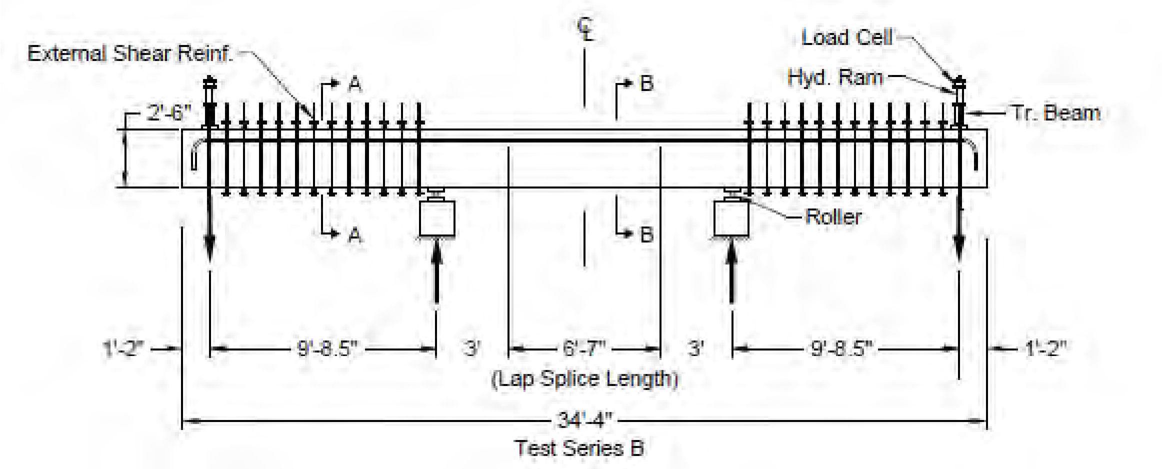


Figure 3 Test Girder Series B

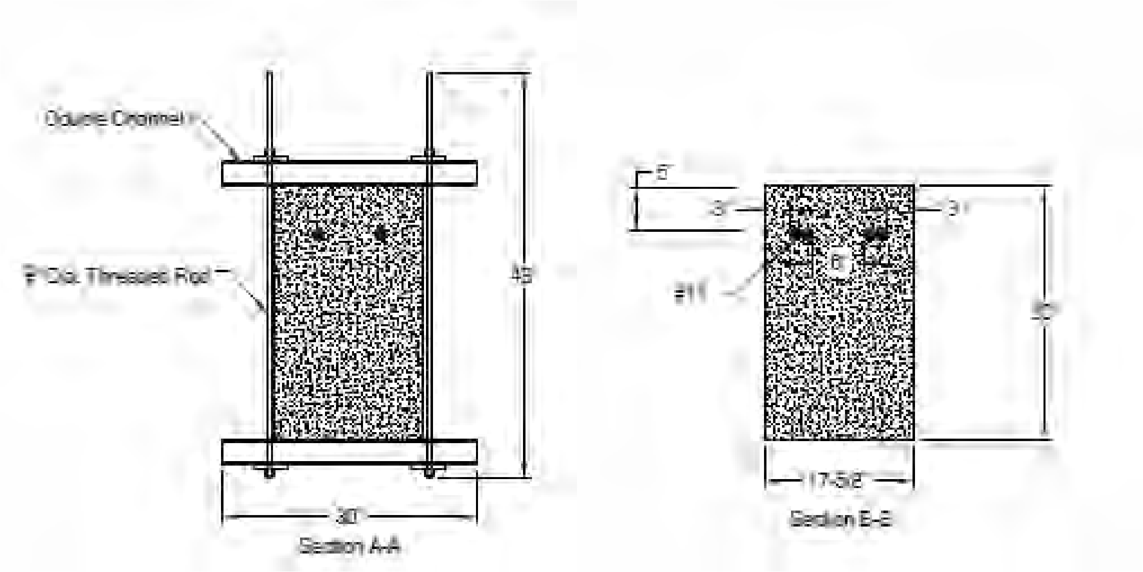


Figure 4 Cross-Sectional Dimensions of Series A and B Girders

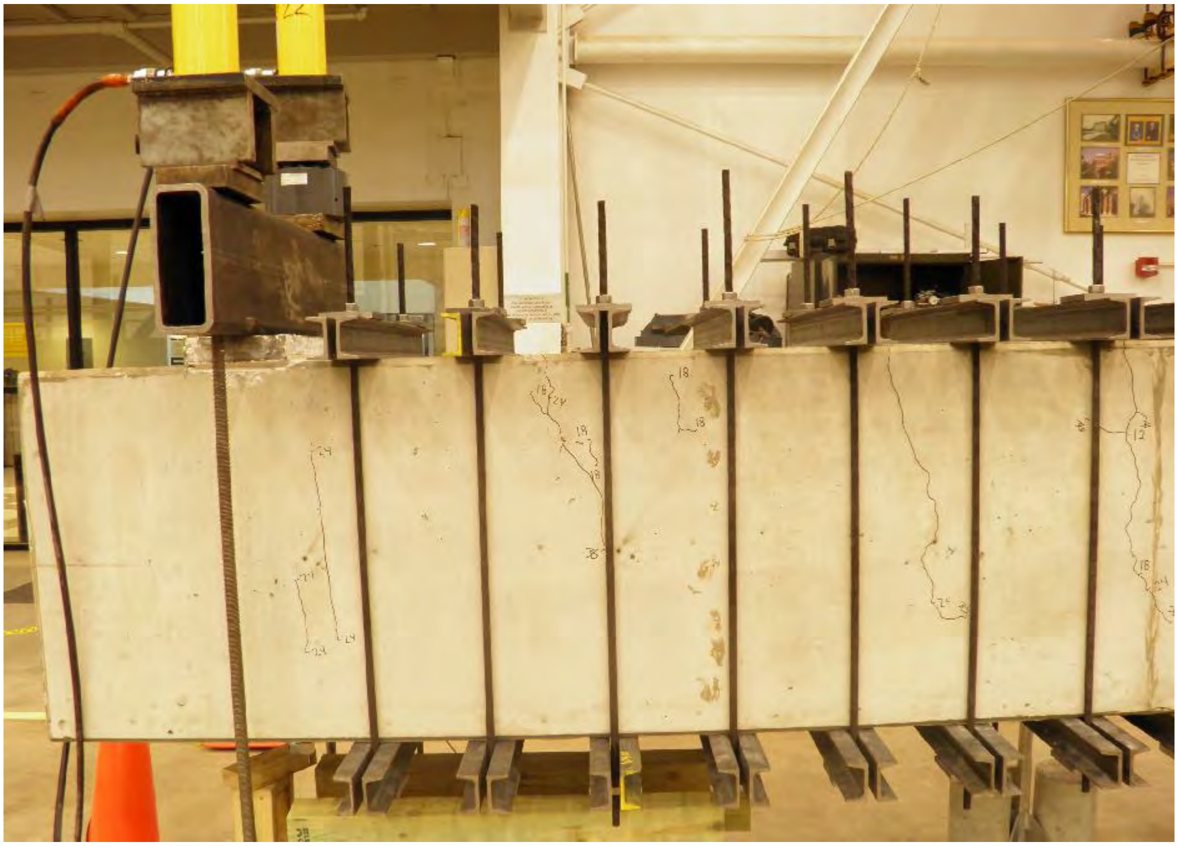


Figure 5 Photograph of One of The Cantilevered Segments of A Test Girder

Figure 6 Flexural Cracks and Bursting Cracks

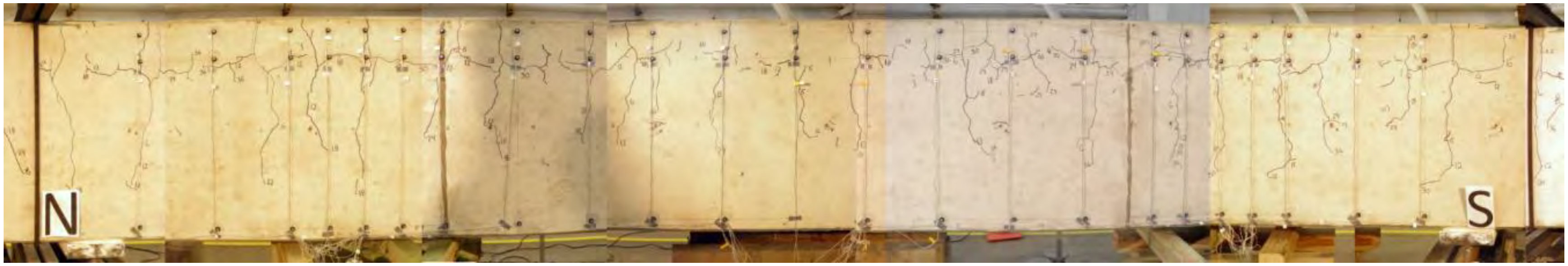


Figure 7 West Elevation of Test Girder A4. Initial Loading. Applied Load = 36 kip

Figure 8 East Elevation of Test Girder A4. Initial Loading. Applied Load = 36 kip

Figure 9 West Elevation of Test Girder A4 Reloaded to 36 kip

Figure 10 East Elevation of Test Girder A4 Reloaded to 36 kip

Figure 11 West Elevation of Test Girder A4 Reloaded to 42 kip

Figure 12 East Elevation of Test Girder A4 Reloaded to 42 kip

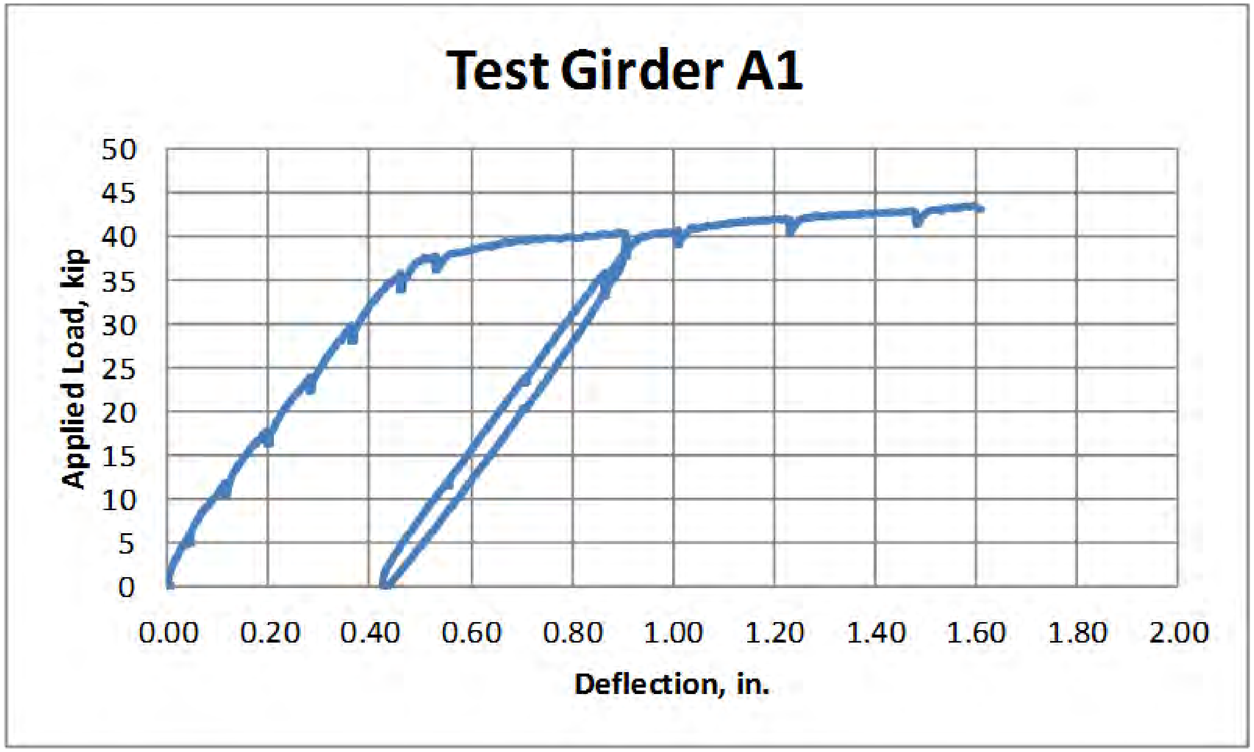


Figure 13 Load-Deflection Plot for Test Girder A1

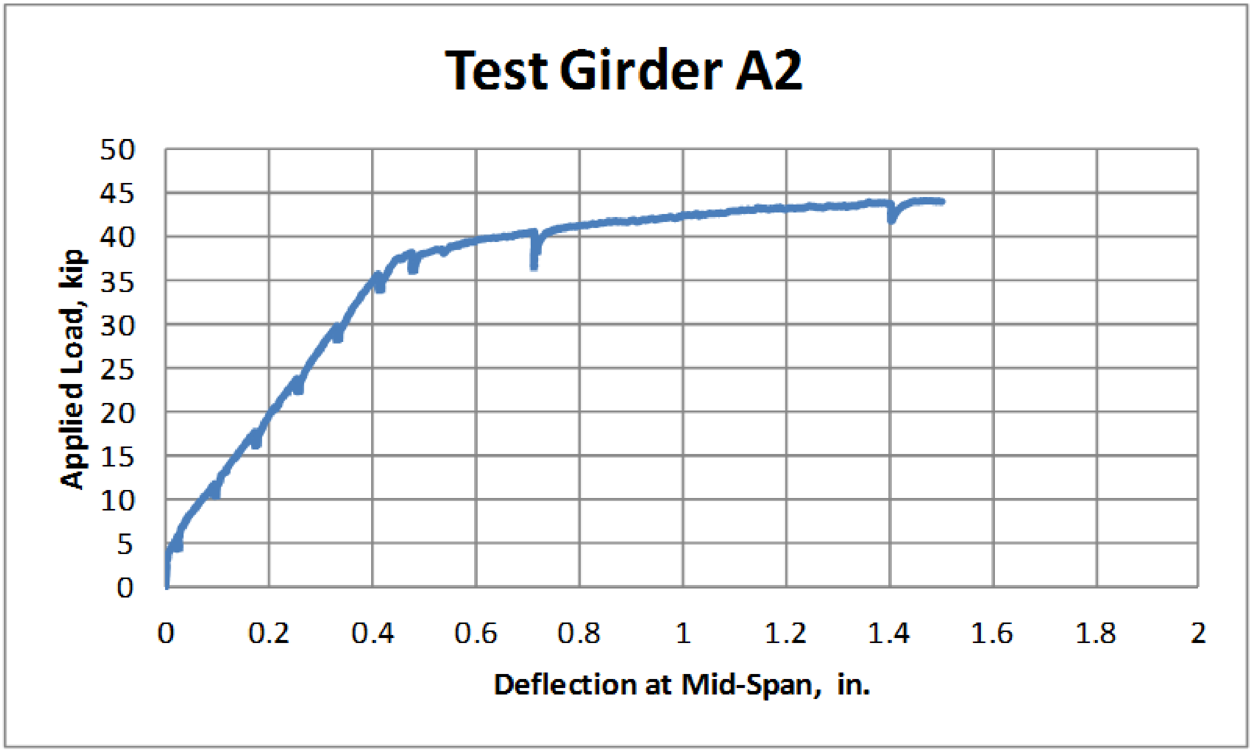


Figure 14 Load-Deflection Plot for Test Girder A2

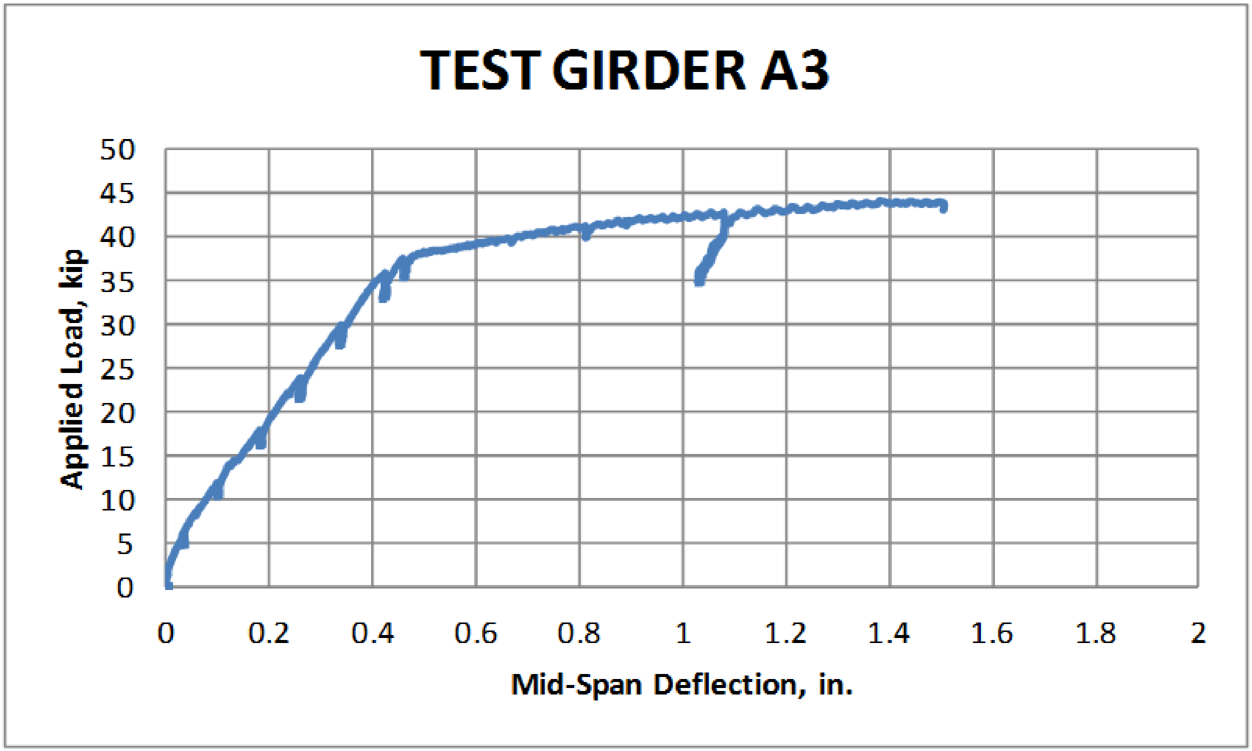


Figure 15 Load-Deflection Plot for Test Girder A3

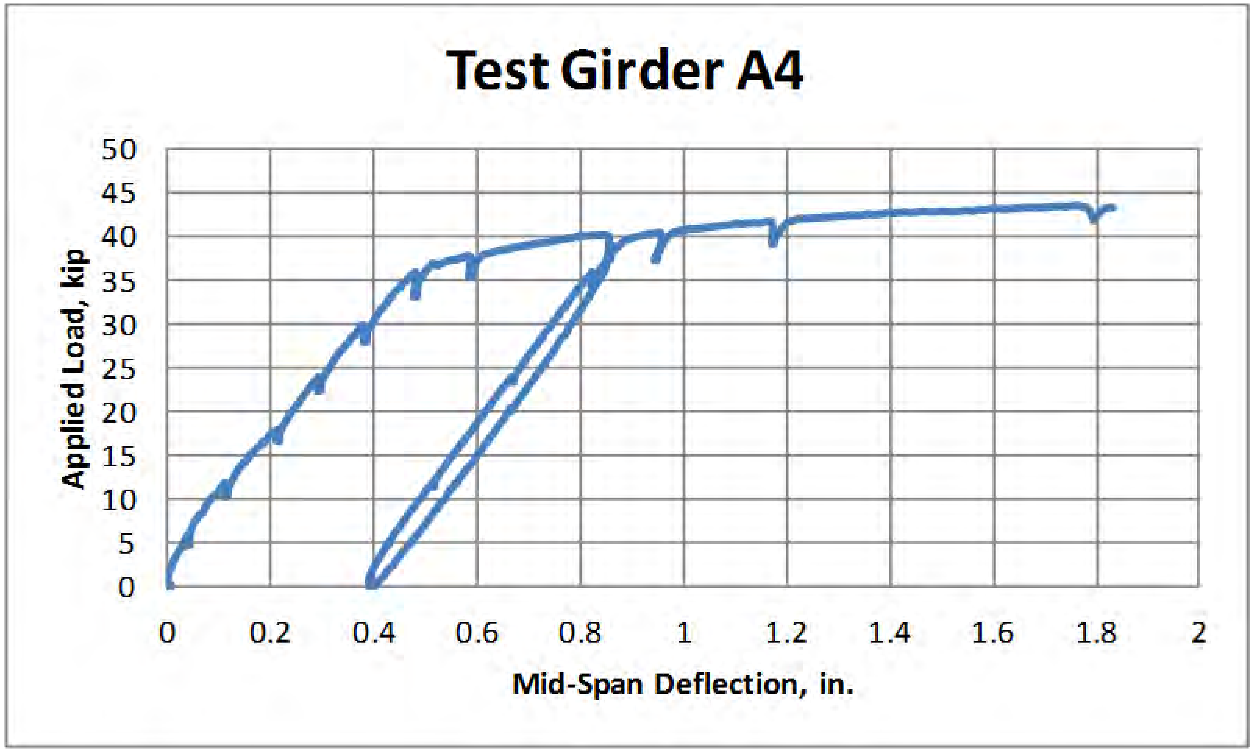


Figure 16 Load-Deflection Plot for Test Girder A4

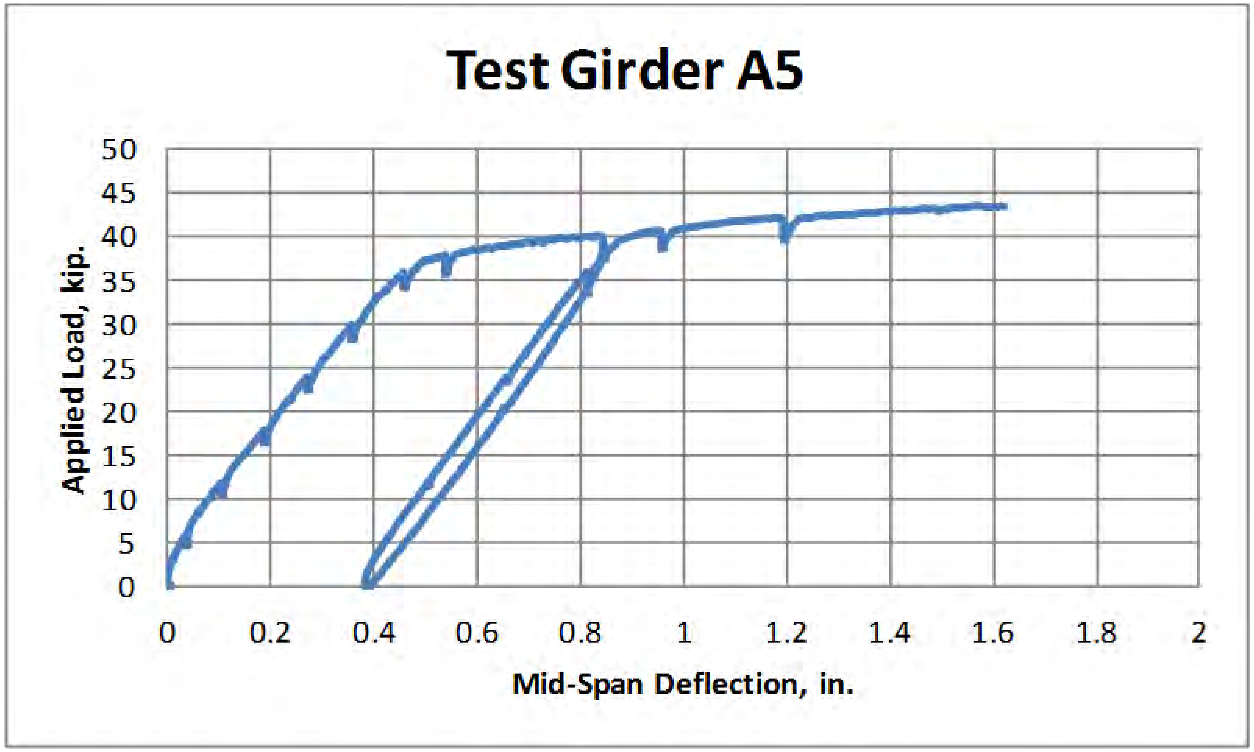


Figure 17 Load-Deflection Plot for Test Girder A5

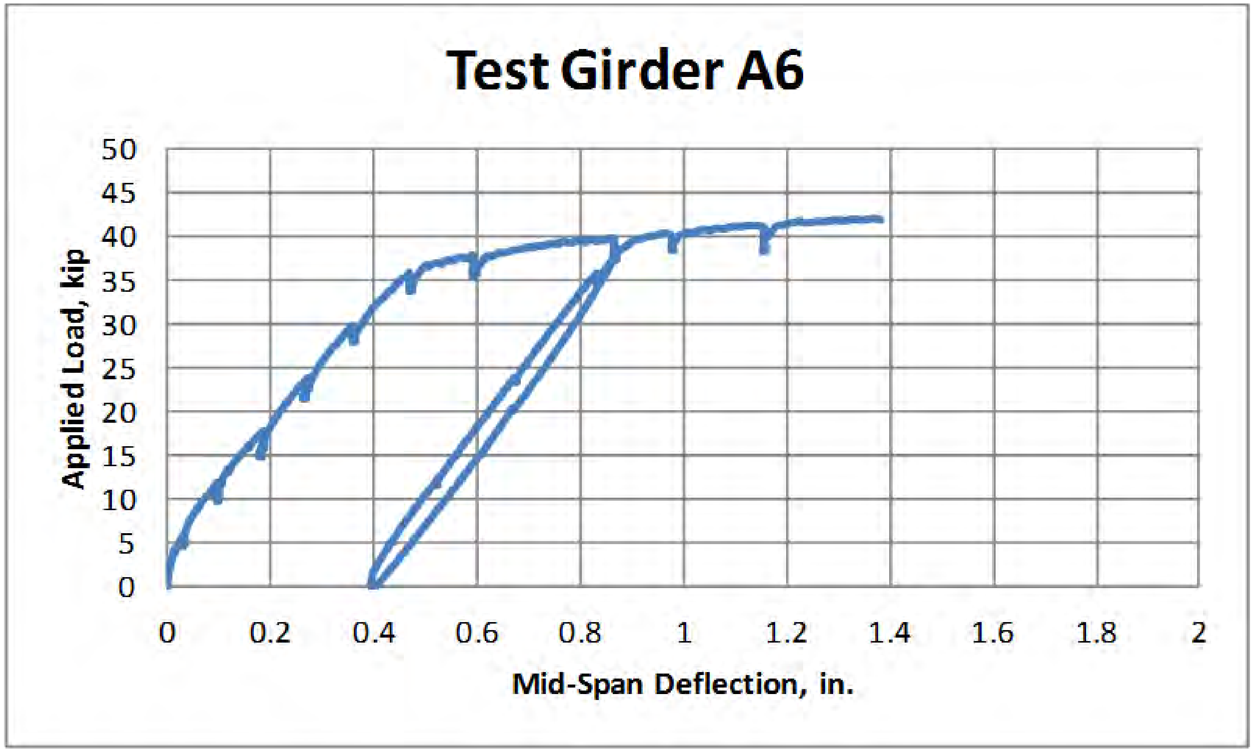


Figure 18 Load-Deflection Plot for Test Girder A6

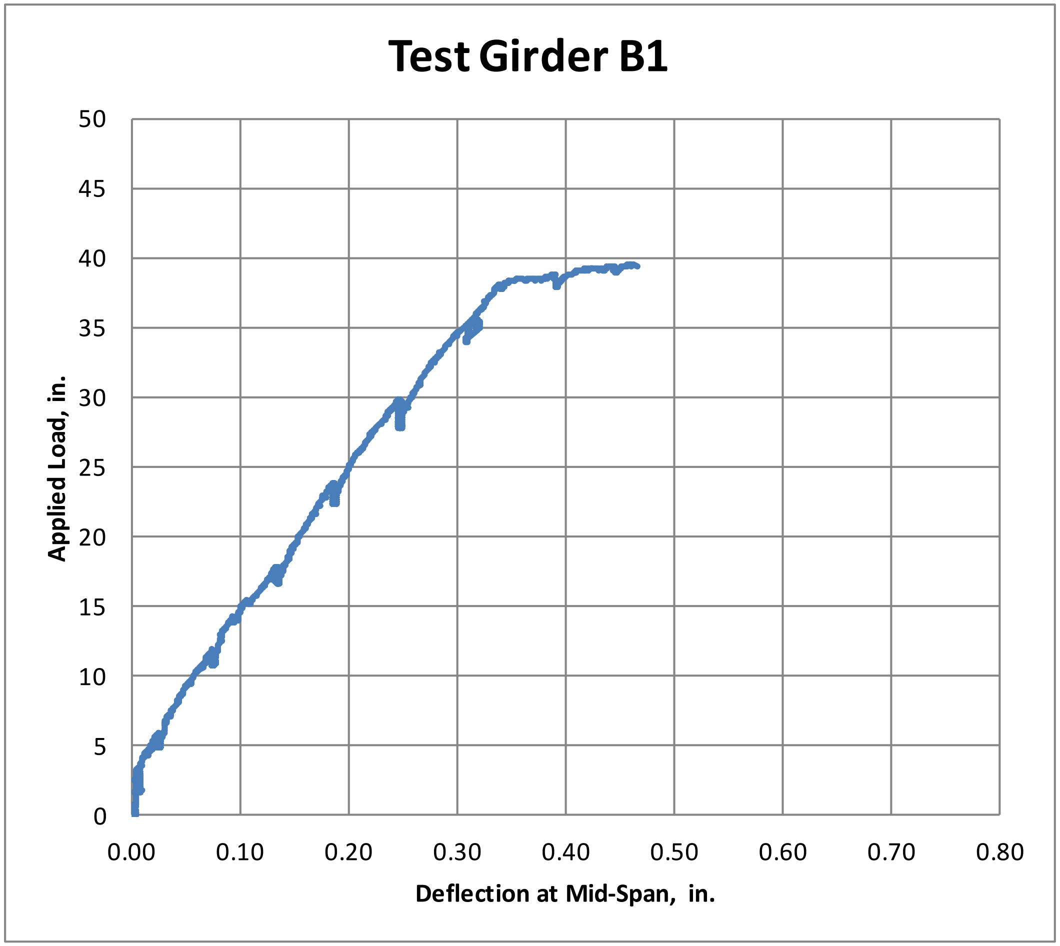


Figure 19 Load-Deflection Plot for Test Girder B1

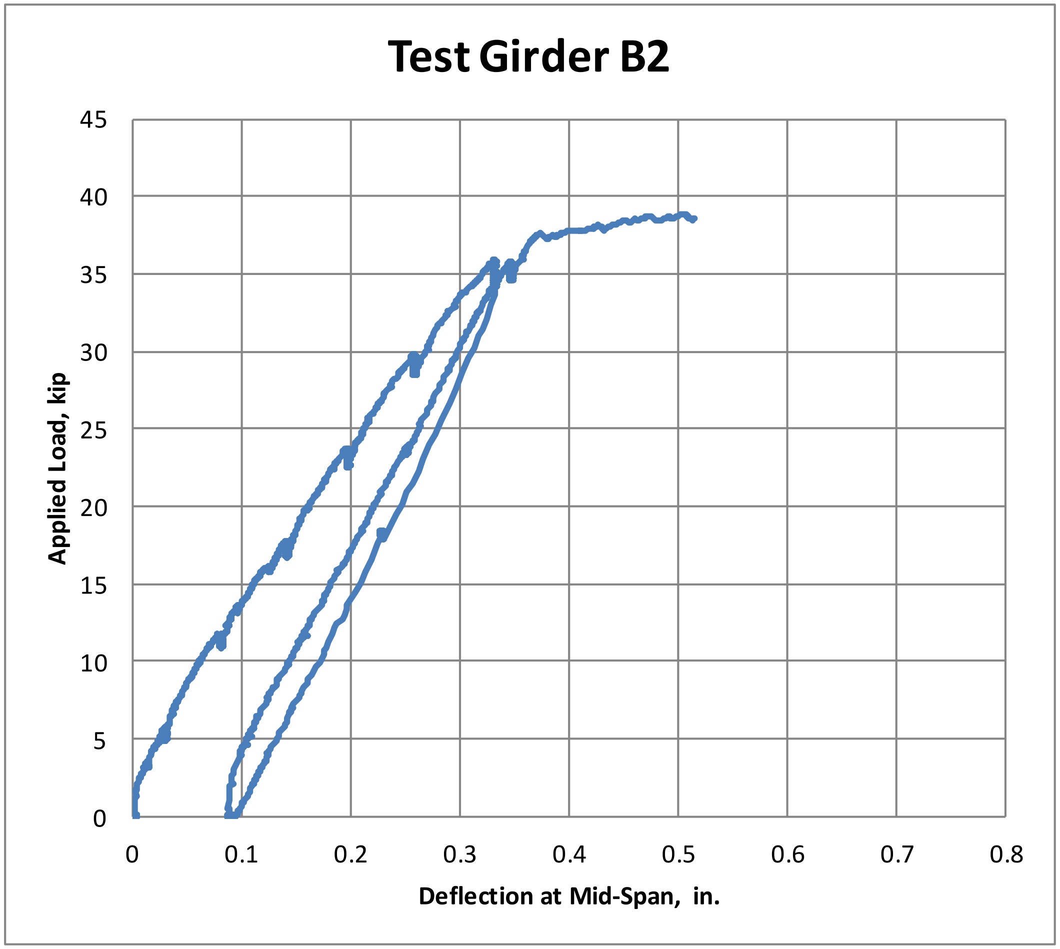


Figure 20 Load-Deflection Plot for test Girder B2

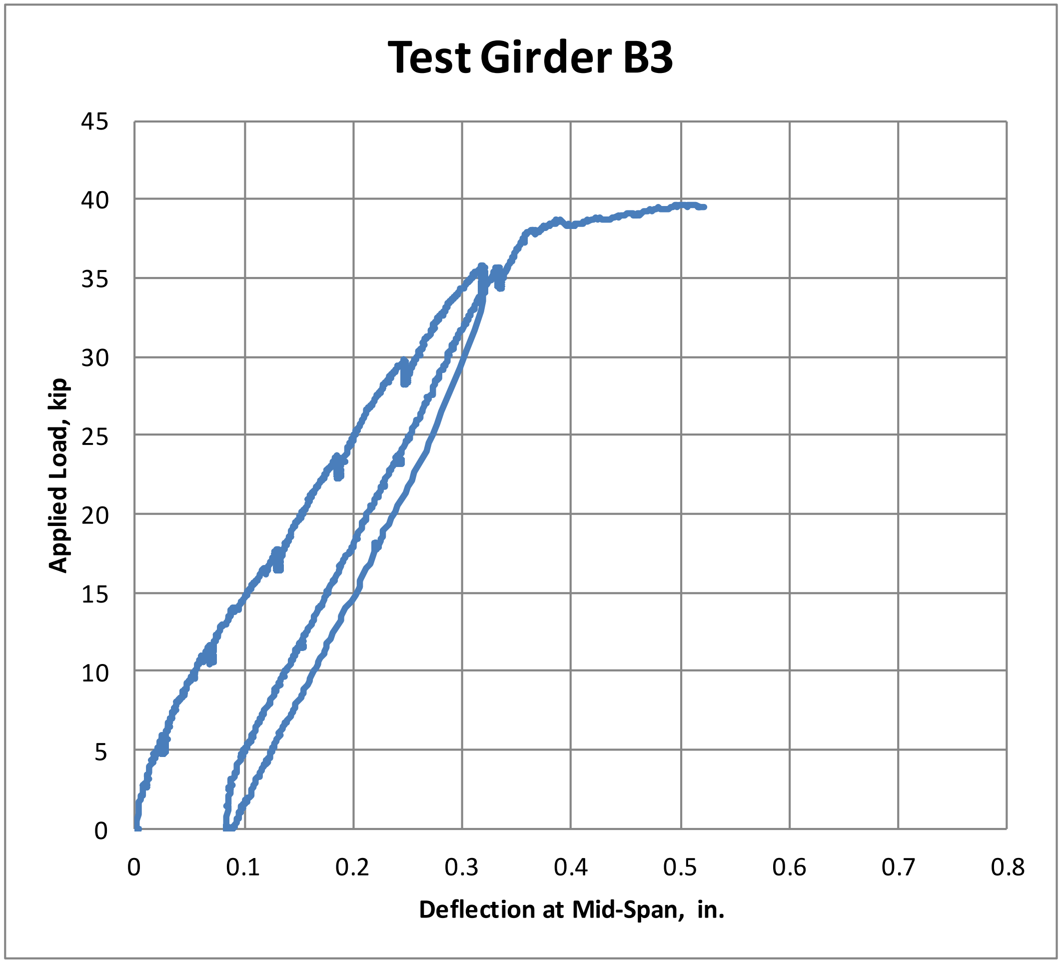


Figure 21 Load-Deflection Plot for Test Girder B3

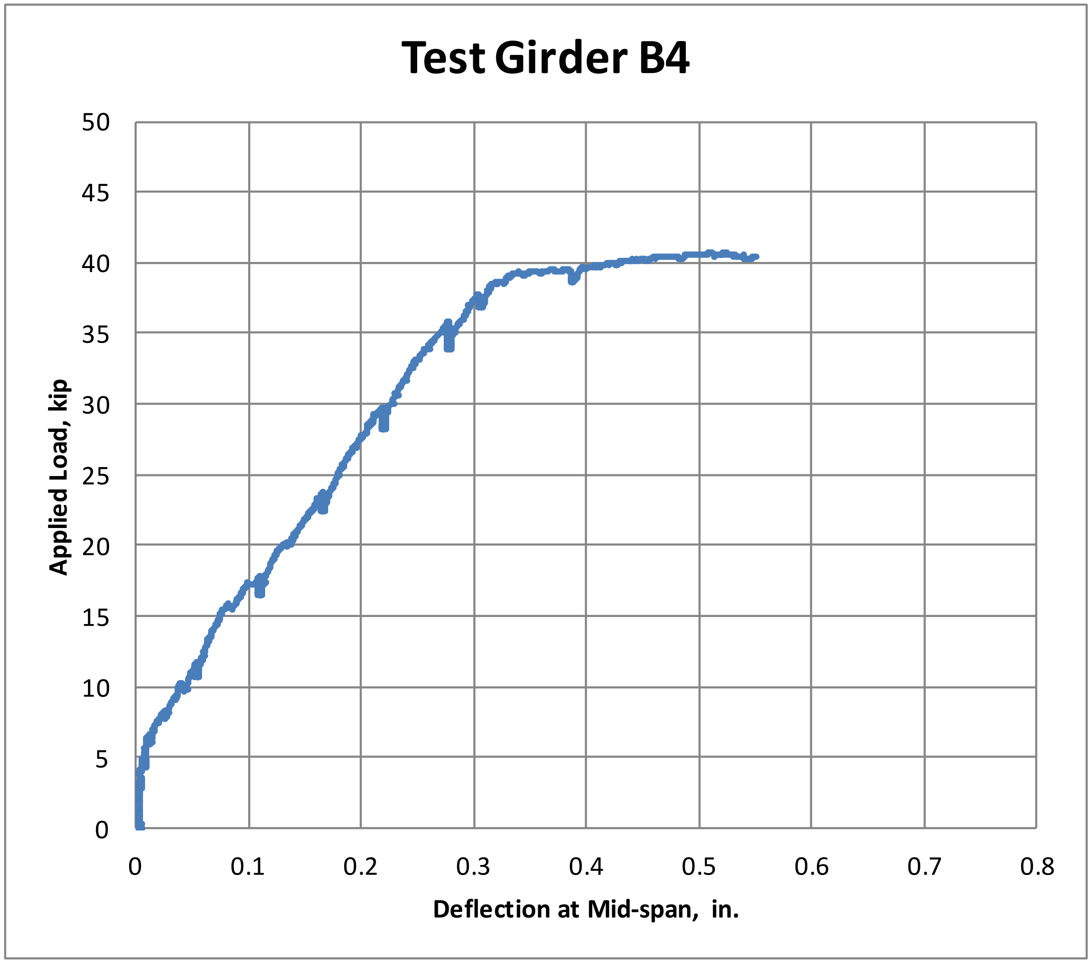


Figure 22 Load-Deflection Plot for Test Girder B4

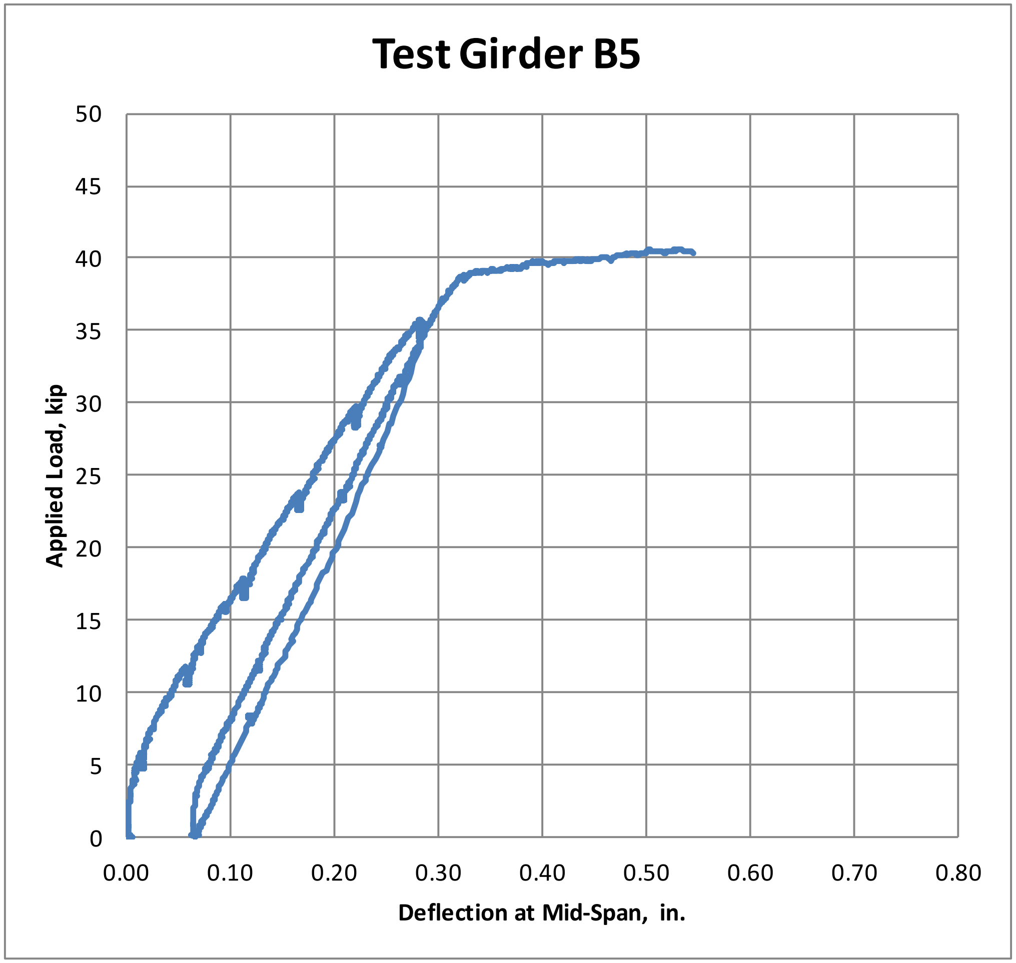


Figure 23 Load-Deflection Plot for Test Girder B5

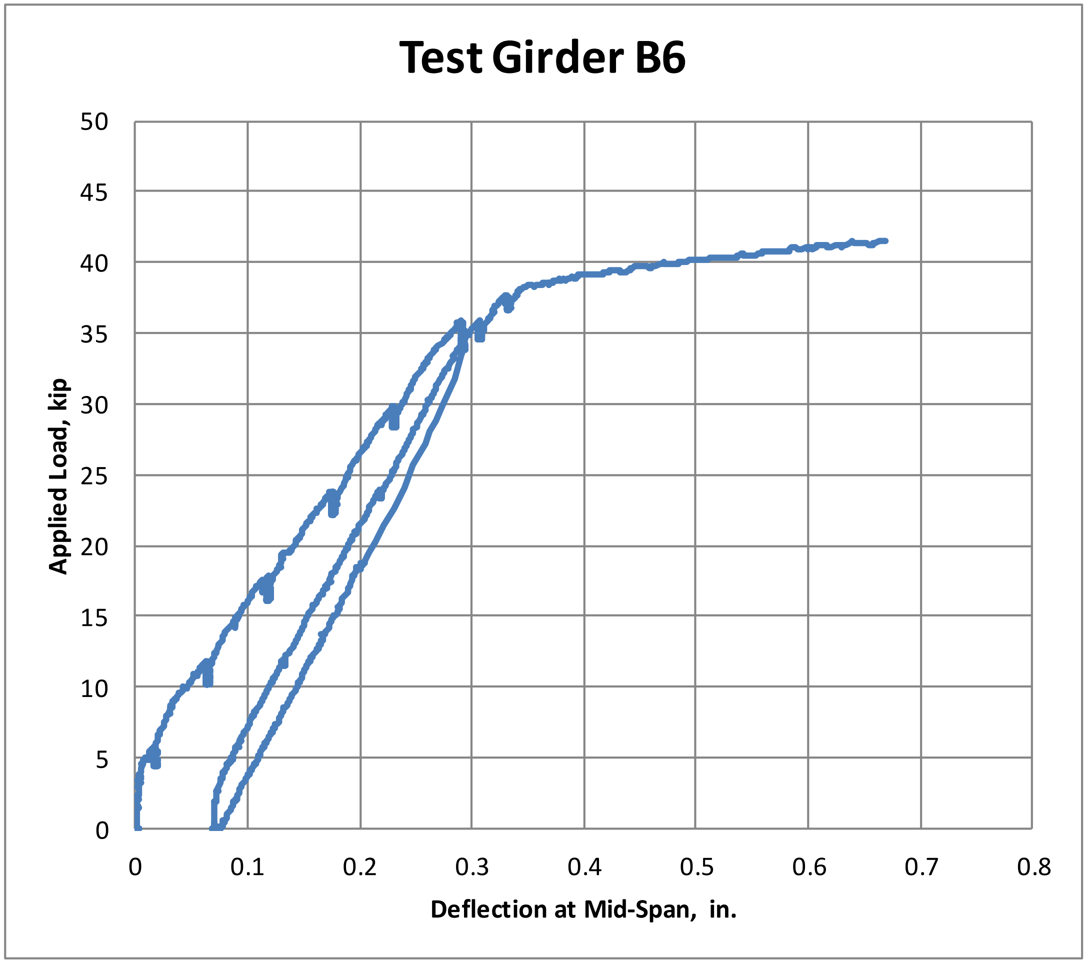


Figure 24 Load-Deflection Plot for Test Girder B6

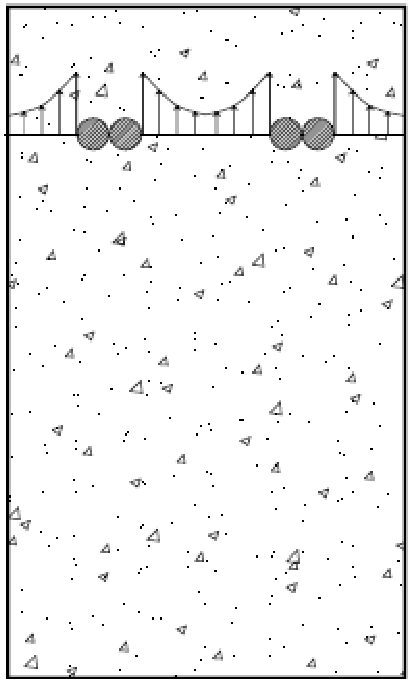


Figure 25 Qualitative Illustration of Internal Stresses Leading to Bursting Cracks

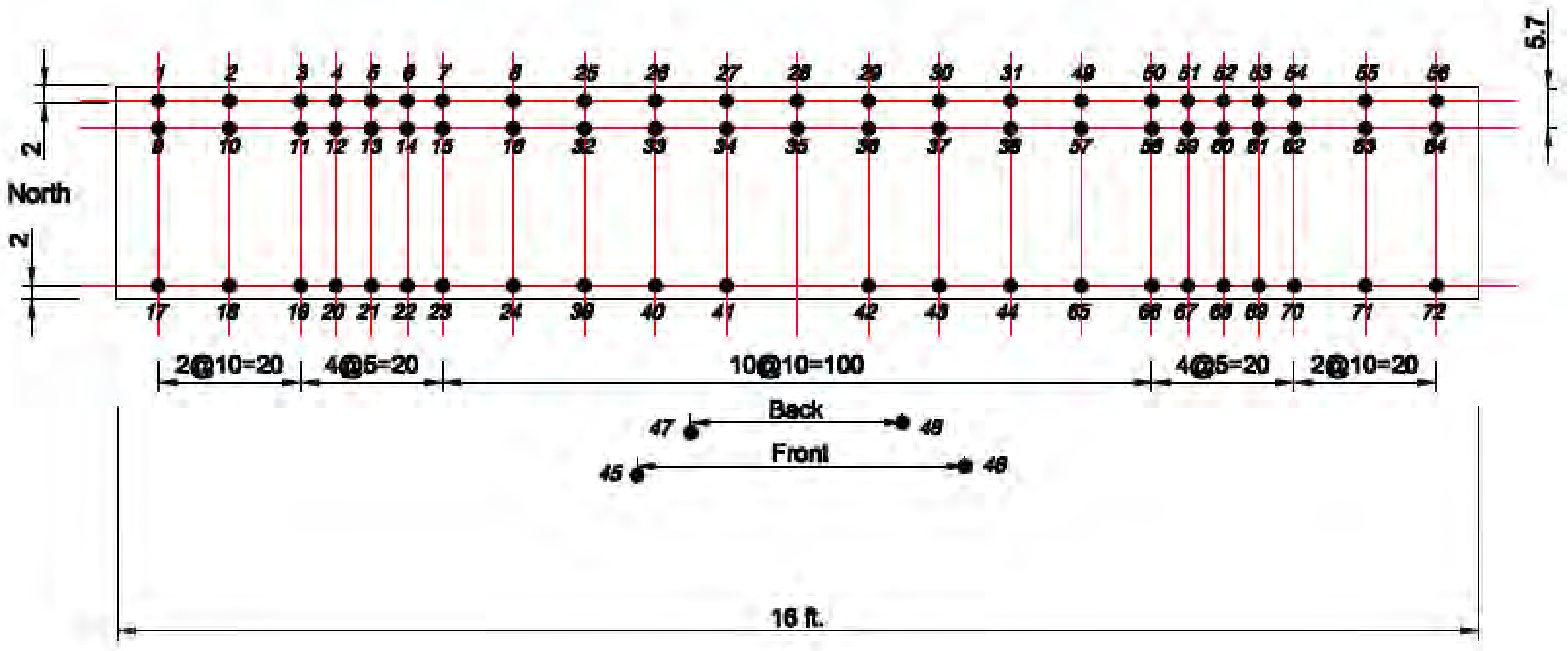


Figure 26 Optotrak Targets on Series A Girders

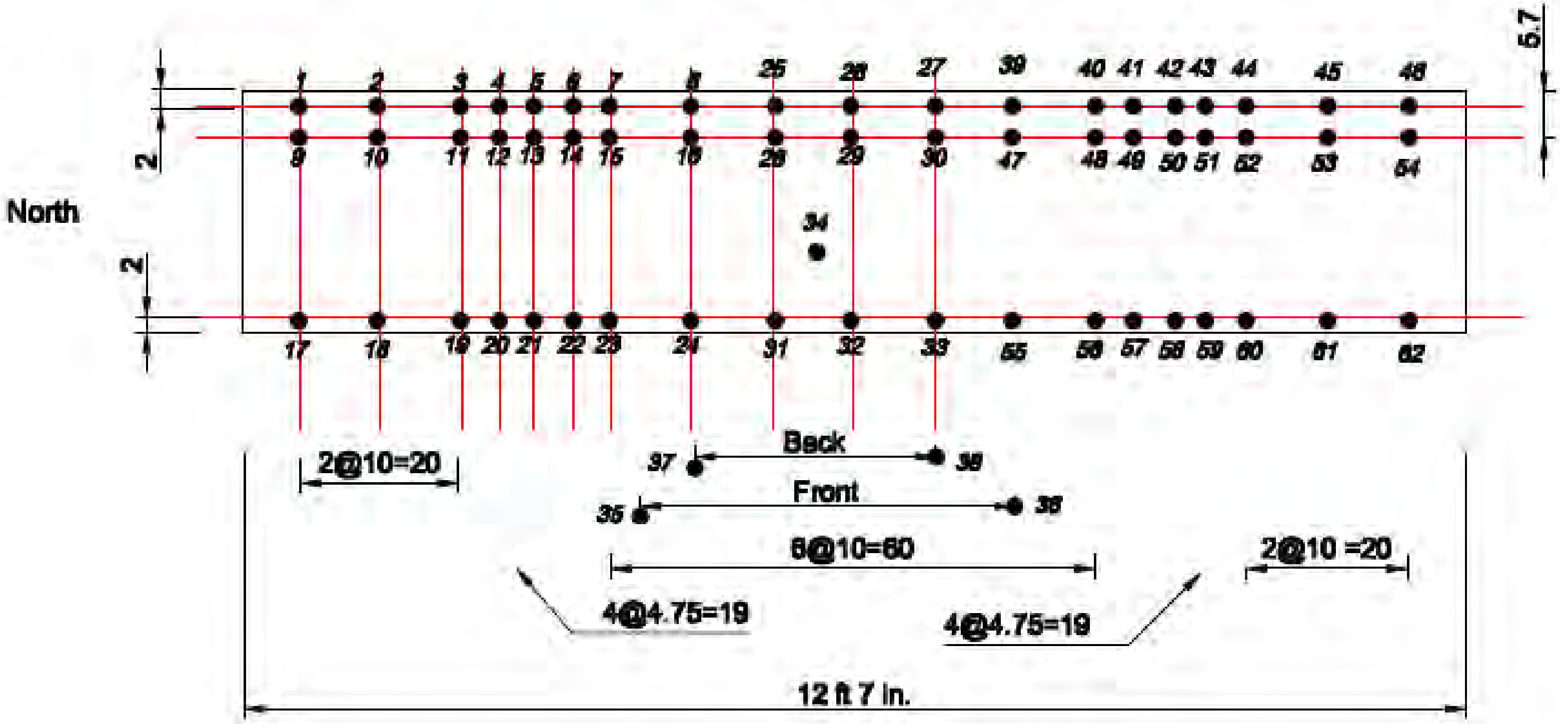


Figure 27 Optotrak Targets on Series B Girders

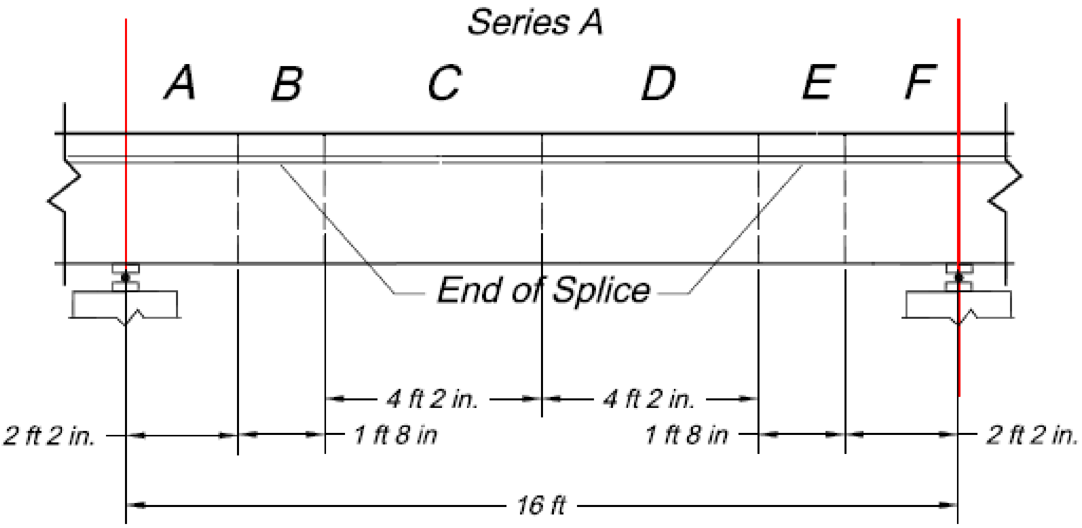


Figure 28 Selected Regions for Maximum Bursting Crack Widths in Series A Girders

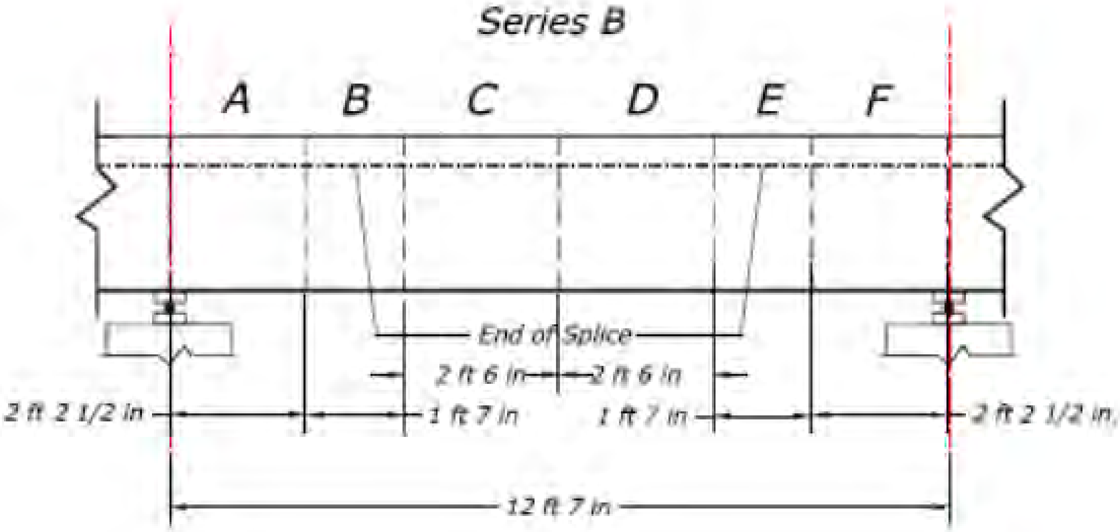


Figure 29 Selected Regions for Maximum Bursting Crack Widths in Series B Girders

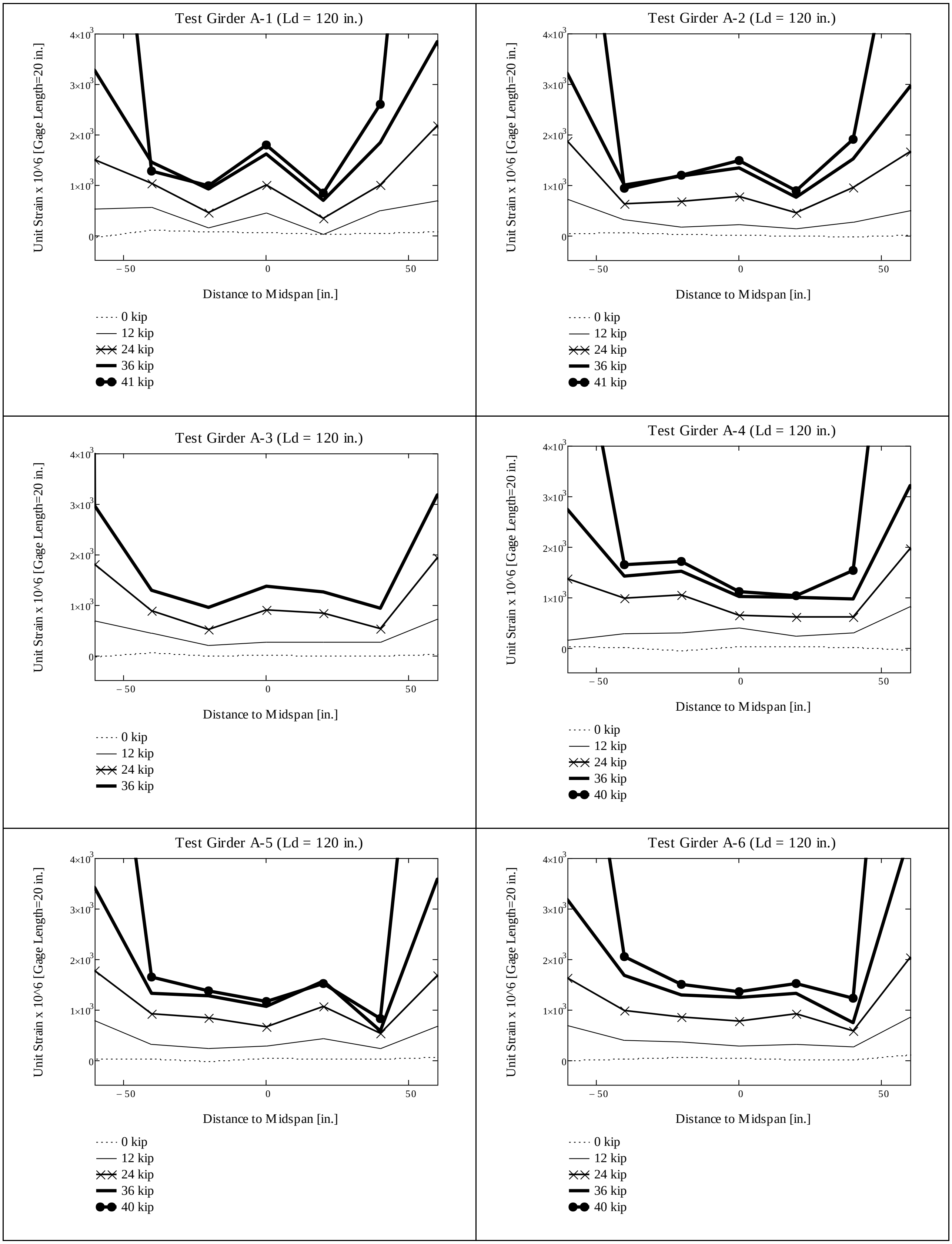


Figure 30 Longitudinal Strains at Level of Reinforcement, First Loading of Series A Girders

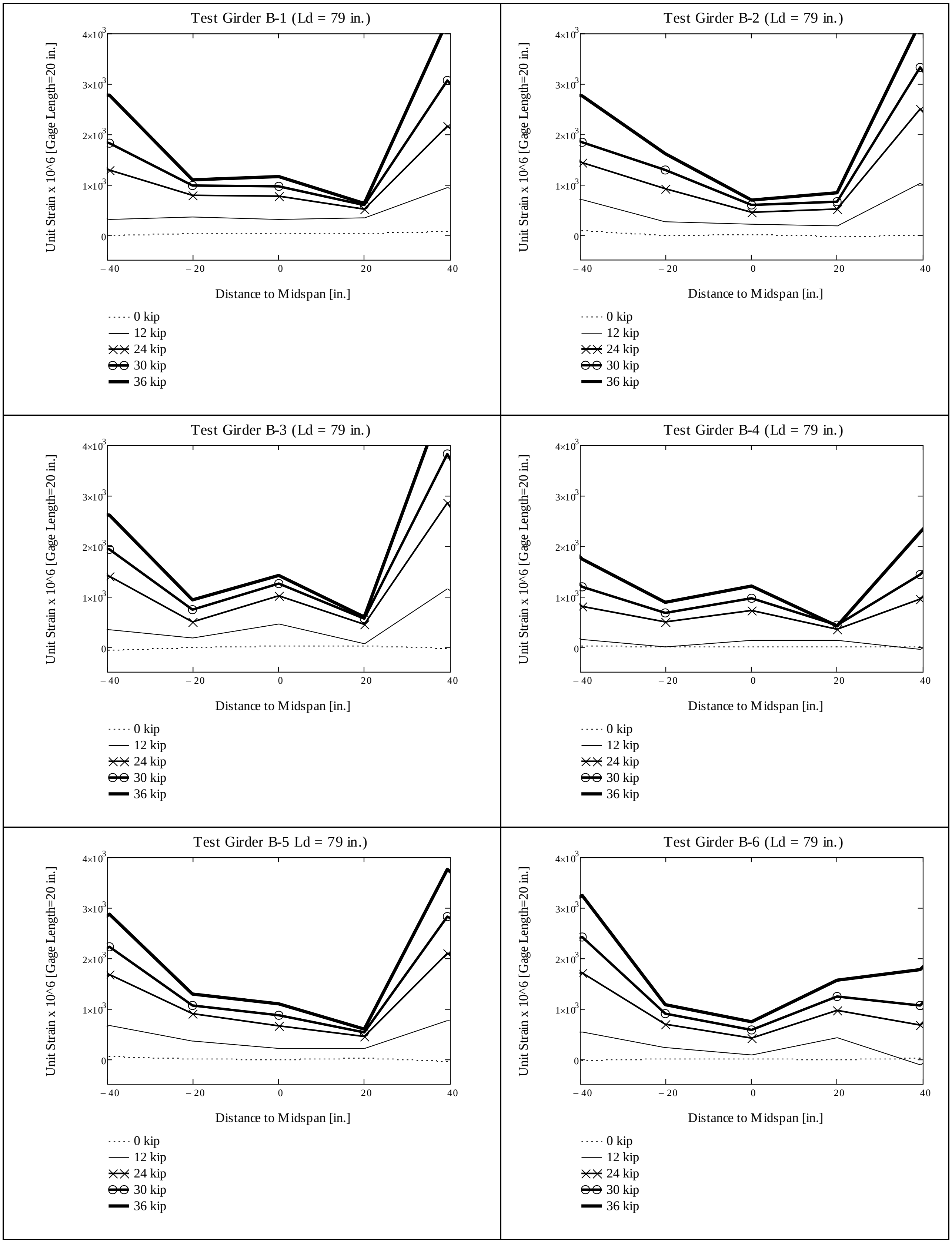


Figure 31 Longitudinal Strains at Level of Reinforcement, First Loading of Series B Girders

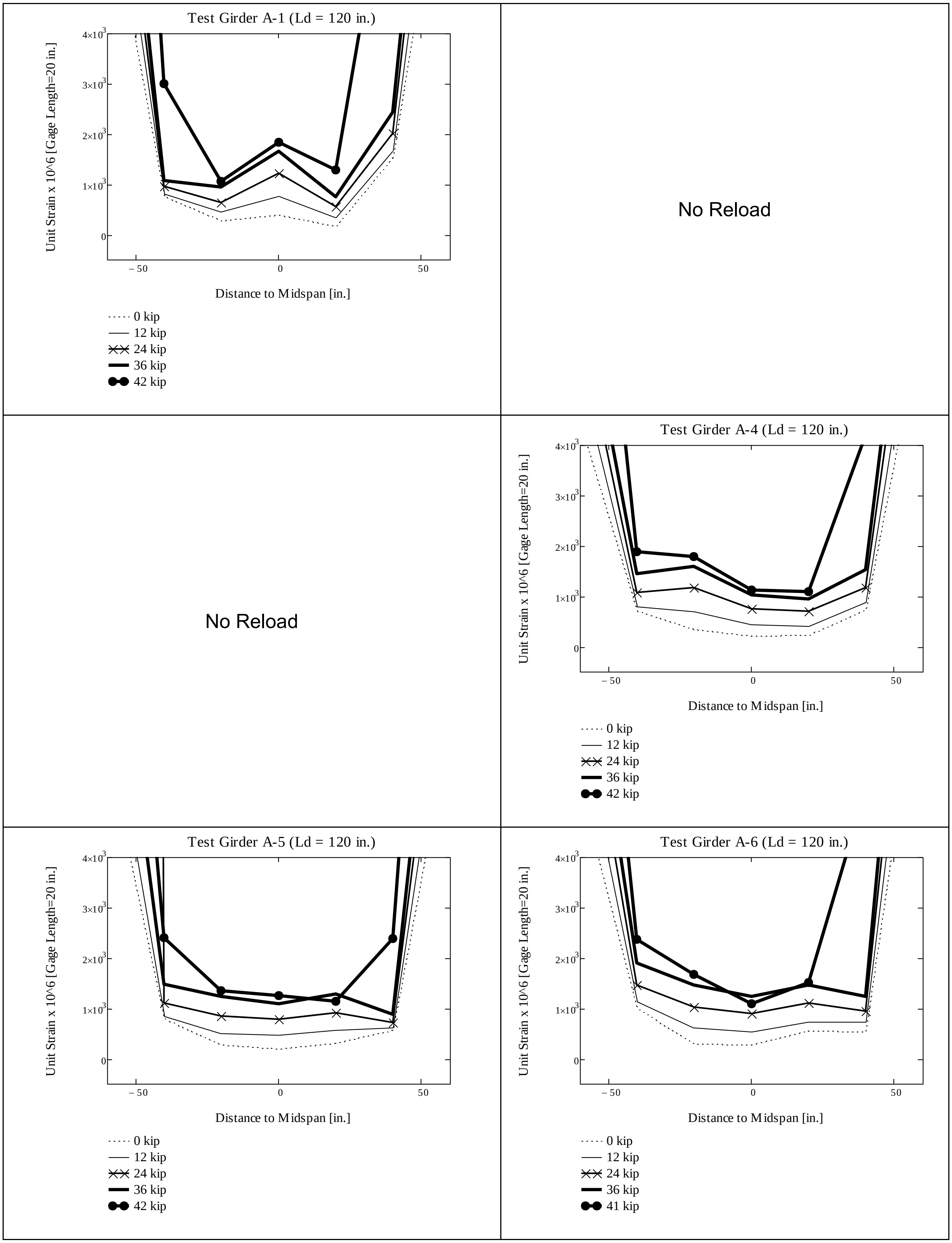


Figure 32 Longitudinal Strains at Level of Reinforcement, Reloading of Series A Girders

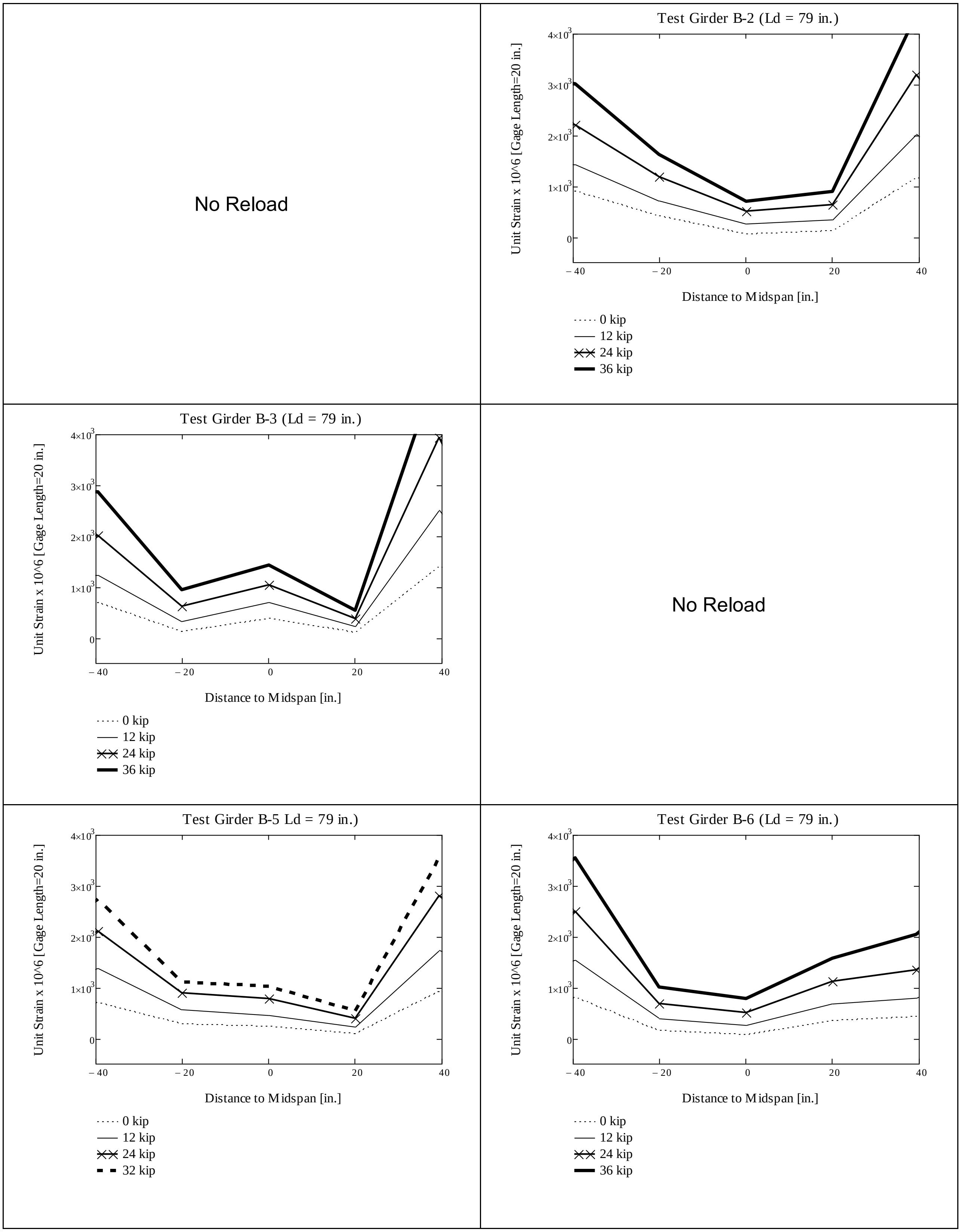
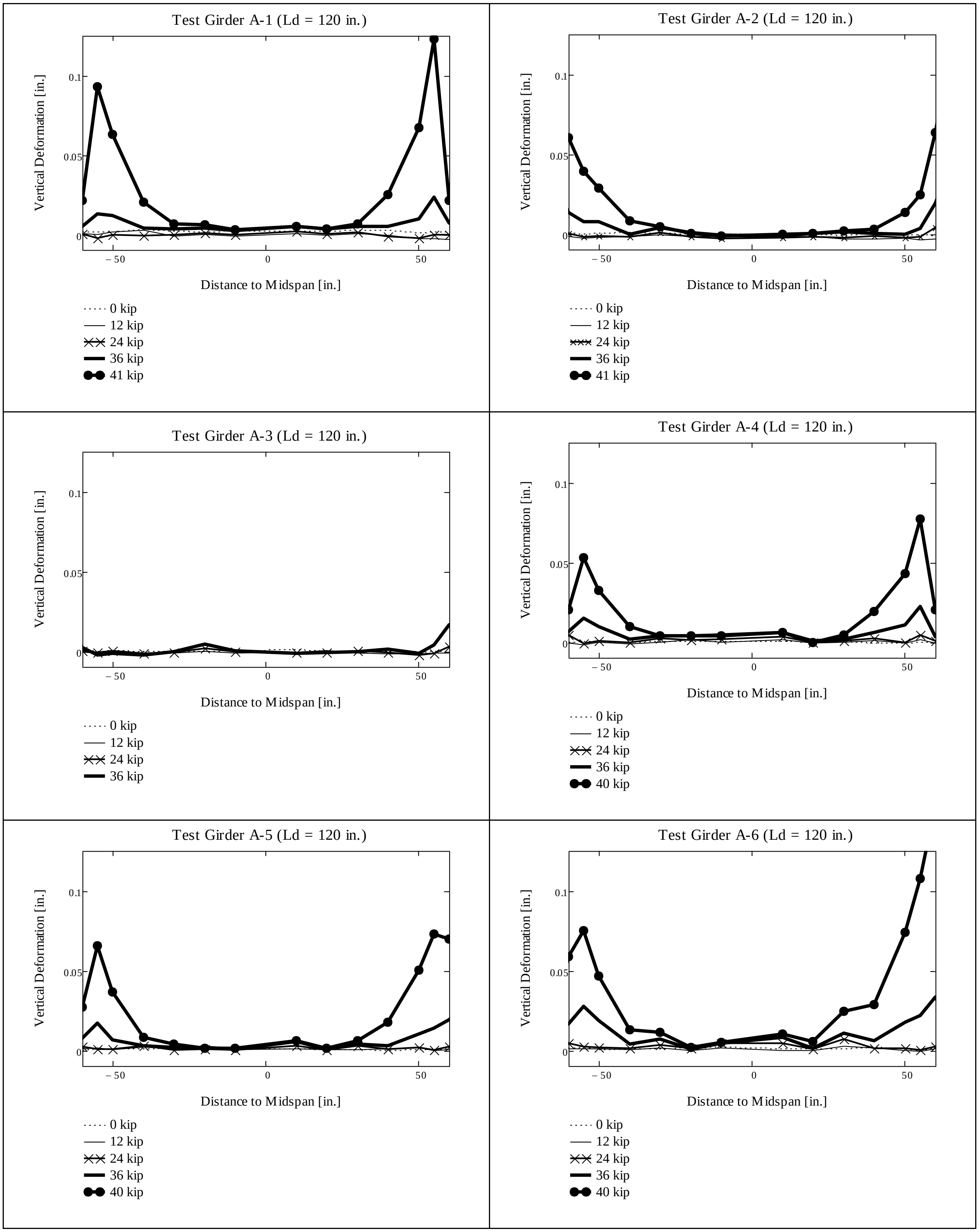


Figure 33 Longitudinal Strains at Level of Reinforcement, Reloading of Series B Girders



Test Girder A-1 (Ld = 120 in.)

Test Girder A-2 (Ld = 120 in.)

Test Girder A-3 (Ld = 120 in.)

Test Girder A-4 (Ld = 120 in.)

Test Girder A-5 (Ld = 120 in.)

Test Girder A-6 (Ld = 120 in.)

Figure 34 Transverse Deformations, First Loading of Series A Girders

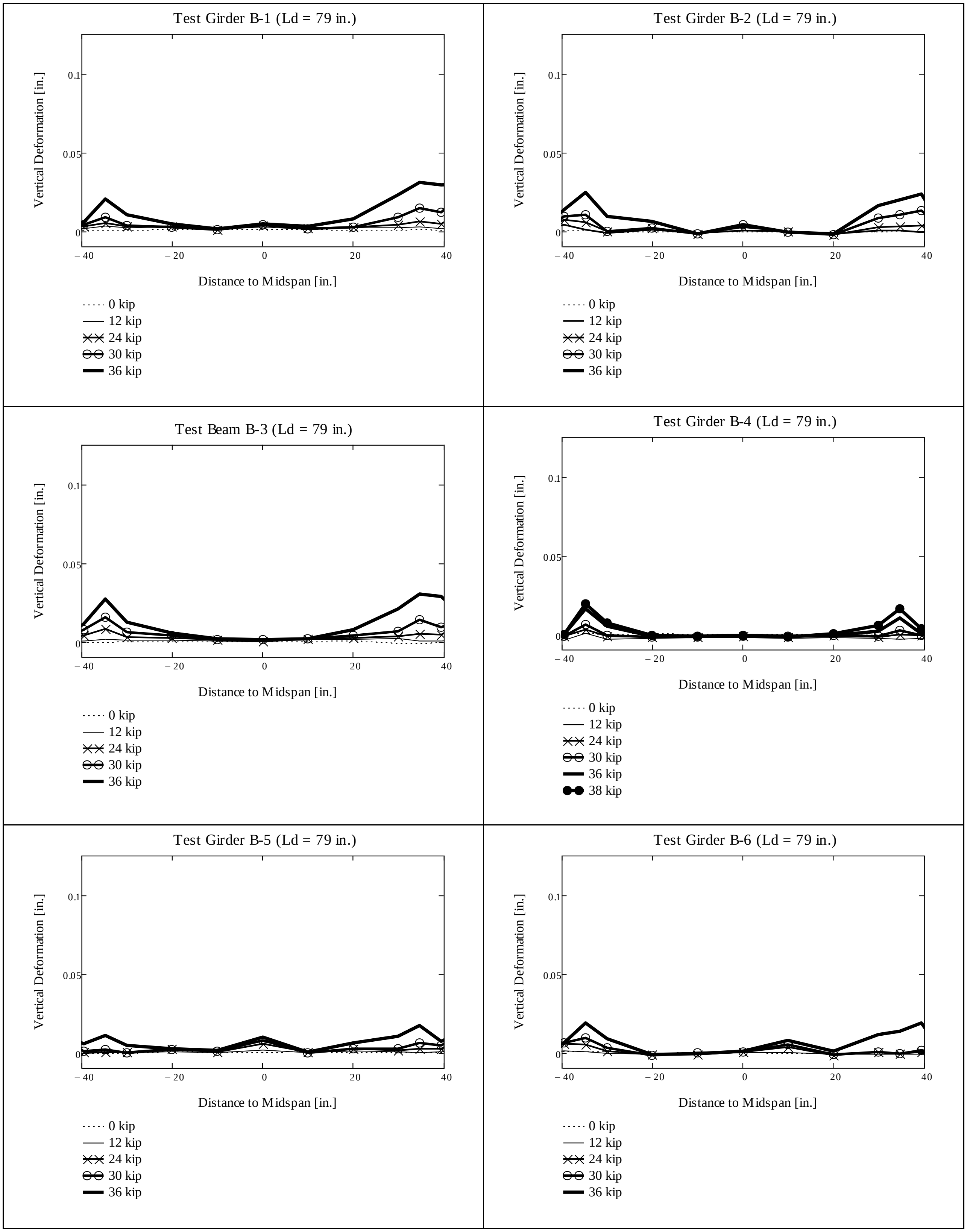
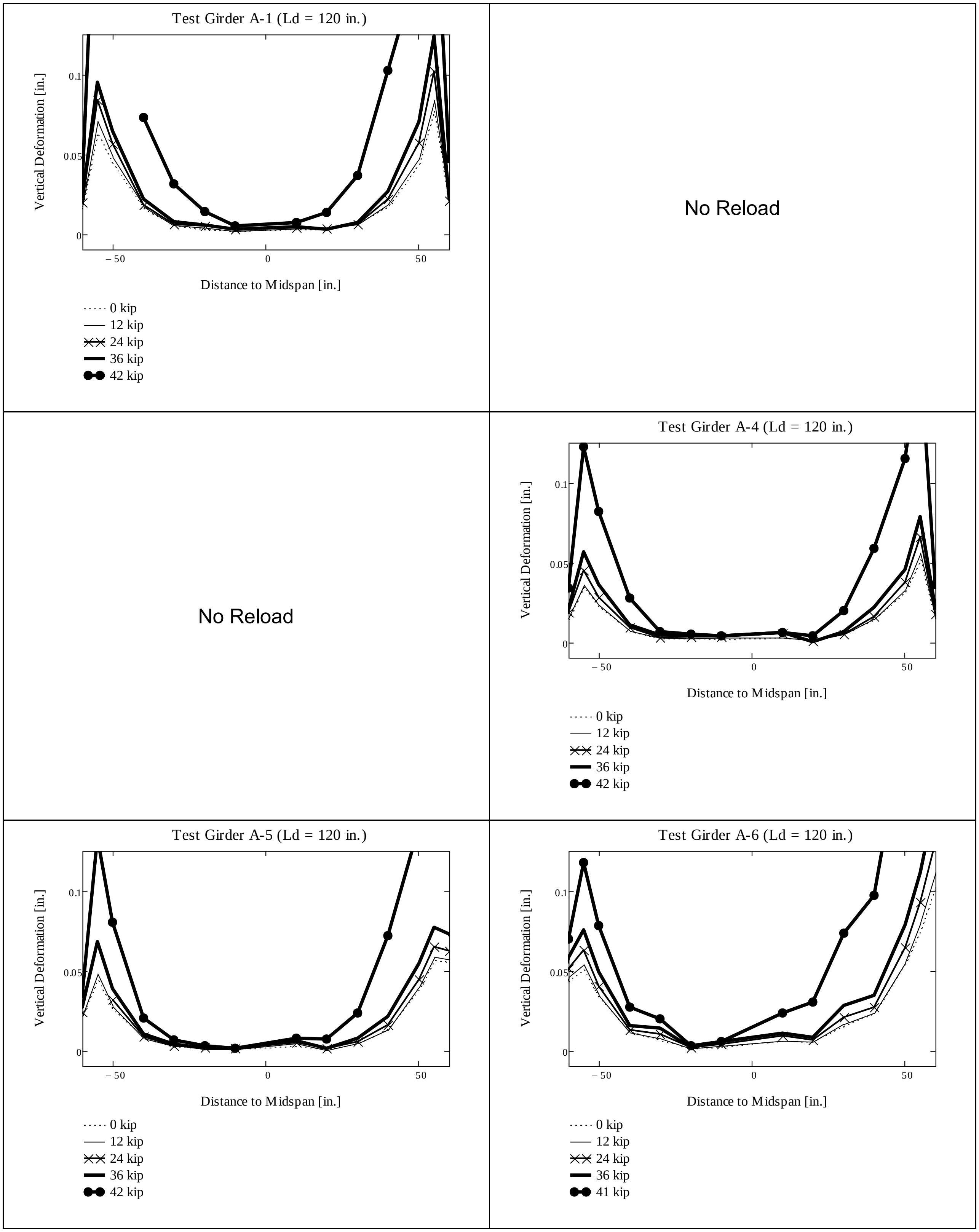


Figure 35 Transverse Deformations, First Loading of Series B Girders



Test Girder A-1 (Ld = 120 in.)

No Reload

No Reload

Test Girder A-4 (Ld = 120 in.)

Test Girder A-5 (Ld = 120 in.)

Test Girder A-6 (Ld = 120 in.)

Figure 36 Transverse Deformations, Reloading of Series A Girders

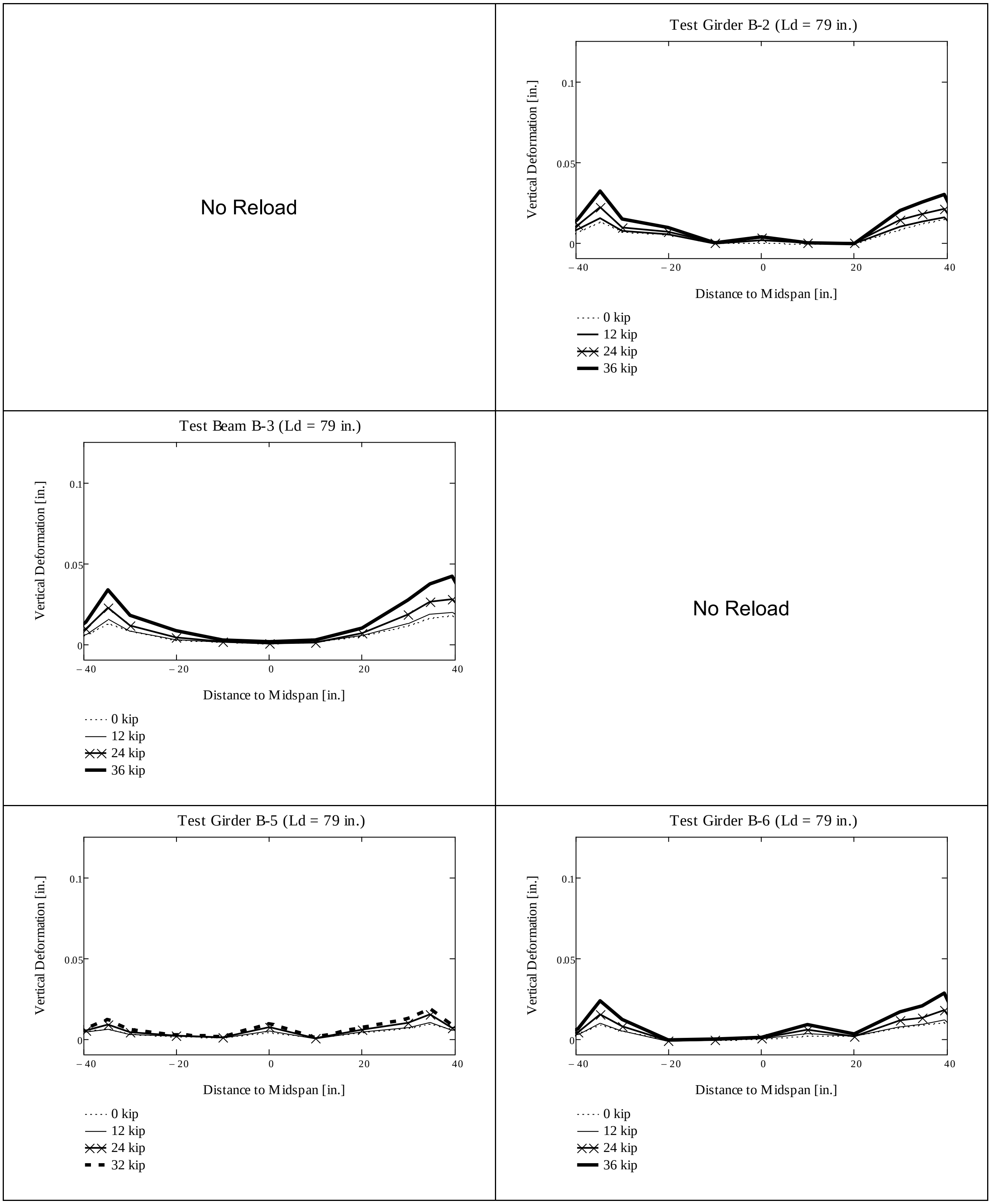
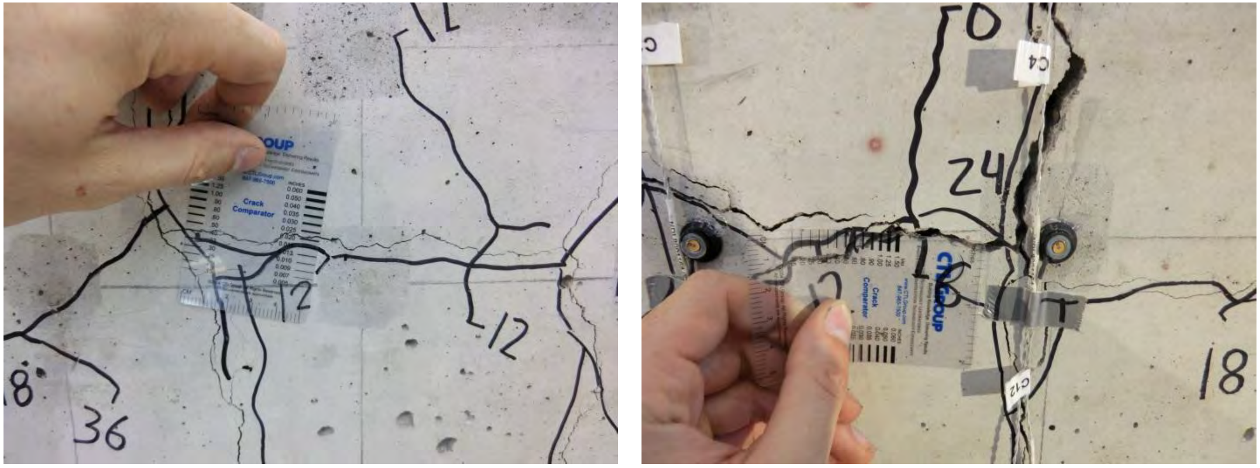


Figure 37 Transverse Deformations, Reloading of Series B Girders

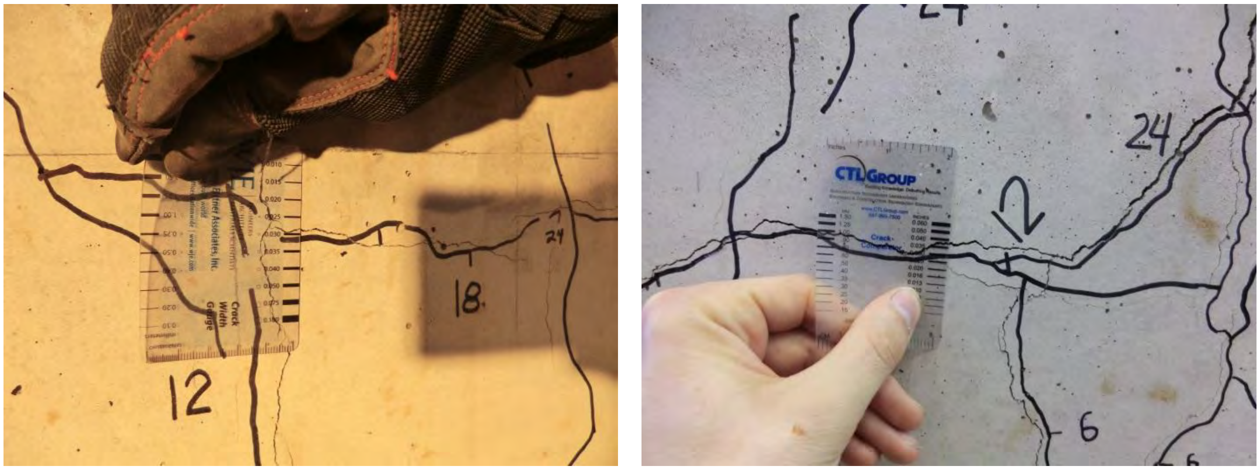
Girder A-1, Load = 36 kip (reload). Girder A-2, Load = 36 kip.



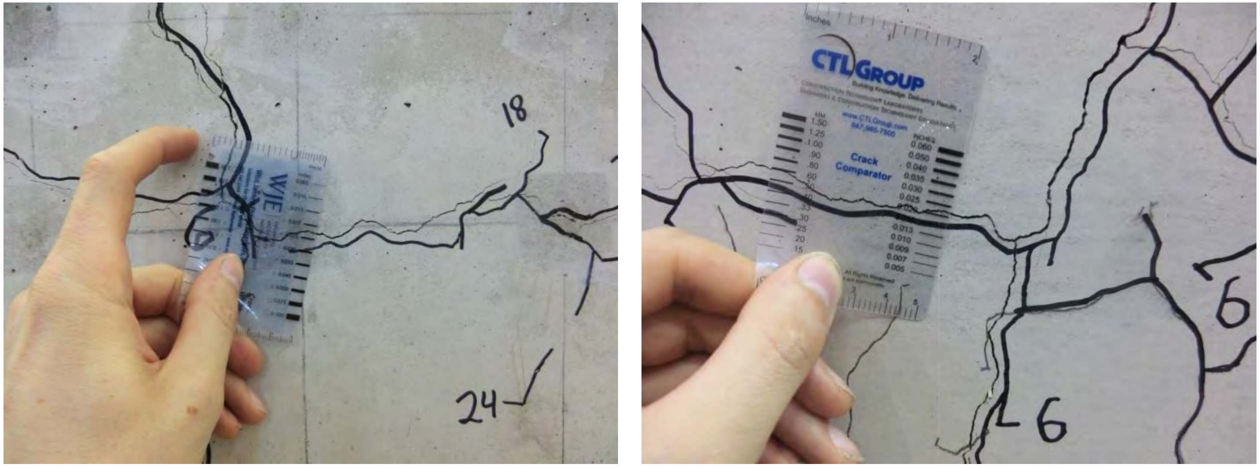
Girder A-3, Load = 36 kip. Girder A-4, Load = 40 kip (reload).

Girder A-5, Load = 40 kip. Girder A-6, Load = 46 kip (reload)

Figure 38 Representative Cracks, Test Series A.

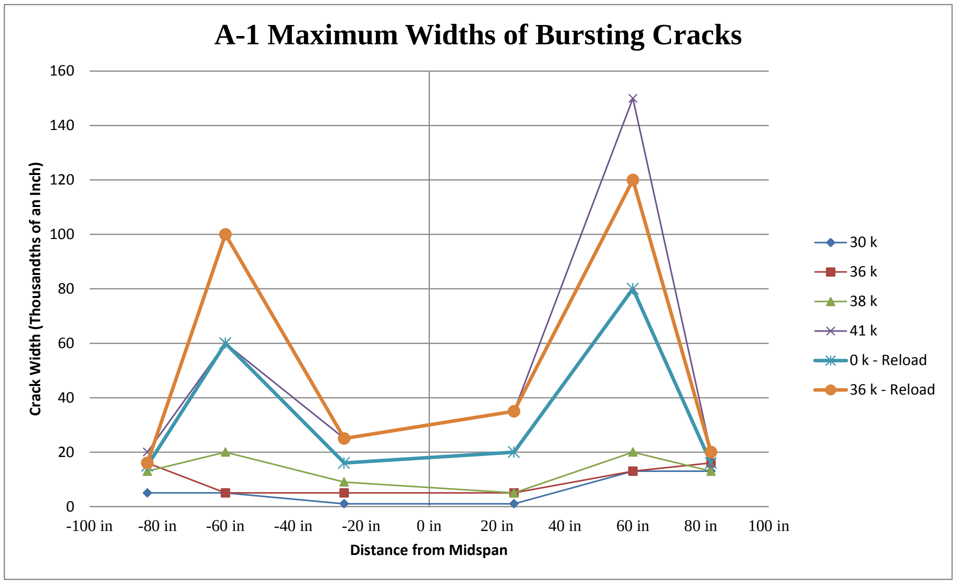


Girder B-1, Load = 36 kip. Girder B-2, Load = 36 kip (reload).



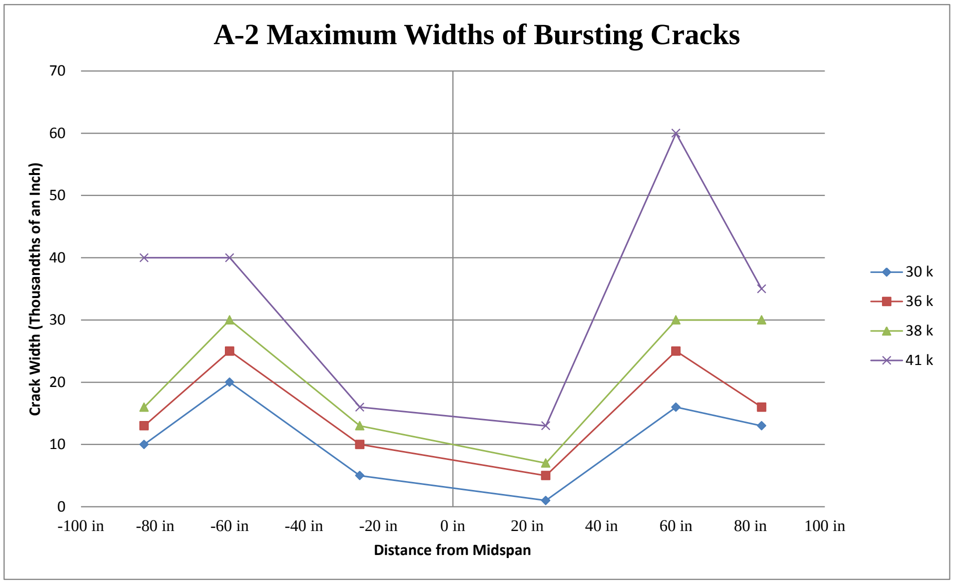
Girder B-3, Load = 36 kip (reload). Girder B-6, Load = 36 kip (reload).

Figure 39 Representative Cracks, Test Series B



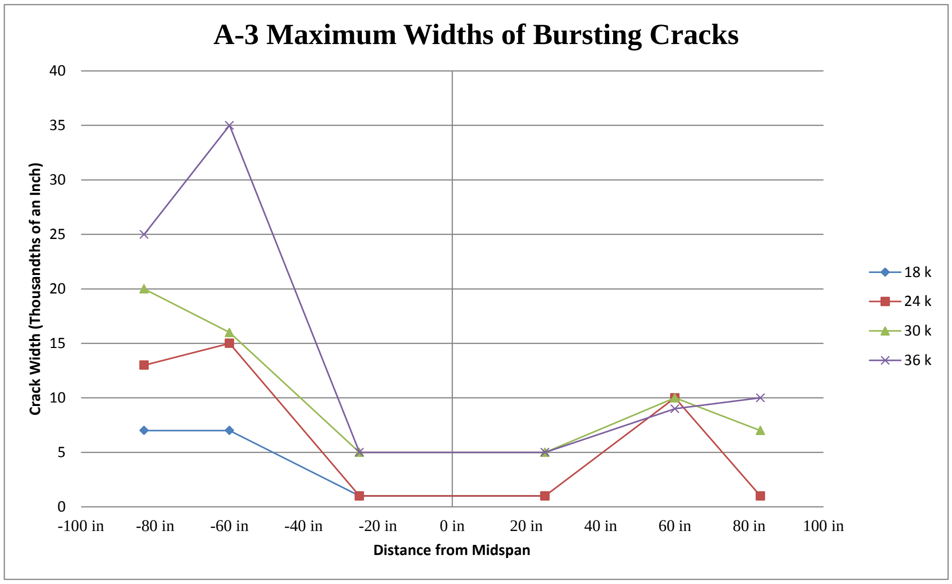
Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
"0 k - Reload" refers to unloaded state of the girder before reloading.
Strip widths are 50, 20, and 26 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 40 Recorded Maximum Surface Widths (in thousands of an inch) (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder A-1.



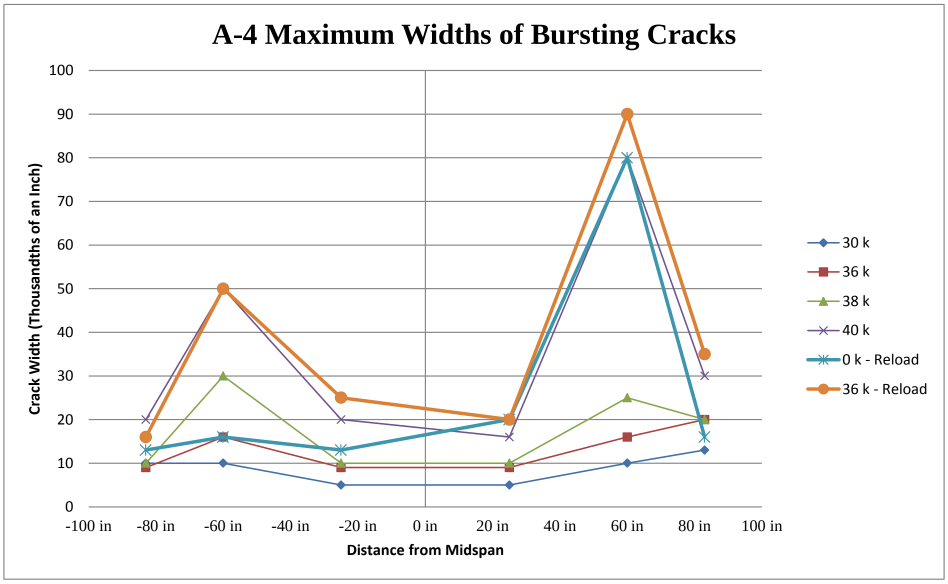
Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
"0 k - Reload" refers to unloaded state of the girder before reloading.
Strip widths are 50, 20, and 26 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 41 Recorded Maximum Surface Widths (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder A-2.



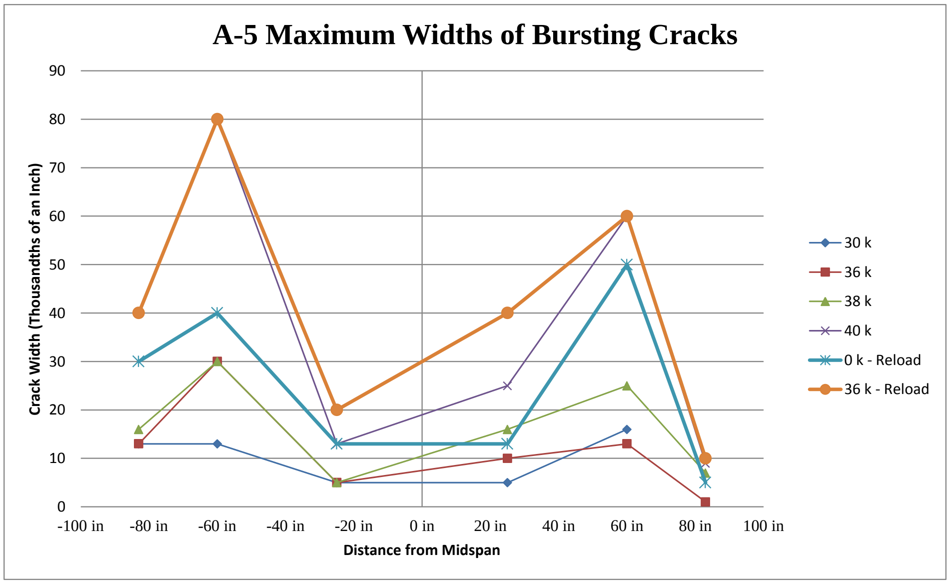
Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
“0 k - Reload” refers to unloaded state of the girder before reloading.
Strip widths are 50, 20, and 26 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 42 Recorded Maximum Surface Widths (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder A-3.



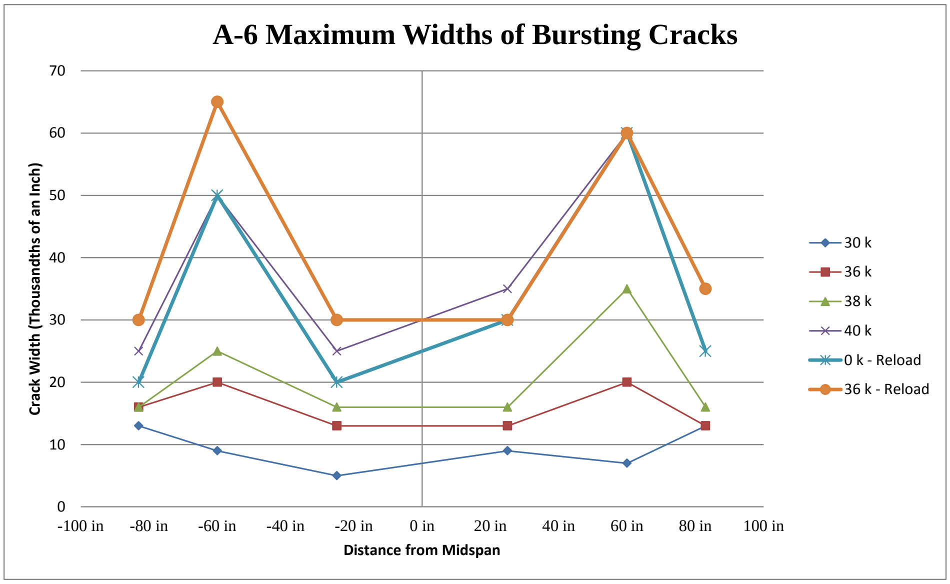
Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
“0 k - Reload” refers to unloaded state of the girder before reloading.
Strip widths are 50, 20, and 26 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 43 Recorded Maximum Surface Widths (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder A-4



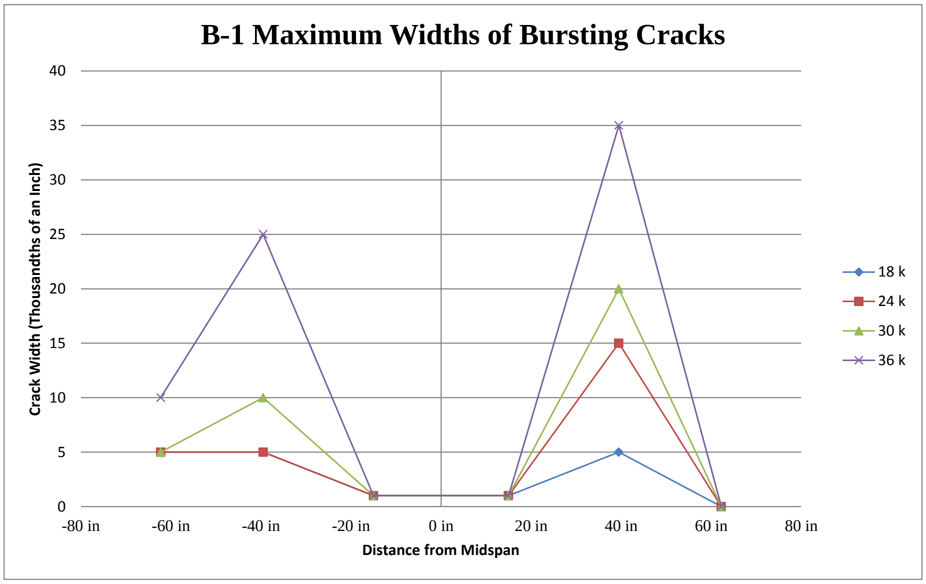
Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
“0 k - Reload” refers to unloaded state of the girder before reloading.
Strip widths are 50, 20, and 26 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 44 Recorded Maximum Surface Widths (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder A-5.



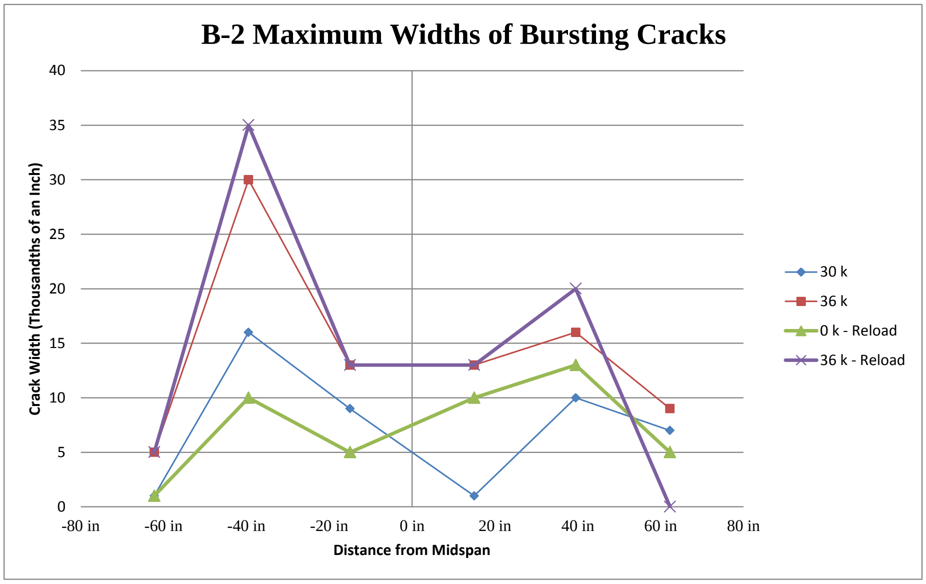
Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
“0 k - Reload” refers to unloaded state of the girder before reloading.
Strip widths are 50, 20, and 26 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 45 Recorded Maximum Surface Widths (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder A-6.



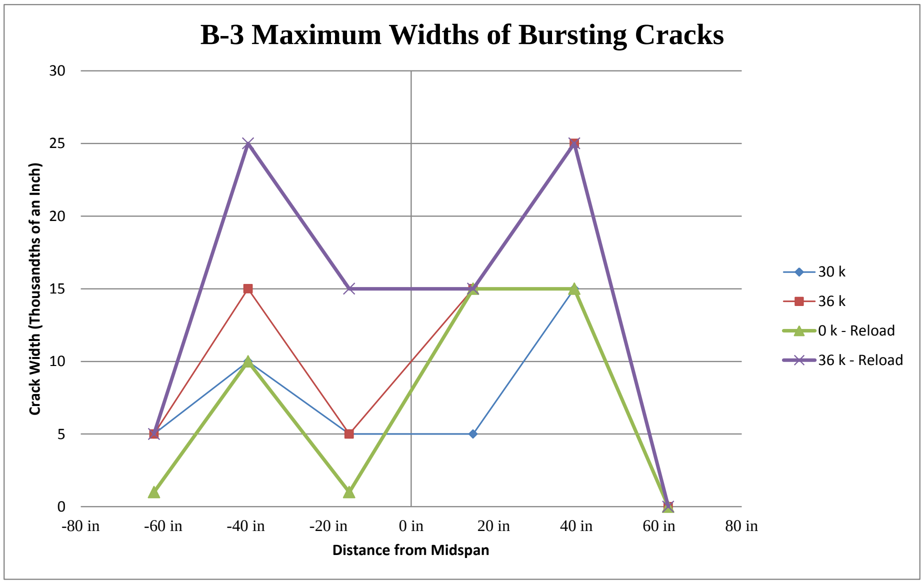
Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
“0 k - Reload” refers to unloaded state of the girder before reloading.
Strip widths are 30, 19, and 26.5 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 46 Recorded Maximum Surface Widths (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder B-1.



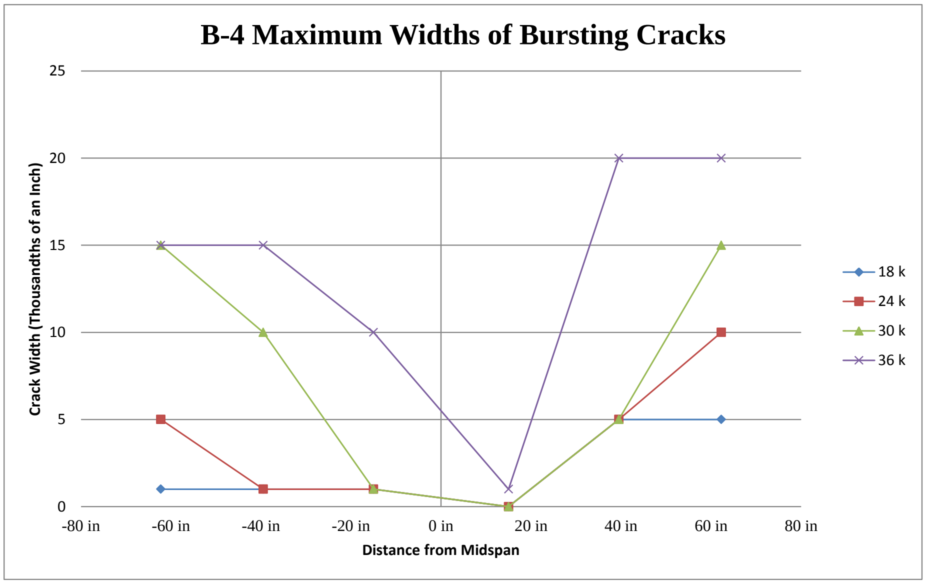
Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
“0 k - Reload” refers to unloaded state of the girder before reloading.
Strip widths are 30, 19, and 26.5 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 47 Recorded Maximum Surface Widths (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder B-2.



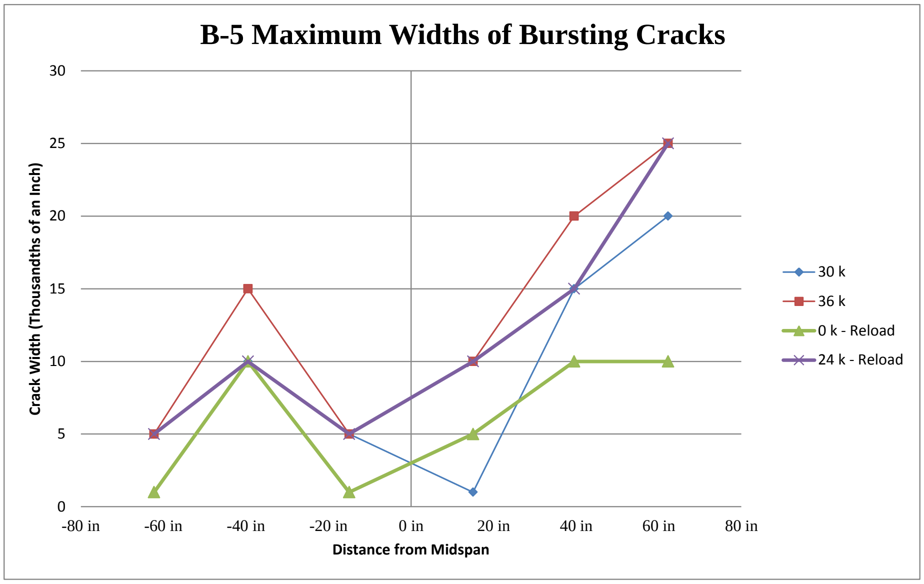
Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
“0 k - Reload” refers to unloaded state of the girder before reloading.
Strip widths are 30, 19, and 26.5 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 48 Recorded Maximum Surface Widths (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder B-3.



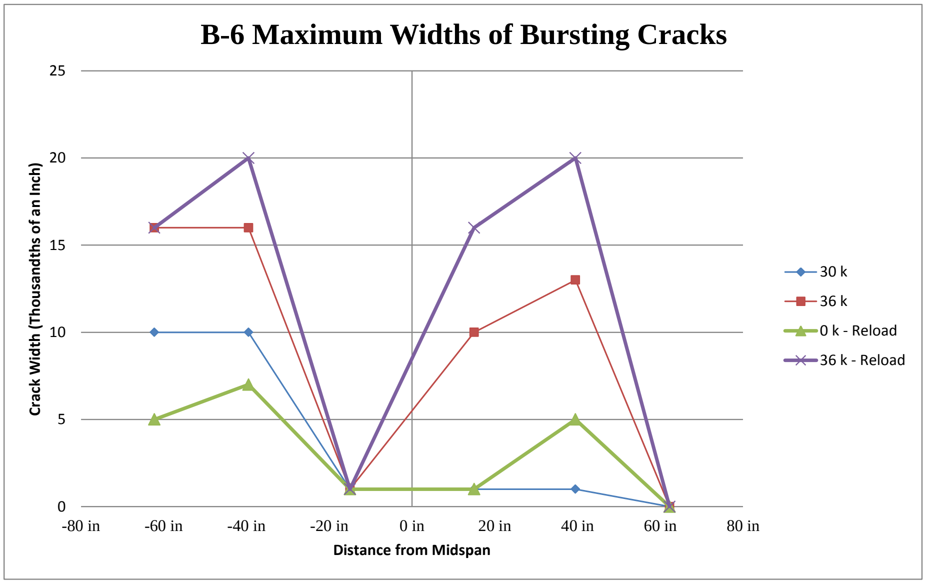
Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
“0 k - Reload” refers to unloaded state of the girder before reloading.
Strip widths are 30, 19, and 26.5 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 49 Recorded Maximum Surface Widths (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder B-4.



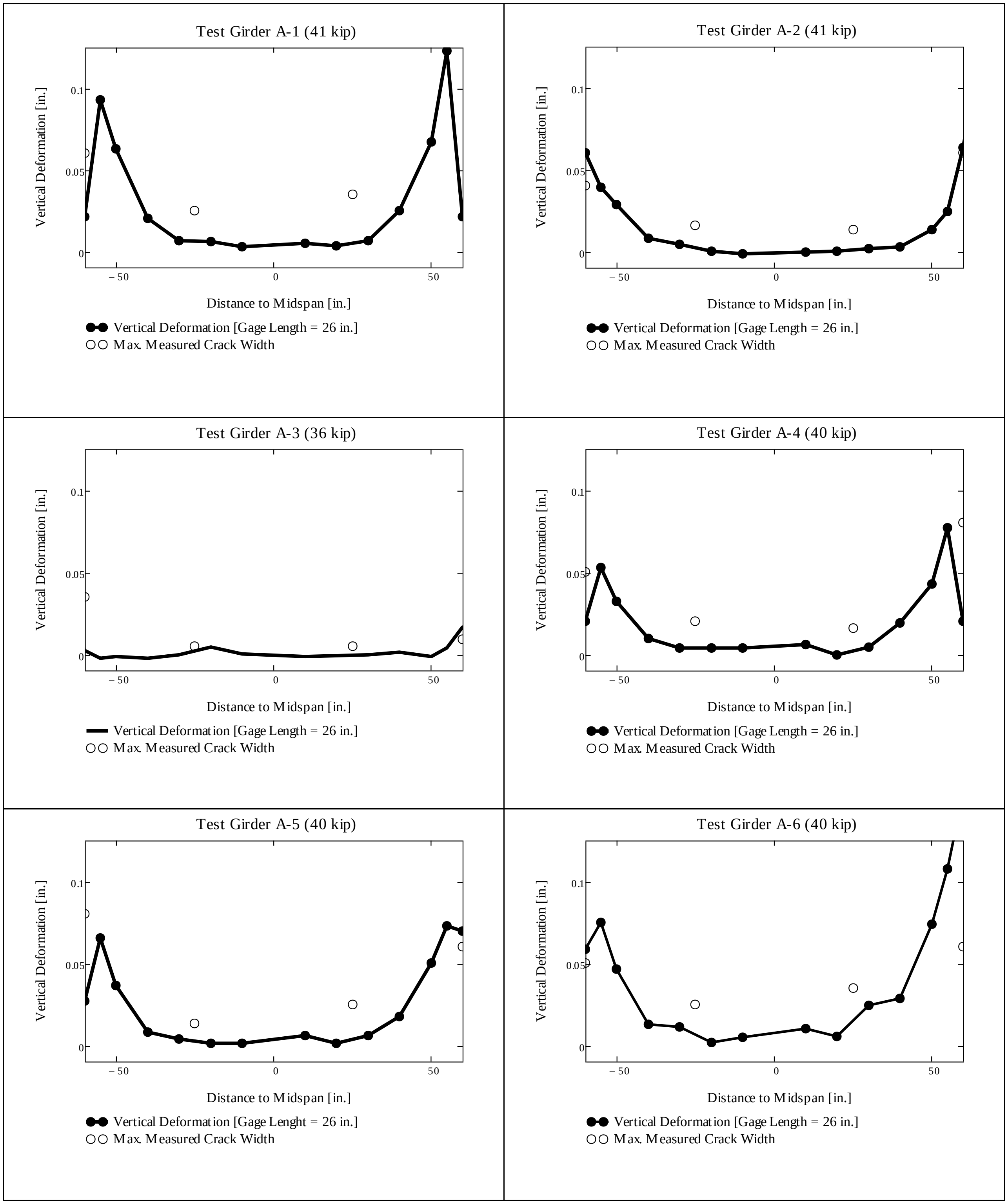
Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
“0 k - Reload” refers to unloaded state of the girder before reloading.
Strip widths are 30, 19, and 26.5 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 50 Recorded Maximum Surface Widths (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder B-5.



Horizontal axis of chart indicates distances of strip centers from mid-span
Maximum crack widths measured in each strip at selected applied loads (legend on right) are listed in the chart.
“0 k - Reload” refers to unloaded state of the girder before reloading.
Strip widths are 30, 19, and 26.5 in. on each side of mid-span.
Value 1 indicates existence of a crack not exceeding 0.004 in. in thickness.

Figure 51 Recorded Maximum Surface Widths (in thousands of an inch) of Bursting Cracks at Reinforcement Level, Test Girder B-6.


Test Girder A-1 (41 kip)

Test Girder A-2 (41 kip)

Test Girder A-3 (36 kip)

Test Girder A-4 (40 kip)

Test Girder A-5 (40 kip)

Test Girder A-6 (40 kip)

Figure 52 Comparison of crack-width measurements and measured vertical deformations, test series A.

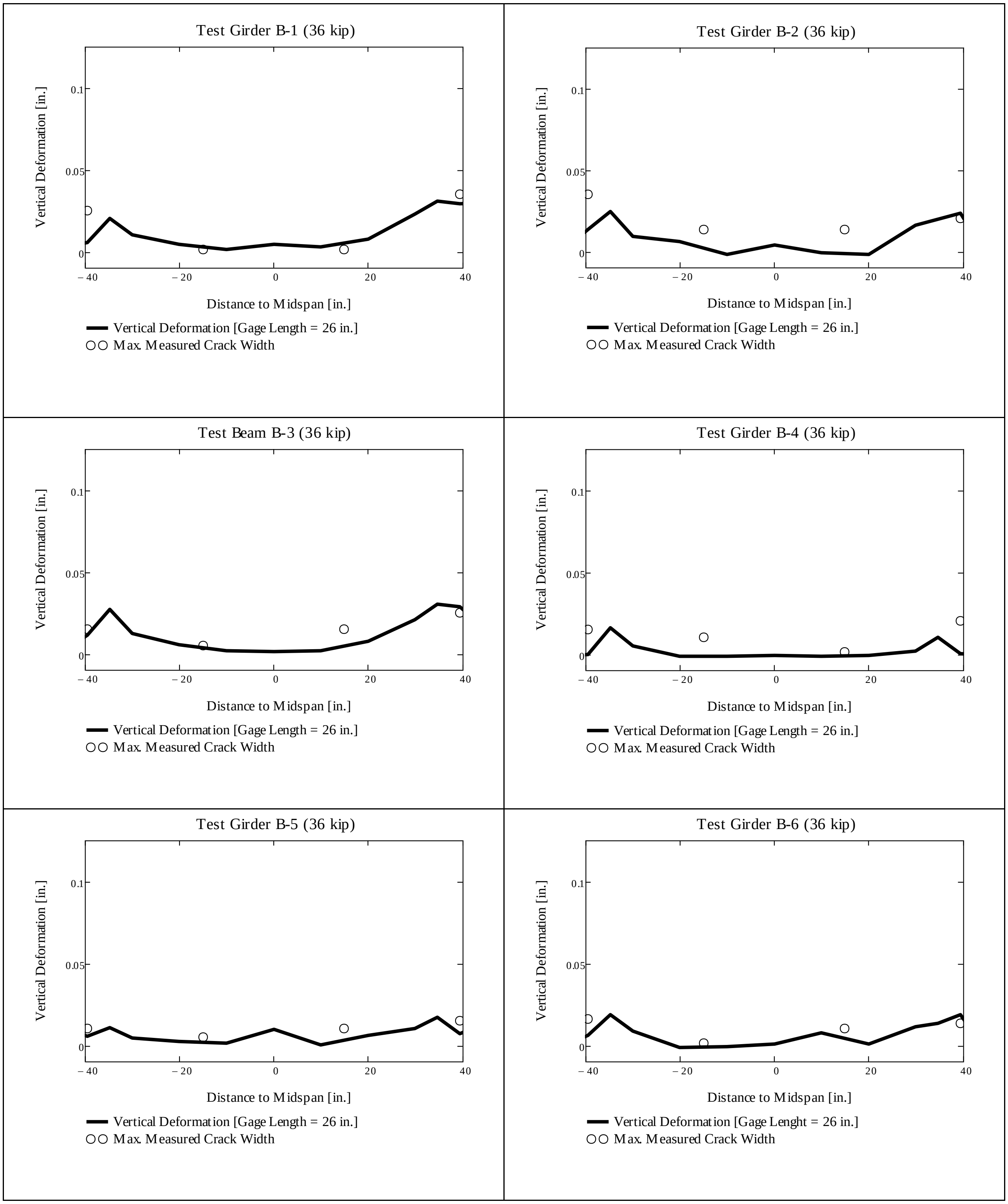


Figure 53 Comparison of crack-width measurements and measured vertical deformations, test series B.

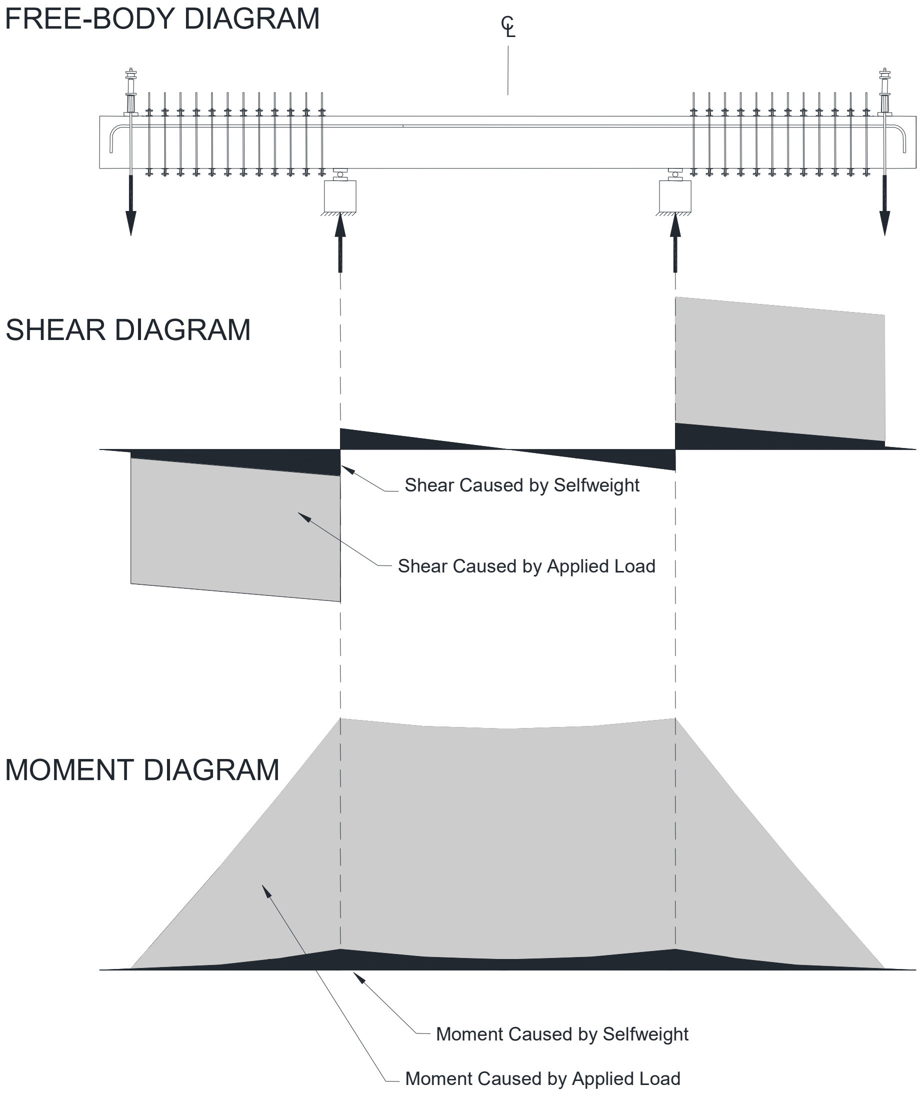


Figure 54 Moment and Shear Diagrams

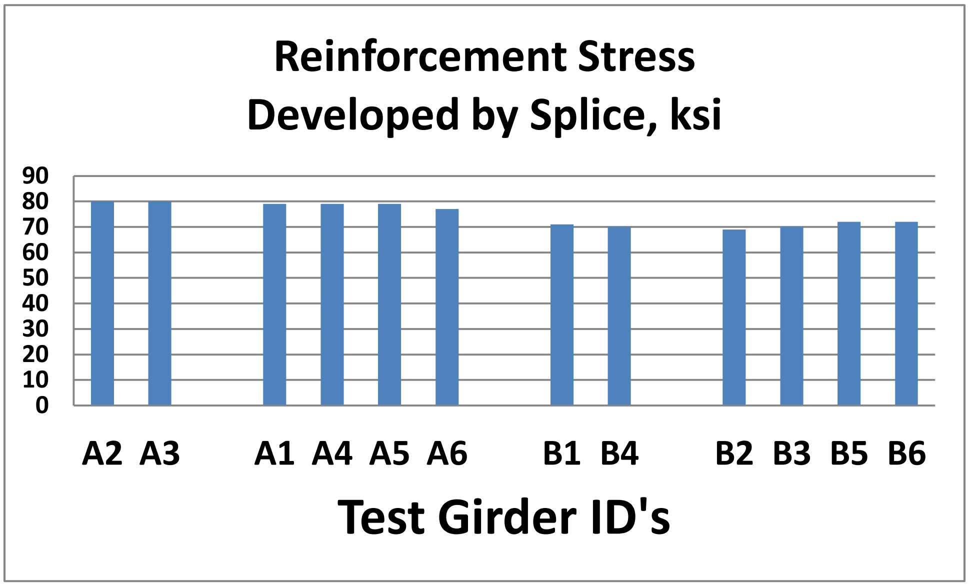


Figure 55 Maximum Unit Stress Reached by Spliced Reinforcement

TEST GIRDER A1

Cast **17 April 2012**
Tested **4 June 2012**

$$A1 := \begin{pmatrix} 5020 \\ 5500 \\ 5190 \\ 5460 \\ 5220 \\ 5210 \end{pmatrix} \text{psi}$$

$$\text{mean}(A1) = 5.27 \cdot \text{ksi}$$

$$\text{stdev}(A1) = 0.17 \cdot \text{ksi}$$

$$\text{COV1} := \frac{\text{stdev}(A1)}{\text{mean}(A1)} \qquad \text{COV1} = 3.1 \cdot \%$$

$$\max(A1) = 5.50 \times 10^{3} \cdot \text{psi}$$

$$\min(A1) = 5.02 \times 10^{3} \cdot \text{psi}$$

TEST GIRDER A2

Cast **17 April 2012**
Tested **4 June 2012**

$$A2 := \begin{pmatrix} 5810 \\ 5620 \\ 5860 \\ 6460 \\ 6330 \\ 6120 \end{pmatrix} \text{psi}$$

$$\text{mean}(A2) = 6.03 \cdot \text{ksi}$$

$$\text{stdev}(A2) = 0.3 \cdot \text{ksi}$$

$$\text{COV2} := \frac{\text{stdev}(A2)}{\text{mean}(A2)} \qquad \text{COV2} = 4.9 \cdot \%$$

$$\max(A2) = 6.46 \times 10^{3} \cdot \text{psi}$$

$$\min(A2) = 5.62 \times 10^{3} \cdot \text{psi}$$

TEST GIRDER A3

Cast
Tested 30 May 2012

$$A3 := \begin{pmatrix} 6000 \\ 6010 \\ 5820 \\ 5840 \\ 5830 \\ 5850 \end{pmatrix} \mathrm{psi}$$

$$\mathrm{mean}(A3) = 5.89 \cdot \mathrm{ksi}$$

$$\mathrm{stdev}(A3) = 0.08 \cdot \mathrm{ksi}$$

$$COV3 := \frac{\mathrm{stdev}(A3)}{\mathrm{mean}(A3)} \quad COV3 = 1.4 \cdot \%$$

$$\max(A3) = 6.01 \times 10^{3} \cdot \mathrm{psi}$$

$$\min(A3) = 5.82 \times 10^{3} \cdot \mathrm{psi}$$

TEST GIRDER A4

Cast 30 April 2012
Tested 22 May 2012

$$A4 := \begin{pmatrix} 5120 \\ 5240 \\ 5270 \\ 4950 \\ 4870 \\ 5240 \end{pmatrix} \mathrm{psi}$$

$$\mathrm{mean}(A4) = 5.11 \cdot \mathrm{ksi}$$

$$\mathrm{stdev}(A4) = 0.15 \cdot \mathrm{ksi}$$

$$COV4 := \frac{\mathrm{stdev}(A4)}{\mathrm{mean}(A4)} \quad COV4 = 3 \cdot \%$$

$$\max(A4) = 5.27 \times 10^{3} \cdot \mathrm{psi}$$

$$\min(A4) = 4.87 \times 10^{3} \cdot \mathrm{psi}$$

TEST GIRDER A5

Cast 30 April 2012
Tested 17 May 2012

$$A5 := \begin{pmatrix} 5320 \\ 5430 \\ 5110 \\ 5360 \\ 4750 \\ 5470 \end{pmatrix} psi$$

$$\text{mean}(A5) = 5.24 \cdot ksi$$

$$\text{stdev}(A5) = 0.25 \cdot ksi$$

$$COV5 := \frac{\text{stdev}(A5)}{\text{mean}(A5)} \qquad COV5 = 4.7 \cdot \%$$

$$\max(A5) = 5.47 \times 10^{3} \cdot psi$$

$$\min(A5) = 4.75 \times 10^{3} \cdot psi$$

TEST GIRDER A6

Cast 24 April 2012
Tested 25 May 2012

$$A6 := \begin{pmatrix} 5170 \\ 5640 \\ 5370 \\ 5690 \\ 5530 \\ 5570 \end{pmatrix} psi$$

$$\text{mean}(A6) = 5.49 \cdot ksi$$

$$\text{stdev}(A6) = 0.18 \cdot ksi$$

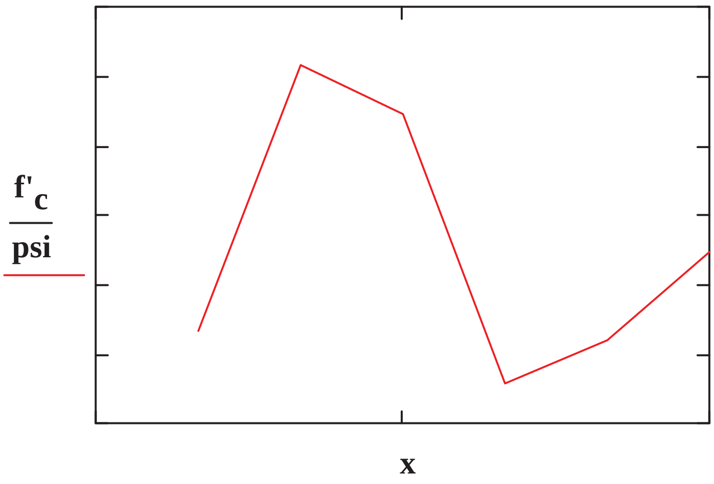
$$COV6 := \frac{\text{stdev}(A6)}{\text{mean}(A6)} \qquad COV6 = 3.2 \cdot \%$$

$$\max(A6) = 5.69 \times 10^{3} \cdot psi$$

$$\min(A6) = 5.17 \times 10^{3} \cdot psi$$

CONCRETE COMPRESSIVE STRENGTH SUMMARY

$$f'_c := \begin{pmatrix} \text{mean}(A1) \\ \text{mean}(A2) \\ \text{mean}(A3) \\ \text{mean}(A4) \\ \text{mean}(A5) \\ \text{mean}(A6) \end{pmatrix} \quad x := \begin{pmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{pmatrix} \quad f'_c = \begin{pmatrix} 5267 \\ 6033 \\ 5892 \\ 5115 \\ 5240 \\ 5495 \end{pmatrix} \cdot \text{psi}$$


Mean Concrete Strength

Test Girders B

FENOC PROJECT 2012 **SUMMARY** **25 May 2012**

CONCRETE STRENGTH

TEST GIRDER B1

Cast 10 April 2012
Tested 10 May 2012

$$B1 := \begin{pmatrix} 4250 \\ 4520 \\ 4720 \\ 4400 \\ 4300 \\ 4600 \end{pmatrix} \cdot psi$$

$$\text{mean}(B1) = 4.46 \cdot ksi$$

$$\text{stdev}(B1) = 0.17 \cdot ksi$$

$$COV1 := \frac{\text{stdev}(B1)}{\text{mean}(B1)} \qquad COV1 = 0.04$$

$$\max(B1) = 4.72 \times 10^{3}\,psi$$

$$\min(B1) = 4.25 \times 10^{3}\,psi$$

TEST GIRDER B2

Cast 10 April 2012
Tested 23 May 2012

$$B2 := \begin{pmatrix} 5080 \\ 4730 \\ 4970 \\ 4660 \\ 4710 \\ 4680 \end{pmatrix} \cdot psi$$

$$\text{mean}(B2) = 4.80 \cdot ksi$$

$$\text{stdev}(B2) = 0.16 \cdot ksi$$

$$COV2 := \frac{\text{stdev}(B2)}{\text{mean}(B2)} \qquad COV2 = 0.03$$

$$\max(B2) = 5.08 \times 10^{3}\,psi$$

$$\min(B2) = 4.66 \times 10^{3}\,psi$$

Sheet 1 of 4

TEST GIRDER B3

Cast 10 April 2012
Tested 21 May 2012

$$B3 := \begin{pmatrix} 4540 \\ 4910 \\ 4760 \\ 4960 \\ 4860 \\ 4670 \end{pmatrix} \cdot psi$$

$\text{mean}(B3) = 4.78 \cdot ksi$

$\text{stdev}(B3) = 0.14 \cdot ksi$

$COV3 := \dfrac{\text{stdev}(B3)}{\text{mean}(B3)}$ $COV3 = 0.03$

$\max(B3) = 4.96 \times 10^3 psi$

$\min(B3) = 4.54 \times 10^3 psi$

TEST GIRDER B5

Cast 30 April 2012
Tested 14 May 2012

$$B4 := \begin{pmatrix} 5470 \\ 5160 \\ 5710 \\ 5540 \\ 5230 \\ 5650 \end{pmatrix} \cdot psi$$

$\text{mean}(B4) = 5.46 \cdot ksi$

$\text{stdev}(B4) = 0.20 \cdot ksi$

$COV4 := \dfrac{\text{stdev}(B4)}{\text{mean}(B4)}$ $COV4 = 0.04$

$\max(B4) = 5.71 \times 10^3 psi$

$\min(B4) = 5.16 \times 10^3 psi$

Sheet 2 of 4

FENOC PROJECT 2012 **SUMMARY** **25 May 2012**

CONCRETE STRENGTH

TEST GIRDER B5
Cast 30 April 2012
Tested 17 May 2012

$$B5 := \begin{pmatrix} 5120 \\ 5340 \\ 5350 \\ 5160 \\ 5370 \\ 5230 \end{pmatrix} \cdot psi$$

$$mean(B5) = 5.26 \cdot ksi$$

$$stdev(B5) = 0.10 \cdot ksi$$

$$COV5 := \frac{stdev(B5)}{mean(B5)} \qquad COV5 = 0.02$$

$$max(B5) = 5.37 \times 10^3 psi$$

$$min(B5) = 5.12 \times 10^3 psi$$

TEST GIRDER B6
Cast 30 April 2012
Tested 25 May 2012

$$B6 := \begin{pmatrix} 5130 \\ 5460 \\ 5130 \\ 5220 \\ 5320 \\ 5120 \end{pmatrix} \cdot psi$$

$$mean(B6) = 5.23 \cdot ksi$$

$$stdev(B6) = 0.12 \cdot ksi$$

$$COV6 := \frac{stdev(B6)}{mean(B6)} \qquad COV6 = 0.02$$

$$max(B6) = 5.46 \times 10^3 psi$$

$$min(B6) = 5.12 \times 10^3 psi$$

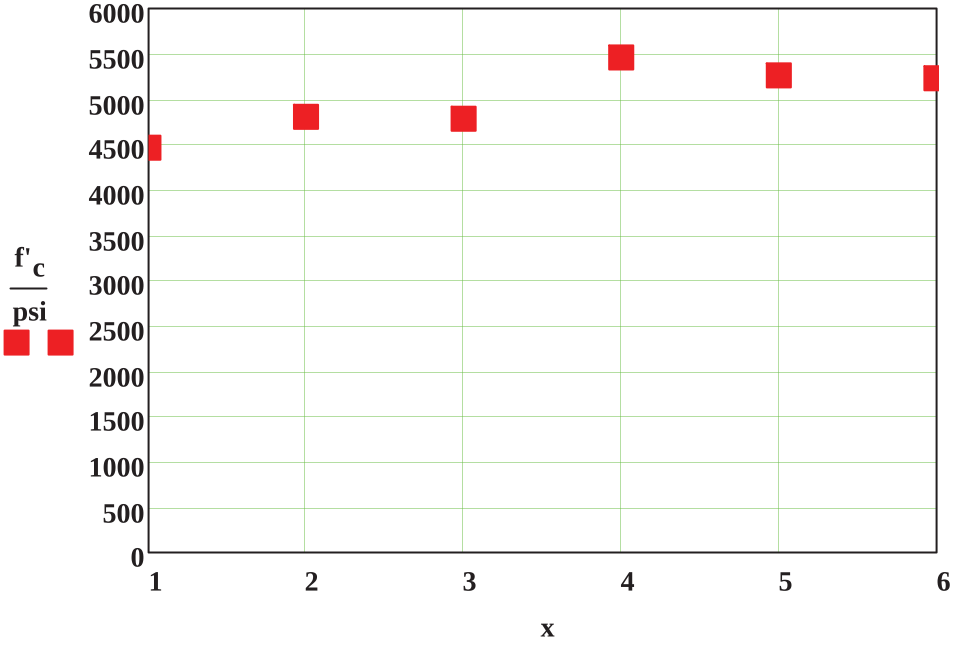
Sheet 3 of 4

FENOC PROJECT 2012 **SUMMARY** **25 May 2012**
CONCRETE STRENGTH

CONCRETE COMPRESSIVE STRENGTH SUMMARY

$$f'_c := \begin{pmatrix} \mathrm{mean}(B1) \\ \mathrm{mean}(B2) \\ \mathrm{mean}(B3) \\ \mathrm{mean}(B4) \\ \mathrm{mean}(B5) \\ \mathrm{mean}(B6) \end{pmatrix} \qquad x := \begin{pmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \end{pmatrix} \qquad f'_c = \begin{pmatrix} 4.46 \times 10^3 \\ 4.80 \times 10^3 \\ 4.78 \times 10^3 \\ 5.46 \times 10^3 \\ 5.26 \times 10^3 \\ 5.23 \times 10^3 \end{pmatrix} \mathrm{psi}$$

Mean Concrete Strength



Test Girders B

Sheet 4 of 4

FENOC PROJECT **CONCRETE TENSILE STRENGTH** **30-May-12**

	ylind	Date	Diam 1 in.	Diam 2	Diam 3 in.	Mean D in.	Length 1 in.	Length 2 in.	Mean L in.	Measured Max. Force lbf	Tensile Strength psi	Mean Tensile Strength psi
GIRDER B1	1	10-May-12	6.03		6.03	6.03	12.10	12.00	12.05	44,320	388	
	2	10-May-12	6.05		6.04	6.05	12.00	12.00	12.00	61,910	543	
	3	10-May-12	6.04		6.04	6.04	12.00	12.00	12.00	45,350	398	
	4	10-May-12	6.05		6.05	6.05	12.00	12.10	12.05	50,500	441	
	5	10-May-12	6.04		6.03	6.04	12.00	12.10	12.05	58,460	512	
	6	10-May-12	6.01		6.01	6.01	12.00	12.10	12.05	44,720	393	
												446
GIRDER B2	1	23-May-12	5.95	5.99	6.04	5.99	12.00	12.00	12.00	49,810	441	
	2	23-May-12	5.97	6.01	6.05	6.01	12.00	11.90	11.95	48,200	427	
	3	23-May-12	5.95	5.98	6.04	5.99	12.00	12.00	12.00	52,890	468	
	4	23-May-12	5.95	5.99	6.05	6.00	12.10	12.10	12.10	60,360	530	
	5	23-May-12	5.96	6.00	6.03	6.00	11.90	12.00	11.95	62,970	559	
	6	23-May-12	5.96	6.00	6.05	6.00	12.00	12.00	12.00	49,490	437	
												477
GIRDER B3	1	21-May-12	6.05	6.00	5.96	6.00	12.00	12.10	12.05	48,840	430	
	2	21-May-12	6.04	6.04	5.96	6.01	12.00	12.00	12.00	42,010	371	
	3	21-May-12	6.05	6.05	5.97	6.02	12.00	12.00	12.00	44,800	395	
	4	21-May-12	6.03	6.03	5.94	6.00	12.00	12.00	12.00	48,410	428	
	5	21-May-12	6.04	6.04	5.96	6.01	12.00	12.00	12.00	49,470	436	
	6	21-May-12	6.05	6.05	5.95	6.02	12.00	12.00	12.00	53,510	472	
												422
GIRDER B4	1	14-May-12	5.93	-	6.04	5.99	12.00	12.00	12.00	52,080	462	
	2	14-May-12	5.94		6.04	5.99	12.00	12.00	12.00	55,050	488	
	3	14-May-12	5.94		6.06	6.00	12.00	12.00	12.00	56,490	499	
	4	14-May-12	5.94		6.06	6.00	12.00	12.00	12.00	52,570	465	
	5	14-May-12	5.94		6.05	6.00	12.00	12.00	12.00	53,690	475	
	6	14-May-12	5.93		6.07	6.00	12.00	12.00	12.00	59,530	526	
												486
GIRDER B5	1	17-May-12	5.96	5.99	6.06	6.00	12.05	12.05	12.05	57,310	504	
	2	17-May-12	5.95	6.00	6.05	6.00	12.05	12.05	12.05	52,820	465	
	3	17-May-12	5.95	5.99	6.06	6.00	12.00	12.00	12.00	51,370	454	
	4	17-May-12	5.96	5.99	6.05	6.00	12.05	12.00	12.03	53,620	473	
	5	17-May-12	5.96	6.00	6.05	6.00	12.00	12.00	12.00	52,730	466	
	6	17-May-12	5.95	6.00	6.06	6.00	12.00	12.05	12.03	54,540	481	
												474
GIRDER B6	1	25-May-12	5.95	5.98	6.04	5.99	12.00	12.00	12.00	49,690	440	
	2	25-May-12	5.96	6.00	6.05	6.00	12.00	11.90	11.95	53,150	472	
	3	25-May-12	5.96	6.01	6.03	6.00	12.00	12.00	12.00	49,780	440	
	4	25-May-12	5.94	5.99	6.04	5.99	12.10	12.00	12.05	45,810	404	
	5	25-May-12	5.95	5.99	6.04	5.99	12.10	12.10	12.10	46,720	410	
	6	25-May-12	5.97	6.00	6.02	6.00	12.00	12.10	12.05	65,270	575	
												457

FENOC PROJECT CONCRETE TENSILE TEST 30-May-12

Specimen ID	Cylinder	Date	Diameter, D in	Length, L in	Measured Max Force lbf	Tensile Strength psi	Mean Tensile Strength psi
A-1	1	14-Jun-12	6.00	12	46820	414	
	2	14-Jun-12	6.00	12	55610	492	
	3	14-Jun-12	6.00	12	65200	576	
	4	14-Jun-12	6.00	12	53470	473	
	5	14-Jun-12	6.00	12	48730	431	
	6	14-Jun-12	6.00	12	57470	508	
							480
A-2	1	1-Jun-12	6.00	12	52370	463	
	2	1-Jun-12	6.00	12	55870	494	
	3	1-Jun-12	6.00	12	49890	441	
	4	1-Jun-12	6.00	12	51740	457	
	5	1-Jun-12	6.00	12	63970	566	
	6	1-Jun-12	6.00	12	63780	564	
							500
A-3	1	30-May-12	6.00	12	48060	425	
	2	30-May-12	6.00	12	58190	515	
	3	30-May-12	6.00	12	59030	522	
	4	30-May-12	6.00	12	50900	450	
	5	30-May-12	6.00	12	55200	488	
	6	30-May-12	6.00	12	55630	492	
							480
A-4	1	8-Jun-12	6.00	12	53900	477	
	2	8-Jun-12	6.00	12	54040	478	
	3	8-Jun-12	6.00	12	47900	424	
	4	8-Jun-12	6.00	12	46800	414	
	5	8-Jun-12	6.00	12	49890	441	
	6	8-Jun-12	6.00	12	48090	425	
							440
A-5	1	7-Jun-12	6.00	12	63340	560	
	2	7-Jun-12	6.00	12	51980	460	
	3	7-Jun-12	6.00	12	44490	393	
	4	7-Jun-12	6.00	12	41500	367	
	5	7-Jun-12	6.00	12	54360	481	
	6	7-Jun-12	6.00	12	45220	400	
							440
A-6	1	5-Jun-12	6.00	12	57870	512	
	2	5-Jun-12	6.00	12	50780	449	
	3	5-Jun-12	6.00	12	45610	403	
	4	5-Jun-12	6.00	12	56820	502	
	5	5-Jun-12	6.00	12	45570	403	
	6	5-Jun-12	6.00	12	46860	414	
							450
B-1	1	10-May-12	6.00	12	44320	392	
	2	10-May-12	6.00	12	61910	547	
	3	10-May-12	6.00	12	45350	401	
	4	10-May-12	6.00	12	50500	447	
	5	10-May-12	6.00	12	58460	517	
	6	10-May-12	6.00	12	44720	395	
							450
B-2	1	23-May-12	6.00	12	49810	440	
	2	23-May-12	6.00	12	48200	426	
	3	23-May-12	6.00	12	52890	468	
	4	23-May-12	6.00	12	60360	534	
	5	23-May-12	6.00	12	62970	557	
	6	23-May-12	6.00	12	49490	438	
							480
B-3	1	21-May-12	6.00	12	48840	432	
	2	21-May-12	6.00	12	42010	371	
	3	21-May-12	6.00	12	44800	396	
	4	21-May-12	6.00	12	48410	428	
	5	21-May-12	6.00	12	49470	437	
	6	21-May-12	6.00	12	53510	473	
							420
B-4	1	14-May-12	6.00	12	52080	460	
	2	14-May-12	6.00	12	55050	487	
	3	14-May-12	6.00	12	56490	499	
	4	14-May-12	6.00	12	52570	465	
	5	14-May-12	6.00	12	53690	475	
	6	14-May-12	6.00	12	59530	526	
							490
B-5	1	17-May-12	6.00	12	57310	507	
	2	17-May-12	6.00	12	52820	467	
	3	17-May-12	6.00	12	51370	454	
	4	17-May-12	6.00	12	53620	474	
	5	17-May-12	6.00	12	52730	466	
	6	17-May-12	6.00	12	54540	482	
							480
B-6	1	25-May-12	6.00	12	46960	415	
	2	25-May-12	6.00	12	53150	470	
	3	25-May-12	6.00	12	49780	440	
	4	25-May-12	6.00	12	45810	405	
	5	25-May-12	6.00	12	46720	413	
	6	25-May-12	6.00	12	65270	577	
							450

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: A-1

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/17	1858981	1669	12:29PM	12:45PM	60°F

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		Air Content (ASTM C231 - 10)		
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter
12:51	7 3/4"	1:04	5.5%	413078689
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale
1:15	7 3/4	1:20	5.7%	0674605 6HM

Unit Weight (ASTM C138 - 10b)

Time$_1$	Wt. of Cont.$_1$	Total Wt. $_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.
1:00	8.5#	44.8#	36.3#	145.2#/cft.
Time$_2$	Wt. of Cont.$_2$	Total Wt. $_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.
1:20	8.5#	44.30	35.8#	143.2#/cft.

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
12:50-1PM	✓	1PM-1:10	✓	1:08	1:08PM
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
1:45PM	1:50PM	10:30PM	10:35PM	10:40PM	10:45PM

Recorded by	Signature	Date	Time
S.P.		4/17/12	
Checked by	Signature	Date	Time
BPR		4/17/12	2:00PM
Checked by	Signature	Date	Time
StWorth	SAWorth	4/17/12	1:11pm

Comments: Concrete Temp: @ 12:56 PM - 68°F by both digital & analog thermometers
Ambient Temp: 60°F

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

```
Truck      Driver     User      Disp Ticket Num  Ticket ID  Time   Date
1669       2140       user      1858981                  0  12:29 4/17/12
Load Size  Mix Code     Returned     Qty     Mix Age     Seq    Load ID
6.50  CYDS 1008                                          D      1105

Material     Design Qty     Required      Batched      % Var % Moisture   Actual   Wat
STONE-8        940 lb       6159 lb       6100 lb      -0.96%   0.80% M        6 gl
STONE-4        620 lb       4030 lb       4000 lb      -0.74%
SAND-23       1435 lb       9962 lb       9920 lb      -0.42%   6.80% M       76 gl
CEMENT         588 lb       3822 lb       3815 lb      -0.18%
WATER        323.2 lb     1417.7 lb     1402.0 lb      -1.10%                168.0 gl
AIR            .80 /C      30.58 oz      30.50 oz      -0.25%

Actual                      Num Batches:  1
Load     25239 lb   Design W/C:   0.550   Water/Cement:   0.551  T   Design  251.7 gl   Actual  249.5 gl  To Add:   2.3 gl
Slump:   6.00 in  #   Water In Truck:   0.0 lb   Adjust Water:   0.0  lb / Load  Trim Water:  0.0  lb /  CYD
```

1

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
18	1858981	1669	6.50cy	1008	6.00	EXTERIOR	04/17/12	16091

Sold To	Tax Code	Driver	Project No.	Order No.
CHARGE CARD - BOWEN LAB	IN	TREVOR WIMBERLY 2146	5	1811

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB	SCN 2523

Job No.: SCN2523

TRUCK RELEASE BRIAN 812 344 0114

Time Printed 12:22

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
6.50	6.50cy	19.50cy	1008	PURDUE EXPERIMENTAL	89.00	578.50
				Environmental Fee		13.00

1

www.irvmat.com

Water Added At Customer's Request	0	Total No. Gallons	
Slump Meter Reading	899		
On Job Time		**Finish Pour Time**	

AUTH.#:

Grand Total: 591.50

Subtotal	591.50
Tax	
Total	591.50

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

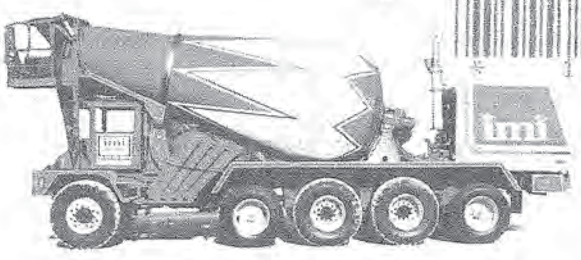
PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

2369443



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Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" General Office (317) 326-3101

CUSTOMER COPY

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-1

Sheet 1 of 2

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan	38'-11 7/8"	38'-11 7/8"	38'-11 7/8"	38'-11 3/4"				
B-B	17-3/8"	30-1/4"	17-11/16"	30-3/8"				
C-C	17-5/8"	30-1/8"	17-3/4"	30-3/16"				
D-D	17-5/16"	30-1/4"	17-3/4"	30-1/8"				
E-E	17-3/4"	30-3/16"	17-11/16"	30-1/16"				
F-F	17-3/4"	30-3/8"	17-3/4"	30-1/16				

Recorded by:	Signature	Date	Time
KAM		6-2-12	1:00pm
Checked by:	Signature	Date	Time
BPR		6/2/12	1:00PM
Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the Behavior of Spliced #11 Bars

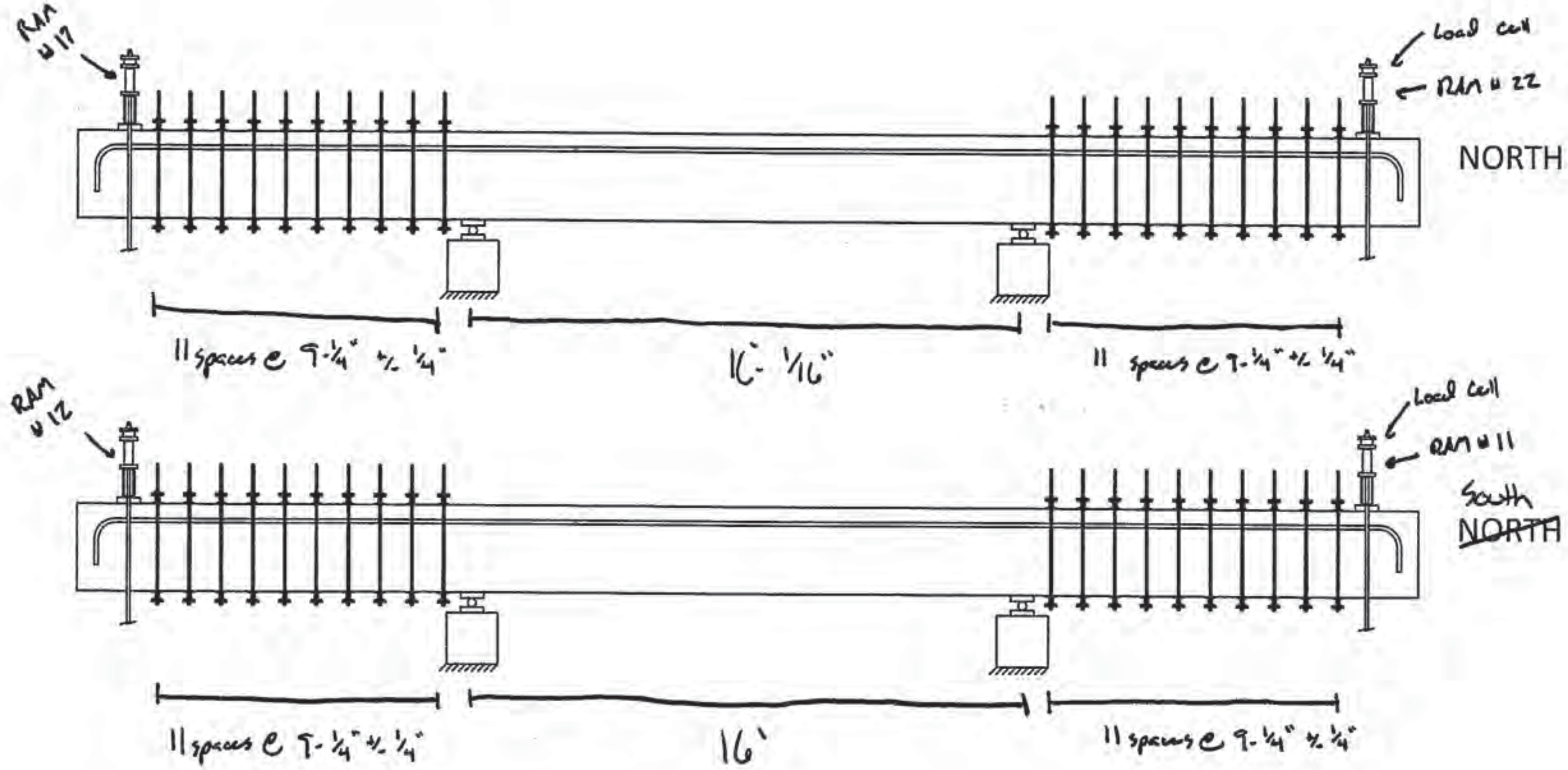
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-1

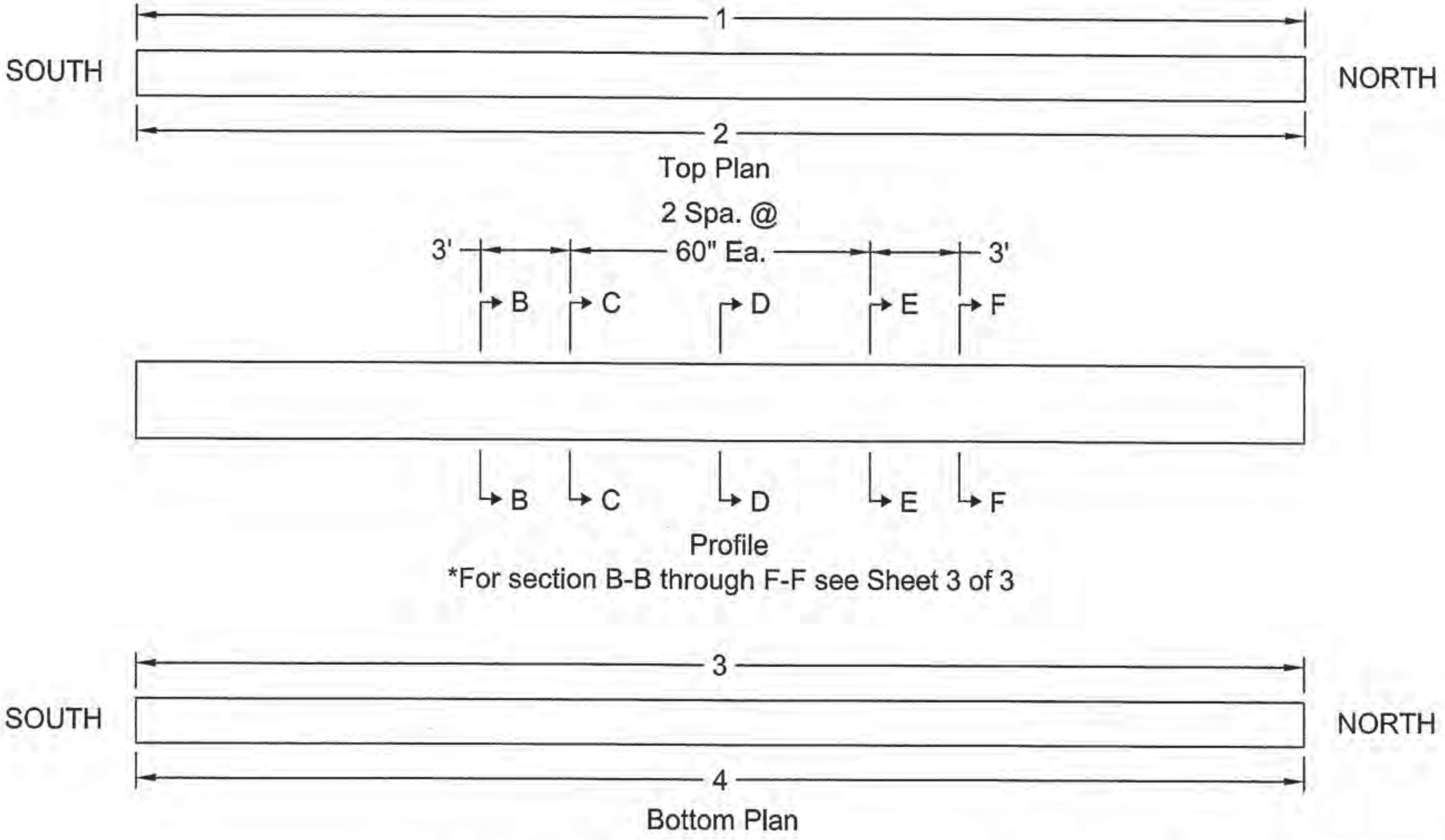
Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

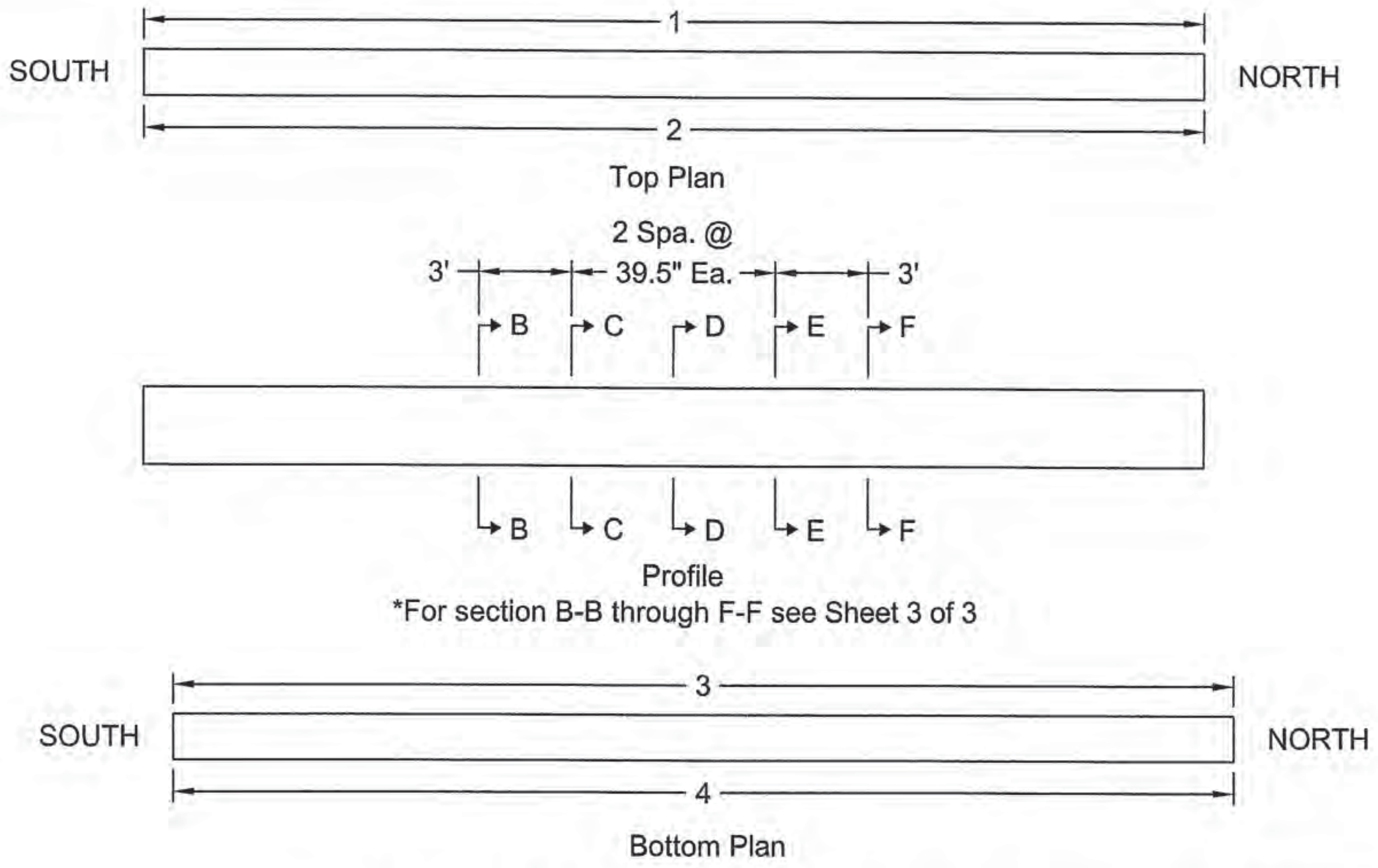


BOWEN LABORATORY PURDUE UNIVERSITY	Specimen A-1	Sheet:	1	of	4
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	KAM	Checked by:	BPR
		Date:	6-2-12		



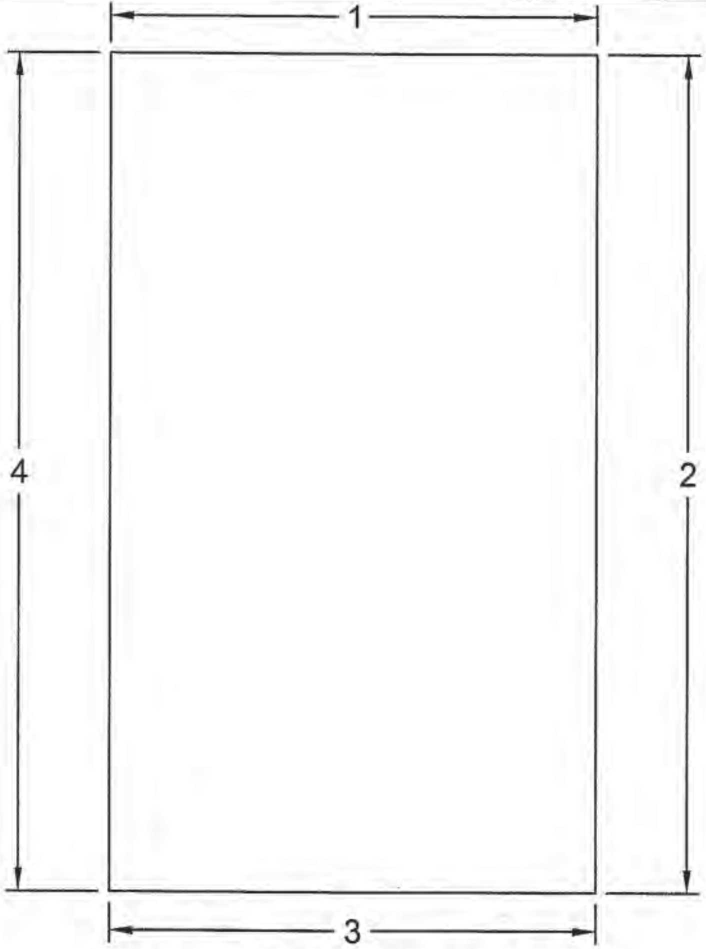
BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



*For section B-B through F-F see Sheet 3 of 3

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Concrete As-built Sections	Sheet:	4	of 4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	

Project: Tests to Determine the
Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-1

Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	173-3/8	120-0	174-0	174-0	120-1/16	173-7/8		
B-B	3-1/8	8-3/4	2-15/16	23-5/8	23-9/16	30-1/8	30-1/8	17-1/2
C-C	3-1/8	5-13/16	3-1/16	23-5/8	23-11/16	30-0	30-1/16	17-1/2
D-D	3-1/8	2-15/16	5-7/8	23-3/4	23-13/16	30-1/8	30-1/16	17-7/16
E-E	3-1/8	6-1/8	2-7/8	23-11/16	23-3/4	30-0	30-1/16	17-~~3/8~~ 7/16
F-F	4-1/2	4-3/16 ↔	6-3/16	23-9/16	23-5/8	30-1/8	30-1/8	17-~~7/16~~ 1/2

Recorded by:	Signature	Date	Time
BPR		4/15	4:40PM
Checked by:	**Signature**	**Date**	**Time**
TD		4/15	4:40PM
Checked by:	**Signature**	**Date**	**Time**

Comments:
* Section ~~A-A~~ B-B & F-F dimensions 1, 2, & 3 are opposite the key

*See formwork as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

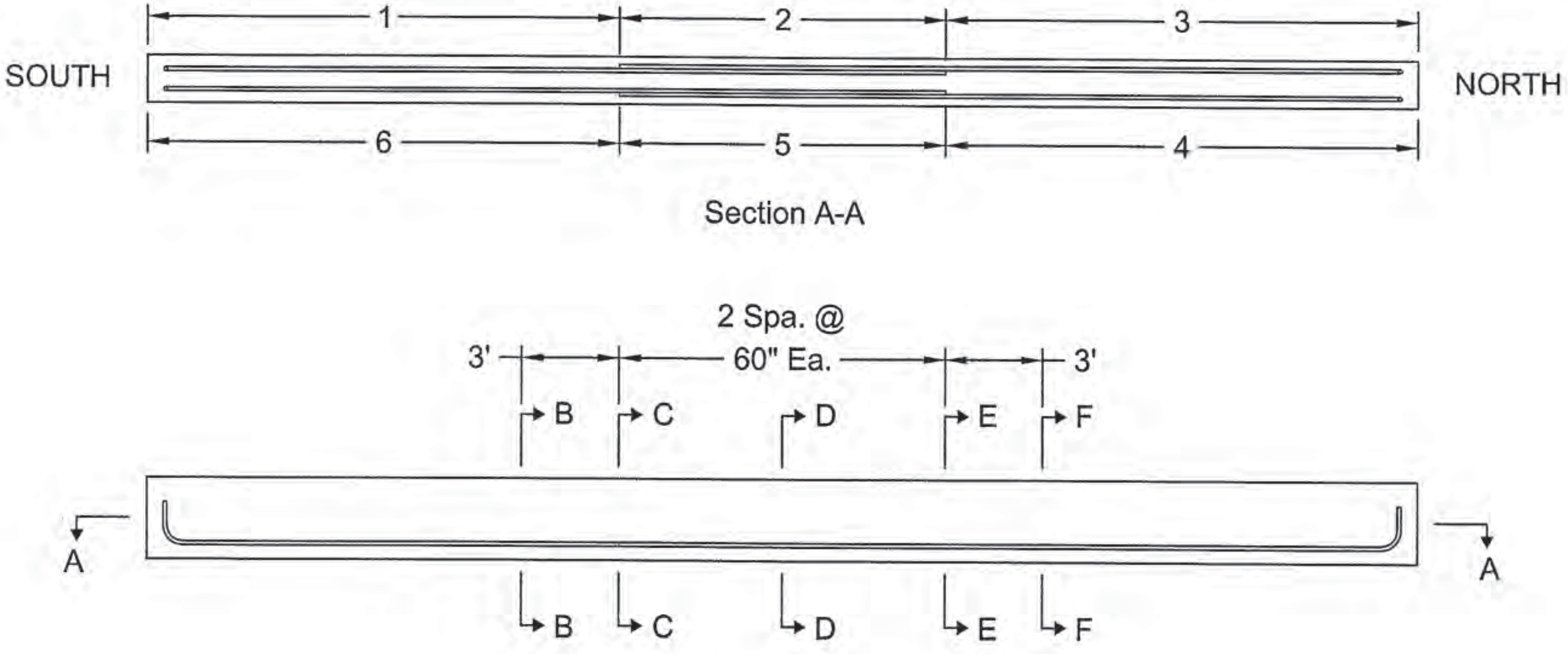
As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-1

Sheet 2 of 2

Section	Formwork As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
A-A	14'-6"	10'-0"	14'-6"	14'-6"	10'-0"	14'-6"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Section	Formwork As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
A-A	13'-10.5"	6'-7"	13'-10.5"	13'-10.5"	6'-7"	13'-10.5"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

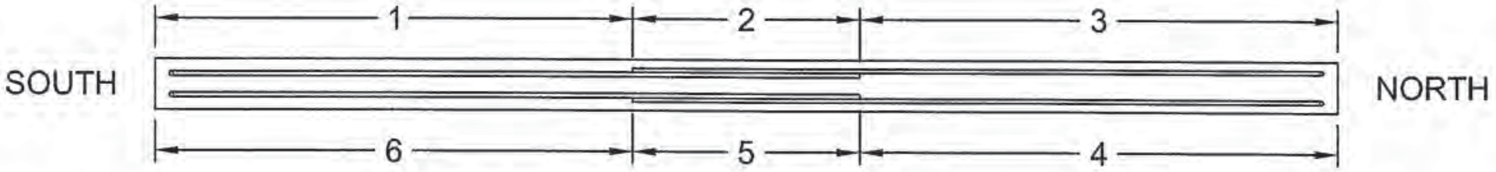


*For section B-B through F-F see Sheet 3 of 3

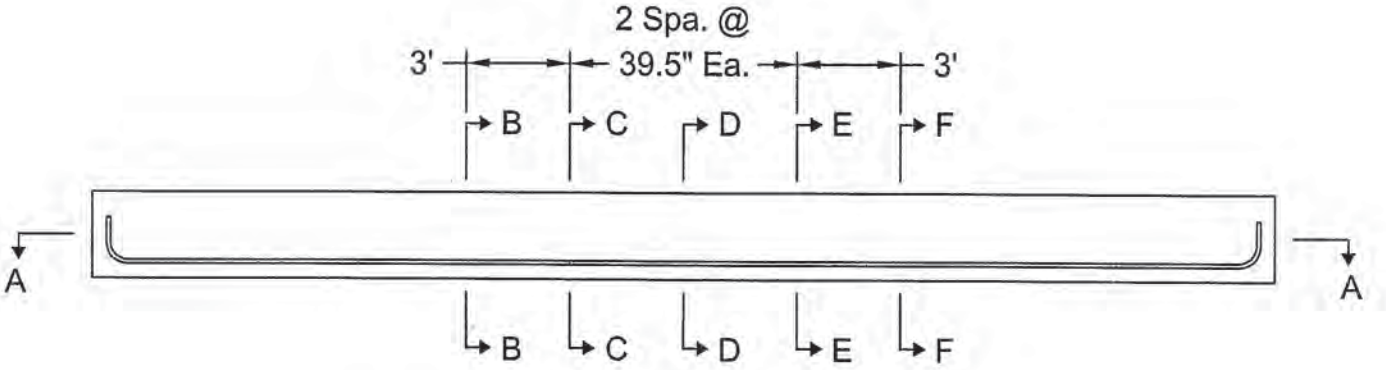
Series A

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section A-A

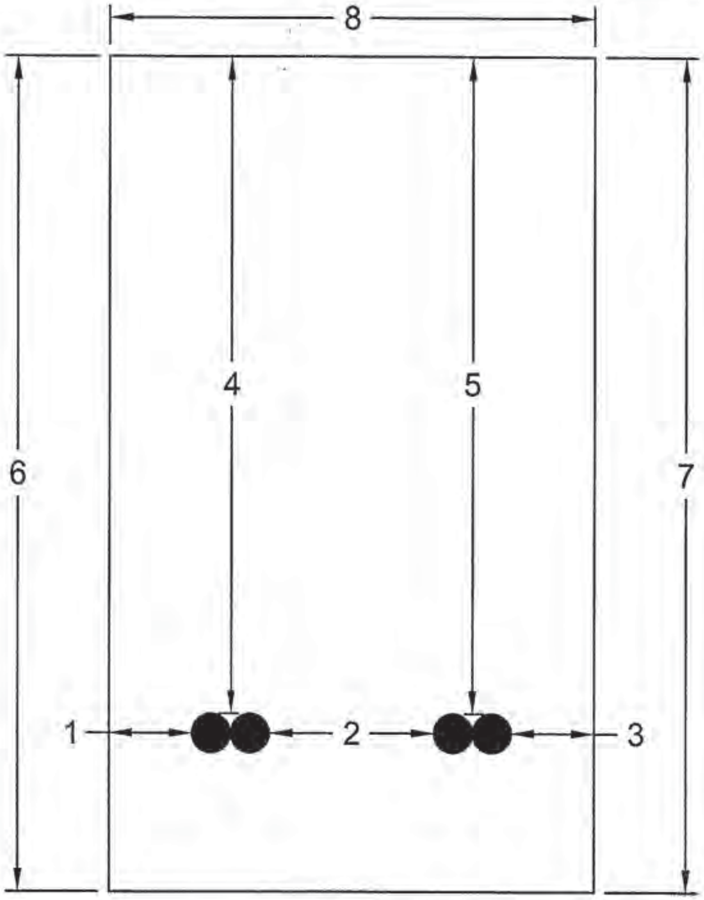


*For section B-B through F-F see Sheet 3 of 3

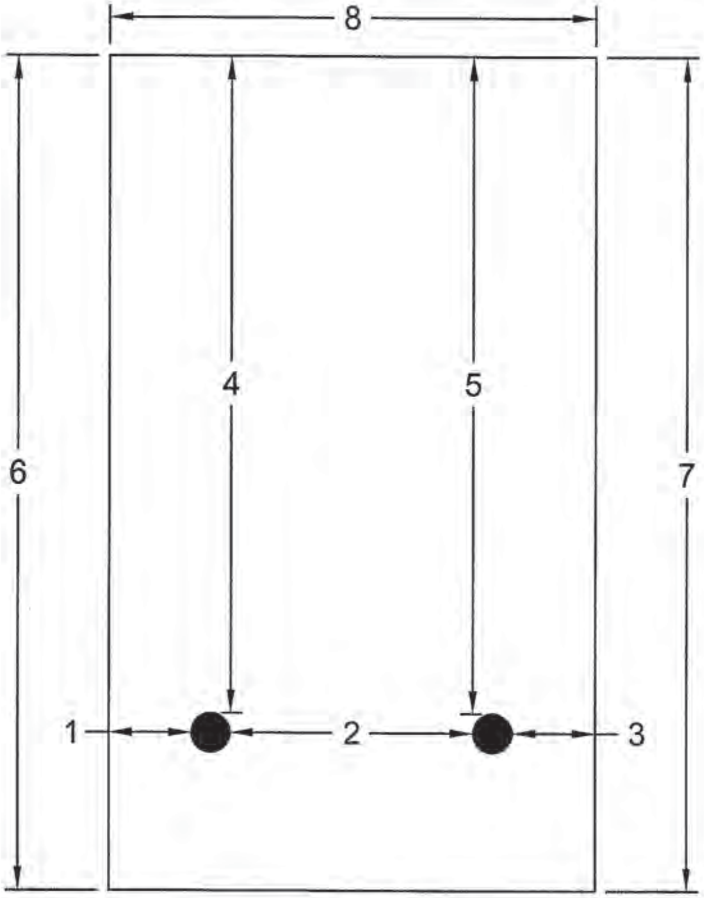
Series B

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series B Formwork As-builts	Sheet:	2	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Formwork As-built Sections	Sheet:	3	of 3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: A-2

Sheet 1 of 1

General Information					
Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/17/12	1858982	1982	3:25	3:42	62°F
Measurements made upon arrival of concrete					
Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**			
$Time_1$	$Result_1$	$Time_1$	$Result_1$	S/N of Air Meter	
3:45	7"	3:52	5.2%	4130786891	
$Time_2$	$Result_2$	$Time_2$	$Result_2$	S/N of Scale	
4:10	6½"	4:17	5.0%	0674605 6HM	
Unit Weight (ASTM C138 - 10b)					
$Time_1$	Wt. of $Cont._1$	Total Wt. $_1$	Wt. of $Conc._1$	$Result_1$ = Wt. of Conc./Vol. of Cont.	
3:50	8.5#	44.8#	~~5~~. 36.3#	145.2#/cft.	
$Time_2$	Wt. of $Cont._2$	Total Wt. $_2$	Wt. of $Conc._2$	Result2 = Wt. of Conc./Vol. of Cont.	
4:15	8:5#	45.0#	36.5#	146.0#/cft.	
Times of actions during and after casting					
Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
3:45-3:55	✓	3:55 -	4:10	4:15	4:18
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
✓	5:20PM	10:50PM	10:55PM	11:00PM	11:05PM
Recorded by		Signature		Date	Time
BPR				4/17/12	5:20PM
Checked by		Signature		Date	Time
KAM				4-17-12	5:30PM
Checked by		Signature		Date	Time
SWORTHY				4/17/12	

Comments:
Concrete
Temp: 69°

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1982	1076	user	1858982	0	15:25	4/17/12
Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
6.50 CYDS	1008				D	1106

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
STONE-8	940 lb	6159 lb	6100 lb	-0.96%	0.80% M	6 gl
STONE-4	620 lb	4030 lb	4000 lb	-0.74%		
SAND-23	1435 lb	9962 lb	9920 lb	-0.42%	6.80% M	76 gl
CEMENT	588 lb	3822 lb	3815 lb	-0.18%		
WATER	323.2 lb	1417.7 lb	1406.0 lb	-0.82%		168.5 gl
AIR	.80 /C	30.58 oz	30.50 oz	-0.25%		

Actual Num Batches: 1

Load 25243 lb Design W/C: 0.550 Water/Cement: ✓ 0.551 T Design 251.7 gl Actual 250.0 gl To Add: 1.8 gl

Slump: 6.00 in # Water In Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD Note: Manual feed occured

2

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
7	1858982	1882	6.50cy	1008	5.00	EXTERIOR	04/17/12	16091

Sold To	Tax Code	Driver		Project No.	Order No.
CHARGE CARD - BOWEN LAB	TN	DOUG PHEBUS	1876	5	181

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB	BCN 2525

Job No: BCN2523

TRUCK RELEASE BRIAN 812 344 0114

Time Printed 15:24

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
6.50	13.00cy	19.50cy	1008	PURDUE EXPERIMENTAL	89.00	578.50
				Environmental Fee		13.00

Water Added At Customer's Request					Total No. Gallons	Slump Meter Reading				

On Job Time	Finish Pour Time

AUTH.#: Grand Total: 1,183.00

Subtotal	591.50
Tax	
Total	591.50

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

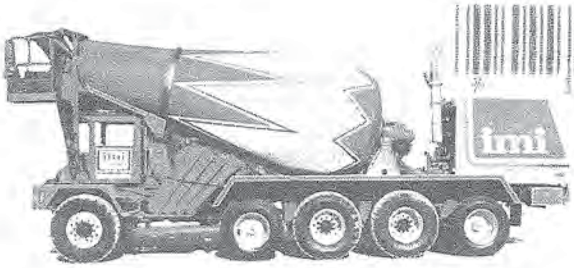
PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

2369444



* 1 8 5 8 9 8 2 *

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

CUSTOMER COPY

Project: Tests to Determine the Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-2

Sheet 1 of 2

BPR 5/31

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan	38'-11 7/8"	38'-11 7/8"	38'-11 3/4"	38'-11 7/8"				
B-B	17-9/16"	30-1/8"	~~3~~17-11/16"	30-1/8"				
C-C	17-5/8"	30-1/8"	17-11/16"	30-3/16"				
D-D	17-9/16"	30-1/16"	17-3/4"	30-1/16"				
E-E	17-5/8"	30-1/4"	17-5/8"	30-1/8"				
F-F	17-9/16"	30-3/16"	17-5/8"	30-3/16"				

Recorded by:	Signature	Date	Time
J.N.H.		5.31.12	2:00
Checked by:	Signature	Date	Time
BPR		5/31/12	3:45PM
Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the Behavior of Spliced #11 Bars

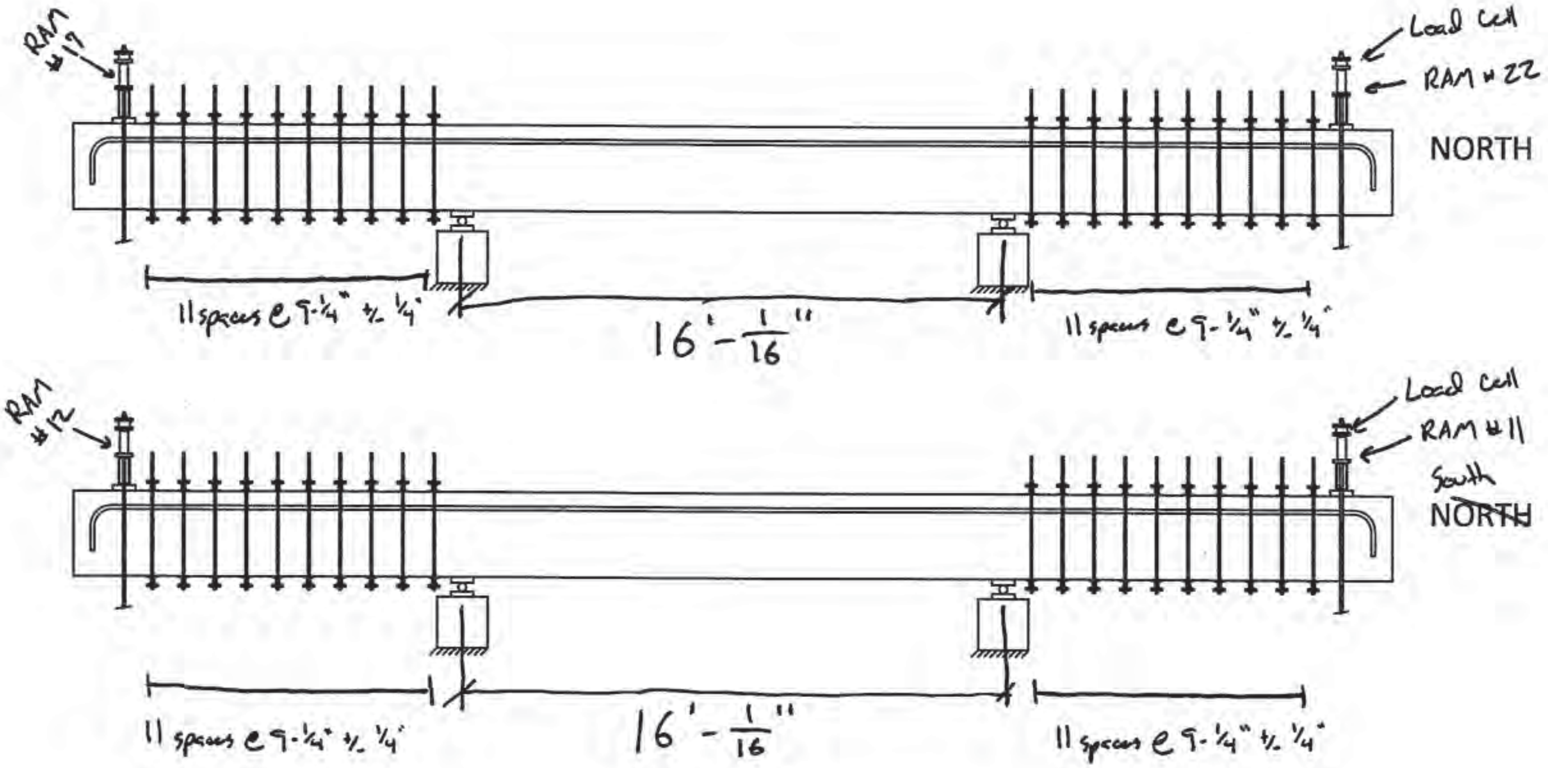
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-2

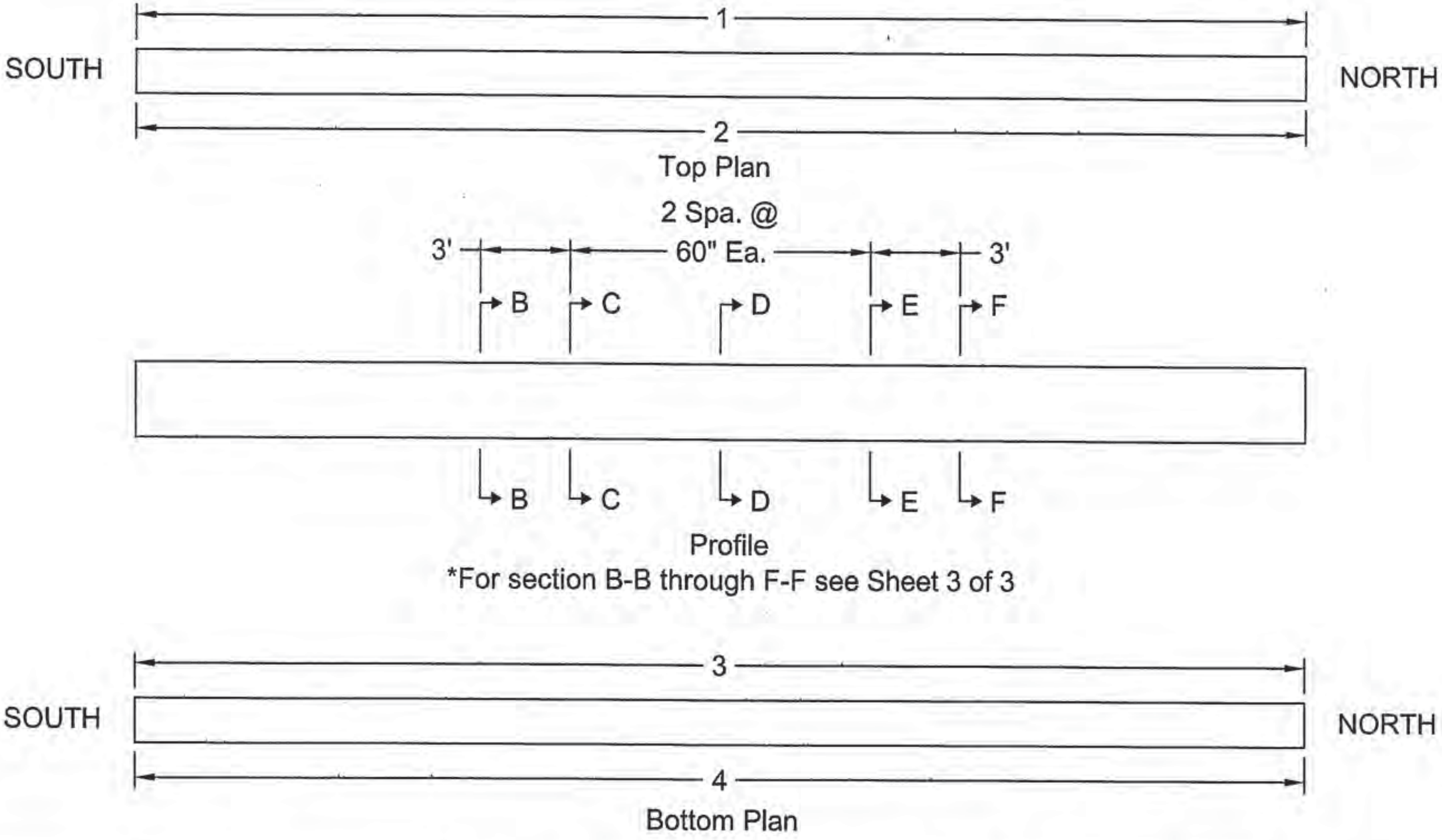
Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

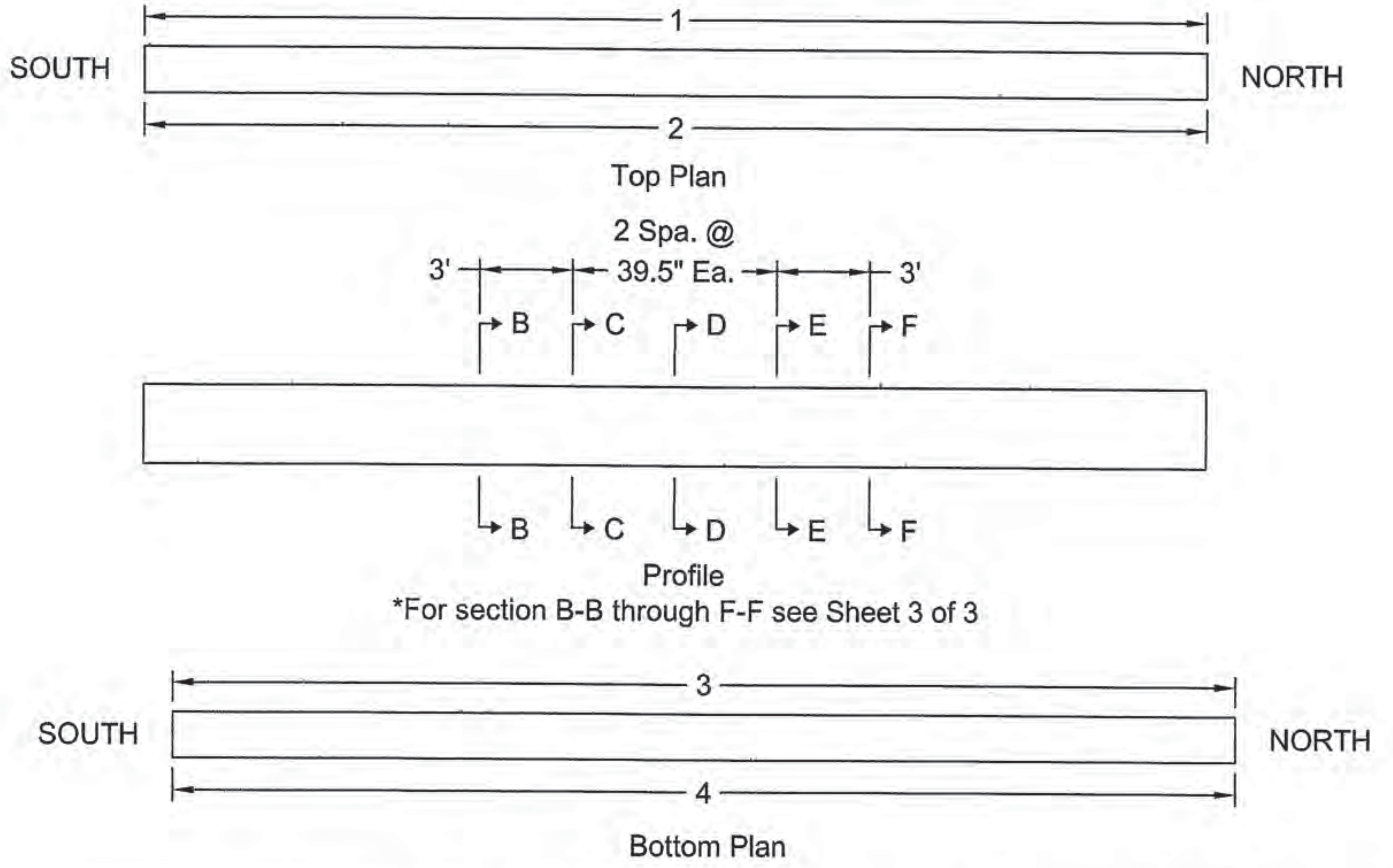


BOWEN LABORATORY PURDUE UNIVERSITY	Specimen A-2	Sheet:	1	of	4
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	KAM	Checked by:	BPR
		Date:	5-31-12		

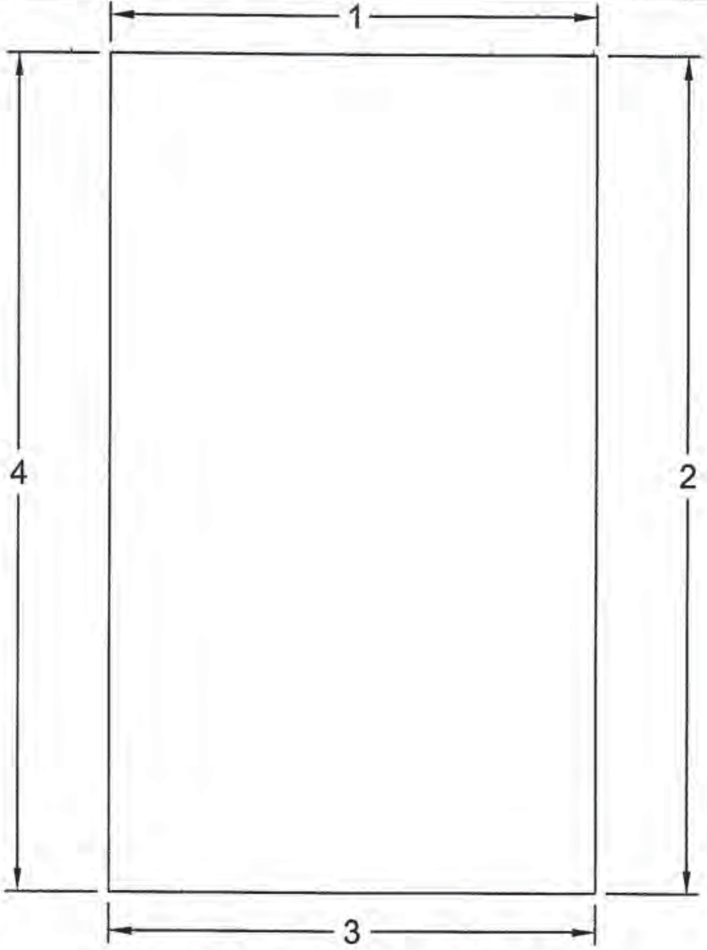


BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing: Concrete As-built Sections	Sheet:	4	of	4
	Project: Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-2

Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	174-1/8	120-1/16	173-15/16	174-0	120-0	174-0		
B-B	2-15/16	8-7/8	3-1/16	23-9/16	23-9/16	30-1/8	30-1/16	17-1/2
C-C	2-15/16	6-1/8	3-1/8	23-11/16	23-5/8	30-0	30-1/16	17-1/2
D-D	2-7/8	6-1/8	3-0	23-7/8	23-7/8	30-0	30-0	17-~~7/16~~1/2
E-E	2-15/16	6-13/16	3-1/16	23-5/8	23-11/16	30-0	30-1/16	17-7/16
F-F	4-5/16	6-1/8	4-5/16	23-5/8	23-5/8	30-1/8	30-1/8	17 1/2

Recorded by:	Signature	Date	Time
BPR		4/15	5:30PM
Checked by:	Signature	Date	Time
TD		4/15	5:30PM
Checked by:	Signature	Date	Time

Comments:
* Section B-B & F-F dimensions 1, 2, & 3 are opposite the key

*See formwork as-built drawings for dimension locations

Project: Tests to Determine the Behavior of Spliced #11 Bars

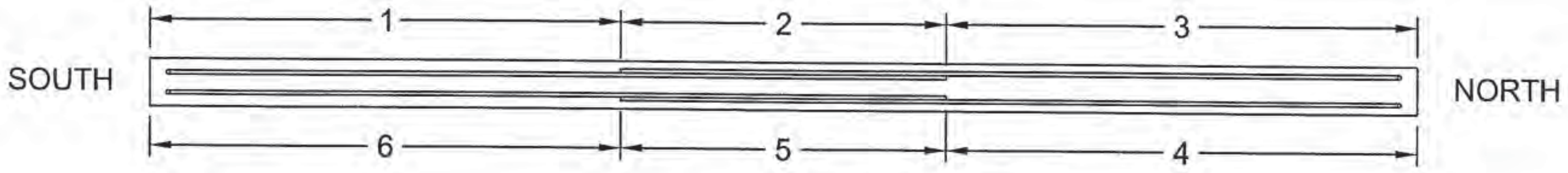
As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-2

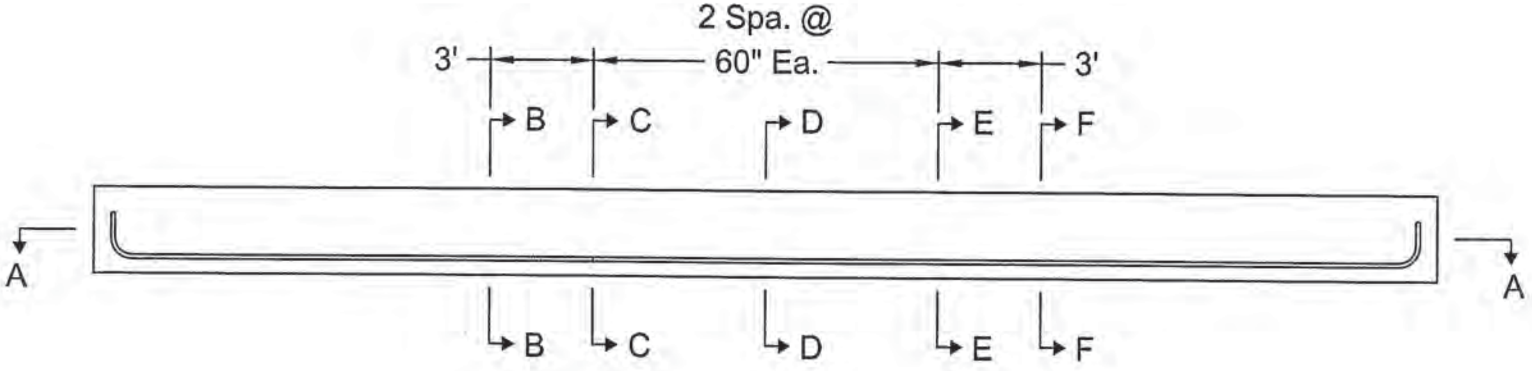
Sheet 2 of 2

Section	Formwork As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
A-A	14'-6"	10'-0"	14'-6"	14'-6"	10'-0"	14'-6"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Section	Formwork As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
A-A	13'-10.5"	6'-7"	13'-10.5"	13'-10.5"	6'-7"	13'-10.5"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"



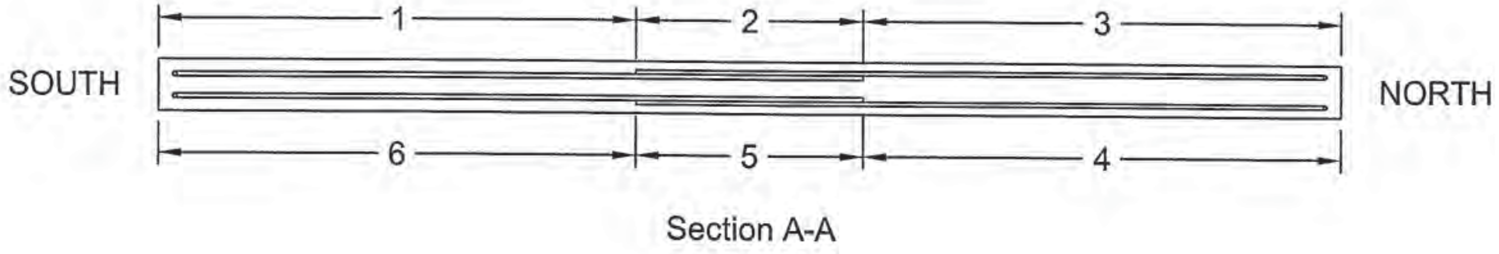
Section A-A



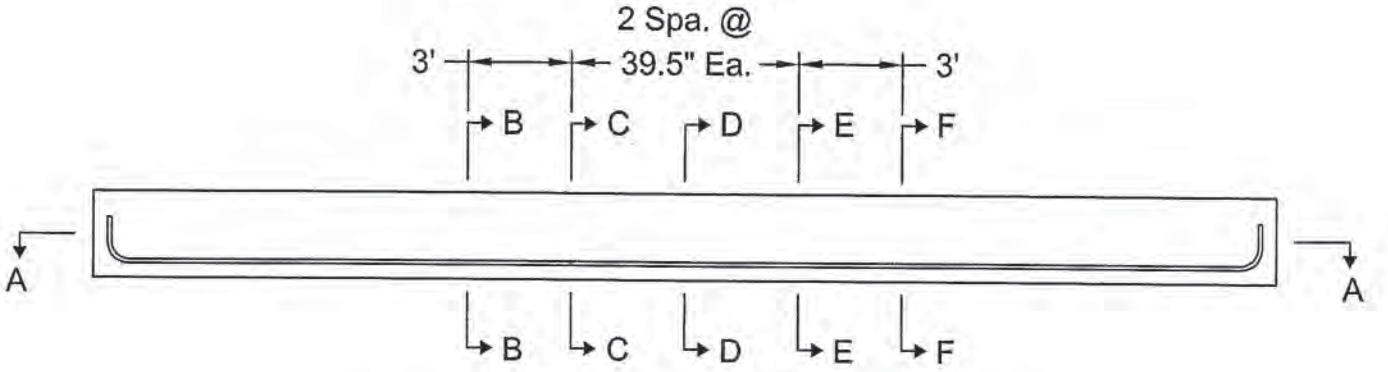
*For section B-B through F-F see Sheet 3 of 3

Series A

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



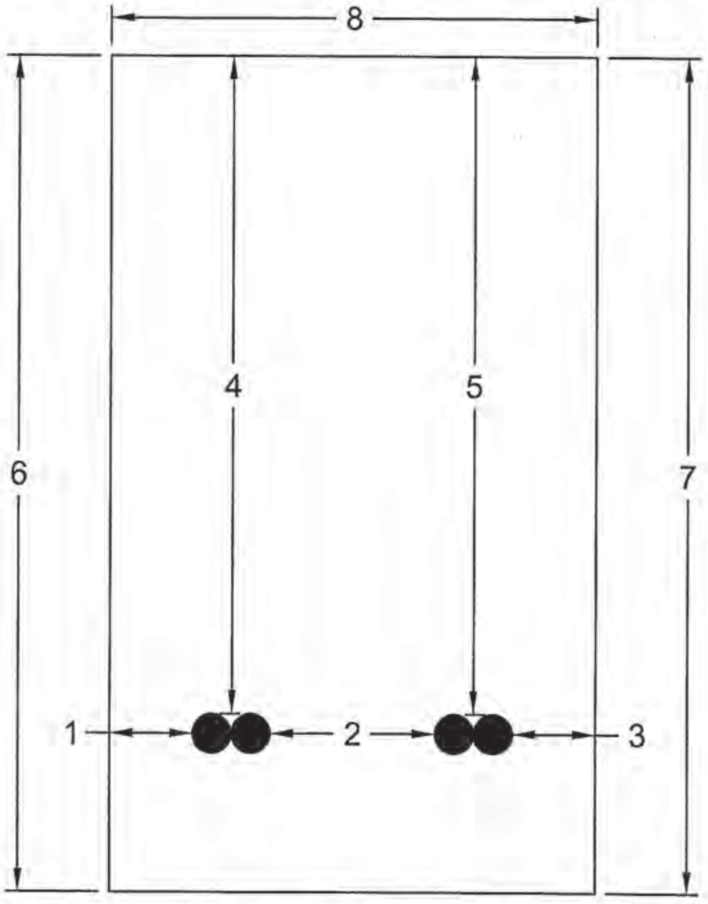
Section A-A



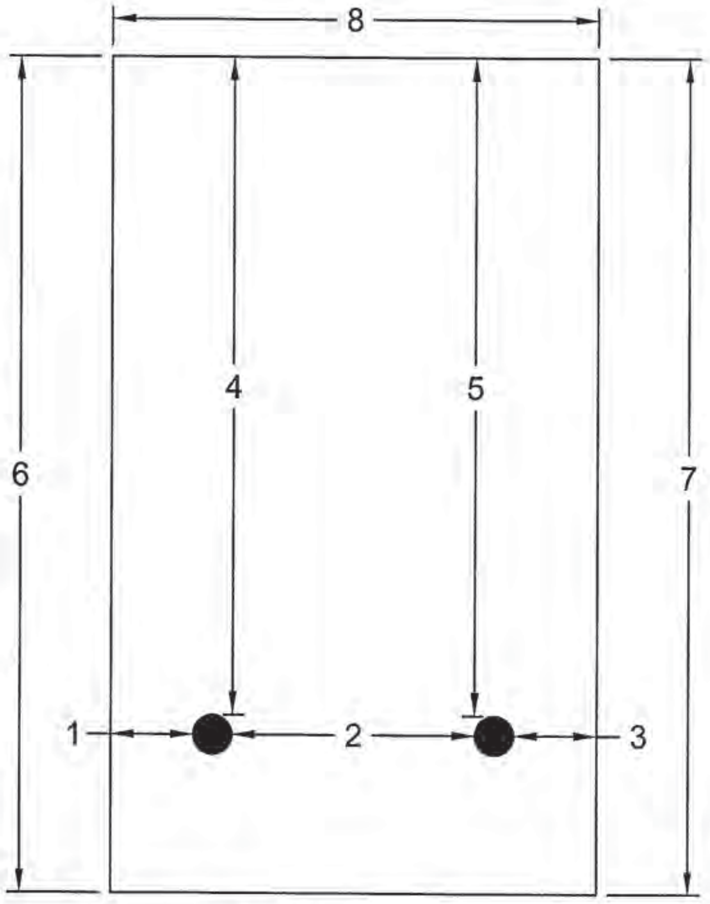
*For section B-B through F-F see Sheet 3 of 3

Series B

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Formwork As-builts	Sheet:	2	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Formwork As-built Sections	Sheet:	3	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: A-3

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/17/12	1858983	1839	15:57	4:15PM	62°F

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		Air Content (ASTM C231 - 10)		
Time_1	Result_1	Time_1	Result_1	S/N of Air Meter
4:23	5½"	4:35	4.9%	4130786891
Time_2	Result_2	Time_2	Result_2	S/N of Scale
4:48	6"	4:55	5.1%	06746056HM

Unit Weight (ASTM C138 - 10b)

Time_1	Wt. of Cont._1	Total Wt. $_1$	Wt. of Conc._1	Result_1 = Wt. of Conc./Vol. of Cont.
4:32	8.5	45.4	36.9#	147.6#/cft.
Time_2	Wt. of Cont._2	Total Wt. $_2$	Wt. of Conc._2	Result2 = Wt. of Conc./Vol. of Cont.
4:52	8.5	44.8	36.3#	145.2#/cft.

Times of actions during and after casting

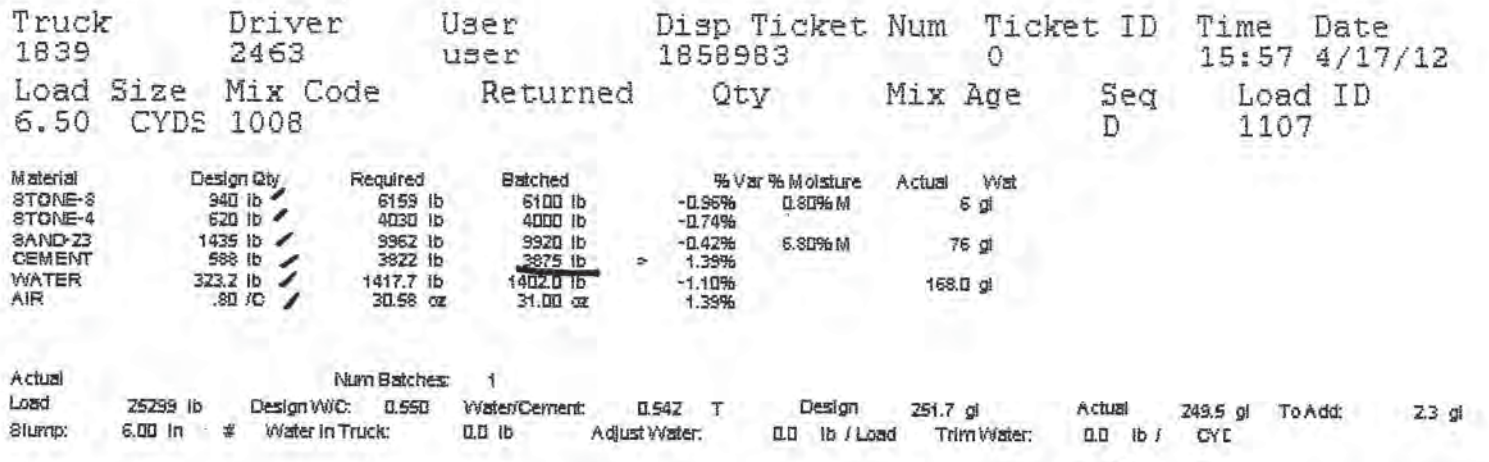
Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
4:25	4:30	✓	✓	✓	✓
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
~~4:~~	5:20PM	11:10PM	11:15PM	11:20PM	11:25PM

Recorded by	Signature	Date	Time
BPR		4/17	4:57PM
Checked by	Signature	Date	Time
KRAM		4-17-12	5:20PM
Checked by	Signature	Date	Time
S Worthy	SA WORTHY	4/17/12	

Comments:

CONCRETE TEMP 60.2°

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09



Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1839	2463	user	1858983	0	15:57	4/17/12

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
6.50 CYDS	1008				D	1107

Material	Design Qty	Required	Batched		% Var	% Moisture	Actual Wat
STONE-8	940 lb ✓	6159 lb	6100 lb		-0.96%	0.80% M	6 gl
STONE-4	620 lb ✓	4030 lb	4000 lb		-0.74%		
SAND-23	1435 lb ✓	9962 lb	9920 lb		-0.42%	6.80% M	76 gl
CEMENT	588 lb ✓	3822 lb	3875 lb	>	1.39%		
WATER	323.2 lb ✓	1417.7 lb	1402.0 lb		-1.10%		168.0 gl
AIR	.80 /C ✓	30.58 oz	31.00 oz		1.39%		

Actual Num Batches: 1

Load 25299 lb Design W/C: 0.550 Water/Cement: 0.542 T Design 251.7 gl Actual 249.5 gl To Add: 2.3 gl

Slump: 6.00 In # Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

3

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
2	250382	1839	6.50cy	1000	5.00	EXTERIOR	04/17/18	16091

Sold To	Tax Code	Driver	Project No.	Order No.
CHARGE CARC - BOWEN LAB	IN	DANNY SMITH	2482 S	1811

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB	SCN 2523
TRUCK RELEASE BRIAN 812 344 0114	Job No. SCN2523

Time Printed 15:55

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
6.50	19.50cy	19.50cy	1008	PURDUE EXPERIMENTAL	89.00	578.50
				Environmental Fee		13.00

3

www.irvmat.com

Water Added At Customer's Request	0	Total No. Gallons	
Slump Meter Reading	/050		
On Job Time		Finish Pour Time	

AUTH.#:

Grand Total: 1,774.50

Subtotal	591.50
Tax	
Total	591.50

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

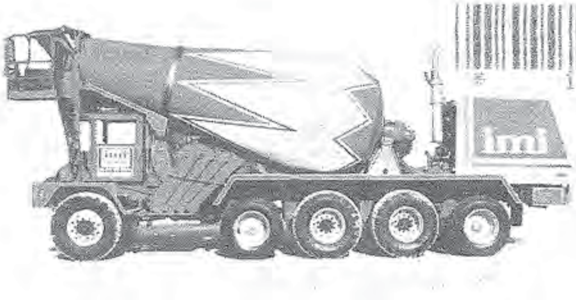
PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

2369445



1858983

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

CUSTOMER COPY

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-3

Sheet 1 of 2

Section	BPR 5/31 Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan	38'-11 7/8"	38'-11 7/8"	39'-0"	39'-0"				
B-B	17-11/16"	30-1/4"	17-11/16"	30-1/4"				
C-C	17-3/4"	30-1/16"	17-3/4"	30-3/16"				
D-D	17-5/8"	30-1/8"	17-3/4"	30-3/16"				
E-E	17-3/4"	30-3/16"	17-3/4"	30-3/16"				
F-F	17-11/16"	30-1/4"	17-3/4"	30-1/4"				

Recorded by:	Signature	Date	Time
J.N.H.		5.29.12	6:40
Checked by:	Signature	Date	Time
BPR		5/29/12	7:00PM
Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

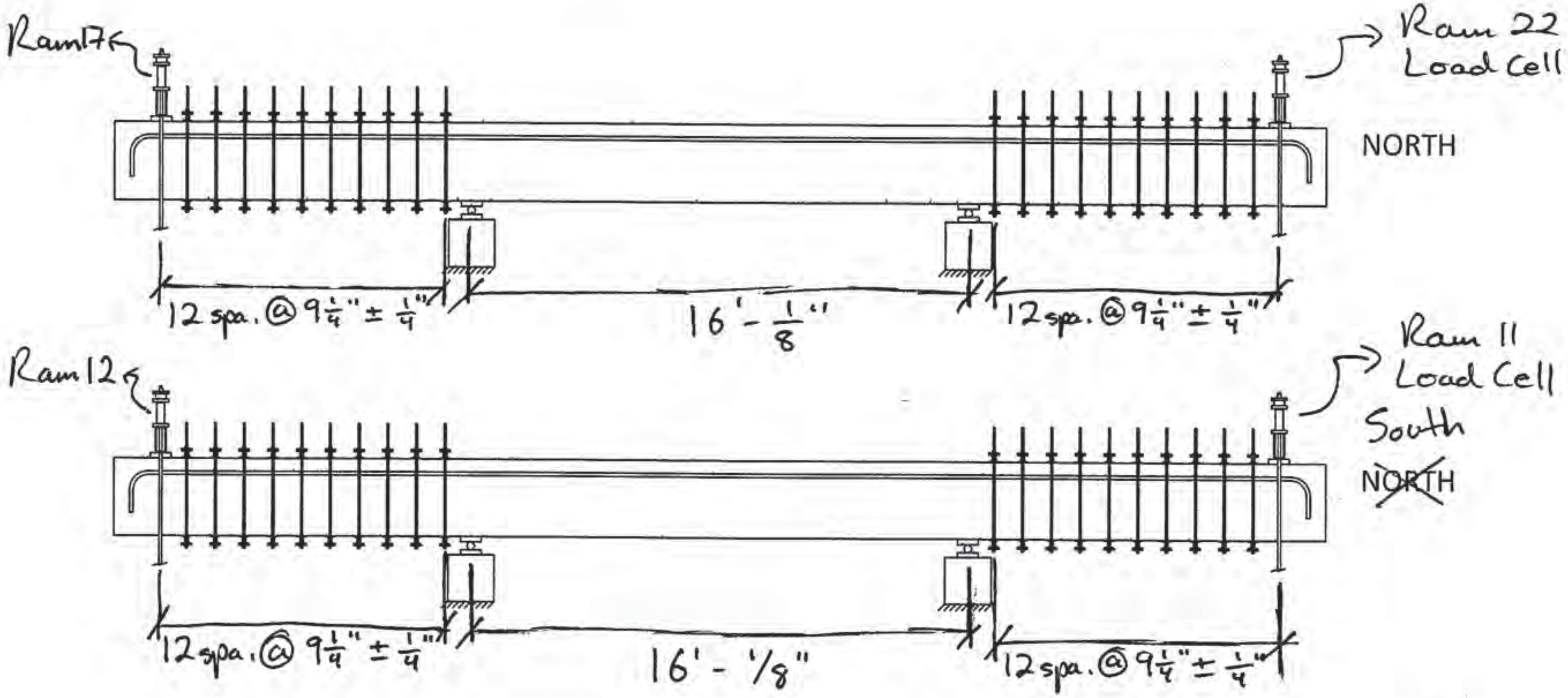
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-3

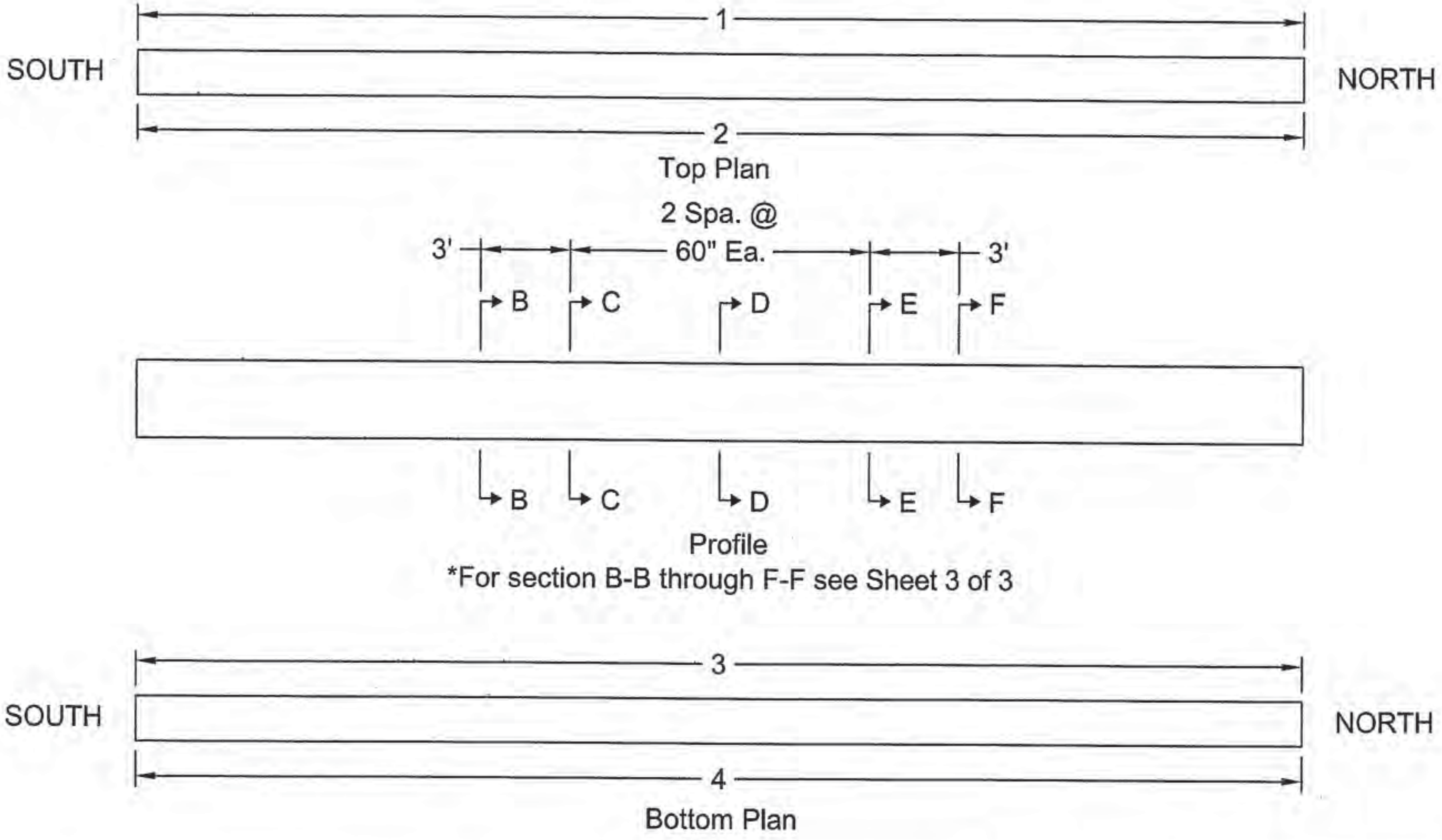
Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A



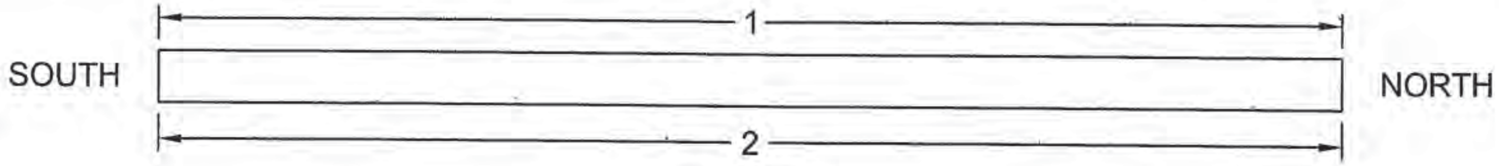
BOWEN LABORATORY PURDUE UNIVERSITY	Specimen A-3	Sheet:	1	of	4
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	VAM
		Date:	5/29/12		



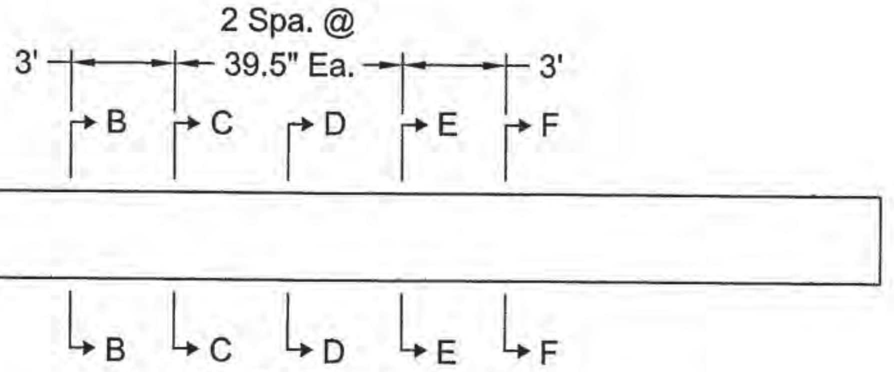
*For section B-B through F-F see Sheet 3 of 3

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

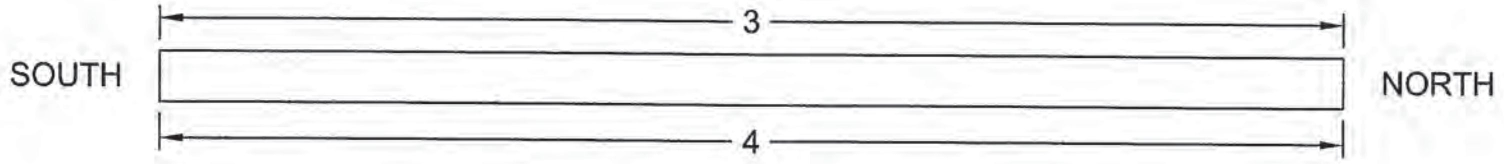


Top Plan



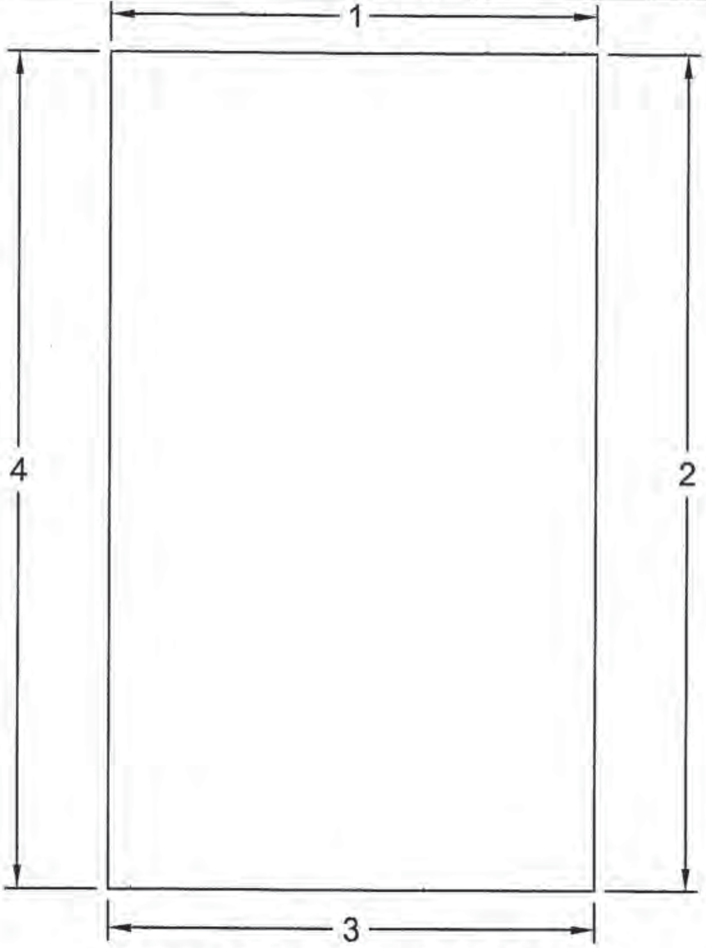
Profile

*For section B-B through F-F see Sheet 3 of 3



Bottom Plan

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Concrete As-built Sections	Sheet:	4	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

Project: Tests to Determine the Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-3

Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	174-1/8	119-15/16	174-0	174-13/16	119-15/16	173-13/16		
B-B	2-15/16	8-7/8	3-1/16	23-5/8	23-9/16	30-1/8	30-1/8	17-1/2
C-C	3-0	6-13/16	3-1/16	23-11/16	23-11/16	30-0	30-1/16	17-1/2
D-D	3-0	6-13/16	3-1/16	23-7/8	23-13/16	30-0	30-1/8	17-1/2
E-E	2-15/16	6-13/16	3-1/16	23-5/8	23-11/16	30-1/16	30-1/8	17-1/2
F-F	4-3/8	6-1/8	4-3/8	23-5/8	23-9/16	30-1/8	30-3/16	17-1/2

Recorded by:	Signature	Date	Time
BPR		4/15	5:50PM
Checked by:	Signature	Date	Time
TD		4/15	5:50PM
Checked by:	Signature	Date	Time

Comments:
* Section B-B & F-F dimensions 1, 2, & 3 are opposite the key

*See formwork as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

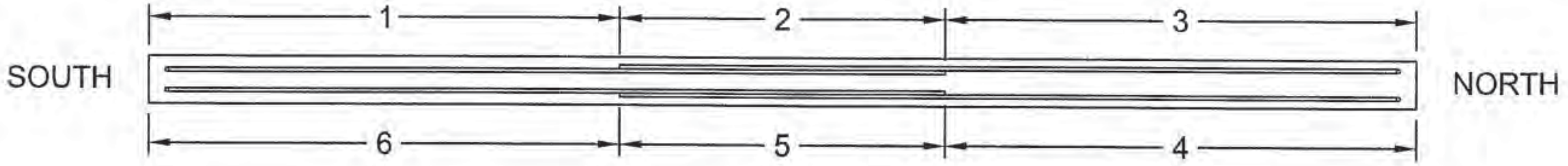
As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-3

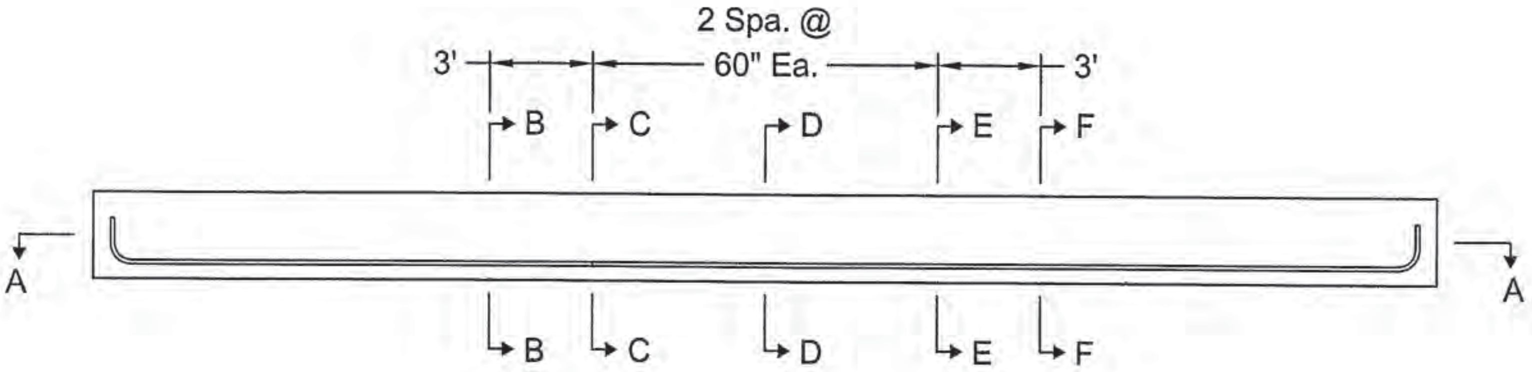
Sheet 2 of 2

Section	Formwork As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
A-A	14'-6"	10'-0"	14'-6"	14'-6"	10'-0"	14'-6"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Section	Formwork As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
A-A	13'-10.5"	6'-7"	13'-10.5"	13'-10.5"	6'-7"	13'-10.5"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"



Section A-A

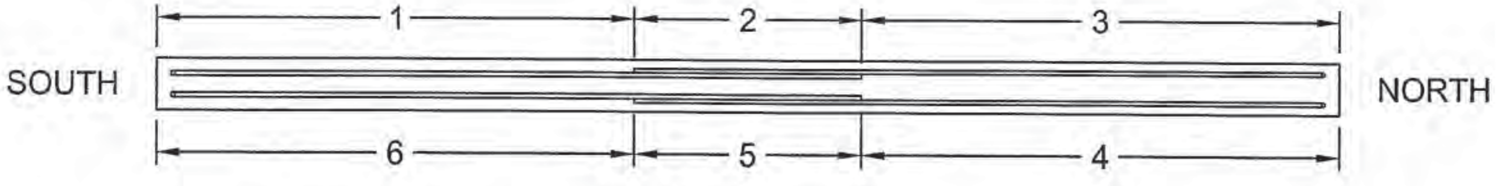


*For section B-B through F-F see Sheet 3 of 3

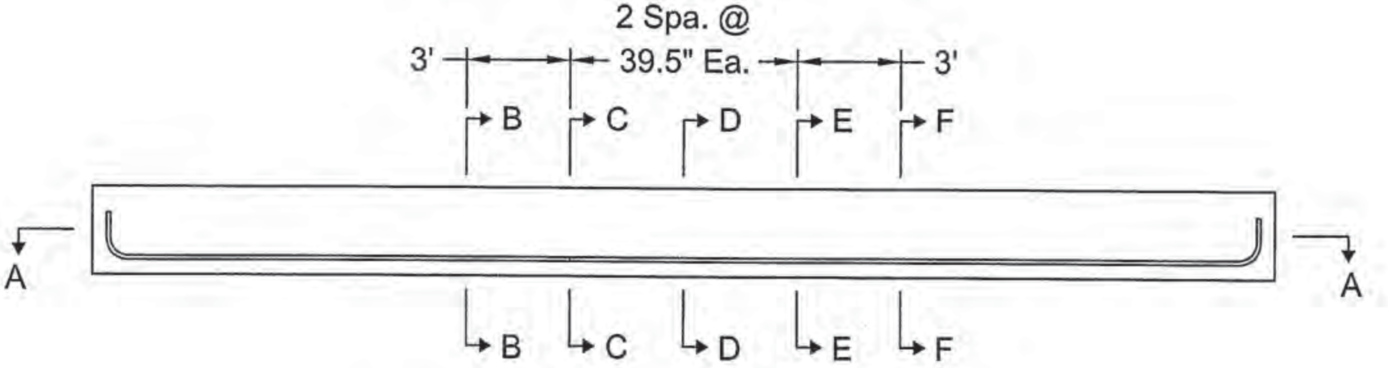
Series A

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



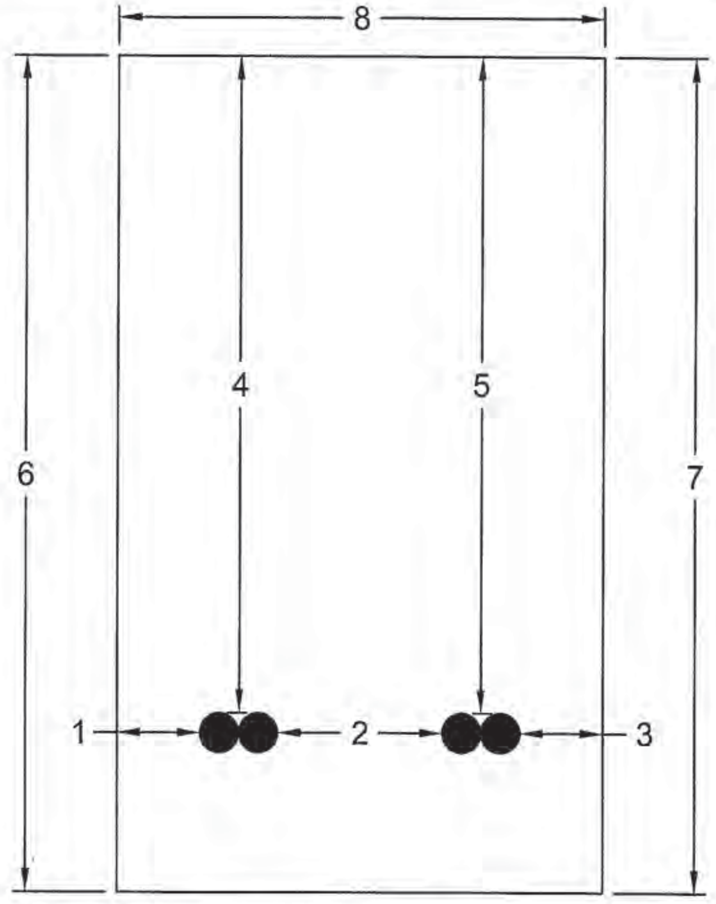
Section A-A



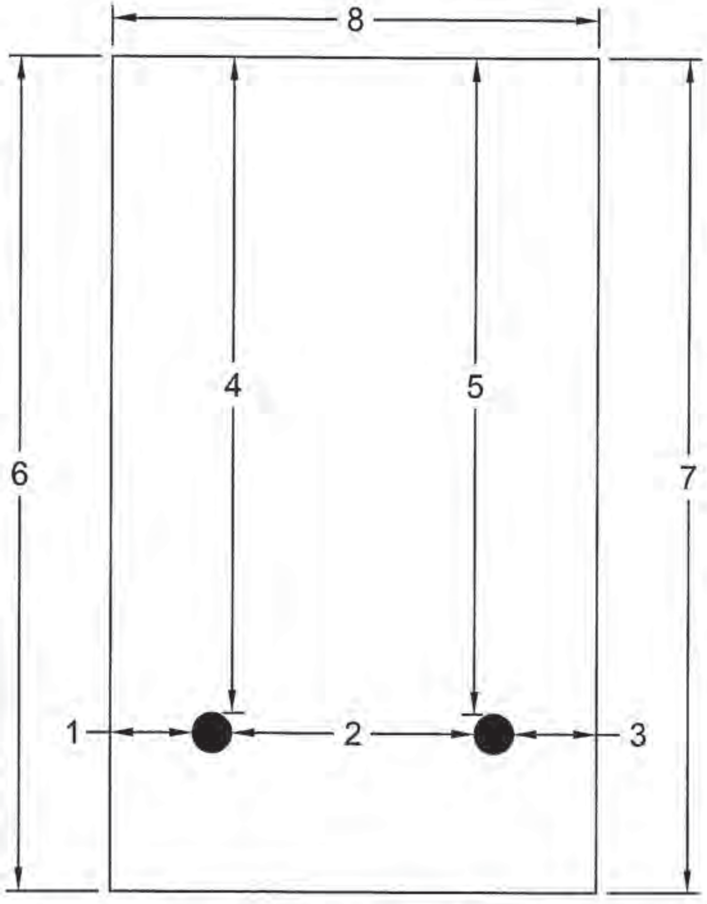
*For section B-B through F-F see Sheet 3 of 3

Series B

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Formwork As-builts	Sheet:	2	of 3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Formwork As-built Sections	Sheet:	3	of 3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: A-4

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/24	1859188	1635	12:26	12:40PM	62°F

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		Air Content (ASTM C231 - 10)		
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter
12:47	7.5"	12:58	4.2%	413078 6891
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale
13:11	8.5"	13:	3.9%	056HM

Unit Weight (ASTM C138 - 10b)

Time$_1$	Wt. of Cont.$_1$	Total Wt. $_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.
12:55	8.5#	44.7	36.2#	144.8 #/cft.
Time$_2$	Wt. of Cont.$_2$	Total Wt. $_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.
13:15	8.5#	44.6	36.1#	144.4 #/cft.

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
✓	✓	✓	✓	✓	1:10PM
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
2:40PM	2:45PM	8:15PM	8:20PM	8:25PM	8:30PM

Recorded by	Signature	Date	Time
S.P.	AD.	4/24	1:20
Checked by	Signature	Date	Time
BPR		4/24	2:34PM
Checked by	Signature	Date	Time
SAWorth	SA WORTHY	4/24	1:20

Comments: 3 layers
CONC. TEMP: 66°F (Dig & Cal gages)

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

1

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1635	1867	user	1859188	0	12:26	4/24/12

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
6.50 CYDS	1008				D	1310

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual	Wat
STONE-8	940 lb	6110 lb	6060 lb	-0.82%	M		
STONE-4	620 lb	4030 lb	4000 lb	-0.74%			
SAND-23	1435 lb	9841 lb	9800 lb	-0.41%	5.50% M	61 gl	
CEMENT	588 lb	3822 lb	3805 lb	-0.44%			
WATER	323.2 lb	1587.8 lb	1578.0 lb	-0.62%		189.1 gl	
AIR	.80 /C	30.58 oz	30.00 oz	-1.88%			

1

Actual Num Batches: 1

Load 25245 lb Design W/C: 0.550 Water/Cement: 0.552 T Design 251.7 gl Actual 250.3 gl To Add: 1.4 gl

Slump: 6.00 in # Water In Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

A-4

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
10	1859188	1635	6.50cy	1008	6.00	BUCKET	04/26/12	10091

Sold To	Tax Code	Driver	Project No.	Order No.
C DGE CARD LAFAYETTE & WINAMA	IN	RICK CLOUGH	1867 5	1803

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB	SCN2535

Job No.: SCN2535

TRUCK RELEASE MIKE 559 708-1934

1

Time Printed 12:22

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
6.50	6.50cy	19.50cy	1008	PURDUE EXPERIMENTAL	89.00	578.50
				Environmental Fee		13.00

www.irvmat.com

1

A

Water Added At Customer's Request	0	Total No. Gallons	
Slump Meter Reading	900		
On Job Time		Finish Pour Time	

AUTH. #:

Grand Total: 591.50

Subtotal 591.50
Tax
Total 591.50

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

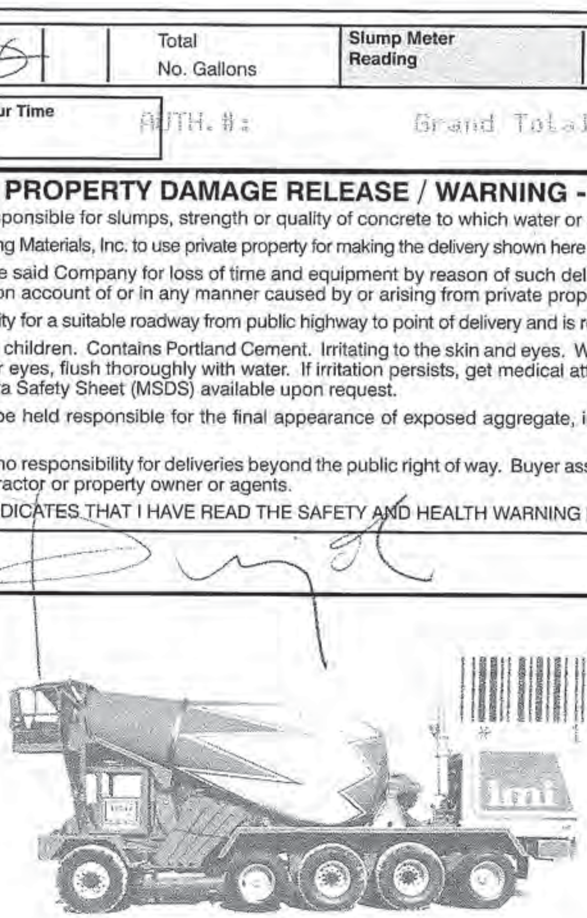
PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

2369649



* 1 8 5 9 1 8 8 *

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" General Office (317) 326-3101

DRIVER COPY

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-4

Sheet 1 of 2

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan	39' 1/8"	39'	39'	39' 1/8"				
B-B	17-3/8"	30-3/16"	17-11/16"	30-1/8"				
C-C	17-1/2"	30-1/16"	17-3/4"	30-1/16"				
D-D	17-7/16"	30-1/8"	17-5/8"	30-1/8"				
E-E	17-11/16"	30-1/16"	17-11/16"	30-1/8"				
F-F	17-11/16"	30-3/16"	17-11/16"	30-3/16"				

Recorded by:	Signature	Date	Time
J.N.H.		6.7.12	1:20
Checked by:	Signature	Date	Time
BPR		6/7/12	4:30PM
Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

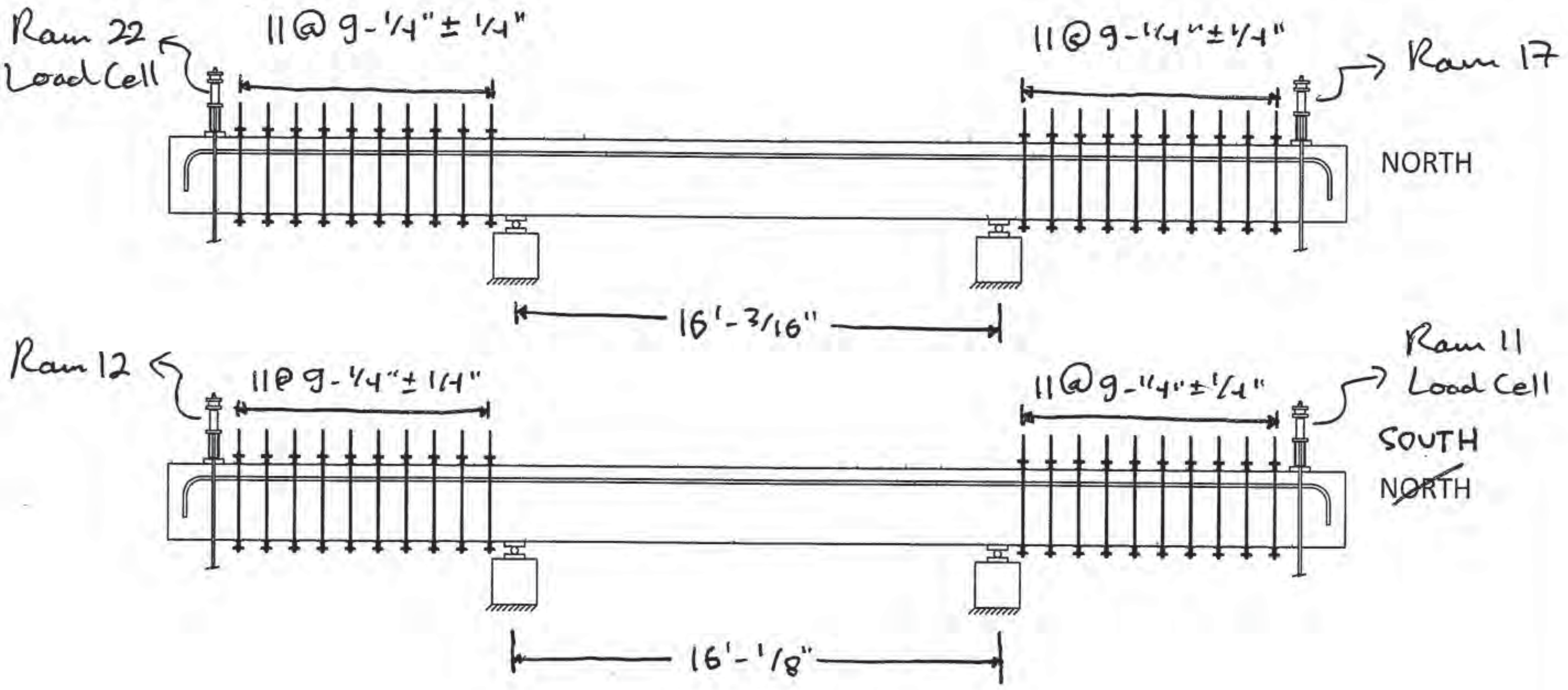
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-4

Sheet 2 of 2

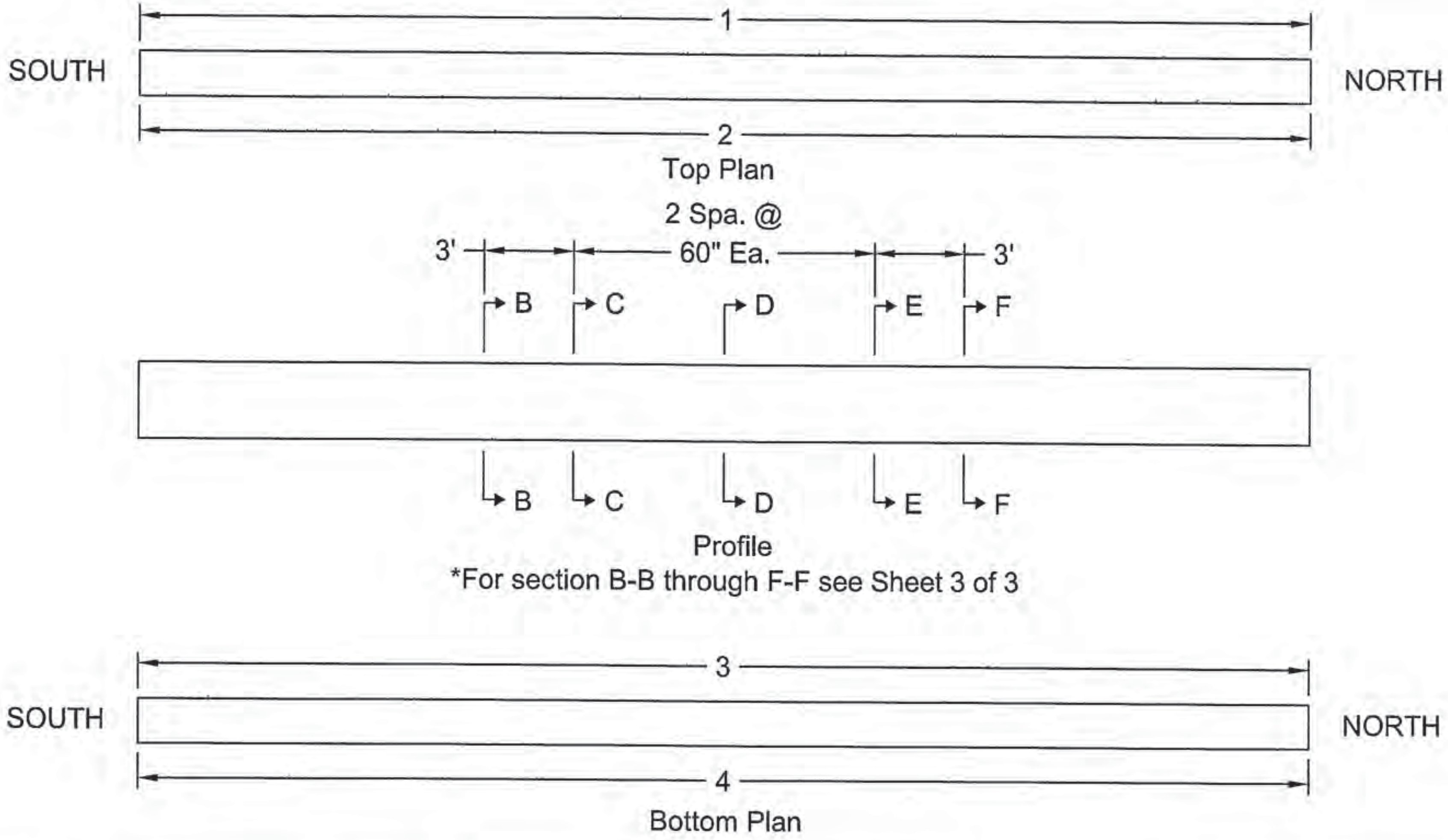
Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30	N/A	N/A	N/A	N/A



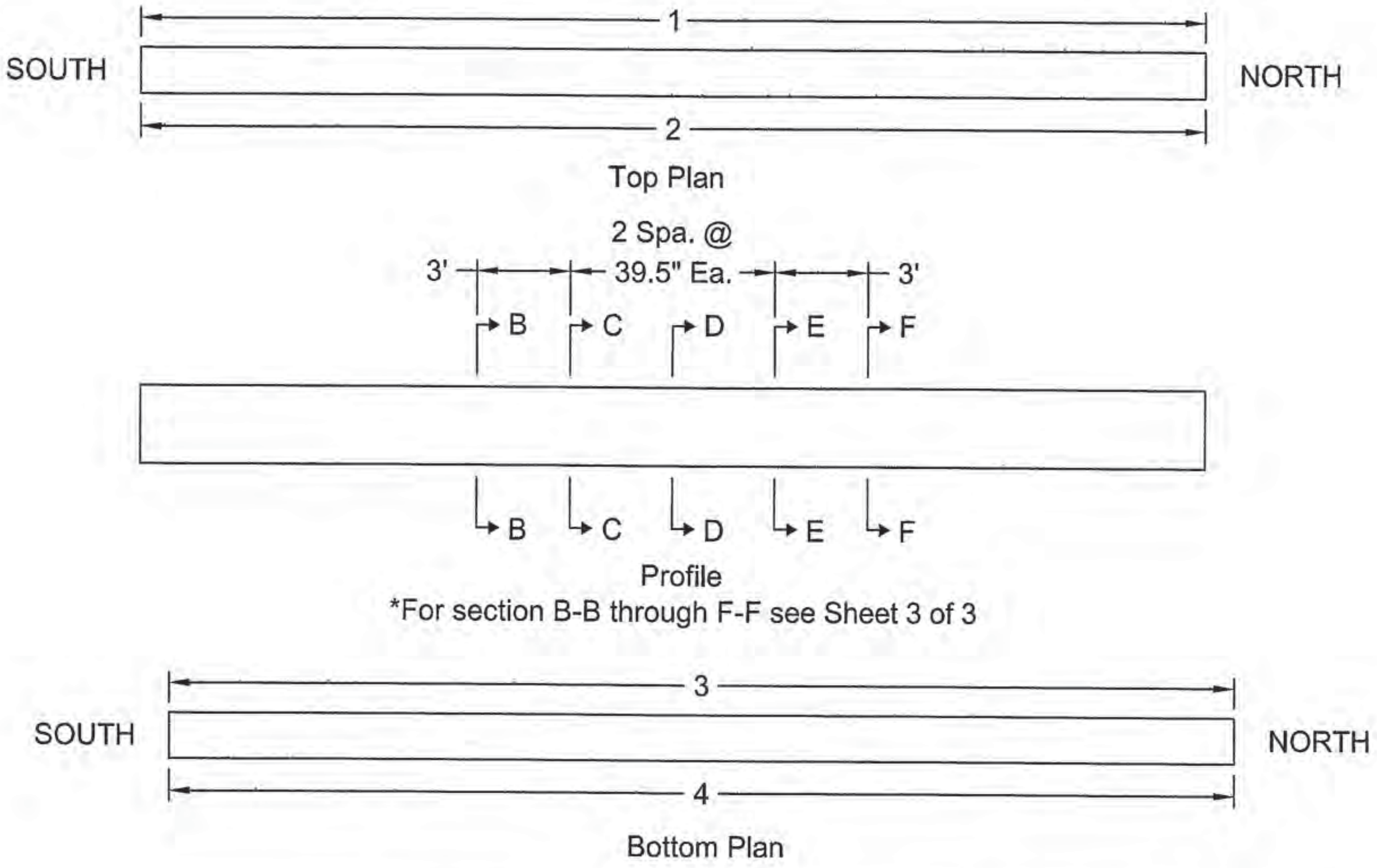
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen A-4	Sheet:	1	of	4
Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	J.N.H.	Checked by:	BPR
	Date:	6.7.12		



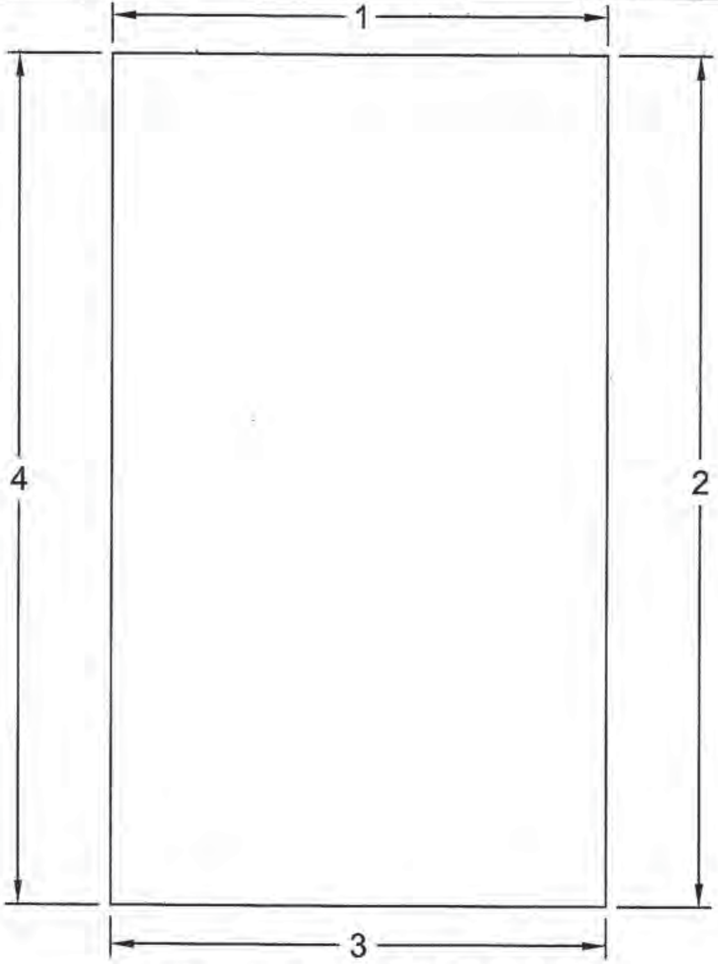
BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Concrete As-built Sections	Sheet:	4	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		

Project: Tests to Determine the Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-4

Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	173 7/8	120 1/16	174 3/16	174 3/16	120-0	173 7/8		
B-B	4-3/8	6-1/8	4-3/16	23-1/2	23-7/16	30-1/16	30-1/16	17-1/2
C-C	3-1/8	6-1/16	2-7/8	23-5/8	23-1/2	30-0	30-1/16	17-1/2
D-D	3-1/8	6-0	2-7/8	23-7/8	23-7/8	30-0	30-1/8	17-1/2
E-E	3-1/8	5-15/16	3-1/16	23-11/16	23-11/16	30-0	30-1/16	17-1/2
F-F	3-1/16	8-3/4	3-1/16	23-9/16	23-11/16	30-1/8	30-3/16	17 1/2

Recorded by:	Signature	Date	Time
BPR		4/23	2:40 PM
Checked by:	Signature	Date	Time
TD		4/23	2:40
Checked by:	Signature	Date	Time

Comments:

*See formwork as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

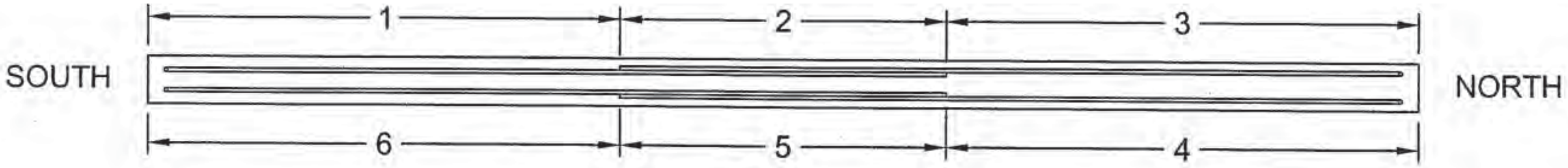
As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen:____________________

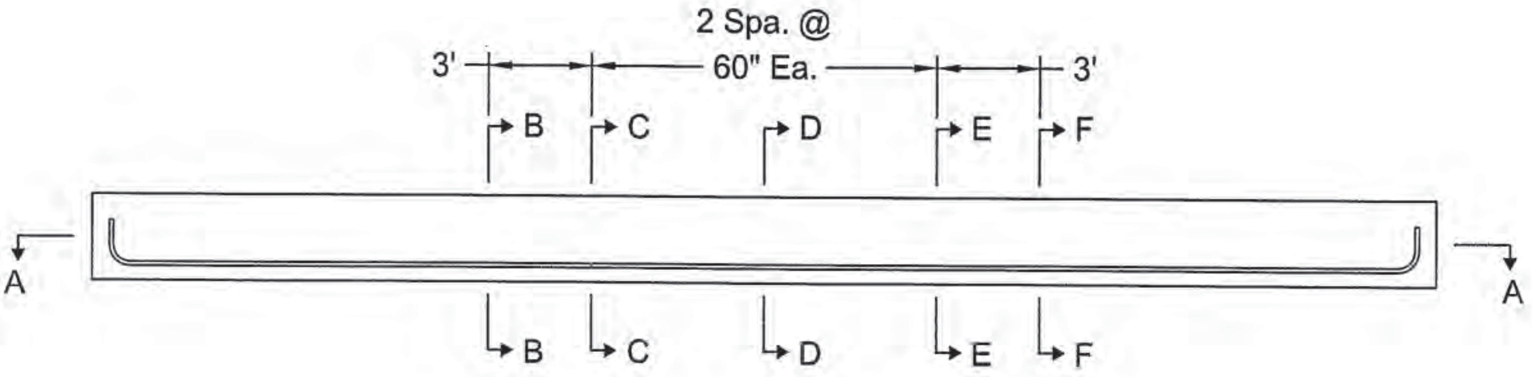
Sheet 2 of 2

Section	Formwork As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
A-A	14'-6"	10'-0"	14'-6"	14'-6"	10'-0"	14'-6"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Section	Formwork As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
A-A	13'-10.5"	6'-7"	13'-10.5"	13'-10.5"	6'-7"	13'-10.5"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"



Section A-A

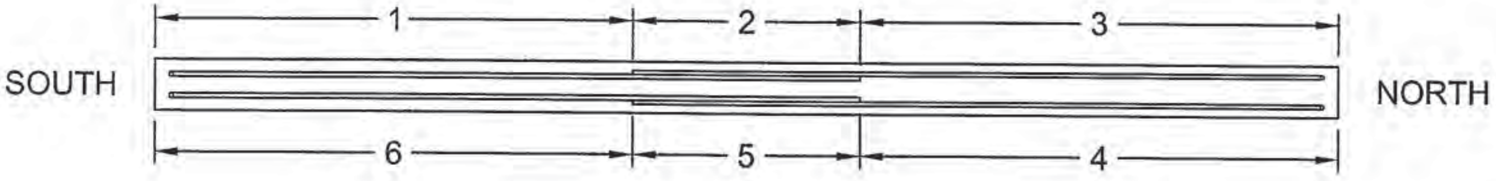


*For section B-B through F-F see Sheet 3 of 3

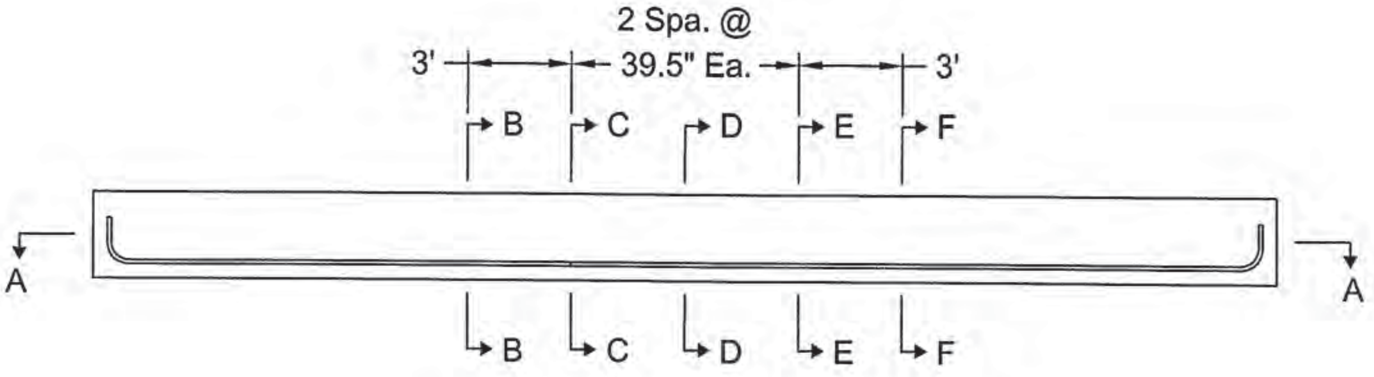
Series A

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



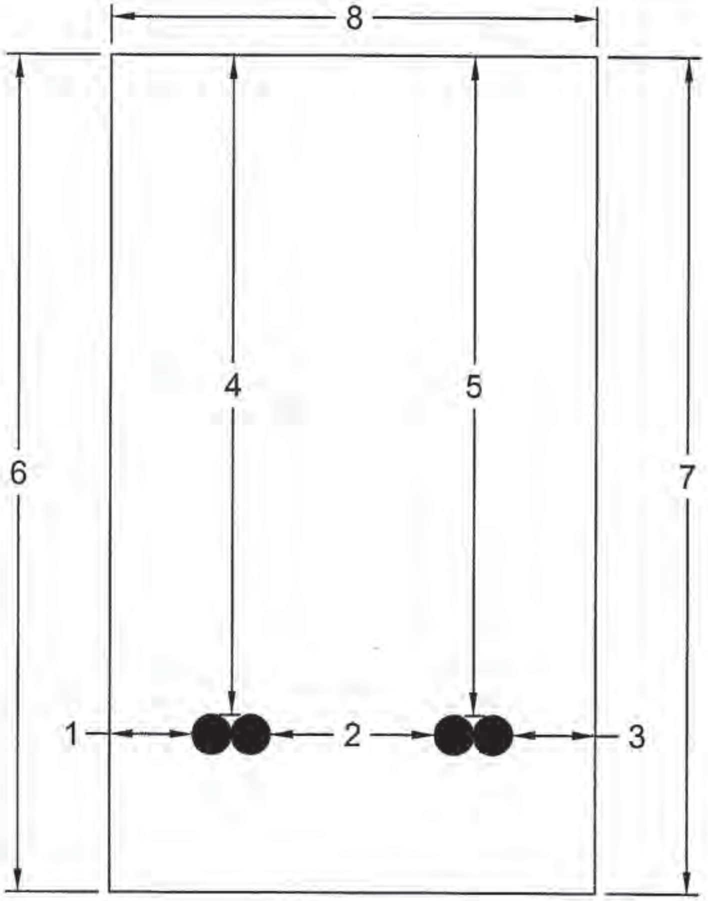
Section A-A



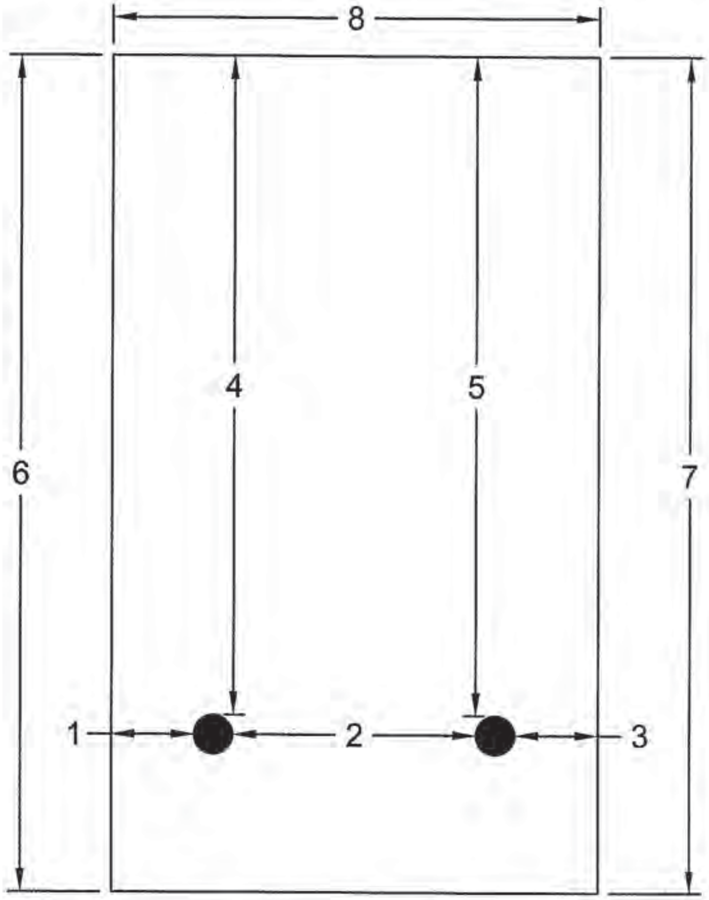
*For section B-B through F-F see Sheet 3 of 3

Series B

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Formwork As-builts	Sheet:	2	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Formwork As-built Sections	Sheet:	3	of 3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by: BPR	Checked by:	SP
			Date:	04/04/2012	

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: A-5
Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/24	1859191	1693	13:01	1:20PM	62°F

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**			
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter	
1:25	8 1/2"	1:33	4.6%	Same as A-4	
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale	
1:50	8 1/2"	1:52	4.6%	Same as A-4	

Unit Weight (ASTM C138 - 10b)

Time$_1$	Wt. of Cont.$_1$	Total Wt. $_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.	
1:31	8.5 #	44.4 #			
Time$_2$	Wt. of Cont.$_2$	Total Wt. $_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.	
1:50	8.5#	44.2#			

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
✓	✓	✓	✓	✓	1:50
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
2:40PM	2:45PM	8:20PM	8:25PM	8:30PM	8:35PM

Recorded by	Signature	Date	Time
S. P.	SP.	4/24	1:53
Checked by	Signature	Date	Time
BPR		4/24	2:39PM
Checked by	Signature	Date	Time
S Worthy		4/24/12	1:55p

Comments: Conc. Temp: 67.5°F
3 layers

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1693	2774	user	1859191	0	13:01	4/24/12

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
6.50 CYDS	1008				D	1313

2

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual Wat
STONE-8	940 lb	6110 lb	6060 lb	-0.82%	M	
STONE-4	620 lb	4030 lb	4000 lb	-0.74%		
SAND-23	1435 lb	9841 lb	9800 lb	-0.41%	5.50% M	61 gl
CEMENT	588 lb	3822 lb	3820 lb	-0.05%		
WATER	323.2 lb	1587.8 lb	1580.0 lb	-0.49%		189.3 gl
AIR	.80 /C	30.58 oz	30.50 oz	-0.25%		

Actual Num Batches: 1

Load 25262 lb Design W/C: 0.550 Water/Cement: 0.550 T Design 251.7 gl Actual 250.6 gl To Add: 1.2 gl

Slump: 6.00 In # Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

A-5

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
10	1859191	1693	6.50cy	1008	6.00	BUCKET	04/24/12	16091

Sold To	Tax Code	Driver		Project No.	Order No.
C[illegible]RGE CARD - LAFAYETTE & WINAMA	IN	RON HOWARD	2774	5	1802

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB	SCN2535

Job No.) SCN2535

TRUCK RELEASE MIKE 559 708 1934

Time Printed 13:00

2

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
6.50	13.00cy	19.50cy	1008	PURDUE EXPERIMENTAL	89.00	578.50
				Environmental Fee		13.00

2

A-5

Water Added At [illegible]omer's Request					Total No. Gallons	Slump Meter Reading					Subtotal	591.50

On Job Time	Finish Pour Time	AUTH.#:	Grand Total: 1,183.00	Tax	
				Total	591.50

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

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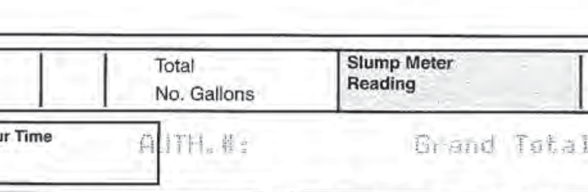
NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

2369652



* 1 8 5 9 1 9 1 *

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DRIVER COPY

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-5

Sheet 1 of 2

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan	39'-11 3/4"	39'-11 3/4"	39'-11 7/8"	39'-11 7/8"				
B-B	17-1/2"	30-1/16"	17-3/4"	30-0"				
C-C	17-1/2"	30-1/16"	17-3/4"	30-1/16"				
D-D	17-1/2"	30-3/16"	17-3/4"	30-1/4"				
E-E	17-9/16"	30-1/8"	17-5/8"	30-1/16"				
F-F	17-9/16"	30-1/4"	17-11/16"	30-1/4"				

Recorded by:	Signature	Date	Time
KAM		6-6-12	4:15 pm
Checked by:	Signature	Date	Time
BPR		6/6/12	4:25 PM
Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the Behavior of Spliced #11 Bars

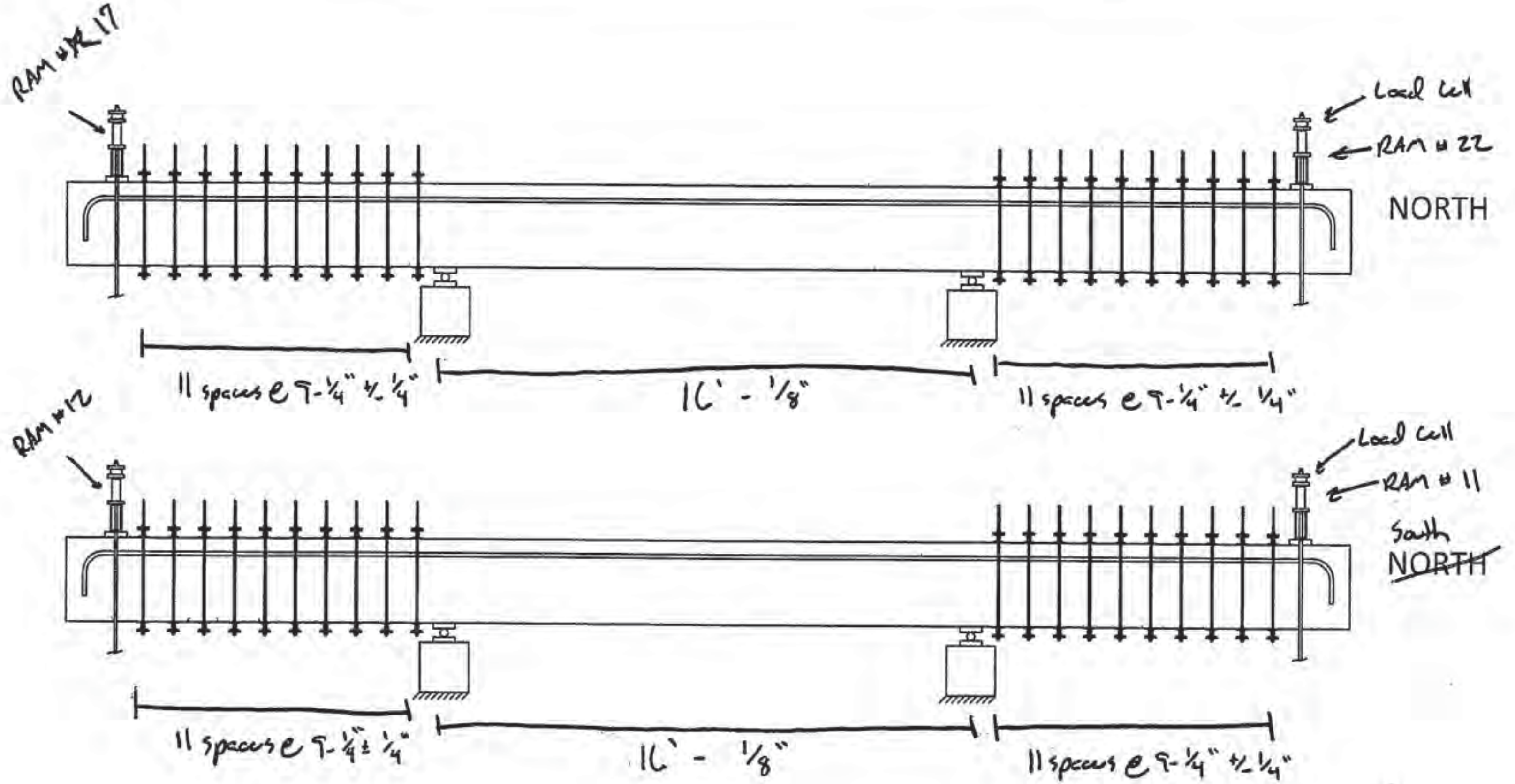
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-5

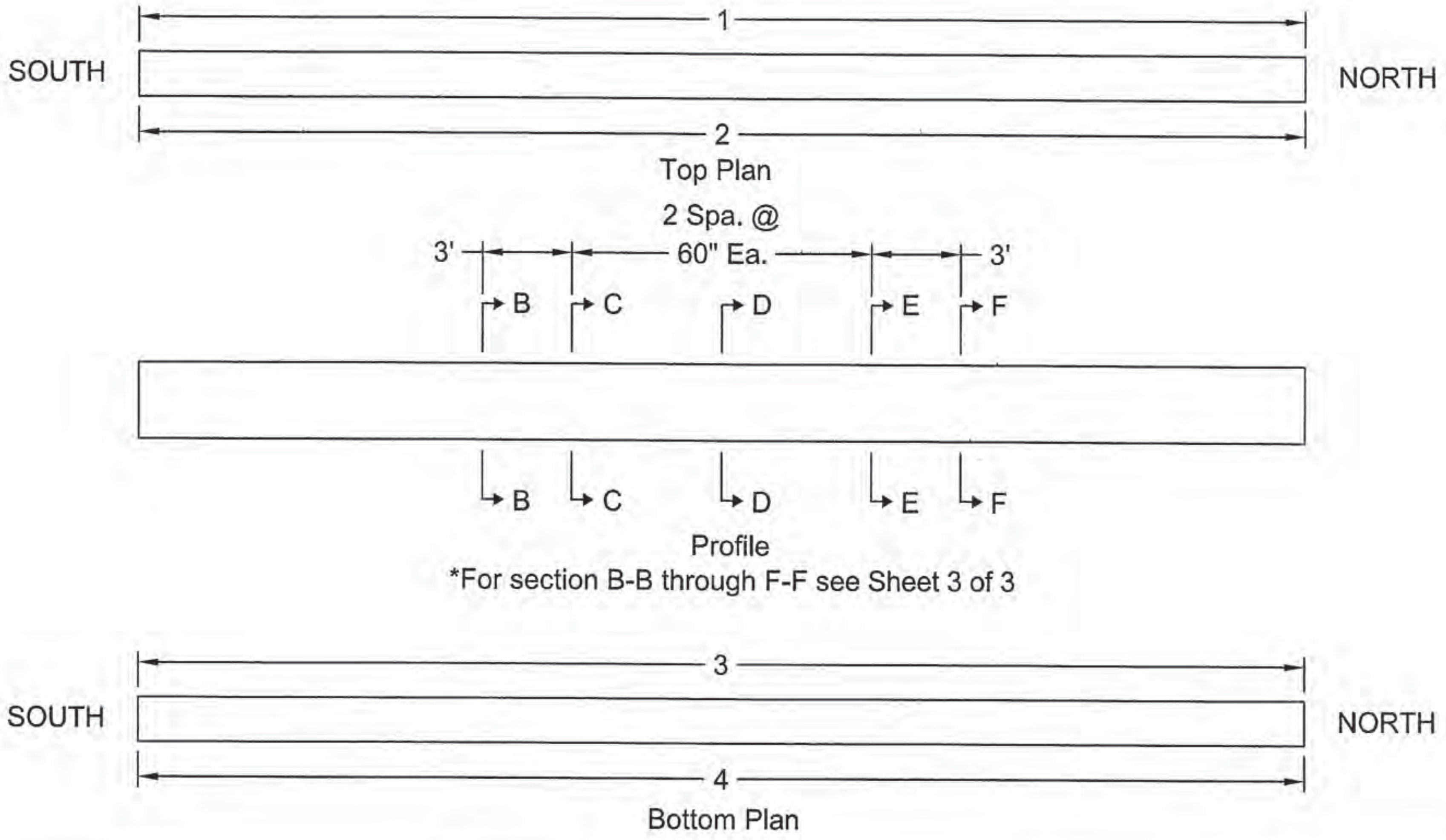
Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

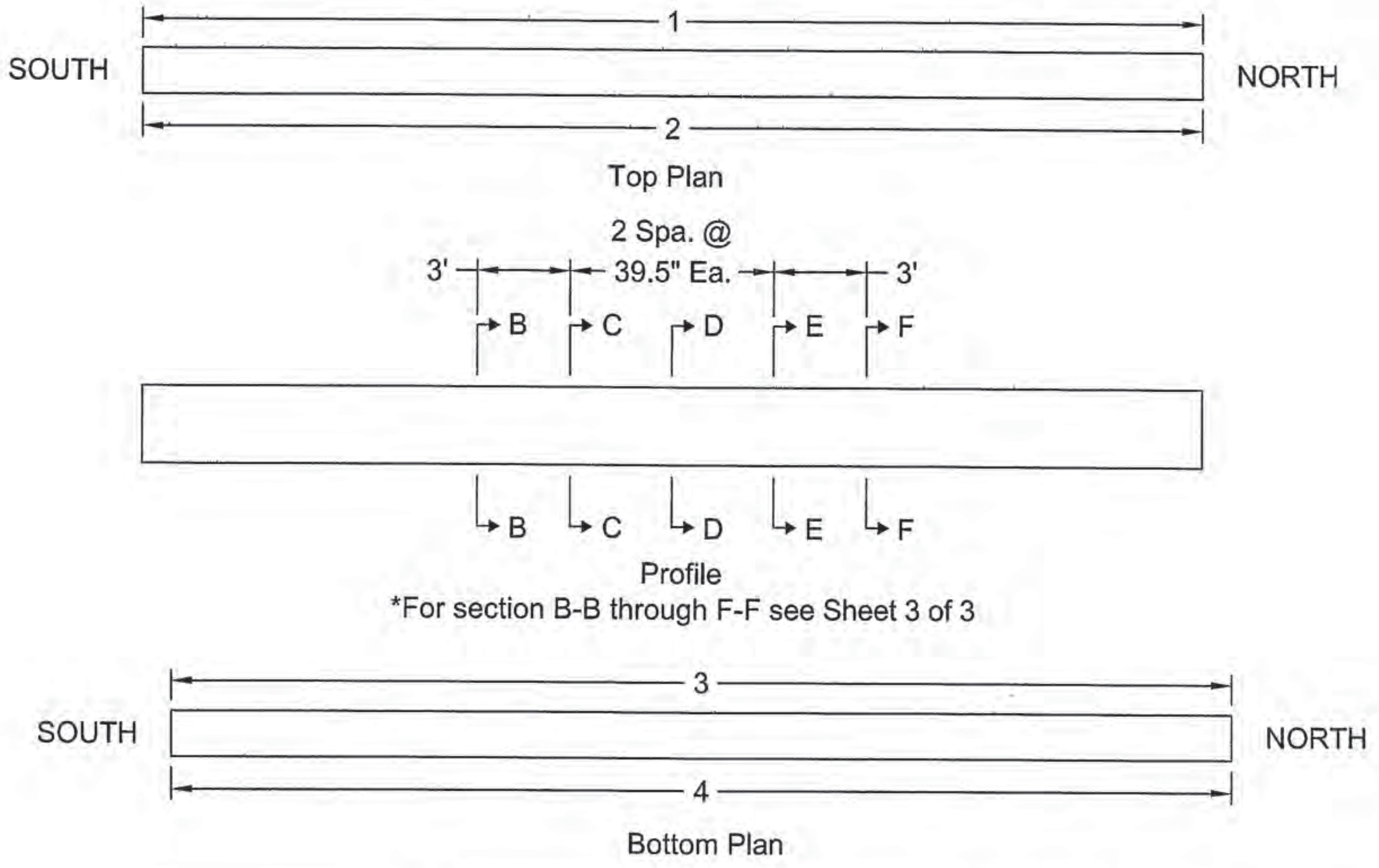


BOWEN LABORATORY PURDUE UNIVERSITY	Specimen A-5	Sheet:	1	of	4
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	KAM	Checked by:	BPR
		Date:	6-6-12		



*For section B-B through F-F see Sheet 3 of 3

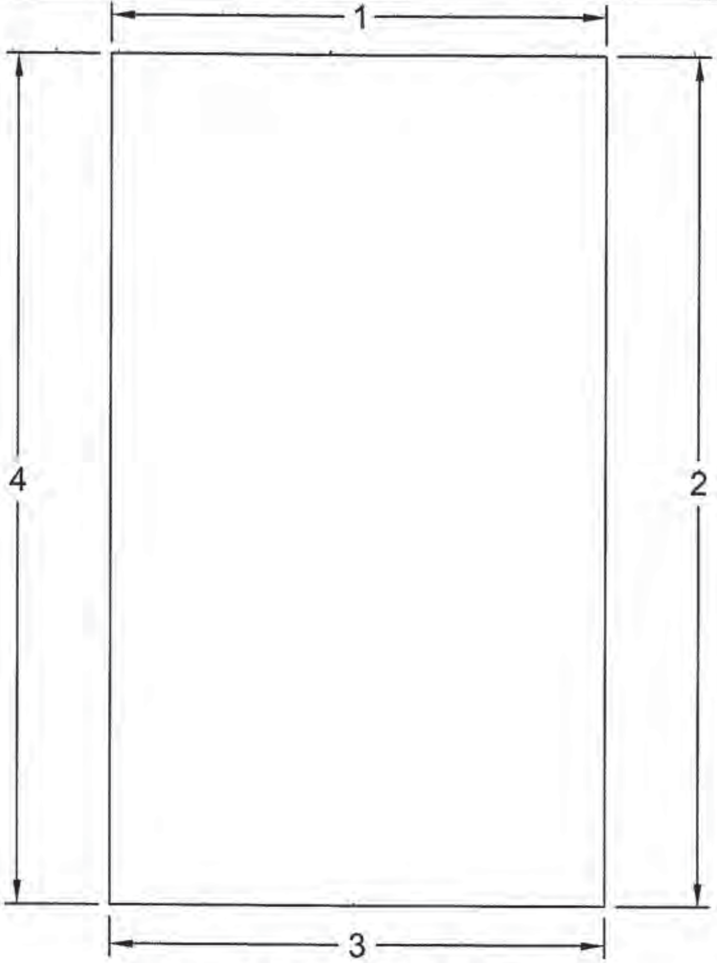
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



*For section B-B through F-F see Sheet 3 of 3

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Concrete As-built Sections	Sheet:	4	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

Project: Tests to Determine the Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A - 5

Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	174-1/16	119-15/16	174-0	174-1/8	120-0	173-7/8		
B-B	4-1/2	5-15/16	4-3/8	23-1/2	23-5/8	30-1/8	30-1/16	17-1/2
C-C	3-1/8	5-7/8	3-0	23-5/8	23-5/8	30-1/8	30-1/8	17-1/2
D-D	3-1/16	5-13/16	3-1/16	23-7/8	23-7/8	30-1/8	30-1/16	17-1/2
E-E	3-0	5-7/8	3-1/8	23-5/8	23-11/16	30-1/16	30-1/16	17-7/16
F-F	2-7/8	8-3/4	3-1/8	23-5/8	23-11/16	30-1/8	30-3/16	17-1/2

Recorded by:	Signature	Date	Time
BPR		4/23	2:50PM
Checked by:	**Signature**	**Date**	**Time**
TD		4/23	2:50PM
Checked by:	**Signature**	**Date**	**Time**

Comments:

*See formwork as-built drawings for dimension locations

Project: Tests to Determine the Behavior of Spliced #11 Bars

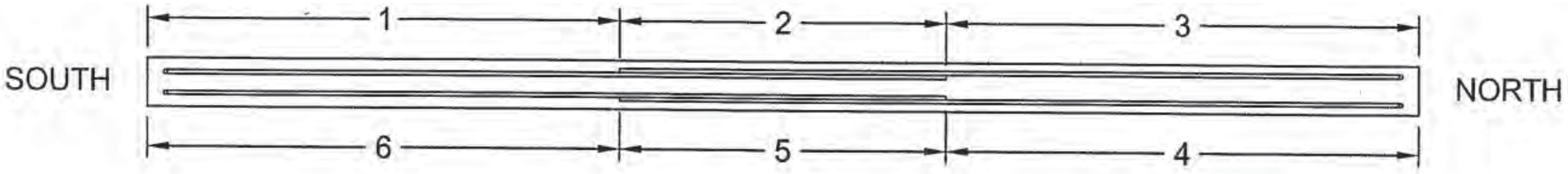
As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen:________________

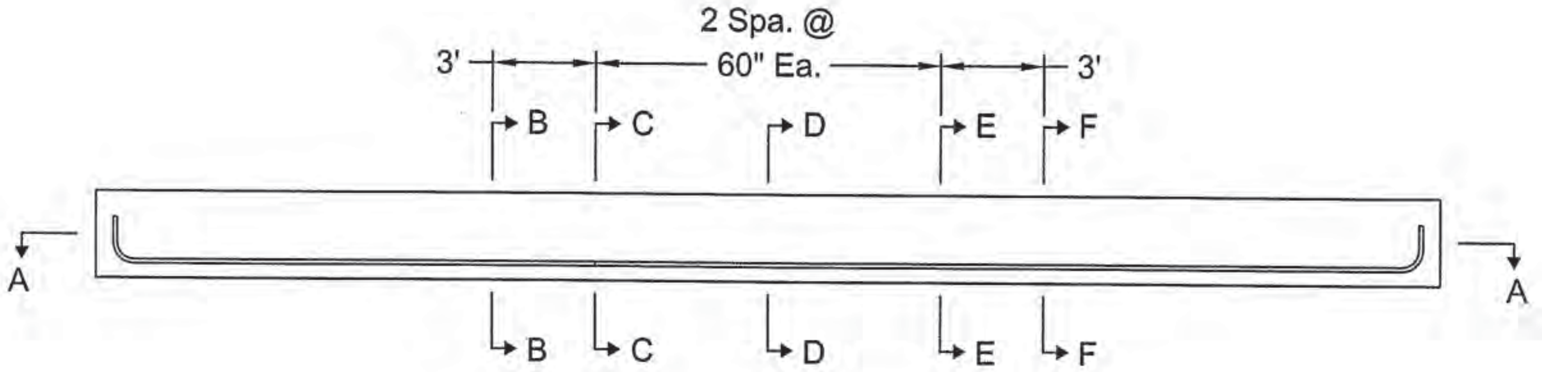
Sheet 2 of 2

Section	Formwork As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
A-A	14'-6"	10'-0"	14'-6"	14'-6"	10'-0"	14'-6"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Section	Formwork As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
A-A	13'-10.5"	6'-7"	13'-10.5"	13'-10.5"	6'-7"	13'-10.5"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"



Section A-A

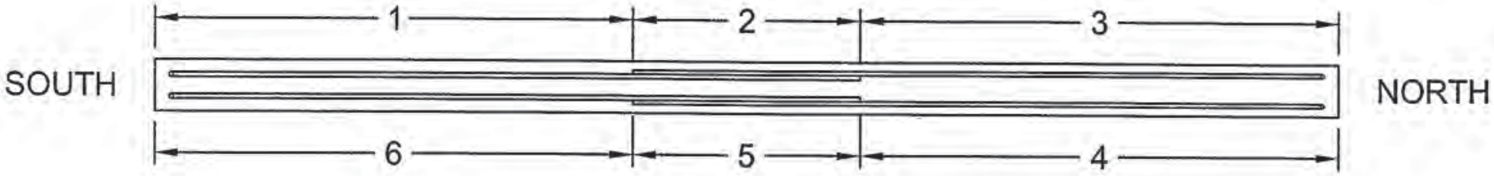


*For section B-B through F-F see Sheet 3 of 3

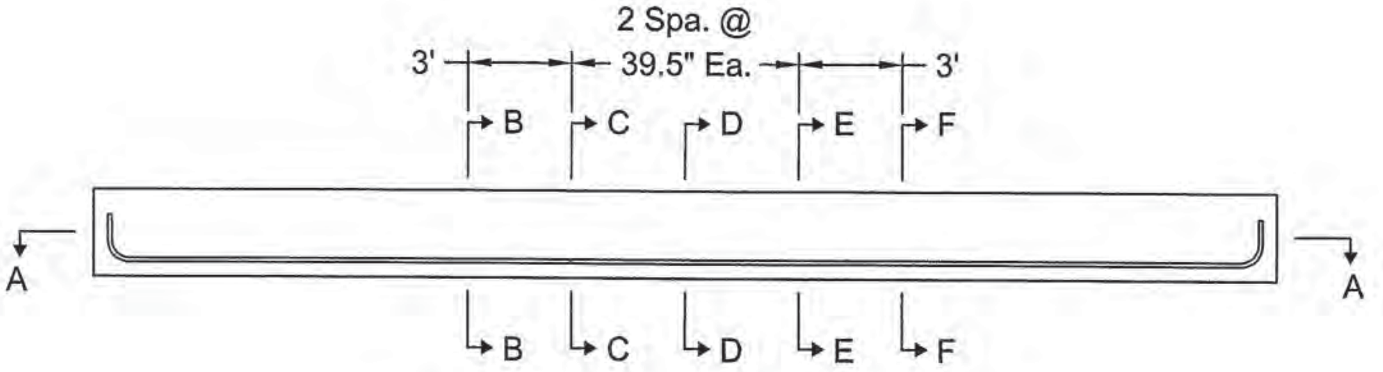
Series A

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



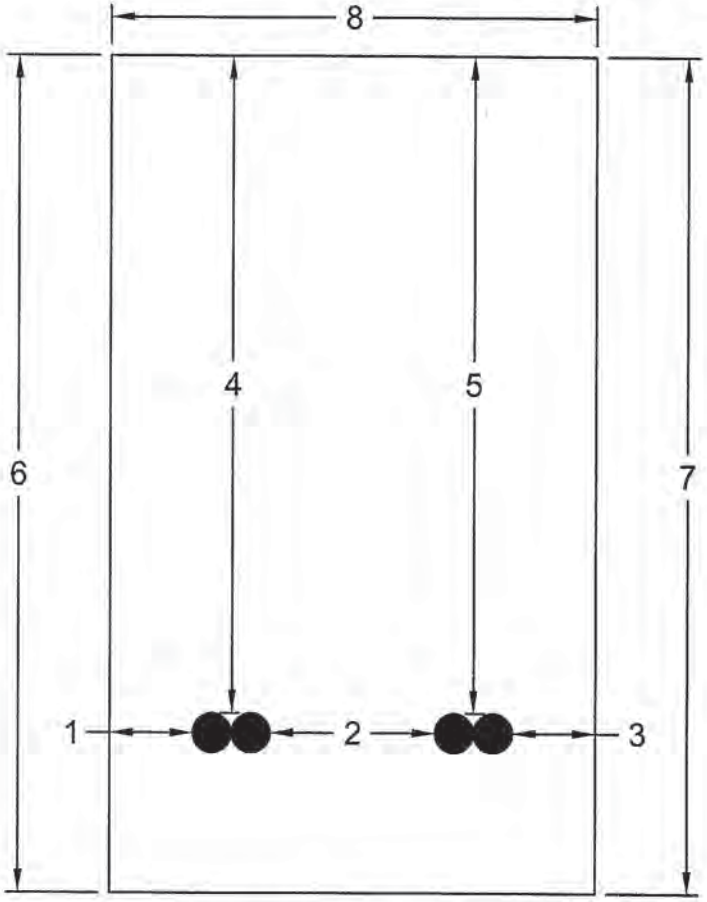
Section A-A



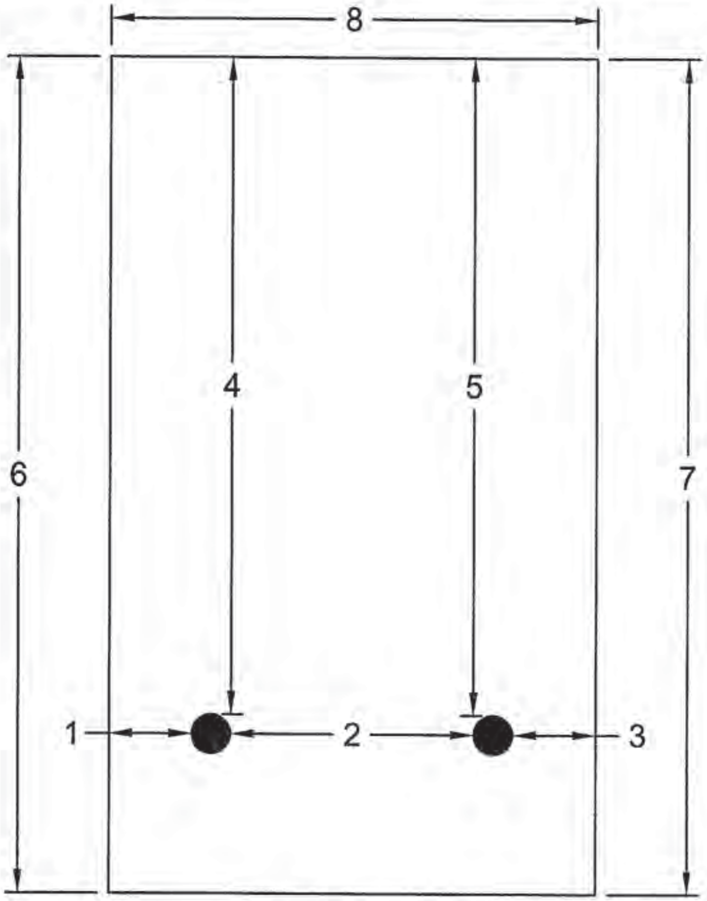
*For section B-B through F-F see Sheet 3 of 3

Series B

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Formwork As-builts	Sheet:	2	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Formwork As-built Sections	Sheet:	3	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: A-6

Sheet 1 of 1

General Information					
Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/24/12	1859193	1839	1:51	2:03	62°F
Measurements made upon arrival of concrete					
Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**			
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter	
2:05	8"	2:15	4.2%	Same as A-5	
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale	
2:25	8 1/2"	2:30	4.6%	Same as A-5	
Unit Weight (ASTM C138 - 10b)					
Time$_1$	Wt. of Cont.$_1$	Total Wt. $_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.	
2:12	8.5#	45#			
Time$_2$	Wt. of Cont.$_2$	Total Wt. $_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.	
2:30	8.5	44.6#			
Times of actions during and after casting					
Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
2:15	✓	✓	✓	✓	2:20PM
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
2:40PM	2:45PM	8:25PM	8:30PM	8:35PM	8:40PM
Recorded by		Signature		Date	Time
M.A. Sozen		Mete A Sozen		24 Apr 12	2:31
Checked by		Signature		Date	Time
BPR				4/24/12	2:33PM
Checked by		Signature		Date	Time
SAWorthy		SAWorth		4/24/12	2:34PM

Comments: Conc Temp. : 67.5°
3 Lifts

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1839	2463	user	1859193	0	13:51	4/24/12

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
6.50 CYDS	1008				D	1315

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual	Wat
STONE-8	940 lb	6110 lb	6060 lb	-0.82%	M		
STONE-4	620 lb	4030 lb	4000 lb	-0.74%			
SAND-23	1435 lb	9841 lb	9800 lb	-0.41%	5.50% M	61 gl	
CEMENT	588 lb	3822 lb	3860 lb	0.99%			
WATER	323.2 lb	1587.8 lb	1576.0 lb	-0.74%		188.9 gl	
AIR	.80 /C	30.58 oz	30.00 oz	-1.88%			

Actual Num Batches: 1

Load 25298 lb Design W/C: 0.550 Water/Cement: 0.544 T Design 251.7 gl Actual 250.1 gl To Add: 1.7 gl

Slump: 6.00 in # Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

3

A-6

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
10	1859193	1839	6.50cy	1000	6.00	BUCKET	04/24/12	16091

Sold To	Tax Code	Driver		Project No.	Order No.
GE CARD - LAFAYETTE & WINAMA	IN	DANNY SMITH	2463	5	1803

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB	3CN2535

Job No. 3CN2535

TRUCK RELEASE MIKE 555 708-1934

Time Printed 13:46

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
6.50	19.50cy	19.50cy	1000	PURDUE EXPERIMENTAL	89.00	578.50
				Environmental Fee		13.00

A-6

er Added At omer's Request		Total No. Gallons	Slump Meter Reading	8.0	Subtotal 591.50
On Job Time	Finish Pour Time	AUTH.#:	Grand Total: 1,774.50		Tax Total 591.50

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

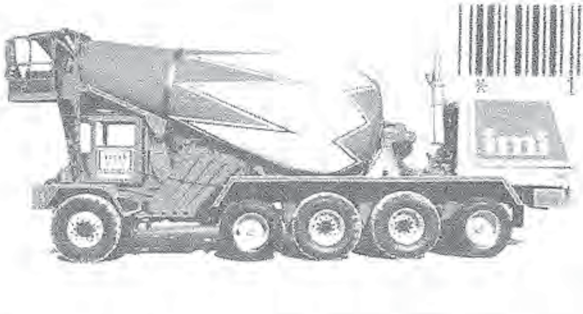
PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

2369654



* 1859193 *

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A6

Sheet 1 of 2

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan	39'-0"	38'-11 3/4"	39'-0"	38'-11 3/4"				
B-B	17-3/4"	30-1/16"	17-3/4"	30-1/8"				
C-C	17-3/4"	30-1/16"	17-3/4"	30-1/16"				
D-D	17-3/4"	30-1/16"	17-13/16"	30-1/8"				
E-E	17-13/16"	30-1/16"	17-13/16"	30-1/8"				
F-F	17-3/4"	30-1/8"	17-13/16"	30-1/8"				

Recorded by:	Signature	Date	Time
KAM		6.4.12	10:30pm
Checked by:	Signature	Date	Time
BPR		6/4/12	10:30PM
Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

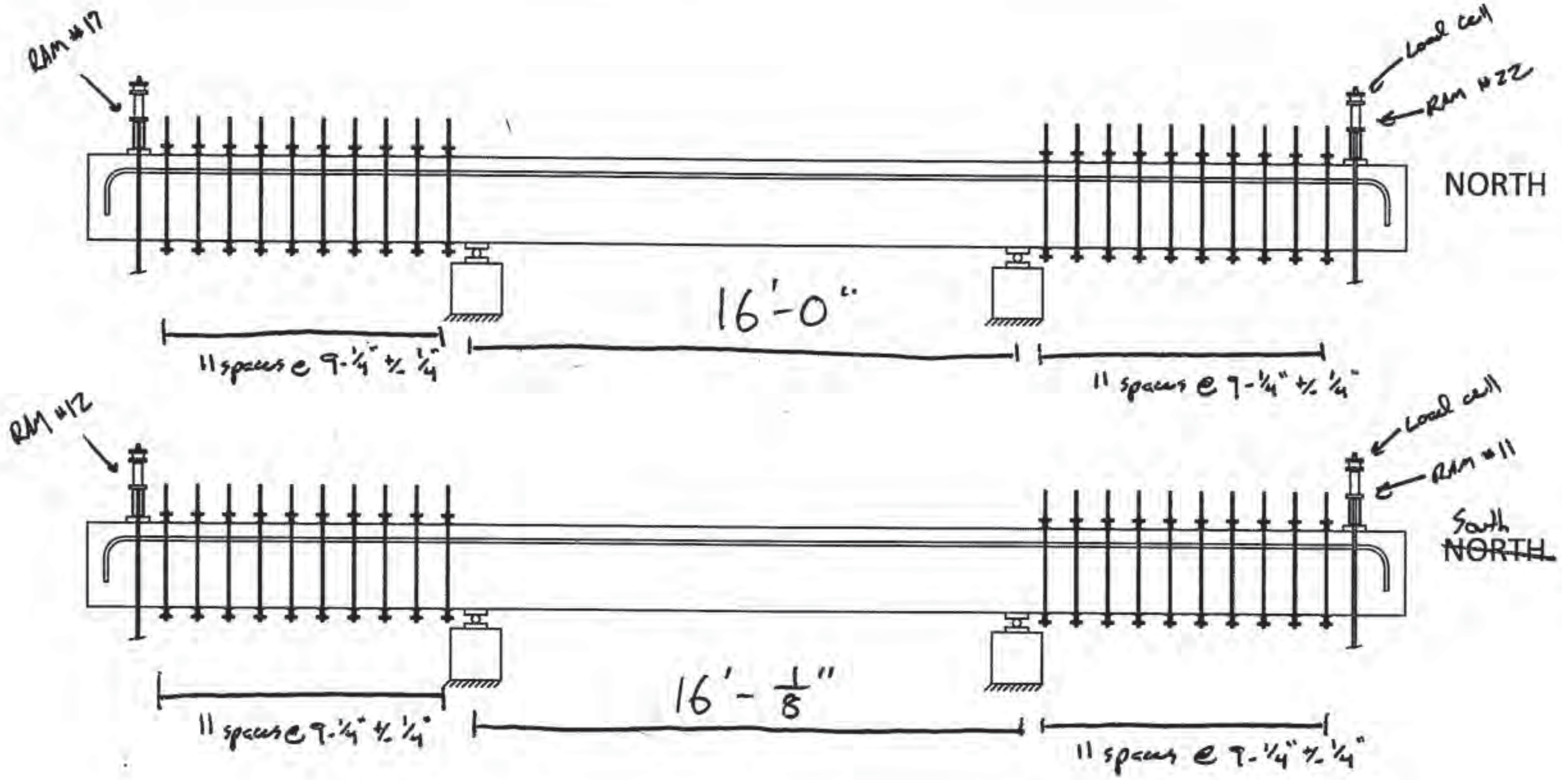
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-6

Sheet 2 of 2

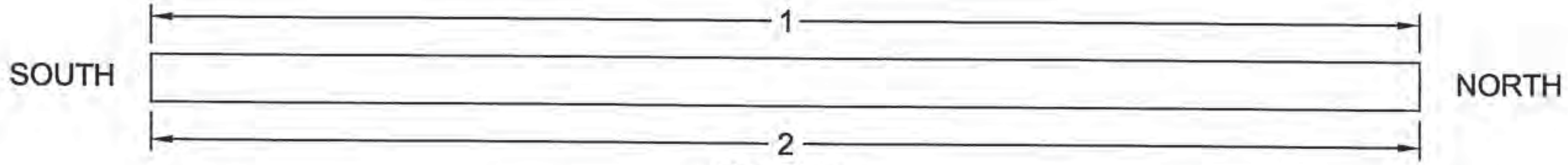
Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

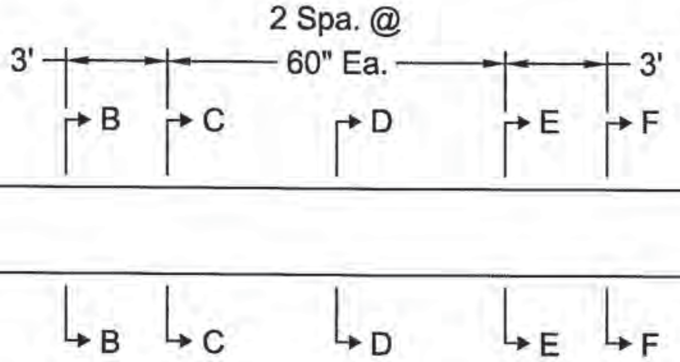


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen A-6	Sheet:	1	of	4
Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	KAn	Checked by:	BPR
	Date:	6-4-12		

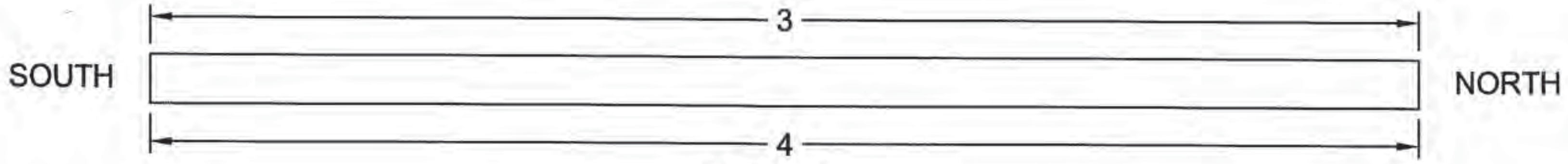


Top Plan



Profile

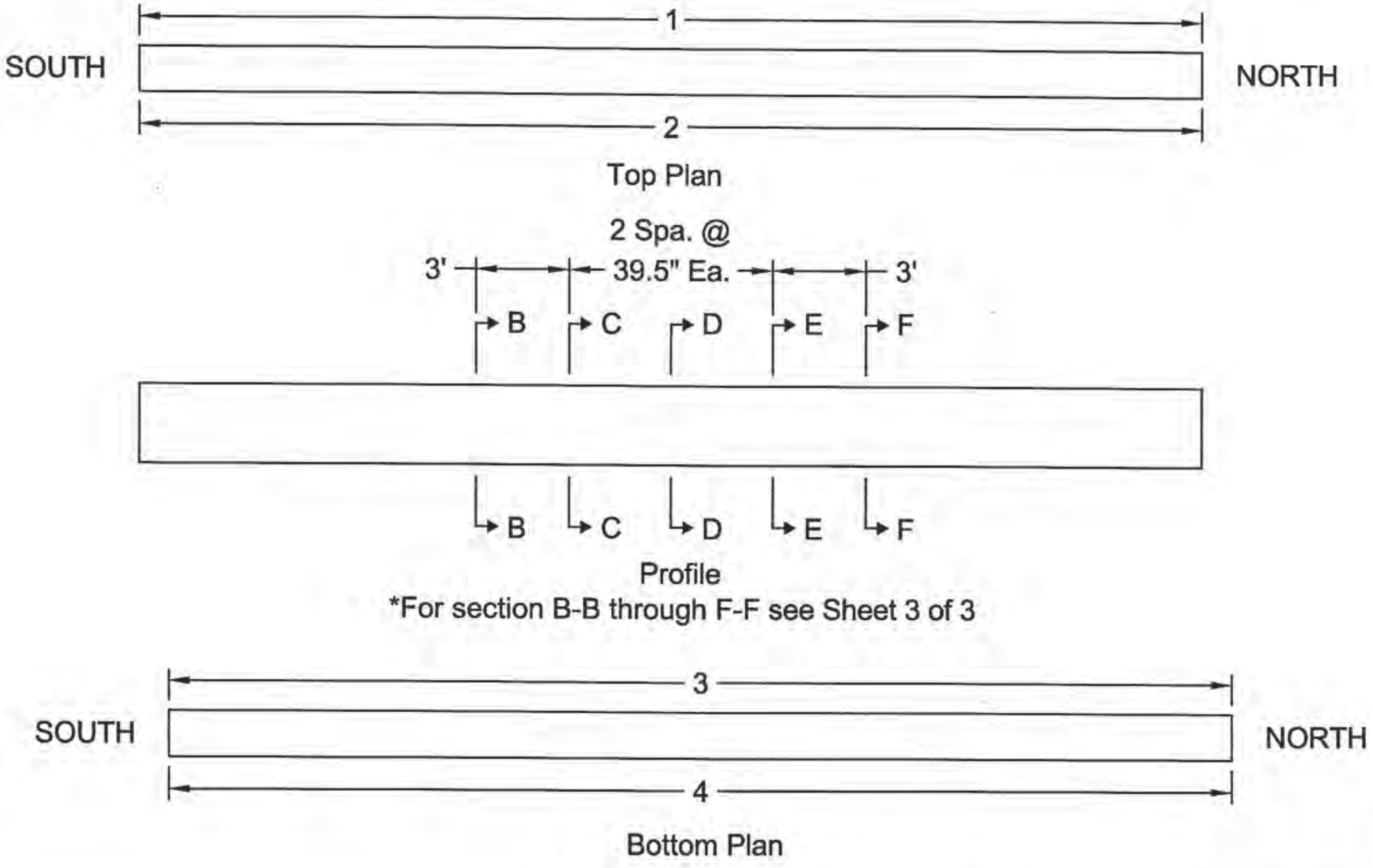
*For section B-B through F-F see Sheet 3 of 3



Bottom Plan

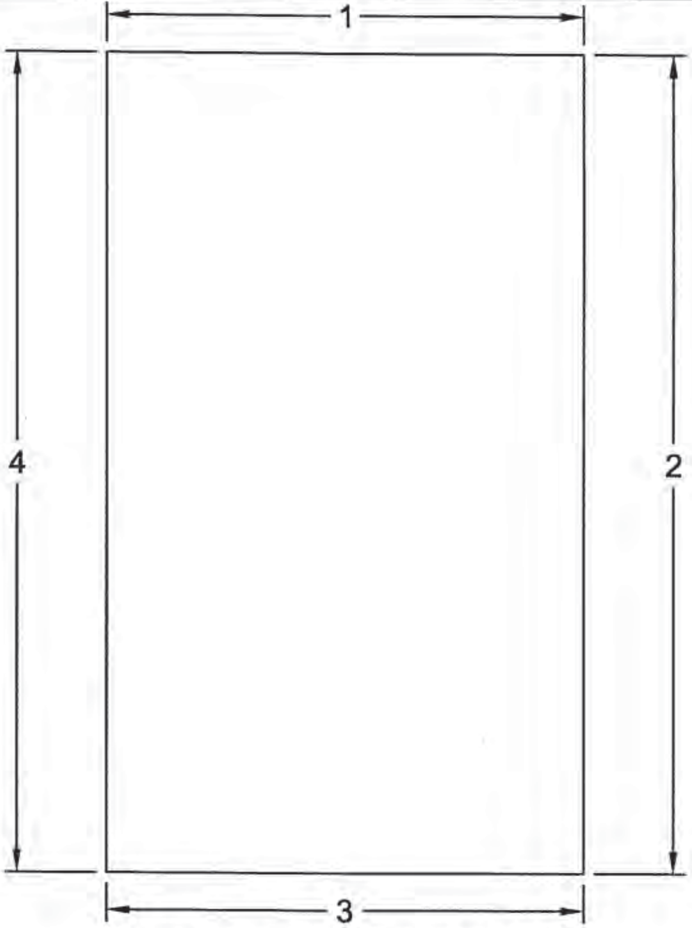
BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



*For section B-B through F-F see Sheet 3 of 3

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Concrete As-built Sections	Sheet:	4	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		

Project: Tests to Determine the Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: A-6

Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	173-15/16	120-1/8	173-7/8	174-0	119-15/16	173-15/16		
B-B	4-3/8	6-1/8	4-3/8	23-1/2	23-1/2	30-3/16	30-1/8	17-1/2
C-C	3-0	6-1/8	3-0	23-5/8	23-5/8	30-1/16	30-1/16	17-7/16
D-D	3-0	6-1/8	2-15/16	23-7/8	23-7/8	30-0	30-1/16	17-7/16
E-E	3-0	6-1/8	2-15/16	23-9/16	23-11/16	30-1/16	30-1/8	17-1/2
F-F	3-1/8	8-13/16	2-15/16	23-9/16	23-5/8	30-1/8	30-1/8	17-7/16

Recorded by:	Signature	Date	Time
BPR		4/23	3:20PM
Checked by:	Signature	Date	Time
TD		4/23	3:20Pm
Checked by:	Signature	Date	Time

Comments:

*See formwork as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

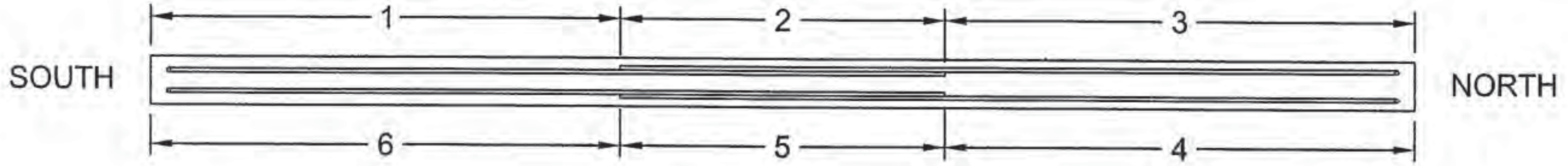
As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen:____________________

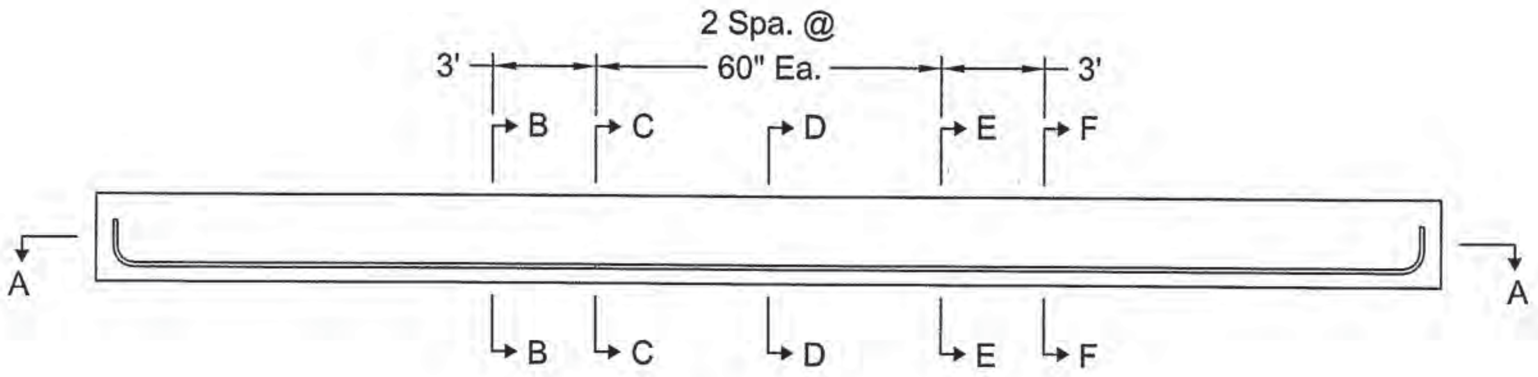
Sheet 2 of 2

Section	Formwork As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
A-A	14'-6"	10'-0"	14'-6"	14'-6"	10'-0"	14'-6"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Section	Formwork As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
A-A	13'-10.5"	6'-7"	13'-10.5"	13'-10.5"	6'-7"	13'-10.5"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"



Section A-A

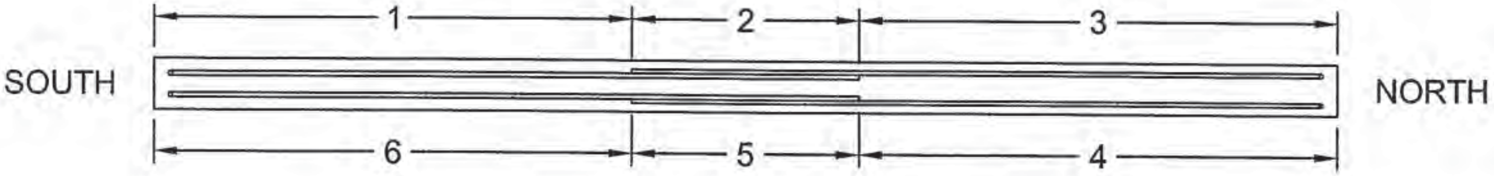


*For section B-B through F-F see Sheet 3 of 3

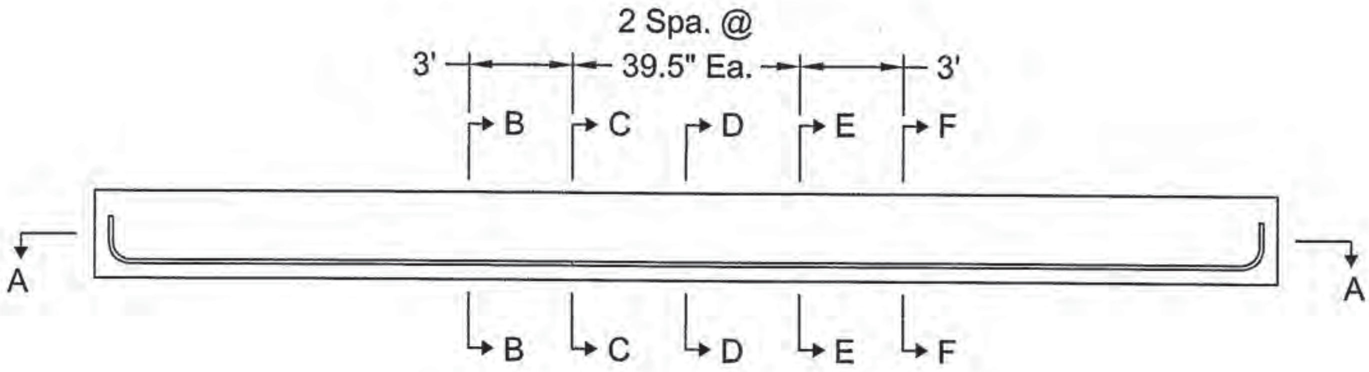
Series A

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section A-A

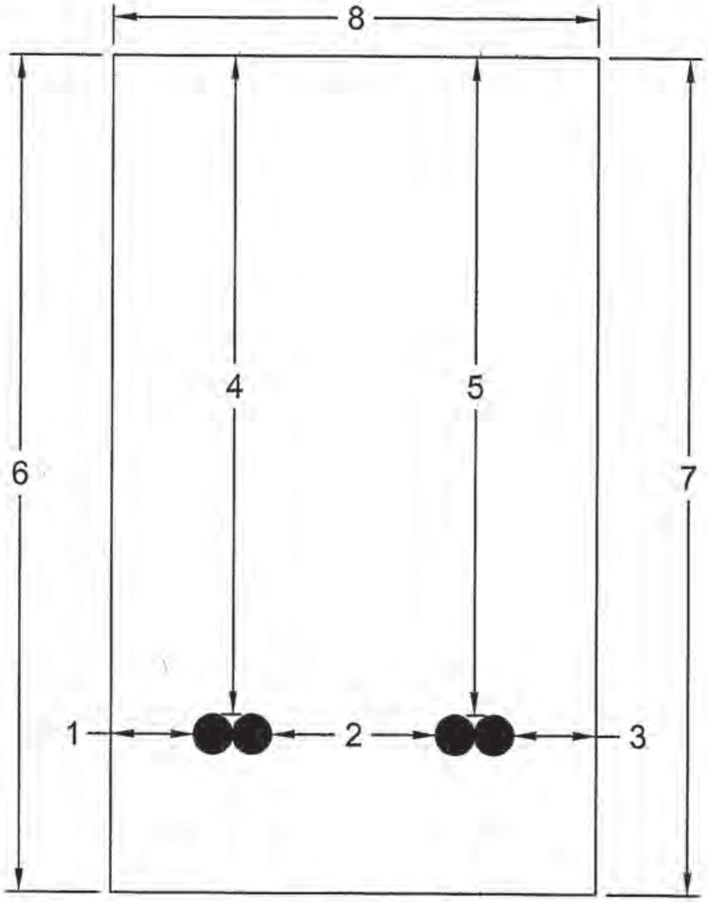


*For section B-B through F-F see Sheet 3 of 3

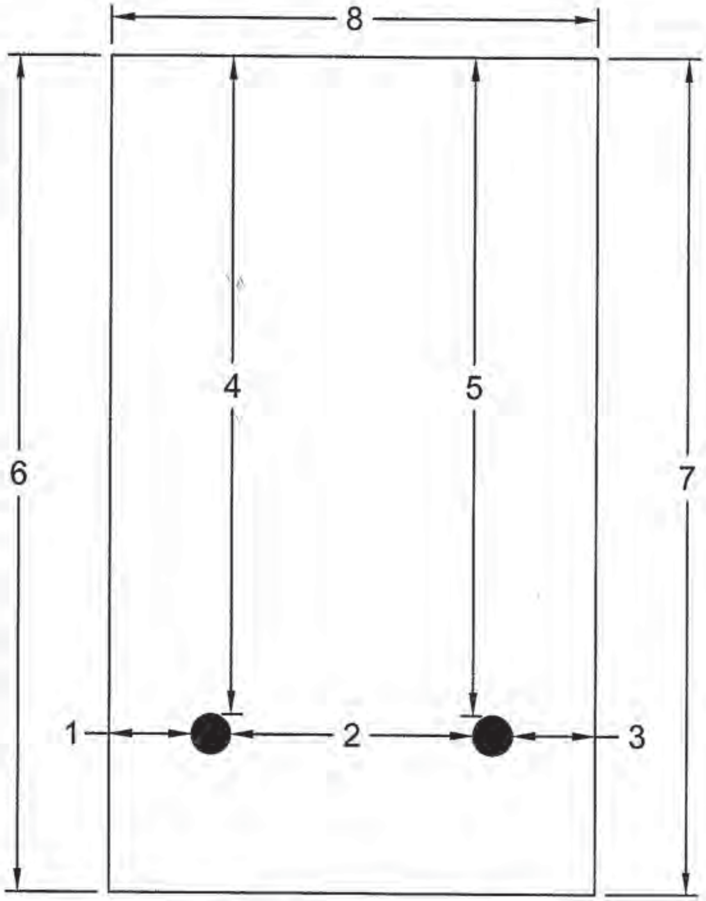
Series B

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series B Formwork As-builts	Sheet:	2	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Formwork As-built Sections	Sheet:	3 of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: B-1

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/10/12	1858848	1982	12:23	1:00 PM	60°F

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		Air Content (ASTM C231 - 10)		
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter
1:05	8.5"	1:17	5.8%	4130786891
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale
1:46	9.0"	1:56	5.8%	06746056HM

Unit Weight (ASTM C138 - 10b)

Time$_1$	Wt. of Cont.$_1$	Total Wt. $_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.
1:08	8.5#	43.9#		
Time$_2$	Wt. of Cont.$_2$	Total Wt. $_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.
1:54	~~9.0~~8.5#	43.3#		

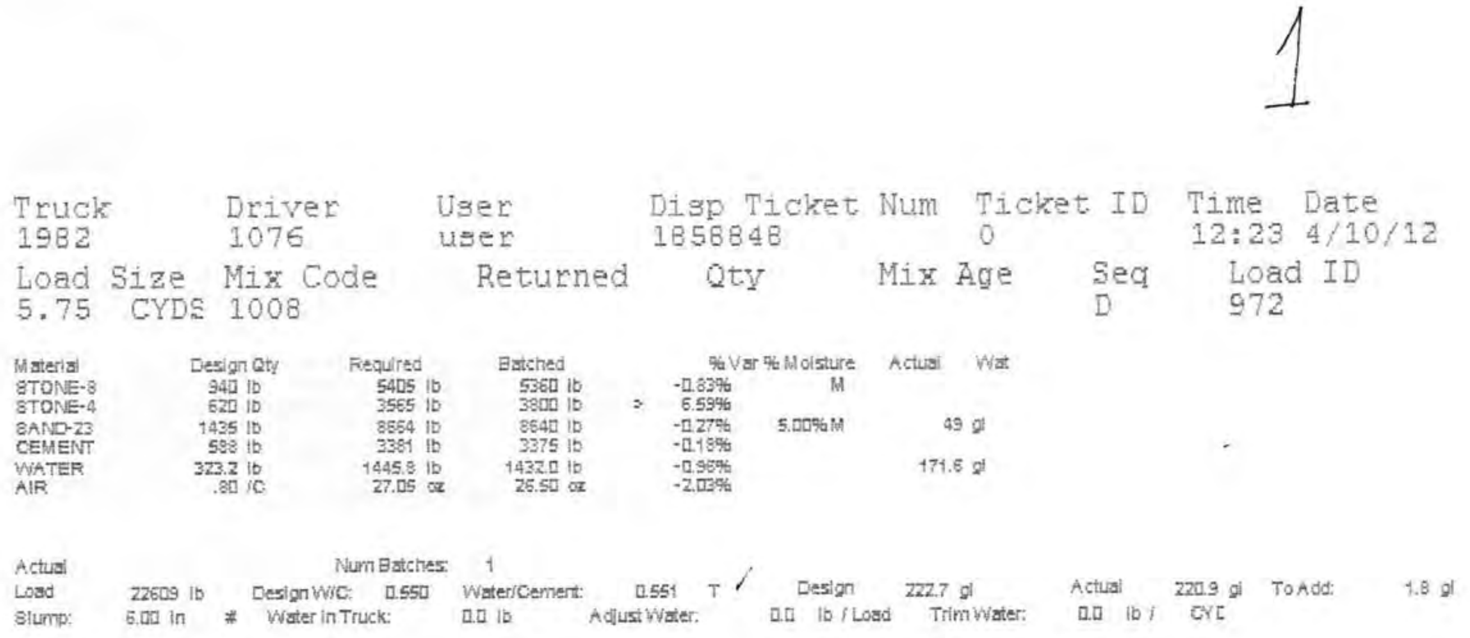
Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
1:17-1:22	✓	✓	1:45	✓	1:50
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
2:48	3:00 PM	8:10	✓	✓	✓

Recorded by	Signature	Date	Time
S.P.	A.D.	4/10/12	2:00
Checked by	Signature	Date	Time
B.R		4/10/12	2:00
Checked by	Signature	Date	Time
SWorth	SWorth	4/10/12	2:00PM

Comments:
Clump near midspan. → Broken
No leaks.
Concrete Temperature: 19°C @ 1:33 PM ← Merc. Probe
63°F @ 1:40 PM E. Probe /Pankow

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09



1

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1982	1076	user	1858848	0	12:23	4/10/12

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
5.75 CYDS	1008				D	972

Material	Design Qty	Required	Batched		% Var	% Moisture	Actual	Wat
STONE-8	940 lb	5405 lb	5360 lb		-0.83%	M		
STONE-4	620 lb	3565 lb	3800 lb	>	6.59%			
SAND-23	1435 lb	8664 lb	8640 lb		-0.27%	5.00% M	49 gl	
CEMENT	588 lb	3381 lb	3375 lb		-0.18%			
WATER	323.2 lb	1445.8 lb	1432.0 lb		-0.96%		171.6 gl	
AIR	.80 /C	27.05 oz	26.50 oz		-2.03%			

Actual Num Batches: 1

Load 22609 lb Design W/C: 0.550 Water/Cement: 0.551 T ✓ Design 222.7 gl Actual 220.9 gl To Add: 1.8 gl

Slump: 6.00 in # Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
15	1858846	1982	5.75cy	1000	6.00		01/10/18	16091

Sold To	Tax Code	Driver	Project No.	Order No.
CHARGE CARD - BOWEN LAB	IN	DOUG PHEBUS	1076 5	1001

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB	012-34x-0175

Job No. BOWEN13

TRUCK RELEASE

1

Time Printed 12:15

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	5.75cy	17.25cy	1000	PURDUE EXPERIMENTAL	89.00	511.75
				Environmental Fee		11.50

www.irvmat.com

Water Added At Customer's Request					Total No. Gallons	Slump Meter Reading				

Subtotal 523.25
Tax
Total 523.25

On Job Time	Finish Pour Time

AUTH.#1 Grand Total: 523.25

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

2369310

1858846

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

CUSTOMER COPY

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
18	1858848	1982	5.75cy	1008	5.00		04/10/12	16091

Sold To	Tax Code	Driver	Project No.	Order No.
CHARGE CARD - BOWEN LAB	IN	DOUG PHEBUS 1076	5	1801

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB	812-344-0114

Job No. SCH2513

TRUCK RELEASE

1

Time Printed 12:19

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	5.75cy	17.25cy	1008	PURDUE EXPERIMENTAL	89.00	511.75
				Environmental Fee		11.50

www.irvmat.com

Water Added At Customer's Request					Total No. Gallons	Slump Meter Reading				

On Job Time	Finish Pour Time

AUTH. #: Grand Total: 523.25

Subtotal	523.25
Tax	
Total	523.25

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X

2369310

1858848

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

DRIVER COPY

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-1

Sheet 1 of 2

Section	Concrete As-built Dimensions T		B					
	1.	2 W	3	4 E	5	6	7	8
Plan	34'-3 1/2"	34'-3 1/2"	34'-3 1/2"	34'-3 1/2"				
B-B	17 11/16	30" 1/16"	17 5/8	30 1/16"				
C-C	17 5/8	30"	17 3/4"	30"				
D-D	17 5/8"	30 1/16	17 5/16	30"				
E-E	17 9/16	30 1/16	17 5/8	30"				
F-F	17 5/8	30 1/16	17 5/8	30 1/16"				

Recorded by:	Signature	Date	Time
M. A. Sozen		9 May 2012	10:20 a

Checked by:	Signature	Date	Time
S. Pujol		9 May 2012	10:22 am

Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

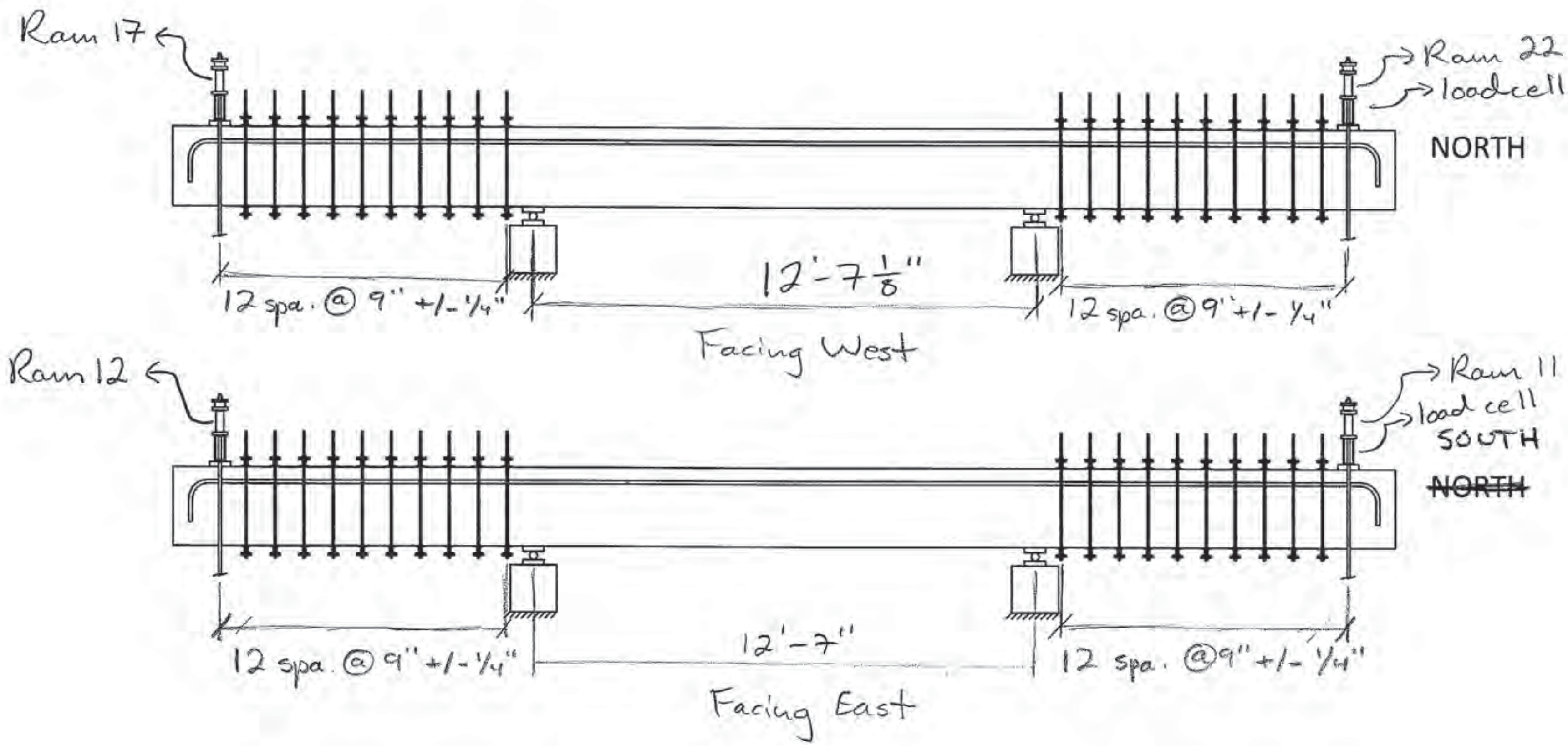
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-1

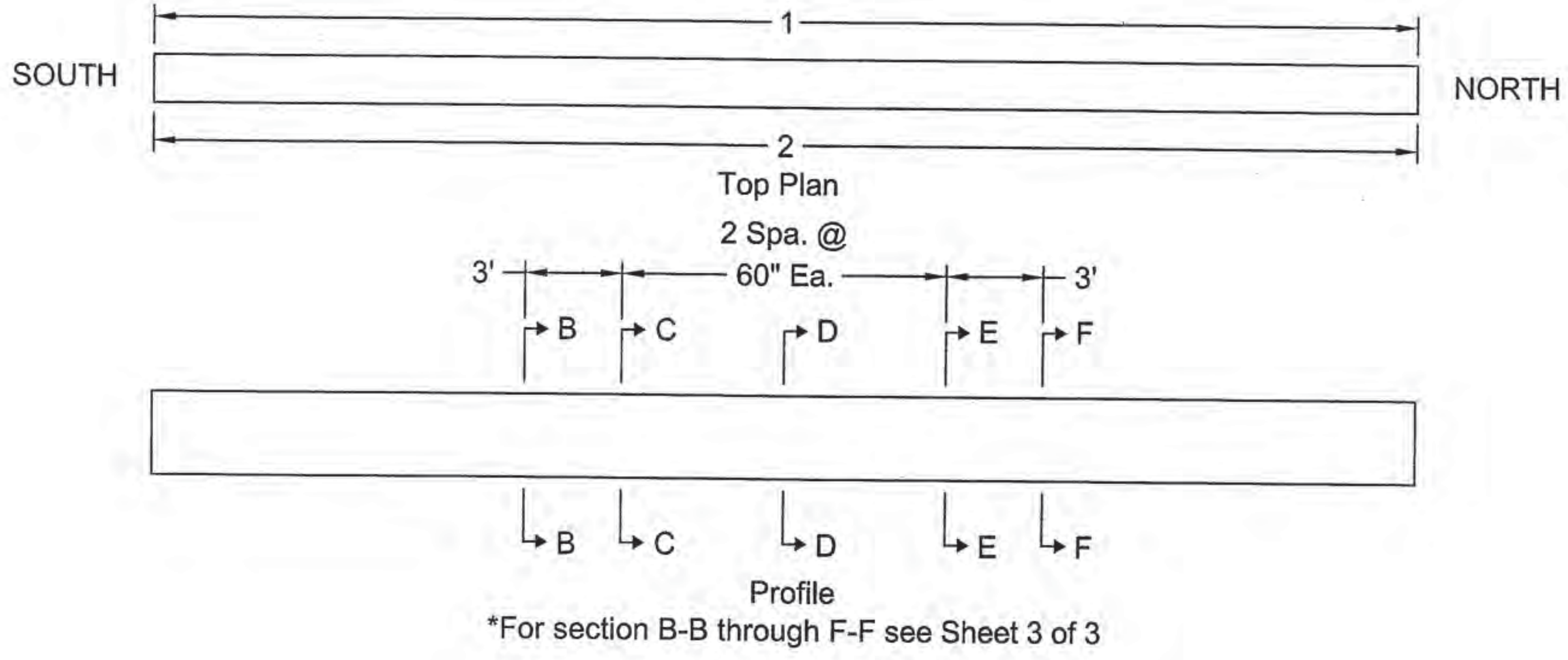
Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

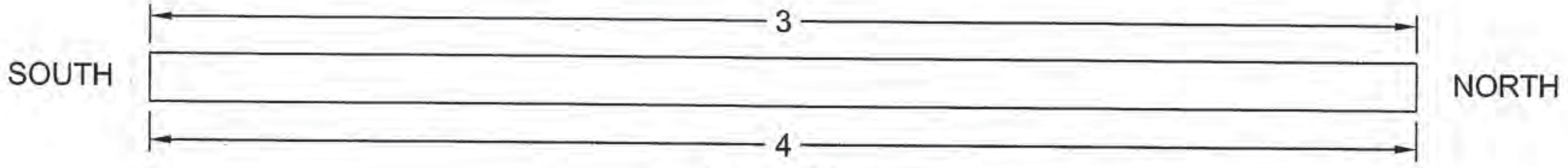
Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A



BOWEN LABORATORY PURDUE UNIVERSITY	Specimen B-1	Sheet: 1	of	4
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by: BPR	Checked by:	S. P
		Date: 5/10/12		



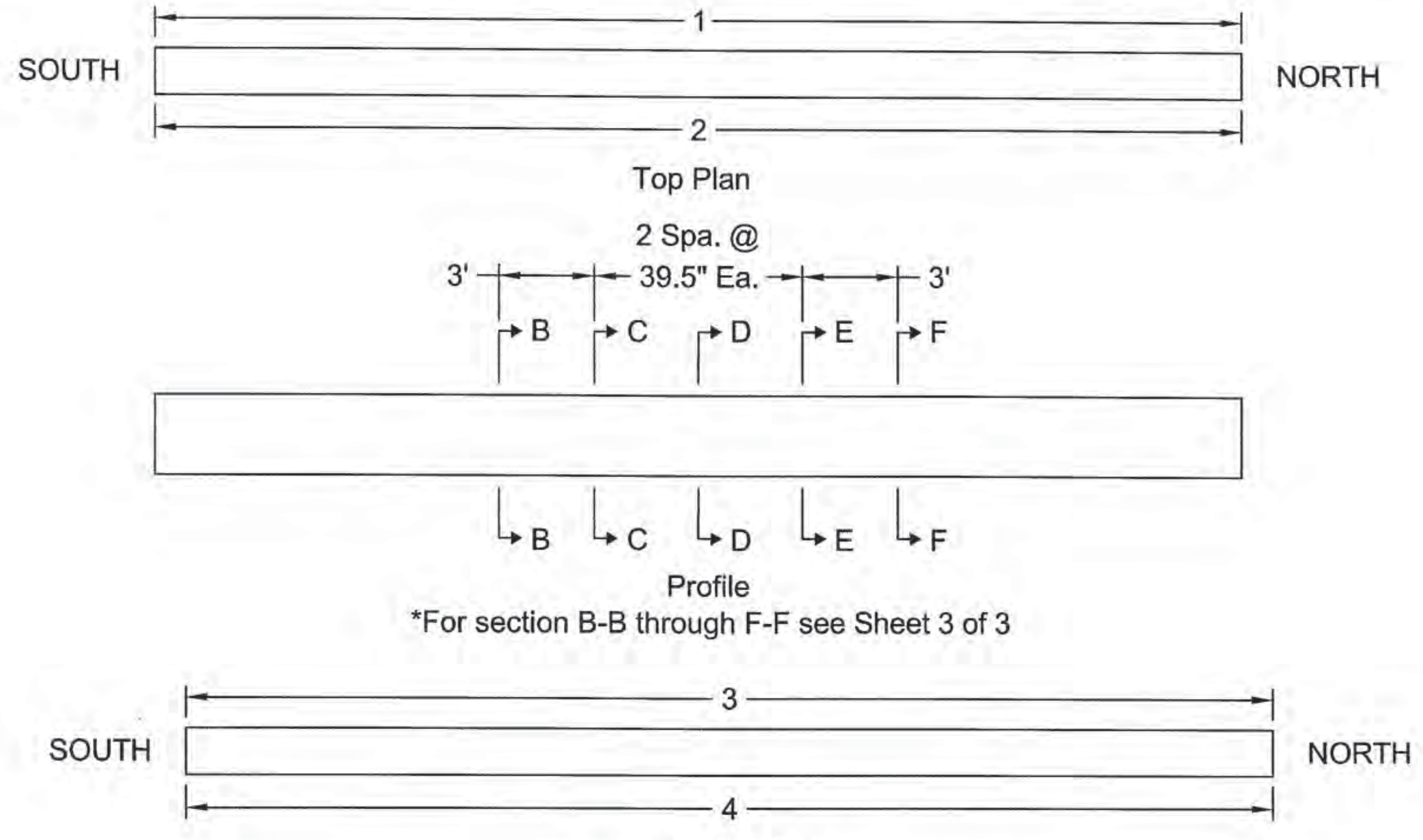
*For section B-B through F-F see Sheet 3 of 3



Bottom Plan

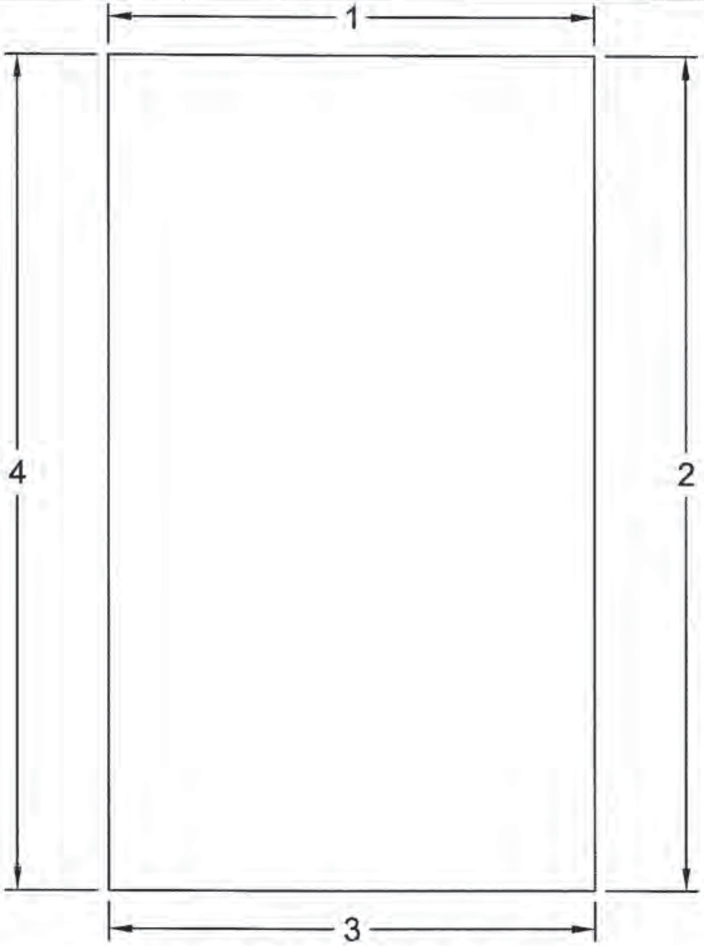
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series A Concrete As-builts	Sheet:	2 of 4	
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by: BPR	Checked by: SP	
			Date:	04/04/2012	

1-24



Bottom Plan

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Concrete As-builts	Sheet:	3	of 4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Concrete As-built Sections	Sheet:	4	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-1

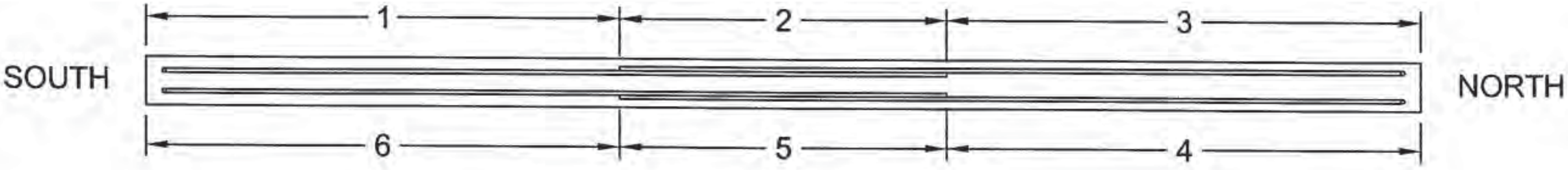
Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	166 5/8	78 15/16	166 7/16	166 1/2	79	166 3/4		
B-B	4 3/8	5 7/8	4 9/16	23 5/8	23 5/8	30 1/8	30 1/8	17 7/16
C-C	2 7/8	5 15/16	3 1/4	23 11/16	23 5/8	30 1/8	30 1/8	17 5/8
D-D	3	6	3	23 11/16	23 5/8	30 1/8	30 3/16	17 7/16
E-E	3 1/16	5 15/16	3	23 5/8	23 3/4	30 1/8	30 1/8	17 7/16
F-F	3 1/8	8 5/8	3 1/16	23 3/4	23 5/8	30 1/8	30 1/8	17 9/16

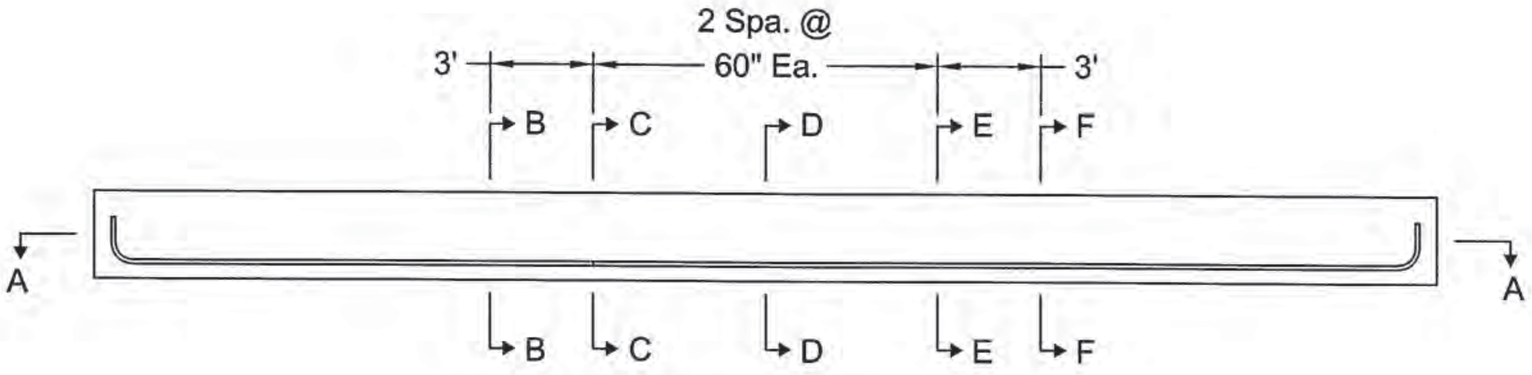
Recorded by:	Signature	Date	Time
KAM		4-8-12	11:15PM
Checked by:	Signature	Date	Time
WHP		4/8/2012	11:30 PM
Checked by:	Signature	Date	Time

Comments:

*See formwork as-built drawings for dimension locations



Section A-A

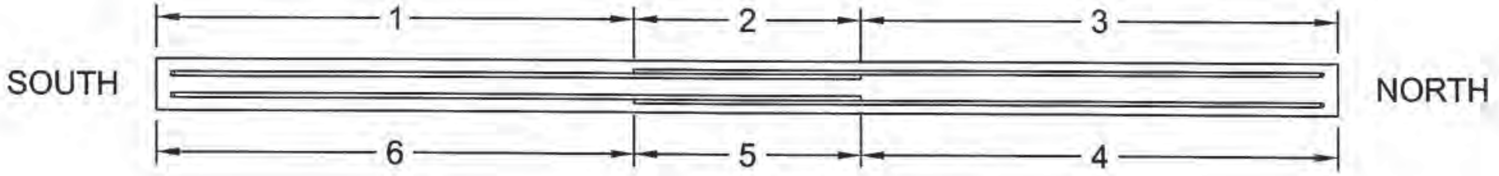


*For section B-B through F-F see Sheet 3 of 3

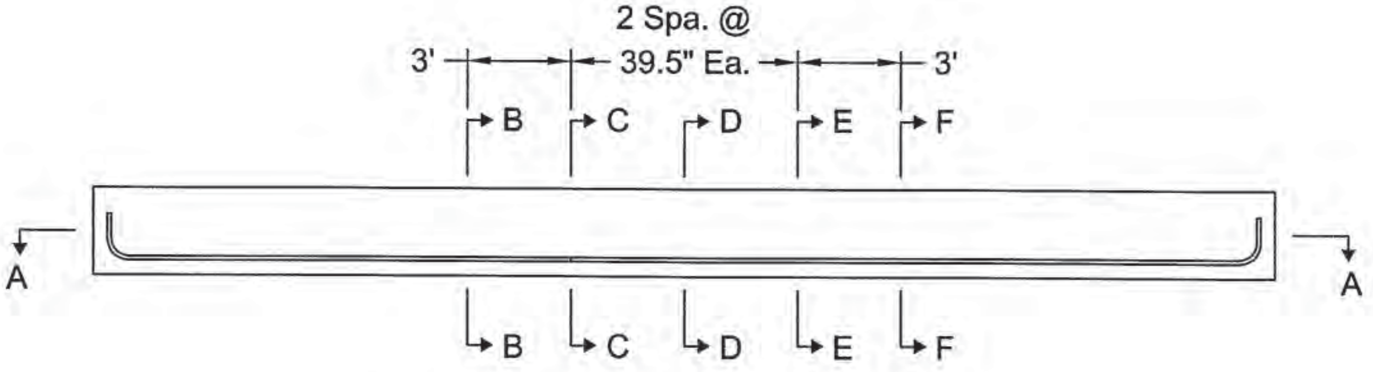
Series A

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section A-A

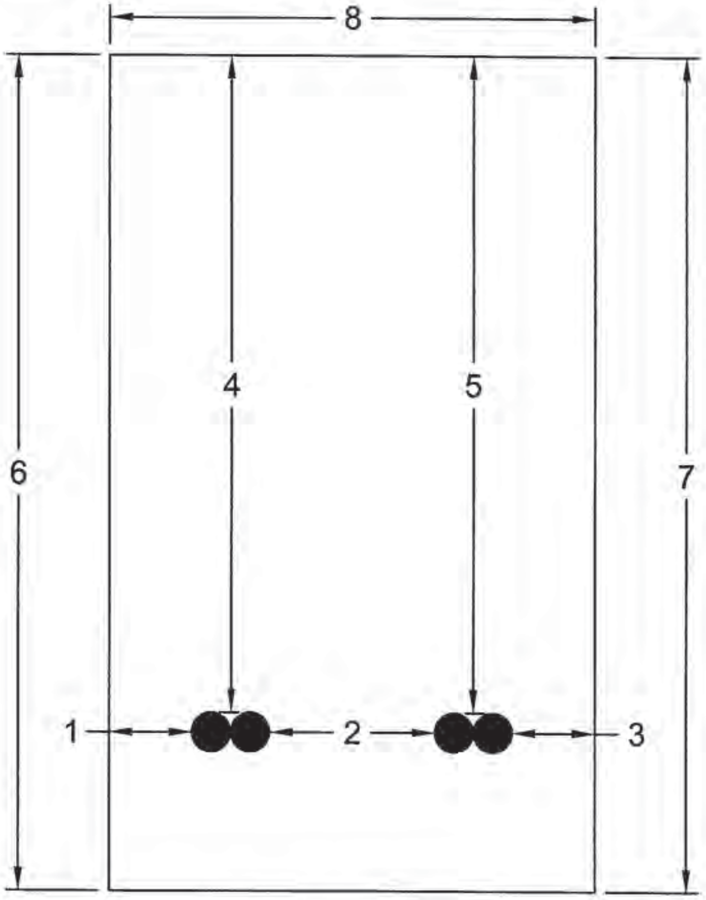


*For section B-B through F-F see Sheet 3 of 3

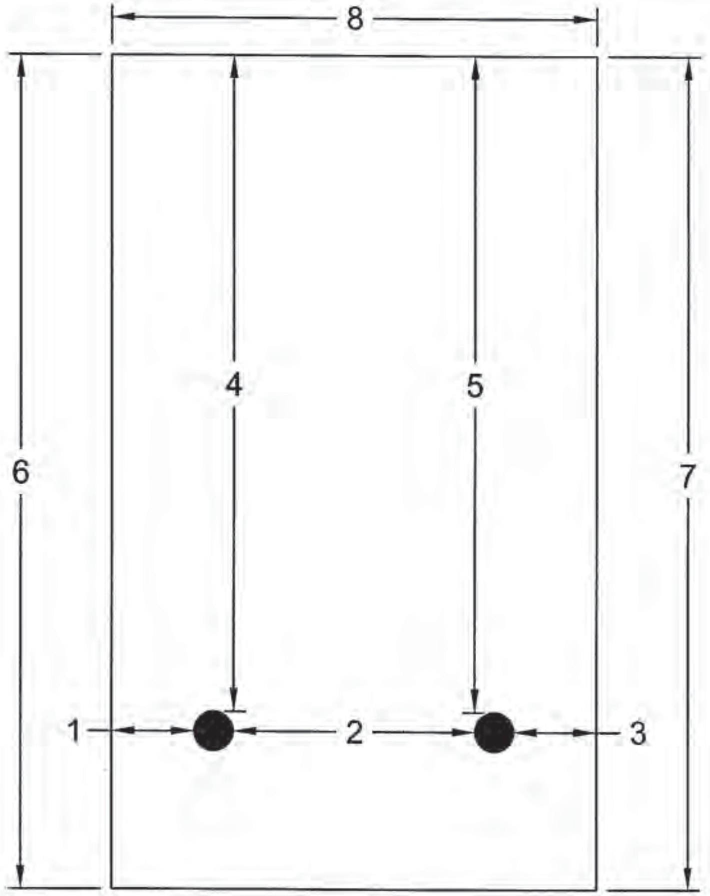
Series B

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series B Formwork As-builts	Sheet:	2	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Formwork As-built Sections	Sheet:	3	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: B-2

Sheet 1 of 1

General Information					
Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/10/12	1858853	1839	1:48	2:08	58°F
Measurements made upon arrival of concrete					
Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**			
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter	
2:10	8 1/2"	2:16	5.4%	4130786891	
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale	
2:36	9"	2:40	5.4%	06746056HM	
Unit Weight (ASTM C138 - 10b)					
Time$_1$	Wt. of Cont.$_1$	Total Wt. $_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.	
2:12	8.5#	43.9#			
Time$_2$	Wt. of Cont.$_2$	Total Wt. $_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.	
2:38	8.5#	43.8			
Times of actions during and after casting					
Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
2:16 To 2:20	✓	2:22–2:24	✓	✓	2:32
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
3:40	3:45	✓	✓	✓	✓
Recorded by		Signature		Date	Time
				4/10/12	2:50
Checked by		Signature		Date	Time
Brian Richter				4/10/12	3:00
Checked by		Signature		Date	Time
				4/10/12	2:51

Comments: Spread 14" @ 2:10, 15" @ 2:36. No leaks
Temp. of concrete: 65 °F E Gage.
3 lifts. : 3rd lift 2:25 To 2:30 · vibrated: ✓

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1839	2463	user	1858853	0	13:48	4/10/12

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
5.75 CYDS	1008				D	977

Material	Design Qty	Required	Batched	% Var	% Moisture	Actual	Wat
STONE-8	940 lb	5405 lb	5360 lb	-0.83%	M		
STONE-4	620 lb	3565 lb	3540 lb	-0.70%			
SAND-23	1435 lb	8664 lb	8640 lb	-0.27%	5.00% M	49 gl	
CEMENT	588 lb	3381 lb	3365 lb	-0.47%			
WATER	323.2 lb	1445.8 lb	1442.0 lb	-0.27%		172.8 gl	
AIR	.80 /C	27.05 oz	27.50 oz	1.67%			

2

Actual Num Batches: 1

Load 22349 lb Design W/C: 0.550 Water/Cement: 0.552 ✓ T Design 222.7 gl Actual 222.1 gl To Add: 0.6 gl

Slump: 6.00 in # Water In Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
10	1858852	1837	5.75yd	1000	6.00		01/10/12	16091

Sold To	Tax Code	Driver	Project No.	Order No.
CHARGE CARD - BOWEN LAB	IN	DANNY SMITH	5	1601

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB	[illegible]

TRUCK RELEASE

2

Job No. [illegible]

Time Printed 13:46

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	11.50yd	17.25yd	1000	PURDUE EXPERIMENTAL	91.00	523.25
				Environmental Fee		0.00

www.irvmat.com

Water Added At Customer's Request	0	Total No. Gallons	Slump Meter Reading	7.00

On Job Time

Finish Pour Time

AUTH.#: Grand Total: 1,046.50

Subtotal 523.25
Tax
Total 523.25

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

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NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

2369315

1858852

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" General Office (317) 326-3101

CUSTOMER COPY

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
18	1858853	1839	5.75cy	1008	6.00		04/10/12	16091

Sold To	Tax Code	Driver		Project No.	Order No.
CHARGE CARD - BOWEN LAB	IN	DANNY SMITH	2463	5	1801

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB	812-349-0119

TRUCK RELEASE

2

Job No. CN2513

Time Printed 13:46

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	11.50cy	17.25cy	1008	PURDUE EXPERIMENTAL	89.00	511.75
				Environmental Fee		11.50

www.irvmat.com

Water Added At Customer's Request			0	Total No. Gallons	Slump Meter Reading	7	0	0	

On Job Time	Finish Pour Time

AUTH.#:

Grand Total: 1,046.50

Subtotal	523.25
Tax	
Total	523.25

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

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Release, Load and Terms Accepted By:
X

2369315

* 1 8 5 8 8 5 3 *

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" General Office (317) 326-3101

DRIVER COPY

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-2

Sheet 1 of 2

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan	34'-4 1/4"	34'-4 3/8"	34'-4 1/4"	34'-4 1/2"				
B-B	17-5/8"	30-1/8"	17-9/16"	30-1/8"				
C-C	17-5/8"	30-1/8"	17-7/16"	30-1/16"				
D-D	17-11/16"	30-1/8"	17-5/8"	30-1/16"				
E-E	17-11/16"	30-1/8"	17-5/8"	30-1/16"				
F-F	17-3/4"	30-1/8"	17-5/8"	30-1/8"				

Recorded by:	Signature	Date	Time
KAM		5-22-12	5:00pm

Checked by:	Signature	Date	Time
BPR		5/22/12	5:10PM

Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the Behavior of Spliced #11 Bars

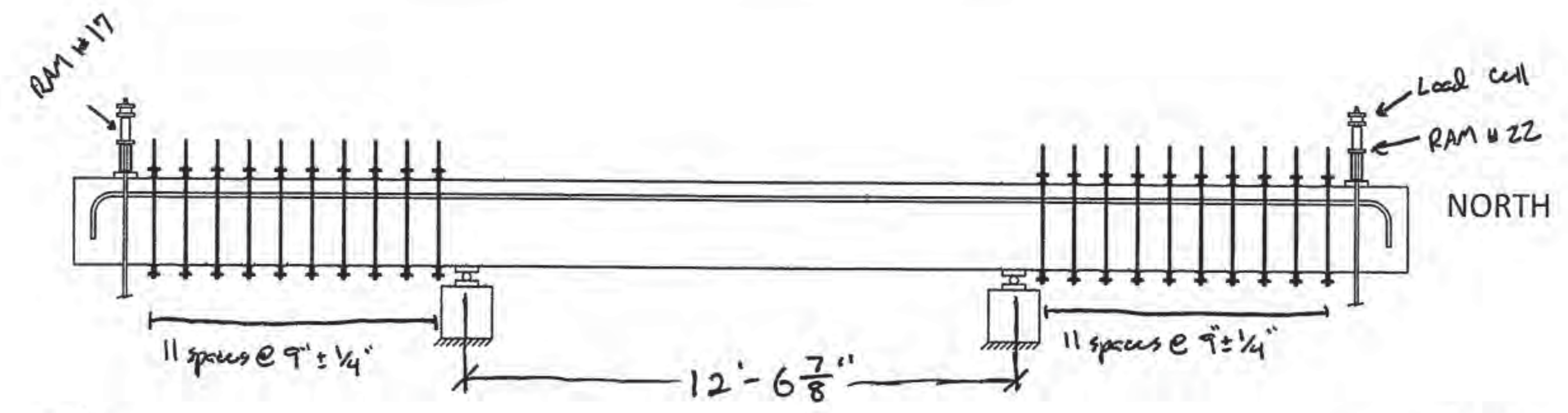
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

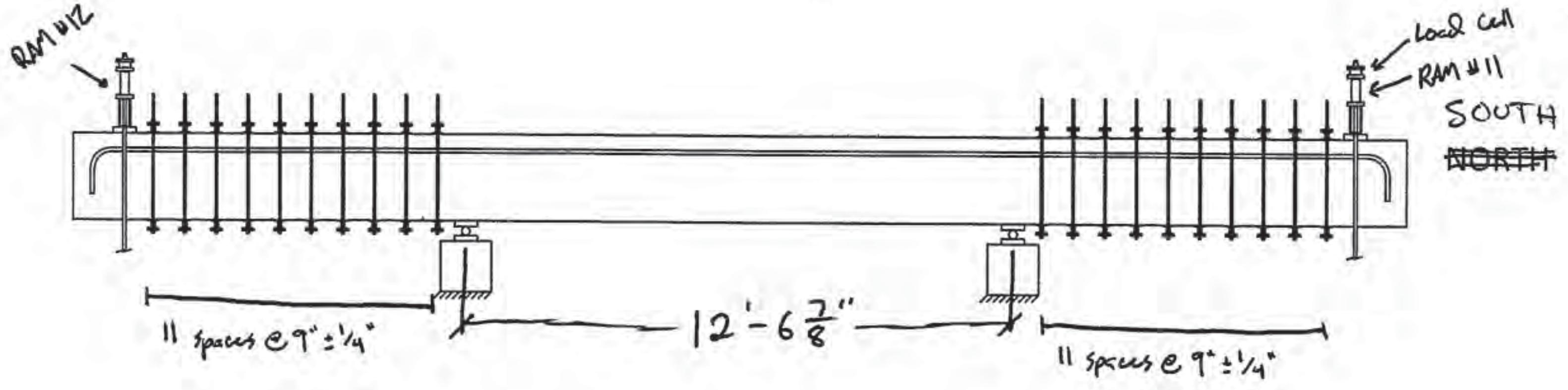
Specimen: B-2

Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

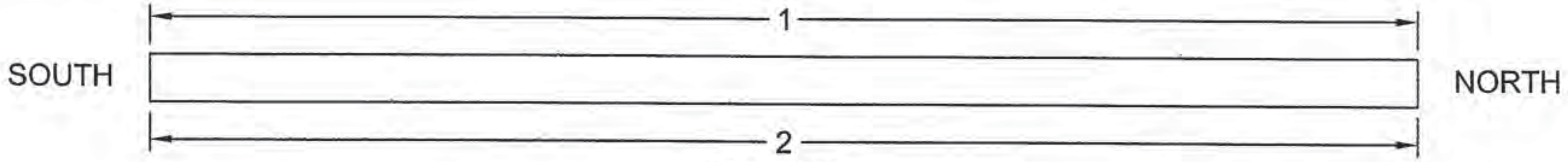
Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A



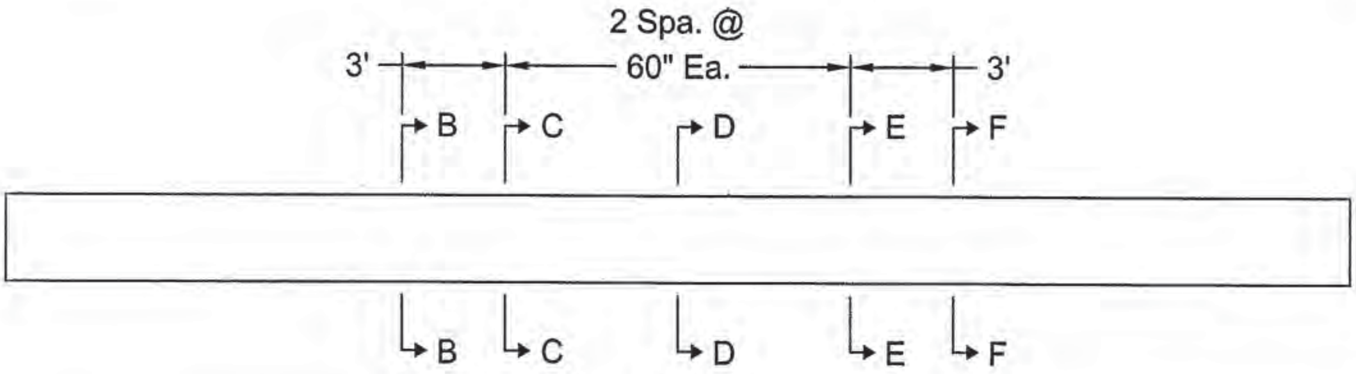


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen B-2	Sheet:	1	of	4
Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	KAM	Checked by:	BPR
	Date:	6-22-12		

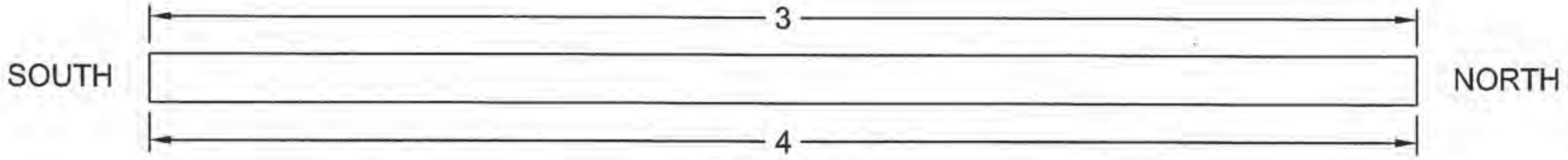


Top Plan



Profile

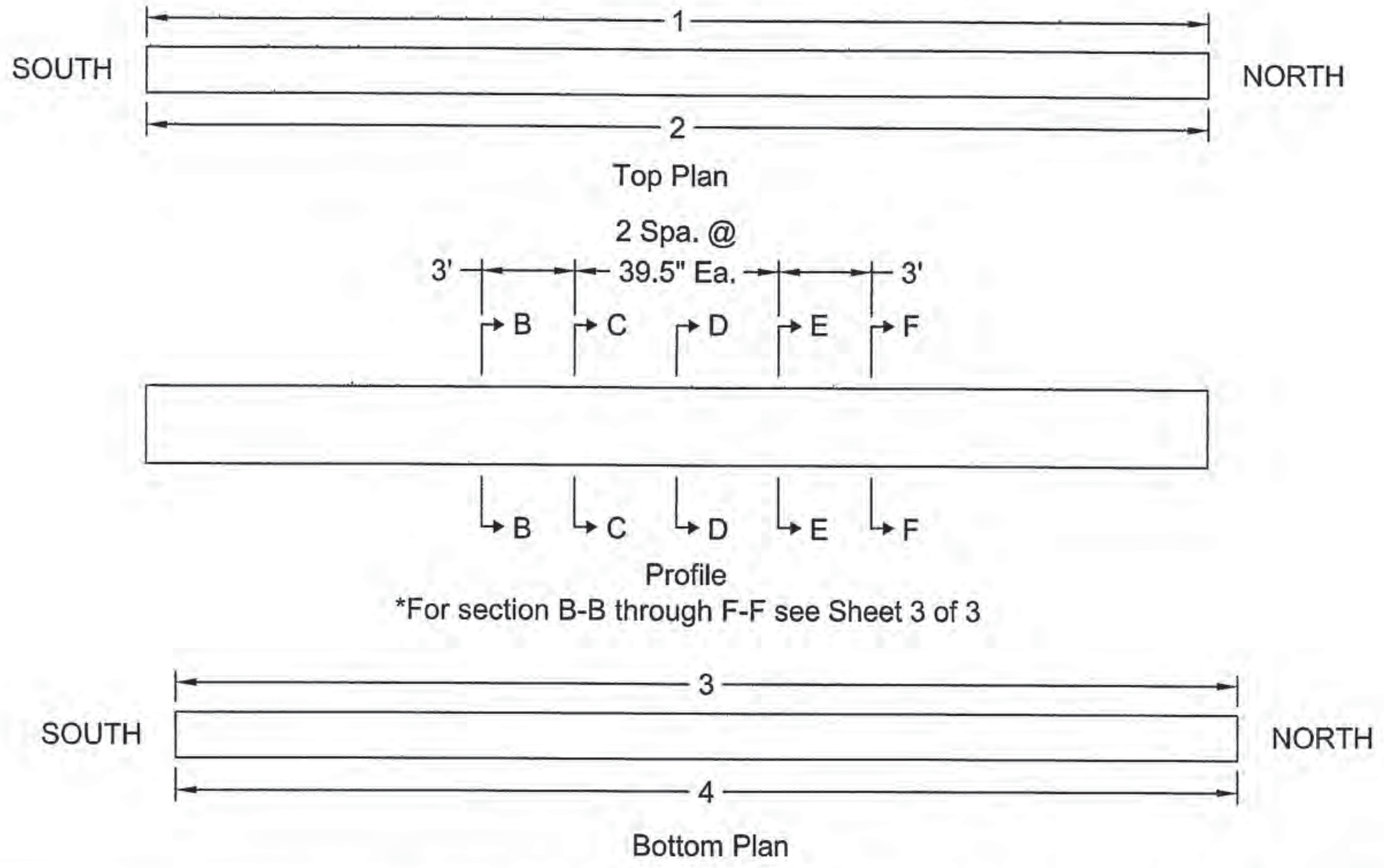
*For section B-B through F-F see Sheet 3 of 3



Bottom Plan

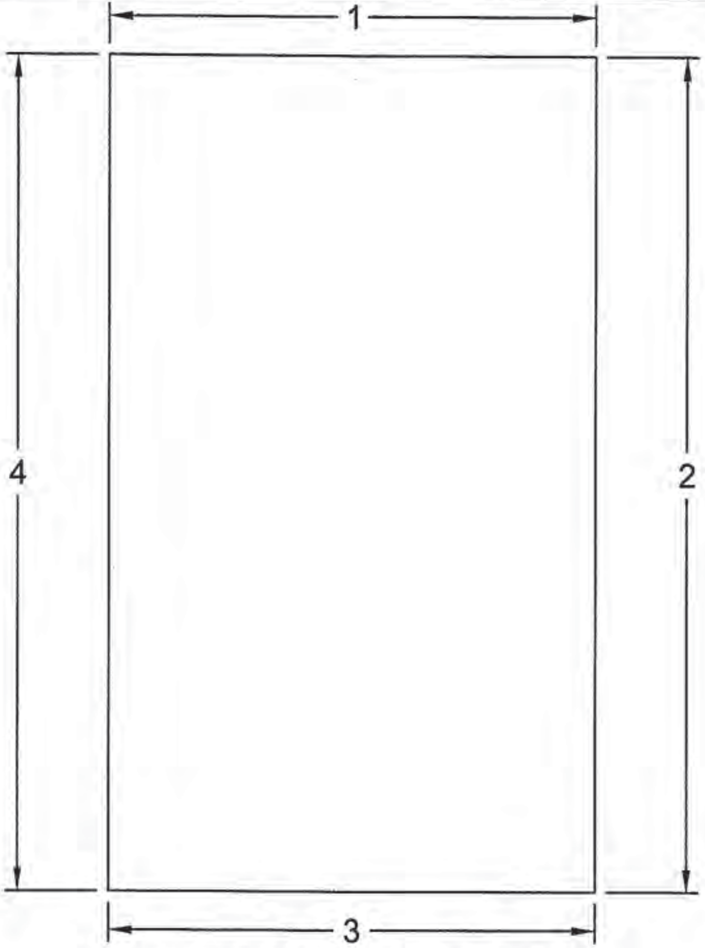
BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Concrete As-built Sections	Sheet:	4	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-2

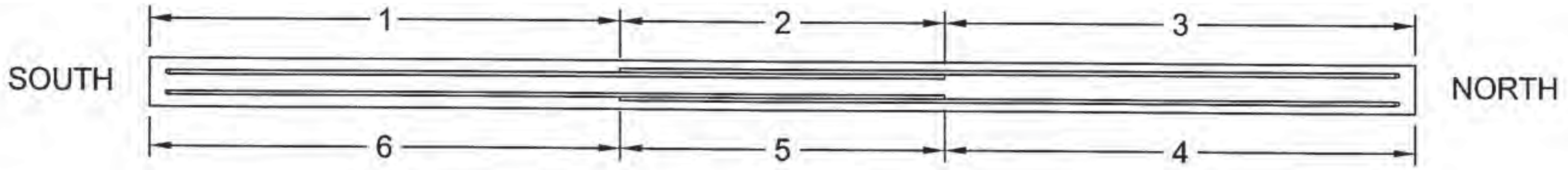
Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	166 5/8	78 7/8	166 7/8	166 5/8	78 15/16	166 3/4		
B-B	4 3/8	9 1/8	4 3/8	23 5/8	~~30 3/16~~ 23 5/8	30 1/8	30 3/16	17 1/2
C-C	3	6 1/16	3 1/16	23 9/16	23 3/4	30 1/8	30 1/8	17 7/16
D-D	3 1/16	6 1/8	3 1/16	23 5/8	23 13/16	30 1/8	30 1/8	17 7/16
E-E	3 1/16	6	3 1/16	23 9/16	23 5/8	30 3/16	30 1/8	17 7/16
F-F	3 1/16	8 3/4	3 3/16	23 9/16	23 9/16	30 3/16	30 3/16	17 7/16

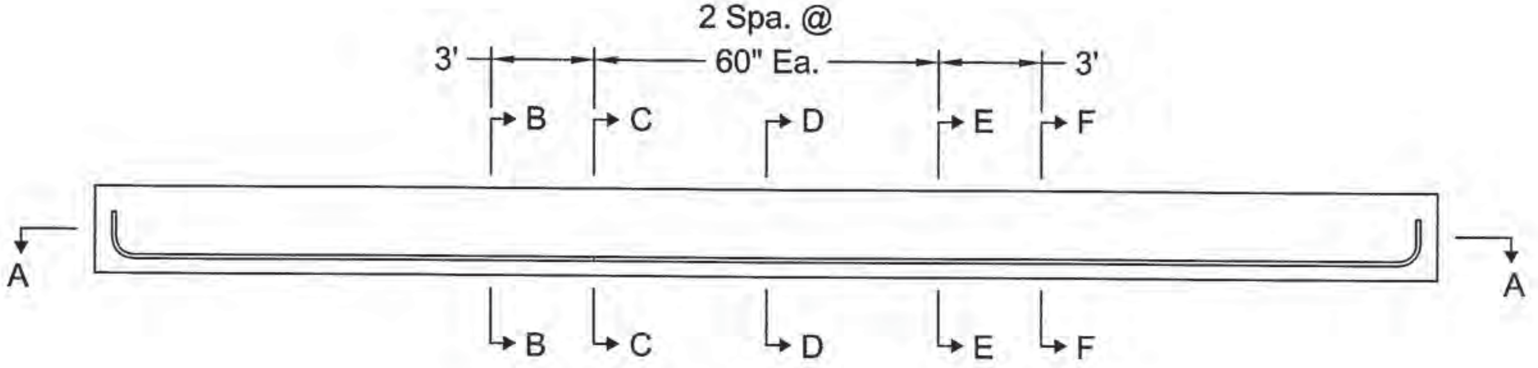
Recorded by:	Signature	Date	Time
KAM	DLL	4-8-12	11:15 PM
Checked by:	Signature	Date	Time
WHP		4/8/2012	11:30 PM
Checked by:	Signature	Date	Time

Comments:

*See formwork as-built drawings for dimension locations



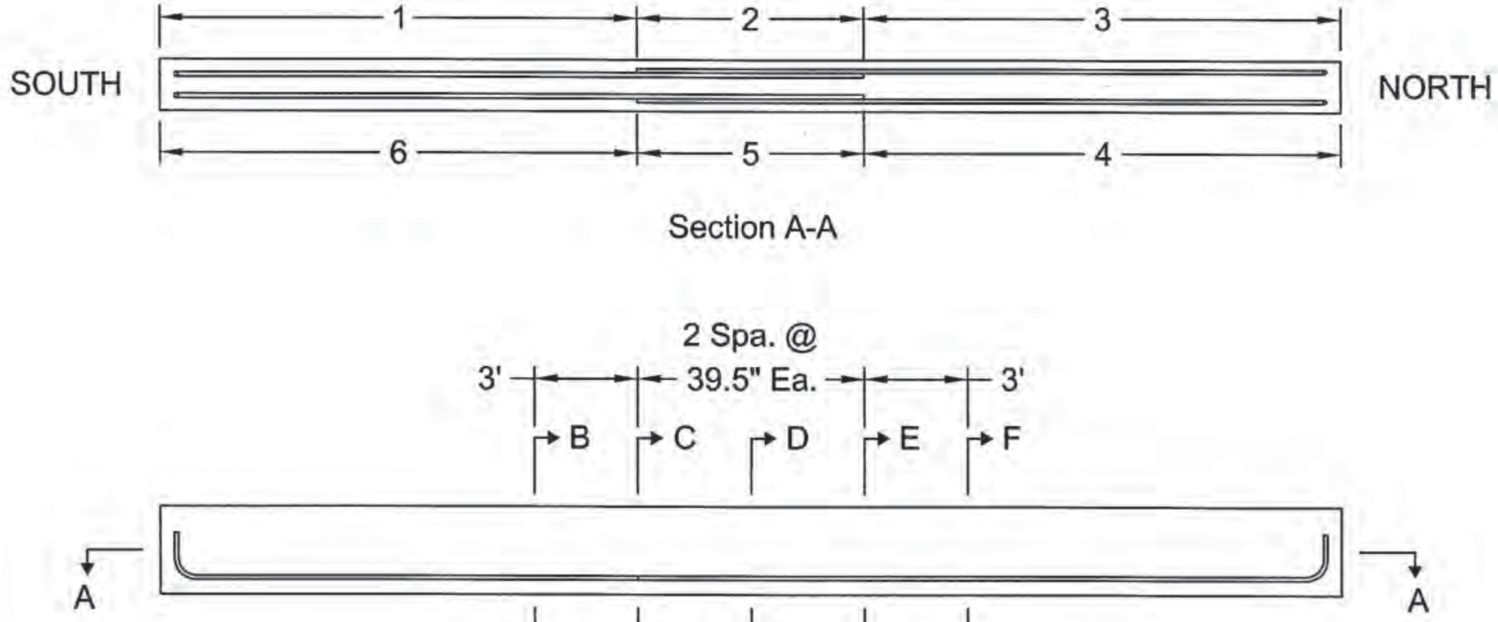
Section A-A



*For section B-B through F-F see Sheet 3 of 3

Series A

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		

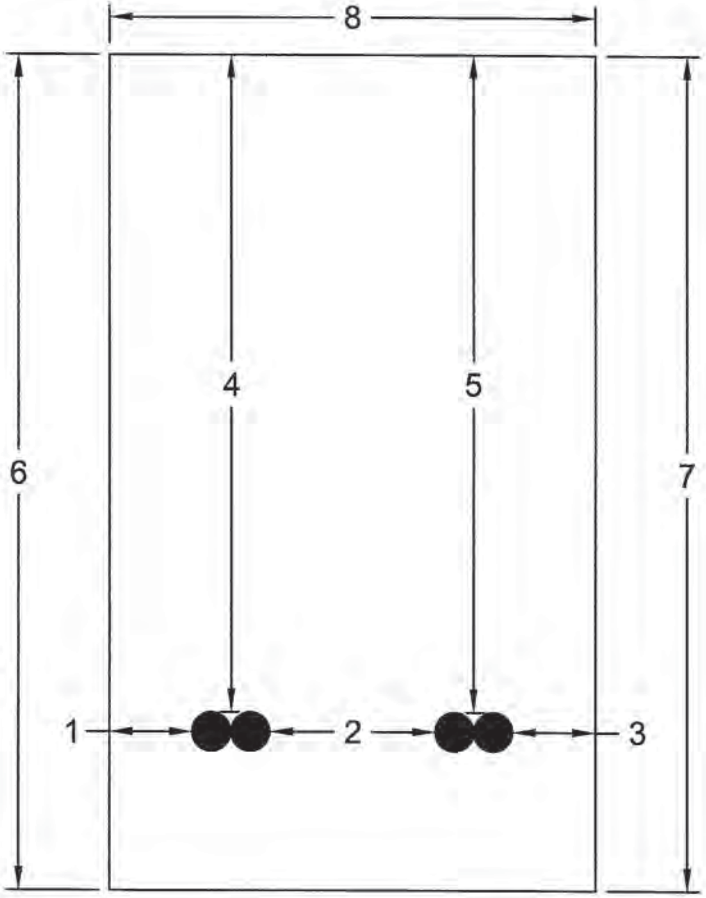


Section A-A

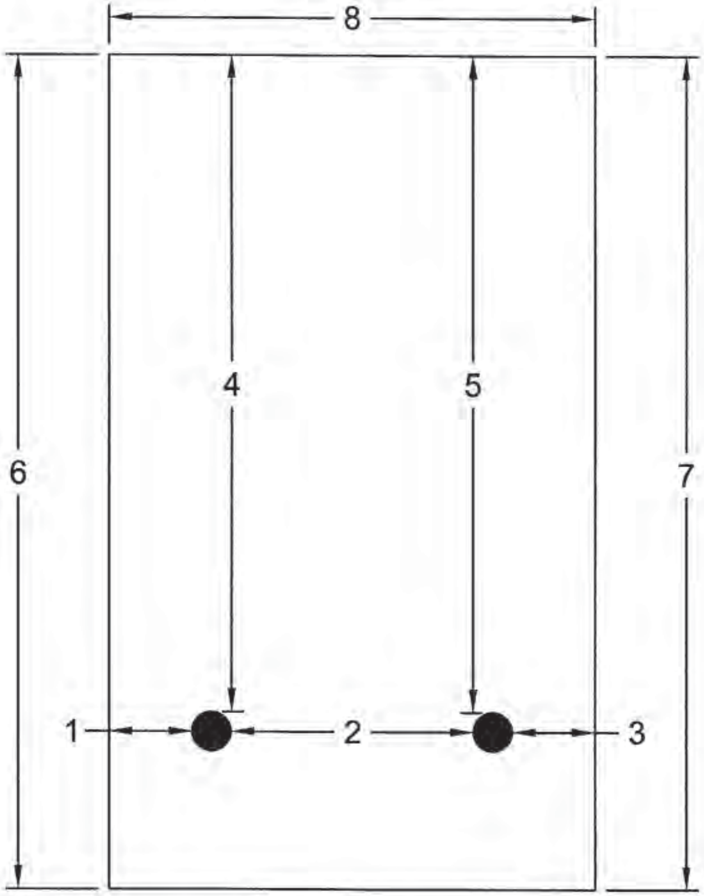
*For section B-B through F-F see Sheet 3 of 3

Series B

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Formwork As-builts	Sheet:	2	of 3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Formwork As-built Sections	Sheet:	3	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: B-~~2~~3

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/10/12	1858861	1839	2:54	3:05	58° F

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		Air Content (ASTM C231 - 10)		
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter
3:12	8 3/4"	3:18	4.8%	4130786891
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale
3:39	8"	3:47	4.8%	06746056HM

Unit Weight (ASTM C138 - 10b)

Time$_1$	Wt. of Cont.$_1$	Total Wt.$_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.
3:16	8.5#	44.3		
Time$_2$	Wt. of Cont.$_2$	Total Wt.$_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.
	8.5#	44.6		

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
3:12	✓	✓	✓	✓	3:33
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
4:10PM	4:15PM	✓	✓	✓	8:35

Recorded by	Signature	Date	Time
B.R.		4/10/12	3:50PM
Checked by	Signature	Date	Time
S.P.		4/10/12	3:50PM
Checked by	Signature	Date	Time
Worth	SAM Worth	4/10/12	3:47pm

Comments: Spread 14"
CONCRETE Temp. 60°F
3 layers + topping
Cyl: 1 insertion of vibrator
Made from 2nd (Mid) 1/3

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1839	2463	user	1858861	0	14:54	4/10/12

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
5.75 CYDS	1008				D	985

Material	Design Qty		Required	Batched	% Var	% Moisture	Actual	Wat
STONE-8	940 lb	✓	5405 lb	5360 lb	-0.83%	M		
STONE-4	620 lb	✓	3565 lb	3580 lb	0.42%			
SAND-23	1435 lb	✓	8664 lb	8640 lb	-0.27%	5.00% M	49 gl	
CEMENT	588 lb	✓	3381 lb	3380 lb	-0.03%			
WATER	323.2 lb	✓	1445.8 lb	1436.0 lb	-0.68%		172.1 gl	
AIR	.80 /C	✓	27.05 oz	26.50 oz	-2.03%			

3

Actual Num Batches: 1

Load 22398 lb Design W/C: 0.550 Water/Cement: 0.550 ✓ T Design 222.7 gl Actual 221.4 gl To Add: 1.3 gl

Slump: 6.00 in # Water In Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
16	1858861	1839	5.75cy	1008	6.00		04/10/12	16091

Sold To	Tax Code	Driver		Project No.	Order No.
CHARGE CARD - BOWEN LAB	IN	DANNY SMITH	2465	5	1801

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB	812-344-0119

3

Job No. 3125NCS

TRUCK RELEASE

Time Printed 14:51

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	17.25cy	17.25cy	1008	PURDUE EXPERIMENTAL	90.00	517.50
				Environmental Fee		10.00

www.irvmat.com

Water Added At Customer's Request				0	Total No. Gallons	Slump Meter Reading	7	0	0	

On Job Time	Finish Pour Time

AUTH.#: Grand Total: 1,569.75

Subtotal 523.25
Tax
Total 523.25

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

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Release, Load and Terms Accepted By:
X

2369323

1858861

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

CUSTOMER COPY

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
18	1058861	1839	5.75cy	1008	6.00		04/10/12	16091

Sold To	Tax Code	Driver		Project No.	Order No.
CHARGE CARD - BOWEN LAB	IN	DANNY SMITH	2463	5	1801

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB TRUCK RELEASE	812-344-0114

3

Job No. CN2513

Time Printed 14:54

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	17.25cy	17.25cy	1008	PURDUE EXPERIMENTAL	89.00	511.75
				Environmental Fee		11.50

www.irvmat.com

Water Added At Customer's Request			0	Total No. Gallons	Slump Meter Reading	7	0	0	

On Job Time	Finish Pour Time

AUTH.#: Grand Total: 1,569.75

Subtotal 523.25
Tax
Total 523.25

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X

2369323

1058861

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

DRIVER COPY

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-3

Sheet 1 of 2

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan	34'-4 1/8"	34'-4	34'-4 1/4"	34'-4"				
B-B	17-3/4"	30-1/8"	30-1/8"	17-5/8"				
C-C	17-3/4"	30-1/8"	30-1/8"	17-5/8"				
D-D	17-3/4"	30 1/8"	30 1/8"	17-5/8"				
E-E	17-3/4"	30-1/8"	30-3/16"	17-5/8"				
F-F	17-3/4"	30-3/16"	30-3/16"	17-5/8"				

Recorded by:	Signature	Date	Time
KAM		5-19-12	4:10pm

Checked by:	Signature	Date	Time
BPR		5/19/12	4:10PM

Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the Behavior of Spliced #11 Bars

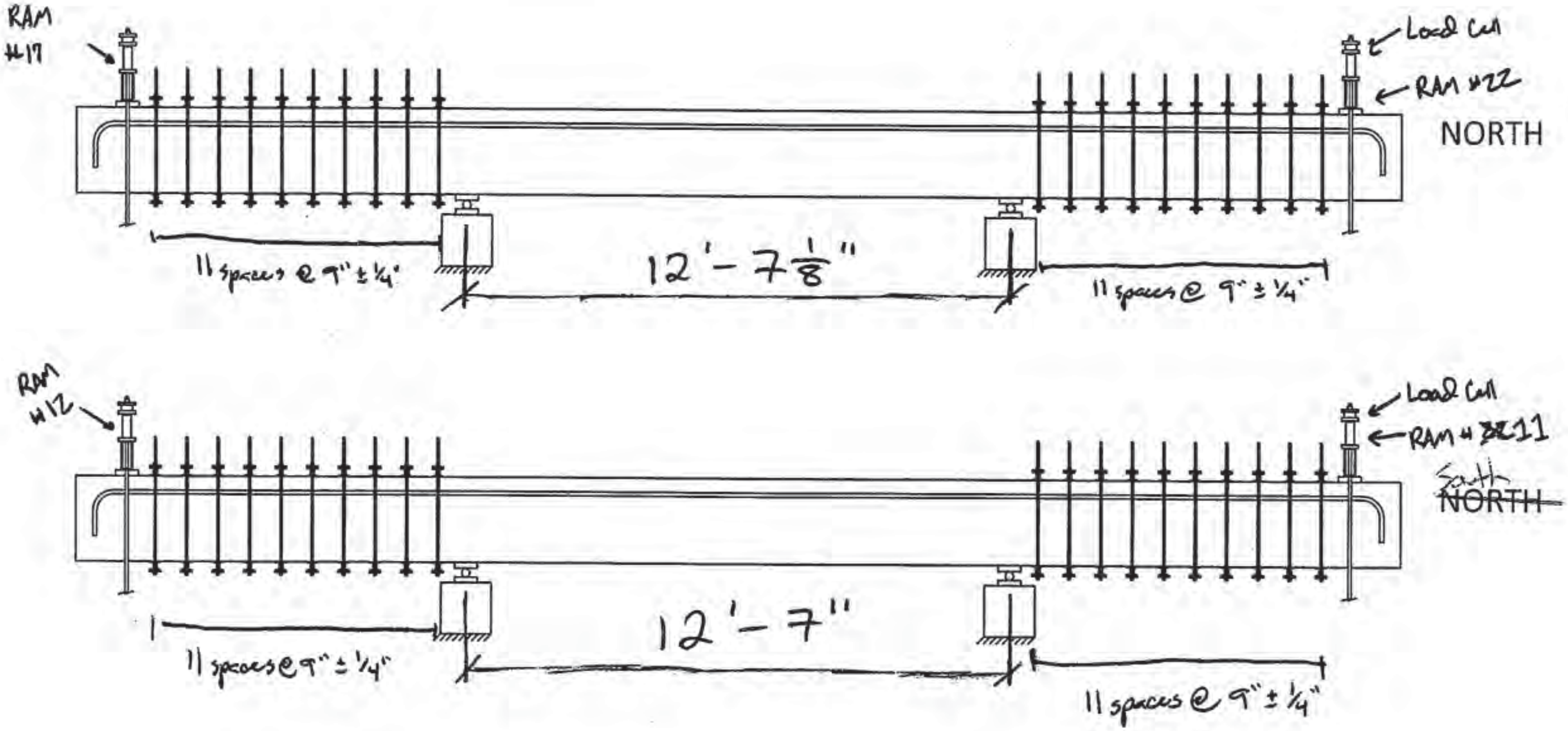
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-3

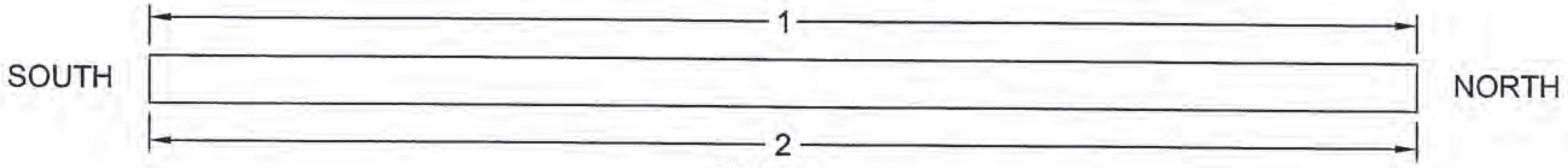
Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

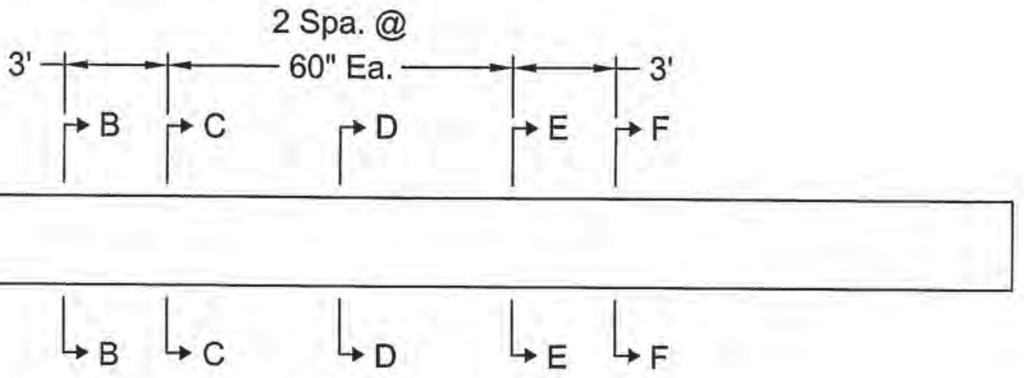
Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A



BOWEN LABORATORY PURDUE UNIVERSITY	Specimen B-3	Sheet:	1	of	4
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	KAM	Checked by:	BVR
		Date:	5-19-12		

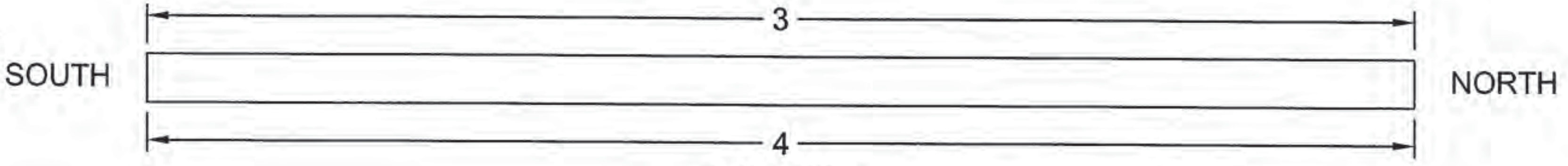


Top Plan



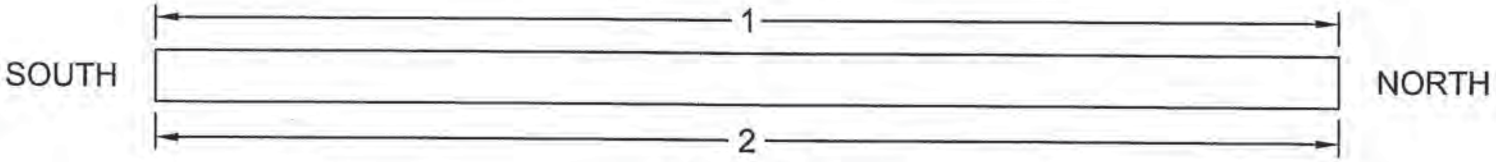
Profile

*For section B-B through F-F see Sheet 3 of 3

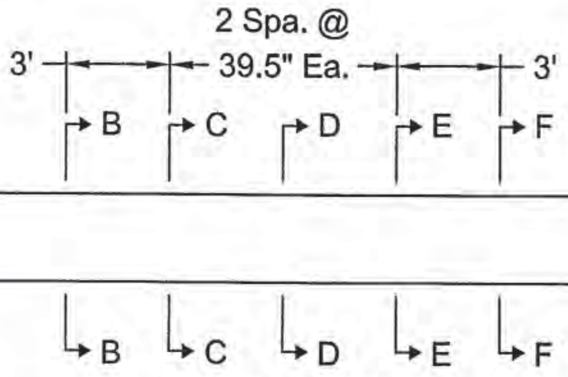


Bottom Plan

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		

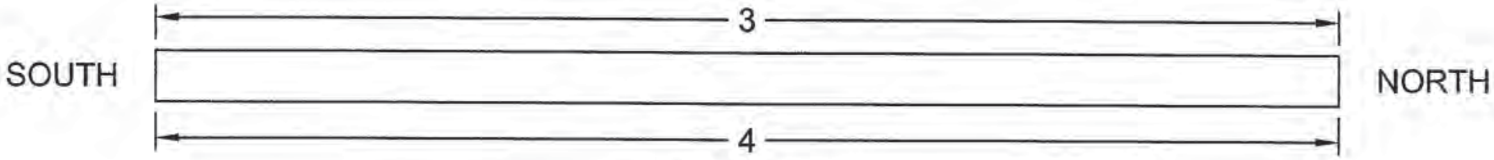


Top Plan



Profile

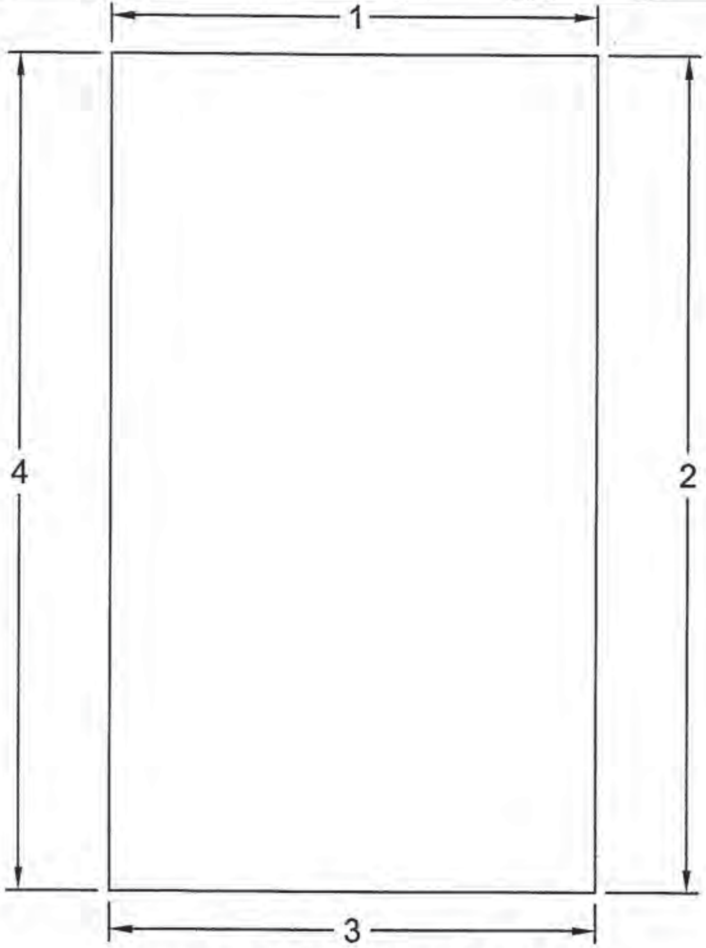
*For section B-B through F-F see Sheet 3 of 3



Bottom Plan

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Concrete As-built Sections	Sheet:	4	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		

Project: Tests to Determine the Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-3

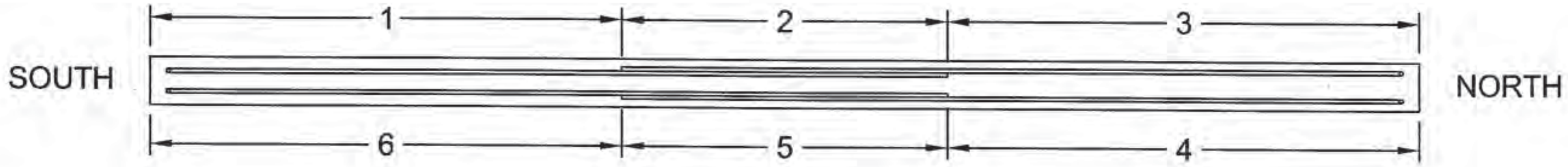
Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	166 3/4	78 7/8	166 3/8	166 1/8	75 1/16	166 5/16		
B-B	4 7/16	6	4 1/2	23 3/4	23 1/2	30	30 1/16	17 3/8
C-C	3	6 1/16	3 1/16	23 3/4	23 9/16	30 1/8	30 1/8	17 7/16
D-D	2 15/16	6 1/16	3	23 3/4	23 5/8	30 1/16	30 1/16	17 7/16
E-E	3	5 15/16	3 1/16	23 5/8	23 3/4	30 1/8	30 1/8	17 1/2
F-F	2 15/16	9	3 1/16	23 1/2	23 3/4	30 1/8	30 1/8	17 1/2

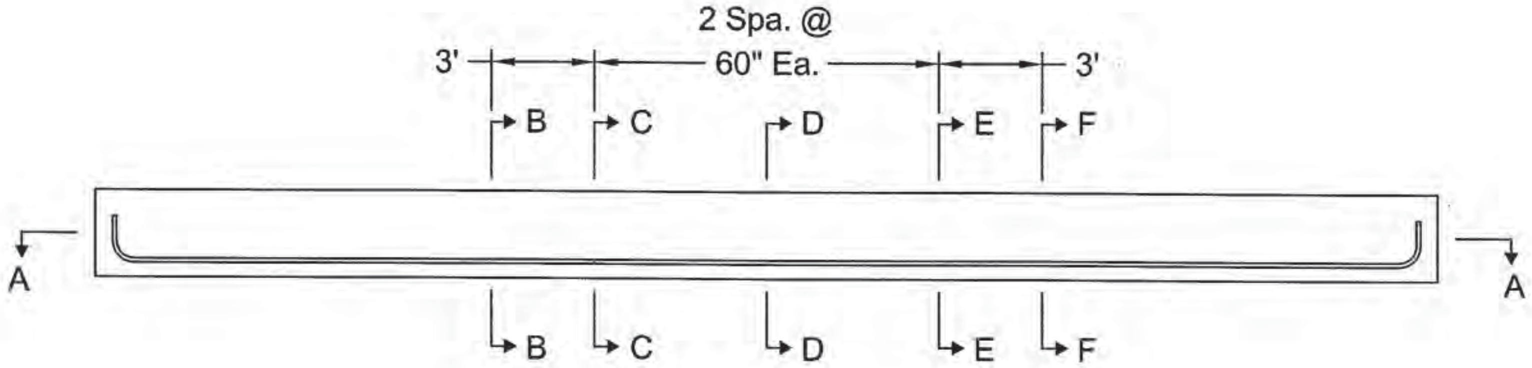
Recorded by:	Signature	Date	Time
KAM		4-8-12	11:15 PM
Checked by:	Signature	Date	Time
WHP		4/8/2012	11:30 PM
Checked by:	Signature	Date	Time

Comments:

*See formwork as-built drawings for dimension locations



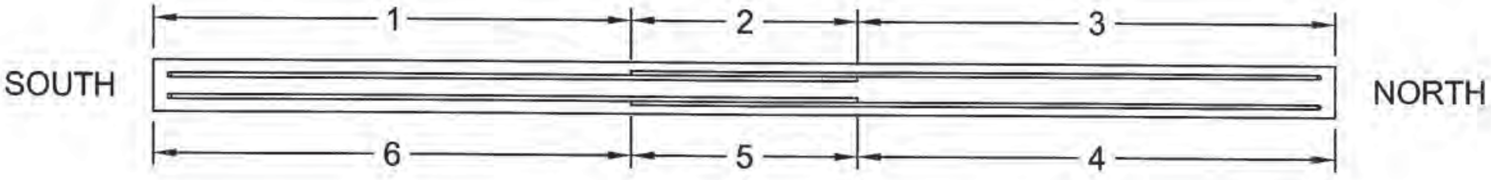
Section A-A



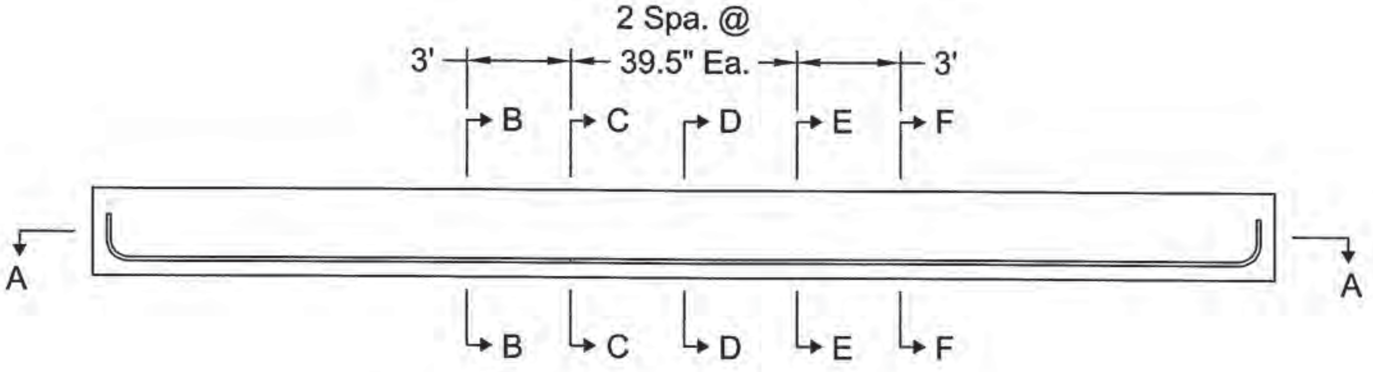
*For section B-B through F-F see Sheet 3 of 3

Series A

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



Section A-A

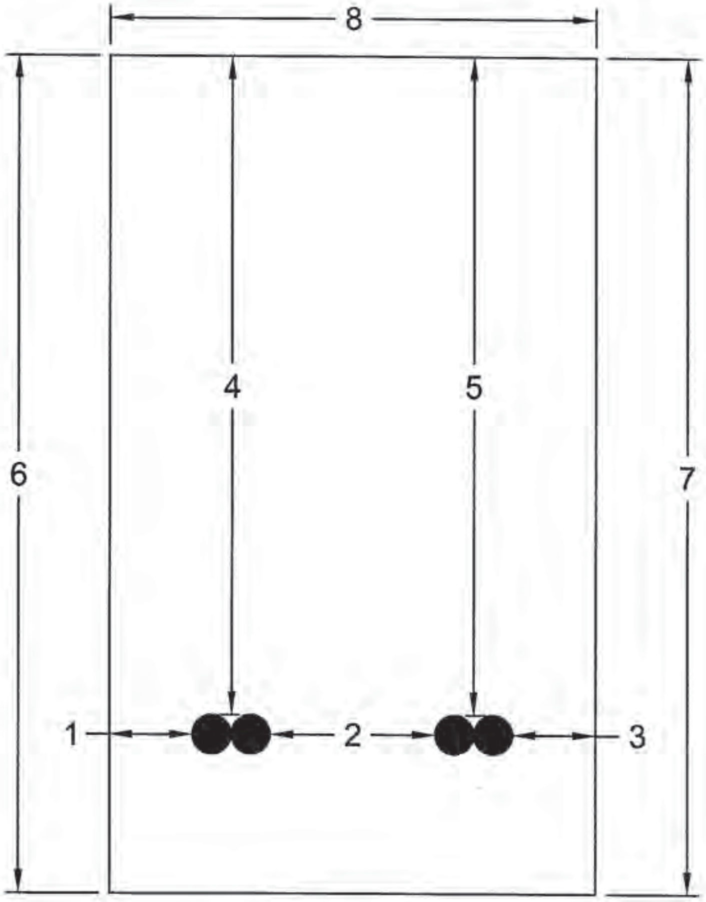


*For section B-B through F-F see Sheet 3 of 3

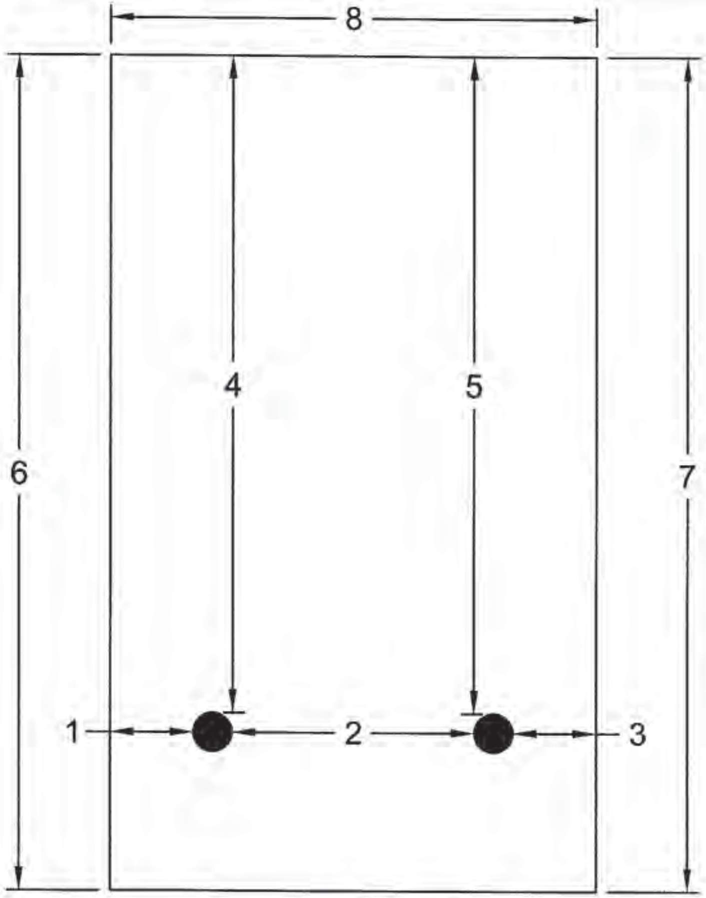
Series B

Drawing:	Series B Formwork As-builts	Sheet:	2	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

BOWEN LABORATORY
PURDUE UNIVERSITY



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Formwork As-built Sections	Sheet:	3	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: B-4
Sheet 1 of 1

General Information					
Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/30	1859311	1982	13:50	2:05PM	70°F
Measurements made upon arrival of concrete					
Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**			
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter	
2:15 pM	5 1/4"	2:26	4.3	4130786891	
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale	
	3 1/4"	2:48	4.0	06746056HM	
Unit Weight (ASTM C138 - 10b)					
Time$_1$	Wt. of Cont.$_1$	Total Wt. $_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.	
2:24	8.5#	45.0	36.5	146 #/cft.	
Time$_2$	Wt. of Cont.$_2$	Total Wt. $_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.	
	8.5#	45.4	36.9	147.6 #/cft.	
Times of actions during and after casting					
Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
2:24	2:30	2:33	2:37	2:40	2:40PM
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
2:40	2:45	9:45 PM	9:50 PM	9:55 PM	10:00 PM
Recorded by		Signature		Date	Time
BPR				4/30	4:25PM
Checked by		Signature		Date	Time
Checked by		Signature		Date	Time
StWorthy		SAWORTHY		4/30/12	4:10

Comments: 2:25pm
Temp 71.5°

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1982	1076	user	1859311	0	13:50	4/30/12

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
5.75 CYDS	1008				D	1436

Material	Design Qty	Required	Batched		% Var	% Moisture	Actual	Wat
STONE-8	940 lb	5454 lb	5400 lb		-0.98%	0.90% M	6	gl
STONE-4	620 lb	3586 lb	3560 lb		-0.74%	0.60% M	3	gl
SAND-23	1435 lb	8804 lb	8730 lb		-0.27%	6.70% M	66	gl
CEMENT	588 lb	3381 lb	3370 lb		-0.33%			
WATER	323.2 lb	861.8 lb	852.0 lb		-1.13%		102.1	gl
AIR	.80 /C	27.05 oz	26.50 oz	*	-2.03%			

Actual Num Batches: 1

Load 21964 lb Design W/C: 0.550 Water/Cement: 0.552 T Design 222.7 gl Actual 176.5 gl To Add: 46.2 gl

Slump: 4.00 in Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: -65.0 lb / CYD

1 B-4

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
10	1859311	1982	5.75cy	1008	4.00	TEST	04/30/12	16091

Sold To	Tax Code	Driver		Project No.	Order No.
C PRE CARD - LAFAYETTE & WINAMA	IN	DOUG PHEBUS	1076	5	1815

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB TRUCK RELEASE	SCN2548

Job No.: SCN2548

TRUCK RELEASE BRIAN

Time Printed 13:44

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	5.75cy	17.25cy	1008	PURDUE EXPERIMENTAL	89.00	511.75
				Environmental Fee		11.50

3/4"
2.78 4.0
2:24
45.0
1 B-4
45.4

Water Added At Customer's Request				Total No. Gallons	Slump Meter Reading				

On Job Time	Finish Pour Time
2:27	2:39

AUTH.#: 2:33 Grand Total: 523.25 2:37

Subtotal	523.25
Tax	
Total	523.25

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

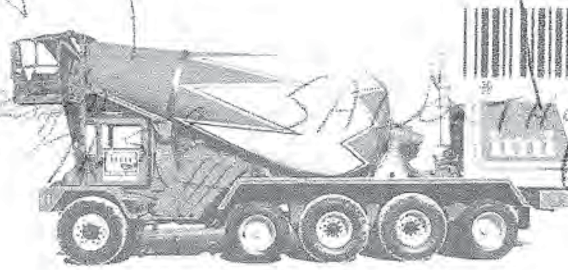
PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

2369776



Temp
5A4
4/30/12
4:10

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" General Office (317) 326-3101

DRIVER COPY

Project: Tests to Determine the Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B4

Sheet 1 of 2

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"				
B-B	17 9/16	30	17 5/8	30 1/16				
C-C	17 5/8	30 1/16	17 5/8	30 1/16				
D-D	17 5/8	30	17 5/8	30 1/16				
E-E	17 9/16	30	17 5/8	30 1/16				
F-F	17 5/8	30	17 5/8	30 1/16				

Recorded by:	Signature	Date	Time
MA Sozen	MeteASozen	11 May 2012	12:05 PM
Checked by:	**Signature**	**Date**	**Time**
S. Pujol		11 May 12	12:20 PM
Checked by:	**Signature**	**Date**	**Time**

Comments: Jacks w. Load Cells: N → 22
S → 11

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

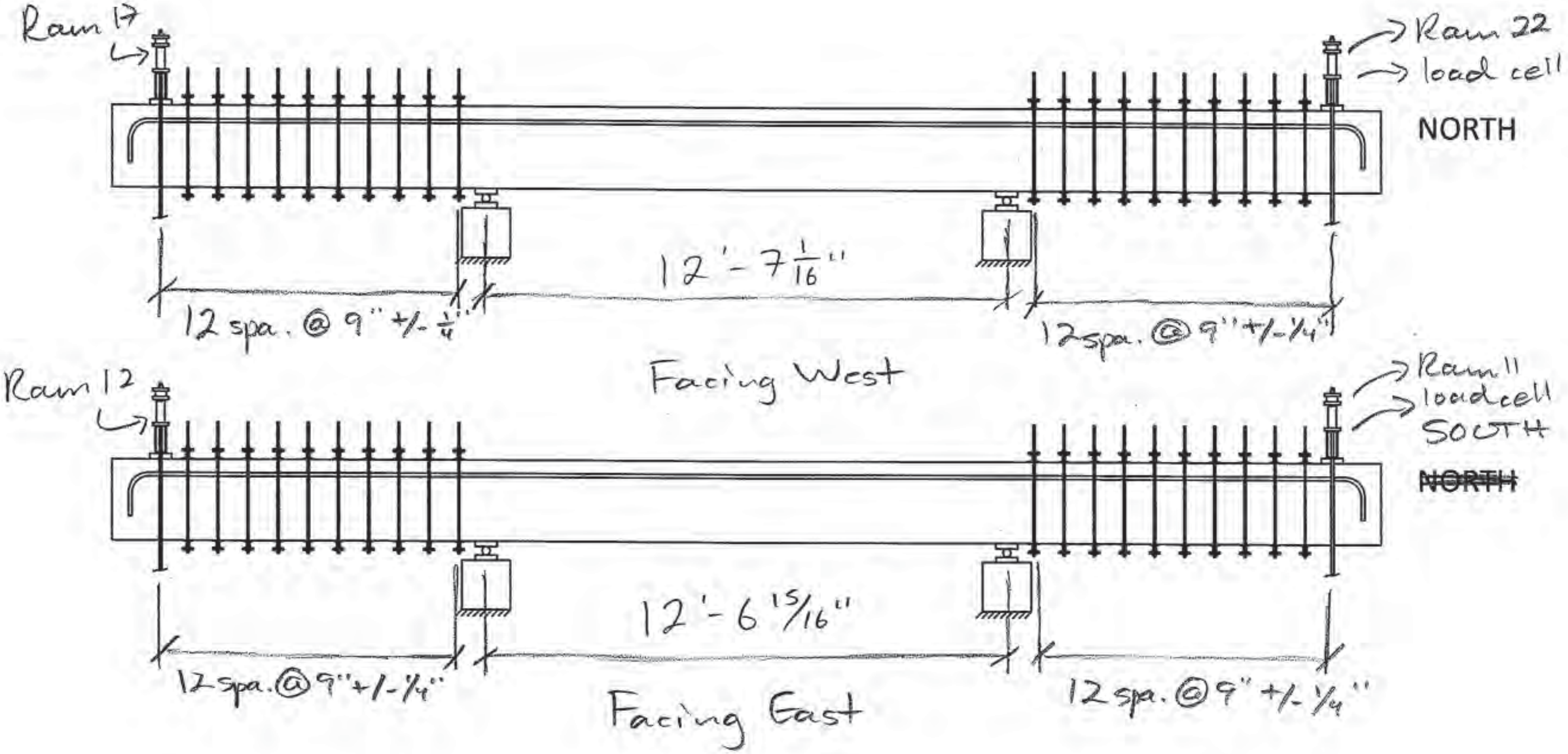
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B4

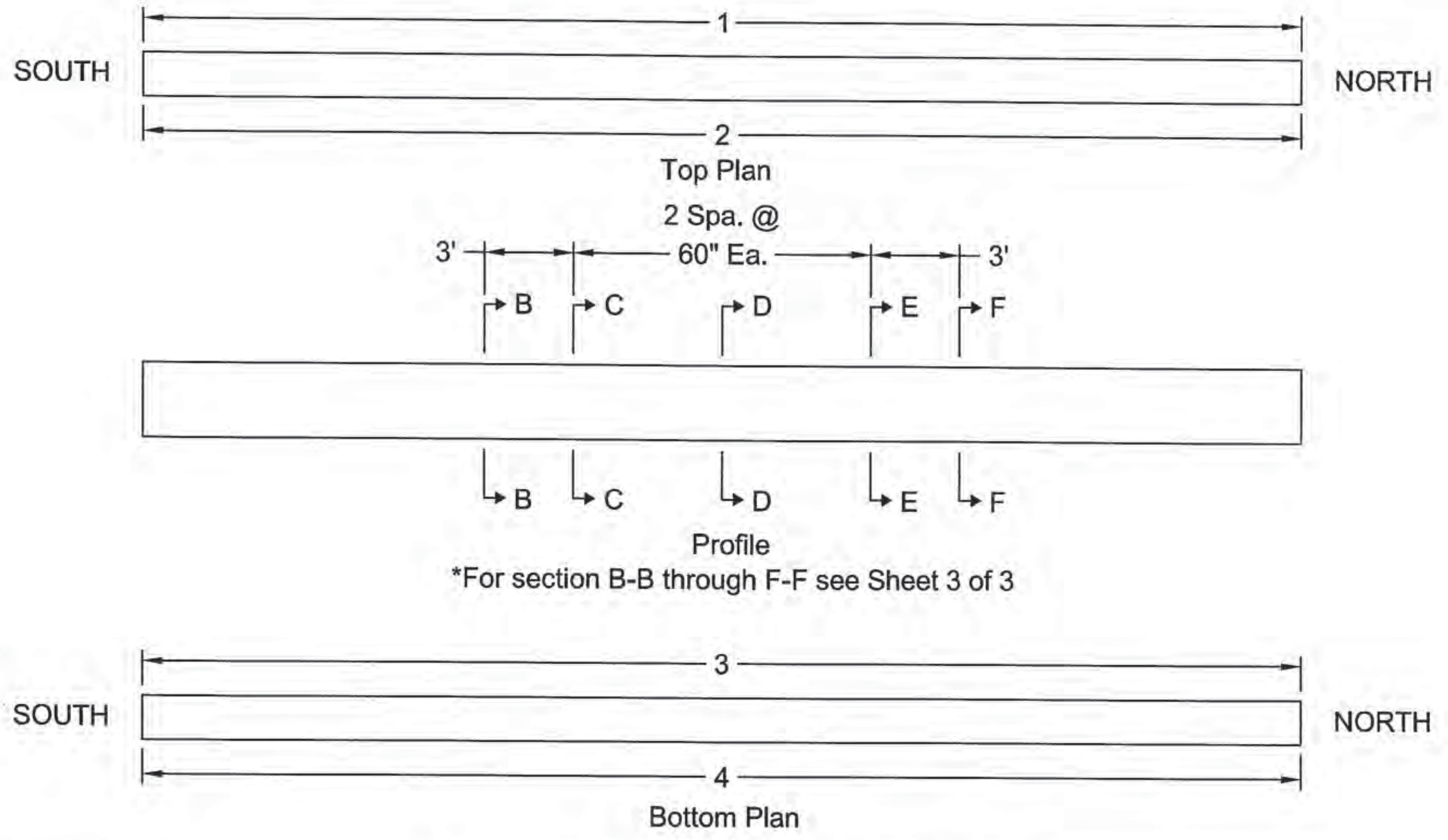
Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A



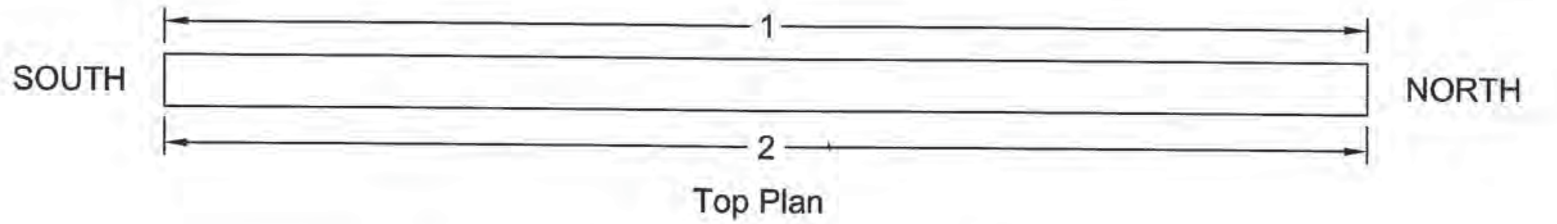
BOWEN LABORATORY **PURDUE UNIVERSITY**	Specimen B-4	Sheet:	1	of	4
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	AK
		Date:	5/14/12		



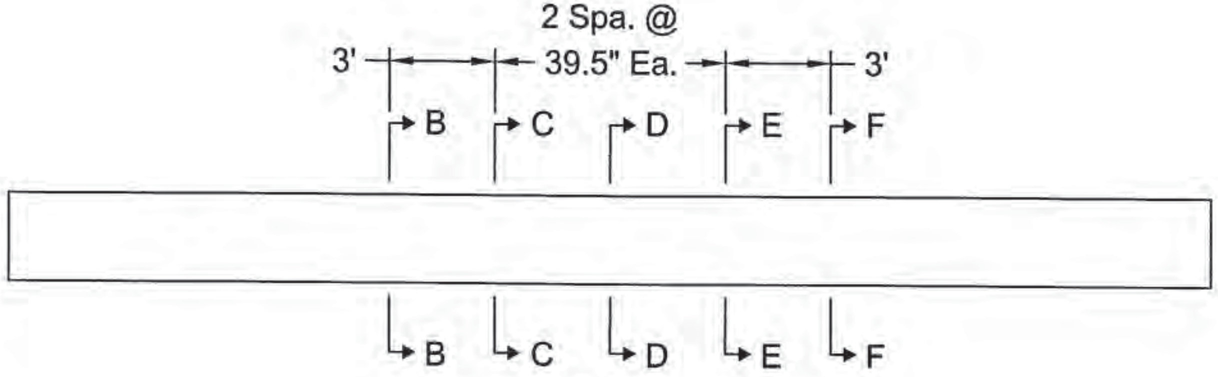
*For section B-B through F-F see Sheet 3 of 3

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

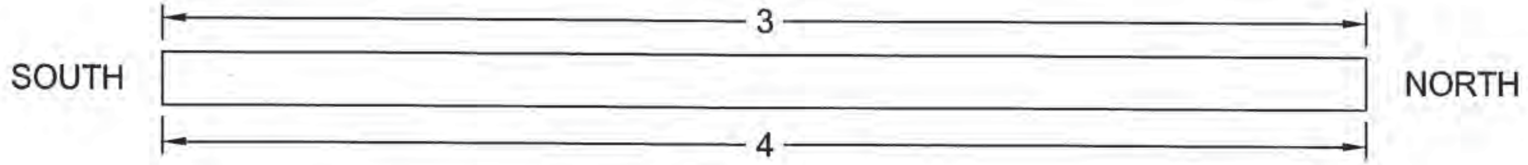


Top Plan



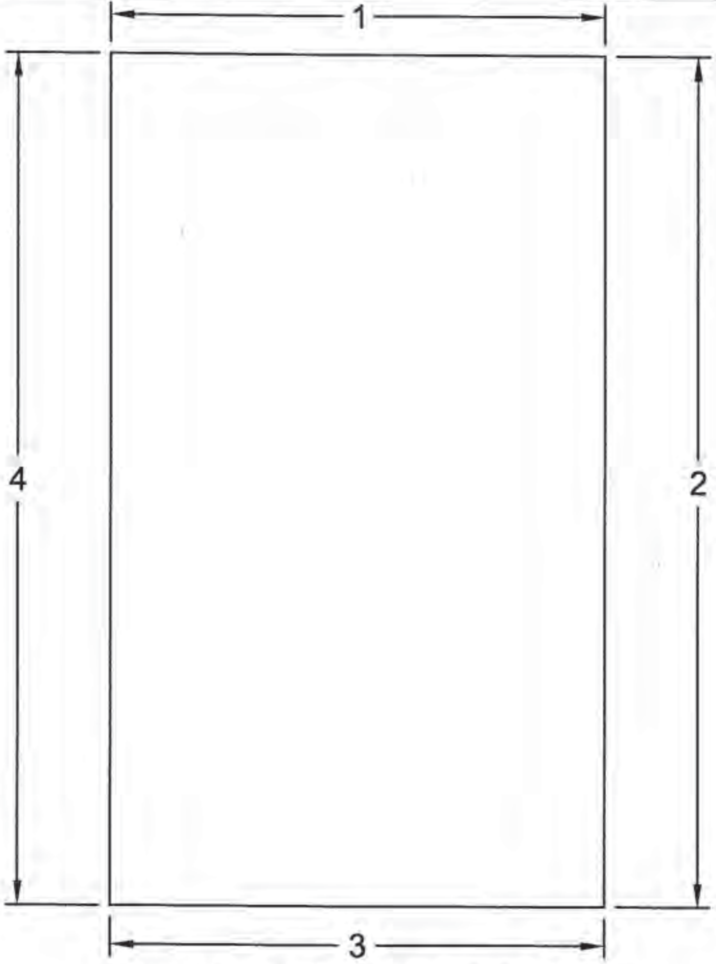
Profile

*For section B-B through F-F see Sheet 3 of 3



Bottom Plan

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Concrete As-builts	Sheet:	3	of 4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Concrete As-built Sections	Sheet:	4	of 4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	

Project: Tests to Determine the
Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-4

Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	166 3/8	79 1/16	166 1/4	166 1/4	78 15/16	166 3/8		
B-B	4 7/16	6 3/8	4 3/16	23 5/8	23 11/16	30 1/8	30 1/16	17 1/2
C-C	3-0	6 3/16	2 13/16	23 3/4	23 3/4	30 1/8	30 1/16	17 9/16
D-D	3 3/16	6-0	2 15/16	23 7/8	23 7/8	30 1/16	30 1/16	17 7/16
E-E	3 3/16	5 15/16	3-0	23 3/4	23 5/8	30 1/16	30 1/8	17 7/16
F-F	3 1/8	8 13/16	3 1/16	23 9/16	23 5/8	30 1/16	30 1/16	17 1/2

Recorded by:	Signature	Date	Time
TD		~~5~~ 4/30	9:30AM
Checked by:	**Signature**	**Date**	**Time**
BPR		4/30	9:30AM
Checked by:	**Signature**	**Date**	**Time**

Comments:

*See formwork as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

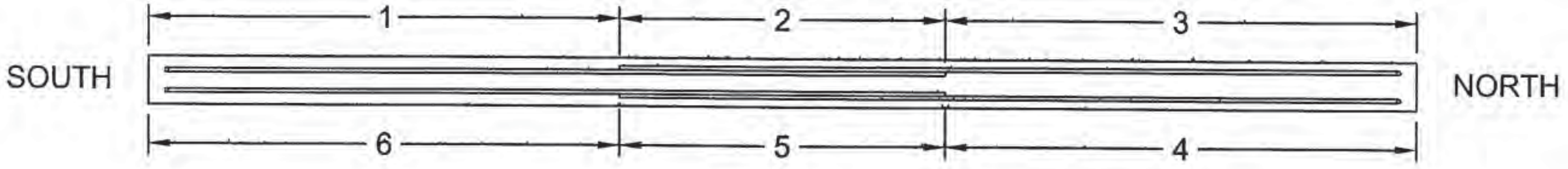
As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-4

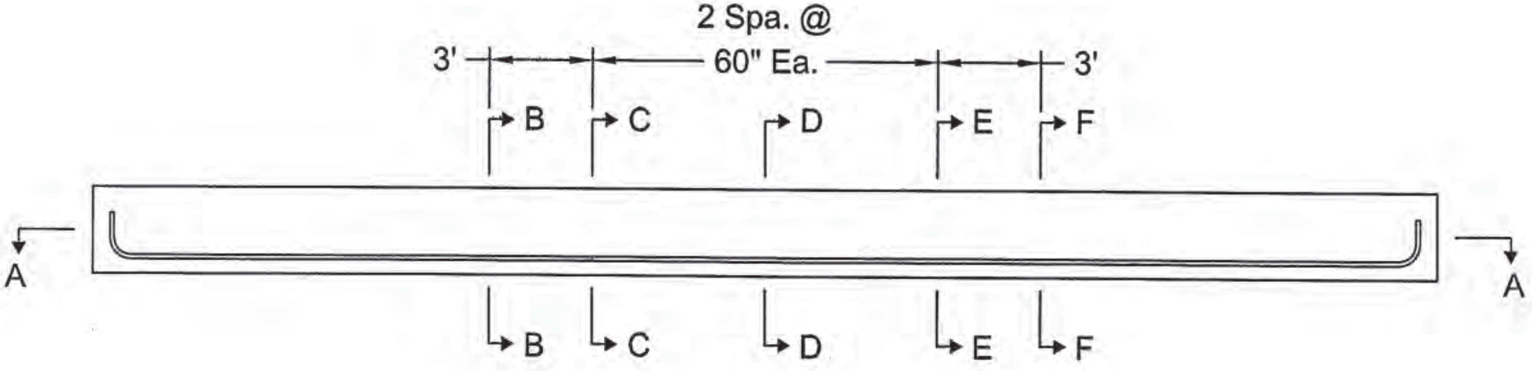
Sheet 2 of 2

Section	Formwork As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
A-A	14'-6"	10'-0"	14'-6"	14'-6"	10'-0"	14'-6"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Section	Formwork As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
A-A	13'-10.5"	6'-7"	13'-10.5"	13'-10.5"	6'-7"	13'-10.5"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"



Section A-A

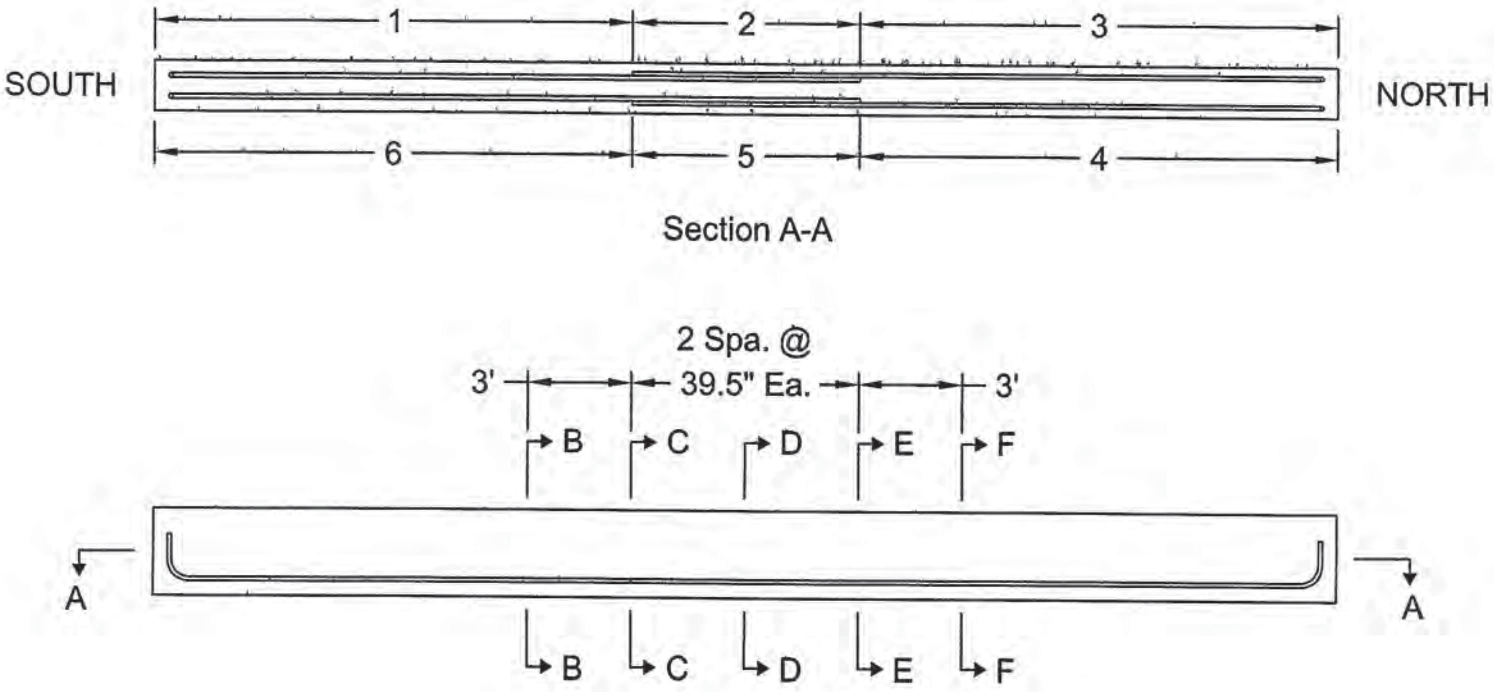


*For section B-B through F-F see Sheet 3 of 3

Series A

BOWEN LABORATORY
PURDUE UNIVERSITY

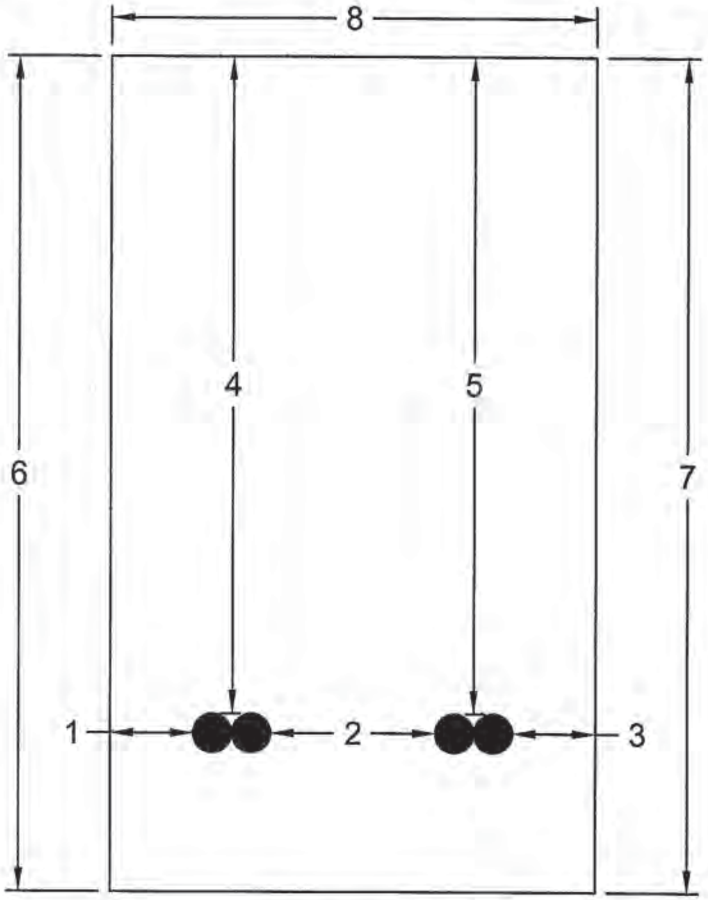
Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



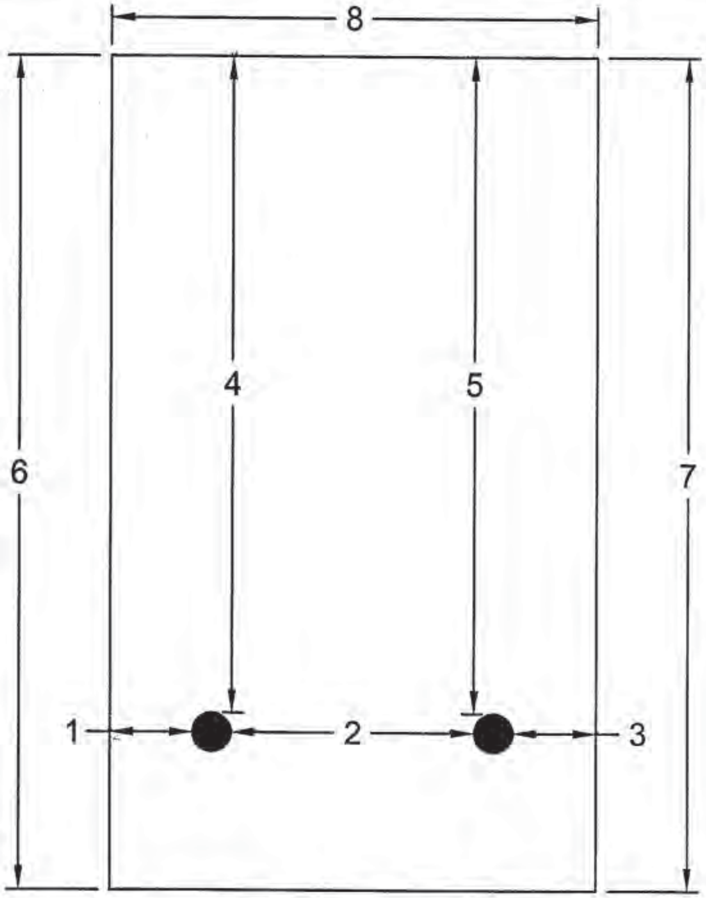
*For section B-B through F-F see Sheet 3 of 3

Series B

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Formwork As-builts	Sheet:	2	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Formwork As-built Sections	Sheet:	3	of 3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by: BPR	Checked by: SP	
			Date:	04/04/2012	

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: B-5

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/30	1859313	1982	14:54	3:05PM	70°F

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**		
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter
3:14	6 1/4"	3:20	4.8	4130786891
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale
3:34pm	7"	3:41	4.6	06746056HM

Unit Weight (ASTM C138 - 10b)

Time$_1$	Wt. of Cont.$_1$	Total Wt. $_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.
3:18	8.5#	44.9	36.4#	145.6#/cft.
Time$_2$	Wt. of Cont.$_2$	Total Wt. $_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.
3:39	8.5#	44.5	36.0#	144#/cft.

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
3:20pm	3:22PM	326pm	3:28pm	✓	✓
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
3:24 [illegible]pm	326	10:00PM	10:05PM	10:10PM	10:15PM

Recorded by	Signature	Date	Time
BPR		4/30	4:25PM
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time
SAlWORTHY		4/30/12	4:10

Comments:
3:18
Temp 69.2%

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

```
Truck        Driver       User         Disp Ticket Num   Ticket ID   Time   Date
1982         1076         user         1859313           1327        14:54 4/30/12
L  d Size    Mix Code       Returned      Qty        Mix Age       Seq      Load ID
5.75   CYDS  1008                                                  D        1437
Material       Design Qty        Required        Batched         % Var       % Moisture      Actual Wat
STONE-8           940 lb          5454  lb        5400 lb       -0.98%      0.90%  M             6  gl
STONE-4           620 lb          3586  lb        3560 lb       -0.74%      0.60%  M             3  gl
SAND-23          1435 lb          8804  lb        8800 lb       -0.05%      6.70%  M            66  gl
CEMENT            588 lb          3381  lb        3375 lb       -0.18%
WATER           323.2 lb        1235.5  lb      1226.0 lb       -0.77%                       146.9  gl
AIR               .80 /C         27.05  oz       27.00 oz     * -0.18%
Actual           Num Batches:   1
Load Total:    22363  lb       Design 0.550  Water/Cement 0.551  T        Design 222.7 gl          Actual 221.4  gl   To Add:   1.3  gl
Slump:    4.00  in       Water in Truck:  0.0 lb   Adjust  Water: 0.0 lb  / Load   Trim Water:  0.0 lb/  CYD
```

2-B-S

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
18	1859313	1982	5.75cy	1008	4.00	TEST	04/30/12	16091

Sold To	Tax Code	Driver		Project No.	Order No.
RGE CARD - LAFAYETTE & WINAMA	IN	DOUG PHEBUS	1076	5	1815

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB TRUCK RELEASE	SCN2548

Job No.: SCN2548

TRUCK RELEASE BRIAN

Time Printed 14:48

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
3:14	6 1/4"	3:25		7.8		
5.75	11.50cy	17.25cy	1008	PURDUE EXPERIMENTAL	89.00	511.75
3:34 pm	7"	3:41		4.62-B-S		
3:18				44.9		
				Environmental Fee		11.50
3:39		44.5				

Water Added At Customer's Request					Total No. Gallons	Slump Meter Reading				

On Job Time	Finish Pour Time
3:20 PM	

AUTH. #: Grand Total: 1,046.50

Subtotal	523.25
Tax	
Total	523.25

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

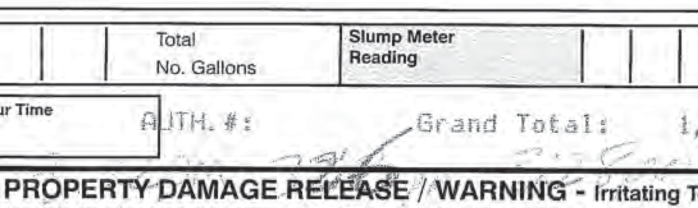
PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

23697784



SAW

3:18
Temp

4/30/12 4:1

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

DRIVER COPY

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-5

Sheet 1 of 2

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan	34'-3 5/8"	34'-3 3/4"	34'-4"	34'-3 7/8"				
B-B	17-5/8"	30-1/16"	17-11/16"	30-1/8"				
C-C	17-5/8"	30-1/8"	17-5/8"	30-1/8"				
D-D	17-5/8"	30-1/8"	17-5/8"	30-1/8"				
E-E	17-9/16"	30-1/8"	17-5/8"	30-1/16"				
F-F	17-11/16"	30-1/8"	17-5/8"	30-1/8"				

Recorded by:	Signature	Date	Time
KAM		5-16-12	
Checked by:	Signature	Date	Time
BPR		5/16/12	11:00AM
Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

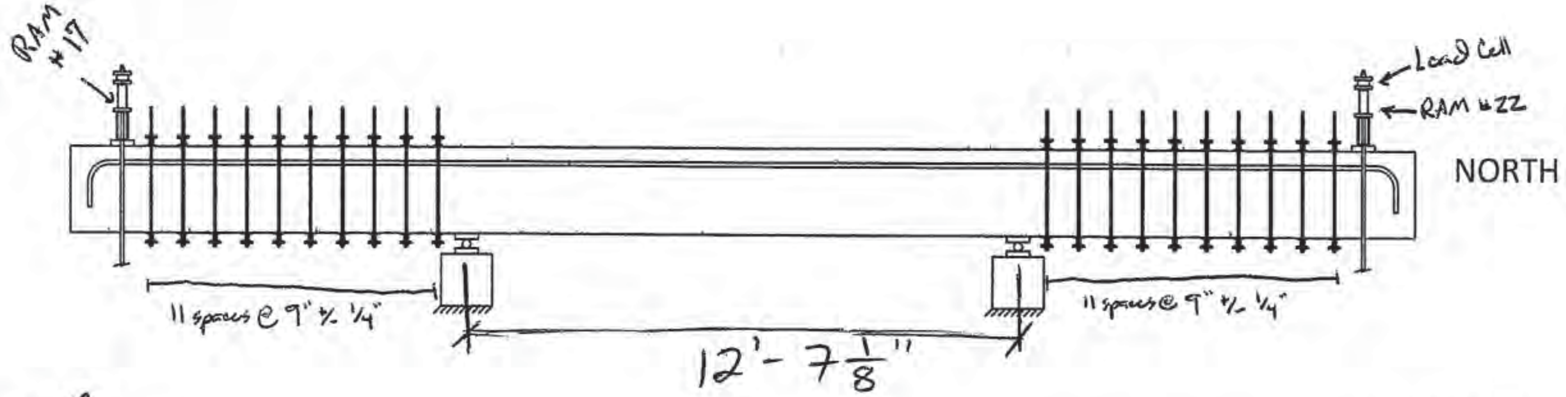
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

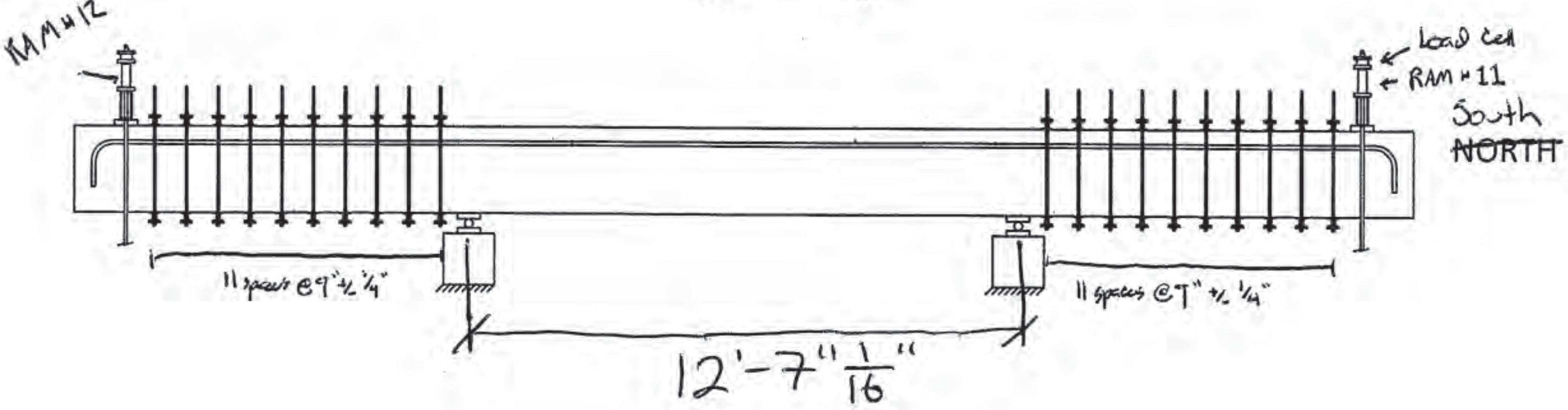
Specimen:____________________

Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

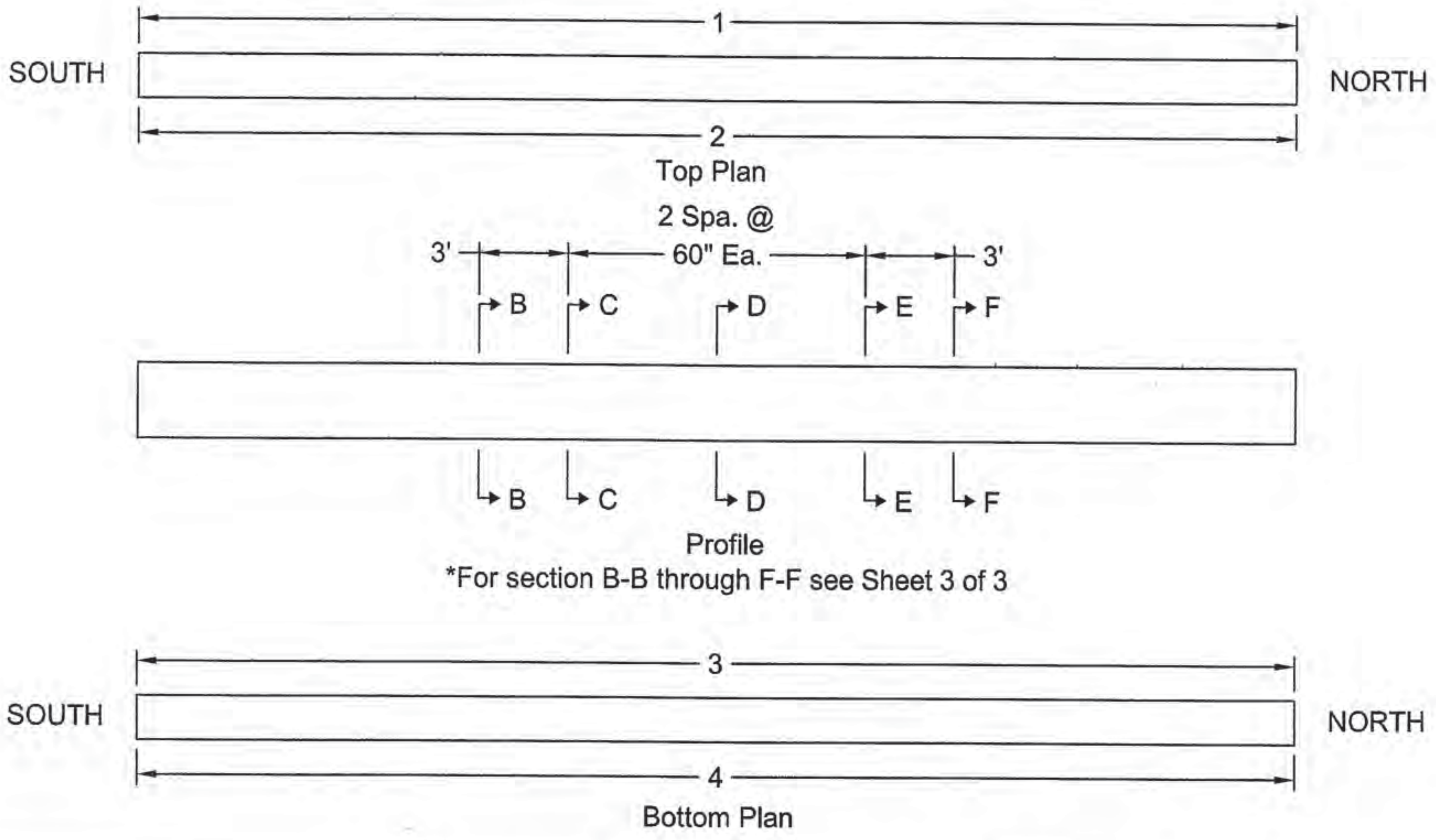
Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A



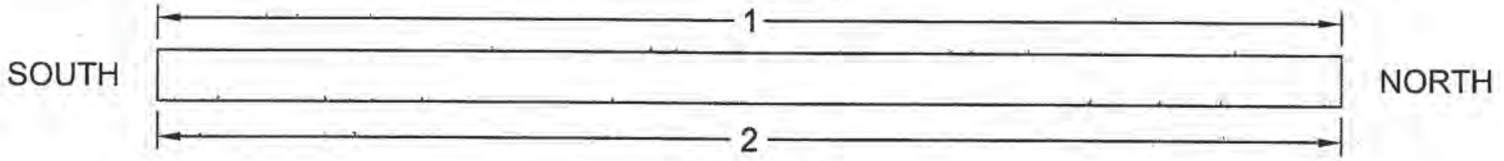


BOWEN LABORATORY
PURDUE UNIVERSITY

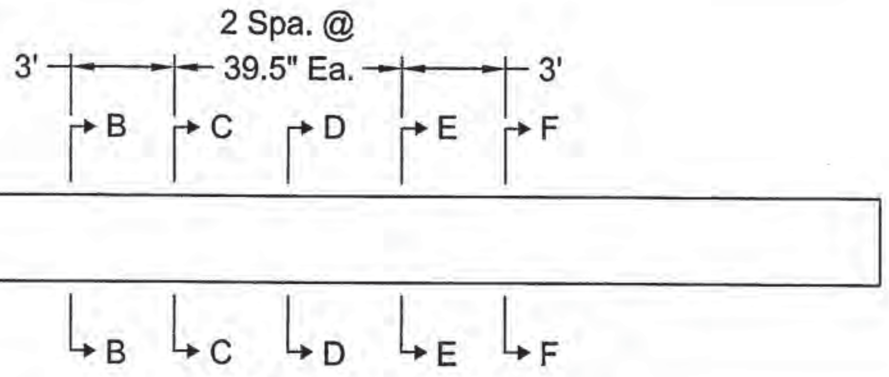
Specimen B-5	Sheet:	1	of	4
Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	KAM	Checked by:	BPR
	Date:	5-16-12		



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		

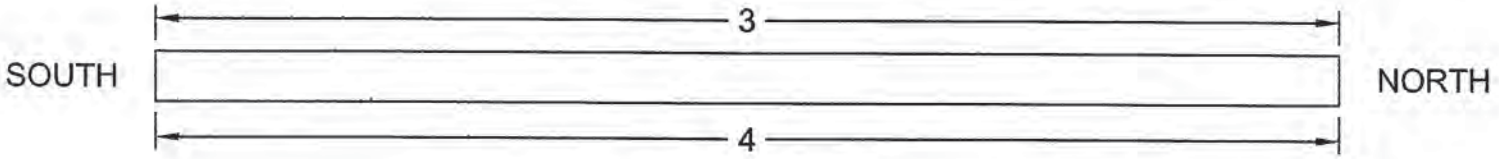


Top Plan



Profile

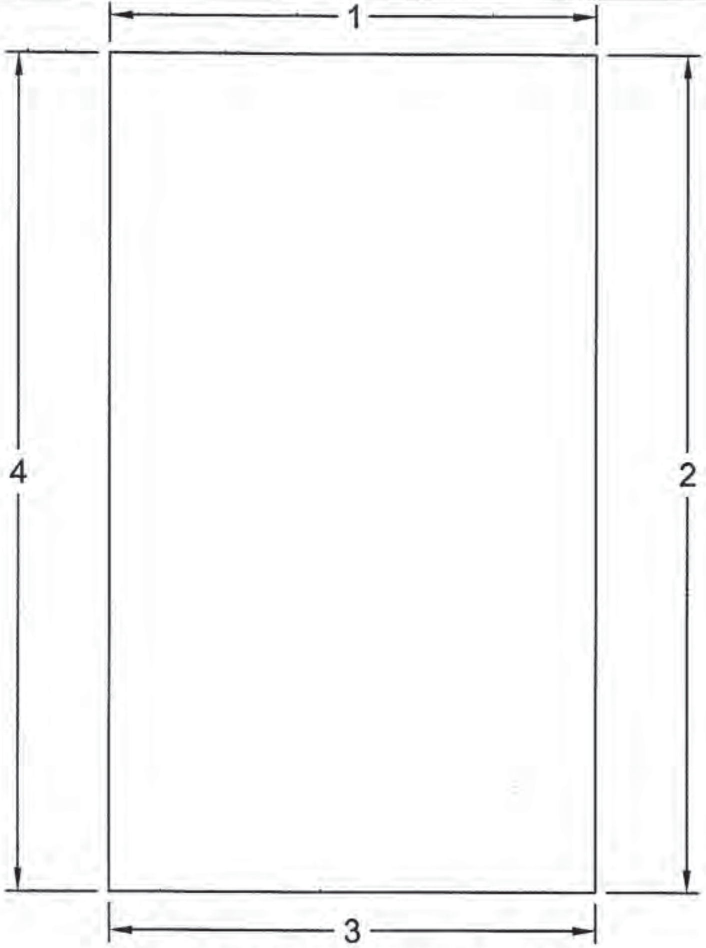
*For section B-B through F-F see Sheet 3 of 3



Bottom Plan

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Concrete As-built Sections	Sheet:	4	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-5

Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	166-3/8	79-1/16	166-1/4	166-1/4	79-0	166-3/8		
B-B	4 3/8	6 3/16	4 3/8	23 5/8	23 9/16	30 1/8	30 1/8	17 1/2
C-C	3-0	6 3/16	2 15/16	23 5/8	23 5/8	30 1/16	30 1/16	17 1/2
D-D	3-1/16	6 3/16	2 15/16	23 3/4	23 3/4	30 1/16	30 1/16	17 7/16
E-E	3 1/8	6-0	3-0	23 11/16	23 11/16	30 1/8	30 1/8	17 7/16
F-F	3-1/8	8 3/4	3-0	23 5/8	23 5/8	30 1/16	30 1/8	17 7/16

Recorded by:	Signature	Date	Time
BPR		4/30	9:50AM
Checked by:	Signature	Date	Time
TD		4/30	9:50Am
Checked by:	Signature	Date	Time

Comments:

*See formwork as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

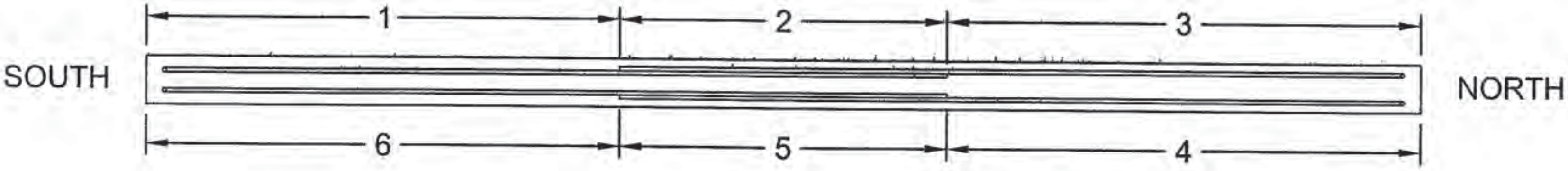
As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-5

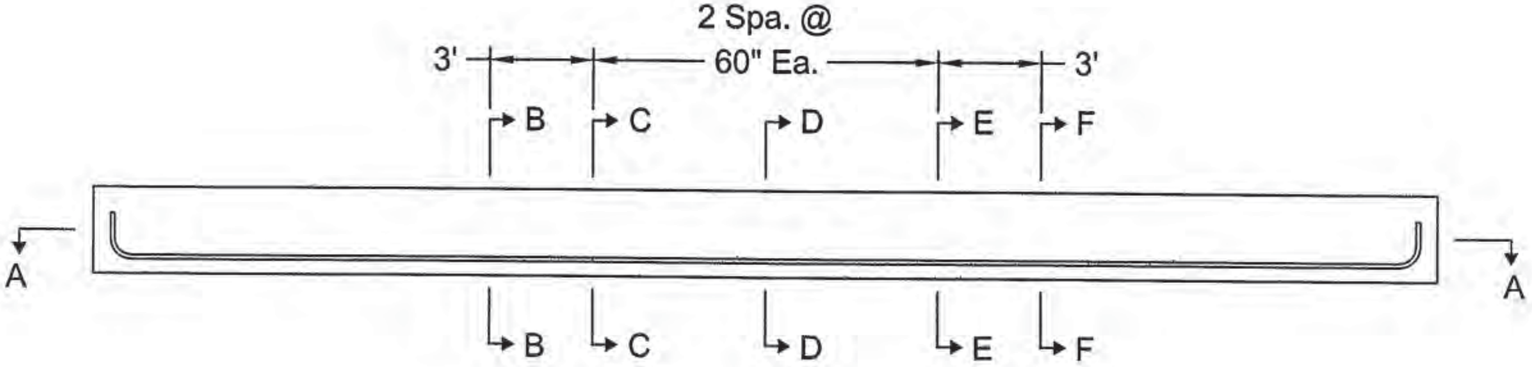
Sheet 2 of 2

Section	Formwork As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
A-A	14'-6"	10'-0"	14'-6"	14'-6"	10'-0"	14'-6"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Section	Formwork As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
A-A	13'-10.5"	6'-7"	13'-10.5"	13'-10.5"	6'-7"	13'-10.5"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"



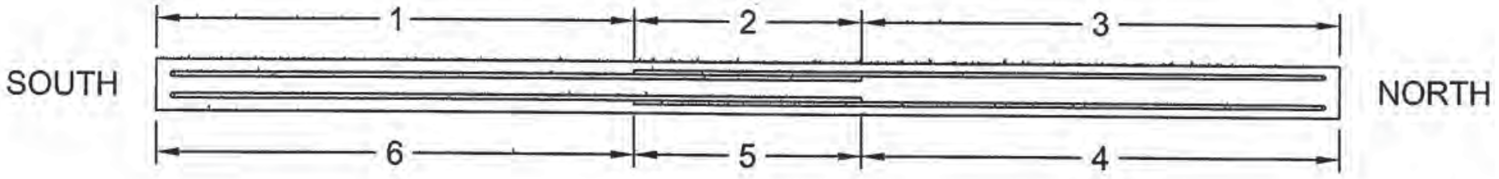
Section A-A



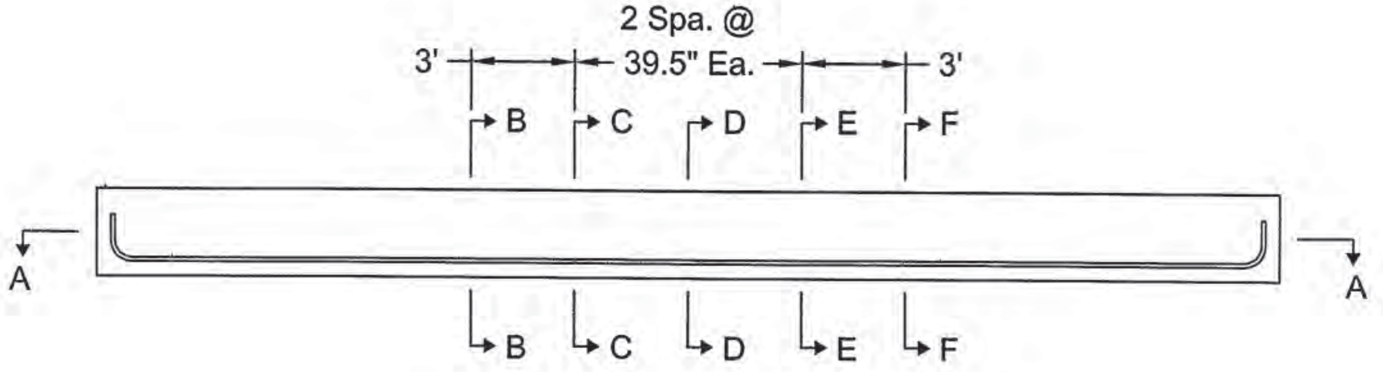
*For section B-B through F-F see Sheet 3 of 3

Series A

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



Section A-A



*For section B-B through F-F see Sheet 3 of 3

Series B

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Formwork As-builts	Sheet: 2	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by: BPR	Checked by:	SP
			Date:	04/04/2012	

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: B-6

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
4/30	1859314	1949	15:30	3:50PM	70°F

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		Air Content (ASTM C231 - 10)		
$Time_1$	$Result_1$	$Time_1$	$Result_1$	S/N of Air Meter
3:56pm	8 1/4"	4:03	5.3%	4130786891
$Time_2$	$Result_2$	$Time_2$	$Result_2$	S/N of Scale
4:16pm	7 1/4"	4:2	5.5%	06746056 HM

Unit Weight (ASTM C138 - 10b)

$Time_1$	Wt. of $Cont._1$	Total Wt. $_1$	Wt. of $Conc._1$	$Result_1$ = Wt. of Conc./Vol. of Cont.
4:01 pm	8.5#	44.7	36.2#	144.8 #/cft.
$Time_2$	Wt. of $Cont._2$	Total Wt. $_2$	Wt. of $Conc._2$	Result2 = Wt. of Conc./Vol. of Cont.
4:20	8.5#	44.2	35.7#	142.8 #/cft.

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
4:05	4:07	4:13	4:15	4:24	✓
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
4:30	4:32	10:15PM	10:20PM	10:25PM	10:30PM

Recorded by	Signature	Date	Time
BPR		4/30	4:25PM
Checked by	Signature	Date	Time
~~BPR~~			
Checked by	Signature	Date	Time
SAWORTHY		4/30/12	4:30pm

Comments:
4.04 PM
Temp 68.1

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

```
Truck       Driver      User        Disp Ticket Num  Ticket ID  Time  Date
1949        1395        user        1859314          0          15:30 4/30/12
   d Size   Mix Code      Returned     Qty        Mix Age     Seq    Load ID
5.75  CYDS 1008                                               D      1438
Material     Design Qty       Required        Batched        % Var     % Moisture    Actual Wat
STONE-8          940 lb        5454  lb        5400 lb      -0.98%     0.90%  M          6  gl
STONE-4          620 lb        3586  lb        3560 lb      -0.74%     0.60%  M          3  gl
SAND-23         1435 lb        8804  lb        8780 lb      -0.27%     6.70%  M         66  gl
CEMENT           588 lb        3381  lb        3380 lb      -0.03%
WATER          323.2 lb      1235.5  lb      1230.0 lb      -0.45%                   147.4  gl
AIR              .80 /C       27.05  oz       27.50 oz    *  1.67%
Actual          Num Batches:    1
Load Total:   22352  lb       Design 0.550  Water/Cement 0.550  T       Design 222.7 gl       Actual 221.8  gl   To Add:   0.9  gl
Slump:    4.00  in       Water in Truck:  0.0 lb   Adjust  Water: 0.0 lb  / Load   Trim Water:  0.0 lb/  CYD
```

3-B-6

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
18	1859314	1949	5.75cy	1008	4.00	TEST	04/30/12	16091

Sold To	Tax Code	Driver		Project No.	Order No.
RGE CARD - LAFAYETTE & WINAMA	IN	JOE ZYGAS	1395	5	1815

Delivery Address	P.O. Number
BOWEN CIVIL ENGINEERING LAB TRUCK RELEASE	SCN2548

Job No.: SCN2548

TRUCK RELEASE BRIAN

Time Printed 15:29

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	17.25cy	17.25cy	1008	PURDUE EXPERIMENTAL	89.00	511.75
				Environmental Fee		11.50

3:56pm 8 1/4 4 03 5.3%

4:16 7 1/4 1.2 5.5%

3-B-6

4:01 pm 44

4:20 44 2

Water Added At Customer's Request					Total No. Gallons	Slump Meter Reading				

On Job Time	Finish Pour Time
4:05	

AUTH. #: Grand Total: 1,569.75

Subtotal	523.25
Tax	
Total	523.25

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

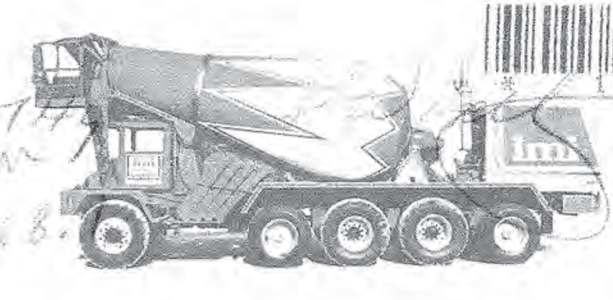
SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X



4:24 pm

4/30/12 4:30 pm

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

DRIVER COPY

Project: Tests to Determine the Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-6

Sheet 1 of 2

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan	34'-3 7/8"	34'-3 7/8"	34'-4"	34'-4"				
B-B	17-5/8"	30-3/16"	17-5/8"	30-3/16"				
C-C	17-11/16"	30-1/8"	17-5/8"	30-1/8"				
D-D	17-11/16"	30 1/8"	17-5/8"	30-1/8"				
E-E	17-11/16"	30"	17-5/8"	30"				
F-F	17-11/16"	30"	17-11/16"	30"				

Recorded by:	Signature	Date	Time
KAM		5-24	3:15pm
Checked by:	Signature	Date	Time
BPR		5/24	3:15PM
Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

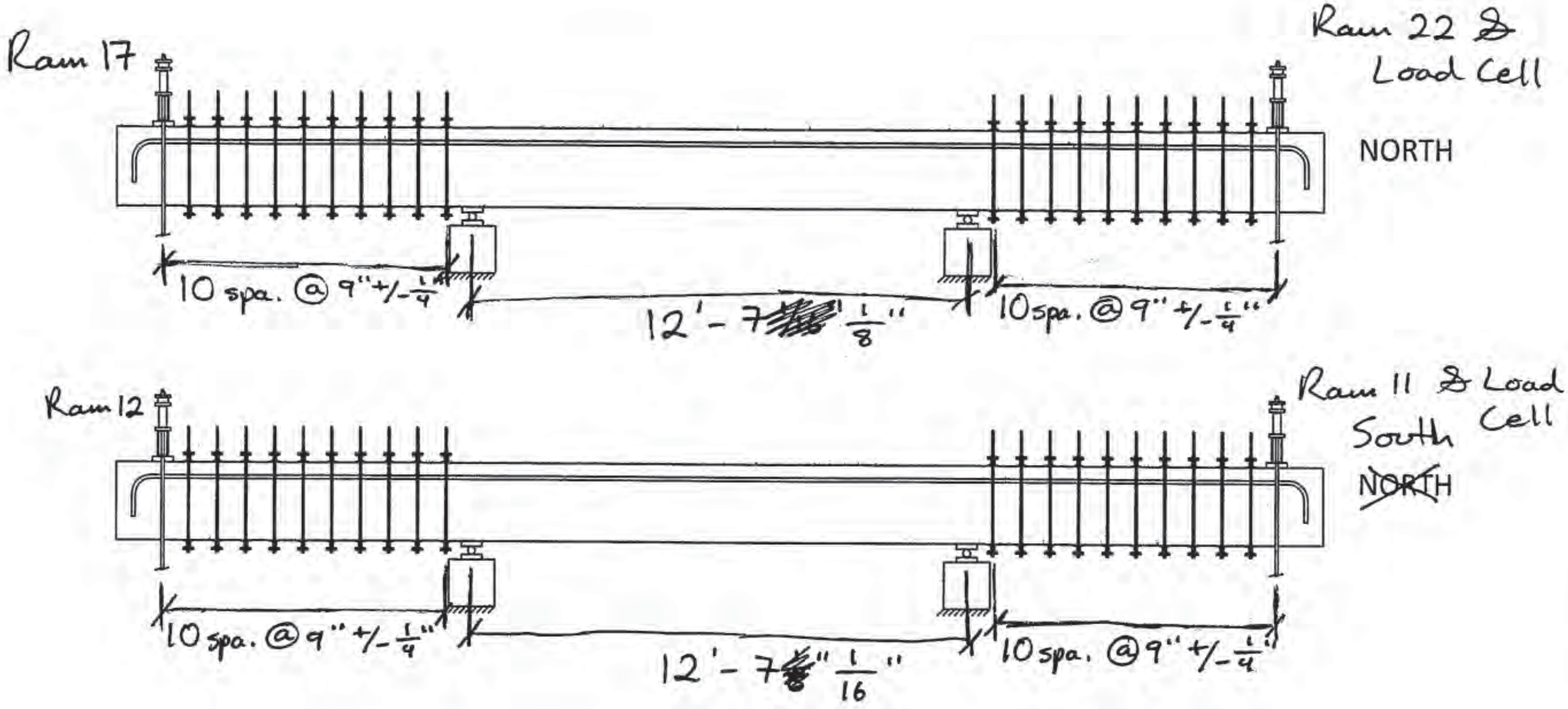
Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-~~2~~6

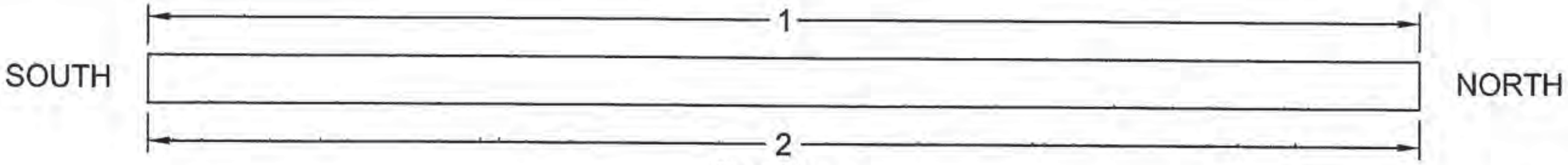
Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

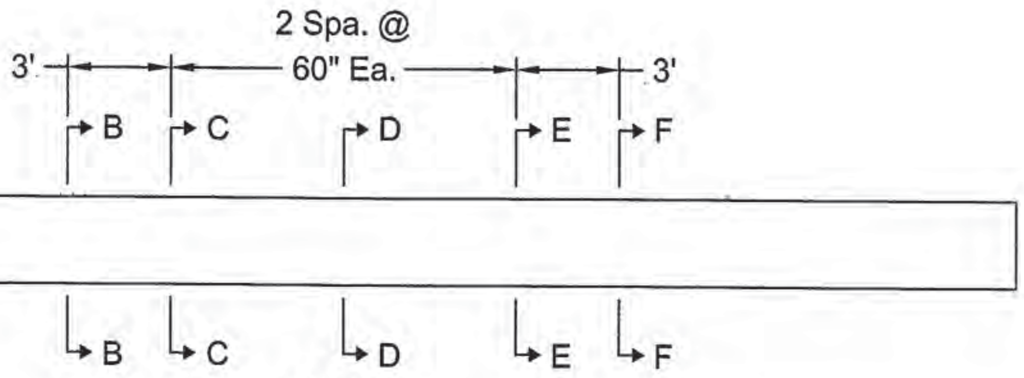
Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A



BOWEN LABORATORY PURDUE UNIVERSITY	Specimen B-6	Sheet:	1	of	4
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	KAM
		Date:	5/24/12		

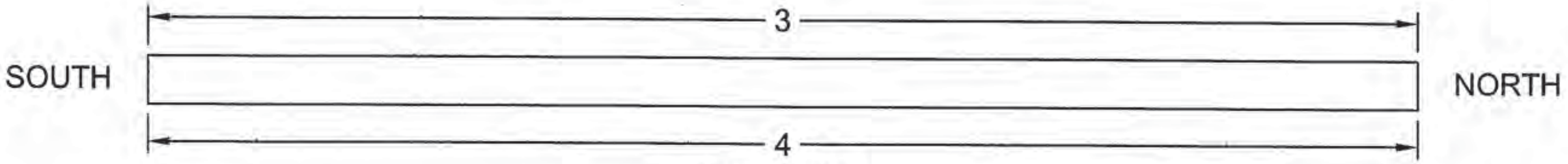


Top Plan



Profile

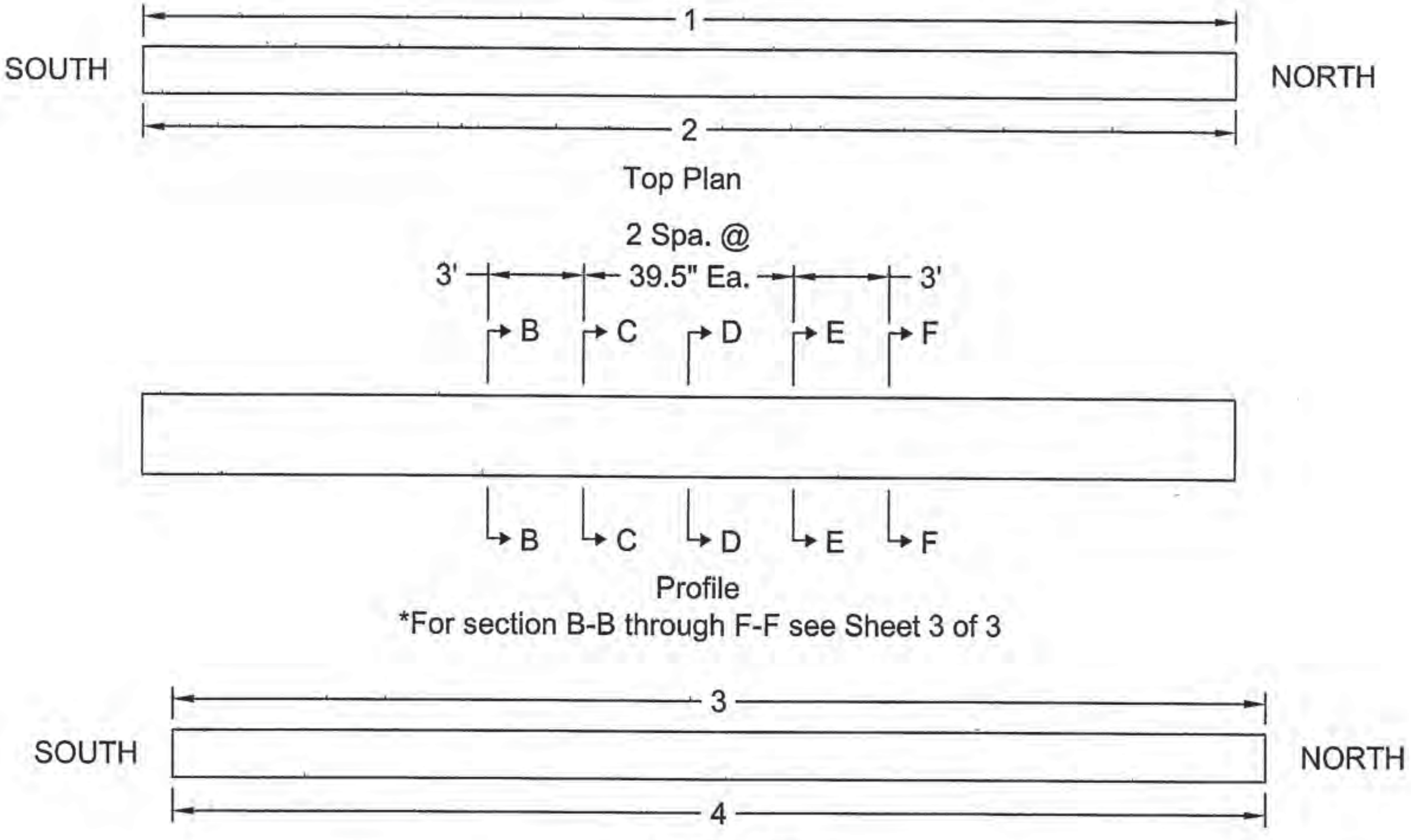
*For section B-B through F-F see Sheet 3 of 3



Bottom Plan

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Top Plan

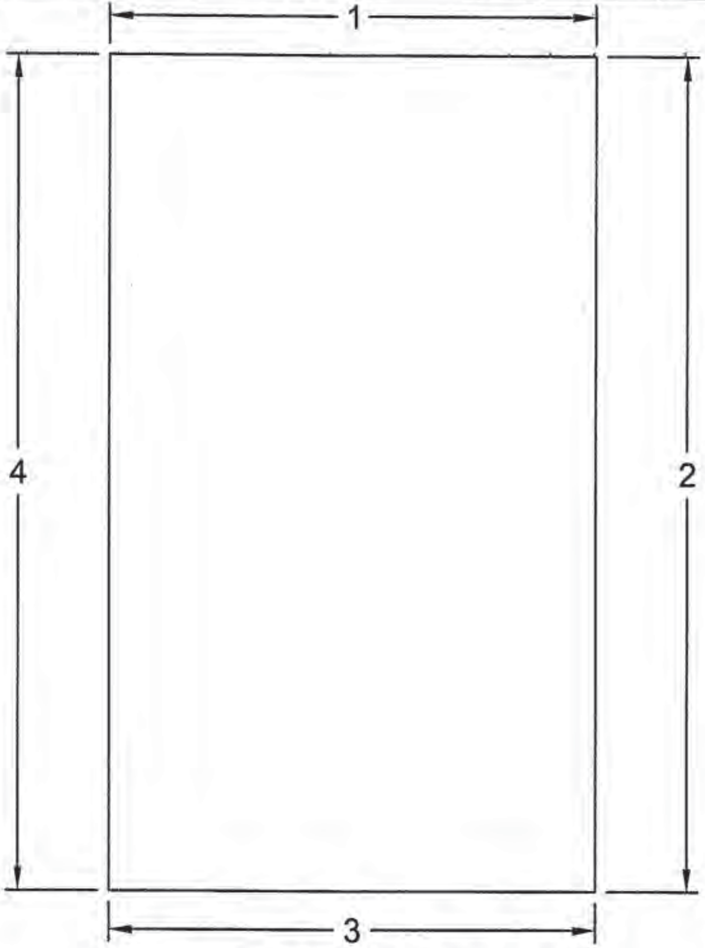
Profile

*For section B-B through F-F see Sheet 3 of 3

Bottom Plan

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Concrete As-built Sections	Sheet:	4	of 4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	

Project: Tests to Determine the
Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-6

Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A	166-1/2	79-0	166-1/2	166-5/8	78-7/8	166-3/8		
B-B	4-7/16	6-0	4 1/2	23-9/16	23 9/16	30 3/16	30 1/8	17 7/16
C-C	3-1/16	6 1/16	3 1/8	23 5/8	23 5/8	30 1/8	30 1/8	17 7/16
D-D	3 1/8	6 1/16	3 1/16	23 11/16	23 7/8	30-0	30 1/8	17 7/16
E-E	3 1/16	6 1/8	3-0	23 1/2	23 9/16	30-0	30 1/16	17 7/16
F-F	3-0	8 3/16	3 1/16	23 7/16	23 7/16	30-0	30 1/8	17 7/16

Recorded by:	Signature	Date	Time
BPR		4/30	10:10AM
Checked by:	**Signature**	**Date**	**Time**
TD		4/30	10:10Am
Checked by:	**Signature**	**Date**	**Time**

Comments:

*See formwork as-built drawings for dimension locations

Project: Tests to Determine the
Behavior of Spliced #11 Bars

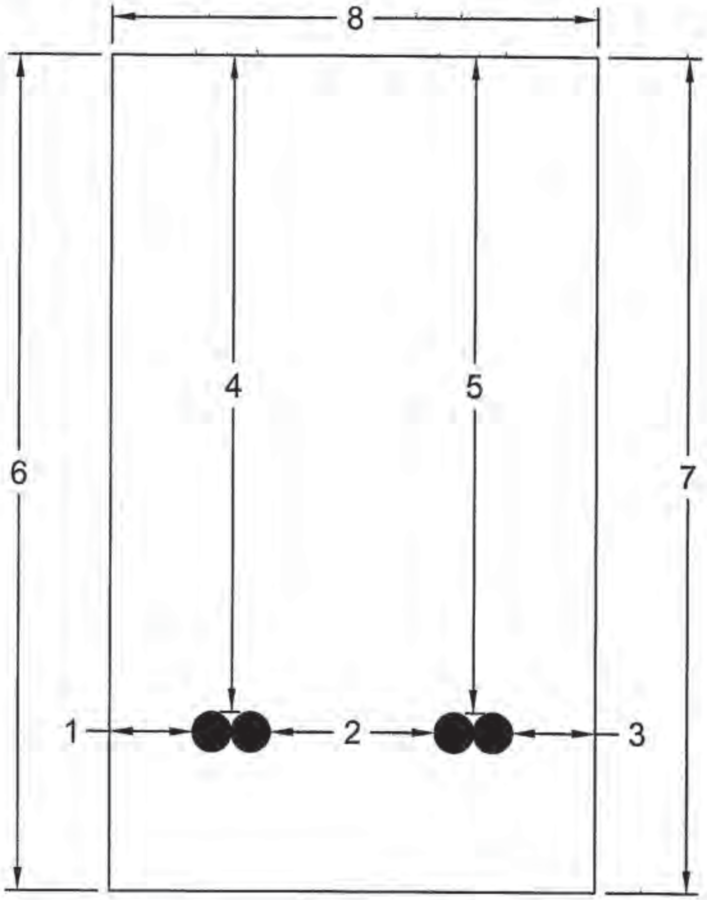
As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen: B-6

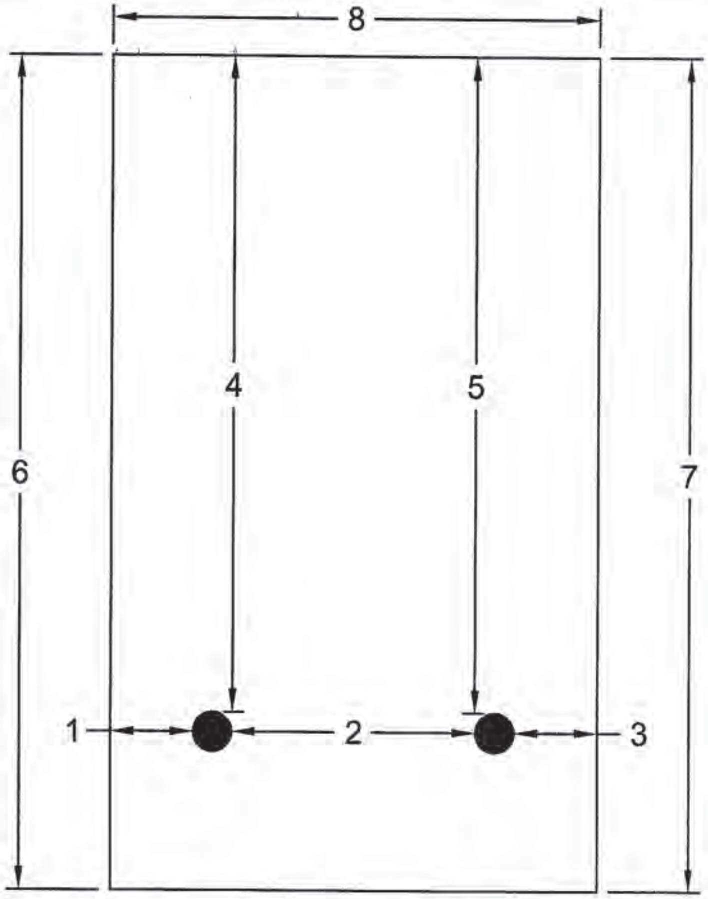
Sheet 2 of 2

Section	Formwork As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
A-A	14'-6"	10'-0"	14'-6"	14'-6"	10'-0"	14'-6"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Section	Formwork As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
A-A	13'-10.5"	6'-7"	13'-10.5"	13'-10.5"	6'-7"	13'-10.5"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

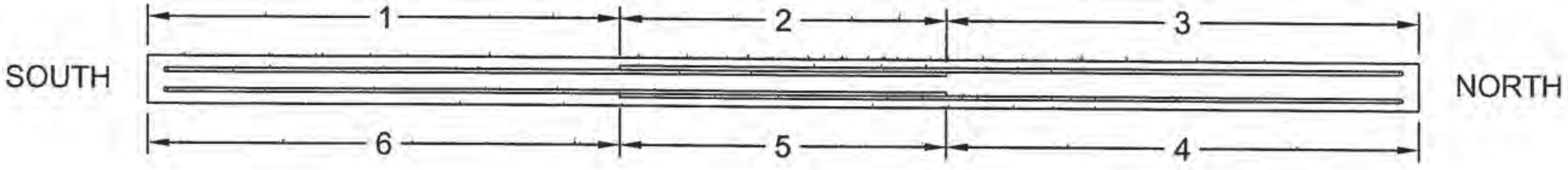


Section C-C, D-D, & E-E
*Facing North

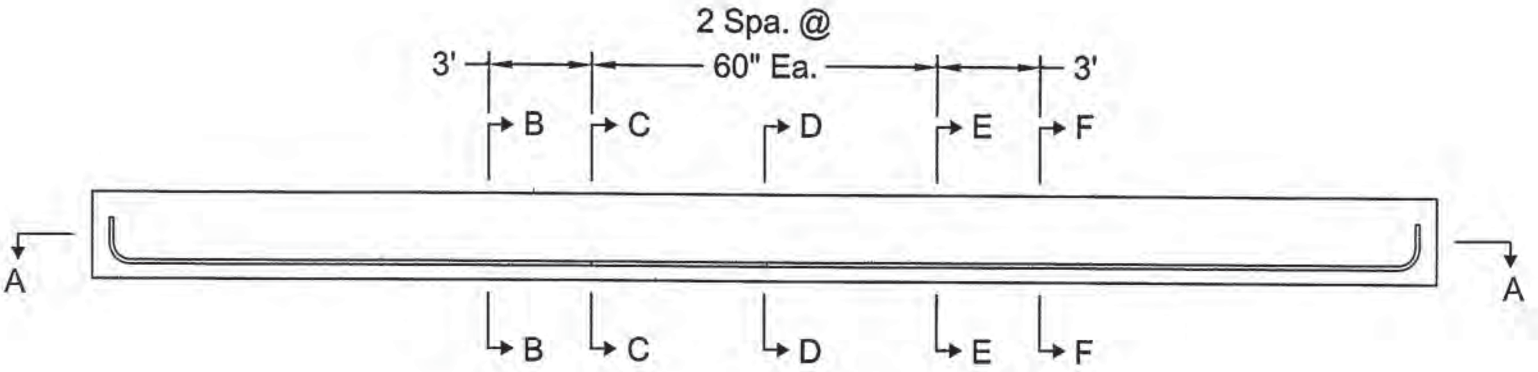


Section B-B & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Formwork As-built Sections	Sheet:	3	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



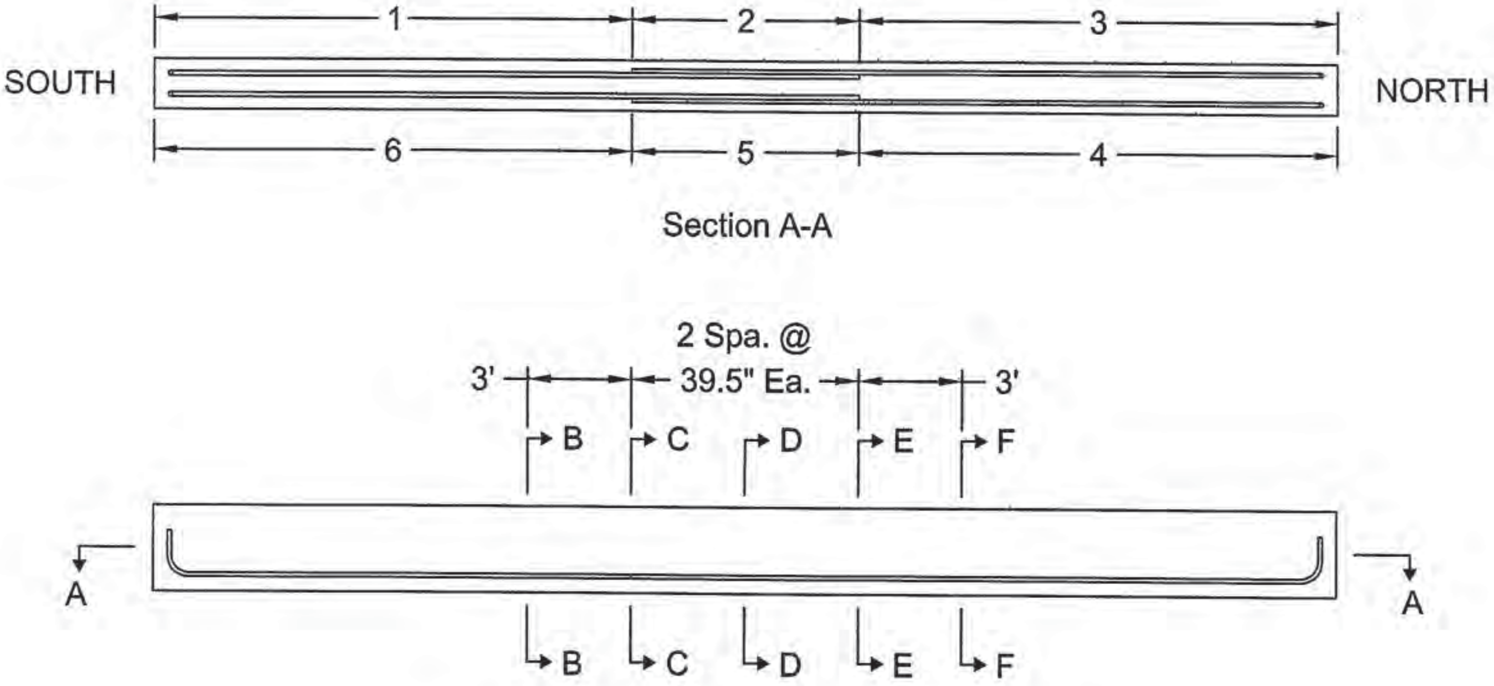
Section A-A



*For section B-B through F-F see Sheet 3 of 3

Series A

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series A Formwork As-builts	Sheet:	1 of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	

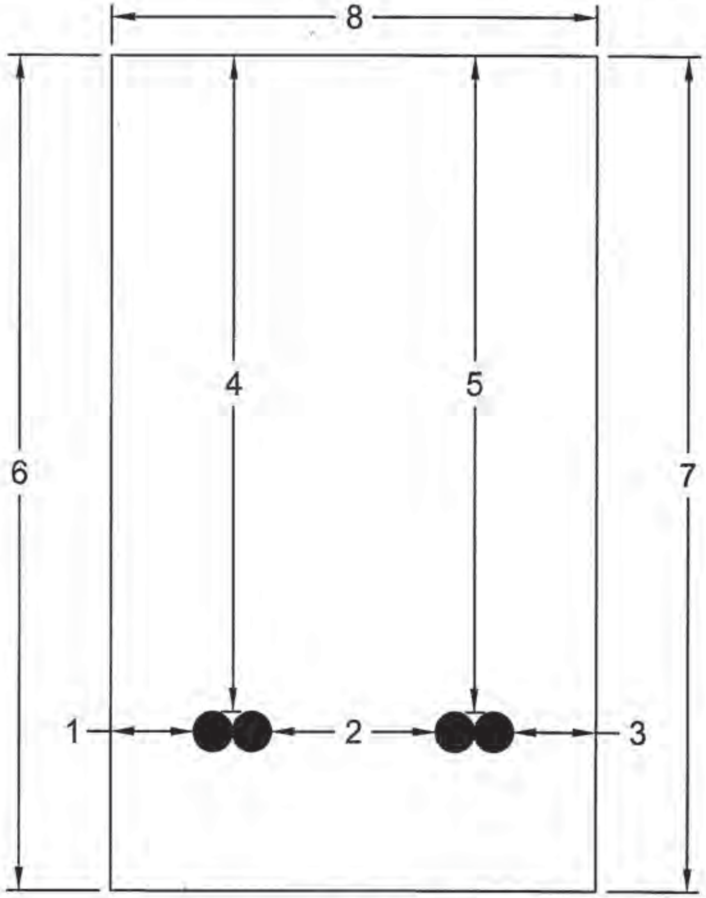


Section A-A

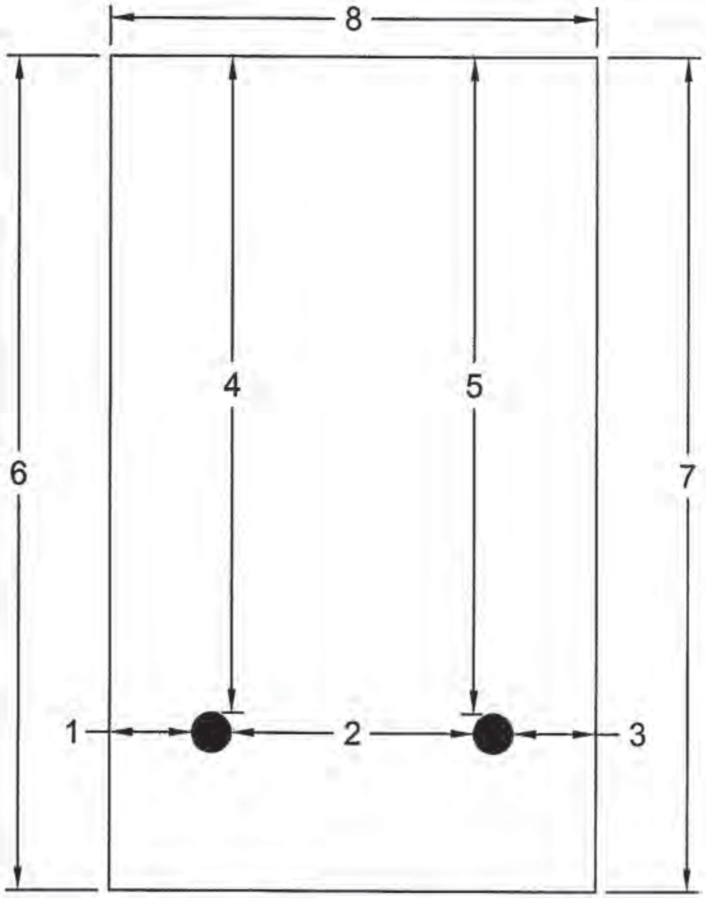
*For section B-B through F-F see Sheet 3 of 3

Series B

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Formwork As-builts	Sheet:	2	of	3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Formwork As-built Sections	Sheet:	3	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-1	4-11-12	1
	Time Beginning	Time Ending
	1:30 pm	1:45pm
	Temperature inside Lab (deg. F)	
	65	

Description of Work Performed

Wetted Burlap B-1 & Cylinders

Recorded by	Signature	Date	Time
KAM		4-11-12	1:45
Checked by	Signature	Date	Time
MAS		4/11/12	1:45 p
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information		
Specimen(s)	Date	Specimen Age
B-2	4-11-12	1
	Time Beginning	Time Ending
	1:30 pm	1:45 pm
	Temperature inside Lab (deg. F)	
	65	

Description of Work Performed

Wetted Burlap B-2 + Cylinders

Recorded by	Signature	Date	Time
KAM		4-11-12	1:45
Checked by	Signature	Date	Time
MAS		4/11/12	1:45 P
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-3	4-11-12	1
	Time Beginning	Time Ending
	1:15 pm	1:30 pm
	Temperature inside Lab (deg. F)	
	65	

Description of Work Performed

Wetted Burlap B-3 + cylinders

Recorded by	Signature	Date	Time
KAM		4-11-12	1:30PM
Checked by	Signature	Date	Time
MAS		4/11/12	1:45P
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1 (Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-1, 2, 3	4/12/12	2 day
	Time Beginning	Time Ending
	11 AM	4 PM
	Temperature inside Lab (deg. F)	
	60°F	

Description of Work Performed

✓ Struck Forms, wet beams
✓ Lifted & Moved Specimens + sprayed all w. water
✓ Covered all w. wet burlap + plastic

Recorded by	Signature	Date	Time
S.P.		4/12/12	5:00PM
Checked by	Signature	Date	Time
KAM		4-12-12	5:30PM
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars	Curing Documentation v.1 (Rev. 03/30/2012)	Purdue University - Bowen Laboratory Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-1,2,3	4-13-12	3 days
	Time Beginning	**Time Ending**
	2:30 pm	2:45 pm
	Temperature inside Lab (deg. F)	
	65°	

Description of Work Performed

Wetted Burlap of Specimens & cylinders

Recorded by	Signature	Date	Time
KAM		4-13-12	2:50pm
Checked by	**Signature**	**Date**	**Time**
S.P.		4/13/12	5:00 PM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-1,2,3	4-14	4 days
	Time Beginning	**Time Ending**
	3:30 pm	3:50pm
	Temperature inside Lab (deg. F)	
	65°	

Description of Work Performed

Wetted Burlap on Specimens B-1,2,3 & cylinders

Recorded by	Signature	Date	Time
KAM		4-14-12	3:50pm
Checked by	**Signature**	**Date**	**Time**
BPR		4/14/12	4:00PM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1 (Rev. 03/30/2012)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-1, B-2, ~~&~~ B-3, + corresponding cylinders	4/15/12	5-days
	Time Beginning	Time Ending
	1:30pm	2:00pm
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

Uncovered

Doused burlap w/ water

Recovered

Recorded by	Signature	Date	Time
BPR		4/15/12	2:00PM
Checked by	Signature	Date	Time
KAM		4-15	2:00PM
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-1,2,3	4/16/12	6 days
	Time Beginning	Time Ending
	3:00pm	3:30pm
	Temperature inside Lab (deg. F)	
	67°	

Description of Work Performed

Doused burlap and recovered beams B-1,2,3 & cylinders

Recorded by	Signature	Date	Time
KAM		4-16	4:00pm
Checked by	Signature	Date	Time
BPR		4/16	4:00PM
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-1, B-2, & B-3 & corresponding cylinders	4/17/12	7-day
	Time Beginning	**Time Ending**
	2:30PM	2:45PM
	Temperature inside Lab (deg. F)	
	62°F	

Description of Work Performed

Doused burlap w/ water
Recovered w/ plastic

Recorded by	**Signature**	**Date**	**Time**
BPR		4/17/12	2:47PM
Checked by	**Signature**	**Date**	**Time**
DPB		4/17/12	2:47PM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-1, B-2, & B-3 & corresponding cylinders	4/18/12	8-day
	Time Beginning	**Time Ending**
	4:30 PM	4:45PM
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

Doused burlap w/ water
Recovered w/ plastic

Recorded by	Signature	Date	Time
BPR		4/18/12	5:00PM
Checked by	**Signature**	**Date**	**Time**
TD		4/18/12	5:00PM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information		
Specimen(s)	Date	Specimen Age
B-1, B-2, & B-3 & cylinders	4/19	9-days
	Time Beginning	Time Ending
	4:00PM	4:15PM
	Temperature inside Lab (deg. F)	
	72°F	

Description of Work Performed

Watered burlap
Covered w/ plastic

Recorded by	Signature	Date	Time
BPR		4/19/12	4:15PM
Checked by	Signature	Date	Time
VAM		4-19-12	4:30PM
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-1, B-2, & B-3 & Cylinders	4/20/12	10-days
	Time Beginning	**Time Ending**
	5:30	6:00
	Temperature inside Lab (deg. F)	
	62°F	

Description of Work Performed

Dowsed burlap w/ water
Recovered w/ plastic

Recorded by	Signature	Date	Time
KAM		4-20-12	6:00pm
Checked by	**Signature**	**Date**	**Time**
BPR		4/20/12	6:05PM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-1,2,3	4-21-12	11-days
	Time Beginning	Time Ending
	3:30 pm	4:00 pm
	Temperature inside Lab (deg. F)	
	62°F	

Description of Work Performed

Doused burlap on specimens & cylinders, recovered with plastic

Recorded by	Signature	Date	Time
KAM		4-21-12	4:15 pm
Checked by	Signature	Date	Time
BPR	Brian Richter	4/21/12	4:20PM
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information		
Specimen(s)	Date	Specimen Age
B-1, B-2, & B-3 + Cylinders	4/23	13-days
	Time Beginning	Time Ending
	2:45PM	3:00PM
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

Watered burlap
Recovered w/ plastic

Recorded by	Signature	Date	Time
BPR		4/23	3:00PM
Checked by	Signature	Date	Time
JNH		4.23.12	3:00PM
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars
Curing Documentation v.1 (Rev. 03/30/2012)
Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-1, B-2, ~~&~~ B-3 & Cylinders	4/24/12	14-days
	Time Beginning	**Time Ending**
	11 AM	11:10 AM
	Temperature inside Lab (deg. F)	
	62°F	

Description of Work Performed

Uncovered specimens (stopped curing)

Recorded by	Signature	Date	Time
BPR		4/24	11:15 AM
Checked by	**Signature**	**Date**	**Time**
DPB		4/24	4:10
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1 (Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
A-1, A-2, & A-3 + corresponding cylinders	4/18/12	1-day
	Time Beginning	**Time Ending**
	3:00 PM	3:30 PM
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

Doused burlap w/ water
Re-covered

Recorded by	**Signature**	**Date**	**Time**
BPR		4/18/12	4:20PM
Checked by	**Signature**	**Date**	**Time**
TD		4/18/12	4:20PM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
A-1, A-2, & A-3 & Cylinders	4/19	2-days
	Time Beginning	**Time Ending**
	10:30 AM	5:15PM
	Temperature inside Lab (deg. F)	
	72°F	

Description of Work Performed

Stripped formwork & removed cylinders from molds (10:30AM-2PM)
Moved beams off of platforms (2PM-4PM)
Covered beams & cyl. w/ wet burlap & plastic (4 PM - 5:15PM)

Recorded by	Signature	Date	Time
BPR		4/19/12	5:15PM
Checked by	**Signature**	**Date**	**Time**
KAM		4-19-12	5:30 PM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1 (Rev. 03/30/2012)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
A-1, A-2, & A-3 & Cylinders	4/20/12	3-days
	Time Beginning	**Time Ending**
	6:30	6:00
	Temperature inside Lab (deg. F)	
	62°F	

Description of Work Performed

Uncovered specimens & cylinders (stopped curing)

Recorded by	Signature	Date	Time
KAM		4-20-12	6:00pm
Checked by	**Signature**	**Date**	**Time**
BPR		4/20/12	6:05PM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars
Curing Documentation v.1 (Rev. 03/30/2012)
Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
A-4, A-5, & A-6 & cylinders	4/25/12	1 ~~#~~-days
	Time Beginning	**Time Ending**
	4:00 PM	4:20PM
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

Doused burlap w/ water
Recovered w/ plastic

Recorded by	Signature	Date	Time
BPR		4/25	7:10PM
Checked by	**Signature**	**Date**	**Time**
KAM		4-25-12	7:30 pm
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
A-4, A-5, & A-6 & corresponding cylinders	4/26/12	2-days
	Time Beginning	**Time Ending**
	10:30 AM	4:45PM
	Temperature inside Lab (deg. F)	
	Not Recorded BPR 6/1/12	

Description of Work Performed

Uncovered specimens & cylinders
Stripped forms & popped cylinders
Moved specimens
Covered spec. & cylinders w/ wet burlap
Covered spec. & cylinders w/ plastic

Recorded by	Signature	Date	Time
BPR		4/26/12	4:50PM
Checked by	**Signature**	**Date**	**Time**
KAM		4-26-12	5:00PM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars
Curing Documentation v.1 (Rev. 03/30/2012)
Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information		
Specimen(s)	Date	Specimen Age
A-4, A-5, & A-6 & corresponding cylinders	4/27	3-days
	Time Beginning	Time Ending
	2:30PM	2:45PM
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

Doused burlap w/ water
Recovered w/ plastic

Recorded by	Signature	Date	Time
BPR		4/27/12	3:00PM
Checked by	Signature	Date	Time
KAM		4-27-12	3:30pm
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
A-4, A-5, & A-6	4/28/12	4-days
	Time Beginning	**Time Ending**
	1:00PM	1:30PM
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

Doused burlap w/ water
Recovered w/ plastic

Recorded by	Signature	Date	Time
BPR		4/28	1:30PM
Checked by	**Signature**	**Date**	**Time**
KAM		4-28-12	1:30 PM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1 (Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
A-4, A-5, & A-6 & Cylinders	4/30/12	6-days
	Time Beginning	**Time Ending**
	8:15 AM	8:45AM
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

Doused burlap w/ water
Recovered w/ plastic

Recorded by	Signature	Date	Time
BPR		4/30/12	9:15AM
Checked by	**Signature**	**Date**	**Time**
KAM		4-30-12	9:15 AM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
A-4, 5, 6	5-1-12	7 days
	Time Beginning	Time Ending
	1:00 pm	1:15 pm
	Temperature inside Lab (deg. F)	
	65°	

Description of Work Performed

Stopped Curing
Removed Plastic from specimens + cylinders

Recorded by	Signature	Date	Time
KAM		5-1-12	1:30
Checked by	**Signature**	**Date**	**Time**
BPR		5/1	4:20 PM
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1 (Rev. 03/30/2012)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
B-4,5,6	5-1-12	1 day
	Time Beginning	Time Ending
	1:15pm	1:30pm
	Temperature inside Lab (deg. F)	
	65°	

Description of Work Performed

Doused Burlap, Recovered Specimens + Cylinders

Recorded by	Signature	Date	Time
KAM		5-1-12	1:30pm
Checked by	Signature	Date	Time
BPR		5/1	4:20PM
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information		
Specimen(s)	Date	Specimen Age
B-4,5,6	5-3-12	3 days
	Time Beginning	Time Ending
	9:00 am	5:00 pm
	Temperature inside Lab (deg. F)	
	70°	

Description of Work Performed

Removed specimens from forms

Recorded by	Signature	Date	Time
VAM		5-3-12	5:00 pm
Checked by	Signature	Date	Time
BPR		5-3-12	5:00PM
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Tinius Olsen Testing Machine Company
Displacement Measuring System Verification Report & Certificate
Specifications per ASTM E 2309

Date of Issue May 02, 2011 **Certificate Number** 9M9AHP05

ilac-MRA ACCREDITED CALIBRATION CERT #987.01

Issued by:

Tinius Olsen Testing Machine Company
1065 Easton Road
P.O. Box 1009
Horsham. PA 19044-8009, USA
Tel (215) 675-7100
Fax (215) 441-0899
www.TiniusOlsen.com

Page 1 of 3
Authorized Signature
Cheryl Spinieo
Cheryl Spinieo

Owner/Location LABORATORY TESTING INC, 2331 Topaz Drive, Hatfield, Pennsylvania 19440

Calibration Location SAME

Item Description S/N 206051P - POSITION #60013377 Ascending - w/ Computer Display #206051 - As Found/As Left - No Adjustments - Good Condition

Year of Manufacture UNKNOWN

Verification Date April 29, 2011 **Verification Recall** April 29, 2012

This is to certify that the above testing equipment has been verified by Tinius Olsen Testing Machine Company personnel on Order Number 448750. The listed data is in accordance with the latest practices of ASTM E 2309, and Tinius Olsen Procedure #2600, and have been temperature corrected as necessary. Tinius Olsen's Quality System is maintained in compliance with ANSI / NCSL Z540-1 1994, ISO/IEC 17025 (Complies with ISO 9000 Series for Calibration Activity), ISO 10012-1, and MIL-STD-45662A.

Range in	Class Range in	Class
9.0000	0.1000 TO 9.0000	B
9.0000	0.9000 TO 9.0000	A

LTI
QA REVIEW
INIT: CLD
DATE 5/11/11

Services have been performed in accordance with Tinius Olsen Quality Manual, dated 03/13/09__.

These results relate only to the items calibrated. This Report and Certificate shall not be reproduced except in full, without the written approval of Tinius Olsen.

Tinius Olsen Testing Machine Company
Displacement Measuring System Verification Report & Certificate
Specifications per ASTM E 2309

Verification Date April 29, 2011

Certificate Number 9M9AHP05

Page 2 of 3

All verification devices are traceable to the International System of Units (SI) through National Institute of Standards and Technology (NIST) or the National Physical Laboratory (NPL). Serial Number, Manufacturer, Type, Maximum Device Error, Calibration Vendor, and Expiry Date for each standard used during the Certification is listed below.

Serial No.	Manufacturer	Type	Max Device Error	Vendor	Expiry Date
655-4041-J-2	Starrett	INDICATOR	.0007500	Olsen	13-Jul-11

The expanded uncertainties reported are estimates of the measurement uncertainty in the errors determined during the verification. They are expressed as percentages of their respective verification readings. The expanded uncertainties reported are based on combined standard uncertainties, multiplied by a coverage factor of 2, which provide a confidence interval of approximately 95%. The uncertainties reported do not represent the uncertainty of the testing machine or the results of any subsequent tests performed with the testing machine.

1.6.17/1.1.34/32

Tinius Olsen Testing Machine Company
Displacement Measuring System Verification Report & Certificate
Specifications per ASTM E 2309

Certificate Number 9M9AHP05

Page 3 of 3

Verification Date April 29, 2011 **Verification Recall Date** April 29, 2012

Owner/Location LABORATORY TESTING INC, 2331 Topaz Drive, Hatfield, Pennsylvania 19440

Calibration Location SAME

Item Description S/N 206051P - POSITION #60013377 Ascending - w/ Computer Display #206051 - As Found/As Left - No Adjustments - Good Condition

Order No. 448750 **Customer PO No.** PO0002821 **Customer ID No.** **Year of Mfg.** UNKNOWN

Backlash As Found **BackLash As Left** **Temp. Start** 22.8 °C **End** 22.8 °C

Range in	Resolution in	Ver Read 1 in	Mach Read1 in	Ver Read 2 in	Mach Read 2 in	Fixed Error in	Error %	Difference %	Uncertainty %	Class
9	0.0001	9.0000	8.9733	9.0000	8.9756	-0.0267	-0.30	-0.03	0.38	A
	0.0001	6.7500	6.7252	6.7500	6.7415	-0.0248	-0.37	-0.24	0.38	A
	0.0001	4.5000	4.4929	4.5000	4.5027	-0.0071	-0.16	-0.22	0.38	A
	0.0001	2.2500	2.2440	2.2500	2.2466	-0.0060	-0.27	-0.12	0.39	A
	0.0001	0.9000	0.9020	0.9000	0.8997	0.0020	0.22	0.26	0.35	A
	0.0001	0.6750	0.6767	0.6750	0.6775	0.0025	0.37	-0.12	0.33	B
	0.0001	0.4500	0.4514	0.4500	0.4516	0.0016	0.36	-0.04	0.33	B
	0.0001	0.2250	0.2255	0.2250	0.2258	0.0008	0.36	-0.13	0.54	B
	0.0001	0.1000	0.1004	0.1000	0.1003	0.0004	0.40	0.10	1.14	B

Calibration Technician/Engineer Brian Campbell

Witness Kevin Kline

1.6.17/1.1.34/32

Tinius Olsen Testing Machine Company
Certificate

ilac-MRA

ACCREDITED
CALIBRATION CERT #687.01

Certificate No. 9M9AHP06 **Certificate page 1 of 1**

Issued By:
Tinius Olsen Testing Machine Company
1065 Easton Road
Horsham, PA 19044 USA
Telephone: 215-675-7100
Fax: 215-441-0899
Email: service@tiniusolsen.com

Cheryl Spencer
Authorized Signature

Owner/Location: LABORATORY TESTING INC., HATFIELD, PA 19440

Calibration Location: SAME AS ABOVE

Item Description: Crosshead Speed Rate on Machine S/N 206051SR (#6001337) - As Found/As Left - No Adjustments - Good Condition

Verification Date: April 29, 2011 **Verificiation Recall Date: April 29, 2012**

This is to certify that the Crosshead Speed Rate on the above testing equipment has been verified by Tinius Olsen Testing Machine Company personnel on Order Number S448750. The listed data is in accordance Tinius Olsen Procedure #2700. Tinius Olsen's Quality System is maintained in compliance with ISO/IEC 17025 (Complies with ISO 9000 Series for Calibration Activity), ANSI / NCSL Z540-1 1994, ISO 10012-1, and MIL-STD-45662A. The estimated expanded uncertainty of the calibration results is: 0.0016 in. The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95 percent.

Crosshead Speed Rate Certificate

All verification devices are traceable to the International System of Units (SI) through either National Institute of Standards and Technology (NIST) or National Physical Laboratory (NPL) and have been verified within one (1) year or less of the above date. For Verification details, refer to the attached Verification Data and Report Form bearing the same Order or Certificate Number as this Certificate.

Serial No	Manufacturer	Description	Calib Vendor	Expiry Date
DSW-0002	HANHART	STOPWATCH	TINIUS OLSEN	4/28/16
655-4041-J-2	STARRETT	DIAL INDICATOR	TINIUS OLSEN	7/13/11

Services have been performed in accordance with Tinius Olsen Quality Manual, dated March 13, 2009.

These results relate only to the items calibrated. This Certificate shall not be reproduced except in full, without the written approval of Tinius Olsen.

Rev. 2009.0

Tinius Olsen Testing Machine Company
Rate Verification Datasheet & Report

Tinius Olsen Procedure used 2700
Rev. 10 April 2007
Page 1 of 2

Date 7/29/11
Certificate # 9M9AHP06
Order No. 448750
Purchase Order No. PO 0002821
Customer LABORATORY TESTING
Machine Mfg. TINIUS OLSEN
Location HATFIELD, PA
Model and Serial # SUPER L 206051
Machine Display 602
Capacity and Units 400,000 LBF
Customer ID No. 60013377
Cal. Technician Brian S. Cogdell
Stopwatch S/N DSW-0002
Strain Device S/N –
Dial Indicator S/N 655-4041-J-2
Gauge Length –
Temperature 73

Condition (Circle One) ~ As Found / As Left / No Adjustments / Limited Calibration / Out of Tolerance

Load Rate (Circle One) Lbf/Min Kgf/Min N/Min Other

Control Setting	Load Range	Load Rate Displayed	Change in Load	Time	Actual Load Rate	Error (actual)	Error %
			N/A				

Strain Rate (Circle One) in/in/min mm/mm/min %/min Other
Split Specimen/Broken Specimen* Previously Untested Specimen

Control Setting	Strain Range	Strain Rate Displayed	Change in Strain	Time	Actual Strain Rate	Error (actual)	Error %
			N/A				

* If a Split Specimen or Broken Specimen was used for Strain Rate then the ability of the machine to control was not verified.

Tinius Olsen Testing Machine Company
Testing Machine Verification Report & Certificate
Specifications per ASTM E 4

ilac-MRA

ACCREDITED
CALIBRATION CERT #867.01

Date of Issue May 02, 2011 **Certificate Number** 9M9AHP07

Issued by:

Tinius Olsen Testing Machine Company
1065 Easton Road
P.O. Box 1009
Horsham. PA 19044-8009, USA
Tel (215) 675-7100
Fax (215) 441-0899
www.TiniusOlsen.com

Page 1 of 3
Authorized Signature

Cheryl Spinieo

Cheryl Spinieo

Owner/Location LABORATORY TESTING INC, 2331 Topaz Drive, Hatfield, Pennsylvania 19440

Calibration Location SAME

Item Description S/N 206051 - 400000 lbf HYD SPR L602 #60013377 - w/ Digital Indicator - As Found/As Left - No Adjustments - Good Condition

Serial Numbers: Machine 206051 **LC #** N/A

Computer # 206051 **REC #** N/A

Year of Manufacture UNKNOWN **Cal-Check No.** 190577

Verification Date April 29, 2011 **Verification Recall** April 29, 2012

This is to certify that the above testing equipment has been verified by Tinius Olsen Testing Machine Company personnel on Order Number 448750. The listed data is in accordance with ASTM E 4-10, and Tinius Olsen Procedure #1000, and have been temperature corrected as necessary. Tinius Olsen's Quality System is maintained in compliance with ANSI / NCSL Z540-1 1994, ISO/IEC 17025 (Complies with ISO 9000 Series for Calibration Activity), ISO 10012-1, and MIL-STD-45662A.

Capacity Range lbf	Loading Range lbf	Percent Error	Range Pass/Fail
0 to 400000	798.00 TO 401000.00	-0.24	Pass

ASTM E 4 Allowable Tolerance ± 1.0%

Services have been performed in accordance with Tinius Olsen Quality Manual, dated 03/13/09__.

These results relate only to the items calibrated. This Report and Certificate shall not be reproduced except in full, without the written approval of Tinius Olsen

Tinius Olsen Testing Machine Company
Testing Machine Verification Report & Certificate
Specifications per ASTM E 4

Verification Date April 29, 2011

Certificate Number 9M9AHP07
Page 2 of 3

All verification devices comply with the latest practices of ASTM E 74, and are traceable to the International System of Units (SI) through National Institute of Standards and Technology (NIST) or the National Physical Laboratory (NPL). Serial Number, Manufacturer, Class A Loading Range, Calibration Vendor, Expiry Date, and Certificate Number for each standard used during the Certification is listed below. The class of the verification equipment was equal to or better than the requirements of the classification to which this device has been verified.

Eqp #	S/N	Manufacturer	Class A Loading Range	Calib. Vendor	Calib. Date	Expiry Date
1	104713A (HI)	Tovey	100.00 to 10000.00 lbf	Morehouse	03-Mar-10	03-Mar-12
2	110211A	Tovey	2017.60 to 60000.00 lbf	Tovey	02-Apr-11	02-Apr-12
3	106244A	Tovey	31836.00 to 600000.00 lbf	Tovey	01-Mar-10	01-Mar-12

This Calibration was performed in Compression for increasing forces only. For Universal Testing Machines that have two work areas with a common force application and indicating device, calibration performed in the lower test area in compression is the same for tension in the upper work area and vice versa.

"The constant indicated/constant true force method was used for the verification. Verification by Standard Weights" and/or "Verification by Elastic Calibration Device"

Informative Notes:

The expanded uncertainties reported are estimates of the measurement uncertainty in the errors determined during the verification. They are expressed as percentages of their respective verification readings. The expanded uncertainties reported are based on combined standard uncertainties, multiplied by a coverage factor of 2, which provide a confidence interval of approximately 95%. The uncertainties reported do not represent the uncertainty of the testing machine or the results of any subsequent tests performed with the testing machine. The accuracy of the testing equipment has been found to conform with the tolerance(s) indicated above.

The uncertainties stated refer to the values obtained during verification and make no allowance for factors such as long-term drift, temperature and alignment effects – the influences of such factors should be taken into account by the user of the testing machine.

1.6.33/1.1.34/32

Tinius Olsen Testing Machine Company
Testing Machine Verification Report & Certificate
Specifications per ASTM E 4

Verification Date April 29, 2011

Certificate No. 9M9AHP07

Page 3 of 3

Owner/Location LABORATORY TESTING INC. 2331 Topaz Drive Hatfield, Pennsylvania 19440

Calibration Location SAME

Item Description S/N 206051 - 400000 lbf HYD SPR L602 #60013377 - w/ Digital Indicator - As Found/As Left - No Adjustments - Good Condition

Customer ID No.

Year of Mfg. UNKNOWN

Cal-Check No. 190577

Order No. 448750

Customer PO No. PO0002821

Temperature Start 22.8 °C **End** 24.4 °C

Serial Numbers: **TM** 206051

LC N/A

REC N/A

COMP 206051

Verification Recall Date April 29, 2012

LOAD RANGE lbf	*	VERIFIC. READ #1 lbf	MACHINE READ #1 lbf	VERIFIC. READ #2 lbf	MACHINE READ #2 lbf	FIXED ERROR lbf	ERROR % OF VALUE	DIFFER. % OF VALUE	UNCERTAINTY % OF VALUE	RESOLUTION FOR RANGE(S) lbf
400000	1	798.2	800.0	802.4	801.4	1.8	0.22	0.35	0.44	4.0
	1	1607.1	1606.9	1606.2	1606.0	-0.3	-0.02	0.01	0.26	4.0
	1	3199.4	3201.6	3201.6	3199.5	2.2	0.07	0.14	0.19	4.0
	2	5600.5	5599.7	5601.1	5600.2	-0.8	-0.02	0.00	0.19	4.0
	2	8003.3	8002.1	8003.4	8002.2	-1.2	-0.01	0.00	0.17	4.0
	2	16010.8	15999.7	16012.0	16000.9	-11.2	-0.07	0.00	0.16	4.0
	2	32028.1	31996.6	32006.7	31999.1	-31.5	-0.10	-0.07	0.16	4.0
	3	56100.9	56004.5	56080.4	55998.6	-96.4	-0.17	-0.03	0.20	4.0
	3	80174.9	79994.9	80165.3	79998.7	-179.9	-0.22	-0.02	0.18	4.0
	3	160383.5	159997.2	160380.8	159995.4	-386.3	-0.24	0.00	0.17	4.0
	3	240465.1	239976.9	240469.2	239982.8	-488.2	-0.20	0.00	0.16	4.0
	3	320610.9	319905.7	320560.3	319989.5	-705.2	-0.22	-0.04	0.16	4.0
	3	401079.8	400352.4	401127.7	400670.5	-727.4	-0.18	-0.07	0.16	4.0
		0.0	0.0	0.0	0.0	0	0.00	0.00	N/A	0.0

Calibration Technician/Engineer Brian Campbell

Witness Kevin Kline

Tinius Olsen Testing Machine Company Certificate

Certificate No. 9M9AHP08 **Certificate page 1 of 1**

Issued By:
Tinius Olsen Testing Machine Company
1065 Easton Road
Horsham, PA 19044 USA
Telephone: 215-675-7100
Fax: 215-441-0899
Email: service@tiniusolsen.com

Cheryl Spencer
Authorized Signature

Owner/Location: LABORATORY TESTING INC., HATFIELD, PA 19440

Calibration Location: SAME AS ABOVE

Item Description: Strain Rate on Machine S/N 206051STR (#60013377) - As Found/As Left - No Adjustments - Good Condition

Verification Date: April 29, 2011 **Verification Recall Date: April 29, 2012**

This is to certify that the Strain Rate on the above testing equipment has been verified by Tinius Olsen Testing Machine Company personnel on Order Number S448750. The listed data is in accordance Tinius Olsen Procedure #2700. Tinius Olsen's Quality System is maintained in compliance with ISO/IEC 17025 (Complies with ISO 9000 Series for Calibration Activity), ANSI / NCSL Z540-1 1994, ISO 10012-1, and MIL-STD-45662A. The estimated expanded uncertainty of the calibration results is: 0.12% of reading. The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95 percent.

Strain Rate Certificate

All verification devices are traceable to the International System of Units (SI) through either National Institute of Standards and Technology (NIST) or National Physical Laboratory (NPL) and have been verified within one (1) year or less of the above date. For Verification details, refer to the attached Verification Data and Report Form bearing the same Order or Certificate Number as this Certificate.

Serial No	Manufacturer	Description	Calib Vendor	Expiry Date
DSW-0002	HANHART	STOPWATCH	TINIUS OLSEN	4/28/16

Services have been performed in accordance with Tinius Olsen Quality Manual, dated March 13, 2009.

These results relate only to the items calibrated. This Certificate shall not be reproduced except in full, without the written approval of Tinius Olsen.

Rev. 2009.0

Tinius Olsen Testing Machine Company
Rate Verification Datasheet & Report

Tinius Olsen Procedure used 2700
Rev. 10 April 2007
Page 1 of 2

Date 4/29/11
Order No. 448750
Customer LABORATORY TESTING
Location HATFIELD, PA
Machine Display 602
Customer ID No. 60613377
Stopwatch S/N DSW-0002
Dial Indicator S/N -
Temperature 73

Certificate # 9M9AHP08
Purchase Order No. PO 0002821
Machine Mfg. TINIUS OLSEN
Model and Serial # SUPER L 206051
Capacity and Units 400,000 LBF
Cal. Technician
Strain Device S/N 207344
Gauge Length 2 INCHES

Condition (Circle One) ~ As Found / As Left / No Adjustments / Limited Calibration / Out of Tolerance

Load Rate (Circle One) Lbf/Min Kgf/Min N/Min Other________

Control Setting	Load Range	Load Rate Displayed	Change in Load	Time	Actual Load Rate	Error (actual)	Error %
			N/A				

Strain Rate (Circle One) in/in/min mm/mm/min %/min Other________
Split Specimen/Broken Specimen* Previously Untested Specimen

Control Setting	Strain Range	Strain Rate Displayed	Change in Strain	Time	Actual Strain Rate	Error (actual)	Error %
.005	N/A	.005	.005	60.10	.005008	.000008	.16

* If a Split Specimen or Broken Specimen was used for Strain Rate then the ability of the machine to control was not verified.

Tinius Olsen Testing Machine Company
Instrument Verification Report & Certificate
Specifications per ASTM E 83

ilac-MRA
ACCREDITED
CALIBRATION CERT #887.01

Date of Issue May 03, 2011 **Certificate Number** 9M9AHP01

Issued by:
Tinius Olsen Testing Machine Company
1065 Easton Road
P.O. Box 1009
Horsham. PA 19044-8009, USA
Tel (215) 675-7100
Fax (215) 441-0899
www.TiniusOlsen.com

Page 1 of 3
Authorized Signature
Cheryl Spinieo
Cheryl Spinieo

Owner/Location LABORATORY TESTING INC, 2331 Topaz Drive, Hatfield, Pennsylvania 19440

Calibration Location SAME

Item Description S/N 207344 - LS-4%-2 EXTENS #60013378 - w/ Digital Indicator #206051 - As Found - Out of Tolerance Condition

Year of Mfr. UNKNOWN **Mfr.** Tinius Olsen **Cal-Check No.** N/A **Cal Factor** N/A

Verification Date April 29, 2011 **Verification Recall** April 29, 2012

This is to certify that the above testing equipment has been verified by Tinius Olsen Testing Machine Company personnel on Order Number 448750. The listed data is in accordance with the latest practices of ASTM E 83, and Tinius Olsen Procedure #2000, and have been temperature corrected as necessary. Tinius Olsen's Quality System is maintained in compliance with ANSI / NCSL Z540-1 1994, ISO/IEC 17025 (Complies with ISO 9000 Series for Calibration Activity), ISO 10012-1, and MIL-STD-45662A.

Range in/in	Calibration Factor	Class Range in/in	Class
0.0400	0.004	0.0010 TO 0.0400	D

NOT USED for
complete range
see page 3
5/9/11

LTI
QA REVIEW
INIT.
DATE 5/11/11

Services have been performed in accordance with Tinius Olsen Quality Manual, dated March 13, 2009.

These results relate only to the items calibrated. This Report and Certificate shall not be reproduced except in full, without the written approval of Tinius Olsen.

Tinius Olsen Testing Machine Company
Instrument Verification Report & Certificate
Specifications per ASTM E 83

Verification Date April 29, 2011

Certificate Number 9M9AHP01

Page 2 of 3

All verification devices comply with the latest practices of ASTM E 83, and are traceable to the International System of Units (SI) through National Institute of Standards and Technology (NIST) or the National Physical Laboratory (NPL). Serial Number, Manufacturer, Type, Calibration Vendor, Expiry Date, and Max Device Error for each standard used during the Certification is listed below. The class of the verification equipment was equal to or better than the requirements of the classification to which this device has been verified.

Serial No.	Manufacturer	Type	Max Device Error	Vendor	Expiry Date
174409-1	Olsen	CALIBRATOR	.00002000	Olsen	15-Jul-11

Informative Notes:

The expanded uncertainties reported are estimates of the measurement uncertainty in the errors determined during the verification. They are expressed as percentages of their respective verification readings. The expanded uncertainties reported are based on combined standard uncertainties, multiplied by a coverage factor of 2, which provide a confidence interval of approximately 95%. The uncertainties reported do not represent the uncertainty of the instrument or the results of any subsequent tests performed with the testing machine. The accuracy of the testing equipment has been found to conform with the tolerance(s) indicated above.

The uncertainties stated refer to the values obtained during verification and make no allowance for factors such as long-term drift, temperature and alignment effects – the influences of such factors should be taken into account by the user of the testing machine.

The expanded uncertainties reported have been calculated in accordance with the latest revision of ASTM E83 - Appendix X4.

1.6.27/1.1.34/32

Tinius Olsen Testing Machine Company
Instrument Verification Report & Certificate
Specifications per ASTM E 83

Verification Date April 29, 2011 **Certificate No.** 9M9AHP01

Page 3 of 3

Owner/Location LABORATORY TESTING INC, 2331 Topaz Drive Hatfield, Pennsylvania 19440

Calibration Location SAME

Item Description S/N 207344 - LS-4%-2 EXTENS #60013378 - w/ Digital Indicator #206051 - As Found - Out of Tolerance Condition

Order No. 448750 **Customer PO No.** PO0002821 **Customer ID No.**

Year of Mfg. UNKNOWN **Temperature Start** 21.7 °C **Mid** N/A °C **End** 21.7 °C

Gauge Length: Design 2.00in **Measured 1** 2.0011in **Error** 0.0011in 0.055%

Measured 2 2.0011 in **Error** 0.0011 in 0.055%

Uncertainty 0.002in **Verification Method** Direct

Attachment Method AS PER INSTRUCTIONS **Calibration Position** Vertical **Readout Method** Digital

Cal-Check No. N/A **Cal Factor** N/A

Verification Recall Date April 29, 2012

STRAIN RANGE in/in	VERIFIC. READ #1 in/in	MACHINE READ #1 in/in	VERIFIC. READ #2 in/in	MACHINE READ #2 in/in	FIXED ERROR in/in	ERROR % OF VALUE	DIFFER. % OF VALUE	UNCERTAINTY % OF VALUE	RESOLUTION FOR RANGE(S) in/in	CLASS FOR READING
0.0400	.0010000	.0009728	.0010000	.0000000	-.0000272	-2.72	-2.72	2.40	0.0000010	B-1
	.0020000	.0016575	.0020000	.0000000	-.0003425	-17.12	-17.12	1.20	0.0000010	C
	.0040000	.0026340	.0040000	.0000000	-.0013660	-34.10	-34.10	0.60	0.0000010	D
	.0070000	.0041731	.0070000	.0000000	-.0028269	-40.40	-40.40	0.34	0.0000010	D
	.0100000	.0072402	.0100000	.0000000	-.0027598	-27.60	-27.60	0.24	0.0000010	D
	.0200000	.0167961	.0200000	.0000000	-.0032039	-16.02	-16.02	0.12	0.0000010	D
	.0400000	.0375147	.0400000	.0000000	-.0024853	-6.21	-6.21	0.12	0.0000010	D

*

* NOT USED IN THIS RANGE

5/9/11

Calibration Technician Brian Campbell **Witness** Kevin Kline

Tinius Olsen Testing Machine Company
Instrument Verification Report & Certificate
Specifications per ASTM E 83

ACCREDITED
CALIBRATION CERT #867.01

Date of Issue May 03, 2011 **Certificate Number** 9M9AHP02

Issued by:
Tinius Olsen Testing Machine Company
1065 Easton Road
P.O. Box 1009
Horsham. PA 19044-8009, USA
Tel (215) 675-7100
Fax (215) 441-0899
www.TiniusOlsen.com

Page 1 of 3
Authorized Signature
Cheryl Spinieo
Cheryl Spinieo

Owner/Location LABORATORY TESTING INC, 2331 Topaz Drive, Hatfield, Pennsylvania 19440

Calibration Location SAME

Item Description S/N 207344 - LS-4%-2 EXTENS #60013378 - w/ Digital Indicator #206051 - As Left - Good Condition

Year of Mfr. UNKNOWN **Mfr.** Tinius Olsen **Cal-Check No.** N/A **Cal Factor** N/A

Verification Date April 29, 2011 **Verification Recall** April 29, 2012

This is to certify that the above testing equipment has been verified by Tinius Olsen Testing Machine Company personnel on Order Number 448750. The listed data is in accordance with the latest practices of ASTM E 83, and Tinius Olsen Procedure #2000, and have been temperature corrected as necessary. Tinius Olsen's Quality System is maintained in compliance with ANSI / NCSL Z540-1 1994, ISO/IEC 17025 (Complies with ISO 9000 Series for Calibration Activity), ISO 10012-1, and MIL-STD-45662A.

Range in/in	Calibration Factor	Class Range in/in	Class
0.0400	0.004	0.0010 TO 0.0400	B-1

Services have been performed in accordance with Tinius Olsen Quality Manual, dated March 13, 2009.

Tinius Olsen Testing Machine Company
Instrument Verification Report & Certificate
Specifications per ASTM E 83

Verification Date April 29, 2011

Certificate Number 9M9AHP02

Page 2 of 3

All verification devices comply with the latest practices of ASTM E 83, and are traceable to the International System of Units (SI) through National Institute of Standards and Technology (NIST) or the National Physical Laboratory (NPL). Serial Number, Manufacturer, Type, Calibration Vendor, Expiry Date, and Max Device Error for each standard used during the Certification is listed below. The class of the verification equipment was equal to or better than the requirements of the classification to which this device has been verified.

Serial No.	Manufacturer	Type	Max Device Error	Vendor	Expiry Date
174409-1	Olsen	CALIBRATOR	.00002000	Olsen	15-Jul-11

Informative Notes:

The expanded uncertainties reported are estimates of the measurement uncertainty in the errors determined during the verification. They are expressed as percentages of their respective verification readings. The expanded uncertainties reported are based on combined standard uncertainties, multiplied by a coverage factor of 2, which provide a confidence interval of approximately 95%. The uncertainties reported do not represent the uncertainty of the instrument or the results of any subsequent tests performed with the testing machine. The accuracy of the testing equipment has been found to conform with the tolerance(s) indicated above.

The uncertainties stated refer to the values obtained during verification and make no allowance for factors such as long-term drift, temperature and alignment effects – the influences of such factors should be taken into account by the user of the testing machine.

The expanded uncertainties reported have been calculated in accordance with the latest revision of ASTM E83 - Appendix X4.

1.6.27/1.1.34/32

Tinius Olsen Testing Machine Company
Instrument Verification Report & Certificate
Specifications per ASTM E 83

Verification Date April 29, 2011

Certificate No. 9M9AHP02

Page 3 of 3

Owner/Location LABORATORY TESTING INC, 2331 Topaz Drive Hatfield, Pennsylvania 19440

Calibration Location SAME

Item Description S/N 207344 - LS-4%-2 EXTENS #60013378 - w/ Digital Indicator #206051 - As Left - Good Condition

Order No. 448750 **Customer PO No.** PO0002821 **Customer ID No.**

Year of Mfg. UNKNOWN **Temperature Start** 21.7 ºC **Mid** 22.8 ºC **End** 22.8 ºC

Gauge Length: Design 2.00in **Measured 1** 2.0011in **Error** 0.0011in 0.055%

Measured 2 2.0011 in **Error** 0.0011 in 0.055%

Uncertainty 0.002in **Verification Method** Direct

Attachment Method AS PER INSTRUCTIONS **Calibration Position** Vertical **Readout Method** Digital

Cal-Check No. N/A **Cal Factor** N/A

Verification Recall Date April 29, 2012

STRAIN RANGE in/in	VERIFIC. READ #1 in/in	MACHINE READ #1 in/in	VERIFIC. READ #2 in/in	MACHINE READ #2 in/in	FIXED ERROR in/in	ERROR % OF VALUE	DIFFER. % OF VALUE	UNCERTAINTY % OF VALUE	RESOLUTION FOR RANGE(S) in/in	CLASS FOR READING
0.0400	.0010000	.0010014	.0010000	.0010015	.0000015	0.15	-0.01	2.40	0.0000010	B-1
	.0020000	.0019952	.0020000	.0020057	.0000057	0.29	-0.53	1.20	0.0000010	B-1
	.0040000	.0039754	.0040000	.0039928	-.0000246	-0.61	-0.43	0.60	0.0000010	B-1
	.0070000	.0069742	.0070000	.0069895	-.0000258	-0.37	-0.22	0.34	0.0000010	B-1
	.0100000	.0099552	.0100000	.0099872	-.0000448	-0.45	-0.32	0.24	0.0000010	B-1
	.0200000	.0199417	.0200000	.0199958	-.0000583	-0.29	-0.27	0.12	0.0000010	B-1
	.0400000	.0399920	.0400000	.0400414	.0000414	0.10	-0.12	0.12	0.0000010	B-1

Calibration Technician Brian Campbell **Witness** Kevin Kline

1.6.27/1.1.34/32

Tinius Olsen

Tinius Olsen Testing Machine C
Corporate Headquarters
1065 Easton Road
Horsham. PA 19044-8009, USA
Tel (215) 675-7100
Fax (215) 441-0899
www.TiniusOlsen.com

May 3, 2011

LABORATORY TESTING INC
2331 Topaz Drive
Hatfield, Pennsylvania 19440

Attn: Frank Peszka

Re: Service Visit S448750

Ladies/Gentlemen:

Enclosed please find your Report and Certificate(s) of Verification covering the following equipment:

S/N 207344 - LS-4%-2 EXTENS #60013378 - w/ Digital Indicator #206051 - As Found - Out of Tolerance Condition
S/N 207344 - LS-4%-2 EXTENS #60013378 - w/ Digital Indicator #206051 - As Left - Good Condition
S/N 64167 - S-1 EXTENS - w/ Digital Indicator #206051 - As Found - Out of Tolerance Condition
S/N 64167 - S-1 EXTENS - w/ Digital Indicator #206051 - As Left - Good Condition
S/N 206051P - POSITION #60013377 Ascending - w/ Computer Display #206051 - No Adjustments - Good Condition
S/N 206051SR - SPEED RATE #60013377 - No Adjustments - Good Condition
S/N 206051 - 400000 lbf HYD SPR L602 #60013377 - w/ Digital Indicator - No Adjustments - Good Condition
S/N 206051-STR - STRAIN RATE #60013377 - No Adjustments - Good Condition

We trust these certificates complete your files.

Very truly yours,

Tinius Olsen Testing Machine Company

Cheryl Spinieo

Cheryl Spinieo
Authorized Signature

Encl.

Tinius Olsen
Corporate Headquarters
1065 Easton Road
Horsham, PA USA 19044-8009
(215) 675-7100; Fax (215) 441-0899
Service@TiniusOlsen.com
www.TiniusOlsen.com

Tinius Olsen

Field Service Report

Date: 29-Apr-2011
Service Order Number: 448750
Customer: Frank Peszka
LABORATORY TESTING INC
2331 Topaz Drive
Hatfield, Pennsylvania 19440
Purchase Order Number: PO0002821
Account Number: 304995

Scheduled Work Completed

Date	Serial Number	Capacity	Name
29-Apr-2011	207344		LS-4%-2 EXTENS #60013378
	Calibration: 1	w/ Digital Indicator #206051 - As Found - Out of Tolerance Condition, Witnessed By: Kevin Kline Notes: I found the pivot screws very loose.	
	Calibration: 2	w/ Digital Indicator #206051 - As Left - Good Condition, Witnessed By: Kevin Kline	
29-Apr-2011	64167		S-1 EXTENS
	Calibration: 1	w/ Digital Indicator #206051 - As Found - Out of Tolerance Condition, Witnessed By: Kevin Kline Notes: I found the readings out over 1%.	
	Calibration: 2	w/ Digital Indicator #206051 - As Left - Good Condition, Witnessed By: Kevin Kline	
29-Apr-2011	206051P		POSITION #60013377
	Calibration: 1	Ascending - w/ Computer Display #206051 - No Adjustments - Good Condition, Witnessed By: Kevin Kline	
29-Apr-2011	206051SR		SPEED RATE #60013377
	Calibration: 1	No Adjustments - Good Condition, Witnessed By: Kevin Kline Notes: THE EQUIPMENT USED FOR THIS CALIBRATION WAS THE MACHINES CALIBRATED POSITION DISPLAY ALONG WITH A CERTIFIED STOP WATCH.	
29-Apr-2011	206051	400000 LBF	HYD SPR L602 #60013377
	Calibration: 1	- w/ Digital Indicator - No Adjustments - Good Condition, Witnessed By: Kevin Kline	
29-Apr-2011	206051-STR		STRAIN RATE #60013377
	Calibration: 1	No Adjustments - Good Condition, Witnessed By: Kevin Kline Notes: THE EQUIPMENT USED FOR THIS CALIBRATION WAS A CALIBRATED EXTENSOMETER AND A DUMMY SPECIMEN.	

Service Technician Notes

The above machine calibrated to within 1% no adjustments were made. Position speed and strain were also performed. As Found and As Left was performed on both extensometers.

Parts Used

Item Number	Description	Qty
90001429	PIVOT SCREW with Hex Nut, Standard 5-44 THDS	2

Work performed by: Campbell, Brian
Page No. 1
Arrive: 29-Apr-2011 08:30 AM
Depart: 29-Apr-2011 01:00 PM

SOLD TO:
HARRIS SUPPLY SOLUTIONS INC
318 ARVIN AVE
STONEY CREEK ON L8E 2M2
CANADA

SHIP TO:
HARRIS SUPPLY SOLUTIONS INC
C/O KINDER MORGAN CHICAGO IL
162 EAST 26TH STREET
CHICAGO HEIGHTS, IL 60411-

NUCOR
NUCOR STEEL KANKAKEE, INC.

CERTIFIED MILL TEST REPORT

Page: 1

Ship from:
Nucor Steel Kankakee, Inc.
One Nucor Way
Bourbonnais, IL 60914
815-937-3131

Date: 24-May-2011
B.L. Number: 424276
Load Number: 211049

Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 March 9, 2011

HEAT NUM. *	DESCRIPTION	PHYSICAL TESTS					CHEMICAL TESTS						
		YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% / DEF	C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
PO# => KN1110050601	P109963-CYCLE 3 Nucor Steel - Kankakee Inc 36/#11 Rebar 60' A615M Gr 420 (Gr60) ASTM A615/A615M-09b GR 60[420] AASHTO M31-07 Melted 01/31/11 Rolled 02/10/11	69,560 480MPa	99,605 687MPa	10.0%	OK	-3.5% .085	.39 .23	1.21 .16	.013 .069	.041 .007	.21 .002	.38	.63
PO# => KN1110054001	P109963-CYCLE 3 Nucor Steel - Kankakee Inc 36/#11 Rebar 60' A615M Gr 420 (Gr60) ASTM A615/A615M-09b GR 60[420] AASHTO M31-07 Melted 02/07/11 Rolled 02/10/11	66,054 455MPa	98,737 681MPa	16.0%	OK	-3.2% .084	.40 .20	1.04 .09	.013 .063	.047 .019	.23 .002	.35	.60

Call ~~D+V~~ Circle City
from which heat
did we get ?

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.
1.) Weld repair was not performed on this material.
2.) Melted and Manufactured in the United States.
3.) Mercury, Radium, or Alpha source materials in any form have not been used in the production of this material.

QUALITY ASSURANCE: Curtis Glenn

SOLD TO:
HARRIS SUPPLY SOLUTIONS INC
318 ARVIN AVE
STONEY CREEK ON L8E 2M2
CANADA

SHIP TO:
HARRIS SUPPLY SOLUTIONS INC
C/O KINDER MORGAN CHICAGO IL
162 EAST 26TH STREET
CHICAGO HEIGHTS, IL 60411-

NUCOR
NUCOR STEEL KANKAKEE, INC.

CERTIFIED MILL TEST REPORT

Page: 1

Ship from:
Nucor Steel Kankakee, Inc.
One Nucor Way
Bourbonnais, IL 60914
815-937-3131

Date: 25-Aug-2011
B.L. Number: 429448
Load Number: 214504

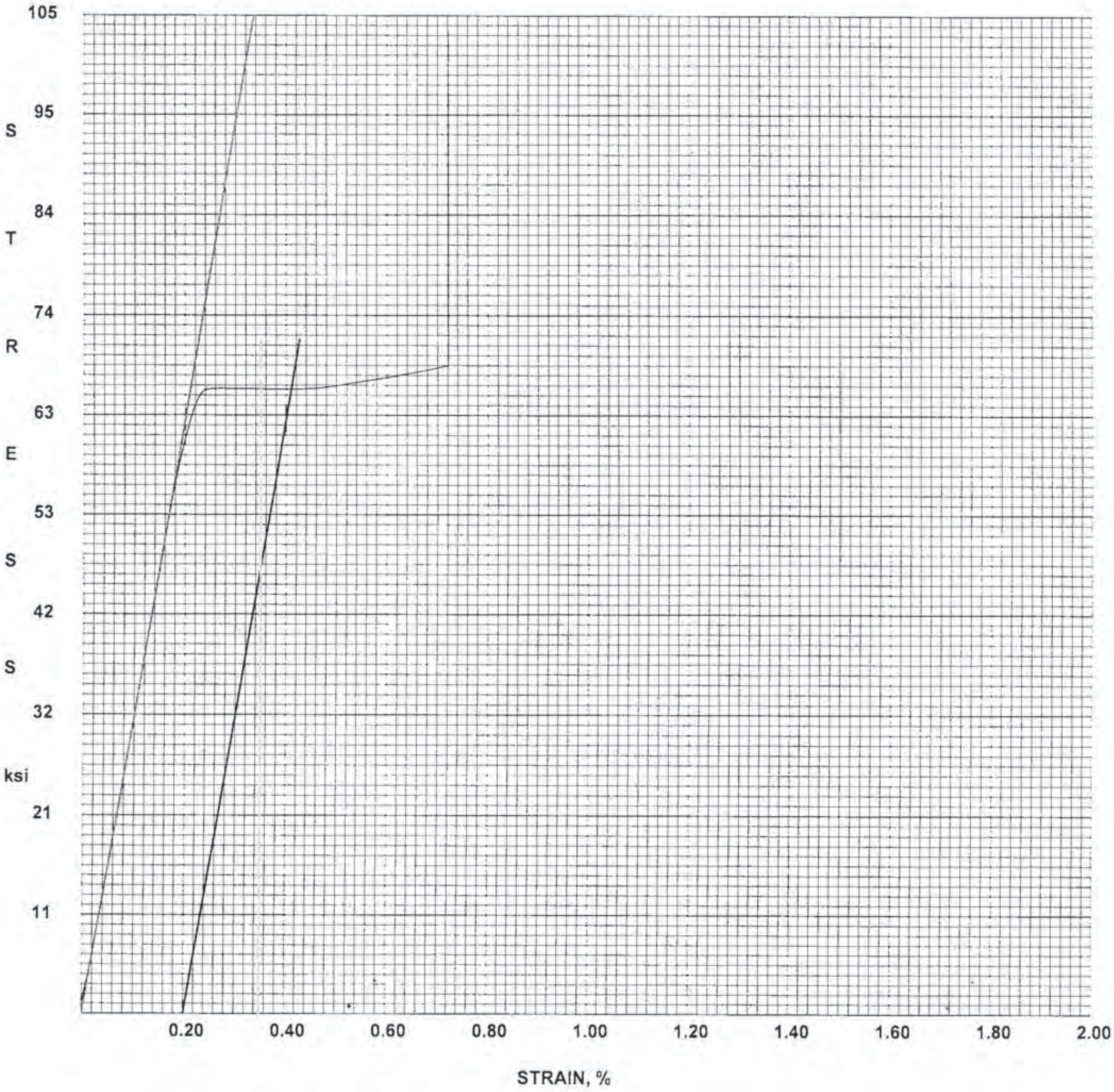
Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 March 5, 2011

HEAT NUM. *	DESCRIPTION	PHYSICAL TESTS					CHEMICAL TESTS						
		YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% / DEF	C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
PO# => KN1110329601	p111330 Nucor Steel - Kankakee Inc 13/#4 Rebar 60' A615M Gr 420 (Gr60) ASTM A615/A615M-09b GR 60[420] AASHTO M31-07 Melted 08/02/11 Rolled 08/10/11	68,748 474MPa	104,388 720MPa	14.8%	OK	-.8% .030	.38 .26	.99 .11	.015 .076	.047 .011	.22 .002	.35	.58
PO# => KN1110329701	p111330 Nucor Steel - Kankakee Inc 13/#4 Rebar 60' A615M Gr 420 (Gr60) ASTM A615/A615M-09b GR 60[420] AASHTO M31-07 Melted 08/02/11 Rolled 08/10/11	64,499 445MPa	97,943 675MPa	17.5%	OK	-2.7% .030	.36 .25	.99 .12	.015 .069	.050 .011	.20 .002	.38	.56

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.
1.) Weld repair was not performed on this material.
2.) Melted and Manufactured in the United States.
3.) Mercury, Radium, or Alpha source materials in any form have not been used in the production of this material.

QUALITY ASSURANCE: Curtis Glenn

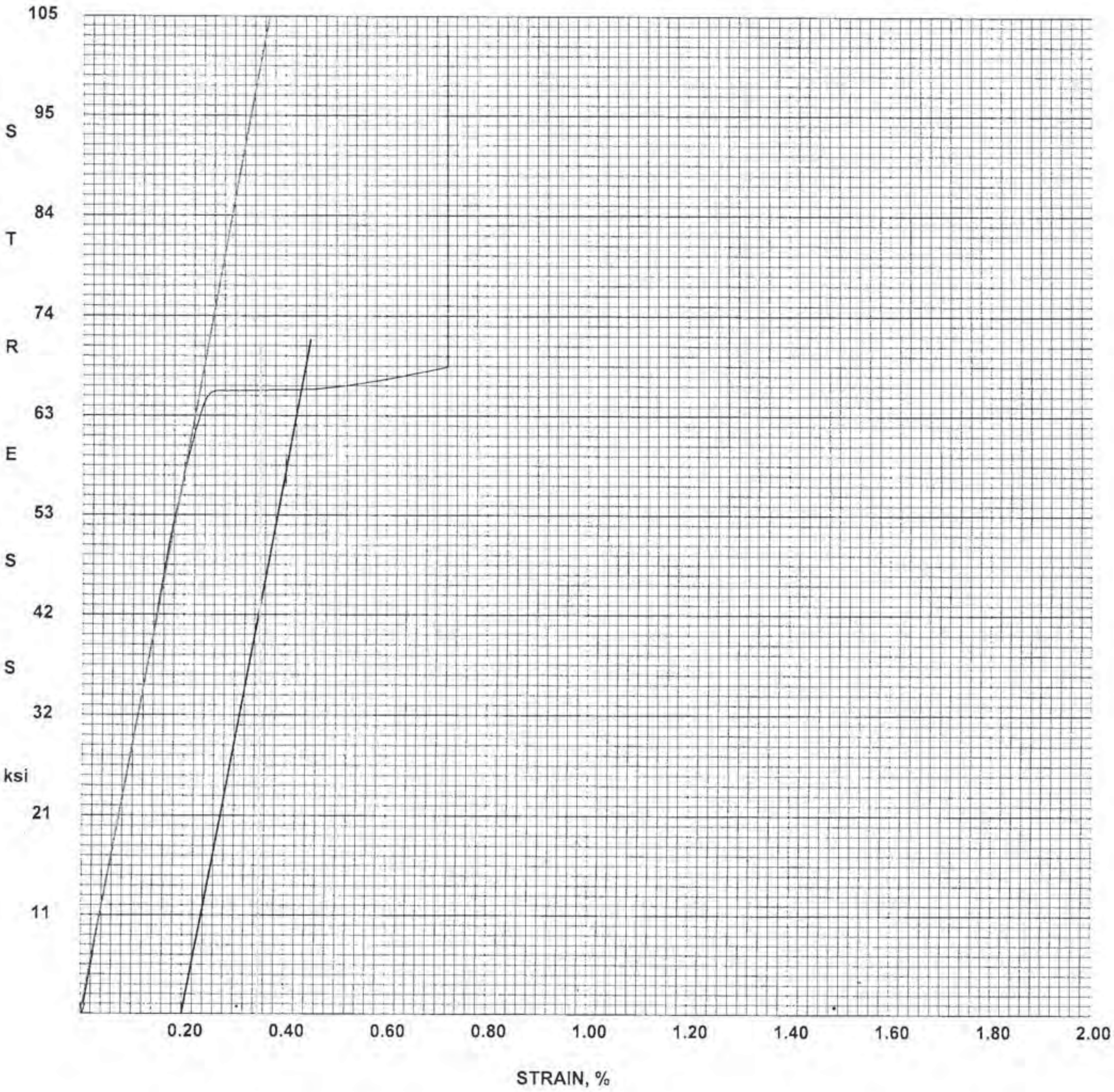


Laboratory Testing Inc.
2331 Topaz Drive
Hatfield, PA 19440

Rebar @ .2% Offset

Customer	Purdue University
Traveler #	12-13151
Machine #	400K (60013377)
Extensometer #	2" (60013378)
Caliper #	(60012882)
Micrometer#	N/A
Operator	PLS
Test Setting	Rebar .2% Offset Yield
--------------------:	
Sample No.:	1
Heat No.:	*****
--------------------:	
Diameter, in:	1.4100
Area, in²:	1.5600
Modulus, Mpsi:	31.2
--------------------:	
Ultimate, lbf:	160911
Yield Pt., lbf:	102674
OS @ .2, lbf:	102558
--------------------:	
Ultimate, ksi:	103
Yield Pt., ksi:	66
OS @ .2, ksi:	65.5
TE, %:	19
Frac. Location:	Within 2/3

Apr 9, 2012 4:18:46 PM
SN: 206046-R2 V7.02.10



Laboratory Testing Inc.
2331 Topaz Drive
Hatfield, PA 19440

Rebar @ .2% Offset

Customer	Purdue University
Traveler #	12-13151
Machine #	400K (60013377)
Extensometer #	2" (60013378)
Caliper #	(60012882)
Micrometer#	N/A
Operator	PLS
Test Setting	Rebar .2% Offset Yield

---------------------:

Sample No.:	2
Heat No.:	*****

---------------------:

Diameter, in:	1.4100
Area, in²:	1.5600
Modulus, Mpsi:	28.5

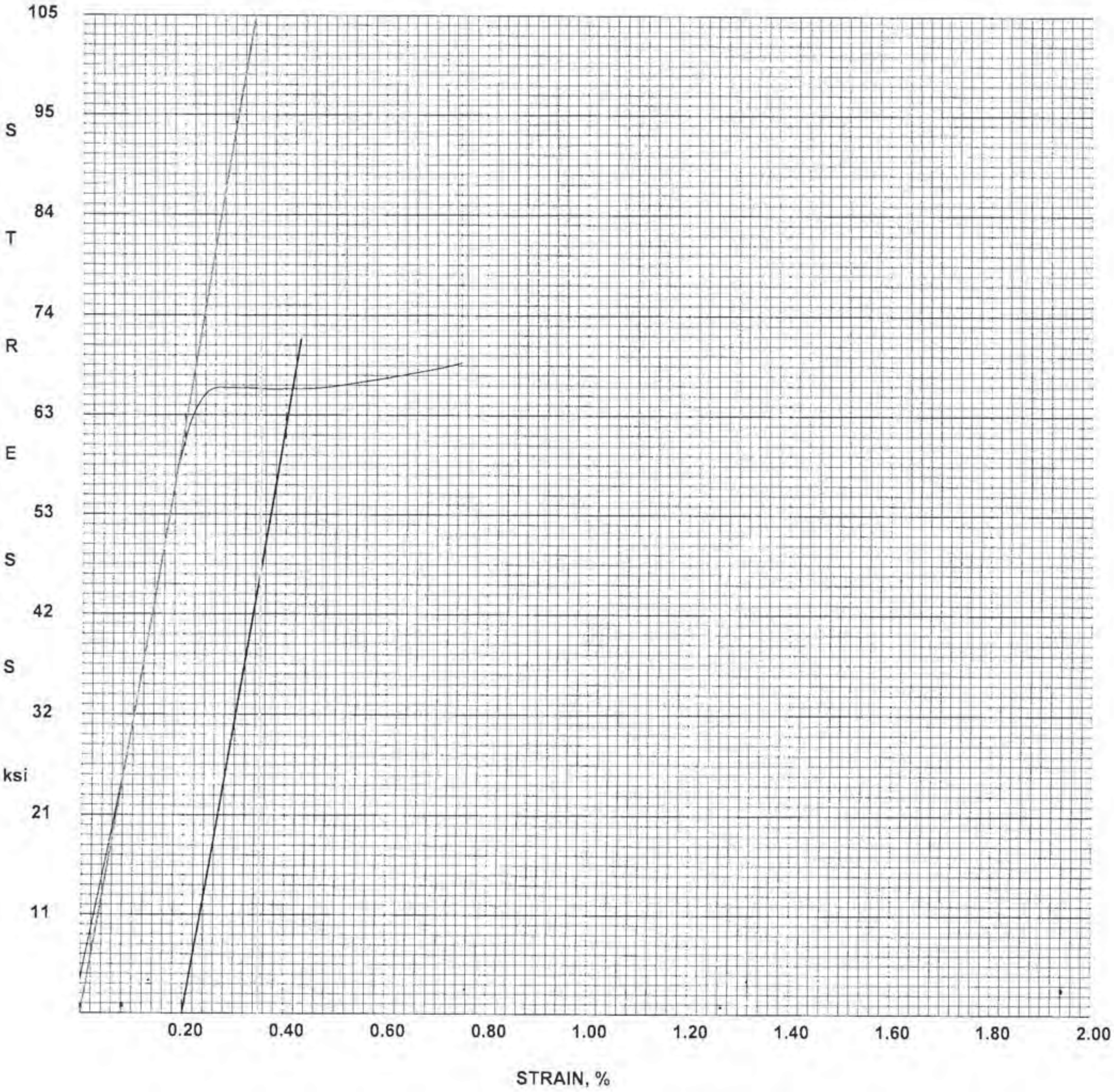
---------------------:

Ultimate, lbf:	160609
Yield Pt., lbf:	102397
OS @ .2, lbf:	102583

---------------------:

Ultimate, ksi:	103
Yield Pt., ksi:	65.5
OS @ .2, ksi:	66
TE, %:	14
Frac. Location:	Outside 2/3

Apr 9, 2012 4:20:56 PM
SN: 206046-R2 V7.02.10



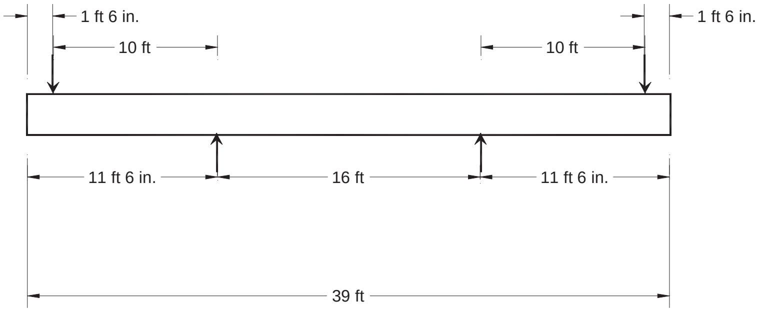
Laboratory Testing Inc.
2331 Topaz Drive
Hatfield, PA 19440

Rebar @ .2% Offset

Customer	Purdue University
Traveler #	12-13151
Machine #	400K (60013377)
Extensometer #	2" (60013378)
Caliper #	(60012882)
Micrometer#	N/A
Operator	PLS
Test Setting	Rebar .2% Offset Yield
--------------------:	
Sample No.:	3
Heat No.:	*****
--------------------:	
Diameter, in:	1.4100
Area, in²:	1.5600
Modulus, Mpsi:	30.9
--------------------:	
Ultimate, lbf:	160453
Yield Pt., lbf:	102794
OS @ .2, lbf:	102589
--------------------:	
Ultimate, ksi:	103
Yield Pt., ksi:	66
OS @ .2, ksi:	66
TE, %:	18
Frac. Location:	Within 2/3

Apr 9, 2012 4:22:16 PM
SN: 206046-R2 V7.02.10

TEST GIRDER A1



X-Sect. Area for a #11 Bar		$A_{sb} := 1.56\,in^2$
Diameter, # 11 Bar		$d_b := 1.41\,in$
Nominal width of Section		$b := \left(17 + \frac{5}{8}\right) \cdot in$
Nominal height of Section		$h := 30\,in$
Top cover		$c_t := 5\,in$
Effective depth	$d := 30\,in - c_t - \frac{d_b}{2}$	$d = 24 \cdot in$
Yield Stress		$f_y := 66\,ksi$
Concrete Strength		$f'_c := 5270\,psi$
Total Length		$L_t := 39\,ft$
Cantilevered Span	$a := 11\,ft + 6\,in$	$a = 11.5\,ft$
Interior Span	$L_m := 16\,ft$	$L_m = 16\,ft$
Reinforcement Ratio	$\rho := 2 \cdot \frac{A_{sb}}{b \cdot d}$	$\rho = 0.73 \cdot \%$
Initial moment at support		$M_{supinit} := 45.8\,kip \cdot ft$

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering
the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \frac{lbf}{ft^3}$ $w_s = 0.55 \cdot \frac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 43.5kip$

Moment at support related to selfweight and loading gear

$M_{supinit} = 46 \cdot kip \cdot ft$

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 18in) + M_{supinit}$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := -M_{supmax} + \frac{w_s \cdot L_m}{2} \cdot 3ft - w_s \cdot \frac{(3ft)^2}{2}$$

$$M_{3ft} = -470 \cdot kip \cdot ft$$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 81ksi}{0.7 \cdot f'_c}\right)} = 81 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot psi}$ $E_c = 4.1 \times 10^{6} psi$

Steel modulus $E_s := 29000ksi$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 7$

Depth to neutral axis from extreme fiber in compression

$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n$ $k = 0.27$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 84 \cdot ksi$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.5 \times 10^{3} \cdot psi \qquad (\text{Compression})$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{-M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 79ksi}{0.7 \cdot f'_c}\right)} = 79 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{-M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 82 \cdot ksi$$

Check related maximum concrete stress

$$f_{clin3} := \frac{-M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.4 \times 10^3 \, psi \qquad (\text{Compression})$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR	LINEAR
$f_{supmaxnon} = 81 \cdot ksi$	$f_{supmaxlin} = 84 \cdot ksi$

At splice end

$f_{snon3} = 79 \cdot ksi$	$f_{slin3} = 82 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice	$L_d := 120in$
Bar diameter	$d_b = 1.41 \cdot in$

Average bond stress at maximum load

$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

$$round\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 230\,psi$$

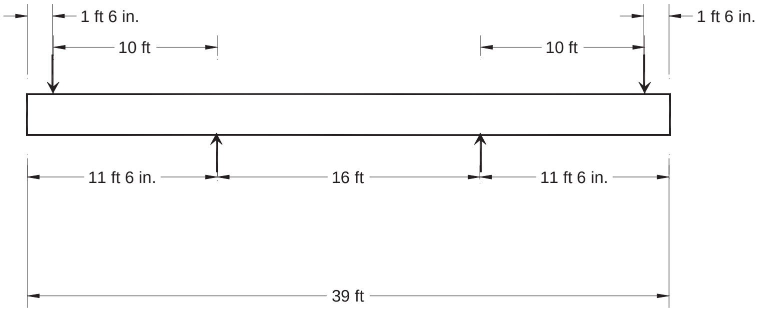
The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

The hard information from the test is that the 120-in splice for No. 11 bars has developed a maximum bar stress of at least

$$\boxed{f_{snon3} = 79 \cdot ksi}$$

Sheet 5 of 5

TEST GIRDER A2



X-Sect. Area for a #11 Bar		$A_{sb} := 1.56 in^2$
Diameter, # 11 Bar		$d_b := 1.41 in$
Nominal width of Section		$b := \left(17 + \frac{5}{8}\right) \cdot in$
Nominal height of Section		$h := 30 in$
Top cover		$c_t := 5 in$
Effective depth	$d := 30 in - c_t - \frac{d_b}{2}$	$d = 24 \cdot in$
Yield Stress		$f_y := 66 ksi$
Concrete Strength		$f'_c := 6030 psi$
Total Length		$L_t := 39 ft$
Cantilevered Span	$a := 11 ft + 6 in$	$a = 11.5 ft$
Interior Span	$L_m := 16 ft$	$L_m = 16 ft$
Reinforcement Ratio	$\rho := 2 \cdot \frac{A_{sb}}{b \cdot d}$	$\rho = 0.73 \cdot \%$
Initial moment at support		$M_{supinit} := 45.8 kip \cdot ft$

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \frac{lbf}{ft^3}$ $w_s = 0.55 \cdot \frac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 44.1kip$

Moment at support related to selfweight and loading gear

$M_{supinit} = 46 \cdot kip \cdot ft$

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 18in) + M_{supinit}$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := -M_{supmax} + \frac{w_s \cdot L_m}{2} \cdot 3ft - w_s \cdot \frac{(3ft)^2}{2}$$

$$M_{3ft} = -476 \cdot kip \cdot ft$$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 82ksi}{0.7 \cdot f'_c}\right)} = 82 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot psi}$ $E_c = 4.4 \times 10^6 psi$

Steel modulus $E_s := 29000ksi$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 7$

Depth to neutral axis from extreme fiber in compression

$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n$ $k = 0.26$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 85 \cdot ksi$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.6 \times 10^3 \cdot psi$$ (Compression)

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{-M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 80ksi}{0.7 \cdot f'_c}\right)} = 80 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{-M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 83 \cdot ksi$$

Check related maximum concrete stress

$$f_{clin3} := \frac{-M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.5 \times 10^3 psi \qquad (\text{Compression})$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR	LINEAR
$f_{supmaxnon} = 82 \cdot ksi$	$f_{supmaxlin} = 85 \cdot ksi$

At splice end

$f_{snon3} = 80 \cdot ksi$	$f_{slin3} = 83 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice $L_d := 120in$

Bar diameter $d_b = 1.41 \cdot in$

Average bond stress at maximum load

$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

$$\mathrm{round}\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 230\,psi$$

The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

The hard information from the test is that the 120-in splice for No. 11 bars has developed a maximum bar stress of at least

$$\boxed{f_{snon3} = 80 \cdot ksi}$$

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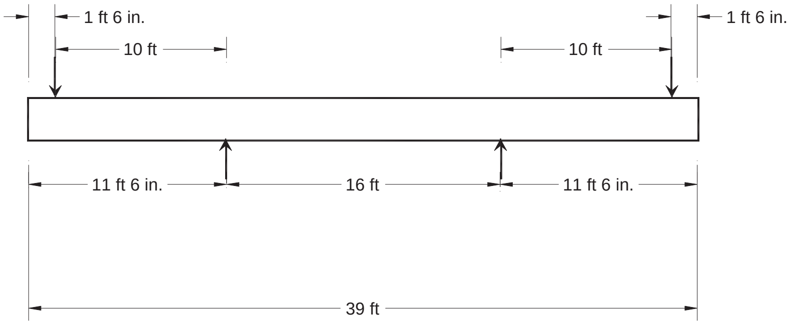
TEST GIRDER A3



X-Sect. Area for a #11 Bar $A_{sb} := 1.56in^2$

Diameter, # 11 Bar $d_b := 1.41in$

Nominal width of Section $b := \left(17 + \frac{5}{8}\right) \cdot in$

Nominal height of Section $h := 30in$

Top cover $c_t := 5in$

Effective depth $d := 30in - c_t - \frac{d_b}{2}$ $d = 24 \cdot in$

Yield Stress $f_y := 66ksi$

Concrete Strength $f'_c := 5890psi$

Total Length $L_t := 39ft$

Cantilevered Span $a := 11ft + 6in$ $a = 11.5\,ft$

Interior Span $L_m := 16ft$ $L_m = 16\,ft$

Reinforcement Ratio $\rho := 2 \cdot \frac{A_{sb}}{b \cdot d}$ $\rho = 0.73 \cdot \%$

Sheet 1 of 5

Initial moment at support $M_{supinit} := 45.8 kip \cdot ft$

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \frac{lbf}{ft^3}$ $w_s = 0.55 \cdot \frac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 44.1 kip$

Moment at support related to selfweight and loading gear

$M_{supinit} = 46 \cdot kip \cdot ft$

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 18in) + M_{supinit}$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := -M_{supmax} + \frac{w_s \cdot L_m}{2} \cdot 3ft - w_s \cdot \frac{(3ft)^2}{2}$$

$$M_{3ft} = -476 \cdot kip \cdot ft$$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 82ksi}{0.7 \cdot f'_c}\right)} = 82 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot psi}$ $E_c = 4.4 \times 10^6 psi$

Steel modulus $E_s := 29000ksi$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 7$

Depth to neutral axis from extreme fiber in compression

$$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n \qquad k = 0.27$$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 85 \cdot ksi$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.6 \times 10^3 \cdot psi \qquad (\text{Compression})$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{-M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 80ksi}{0.7 \cdot f'_c}\right)} = 80 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{-M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 83 \cdot ksi$$

Check related maximum concrete stress

$$f_{clin3} := \frac{-M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.5 \times 10^3 psi \qquad (\text{Compression})$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR	LINEAR
$f_{supmaxnon} = 82 \cdot ksi$	$f_{supmaxlin} = 85 \cdot ksi$

At splice end

$f_{snon3} = 80 \cdot ksi$	$f_{slin3} = 83 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice	$L_d := 120in$
Bar diameter	$d_b = 1.41 \cdot in$

Average bond stress at maximum load

$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

$$\text{round}\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 230\,psi$$

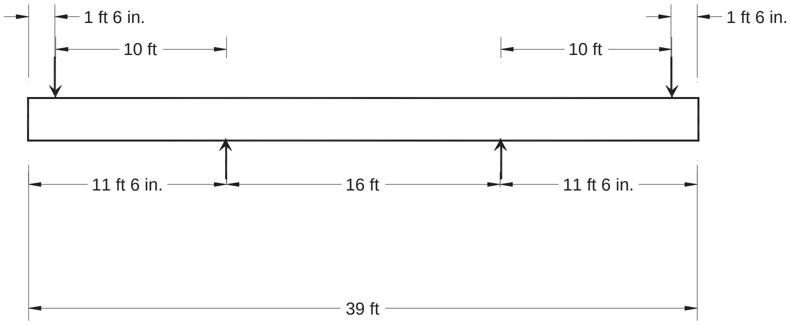
The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

The hard information from the test is that the 120-in splice for No. 11 bars has developed a maximum bar stress of at least

$$\boxed{f_{snon3} = 80 \cdot ksi}$$

Sheet 5 of 5

TEST GIRDER A4



X-Sect. Area for a #11 Bar		$A_{sb} := 1.56in^2$
Diameter, # 11 Bar		$d_b := 1.41in$
Nominal width of Section		$b := \left(17 + \frac{5}{8}\right) \cdot in$
Nominal height of Section		$h := 30in$
Top cover		$c_t := 5in$
Effective depth	$d := 30in - c_t - \frac{d_b}{2}$	$d = 24 \cdot in$
Yield Stress		$f_y := 66ksi$
Concrete Strength		$f'_c := 5110psi$
Total Length		$L_t := 39ft$
Cantilevered Span	$a := 11ft + 6in$	$a = 11.5\,ft$
Interior Span	$L_m := 16ft$	$L_m = 16\,ft$
Reinforcement Ratio	$\rho := 2 \cdot \frac{A_{sb}}{b \cdot d}$	$\rho = 0.73 \cdot \%$
Initial moment at support		$M_{supinit} := 45.8kip \cdot ft$

Sheet 1 of 5

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \frac{lbf}{ft^3}$ $w_s = 0.55 \cdot \frac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 43.3kip$

Moment at support related to selfweight and loading gear

$M_{supinit} = 46 \cdot kip \cdot ft$

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 18in) + M_{supinit}$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := M_{supmax} - \frac{w_s \cdot L_m}{2} \cdot 3ft + w_s \cdot \frac{(3ft)^2}{2} = 468 \cdot kip \cdot ft$$

$M_{3ft} = 468 \cdot kip \cdot ft$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 82ksi}{0.7 \cdot f'_c}\right)} = 81 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot psi}$ $E_c = 4.1 \times 10^6 psi$

Steel modulus $E_s := 29000ksi$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 7$

Depth to neutral axis from extreme fiber in compression

$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n$ $k = 0.27$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 83 \cdot ksi$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.4 \times 10^3 \cdot psi \quad (Compression)$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 80ksi}{0.7 \cdot f'_c}\right)} = 79 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 82 \cdot ksi$$

Check related maximum concrete stress

$$f_{clin3} := \frac{M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.3 \times 10^3 psi \qquad (\text{Compression})$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR **LINEAR**

$f_{supmaxnon} = 81 \cdot ksi$ $f_{supmaxlin} = 83 \cdot ksi$

At splice end

$f_{snon3} = 79 \cdot ksi$ $f_{slin3} = 82 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice $L_d := 120in$

Bar diameter $d_b = 1.41 \cdot in$

Average bond stress at maximum load

$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

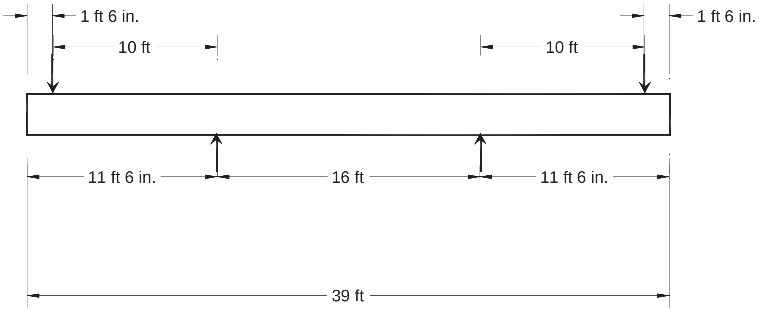
$$\mathrm{round}\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 230\,psi$$

The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

The hard information from the test is that the 120-in splice for No. 11 bars has developed a maximum bar stress of at least

$$\boxed{f_{snon3} = 79 \cdot ksi}$$

TEST GIRDER A5



X-Sect. Area for a #11 Bar		$A_{sb} := 1.56in^2$
Diameter, # 11 Bar		$d_b := 1.41in$
Nominal width of Section		$b := \left(17 + \frac{5}{8}\right) \cdot in$
Nominal height of Section		$h := 30in$
Top cover		$c_t := 5in$
Effective depth	$d := 30in - c_t - \frac{d_b}{2}$	$d = 24 \cdot in$
Yield Stress		$f_y := 66ksi$
Concrete Strength		$f'_c := 5240psi$
Total Length		$L_t := 39ft$
Cantilevered Span	$a := 11ft + 6in$	$a = 11.5\,ft$
Interior Span	$L_m := 16ft$	$L_m = 16\,ft$
Reinforcement Ratio	$\rho := 2 \cdot \frac{A_{sb}}{b \cdot d}$	$\rho = 0.73 \cdot \%$
Initial moment at support		$M_{supinit} := 45.8kip \cdot ft$

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \frac{lbf}{ft^3}$ $w_s = 0.55 \cdot \frac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 43.4kip$

Moment at support related to selfweight and loading gear

$M_{supinit} = 46 \cdot kip \cdot ft$

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 18in) + M_{supinit}$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := M_{supmax} - \frac{w_s \cdot L_m}{2} \cdot 3ft + w_s \cdot \frac{(3ft)^2}{2}$$

$$M_{3ft} = 469 \cdot kip \cdot ft$$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 81ksi}{0.7 \cdot f'_c}\right)} = 81 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot psi}$ $E_c = 4.1 \times 10^6 psi$

Steel modulus $E_s := 29000ksi$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 7$

Depth to neutral axis from extreme fiber in compression

$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n$ $k = 0.27$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 84 \cdot ksi$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.5 \times 10^3 \cdot psi \qquad (Compression)$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 79\text{ksi}}{0.7 \cdot f'_c}\right)} = 79 \cdot \text{ksi}$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 82 \cdot \text{ksi}$$

Check related maximum concrete stress

$$f_{clin3} := \frac{M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.4 \times 10^3 \text{psi} \qquad (\text{Compression})$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR

$f_{supmaxnon} = 81 \cdot ksi$

LINEAR

$f_{supmaxlin} = 84 \cdot ksi$

At splice end

$f_{snon3} = 79 \cdot ksi$

$f_{slin3} = 82 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice $L_d := 120in$

Bar diameter $d_b = 1.41 \cdot in$

Average bond stress at maximum load

$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

$$\text{round}\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 230\,psi$$

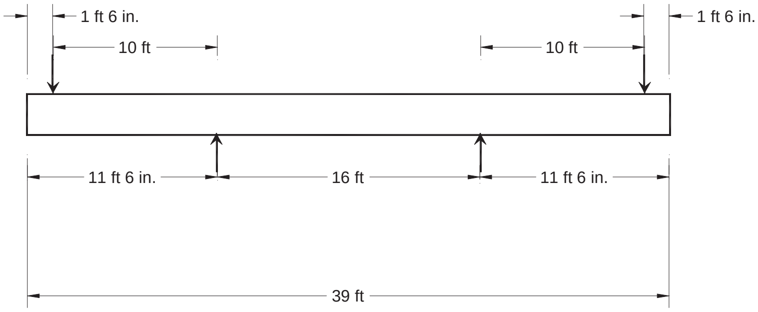
The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

The hard information from the test is that the 120-in splice for No. 11 bars has developed a maximum bar stress of at least

$$\boxed{f_{snon3} = 79 \cdot ksi}$$

Sheet 5 of 5

TEST GIRDER A6



X-Sect. Area for a #11 Bar $A_{sb} := 1.56\text{in}^2$

Diameter, # 11 Bar $d_b := 1.41\text{in}$

Nominal width of Section $b := \left(17 + \frac{5}{8}\right)\cdot\text{in}$

Nominal height of Section $h := 30\text{in}$

Top cover $c_t := 5\text{in}$

Effective depth $d := 30\text{in} - c_t - \frac{d_b}{2}$ $d = 24\cdot\text{in}$

Yield Stress $f_y := 66\text{ksi}$

Concrete Strength $f'_c := 5490\text{psi}$

Total Length $L_t := 39\text{ft}$

Cantilevered Span $a := 11\text{ft} + 6\text{in}$ $a = 11.5\,\text{ft}$

Interior Span $L_m := 16\text{ft}$ $L_m = 16\,\text{ft}$

Reinforcement Ratio $\rho := 2\cdot\frac{A_{sb}}{b\cdot d}$ $\rho = 0.73\cdot\%$

Initial moment at support $M_{supinit} := 45.8\text{kip}\cdot\text{ft}$

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \frac{lbf}{ft^3}$ $w_s = 0.55 \cdot \frac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 42.0 kip$

Moment at support related to selfweight and loading gear

$M_{supinit} = 46 \cdot kip \cdot ft$

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 18in) + M_{supinit} = 466 \, kip \cdot ft$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := M_{supmax} - \frac{w_s \cdot L_m}{2} \cdot 3ft + w_s \cdot \frac{(3ft)^2}{2}$$

$$M_{3ft} = 455 \cdot kip \cdot ft$$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 78ksi}{0.7 \cdot f'_c}\right)} = 78 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot psi}$ $E_c = 4.2 \times 10^6 psi$

Steel modulus $E_s := 29000ksi$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 7$

Depth to neutral axis from extreme fiber in compression

$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n$ $k = 0.27$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 81 \cdot ksi$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.4 \times 10^3 \cdot psi \qquad (\text{Compression})$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 77ksi}{0.7 \cdot f'_c}\right)} = 77 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 79 \cdot ksi$$

Check related maximum concrete stress

$$f_{clin3} := \frac{M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4.3 \times 10^3 psi \qquad (Compression)$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR

$f_{supmaxnon} = 78 \cdot ksi$

LINEAR

$f_{supmaxlin} = 81 \cdot ksi$

At splice end

$f_{snon3} = 77 \cdot ksi$

$f_{slin3} = 79 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice $L_d := 120in$

Bar diameter $d_b = 1.41 \cdot in$

Average bond stress at maximum load

$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

$$round\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 220\,psi$$

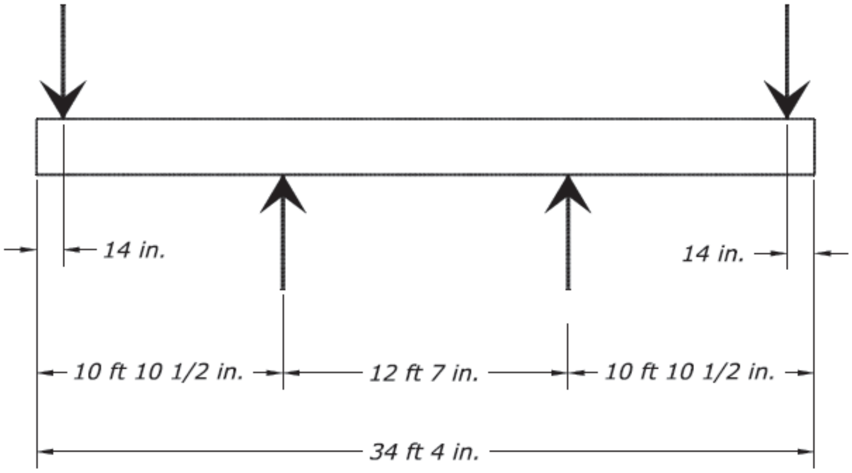
The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

The hard information from the test is that the 120-in splice for No. 11 bars has developed a maximum bar stress of at least

$$\boxed{f_{snon3} = 77 \cdot ksi}$$

Sheet 5 of 5

TEST GIRDER B1



X-Sect. Area for a #11 Bar $A_{sb} := 1.56in^2$

Diameter, # 11 Bar $d_b := 1.41in$

Nominal width of Section $b := \left(17 + \frac{5}{8}\right) \cdot in$

Nominal height of Section $h := 30in$

Top cover $c_t := 5in$

Effective depth $d := 30in - c_t - \frac{d_b}{2}$ $d = 24 \cdot in$

Yield Stress $f_y := 66ksi$

Concrete Strength $f'_c := 4460psi$

Total Length

$L_t := 2 \cdot 14in + 2 \cdot 9ft + 2 \cdot 8.5in + 2 \cdot 3ft + 6ft + 7in$ $L_t = 34.3\,ft$

Cantilevered Span $a := 10ft + 10.5in$ $a = 10.9\,ft$

Interior Span $L_m := 12ft + 7in$ $L_m = 13\,ft$

Reinforcement Ratio $\rho := 2 \cdot \frac{A_{sb}}{b \cdot d}$ $\rho = 0.73 \cdot \%$

Initial moment at support $M_{supinit} := 40.5kip \cdot ft$

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \dfrac{lbf}{ft^3}$ $w_s = 0.55 \cdot \dfrac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 39.5kip$

Moment at support related to selfweight and loading gear

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 14in) + M_{supinit}$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := M_{supmax} - \frac{w_s \cdot L_m}{2} \cdot 3ft + w_s \cdot \frac{(3ft)^2}{2}$$

$$M_{3ft} = 416 \cdot kip \cdot ft$$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 72\text{ksi}}{0.7 \cdot f'_c}\right)} = 72 \cdot \text{ksi}$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot \text{psi}}$ $E_c = 3.8 \times 10^6 \text{psi}$

Steel modulus $E_s := 29000\text{ksi}$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 8$

Depth to neutral axis from extreme fiber in compression

$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n$ $k = 0.28$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 74 \cdot \text{ksi}$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 3.8 \times 10^3 \cdot \text{psi} \qquad (\text{Compression})$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 71ksi}{0.7 \cdot f'_c}\right)} = 71 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 73 \cdot ksi$$

Check related maximum concrete stress

$$f_{clin3} := \frac{M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 3.8 \times 10^3 psi \qquad (\text{Compression})$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR **LINEAR**

$f_{supmaxnon} = 72 \cdot ksi$ $f_{supmaxlin} = 74 \cdot ksi$

At splice end

$f_{snon3} = 71 \cdot ksi$ $f_{slin3} = 73 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice $L_d := 79in$

Bar diameter $d_b = 1.41 \cdot in$

Average bond stress at maximum load

$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

$$\text{round}\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 310\,psi$$

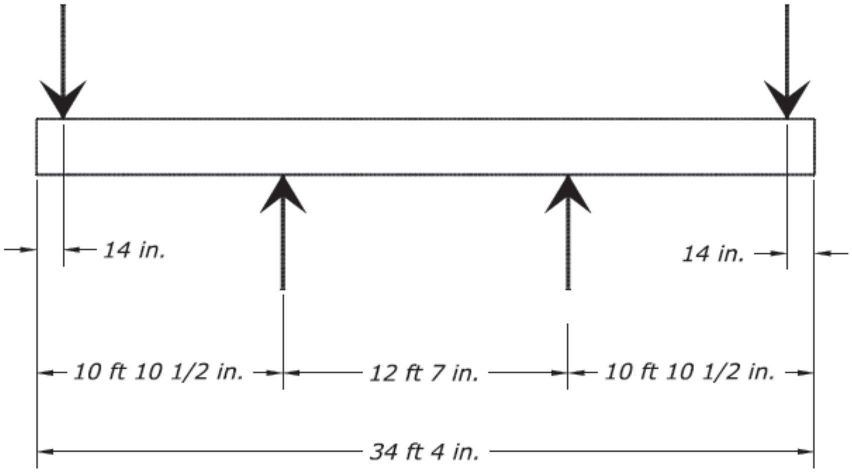
The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

The hard information from the test is that the 79-in splice for No. 11 bars has developed a maximum bar stress of at least

$\boxed{f_{snon3} = 71 \cdot ksi}$

Sheet 5 of 5

TEST GIRDER B2



X-Sect. Area for a #11 Bar $A_{sb} := 1.56in^2$

Diameter, # 11 Bar $d_b := 1.41in$

Nominal width of Section $b := \left(17 + \frac{5}{8}\right) \cdot in$

Nominal height of Section $h := 30in$

Top cover $c_t := 5in$

Effective depth $d := 30in - c_t - \frac{d_b}{2}$ $d = 24 \cdot in$

Yield Stress $f_y := 66ksi$

Concrete Strength $f'_c := 4800psi$

Total Length

$L_t := 2 \cdot 14in + 2 \cdot 9ft + 2 \cdot 8.5in + 2 \cdot 3ft + 6ft + 7in$ $L_t = 34.3\,ft$

Cantilevered Span $a := 10ft + 10.5in$ $a = 10.9\,ft$

Interior Span $L_m := 12ft + 7in$ $L_m = 13\,ft$

Reinforcement Ratio $\rho := 2 \cdot \frac{A_{sb}}{b \cdot d}$ $\rho = 0.73 \cdot \%$

Initial moment at support $M_{supinit} := 40.5kip \cdot ft$

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \frac{lbf}{ft^3}$ $w_s = 0.55 \cdot \frac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 38.9kip$

Moment at support related to selfweight and loading gear

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 14in) + M_{supinit}$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := M_{supmax} - \frac{w_s \cdot L_m}{2} \cdot 3ft + w_s \cdot \frac{(3ft)^2}{2}$$

$$M_{3ft} = 410 \cdot kip \cdot ft$$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 72\text{ksi}}{0.7 \cdot f'_c}\right)} = 71 \cdot \text{ksi}$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot \text{psi}}$ $E_c = 3.9 \times 10^6 \text{psi}$

Steel modulus $E_s := 29000\text{ksi}$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 7$

Depth to neutral axis from extreme fiber in compression

$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n$ $k = 0.28$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 73 \cdot \text{ksi}$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 3.8 \times 10^3 \cdot \text{psi} \qquad (\text{Compression})$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 69ksi}{0.7 \cdot f'_c}\right)} = 69 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 72 \cdot ksi$$

Check related maximum concrete stress

$$f_{clin3} := \frac{M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 3.8 \times 10^3 psi \qquad (\text{Compression})$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR **LINEAR**

$f_{supmaxnon} = 71 \cdot ksi$

$f_{supmaxlin} = 73 \cdot ksi$

At splice end

$f_{snon3} = 69 \cdot ksi$

$f_{slin3} = 72 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice $L_d := 79in$

Bar diameter $d_b = 1.41 \cdot in$

Average bond stress at maximum load

$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

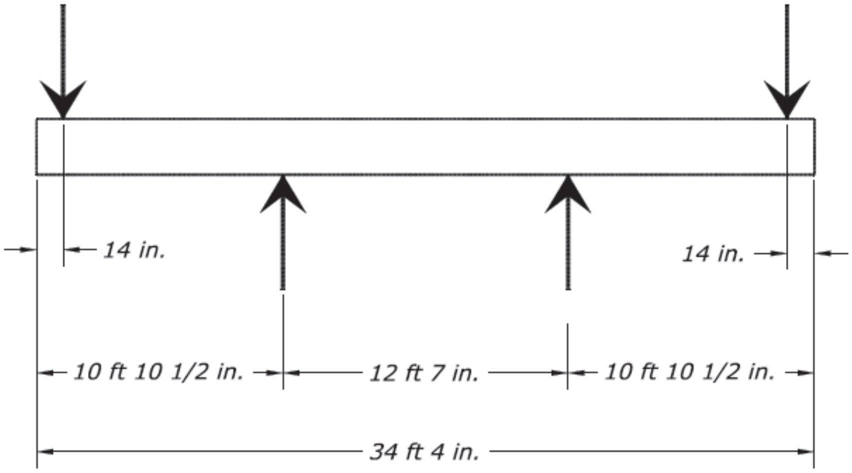
$$\text{round}\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 310\,psi$$

The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

The hard information from the test is that the 79-in splice for No. 11 bars has developed a maximum bar stress of at least

$\boxed{f_{snon3} = 69 \cdot ksi}$

TEST GIRDER B3



X-Sect. Area for a #11 Bar		$A_{sb} := 1.56in^2$
Diameter, # 11 Bar		$d_b := 1.41in$
Nominal width of Section		$b := \left(17 + \frac{5}{8}\right) \cdot in$
Nominal height of Section		$h := 30in$
Top cover		$c_t := 5in$
Effective depth	$d := 30in - c_t - \frac{d_b}{2}$	$d = 24 \cdot in$
Yield Stress		$f_y := 66ksi$
Concrete Strength		$f'_c := 4780psi$
Total Length		
$L_t := 2 \cdot 14in + 2 \cdot 9ft + 2 \cdot 8.5in + 2 \cdot 3ft + 6ft + 7in$		$L_t = 34.3\,ft$
Cantilevered Span	$a := 10ft + 10.5in$	$a = 10.9\,ft$
Interior Span	$L_m := 12ft + 7in$	$L_m = 13\,ft$
Reinforcement Ratio	$\rho := 2 \cdot \frac{A_{sb}}{b \cdot d}$	$\rho = 0.73 \cdot \%$
Initial moment at support		$M_{supinit} := 40.5kip \cdot ft$

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \frac{lbf}{ft^3}$ $w_s = 0.55 \cdot \frac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 39.7 kip$

Moment at support related to selfweight and loading gear

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 14in) + M_{supinit}$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := M_{supmax} - \left(\frac{w_s \cdot L_m}{2} \cdot 3\right) ft + w_s \cdot \frac{(3ft)^2}{2}$$

$$M_{3ft} = 418 \cdot kip \cdot ft$$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 72ksi}{0.7 \cdot f'_c}\right)} = 72 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot psi}$ $E_c = 3.9 \times 10^6 psi$

Steel modulus $E_s := 29000ksi$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 7$

Depth to neutral axis from extreme fiber in compression

$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n$ $k = 0.28$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 74 \cdot ksi$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 3.9 \times 10^3 \cdot psi \qquad (Compression)$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 70ksi}{0.7 \cdot f'_c}\right)} = 70 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 73 \cdot ksi$$

Check related maximum concrete stress

$$f_{clin3} := \frac{M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 3.8 \times 10^3 psi \qquad (\text{Compression})$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR	LINEAR
$f_{supmaxnon} = 72 \cdot ksi$	$f_{supmaxlin} = 74 \cdot ksi$

At splice end

$f_{snon3} = 70 \cdot ksi$	$f_{slin3} = 73 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice $L_d := 79in$

Bar diameter $d_b = 1.41 \cdot in$

Average bond stress at maximum load

$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

$$round\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 310\,psi$$

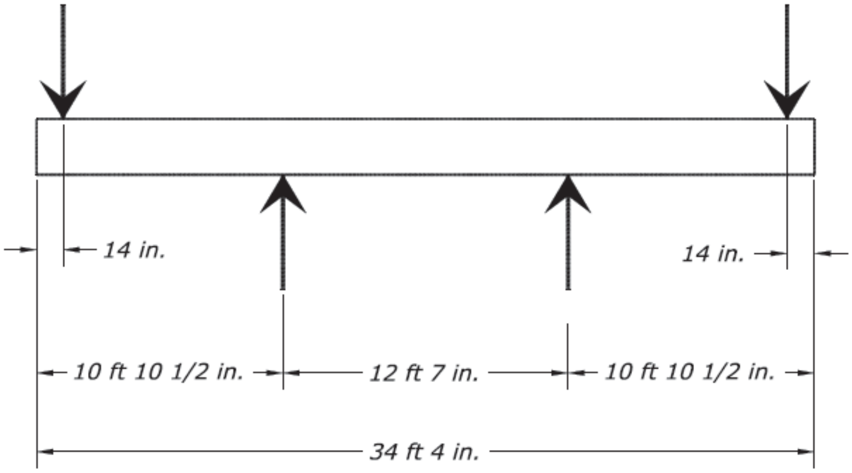
The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

The hard information from the test is that the 79-in splice for No. 11 bars has developed a maximum bar stress of at least

$$\boxed{f_{snon3} = 70 \cdot ksi}$$

Sheet 5 of 5

TEST GIRDER B4



X-Sect. Area for a #11 Bar $A_{sb} := 1.56in^2$

Diameter, # 11 Bar $d_b := 1.41in$

Nominal width of Section $b := \left(17 + \frac{5}{8}\right) \cdot in$

Nominal height of Section $h := 30in$

Top cover $c_t := 5in$

Effective depth $d := 30in - c_t - \frac{d_b}{2}$ $d = 24 \cdot in$

Yield Stress $f_y := 66ksi$

Concrete Strength $f'_c := 5460psi$

Total Length

$L_t := 2 \cdot 14in + 2 \cdot 9ft + 2 \cdot 8.5in + 2 \cdot 3ft + 6ft + 7in$ $L_t = 34.3\,ft$

Cantilevered Span $a := 10ft + 10.5in$ $a = 10.9\,ft$

Interior Span $L_m := 12ft + 7in$ $L_m = 13\,ft$

Reinforcement Ratio $\rho := 2 \cdot \frac{A_{sb}}{b \cdot d}$ $\rho = 0.73 \cdot \%$

Initial moment at support $M_{supinit} := 40.5kip \cdot ft$

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \frac{lbf}{ft^3}$ $w_s = 0.55 \cdot \frac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 39.7kip$

Moment at support related to selfweight and loading gear

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 14in) + M_{supinit} = 426 \cdot kip \cdot ft$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := M_{supmax} - \frac{w_s \cdot L_m}{2} \cdot 3ft + w_s \cdot \frac{(3ft)^2}{2}$$

$$M_{3ft} = 418 \cdot kip \cdot ft$$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 71ksi}{0.7 \cdot f'_c}\right)} = 71 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot psi}$ $E_c = 4.2 \times 10^6 psi$

Steel modulus $E_s := 29000ksi$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 7$

Depth to neutral axis from extreme fiber in compression

$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n$ $k = 0.27$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 74 \cdot ksi$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4 \times 10^3 \cdot psi \qquad \text{(Compression)}$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 70ksi}{0.7 \cdot f'_c}\right)} = 70 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 73 \cdot ksi$$

Check related maximum concrete stress

$$f_{clin3} := \frac{M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 3.9 \times 10^3 psi \qquad (\text{Compression})$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR **LINEAR**

$f_{supmaxnon} = 71 \cdot ksi$ $f_{supmaxlin} = 74 \cdot ksi$

At splice end

$f_{snon3} = 70 \cdot ksi$ $f_{slin3} = 73 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice $L_d := 79in$

Bar diameter $d_b = 1.41 \cdot in$

Average bond stress at maximum load

$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

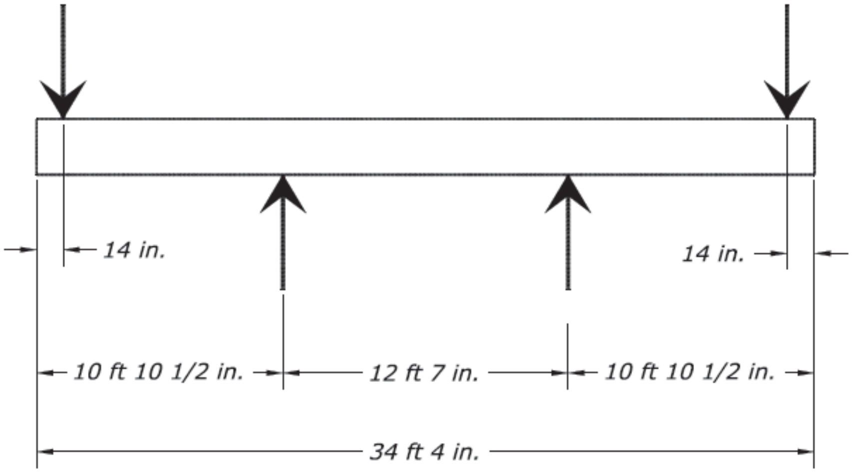
$$\text{round}\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 310\,psi$$

The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

The hard information from the test is that the 79-in splice for No. 11 bars has developed a maximum bar stress of at least

$$\boxed{f_{snon3} = 70 \cdot ksi}$$

TEST GIRDER B5



X-Sect. Area for a #11 Bar $A_{sb} := 1.56in^2$

Diameter, # 11 Bar $d_b := 1.41in$

Nominal width of Section $b := \left(17 + \frac{5}{8}\right) \cdot in$

Nominal height of Section $h := 30in$

Top cover $c_t := 5in$

Effective depth $d := 30in - c_t - \frac{d_b}{2}$ $d = 24 \cdot in$

Yield Stress $f_y := 66ksi$

Concrete Strength $f'_c := 5260psi$

Total Length

$L_t := 2 \cdot 14in + 2 \cdot 9ft + 2 \cdot 8.5in + 2 \cdot 3ft + 6ft + 7in$ $L_t = 34.3\,ft$

Cantilevered Span $a := 10ft + 10.5in$ $a = 10.9\,ft$

Interior Span $L_m := 12ft + 7in$ $L_m = 13\,ft$

Reinforcement Ratio $\rho := 2 \cdot \frac{A_{sb}}{b \cdot d}$ $\rho = 0.73 \cdot \%$

Initial moment at support $M_{supinit} := 40.5kip \cdot ft$

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \frac{lbf}{ft^3}$ $w_s = 0.55 \cdot \frac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 40.6kip$

Moment at support related to selfweight and loading gear

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 14in) + M_{supinit}$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := M_{supmax} - \frac{w_s \cdot L_m}{2} \cdot 3ft + w_s \cdot \frac{(3ft)^2}{2}$$

$$M_{3ft} = 427 \cdot kip \cdot ft$$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 73ksi}{0.7 \cdot f'_c}\right)} = 73 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot psi}$ $E_c = 4.1 \times 10^6 psi$

Steel modulus $E_s := 29000ksi$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 7$

Depth to neutral axis from extreme fiber in compression

$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n$ $k = 0.27$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 76 \cdot ksi$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4 \times 10^3 \cdot psi \qquad (Compression)$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 70ksi}{0.7 \cdot f'_c}\right)} = 72 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 74 \cdot ksi$$

Check related maximum concrete stress

$$f_{clin3} := \frac{M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4 \times 10^3 psi \qquad (\text{Compression})$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR

$f_{supmaxnon} = 73 \cdot ksi$

LINEAR

$f_{supmaxlin} = 76 \cdot ksi$

At splice end

$f_{snon3} = 72 \cdot ksi$

$f_{slin3} = 74 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice $L_d := 79in$

Bar diameter $d_b = 1.41 \cdot in$

Average bond stress at maximum load

$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

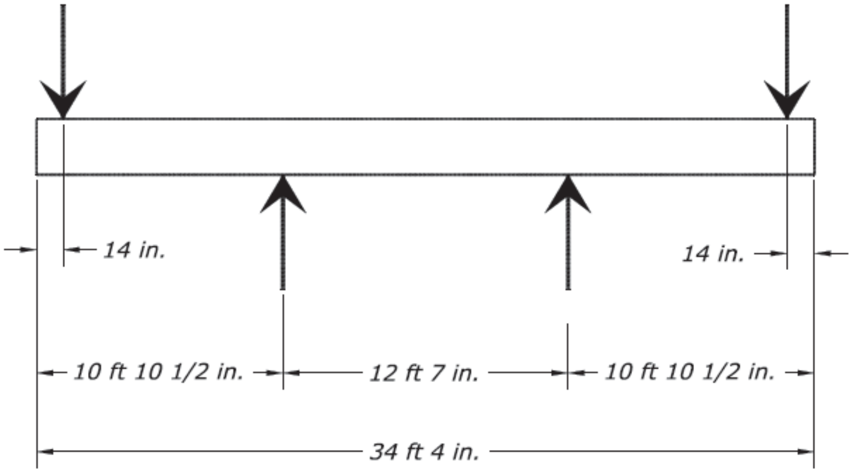
$$\mathrm{round}\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 320\,psi$$

The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

The hard information from the test is that the 79-in splice for No. 11 bars has developed a maximum bar stress of at least

$$\boxed{f_{snon3} = 72 \cdot ksi}$$

TEST GIRDER B6



X-Sect. Area for a #11 Bar $A_{sb} := 1.56in^2$

Diameter, # 11 Bar $d_b := 1.41in$

Nominal width of Section $b := \left(17 + \frac{5}{8}\right) \cdot in$

Nominal height of Section $h := 30in$

Top cover $c_t := 5in$

Effective depth $d := 30in - c_t - \frac{d_b}{2}$ $d = 24 \cdot in$

Yield Stress $f_y := 66ksi$

Concrete Strength $f'_c := 5230psi$

Total Length

$L_t := 2 \cdot 14in + 2 \cdot 9ft + 2 \cdot 8.5in + 2 \cdot 3ft + 6ft + 7in$ $L_t = 34.3\,ft$

Cantilevered Span $a := 10ft + 10.5in$ $a = 10.9\,ft$

Interior Span $L_m := 12ft + 7in$ $L_m = 13\,ft$

Reinforcement Ratio $\rho := 2 \cdot \frac{A_{sb}}{b \cdot d}$ $\rho = 0.73 \cdot \%$

Initial moment at support $M_{supinit} := 40.5kip \cdot ft$

EVALUATION AFTER TEST TO FAILURE

REINFORCEMENT STRESS AT MEASURED MAXIMUM LOAD

Note : Following calculations are made considering the supports not to have width in the direction of the span.

Unit selfweight $w_s := b \cdot h \cdot 150 \frac{lbf}{ft^3}$ $w_s = 0.55 \cdot \frac{kip}{ft}$

Measured Maximum Applied Load $P_{max} := 40.6kip$

Moment at support related to selfweight and loading gear

Maximum moment at support

$$M_{supmax} := P_{max} \cdot (a - 14in) + M_{supinit}$$

Moment at 3 ft toward mid-span from support

$$M_{3ft} := M_{supmax} - \frac{w_s \cdot L_m}{2} \cdot 3ft + w_s \cdot \frac{(3ft)^2}{2}$$

$$M_{3ft} = 427 \cdot kip \cdot ft$$

NOTE : Strain distributions over the depth of the section at the supports and at ends of the spliced bars are not linear once cracking is initiated. To assume a linear strain distribution and then to use an "exact" stress-strain relationship for the concrete is not correct. In the following, stresses in the reinforcement will be calculated assuming both linear and nonlinear response in the compressed concrete, and the lower value determined will be taken as the stress achieved. In both sets of calculations, contribution of the tensile strength of the concrete will be considered negligible.

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{supmaxnon} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 73ksi}{0.7 \cdot f'_c}\right)} = 73 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS AT SUPPORT ASSUMING FULLY LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

Conc. modulus $E_c := 57000 \cdot \sqrt{f'_c \cdot psi}$ $E_c = 4.1 \times 10^6 psi$

Steel modulus $E_s := 29000ksi$

Modular ratio $n := \frac{E_s}{E_c}$ $n = 7$

Depth to neutral axis from extreme fiber in compression

$$k := \sqrt{(\rho \cdot n)^2 + 2 \cdot \rho \cdot n} - \rho \cdot n \qquad k = 0.27$$

$$f_{supmaxlin} := \frac{M_{supmax}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 76 \cdot ksi$$

Check related maximum compressive stress in concrete

$$f_{clin1} := \frac{M_{supmax}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4 \times 10^3 \cdot psi \qquad \text{(Compression)}$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING FULLY NONLINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{snon3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - 0.4 \cdot \frac{\rho \cdot 72ksi}{0.7 \cdot f'_c}\right)} = 72 \cdot ksi$$

MAXIMUM REINFORCEMENT STRESS IN CONTINUOUS BAR AT END OF SPLICE ASSUMING LINEAR DISTRIBUTION OF COMPRESSIVE STRESS IN THE CONCRETE

$$f_{slin3} := \frac{M_{3ft}}{2 \cdot A_{sb} \cdot d \cdot \left(1 - \frac{k}{3}\right)} = 74 \cdot ksi$$

Check related maximum concrete stress

$$f_{clin3} := \frac{M_{3ft}}{\left(\frac{k \cdot b \cdot d^2}{2}\right) \cdot \left(1 - \frac{k}{3}\right)} = 4 \times 10^3 \, psi \qquad (Compression)$$

SUMMARY

Reinforcement stress based on observed maximum load

At support

NONLINEAR **LINEAR**

$f_{supmaxnon} = 73 \cdot ksi$ $f_{supmaxlin} = 76 \cdot ksi$

At splice end

$f_{snon3} = 72 \cdot ksi$ $f_{slin3} = 74 \cdot ksi$

NOMINAL UNIT BOND STRESS

Length of splice $L_d := 79in$

Bar diameter $d_b = 1.41 \cdot in$

Average bond stress at maximum load

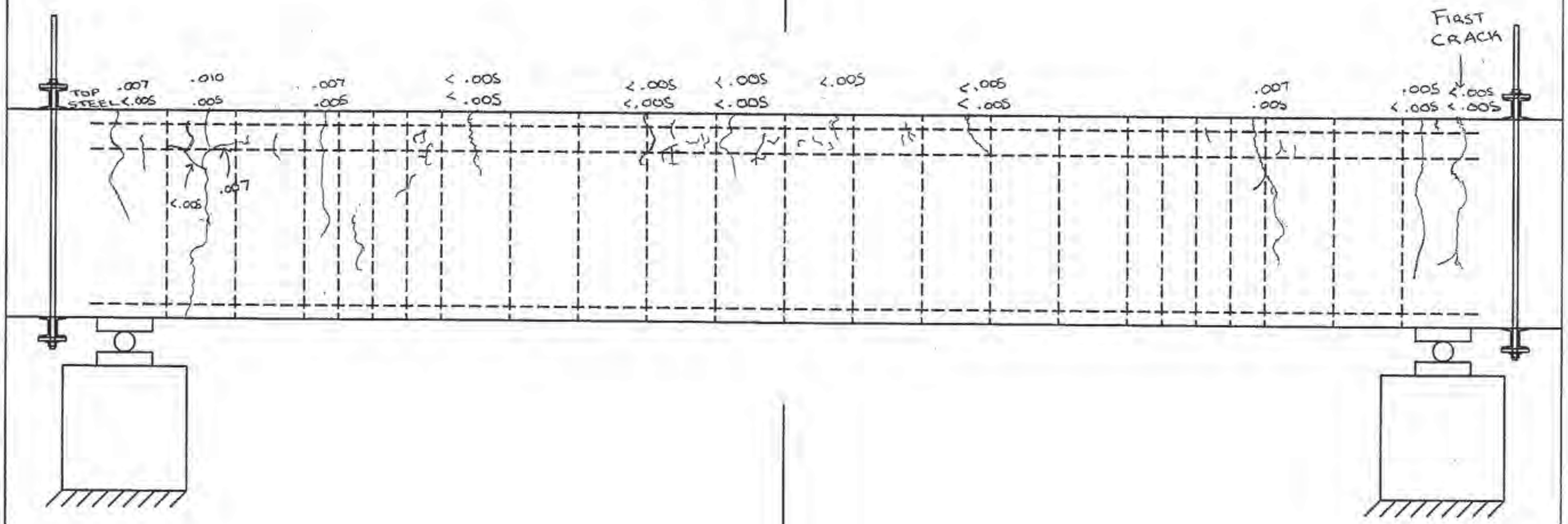
$$\mu_{avg} := \frac{f_{snon3} \cdot d_b}{4 \cdot L_d}$$

$$\text{round}\left(\frac{\mu_{avg}}{psi}, -1\right) \cdot psi = 320\,psi$$

The number listed above for bond stress has relevance to design but is irrelevant to the actual bond stress at maximum load.

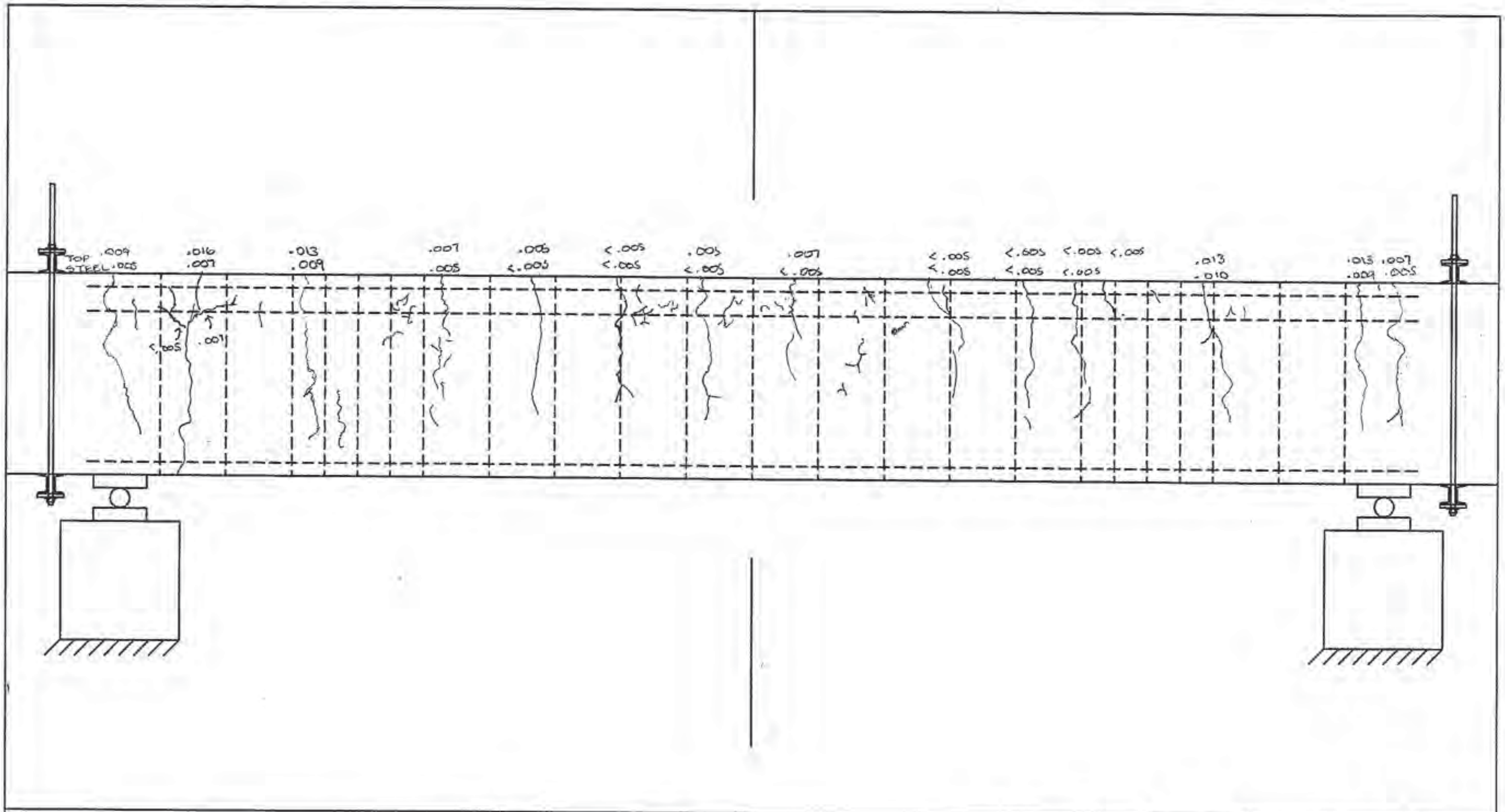
The hard information from the test is that the 79-in splice for No. 11 bars has developed a maximum bar stress of at least

$\boxed{f_{snon3} = 72 \cdot ksi}$

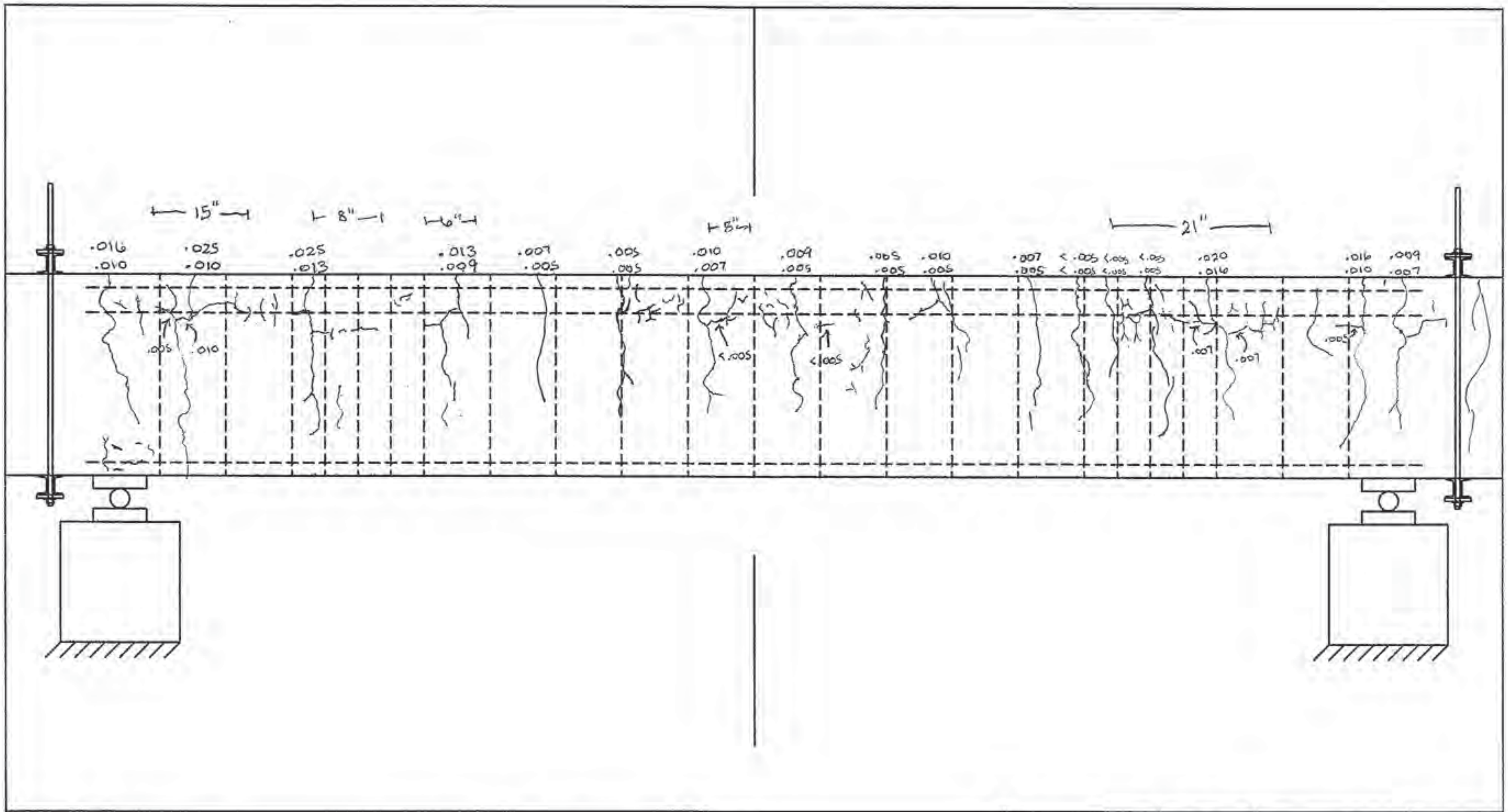


Specimen: A-1	**Sheet:**	1	**of**	1
Average Load: 6 KIPS	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	**Date:**	6/4/12		

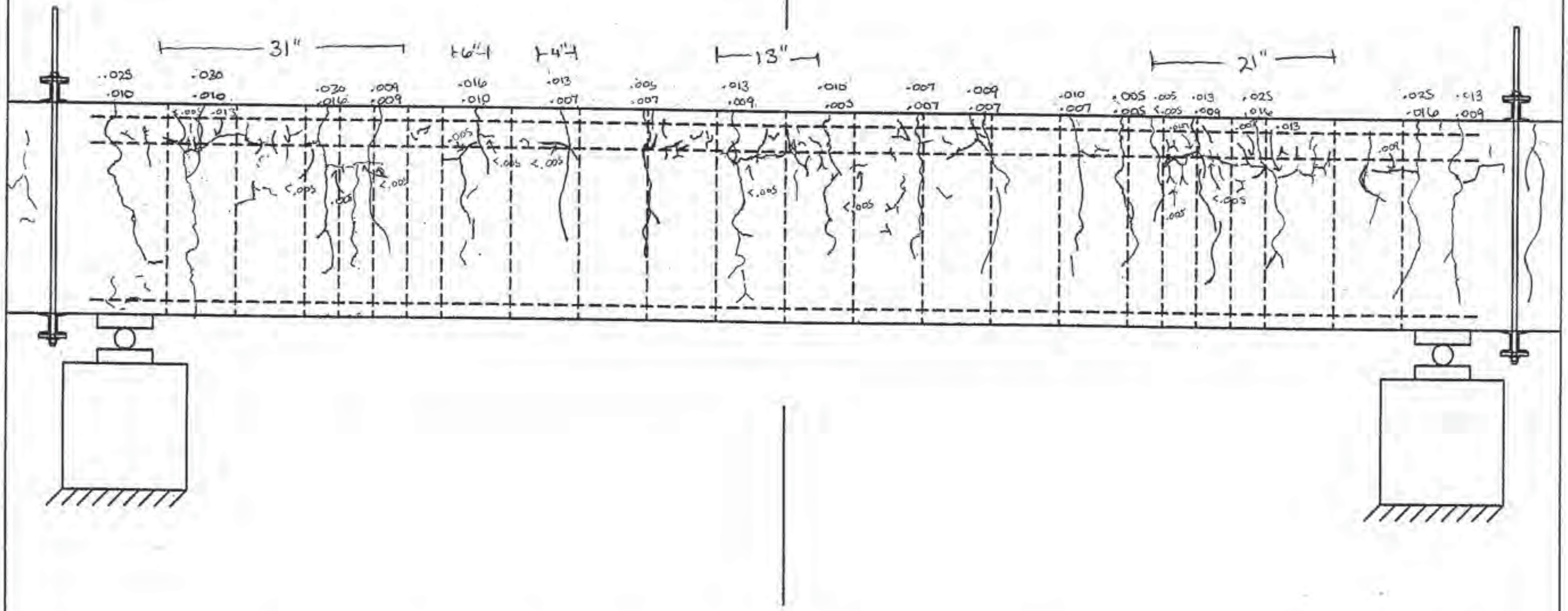
BOWEN LABORATORY
PURDUE UNIVERSITY



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-1	**Sheet:**	1	**of**	1
	Average Load: 12 KIPS	**Drawn by:**	MDN	**Checked by:**	
	Average Deflection:	**Date:**	6/4/12		

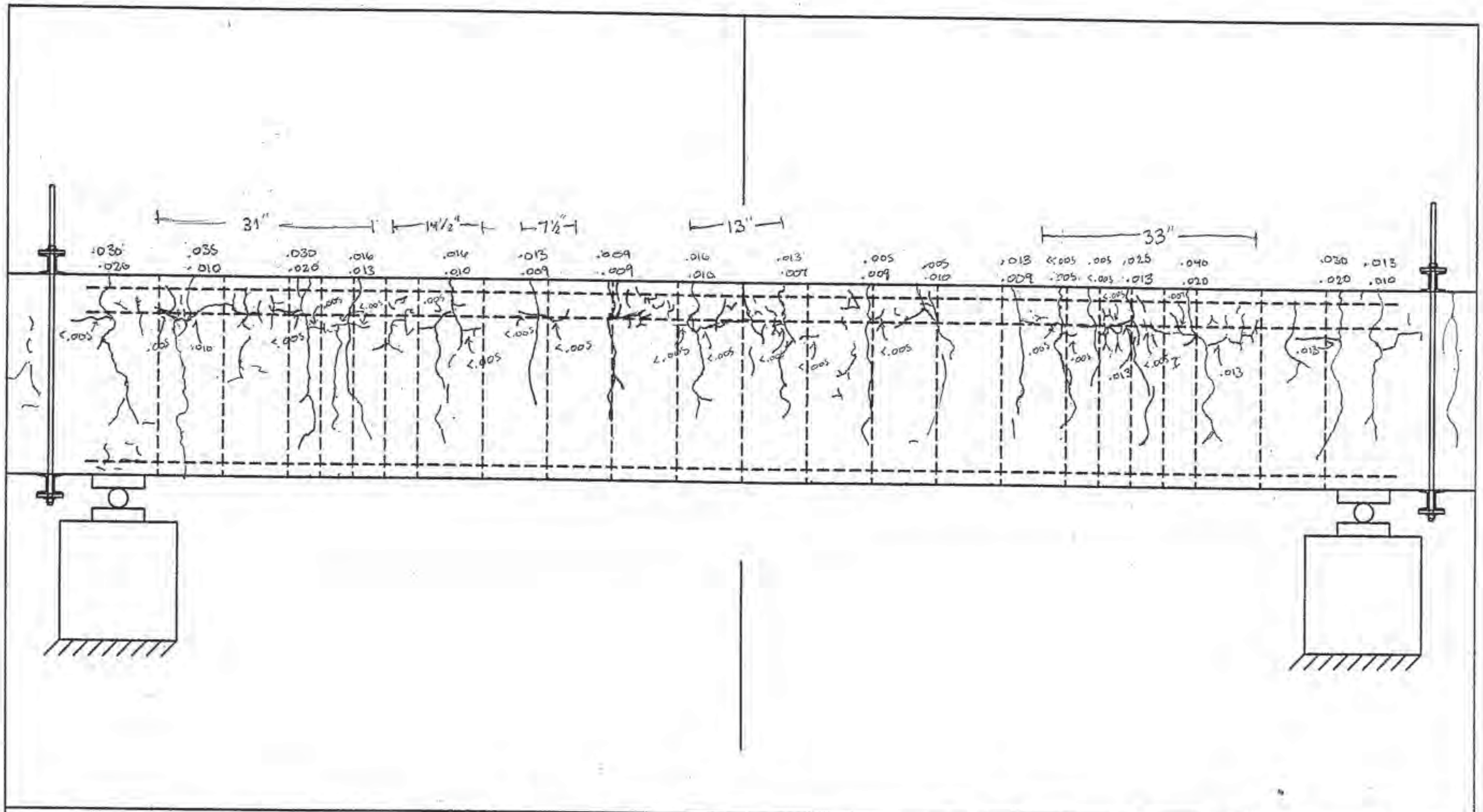


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-1	**Sheet:**	1	**of** 1
	Average Load: 18 kips	**Drawn by:**	MDN	**Checked by:**
	Average Deflection:	**Date:**	6/4/12	



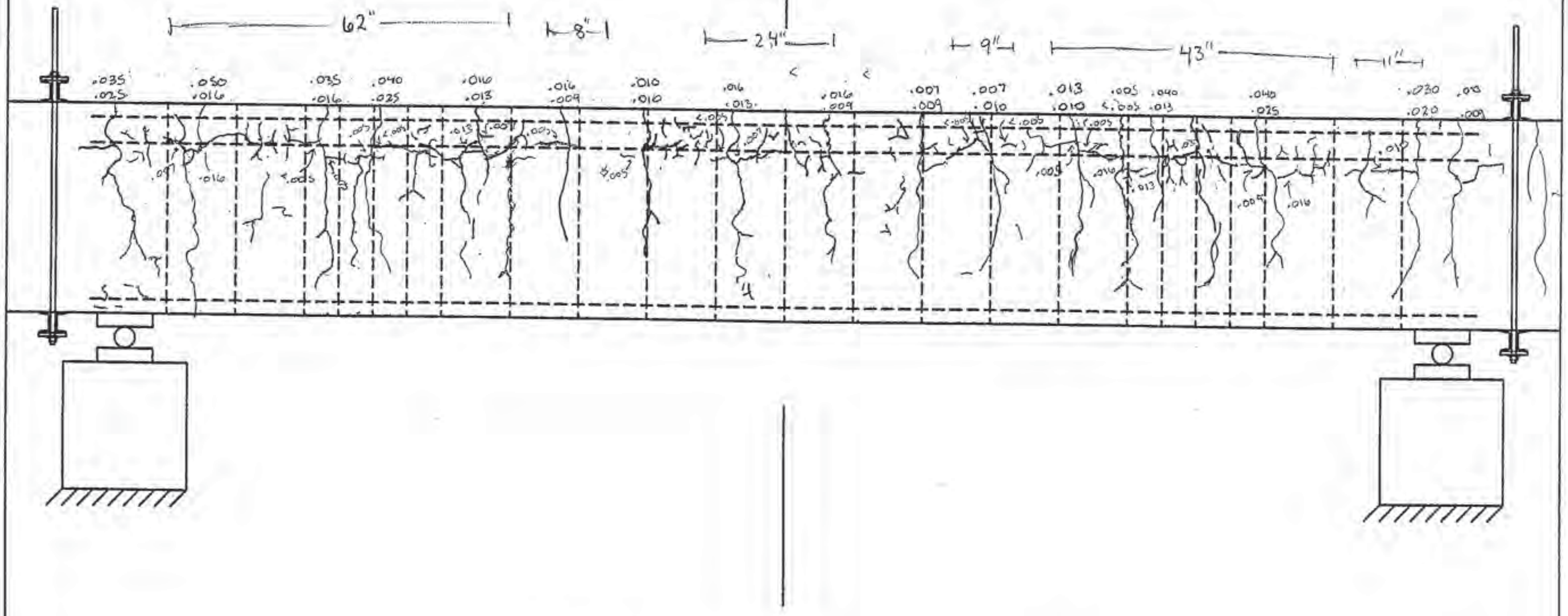
Specimen: A-1		**Sheet:**	1	**of**	1
Average Load: 24 KIPS		**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 1.25"		**Date:**	6/4/12		

BOWEN LABORATORY
PURDUE UNIVERSITY



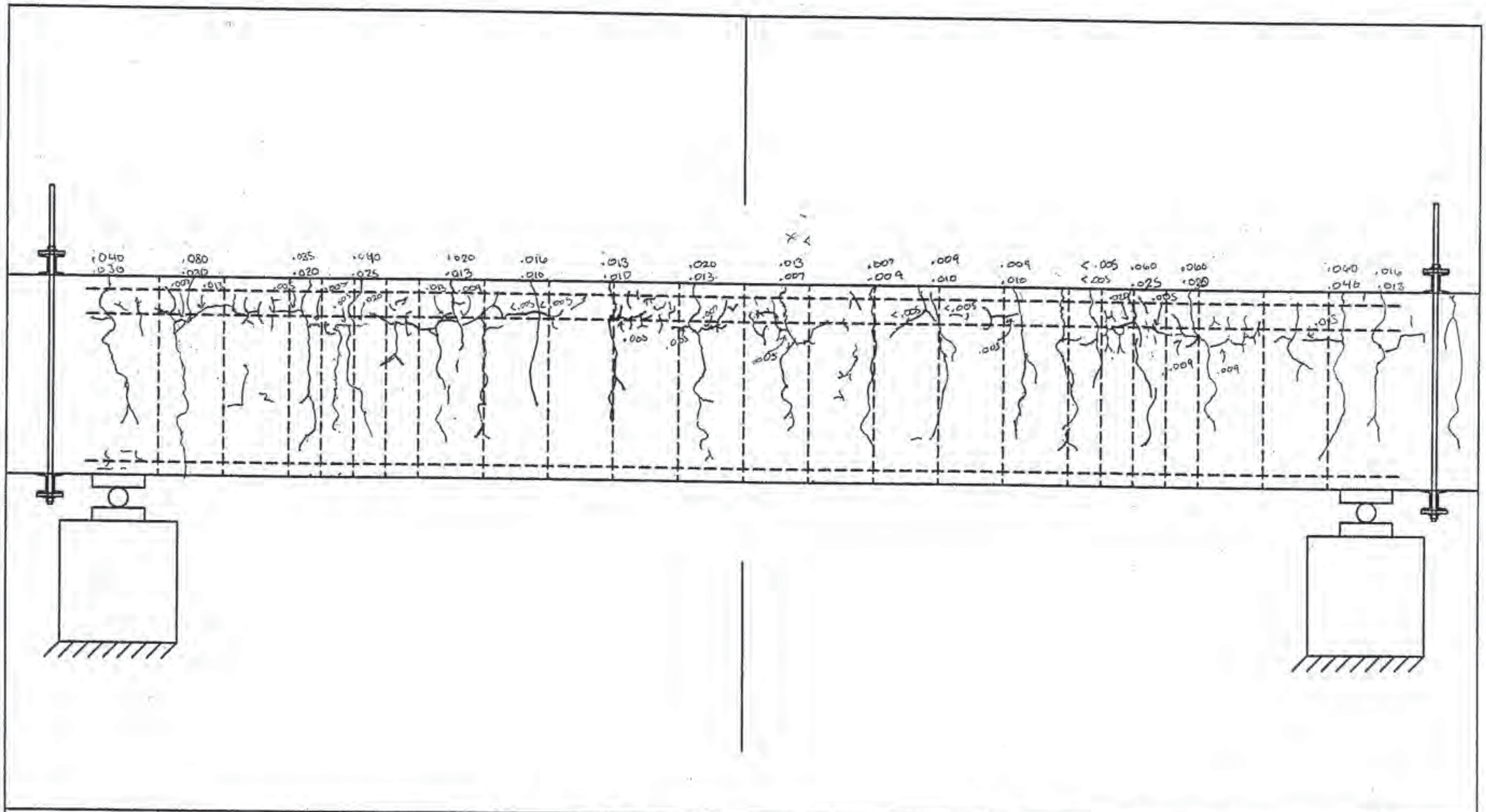
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	A-1	**Sheet:**	1	**of**	1
Average Load:	30 KIPS	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	1.66"	**Date:**	6/4/12		



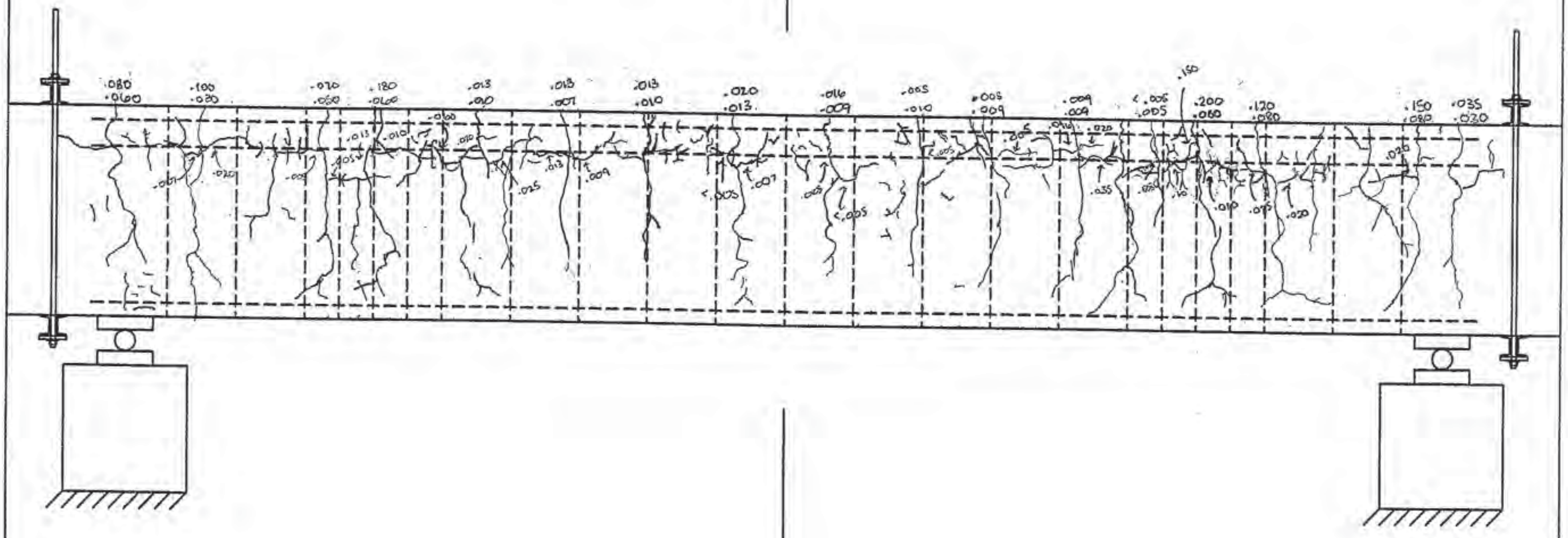
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-1	**Sheet:**	1	**of**	1
Average Load: 36 kips	**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 2.07"	**Date:**	6/4/12		



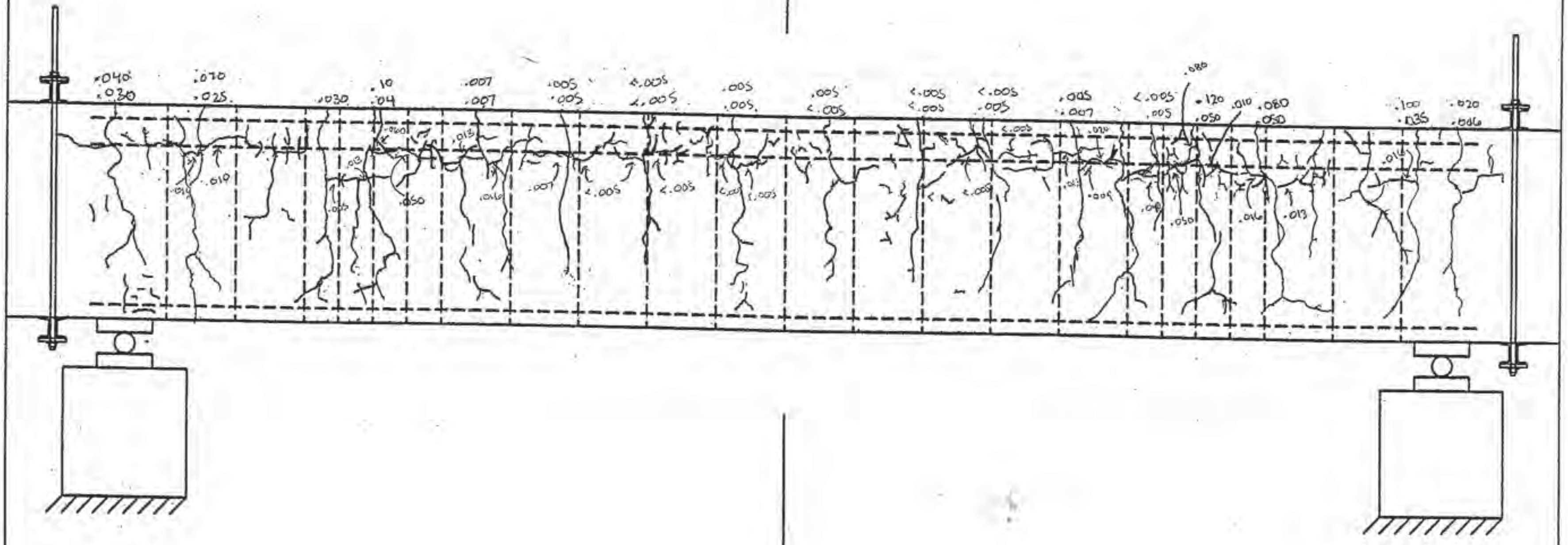
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-1	**Sheet:**	1	of	1
Average Load: 38 k (YIELD)	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	**Date:**	6/4/12		



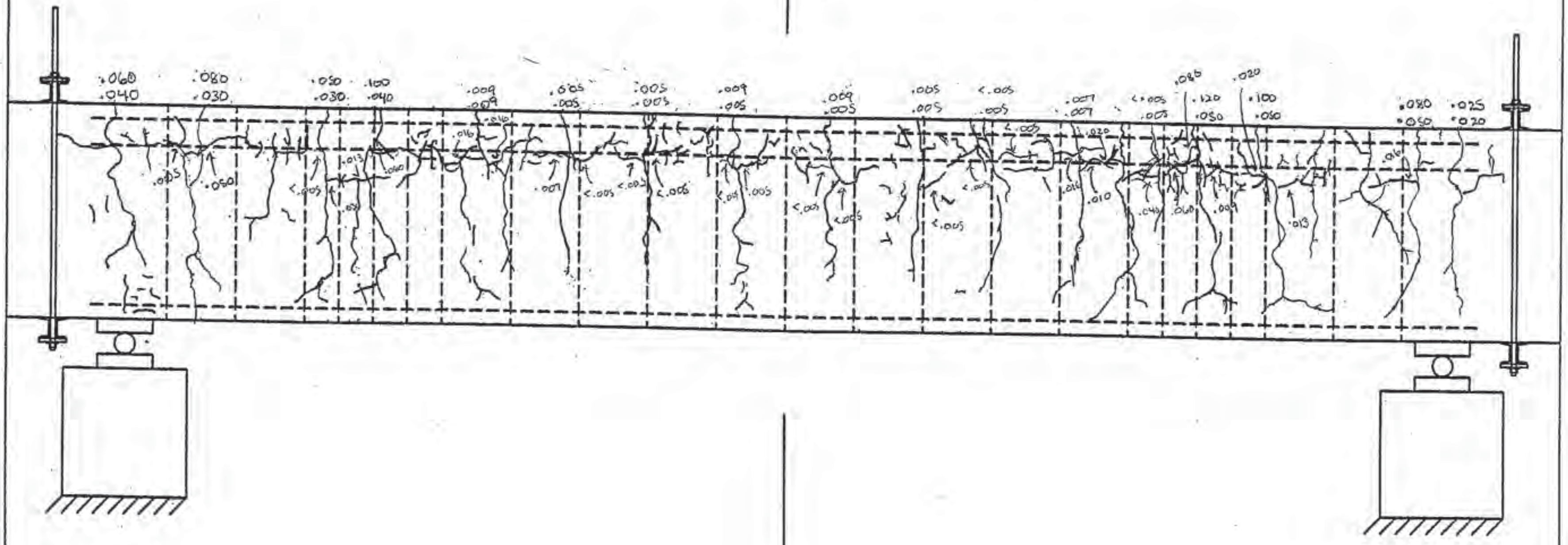
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-1	**Sheet:**	1	of	1
Average Load: 41 kips	**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 4.00"	**Date:**	6/4/12		

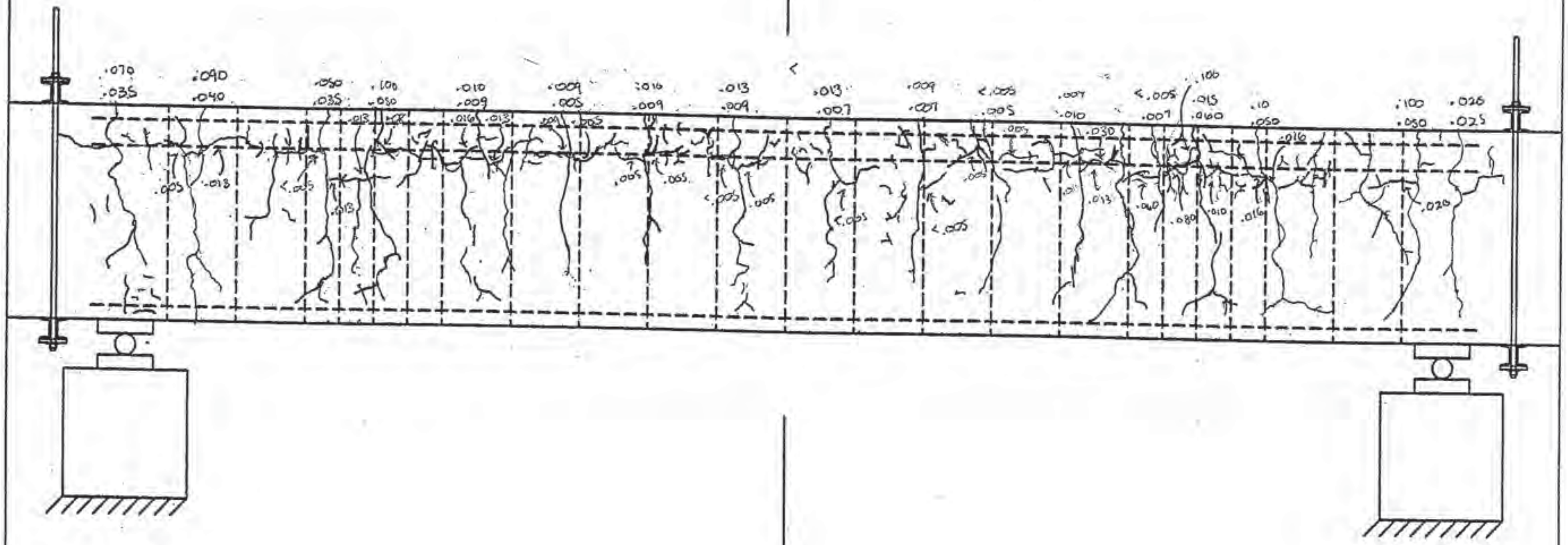


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-1	**Sheet:**	1	of	1
Average Load: ~~[illegible]~~ 0 kips	**Drawn by:**	MDN	**Checked by:**	
Average Deflection: ~~[illegible]~~	**Date:**	6/4/12		

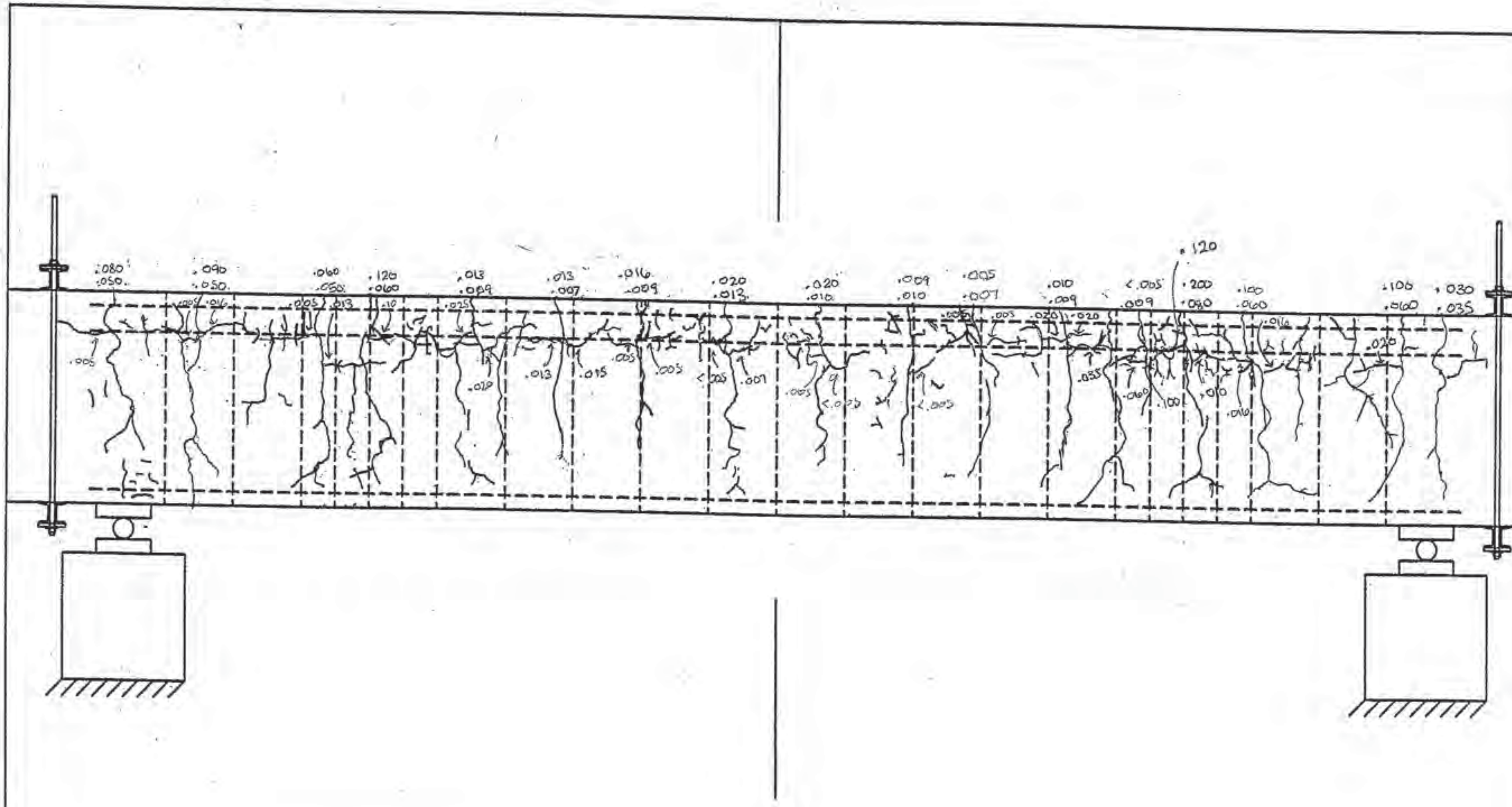


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-1	**Sheet:** 1	**of**	1
	Average Load: ~~4 KIPS~~ 12 KIPS (RELOADED)	**Drawn by:** MDN	**Checked by:**	
	Average Deflection: [illegible]	**Date:** 6/4/12		



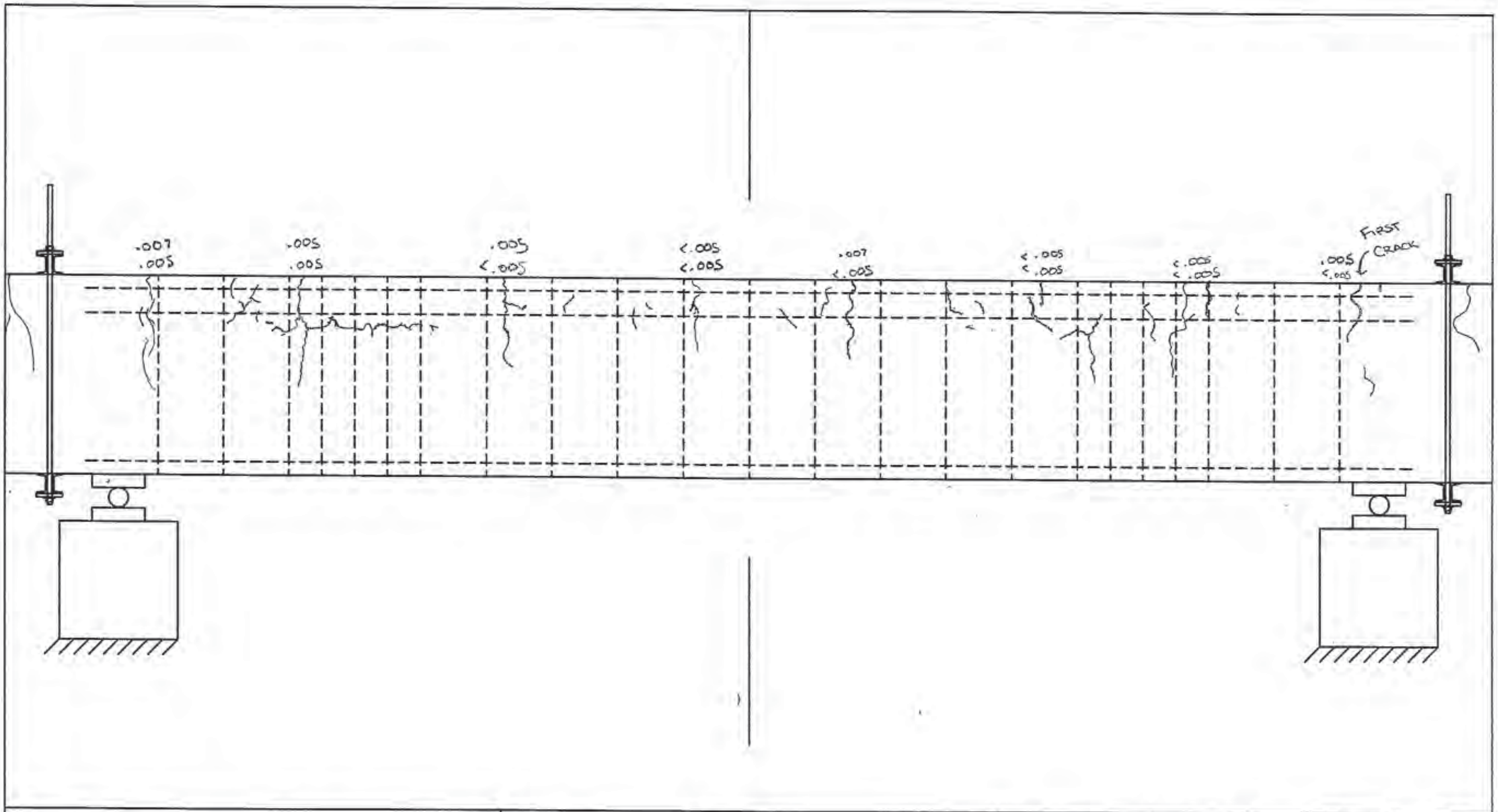
BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-1	**Sheet:** 1	of	1
	Average Load: ~~41 kips~~ 24 kips (RELOADED)	**Drawn by:** MDN	**Checked by:**	
	Average Deflection: ~~4.00"~~	**Date:** 6/4/12		

)



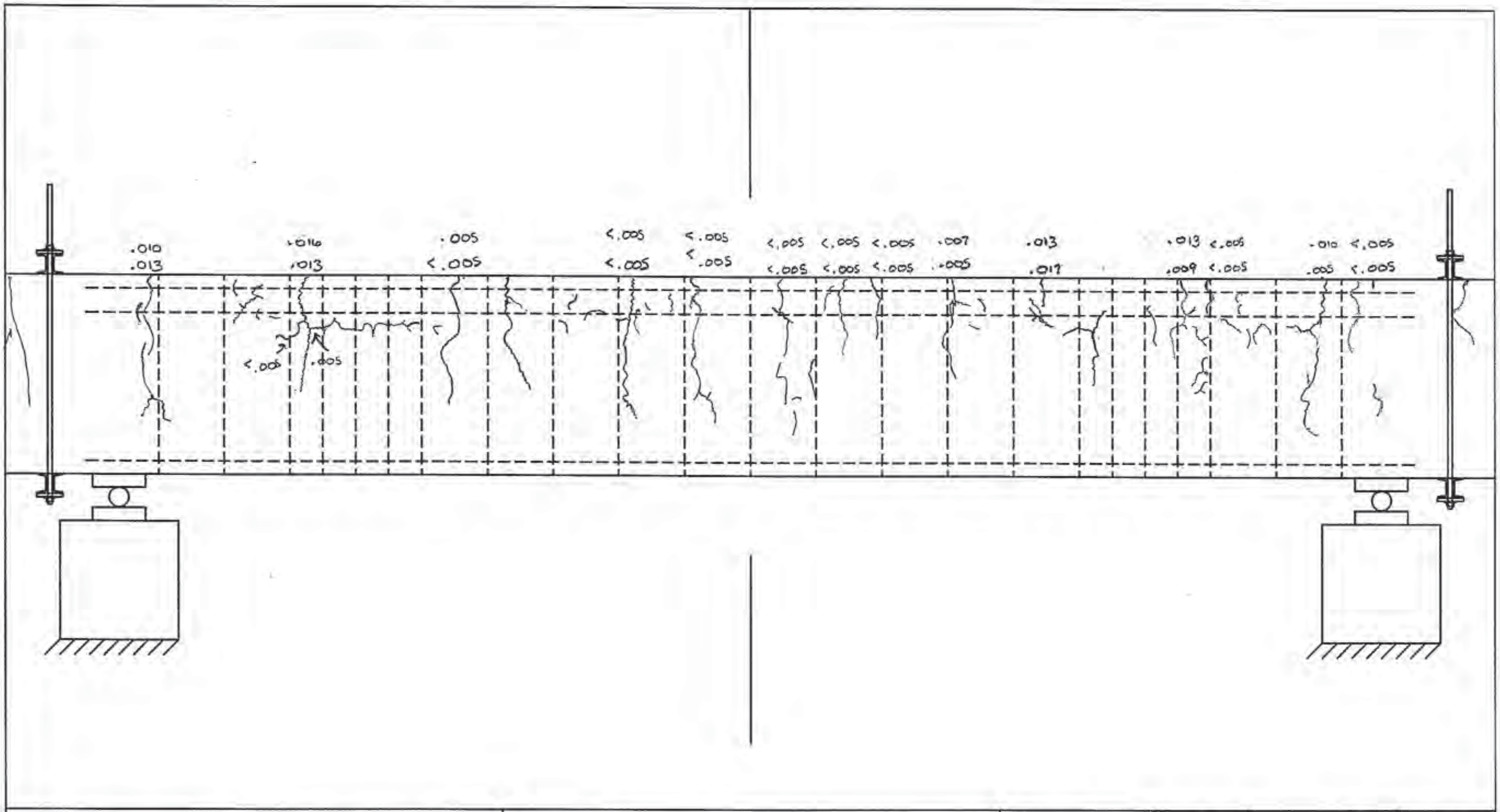
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	A-1	**Sheet:**	1	of	1
Average Load:	~~[illegible] KIPS~~ 36 KIPS (RELOADED)	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	~~[illegible]~~"	**Date:**	6/4/12		



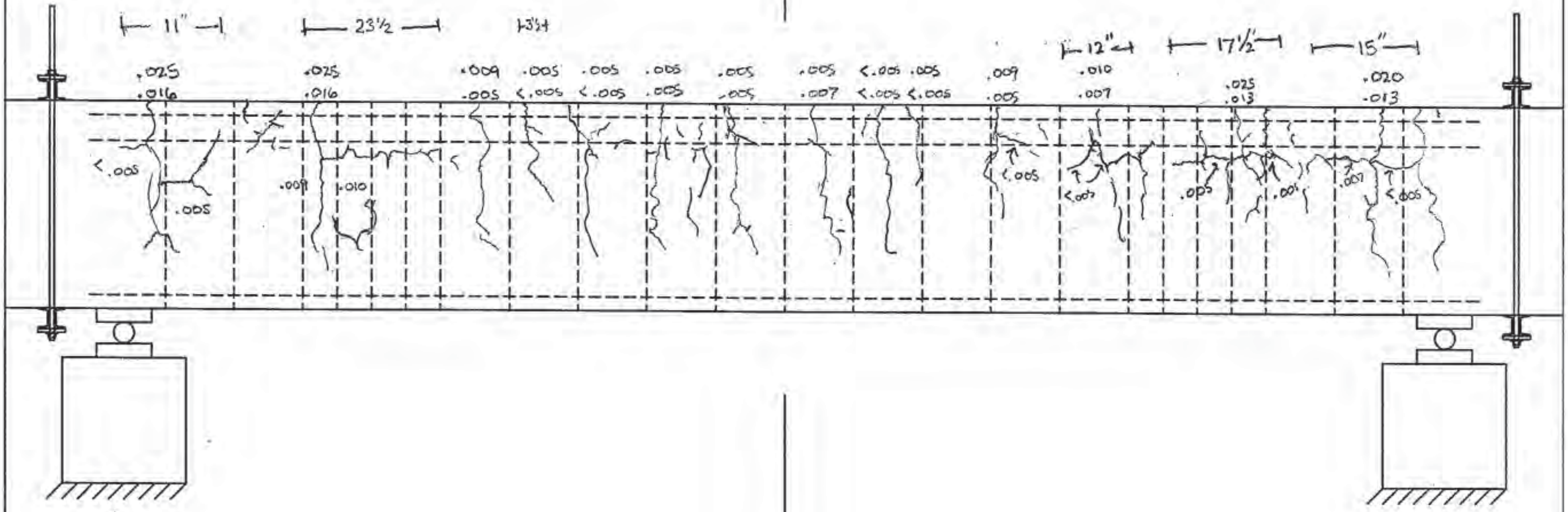
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	A-2	**Sheet:**	1	of	1
Average Load:	6 KIPS	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	0.13"	**Date:**	06/01/12		



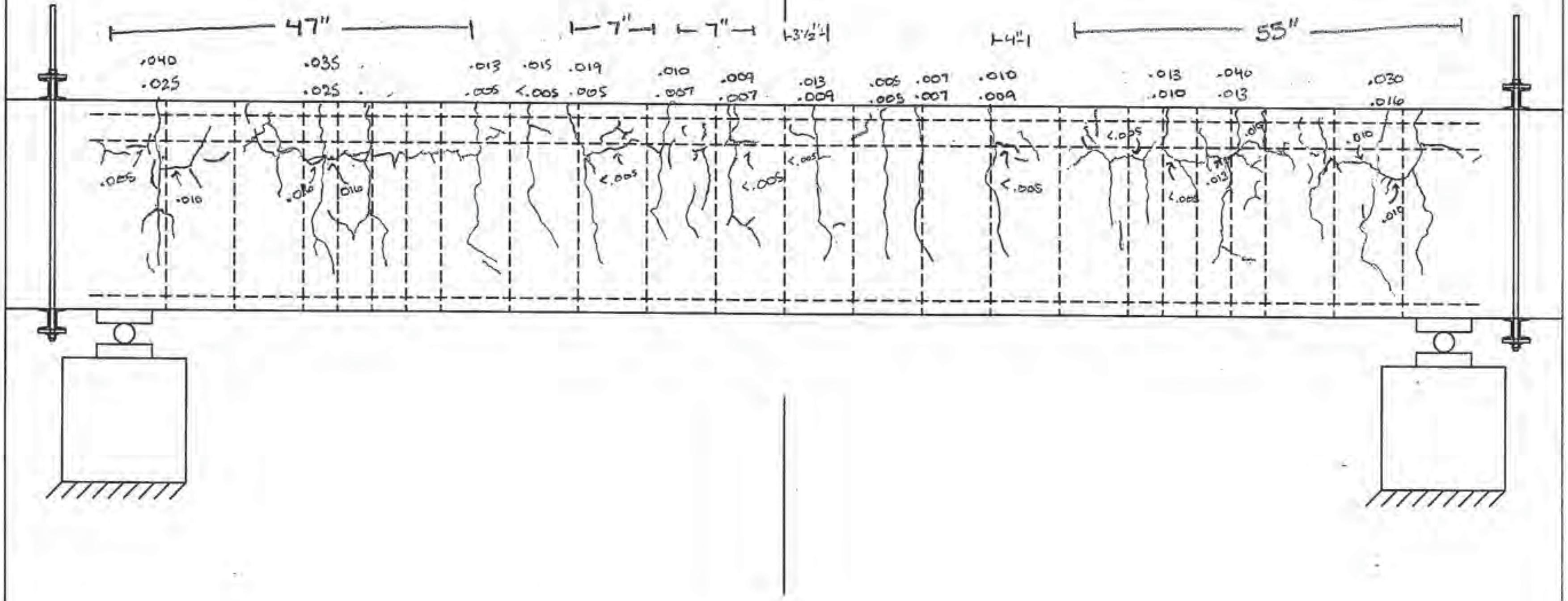
Specimen: A-2	**Sheet:**	1	of	1
Average Load: 12 KIPS	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	**Date:**	6-1-12		

BOWEN LABORATORY
PURDUE UNIVERSITY

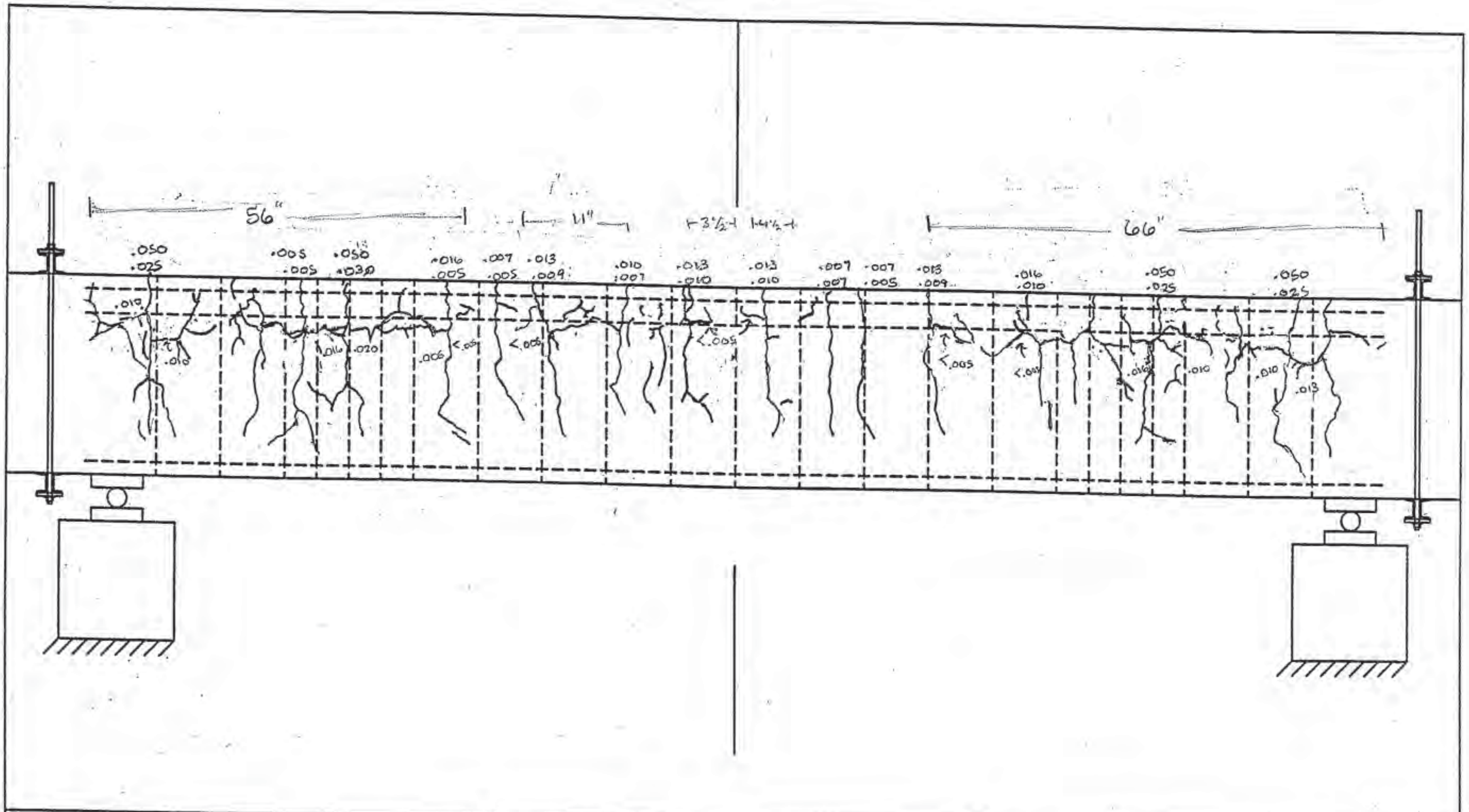


Specimen: A-2	**Sheet:**	1	of	1
Average Load: 18 kips	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	**Date:**	6-01-12		

BOWEN LABORATORY
PURDUE UNIVERSITY

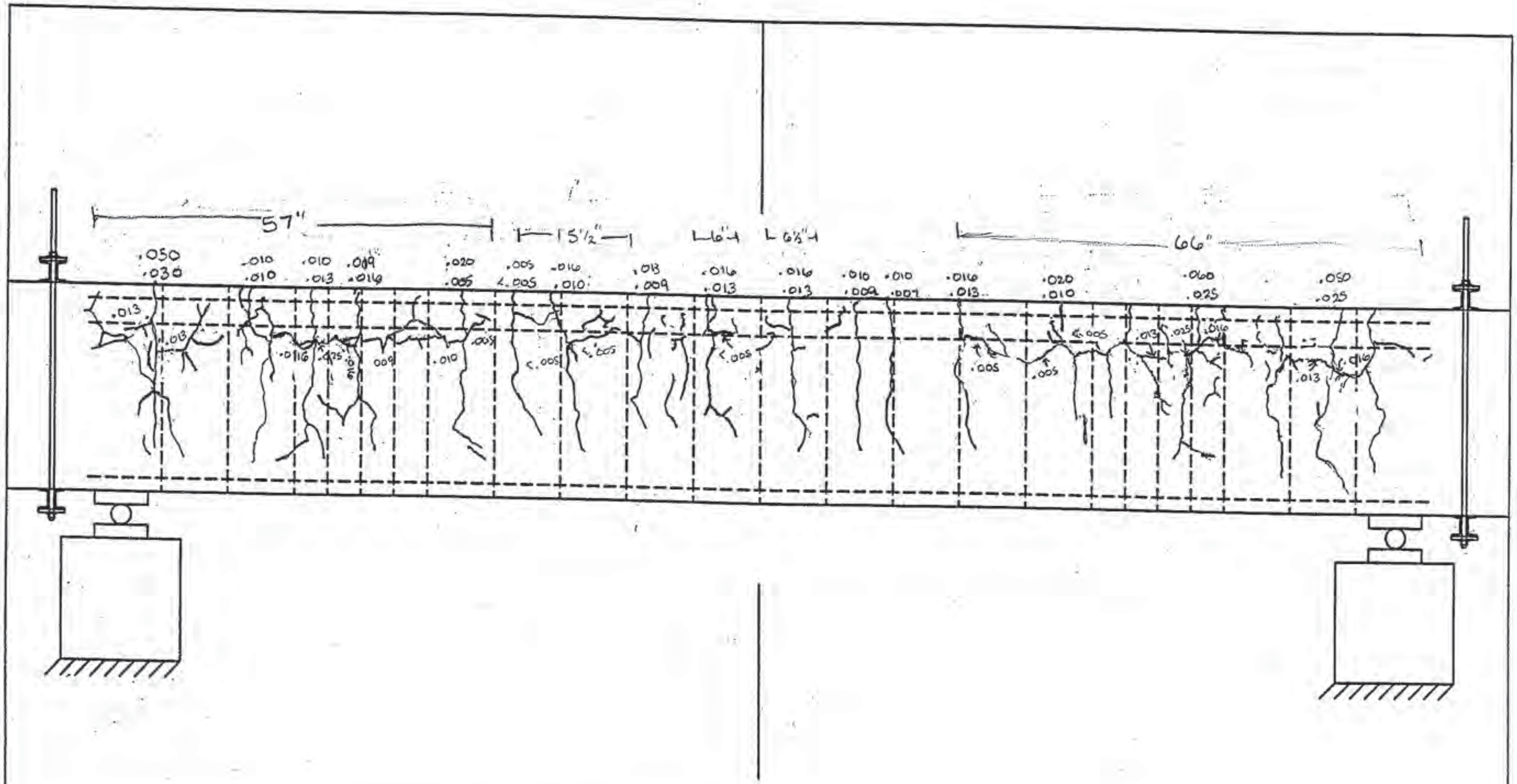


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-2	**Sheet:**	1	**of**	1
	Average Load: 24 kips	**Drawn by:**		**Checked by:**	
	Average Deflection: 1.17"	**Date:**			



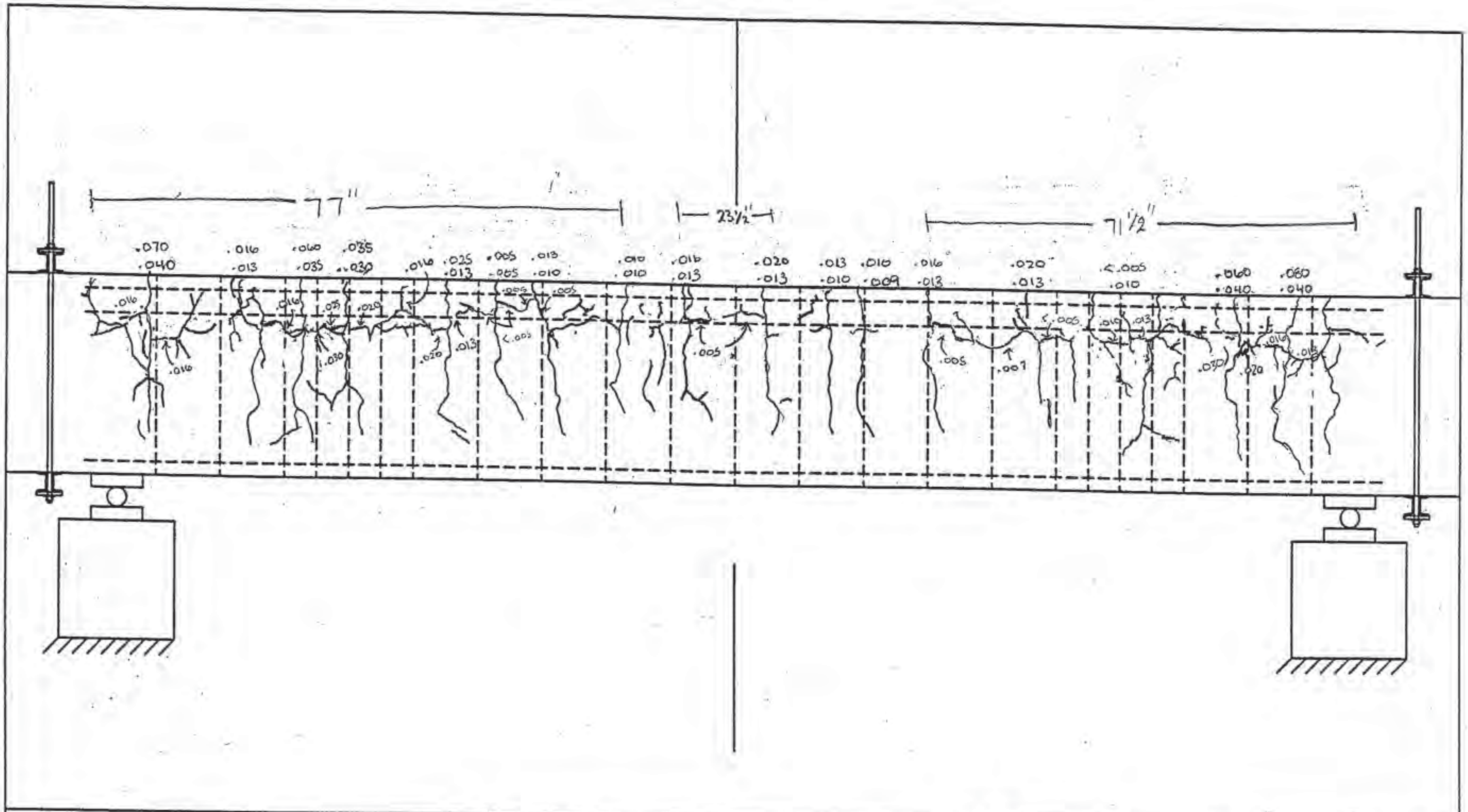
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-2	**Sheet:**	1	**of**	1
Average Load: 30 kips	**Drawn by:**		**Checked by:**	
Average Deflection: 1.54"	**Date:**			

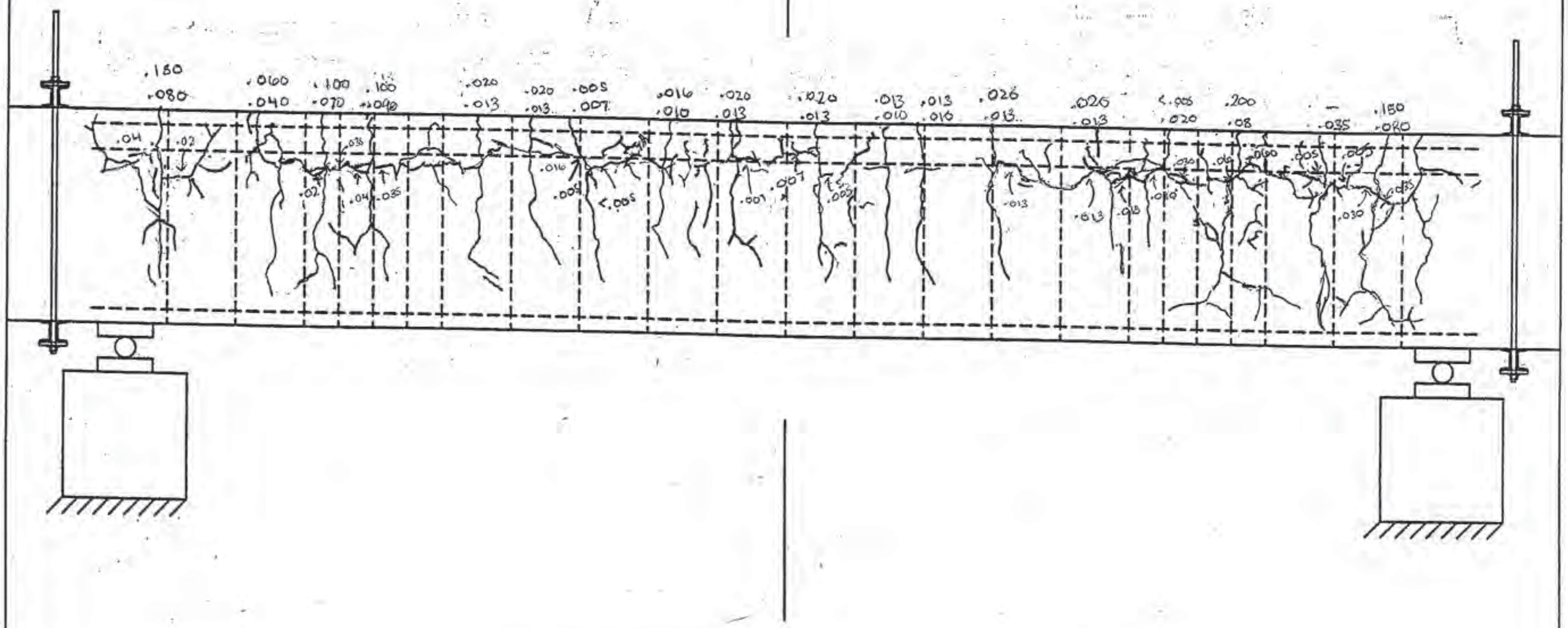


BOWEN LABORATORY
PURDUE UNIVERSITY

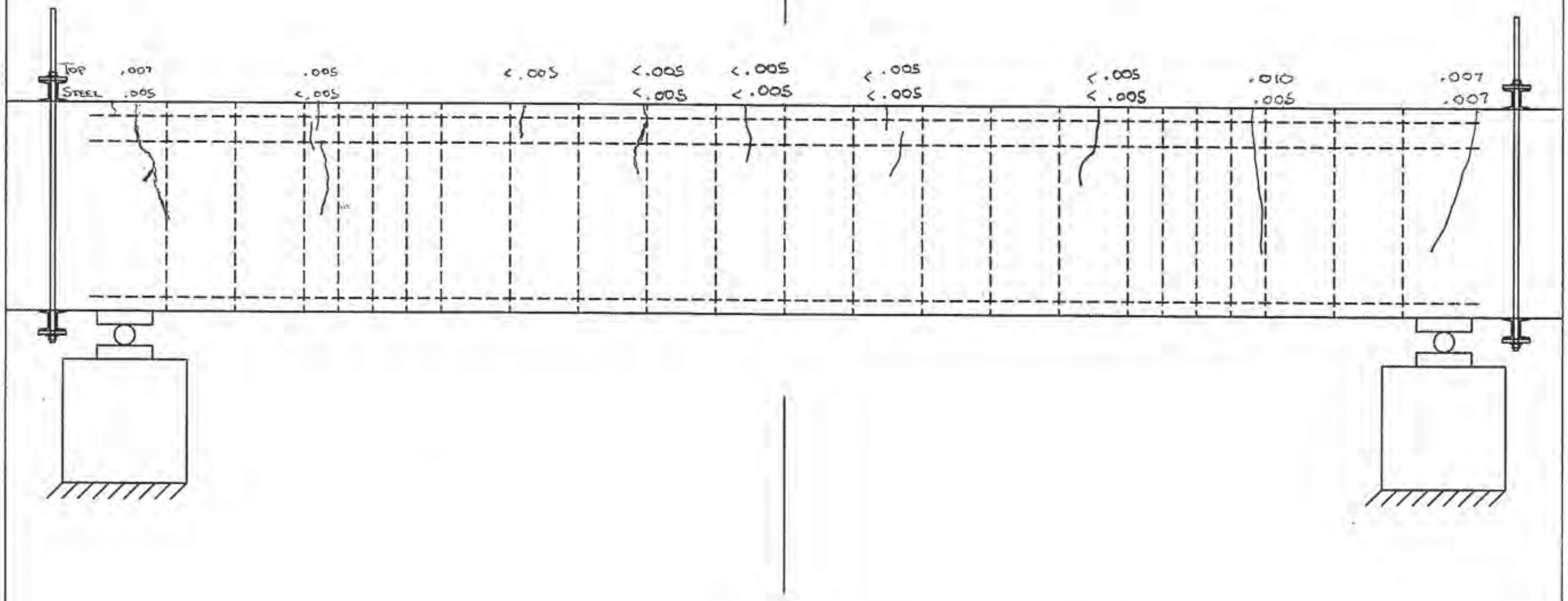
Specimen: A-2		**Sheet:**	1	of	1
Average Load: 36 kips		**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 1.91"		**Date:**	6-01-12		



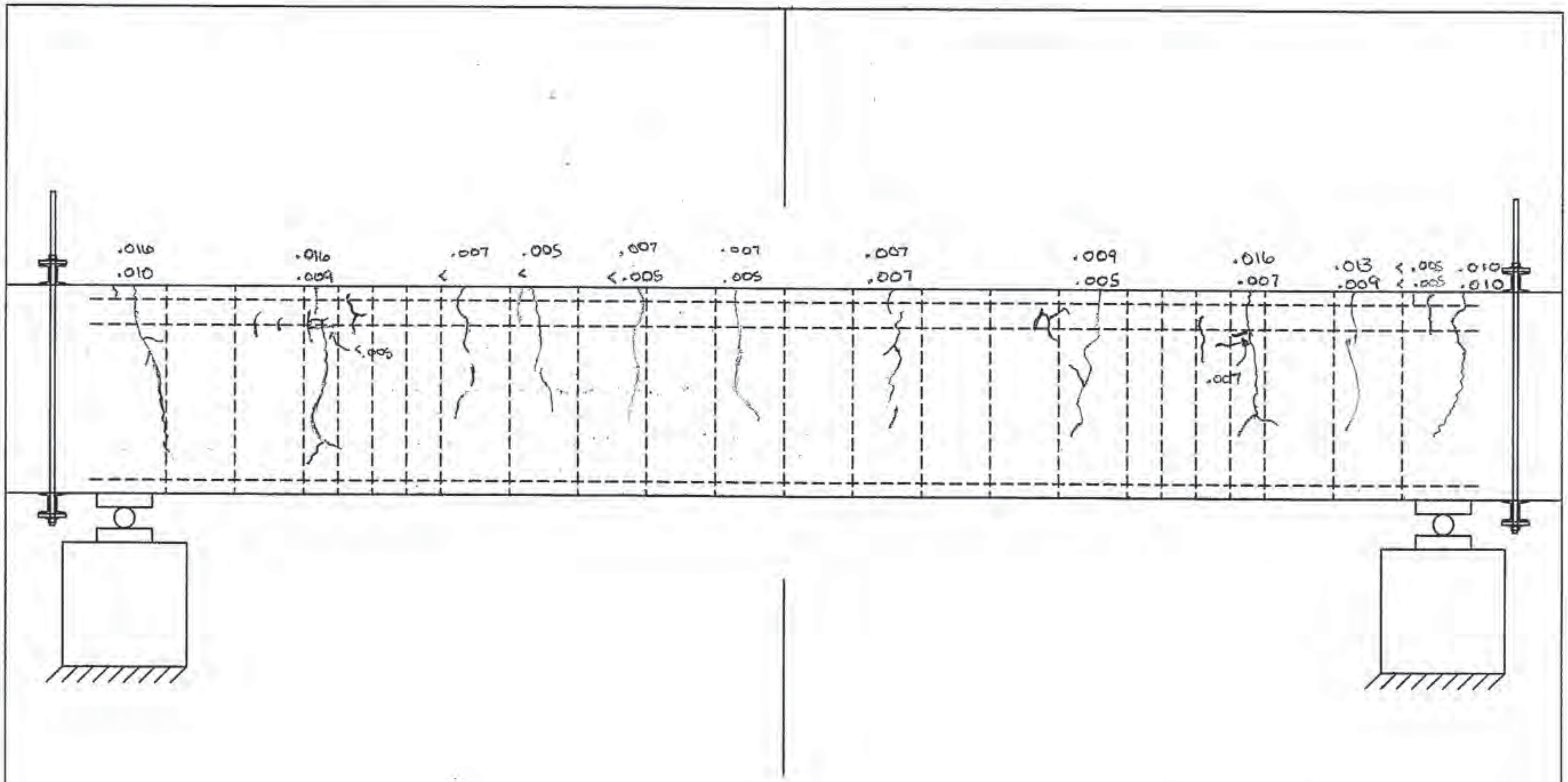
BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-2	**Sheet:**	1	of	1
	Average Load: 38 KIP (YIELD)	**Drawn by:**		**Checked by:**	
	Average Deflection:	**Date:**			



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:**	A-2	**Sheet:**	1	**of**	1
	Average Load:	41 KIP	**Drawn by:**		**Checked by:**	
	Average Deflection:		**Date:**			

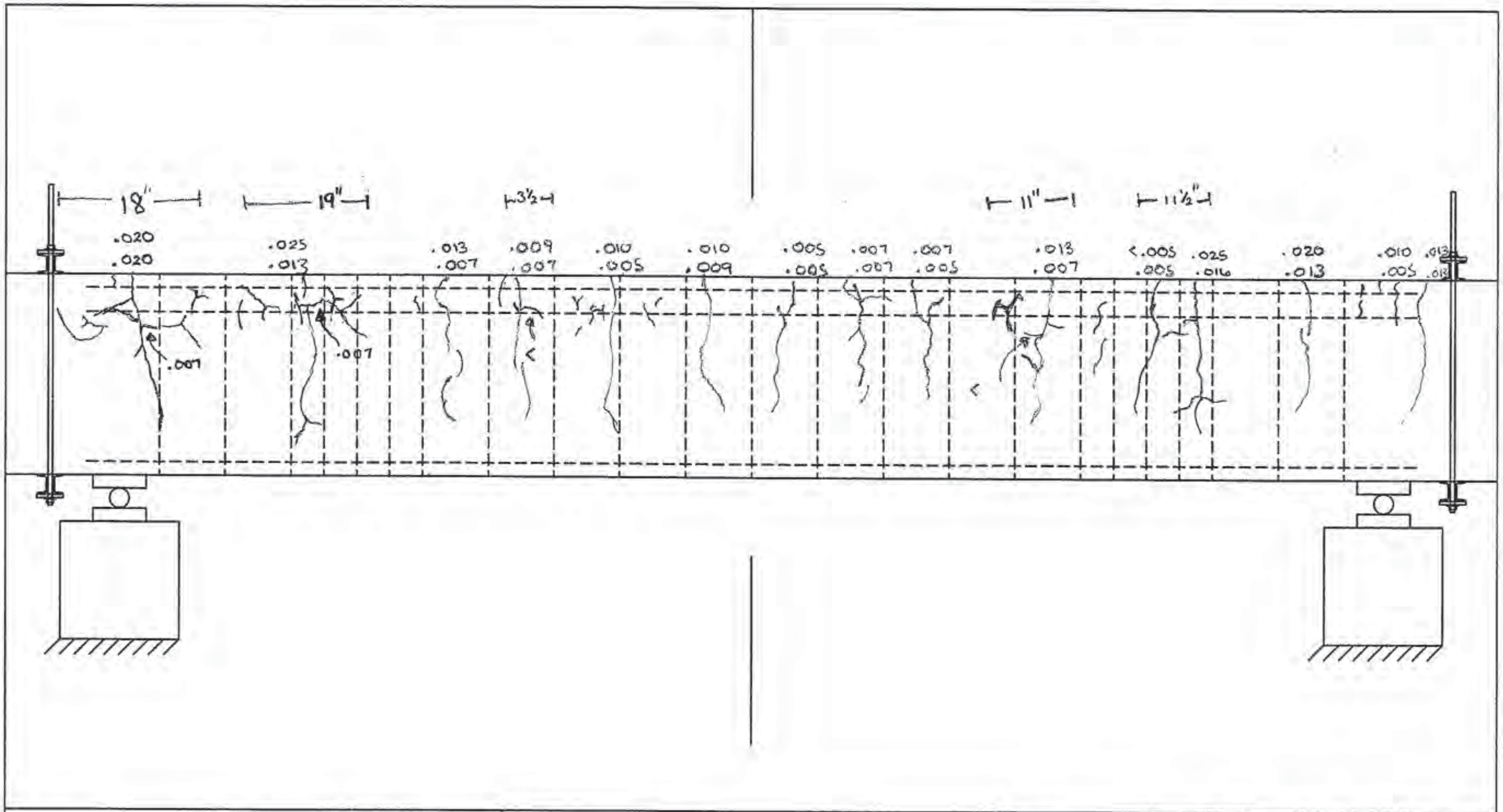


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-3	**Sheet:**	1	**of**	1
	Average Load: 6 KIPS	**Drawn by:**	MDN	**Checked by:**	
	Average Deflection: 0.14"	**Date:**	5/30/12		

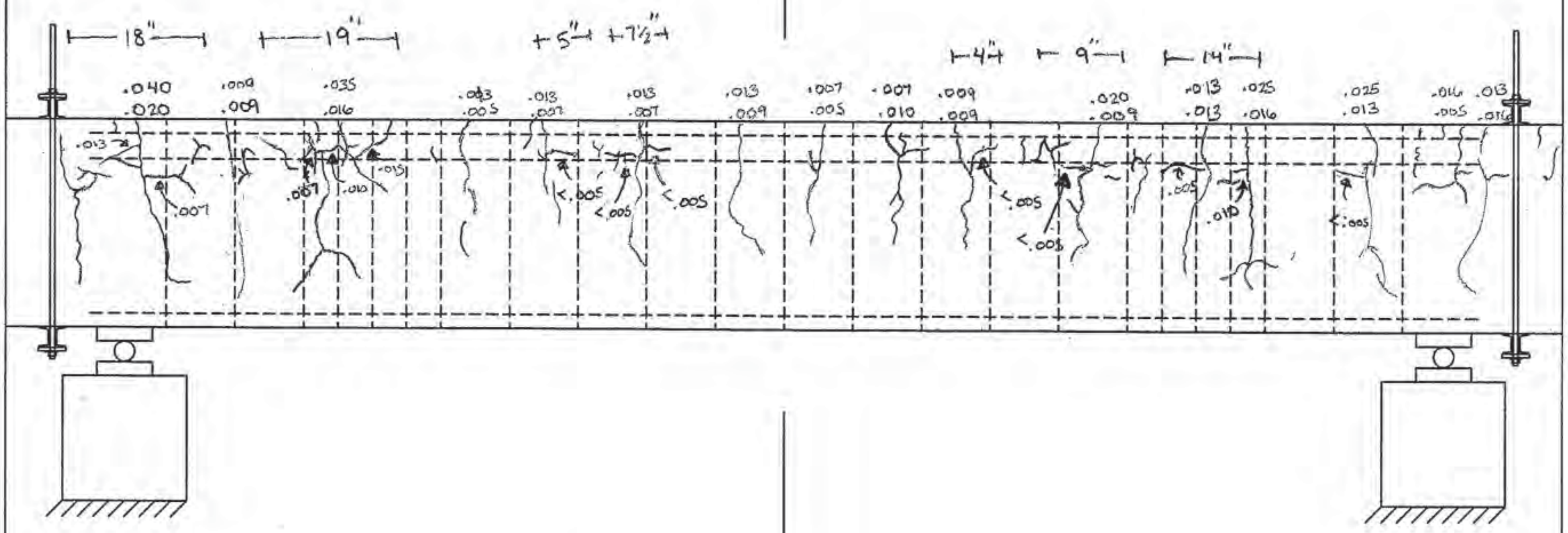


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-3	**Sheet:**	1	**of**	1
Average Load: 12 KIPS	**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 0.46"	**Date:**			

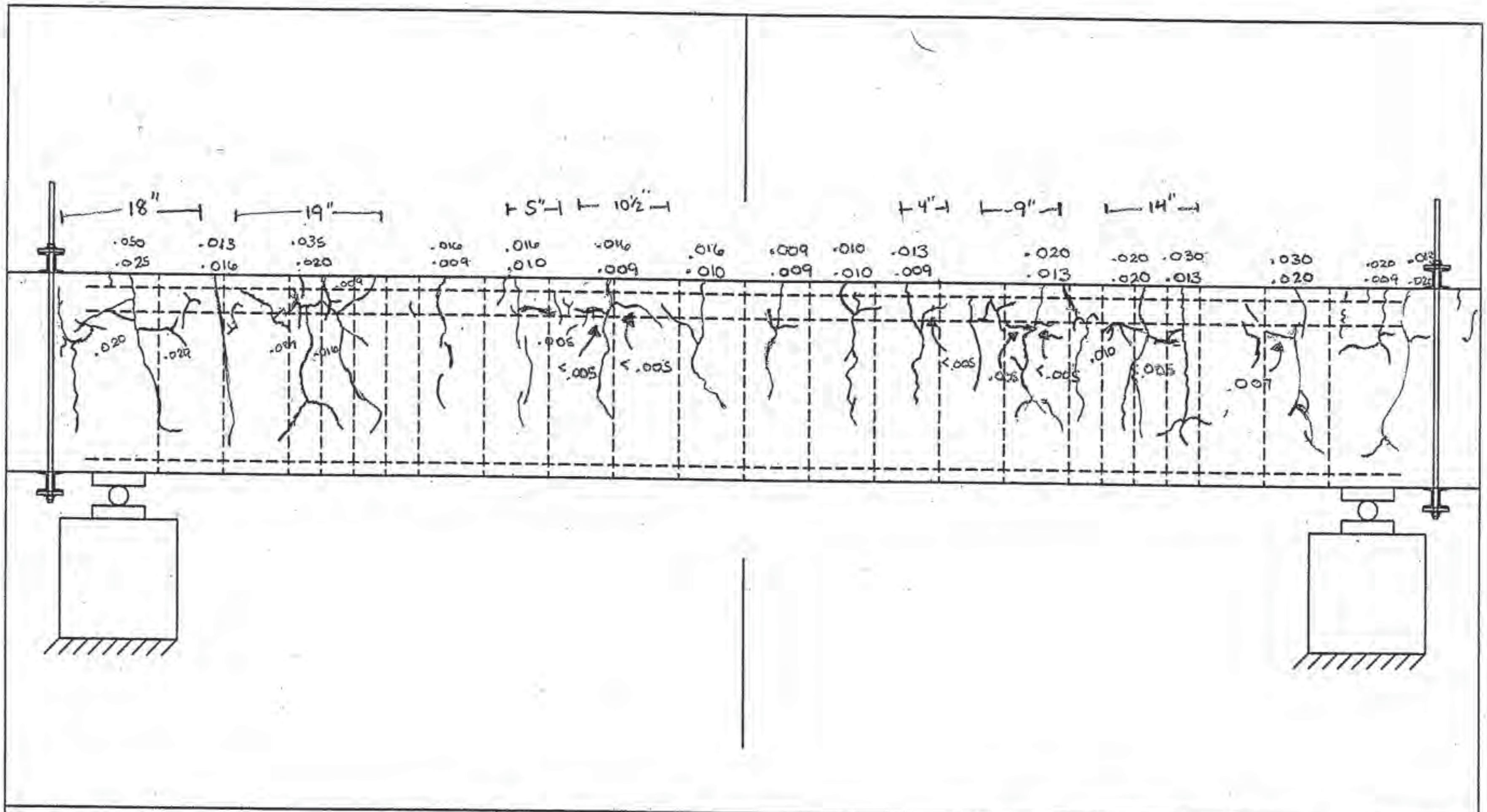


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-3	**Sheet:**	1	**of**	1
	Average Load: 18 KIPS	**Drawn by:**	MDN	**Checked by:**	
	Average Deflection:	**Date:**	5-30-12		



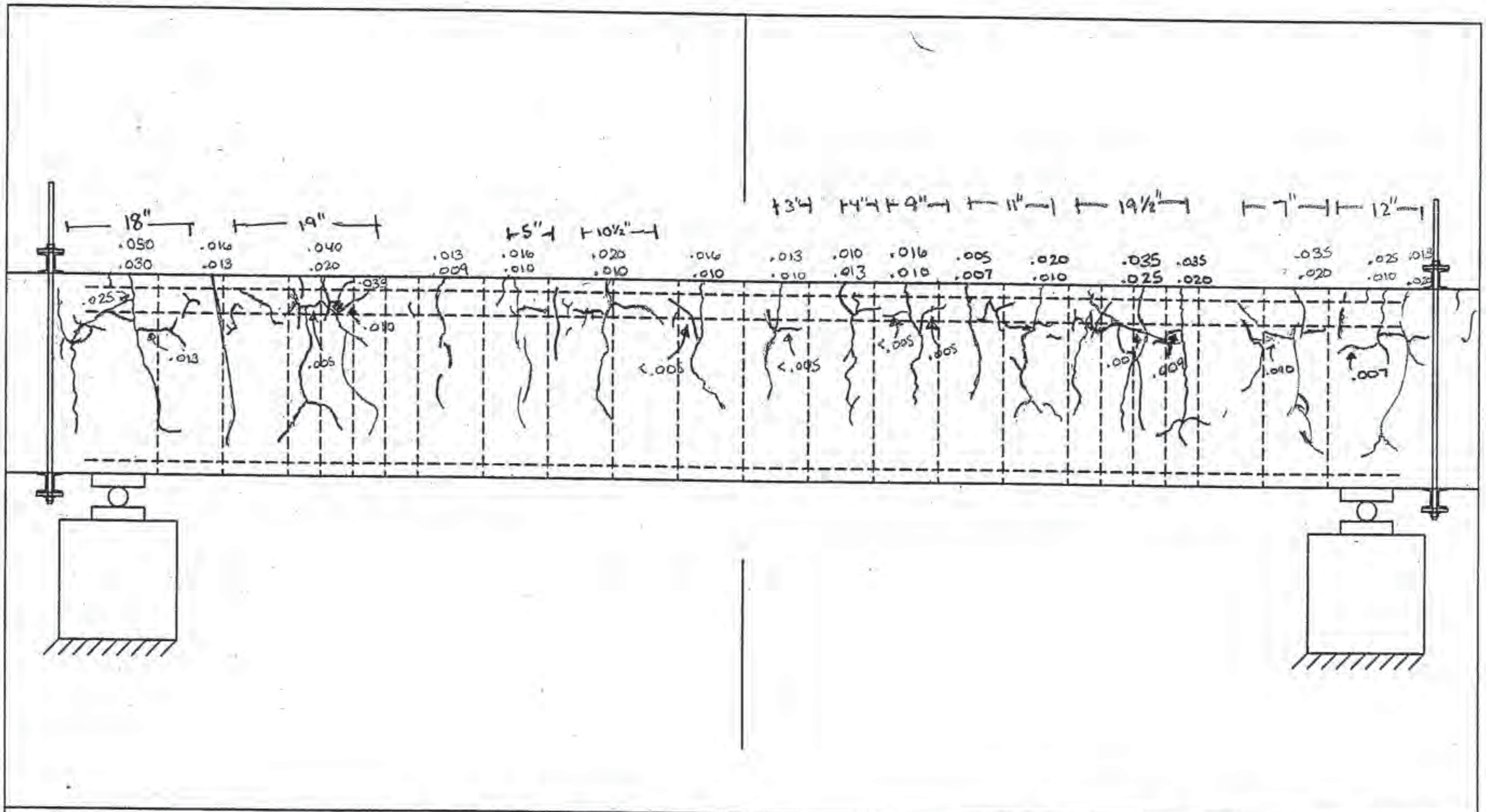
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-3	**Sheet:**	1	**of**	1
Average Load: 24 kips	**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 1.2"	**Date:**	5-30-12		

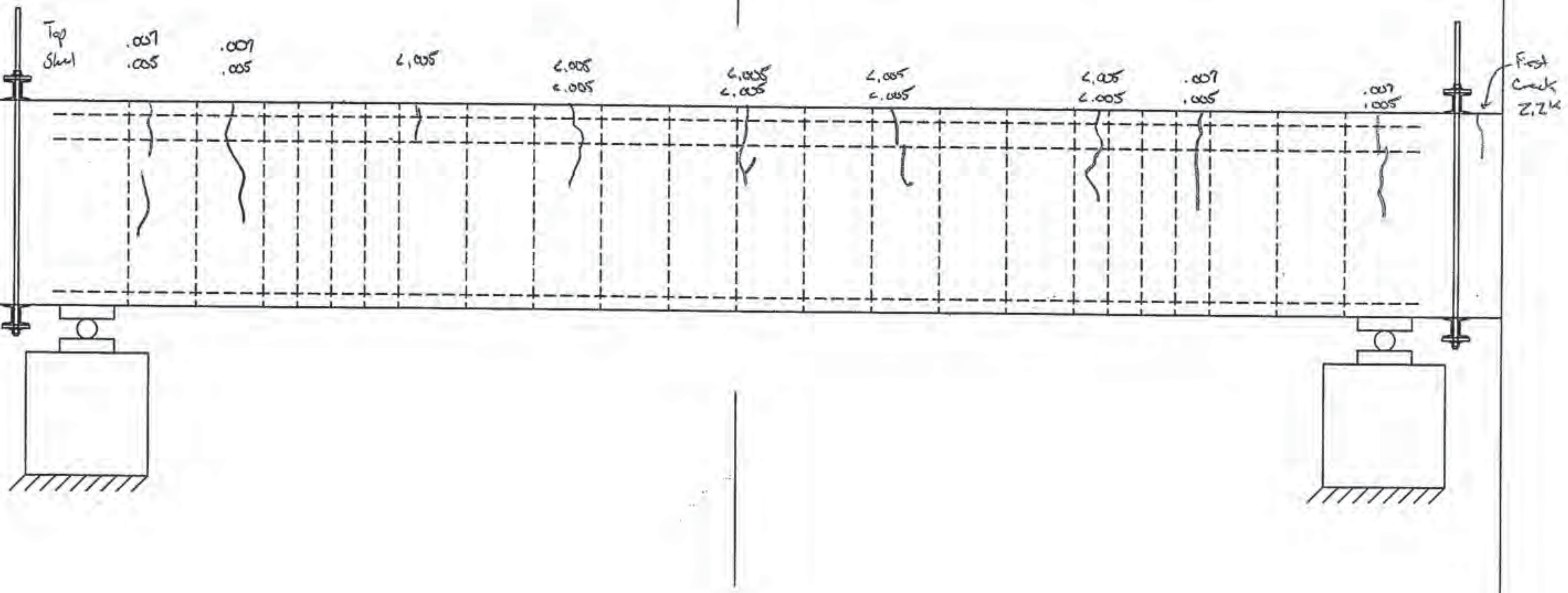


Specimen: A-3	**Sheet:**	1	of	1
Average Load: 30 KIPS	**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 1.6"	**Date:**	5-30-12		

BOWEN LABORATORY
PURDUE UNIVERSITY

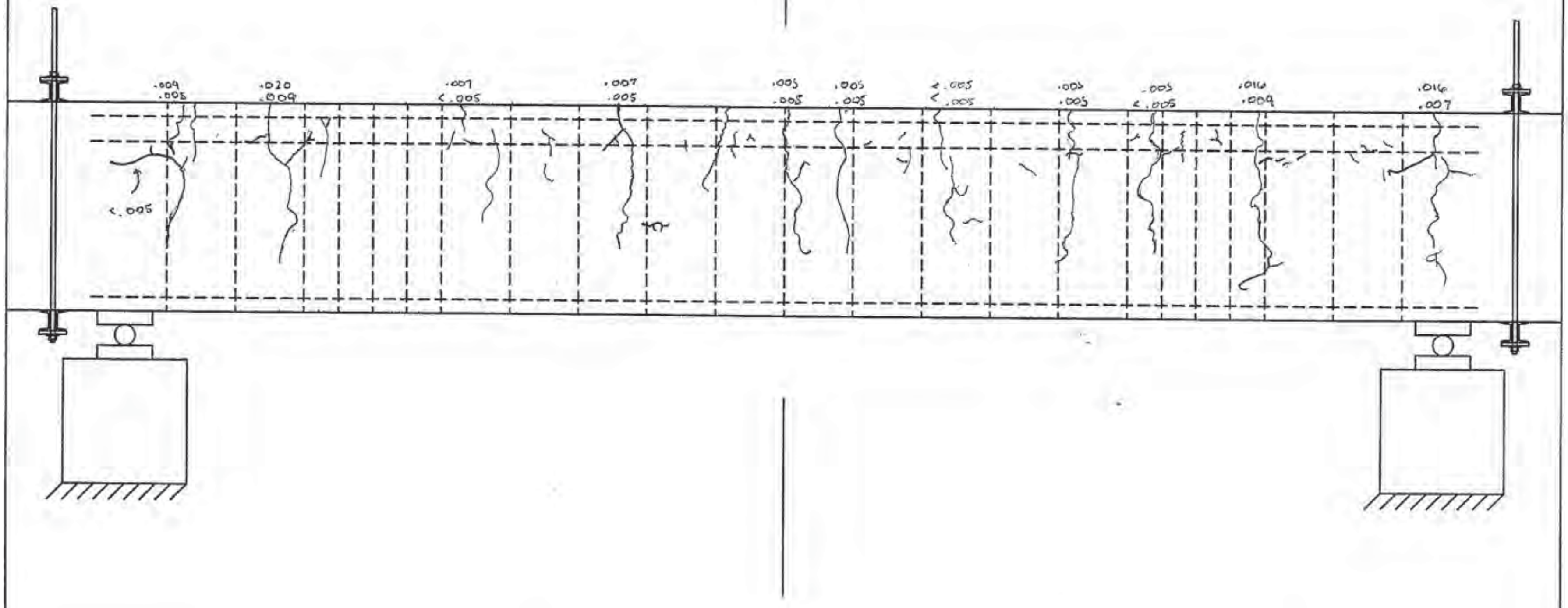


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-3	**Sheet:**	1	**of**	1
	Average Load: 36 kips	**Drawn by:**	MDN	**Checked by:**	
	Average Deflection: 1.95"	**Date:**	5-30-12		

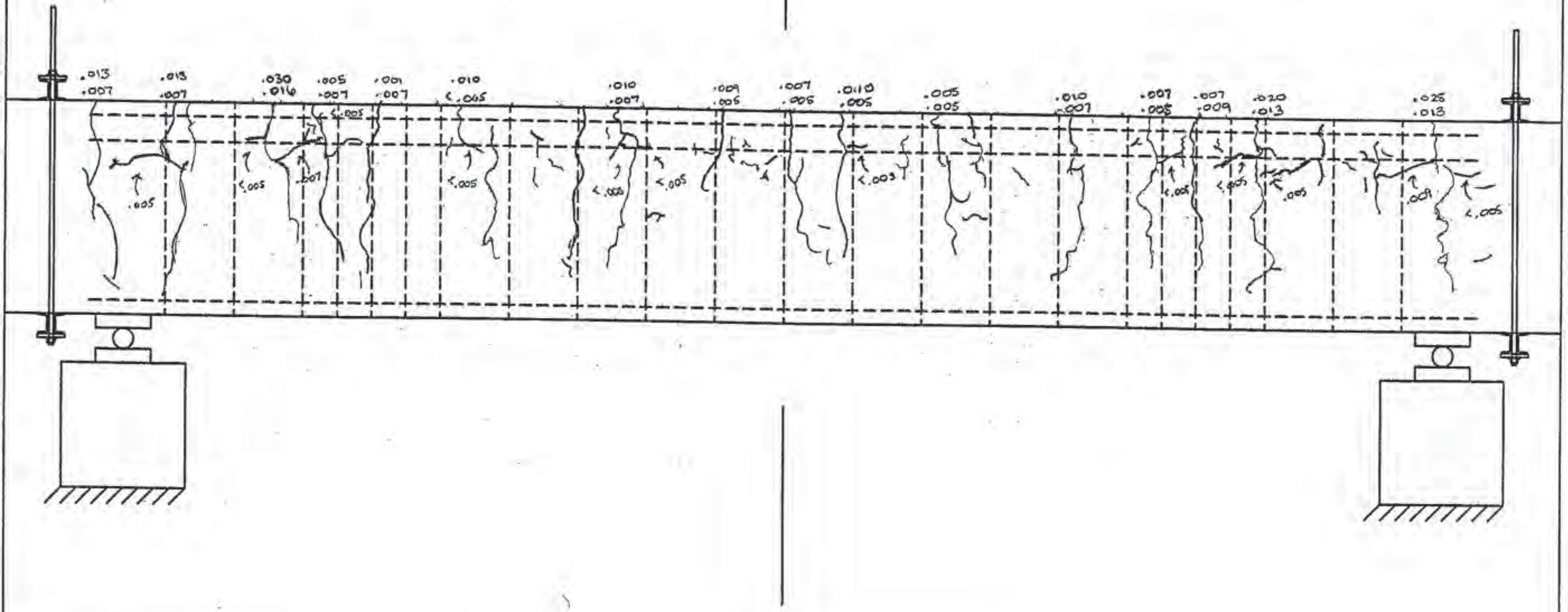


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	A-4	**Sheet:**	1	**of**	1
Average Load:	6^{K}	**Drawn by:**		**Checked by:**	
Average Deflection:	0.17"	**Date:**	6/8/12		

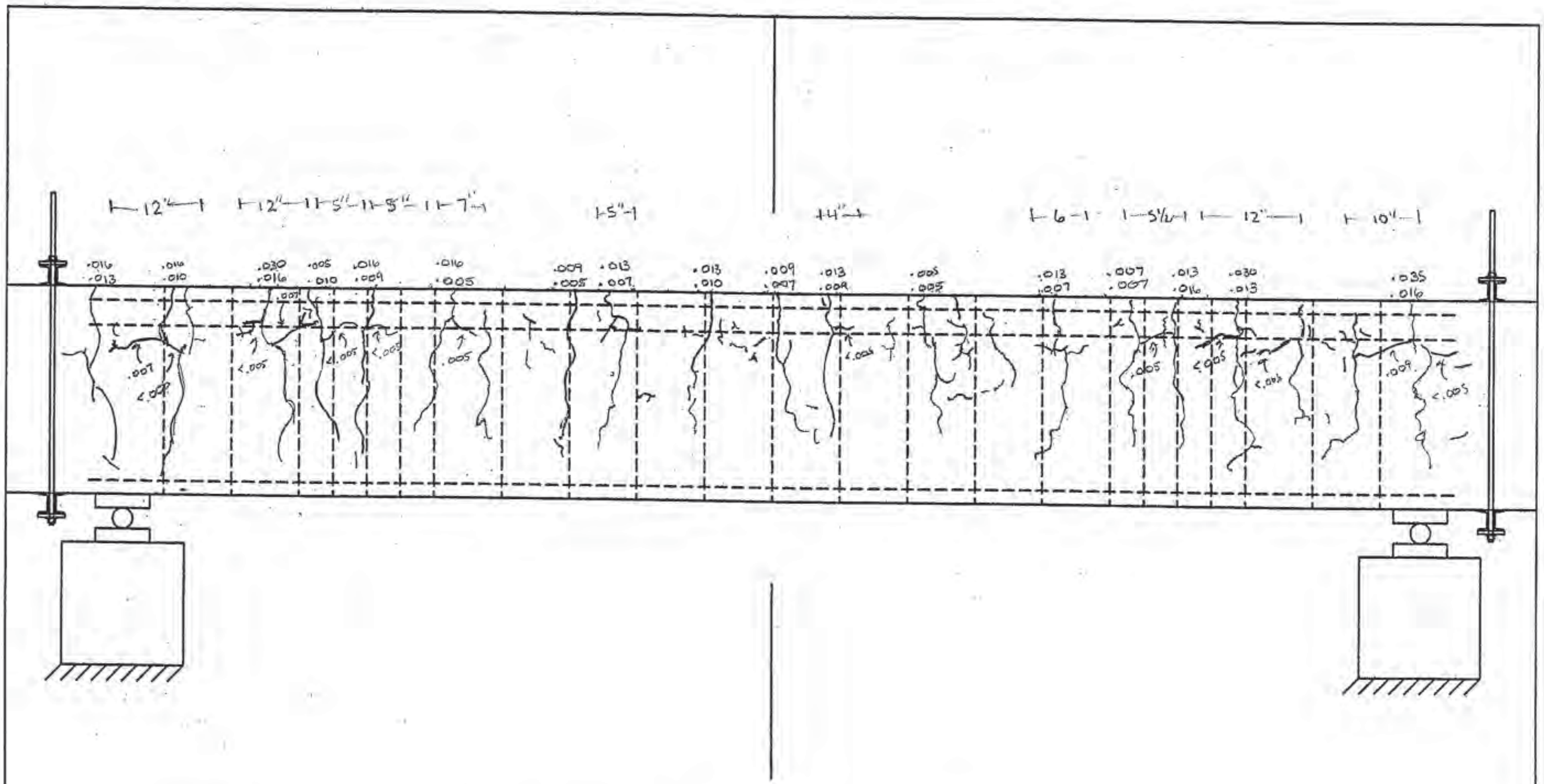


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-4	**Sheet:**	1	**of** 1
	Average Load: 12 K	**Drawn by:**		**Checked by:**
	Average Deflection:	**Date:**	6-8-12	



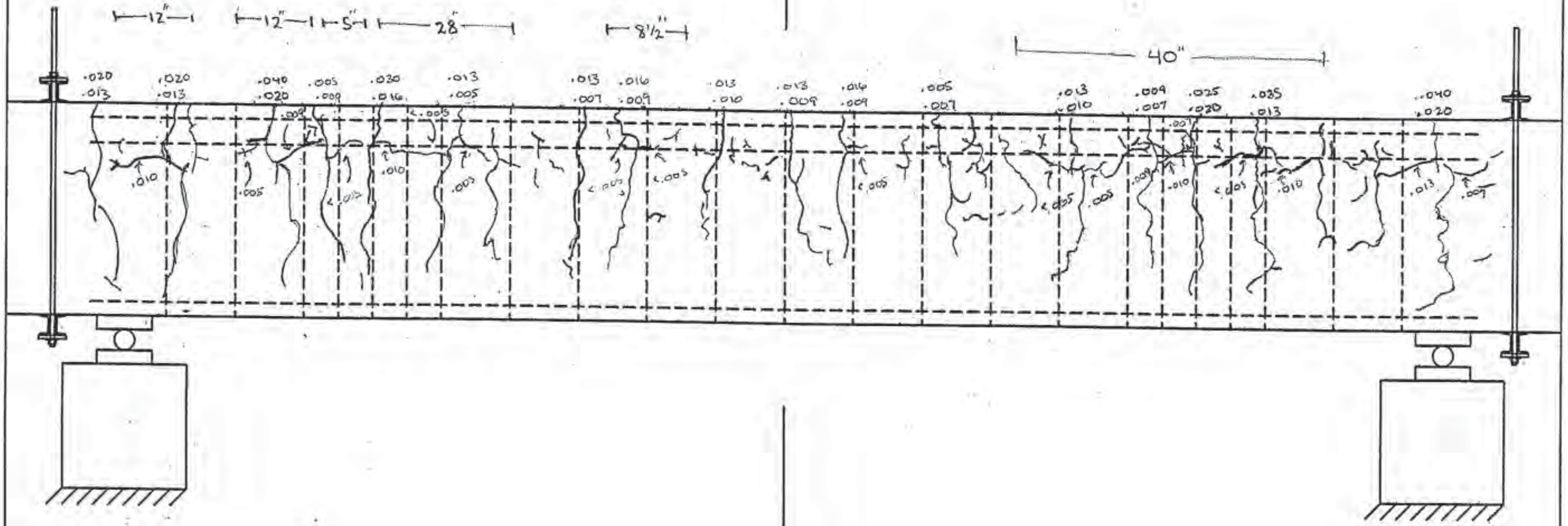
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	A - 4	**Sheet:**	1	**of**	1
Average Load:	18 K	**Drawn by:**		**Checked by:**	
Average Deflection:		**Date:**	6 - 8 - 12		



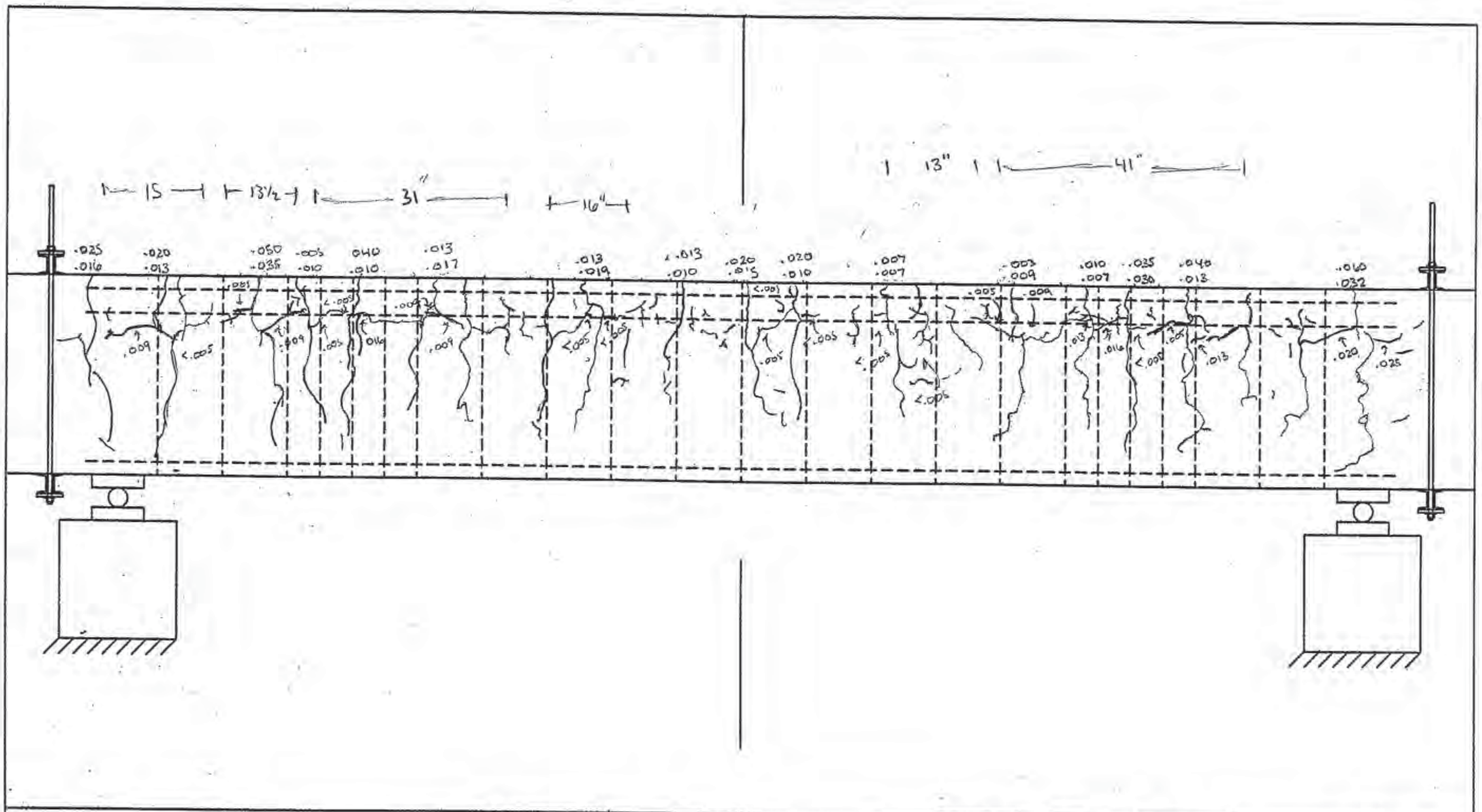
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-4	**Sheet:**	1	of	1
Average Load: 24 K	**Drawn by:**		**Checked by:**	
Average Deflection:	**Date:**	6/8/12		



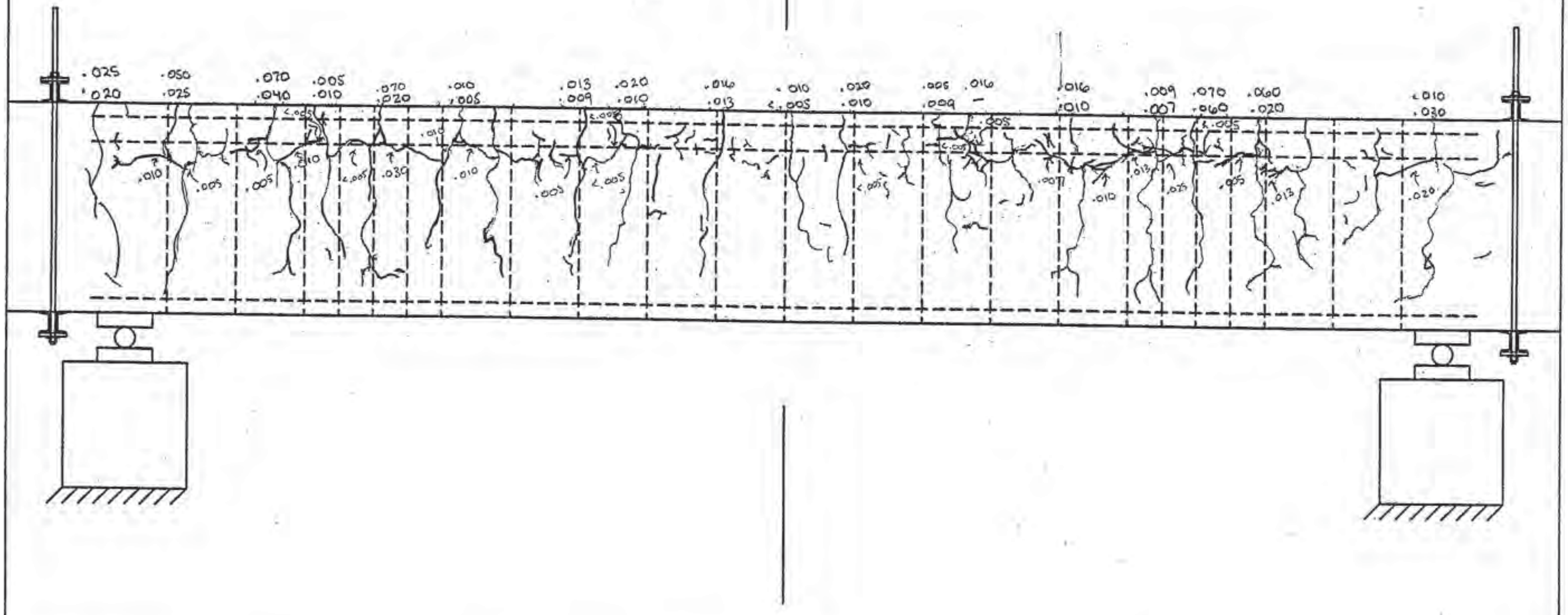
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	A-4	**Sheet:**	1	**of**	1
Average Load:	30k	**Drawn by:**		**Checked by:**	
Average Deflection:	1.71"	**Date:**	6/8/12		

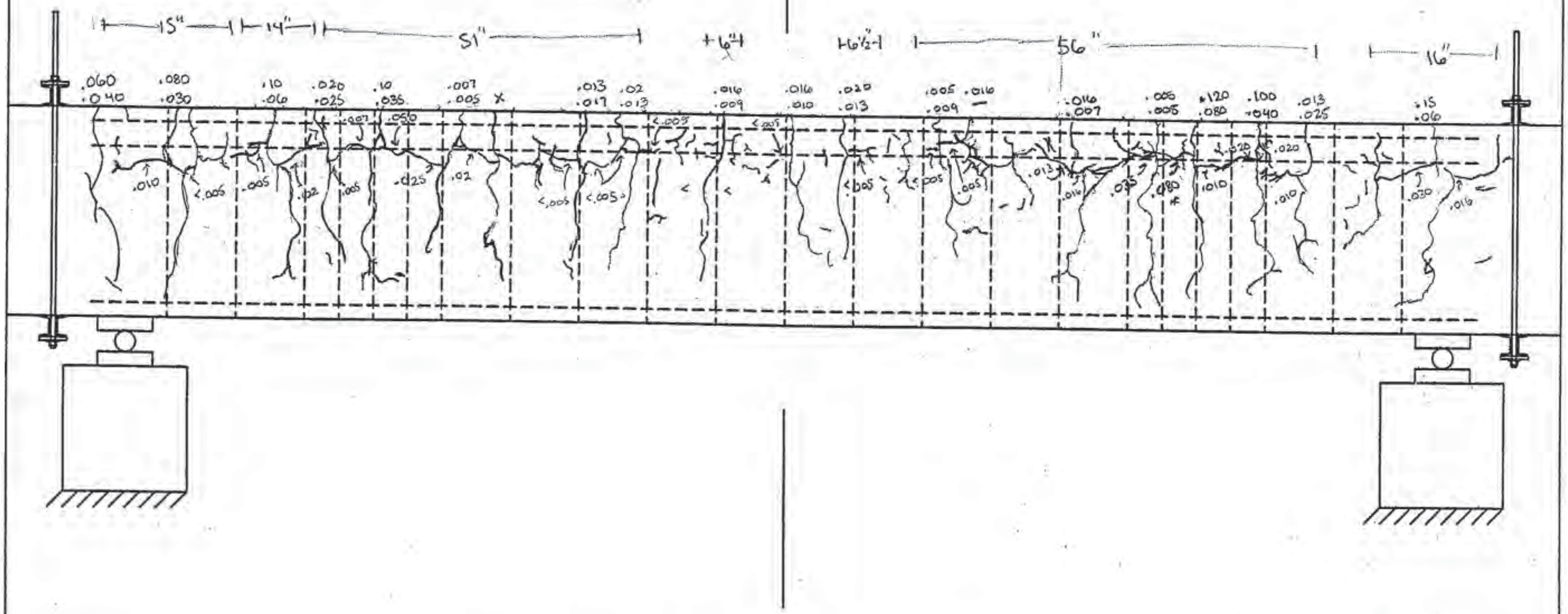


Specimen:	Sheet:	1	of	1
Average Load: 36 k	Drawn by:		Checked by:	
Average Deflection:	Date:			

BOWEN LABORATORY
PURDUE UNIVERSITY



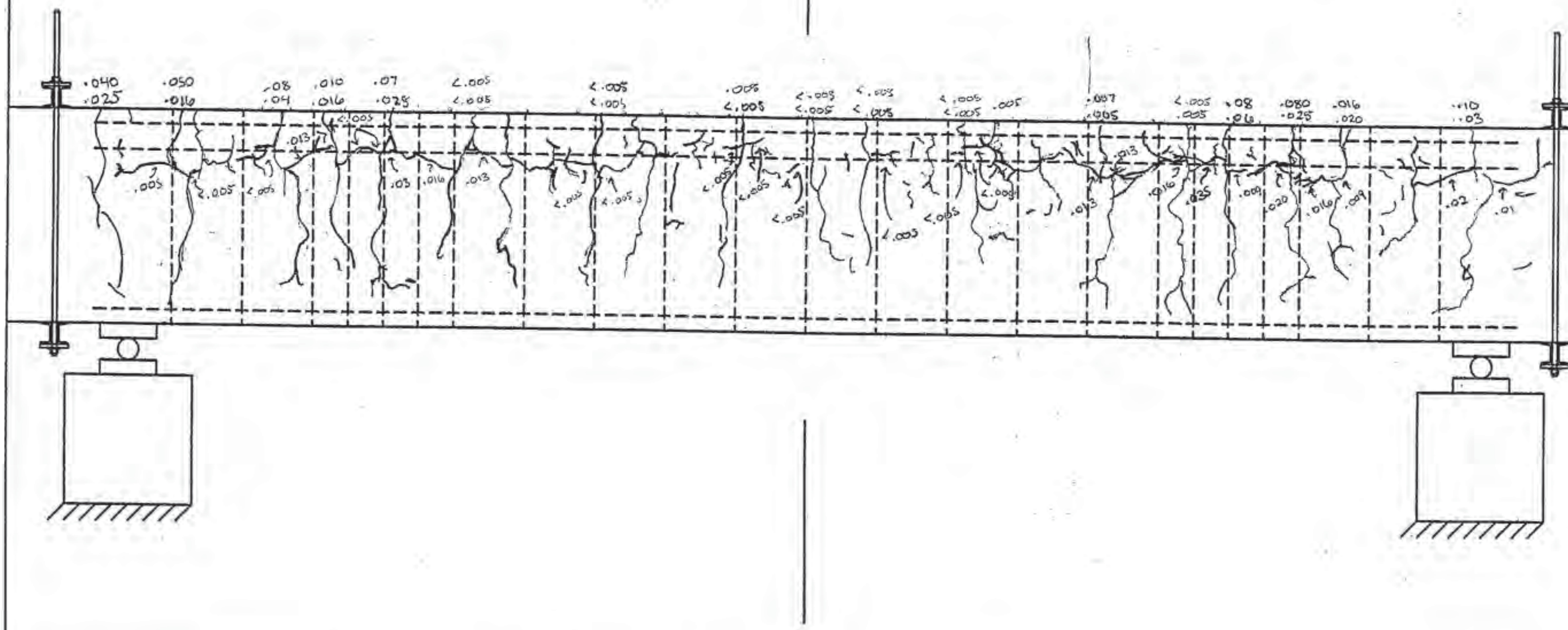
BOWEN LABORATORY **PURDUE UNIVERSITY**	**Specimen:**	**Sheet:**	1	**of**	1
	Average Load: 38 k (YIELD)	**Drawn by:**		**Checked by:**	
	Average Deflection: 2.7"	**Date:**			



*AT LARGEST POINT

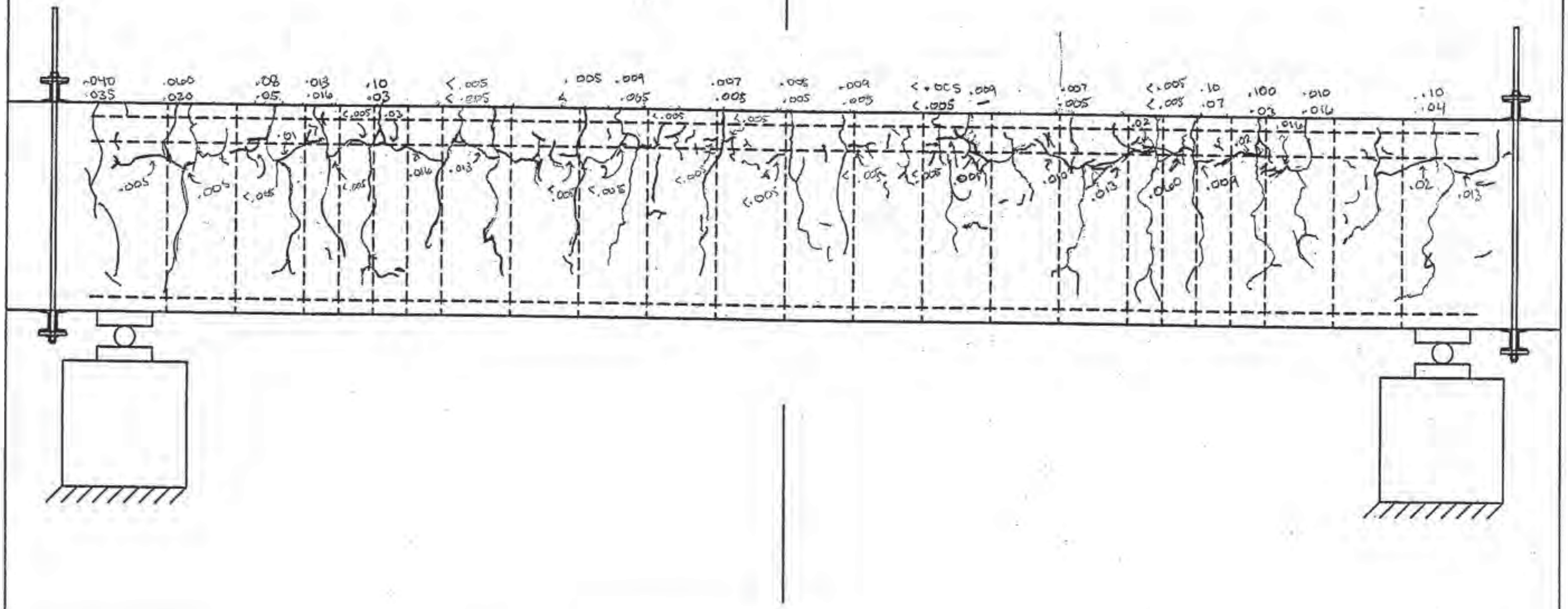
Specimen: A-4	**Sheet:**	1	**of**	1
Average Load: 40k	**Drawn by:**		**Checked by:**	
Average Deflection: 4"	**Date:**	6-8-12		

BOWEN LABORATORY
PURDUE UNIVERSITY



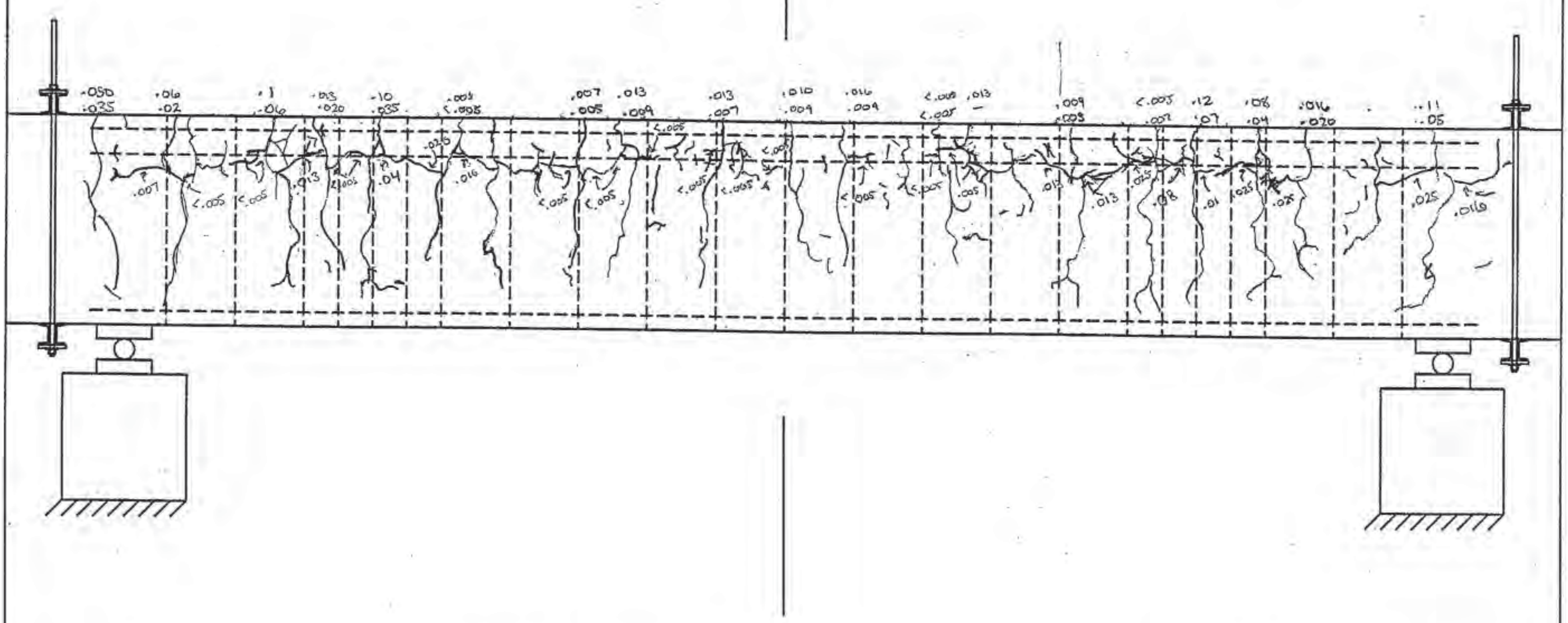
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:		**Sheet:** 1	**of** 1
Average Load: Ok		**Drawn by:**	**Checked by:**
Average Deflection:		**Date:**	



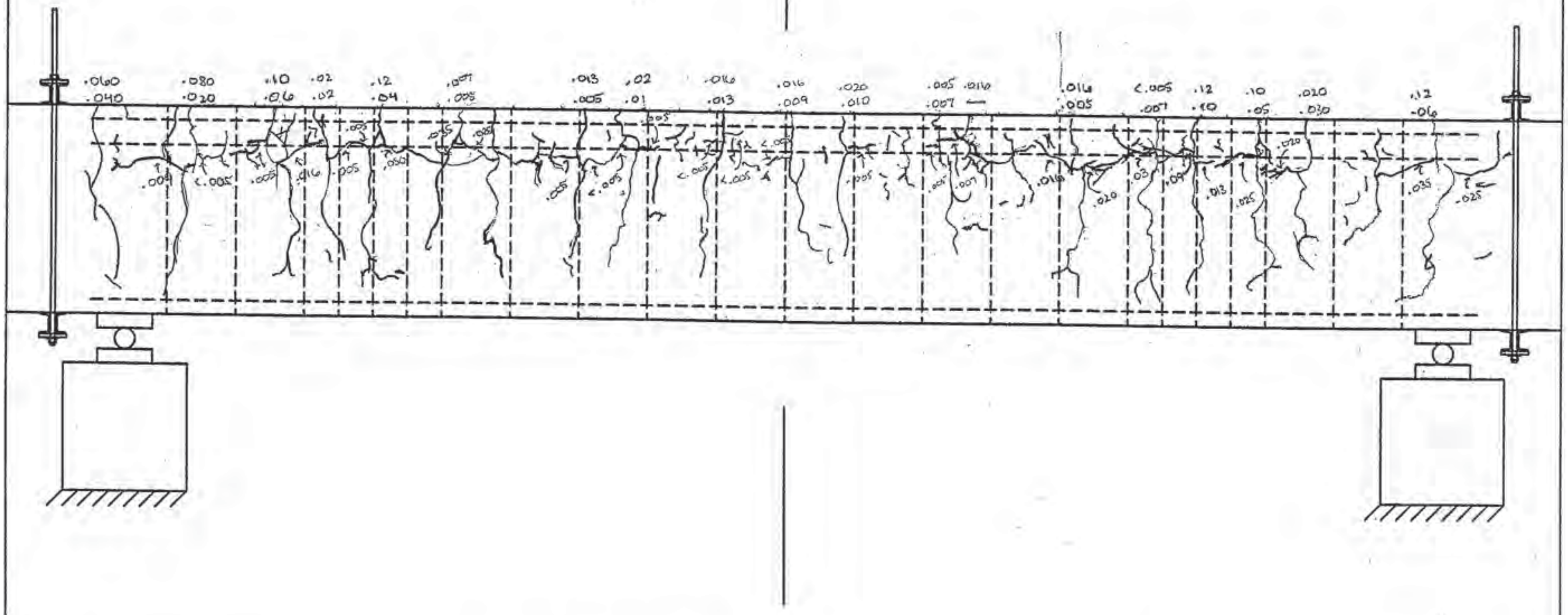
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-4	**Sheet:**	1	**of**	1
Average Load: 12 k (RELOADED)	**Drawn by:**		**Checked by:**	
Average Deflection:	**Date:**			



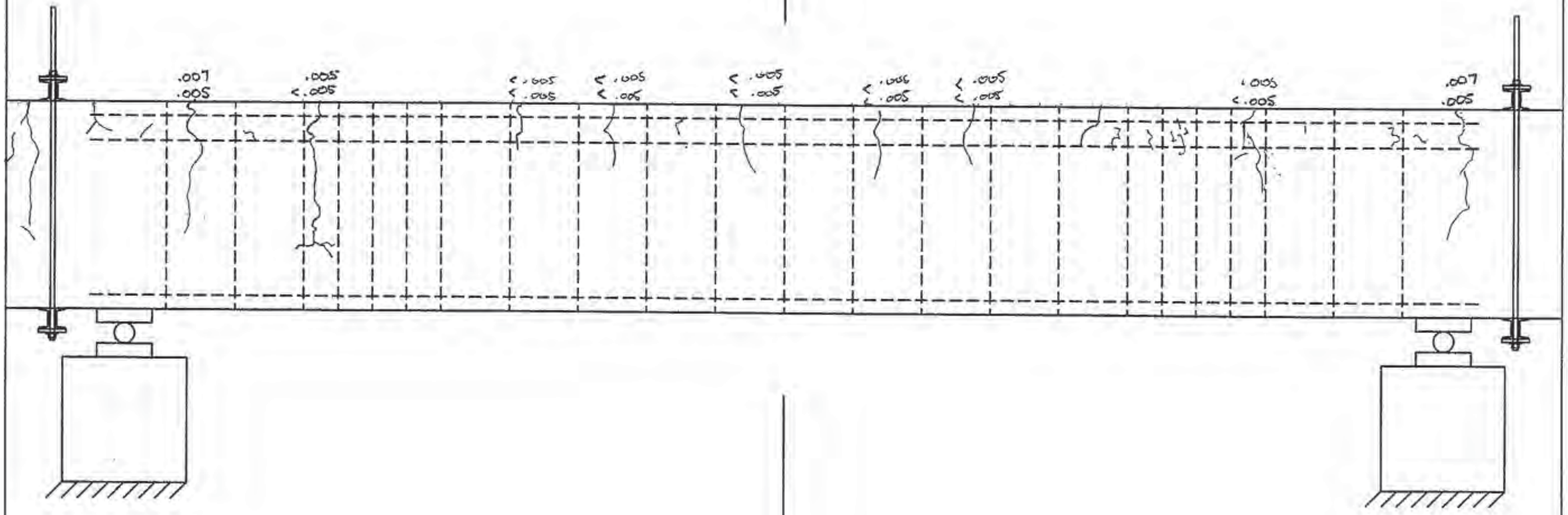
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:		**Sheet:**	1	**of** 1
Average Load: 24 K (RELOADED)		**Drawn by:**		**Checked by:**
Average Deflection:		**Date:**		

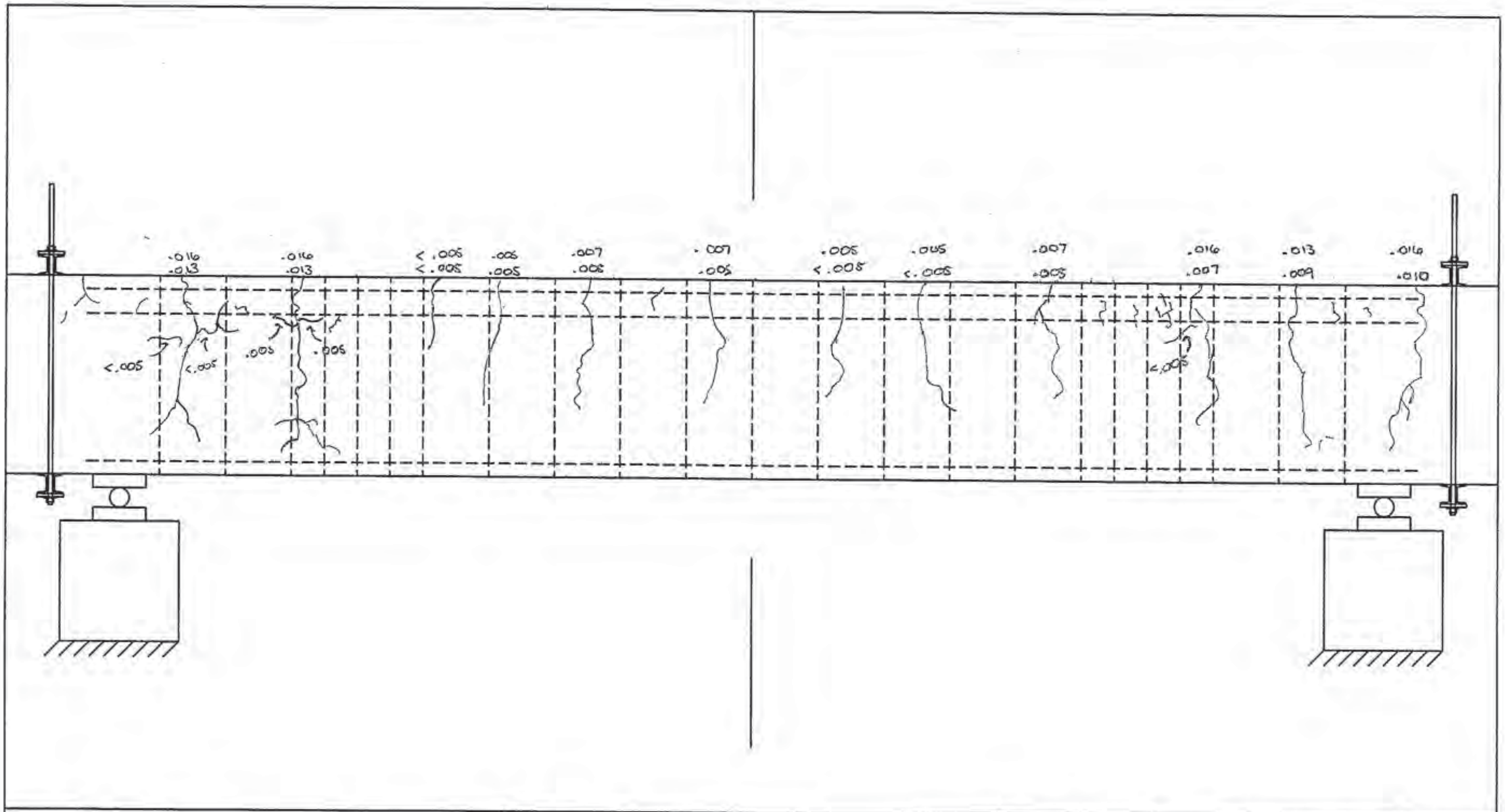


BOWEN LABORATORY
PURDUE UNIVERSITY

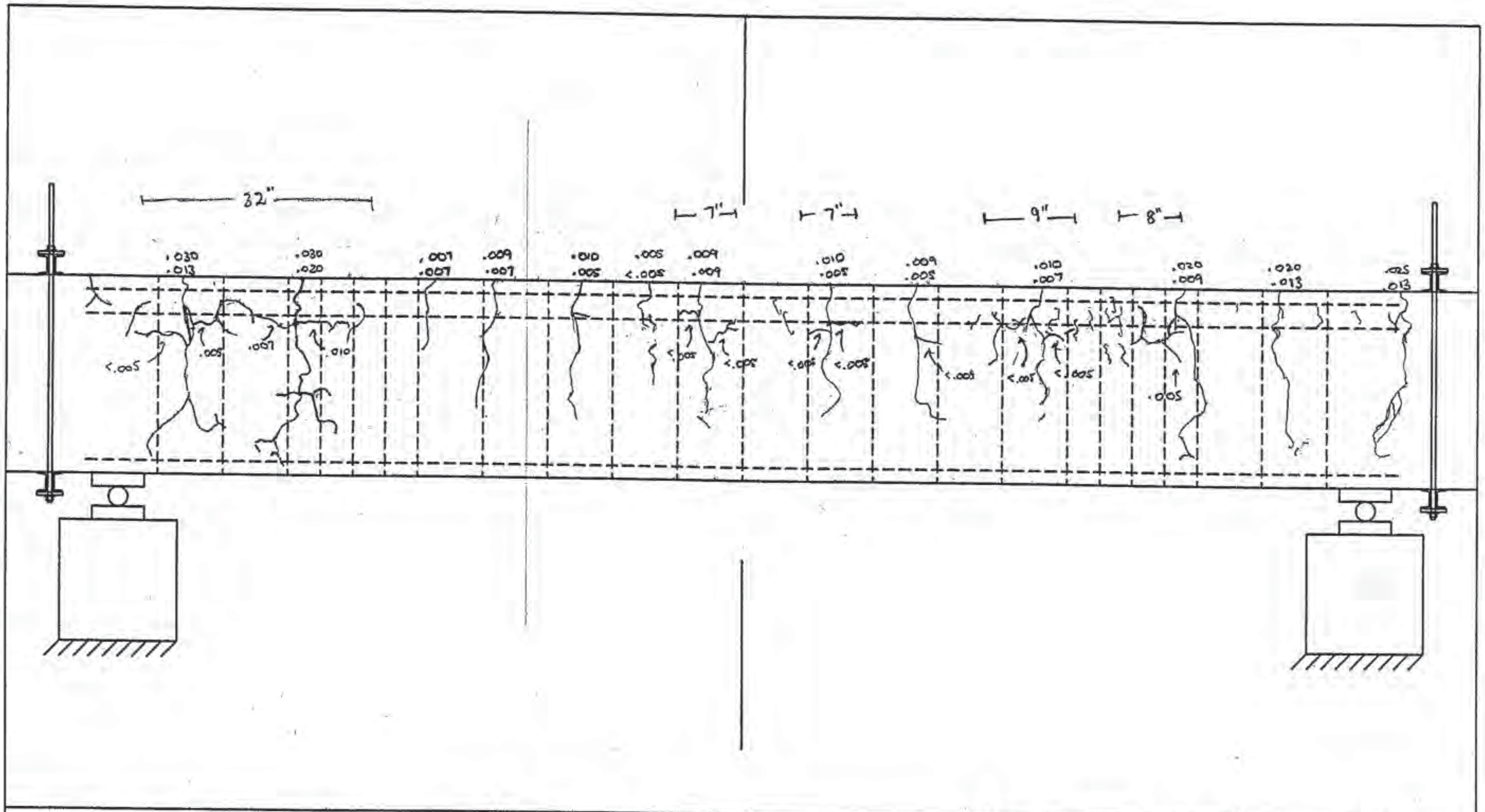
Specimen: A-4
Average Load: 36k (RELOADED)
Average Deflection:
Sheet: 1 **of** 1
Drawn by:
Checked by:
Date:



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-5	**Sheet:**	1	**of**	1
	Average Load: 6K	**Drawn by:**		**Checked by:**	
	Average Deflection: 0.16"	**Date:**	6/7/12		

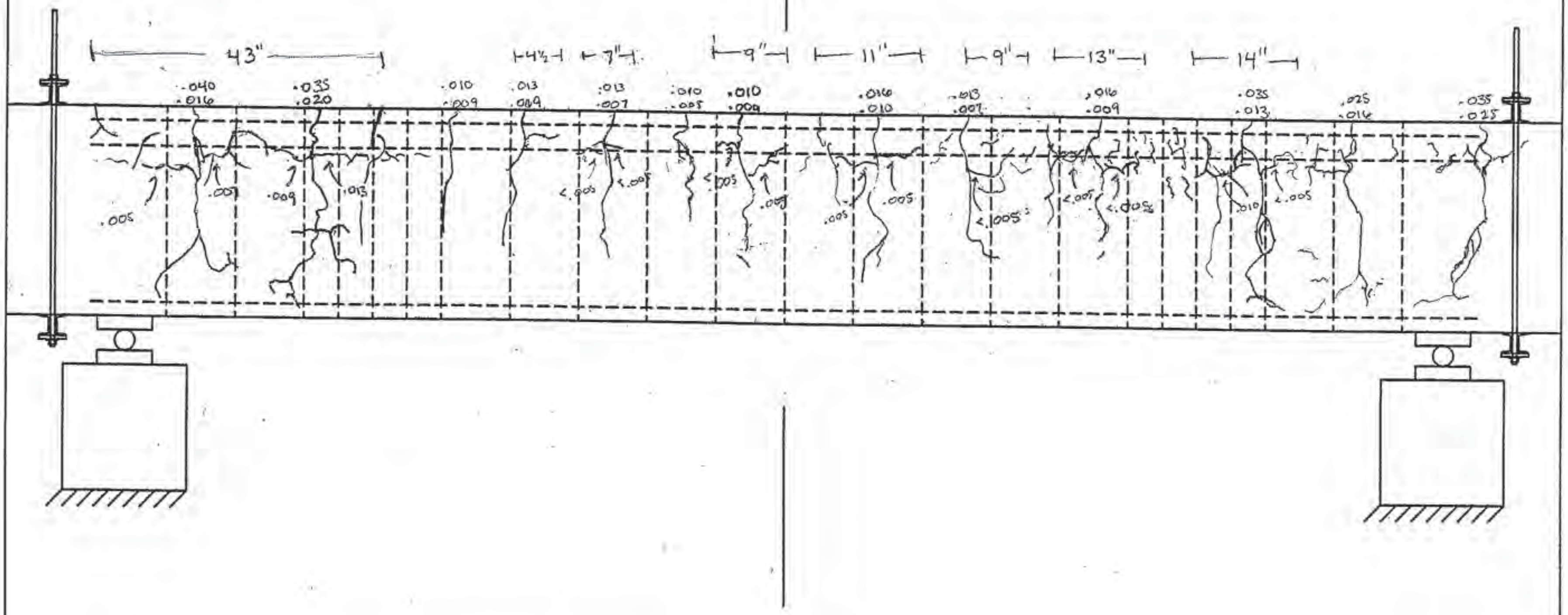


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-5	**Sheet:**	1	**of** 1
	Average Load: 12 K	**Drawn by:**		**Checked by:**
	Average Deflection: 0.49"	**Date:**		

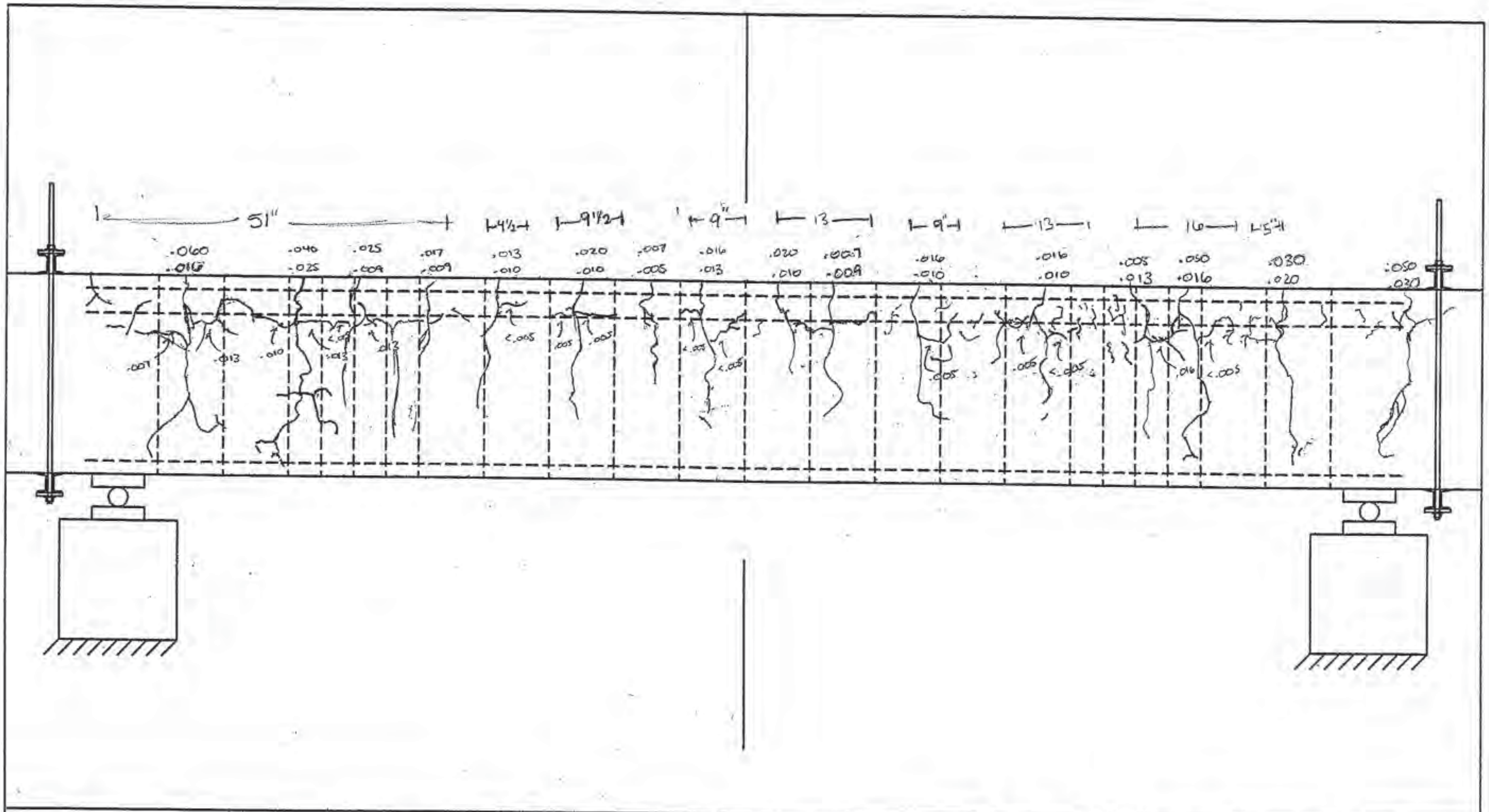


BOWEN LABORATORY
PURDUE UNIVERSITY

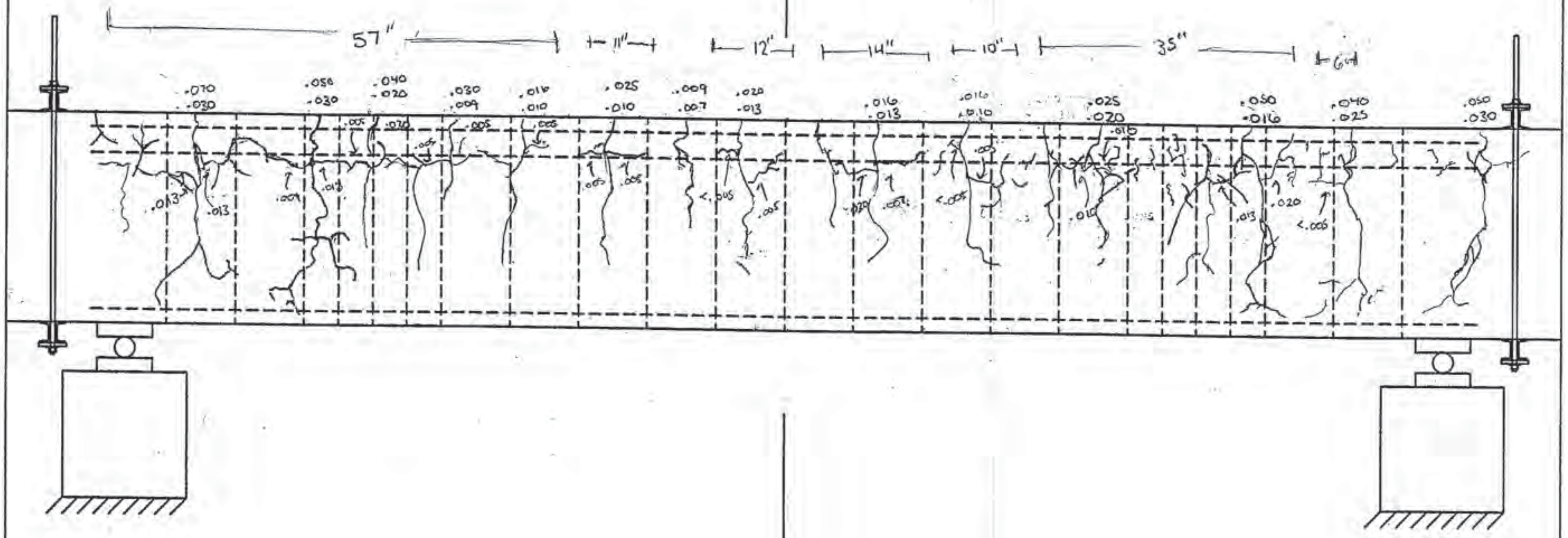
Specimen:		**Sheet:**	1	**of**	1
Average Load:	18 k	**Drawn by:**		**Checked by:**	
Average Deflection:		**Date:**			



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:**	**Sheet:**	1	**of**	1
	Average Load: ~~18K~~ 24 K	**Drawn by:**		**Checked by:**	
	Average Deflection:	**Date:**			

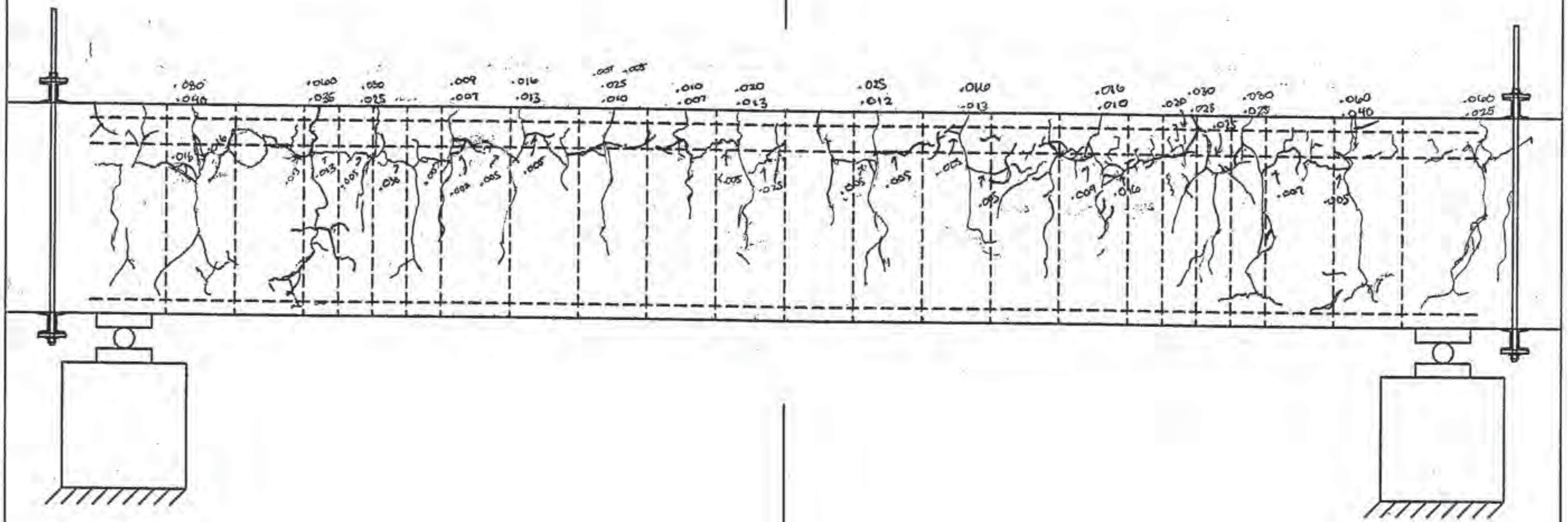


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:**	**Sheet:**	1	**of**	1
	Average Load: 30K	**Drawn by:**		**Checked by:**	
	Average Deflection:	**Date:**			



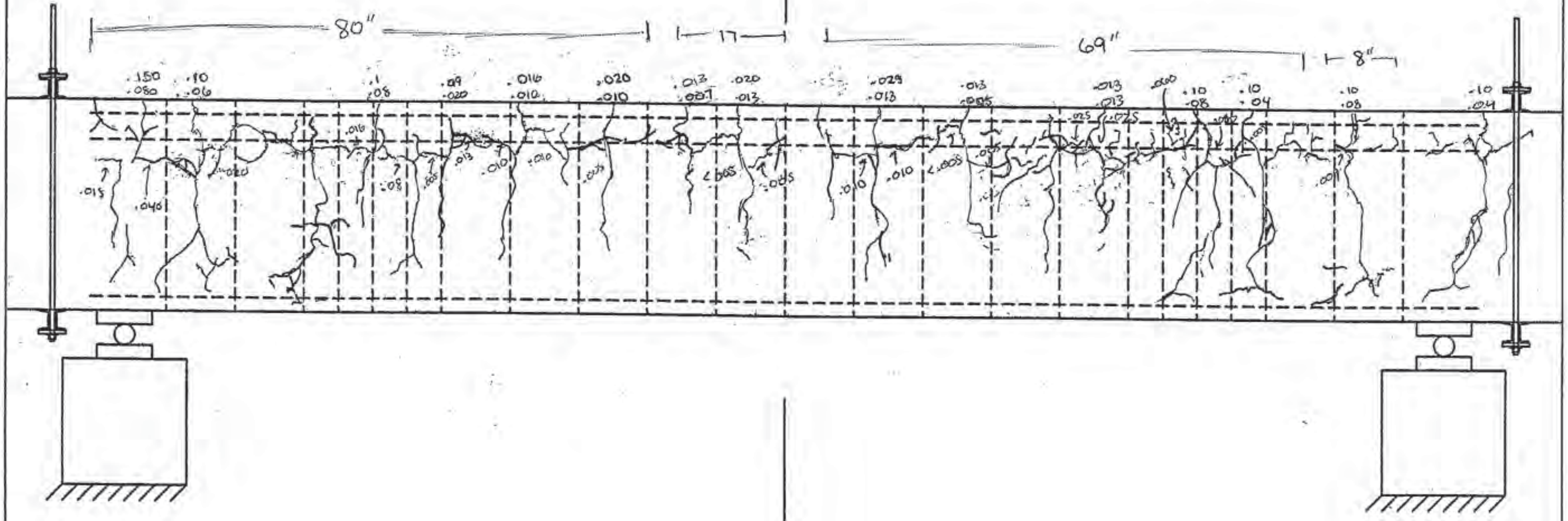
Specimen: A-S		**Sheet:**	1	**of**	1
Average Load: 36 K		**Drawn by:**		**Checked by:**	
Average Deflection:		**Date:**			

BOWEN LABORATORY
PURDUE UNIVERSITY

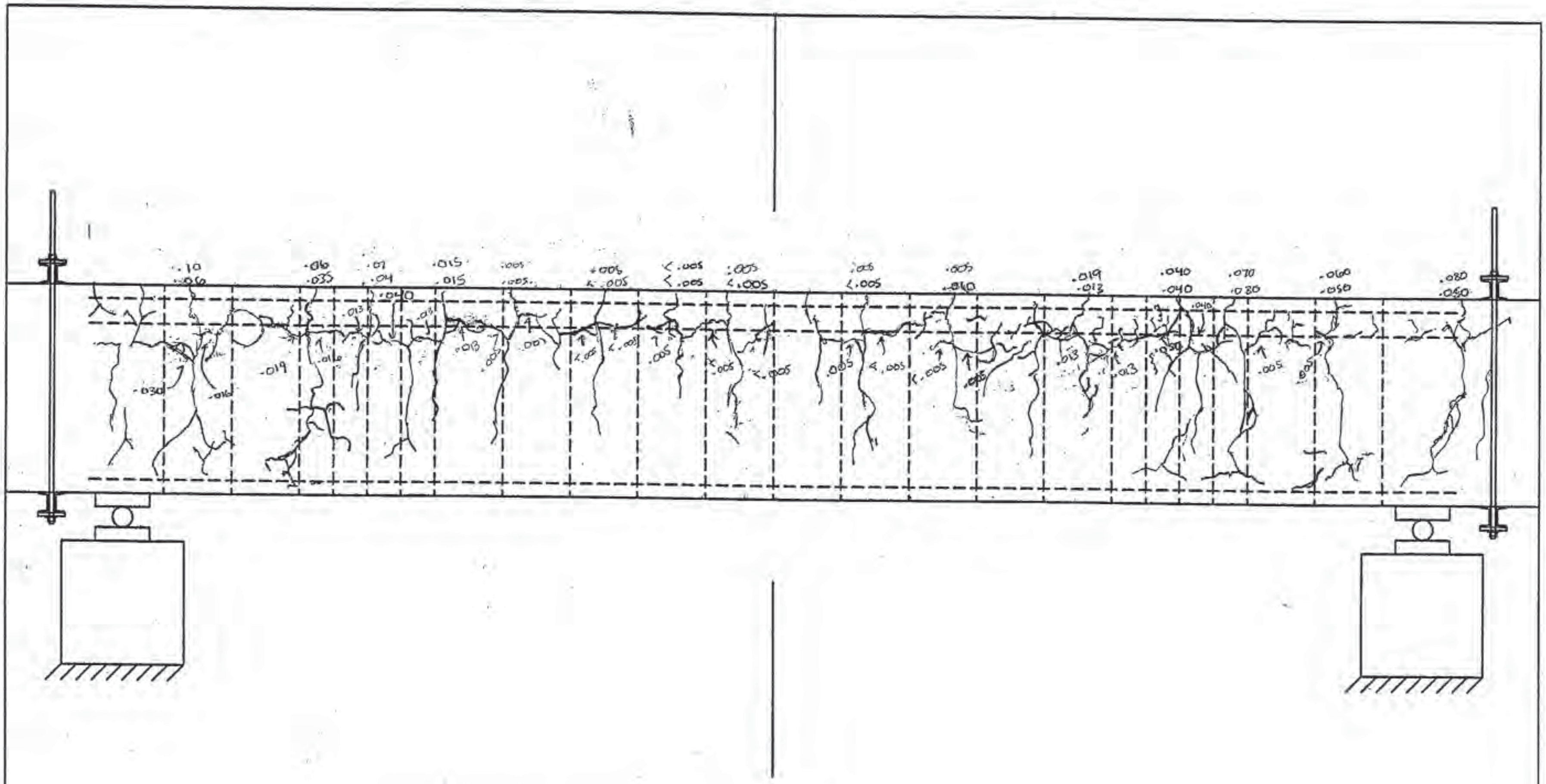


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:		**Sheet:**	1	**of**	1
Average Load:	38k(YIELD)	**Drawn by:**		**Checked by:**	
Average Deflection:		**Date:**			

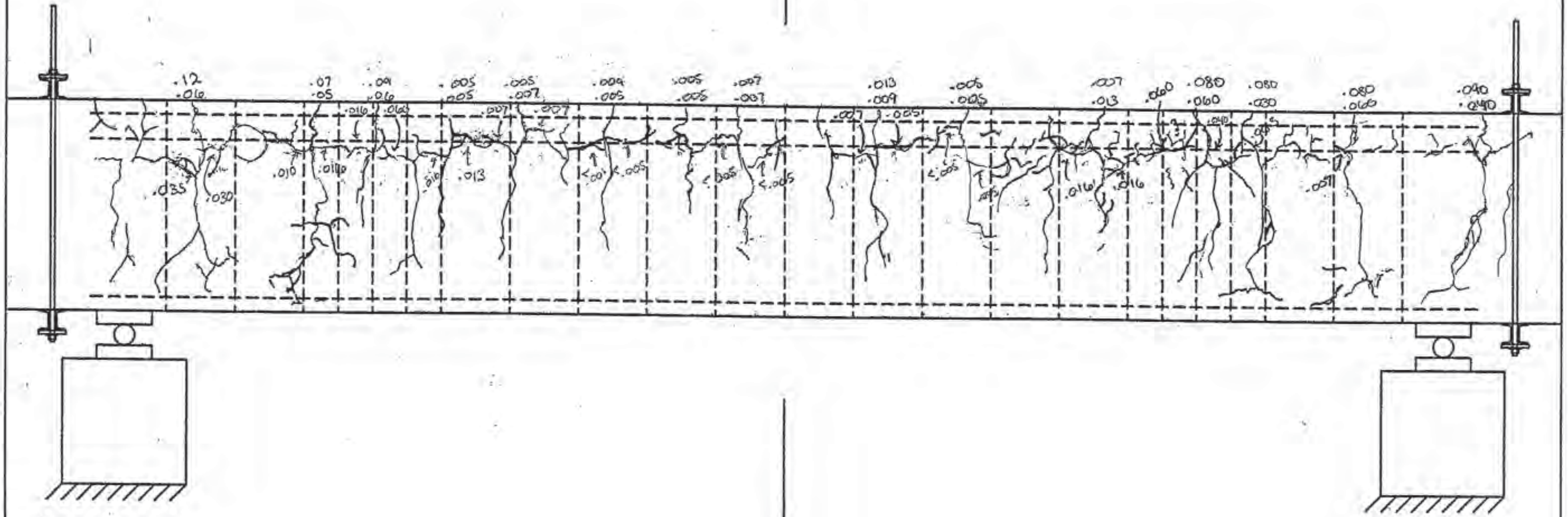


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-5	**Sheet:**	1	of	1
	Average Load: 40k	**Drawn by:**		**Checked by:**	
	Average Deflection: 4.0"	**Date:**	6/7/12		



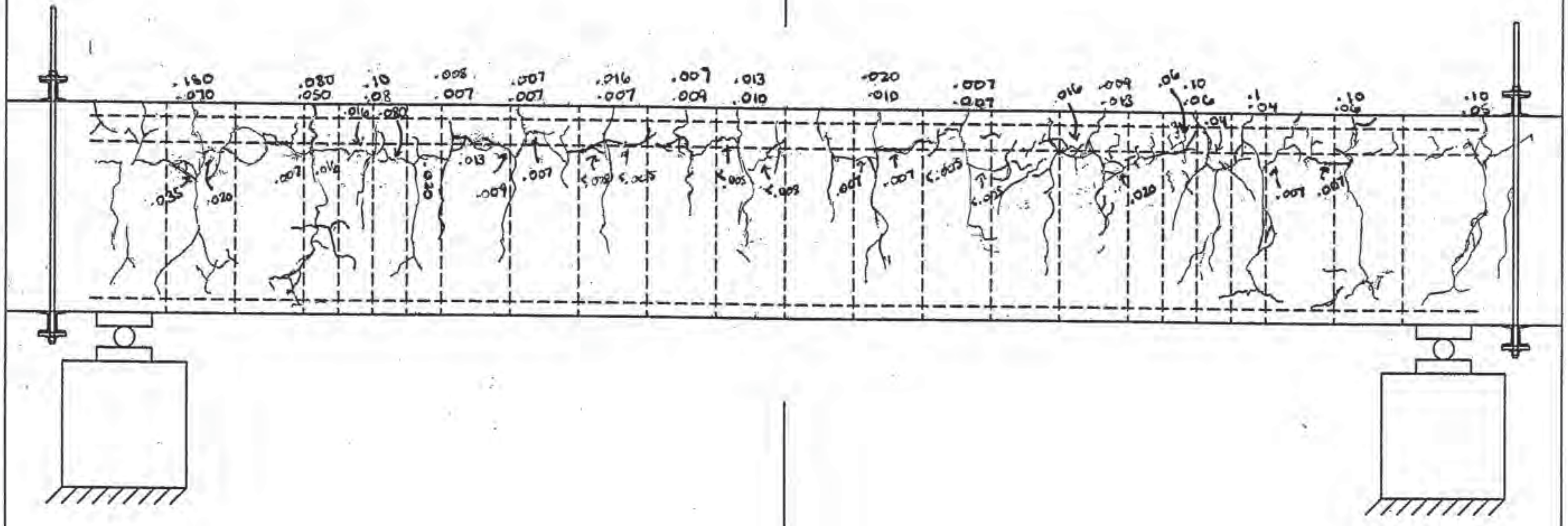
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-S	**Sheet:**	1	**of**	1
Average Load: 0 kips	**Drawn by:**		**Checked by:**	
Average Deflection: 2.0"	**Date:**	6/7/12		



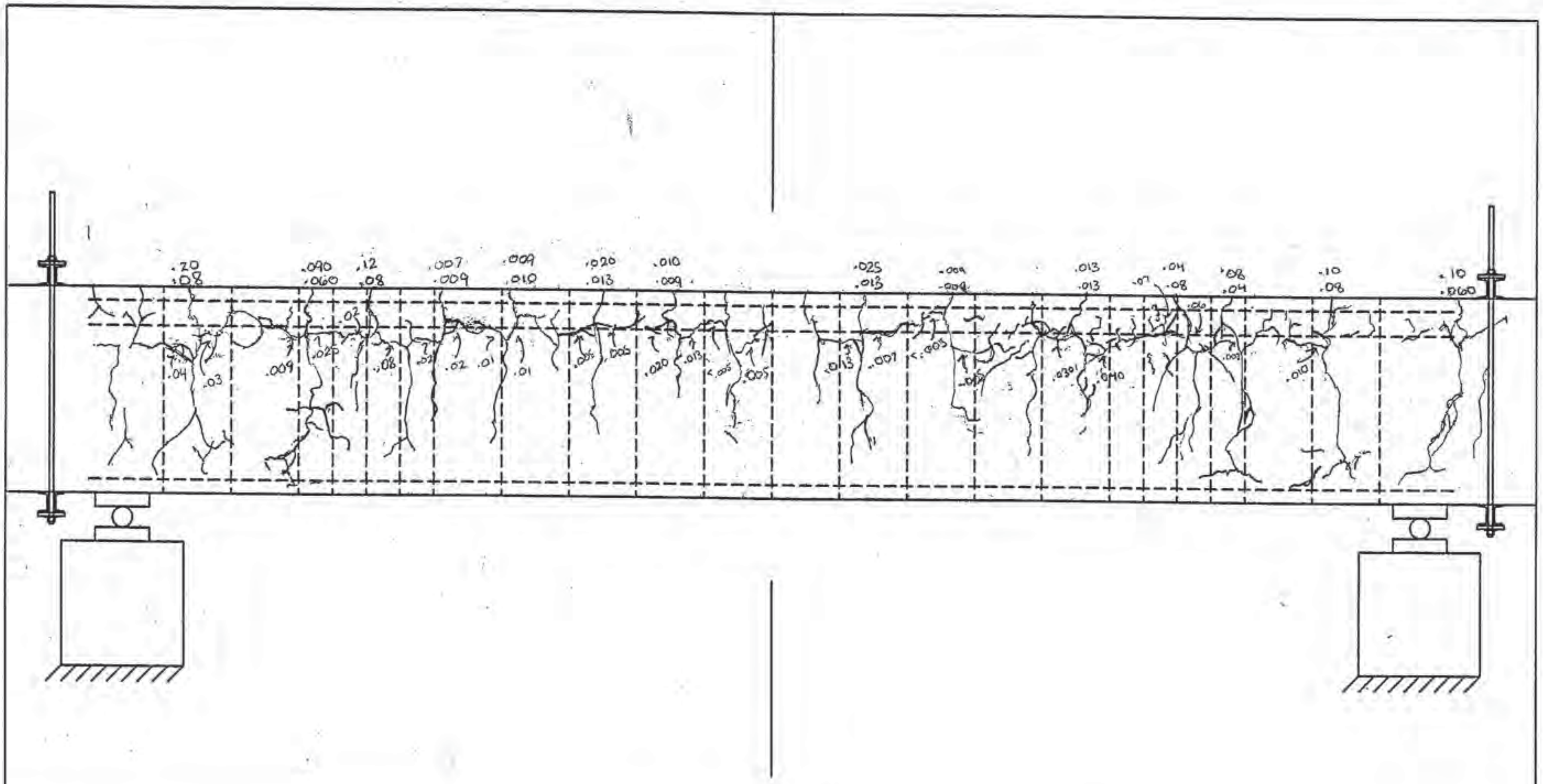
Specimen: A-S	**Sheet:**	1	of	1
Average Load: 12k (RELOADED)	**Drawn by:**		**Checked by:**	
Average Deflection: 2.57"	**Date:**	6/7/12		

BOWEN LABORATORY
PURDUE UNIVERSITY

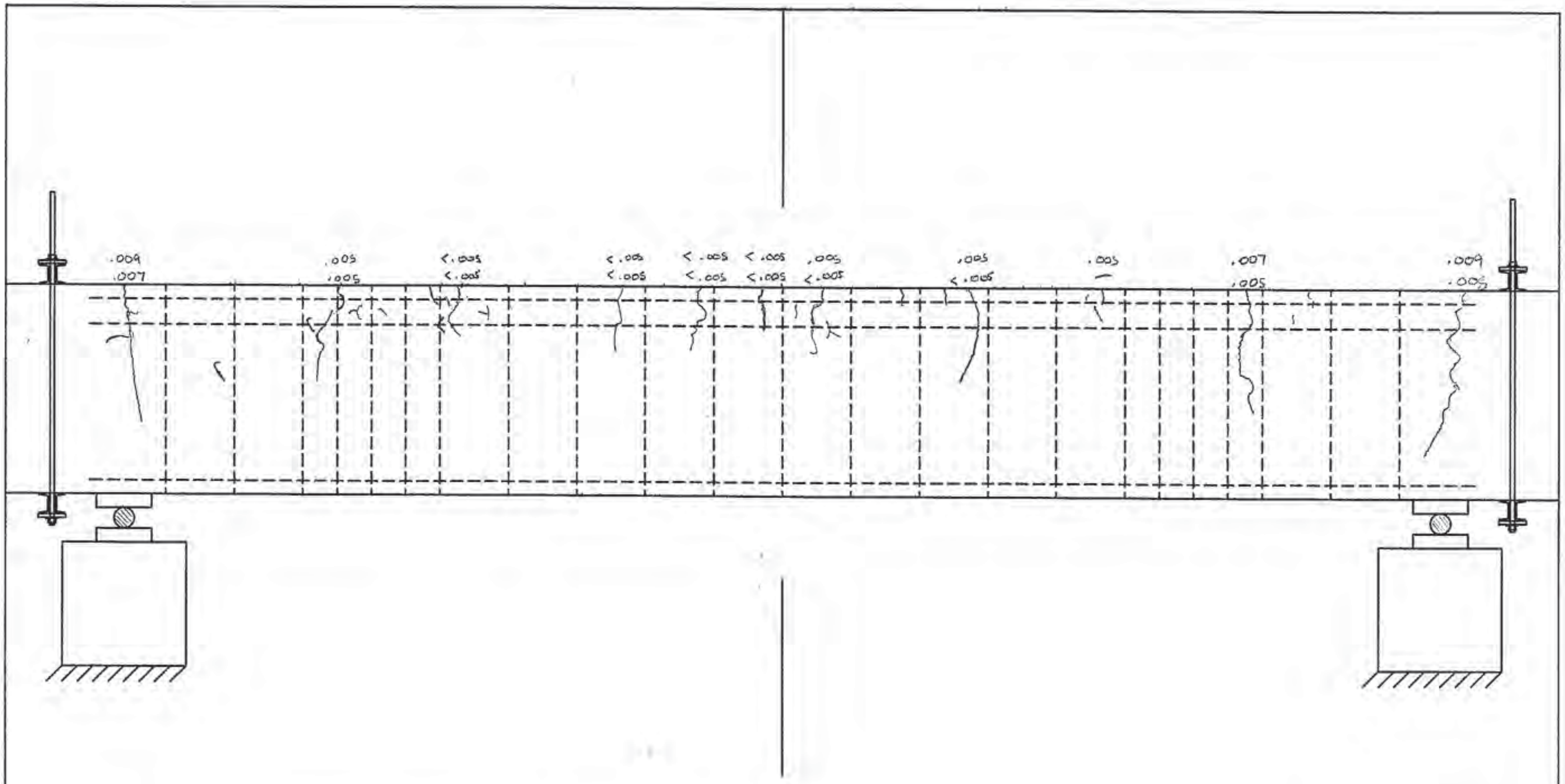


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-S	**Sheet:**	1	**of**	1
Average Load: 24 k (RELOADED)	**Drawn by:**		**Checked by:**	
Average Deflection: 3.22"	**Date:**	6/7/12		

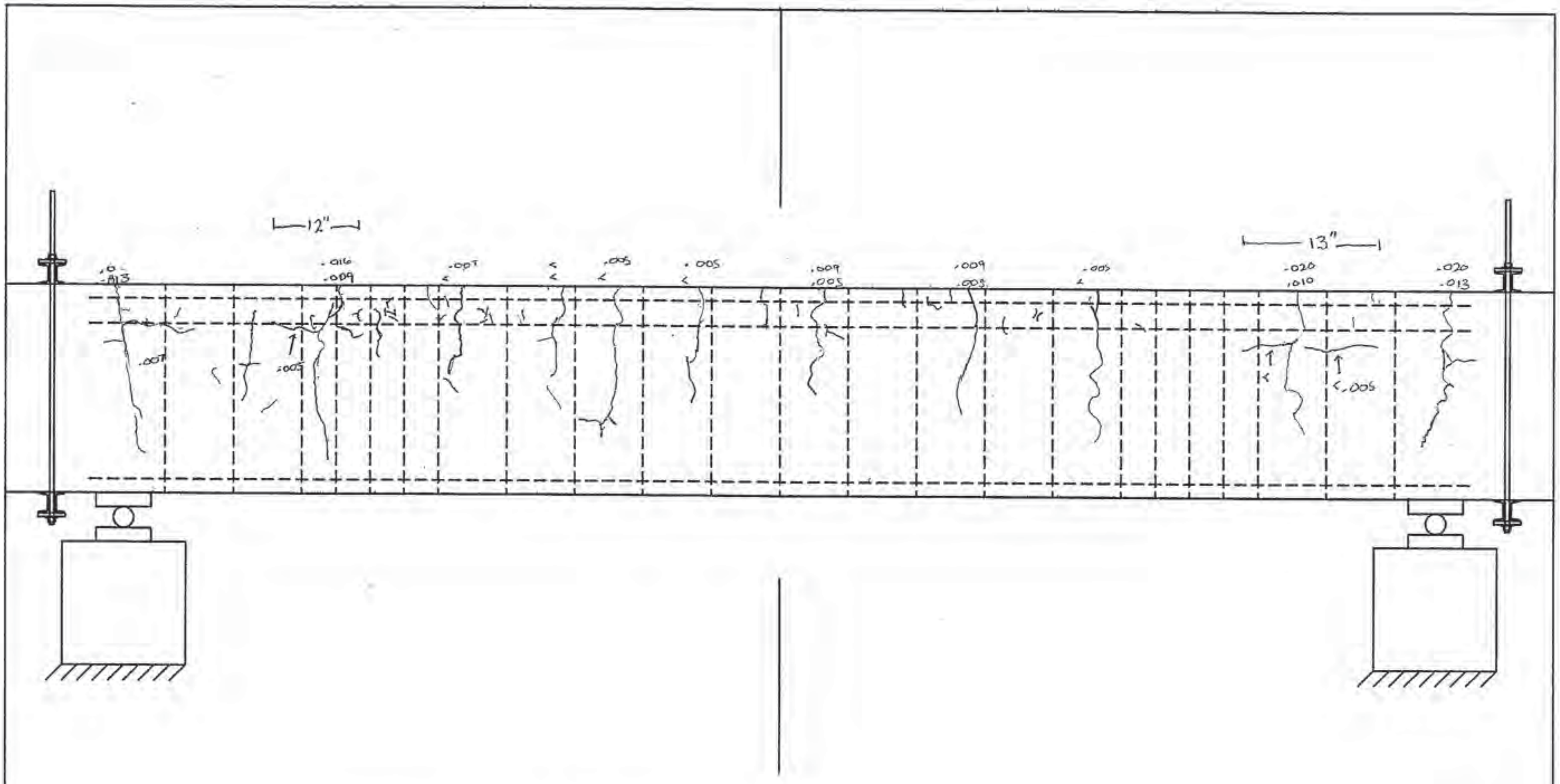


BOWEN LABORATORY **PURDUE UNIVERSITY**	**Specimen:** A-S	**Sheet:**	1	**of**	1
	Average Load: 36 K (RELOADED)	**Drawn by:**		**Checked by:**	
	Average Deflection: 3.89"	**Date:**	6/7/12		

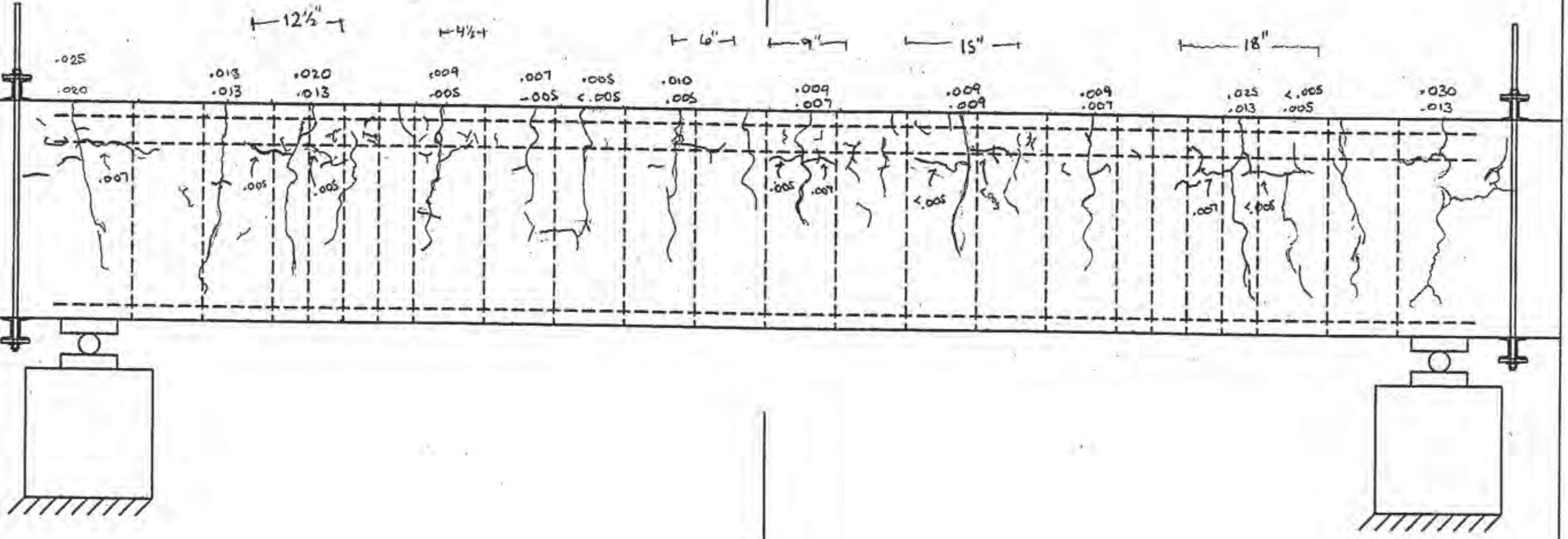


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-6	**Sheet:**	1	of	1
Average Load: 6 KIPS	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	**Date:**	6/05/12		

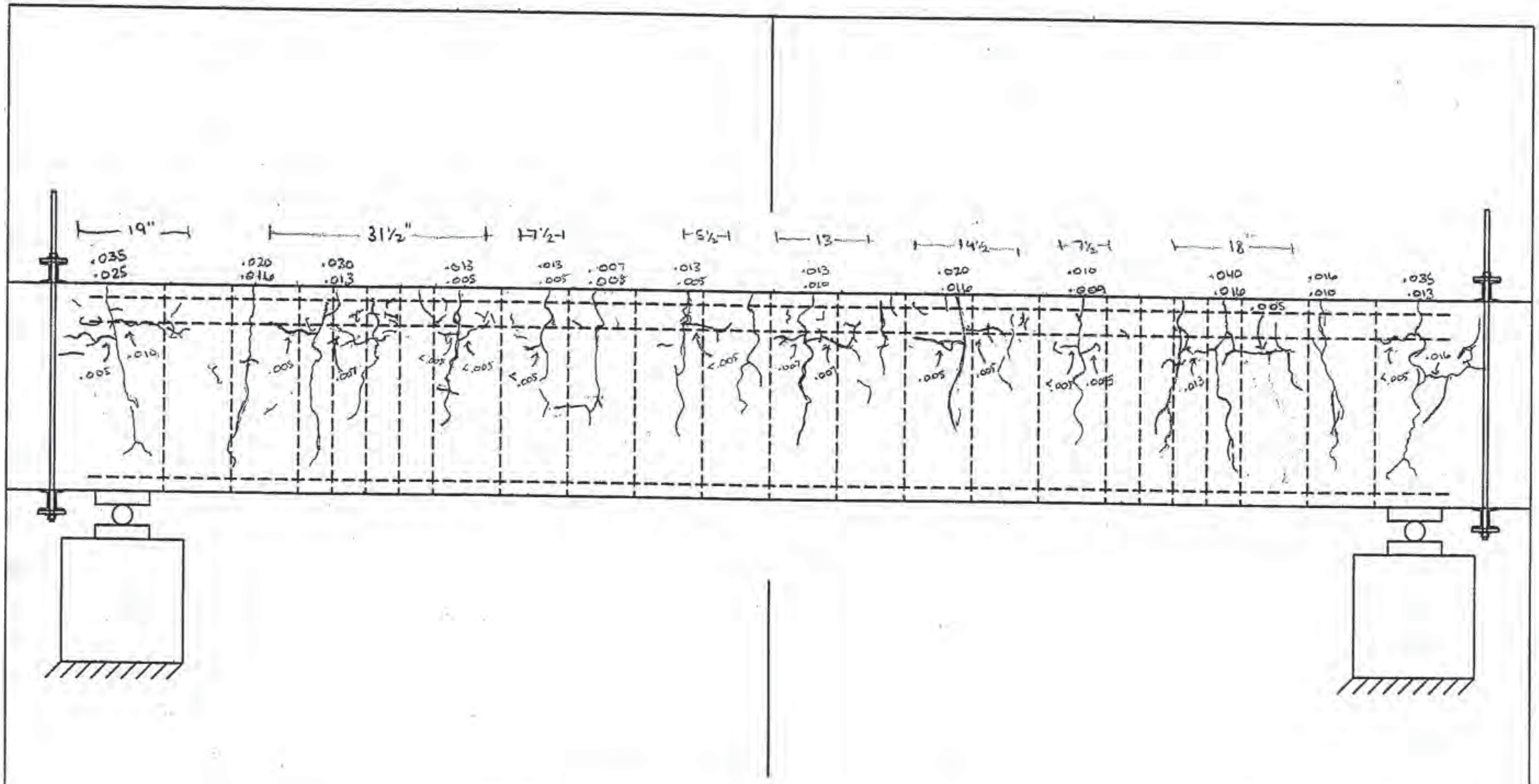


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-6	**Sheet:**	1	**of**	1
	Average Load: 12 KIPS	**Drawn by:**	MDN	**Checked by:**	
	Average Deflection:	**Date:**	6/5/12		

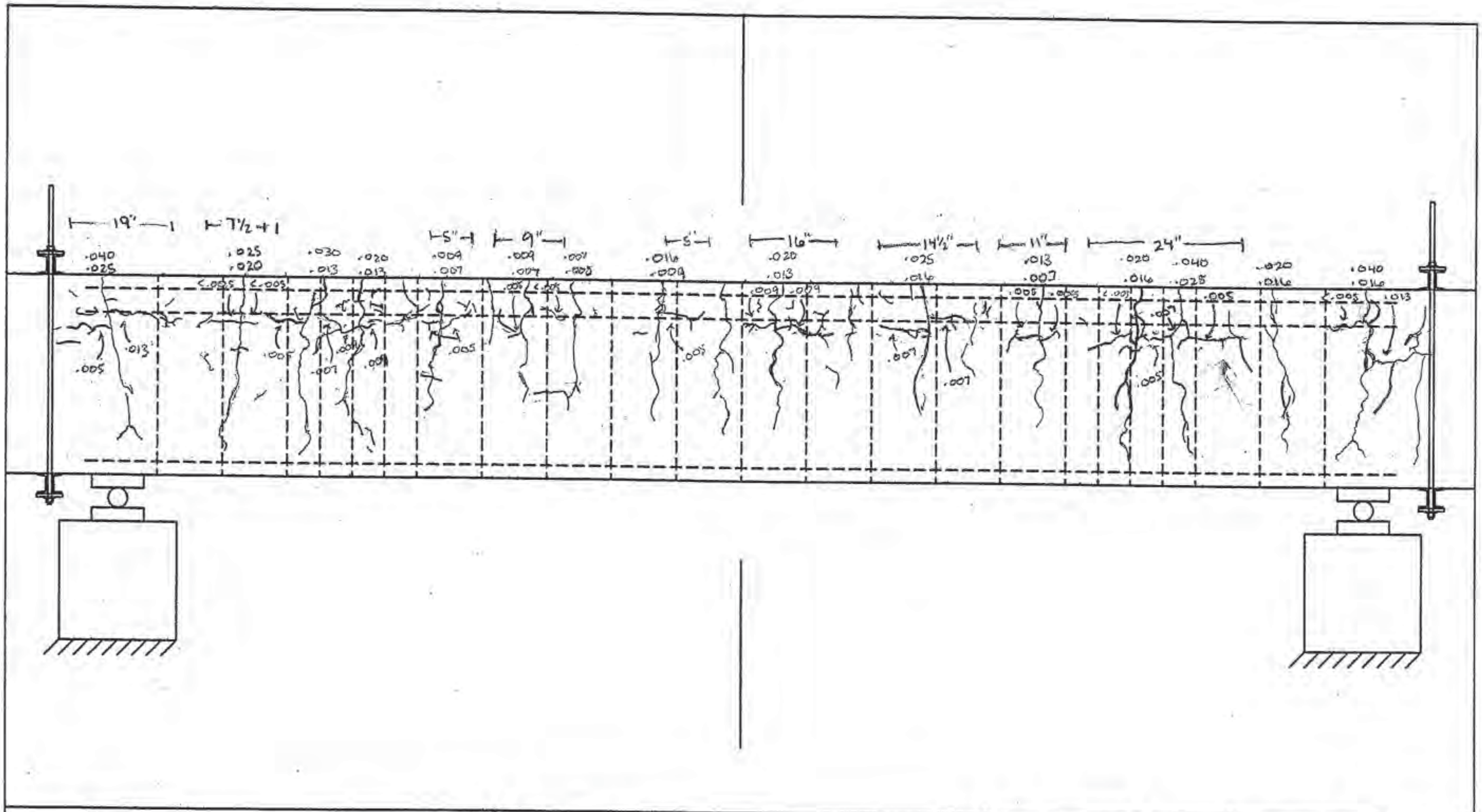


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-6	**Sheet:**	1	of	1
Average Load: 18 kips	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	**Date:**	6/05/12		

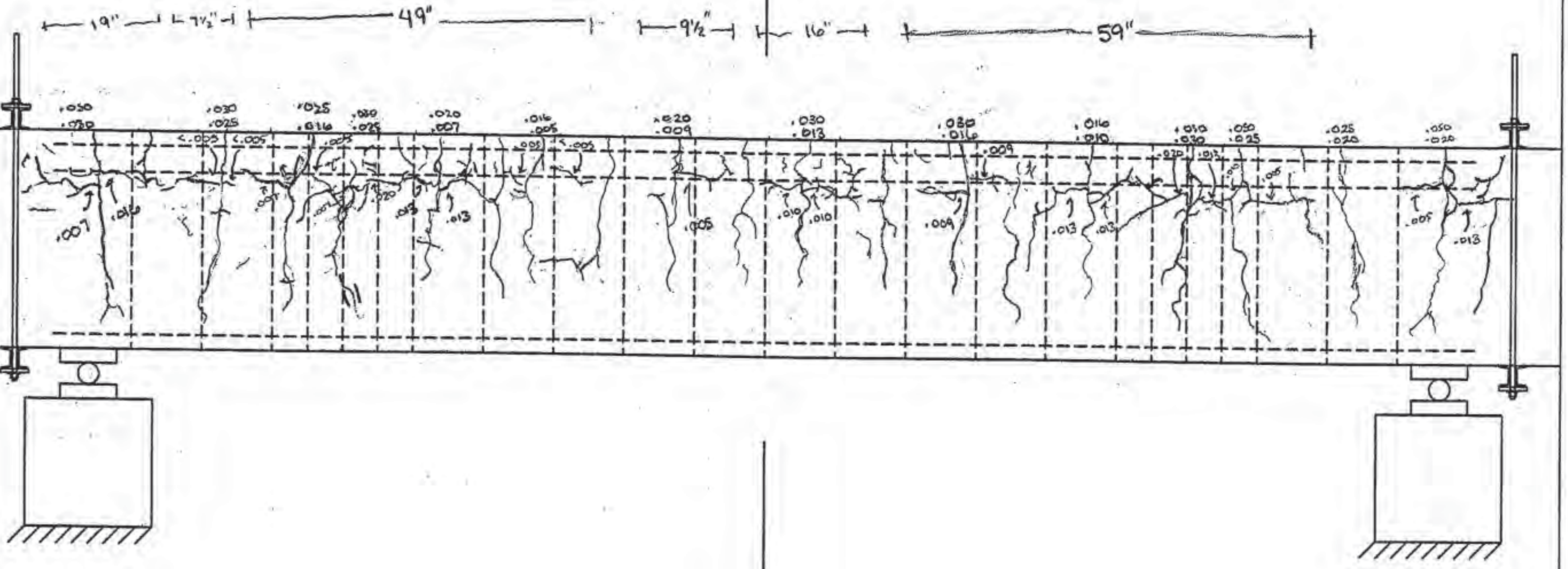


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-6	**Sheet:**	1	**of**	1
	Average Load: 24 KIPS	**Drawn by:**	MDN	**Checked by:**	
	Average Deflection:	**Date:**	6/05/12		



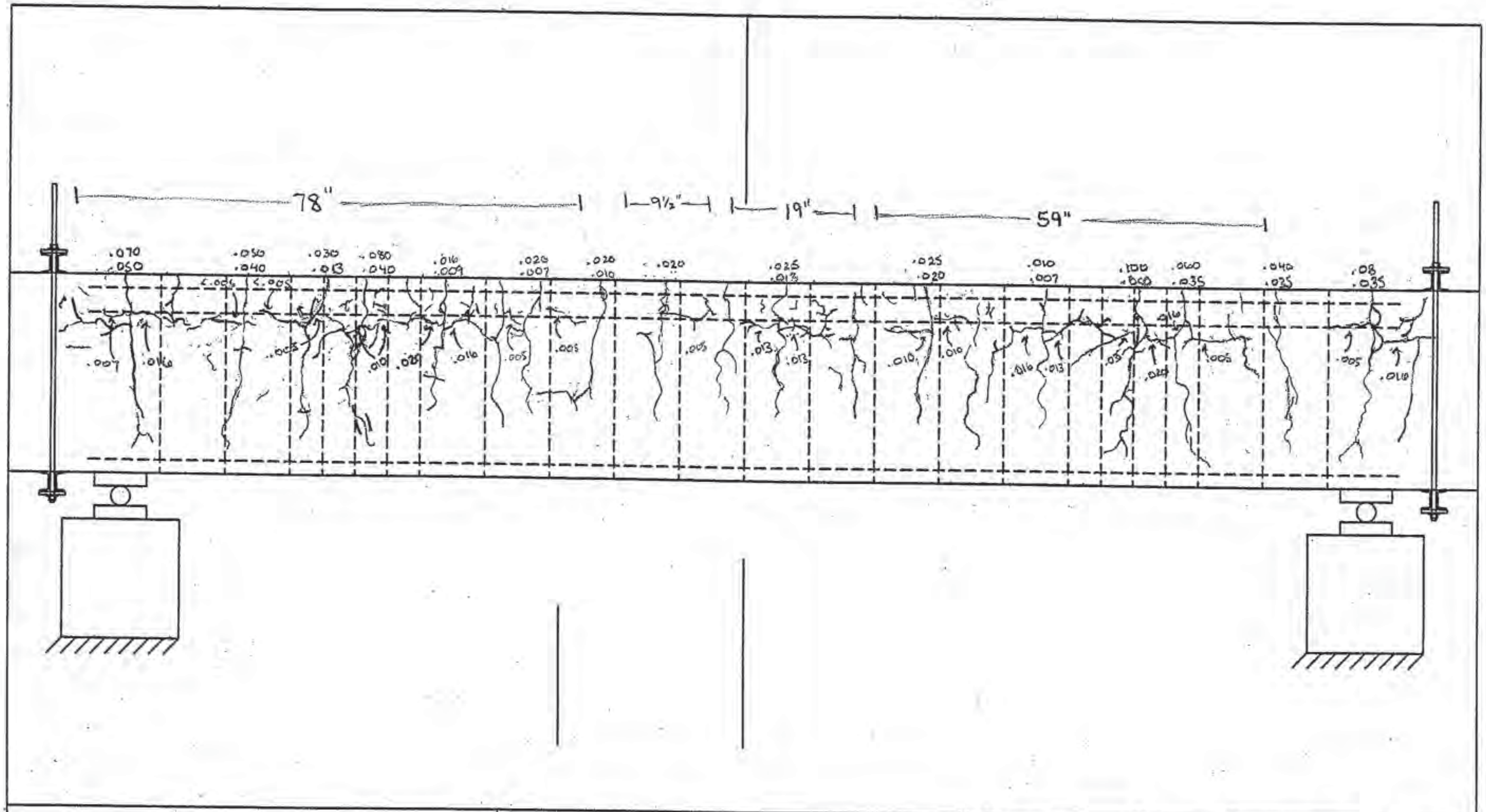
Specimen: A-6	**Sheet:**	1	of	1
Average Load: 30 kips	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	**Date:**	6/05/12		

BOWEN LABORATORY
PURDUE UNIVERSITY



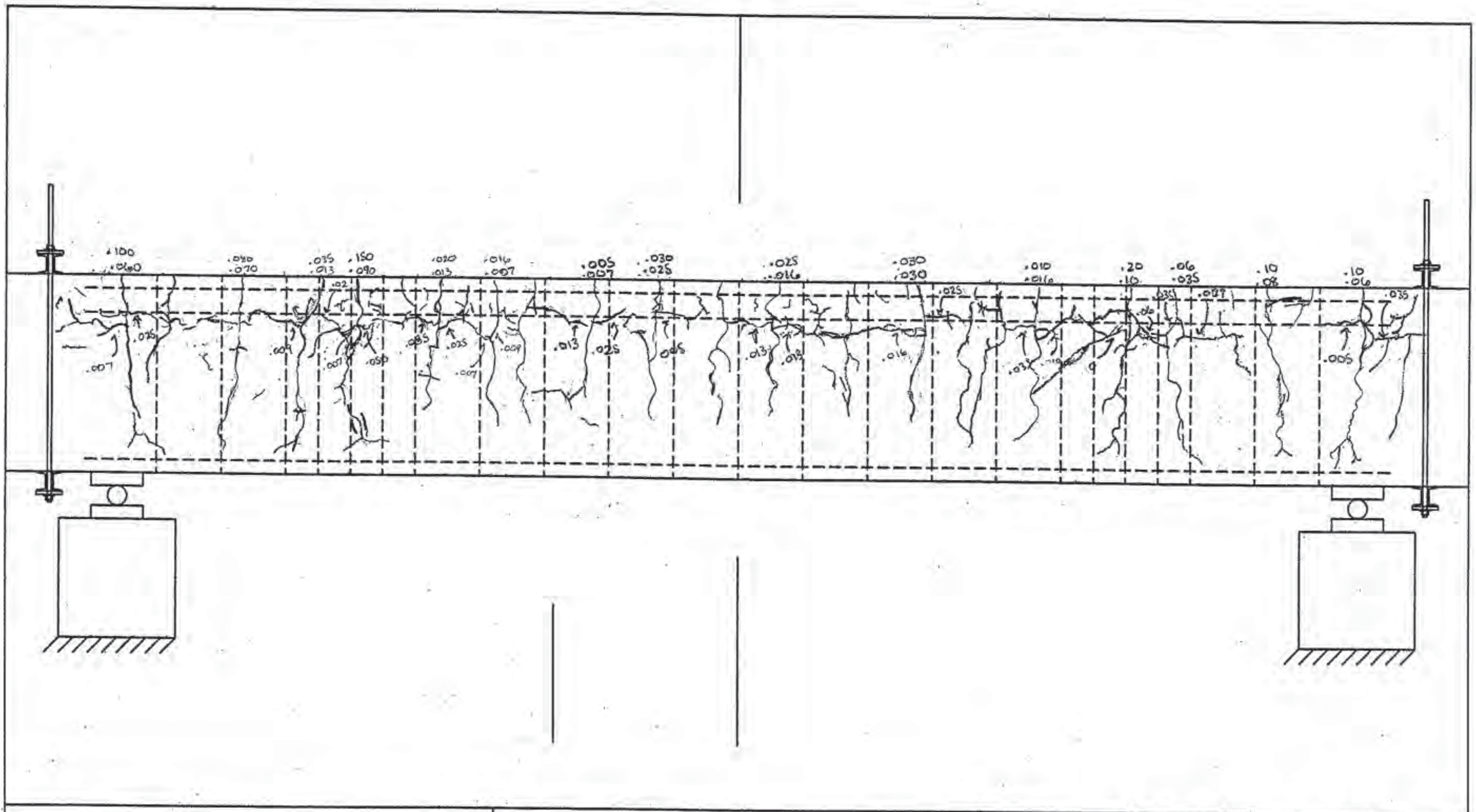
Specimen: A-6	**Sheet:**	1	of	1
Average Load: 36 KIPS	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	**Date:**	6/05/12		

BOWEN LABORATORY
PURDUE UNIVERSITY



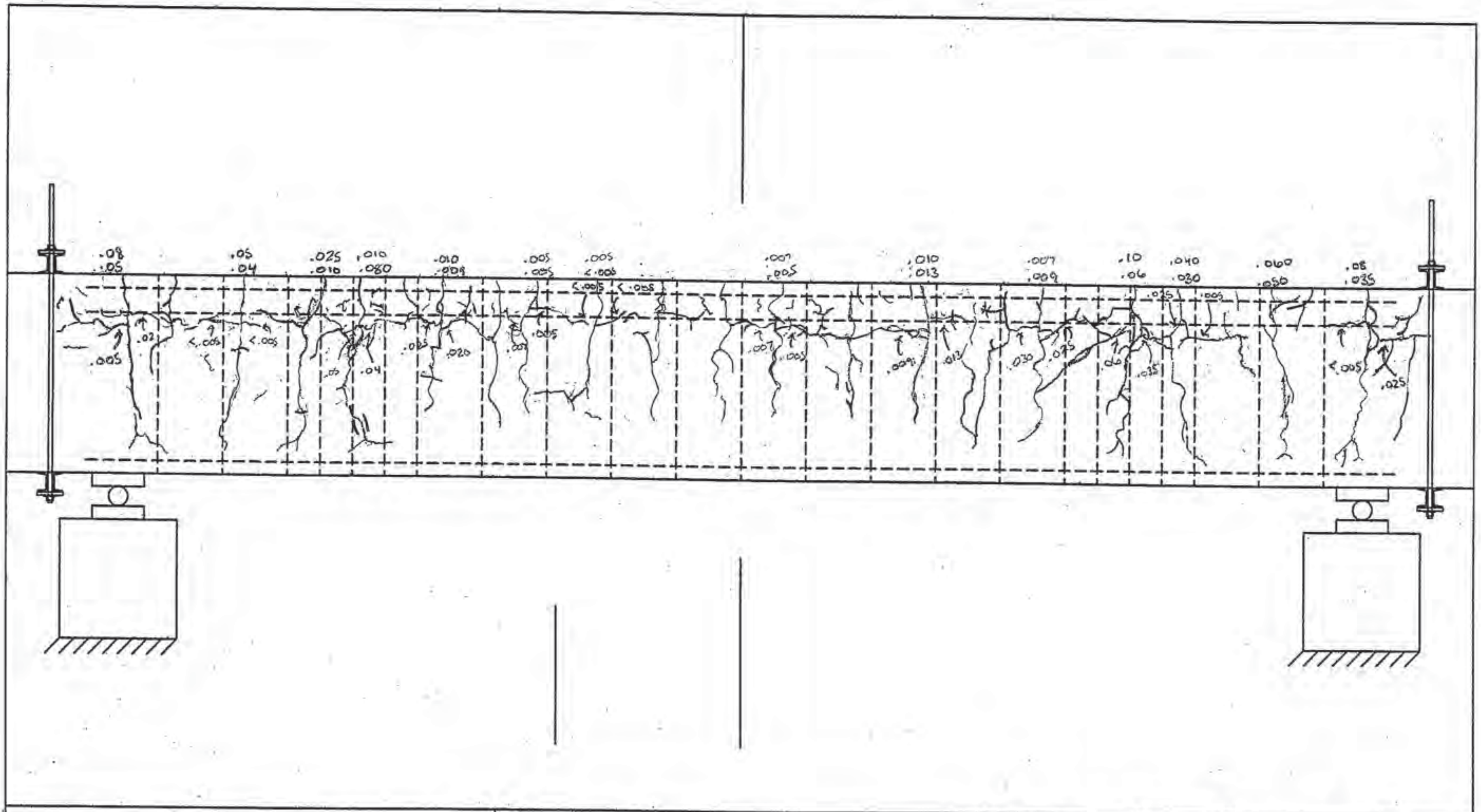
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: A-6		**Sheet:**	1	**of**	1
Average Load: 38k (YIELD)		**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 2.72"		**Date:**	6/05/12		



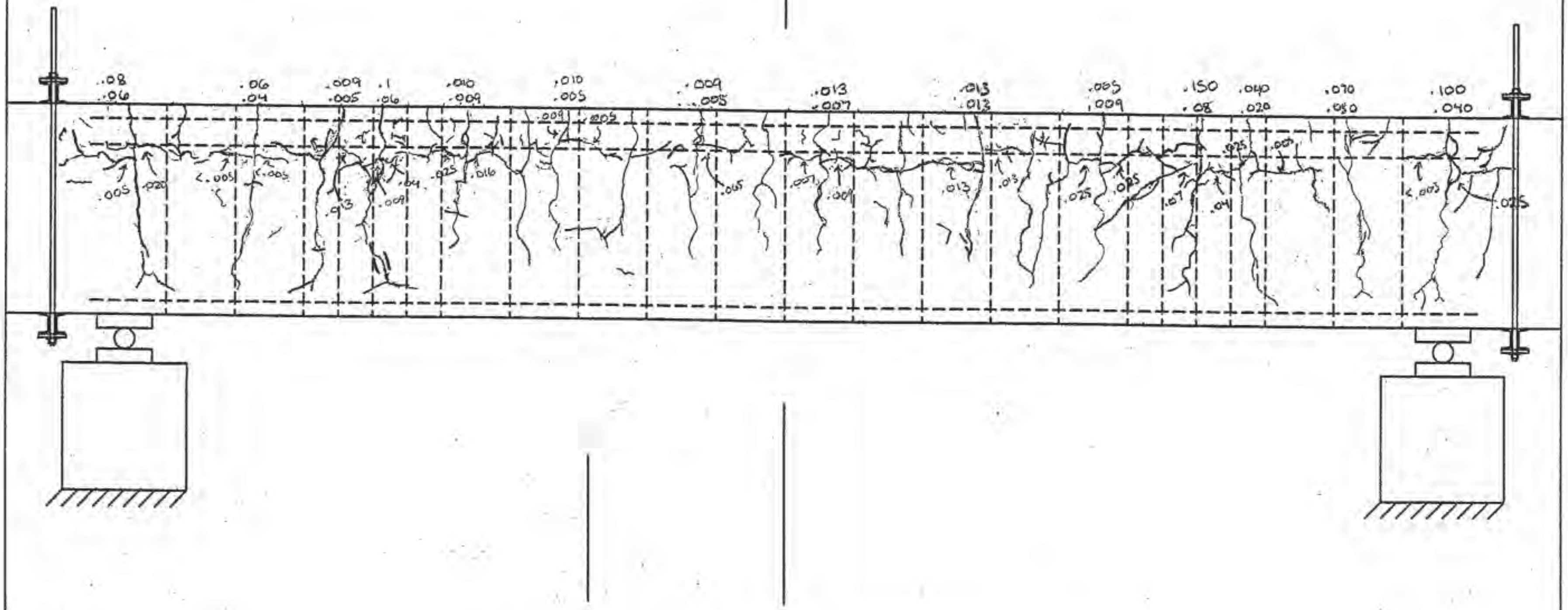
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	A-6	**Sheet:**	1	**of**	1
Average Load:	40k	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	4.0"	**Date:**	6/05/12		



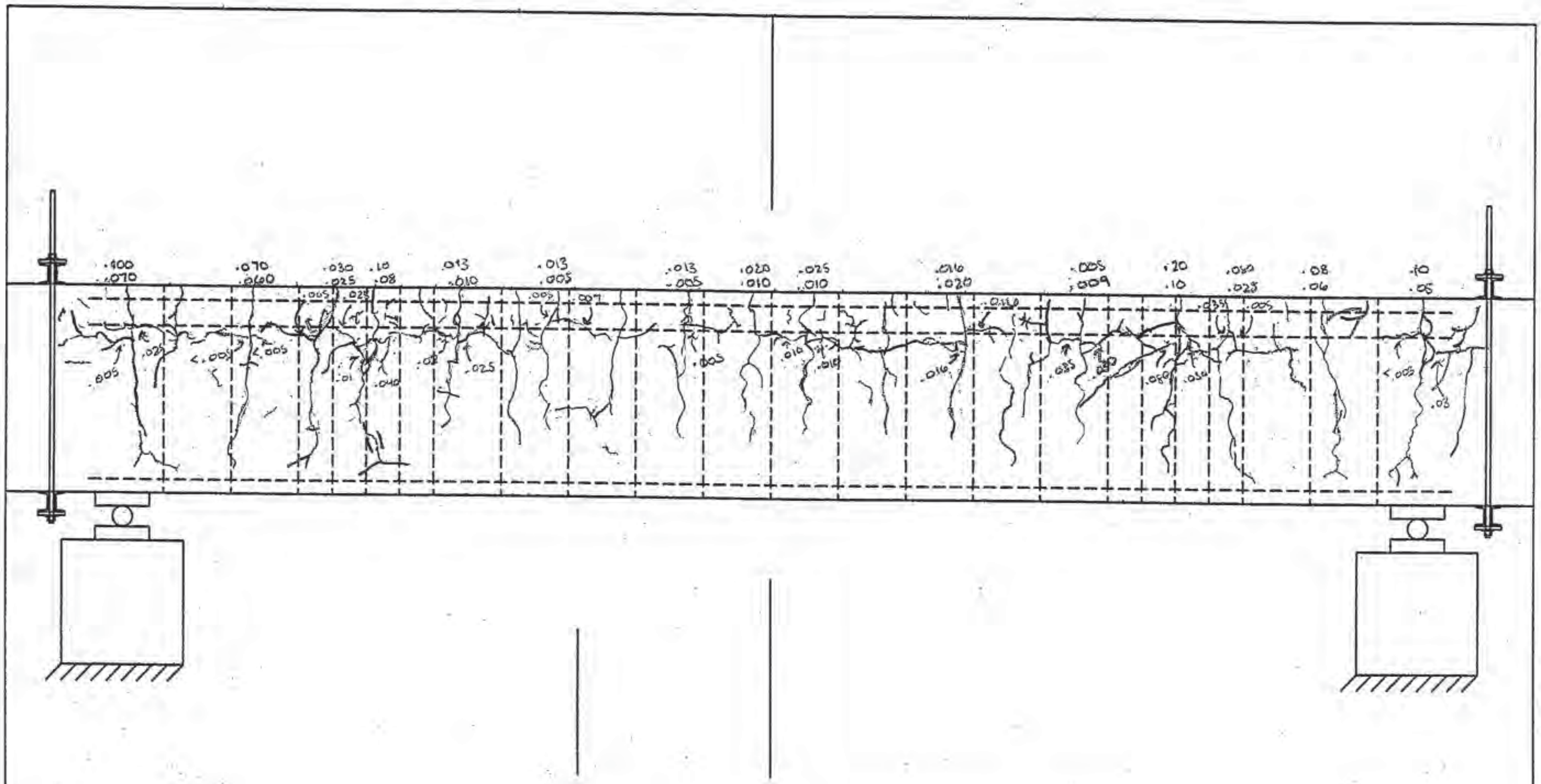
Specimen: A-6	**Sheet:**	1	**of**	1
Average Load: 0 KIPS	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	**Date:**	6/05/12		

BOWEN LABORATORY
PURDUE UNIVERSITY

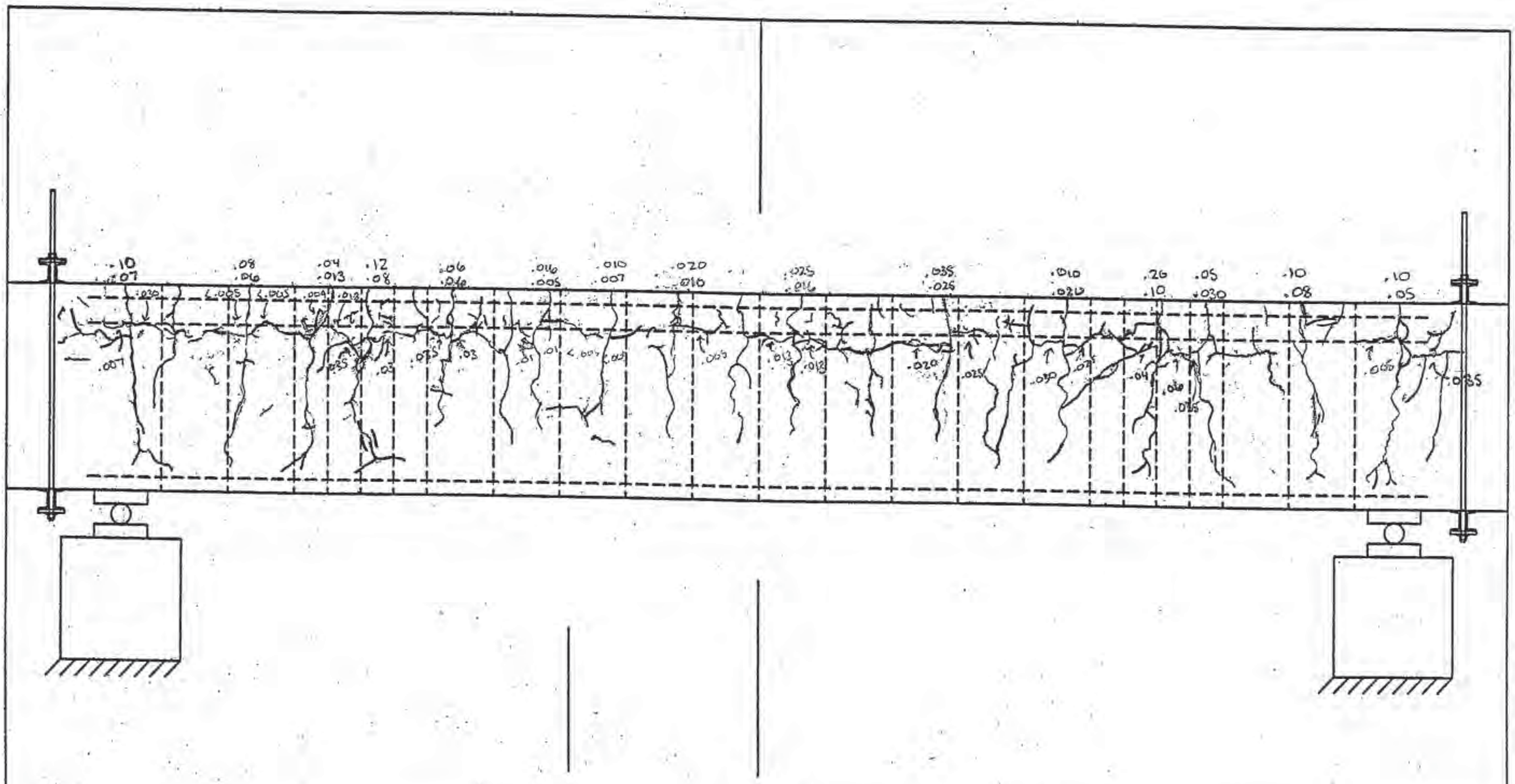


BOWEN LABORATORY
PURDUE UNIVERSITY

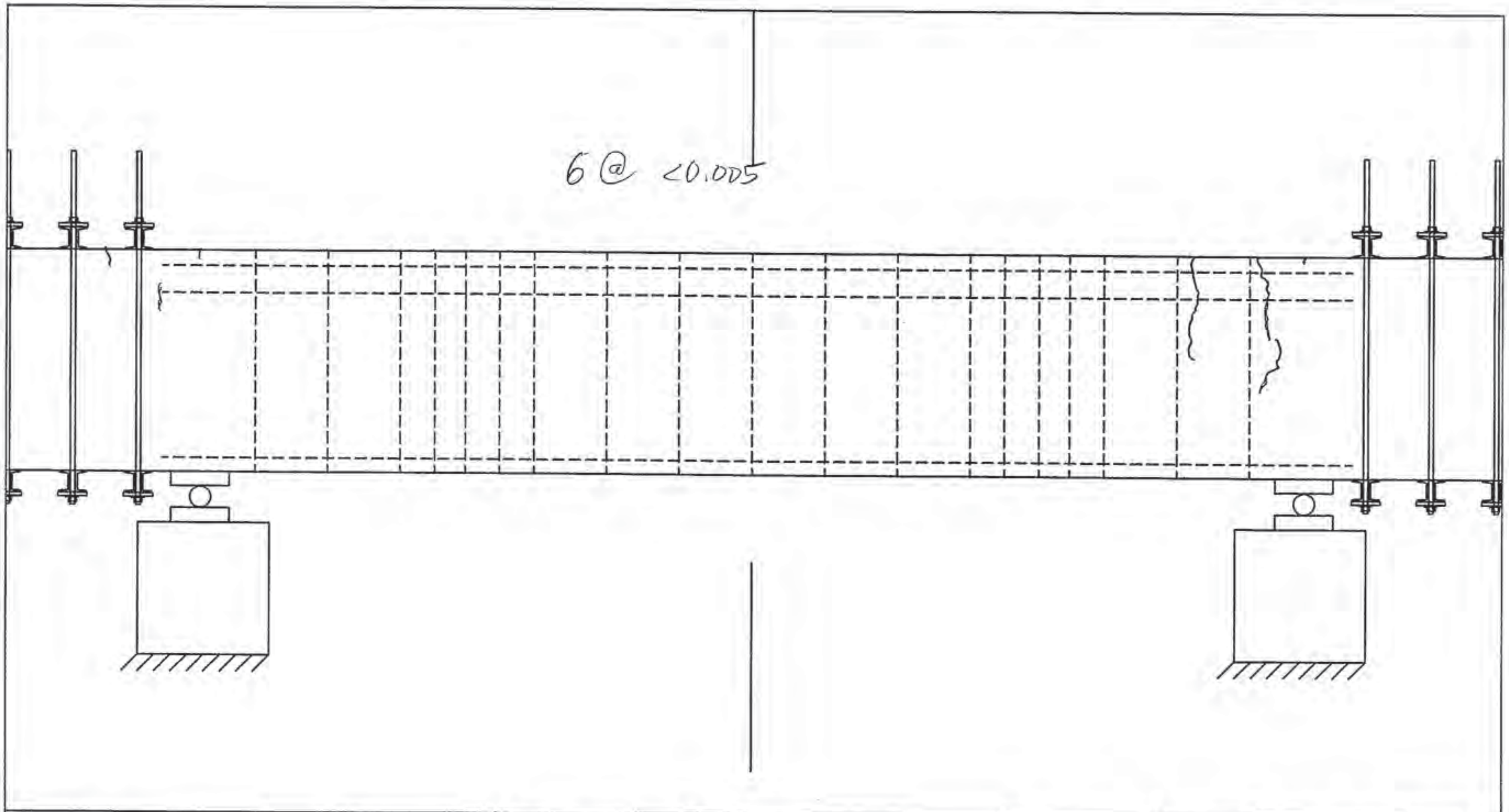
Specimen: A-6	**Sheet:**	1	**of**	1
Average Load: 12 kips (Reloaded)	**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 2.6"	**Date:**	6/05/12		



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-6	**Sheet:**	1	**of**	1
	Average Load: 24 K (RELOADED)	**Drawn by:**	MDN	**Checked by:**	
	Average Deflection:	**Date:**	6/05/12		

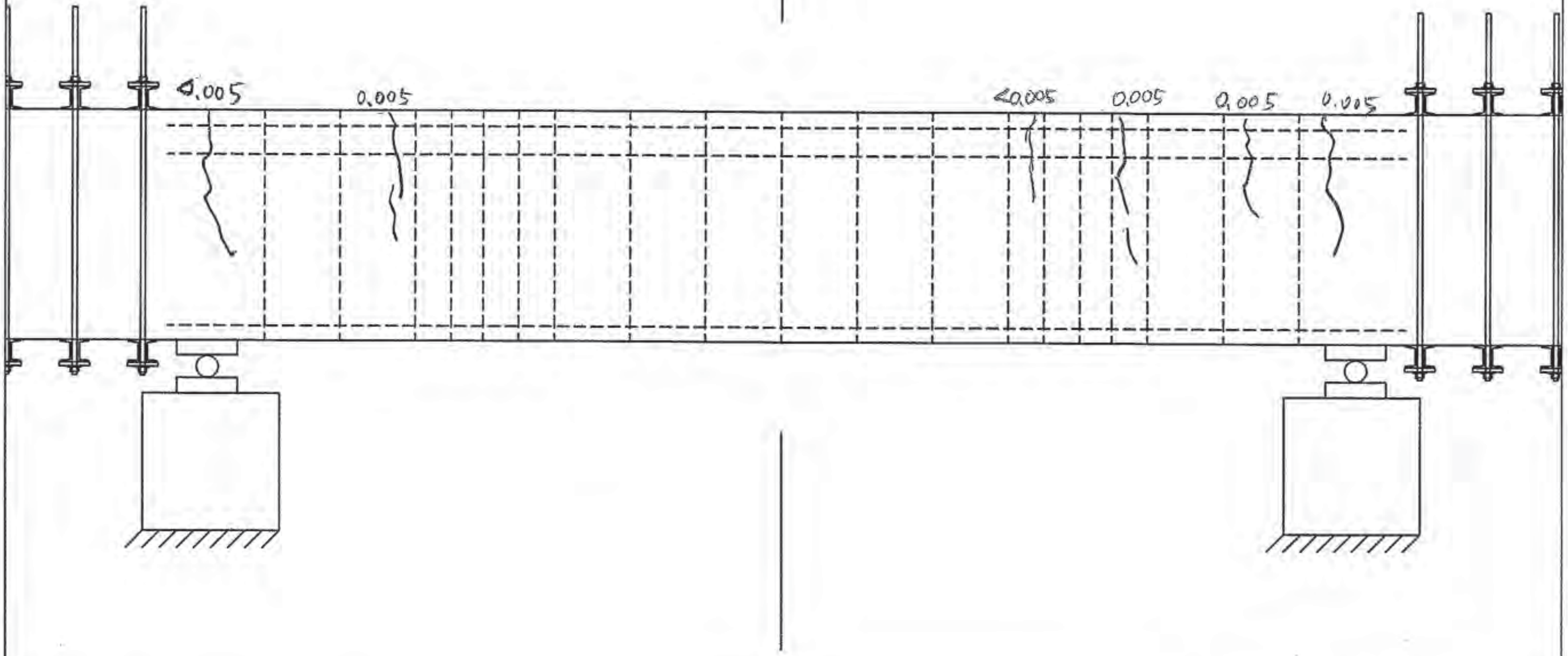


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** A-6	**Sheet:**	1	**of**	1
	Average Load: 36 K (RELOADED)	**Drawn by:**	MDN	**Checked by:**	
	Average Deflection: 3.89"	**Date:**	6/05/12		



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-1	**Sheet:**	1	of	1
	Average Load: 3.5	**Drawn by:**		**Checked by:**	
	~~Midspan~~ Deflection: 0.045	**Date:**	05/10/2012		

Avg.



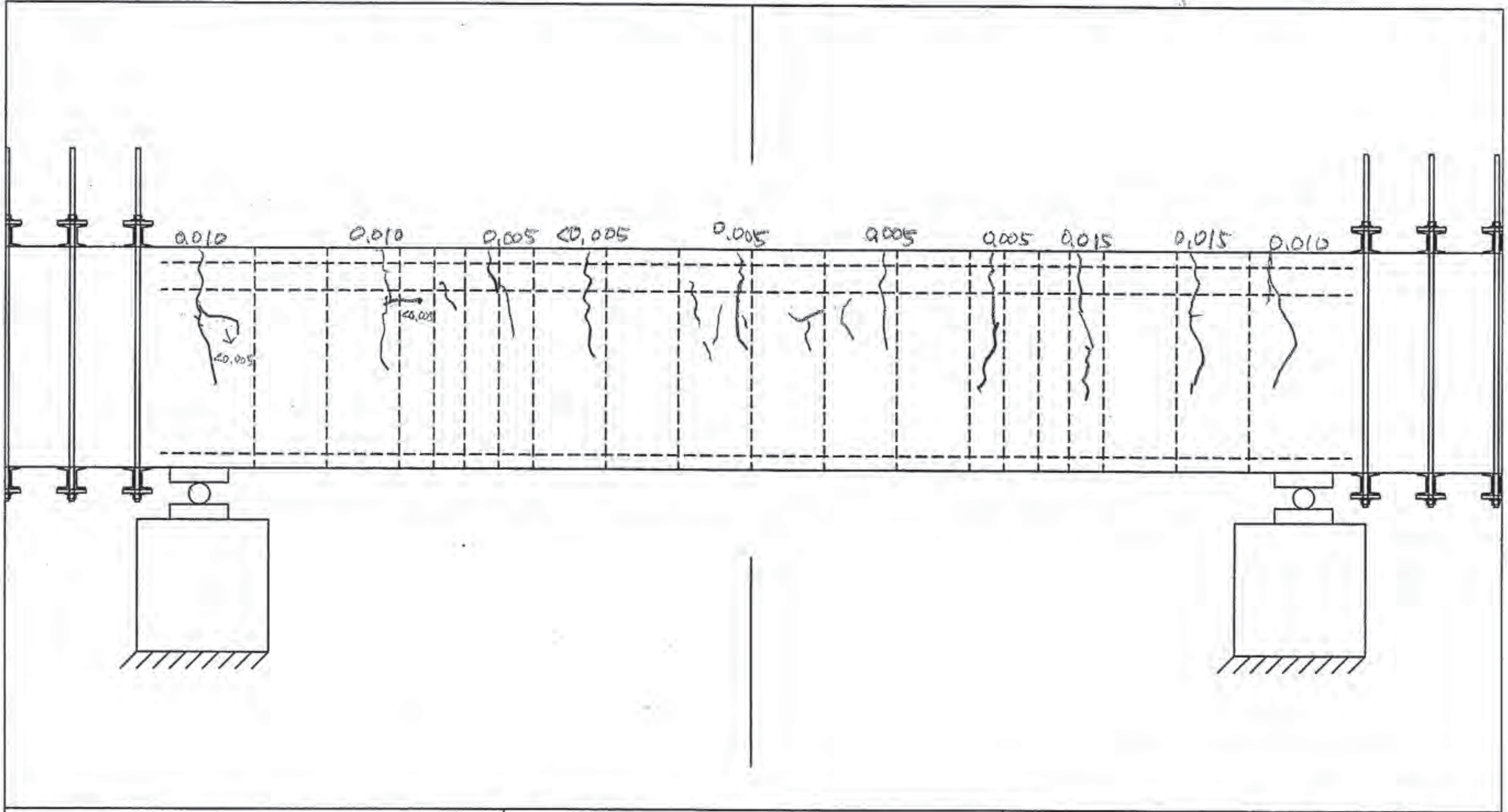
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: B-1	**Sheet:**	1	of	1
Average Load: 6.0 K	**Drawn by:**	Y. W.	**Checked by:**	
~~Midspan~~ Deflection: 0.14	**Date:**	05/10/12		

Avg.

2

crack width measured at the level of steel

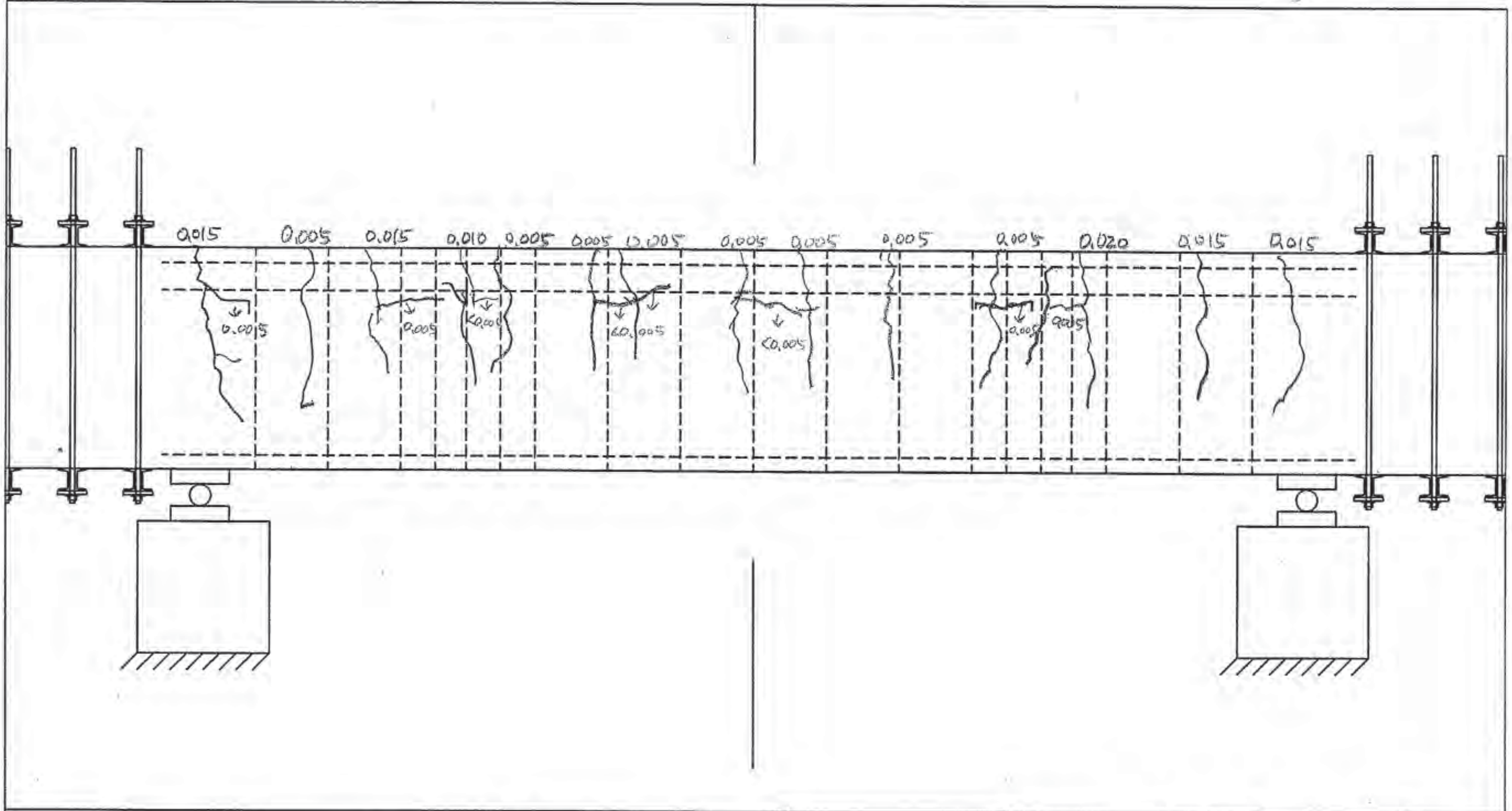


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-1	**Sheet:**	1	**of**	1
Average Load:	12.00 K	**Drawn by:**	Y W	**Checked by:**	
Midspan Deflection:	0.43	**Date:**	05/10/12		

Avg.

crack width measured at the level of steel



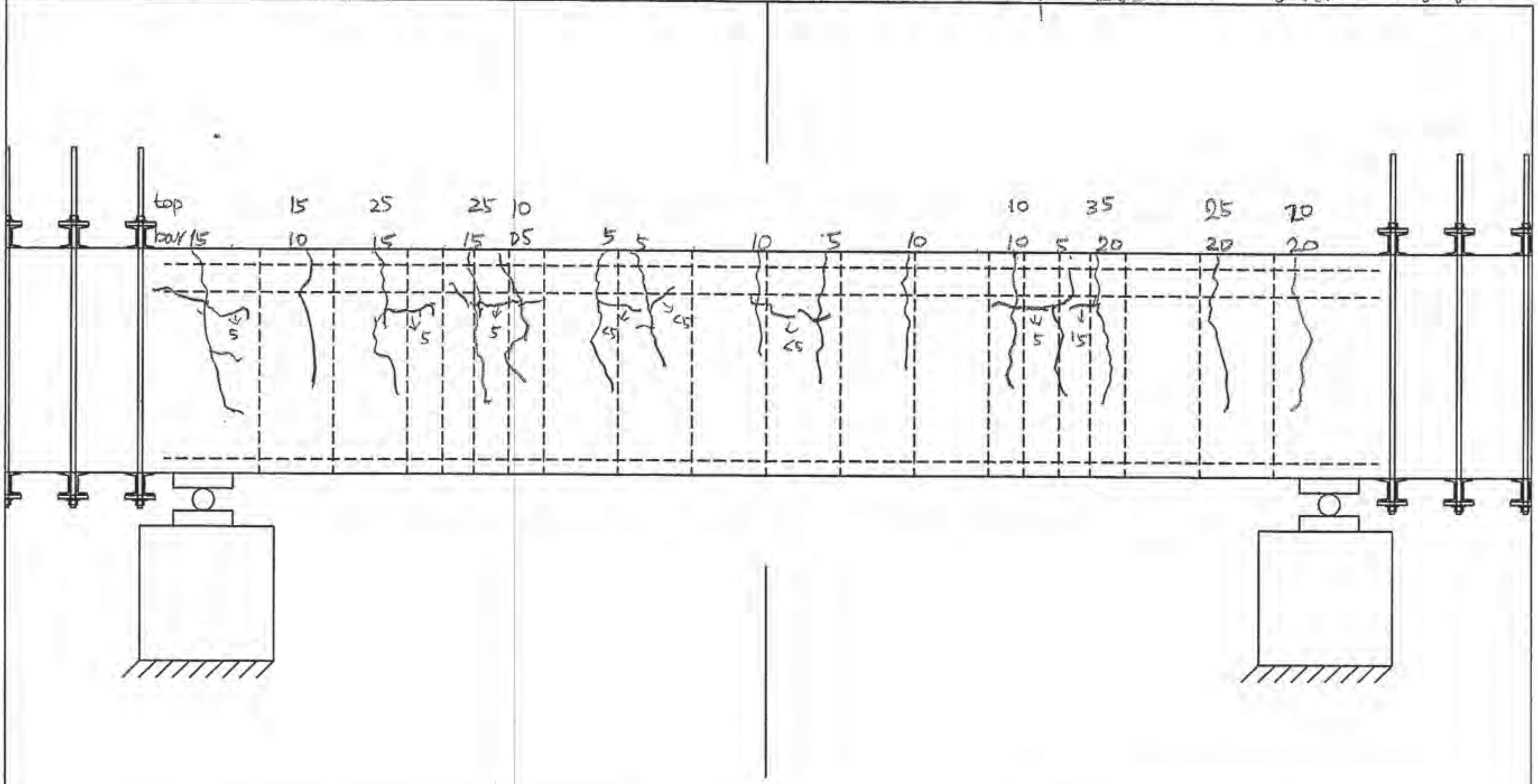
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-1	**Sheet:**	1	of	1
Average Load:	18.0 K	**Drawn by:**	Y.W.	**Checked by:**	
Midspan Deflection:	0.78 in	**Date:**	05/10/12		

Avg.

4

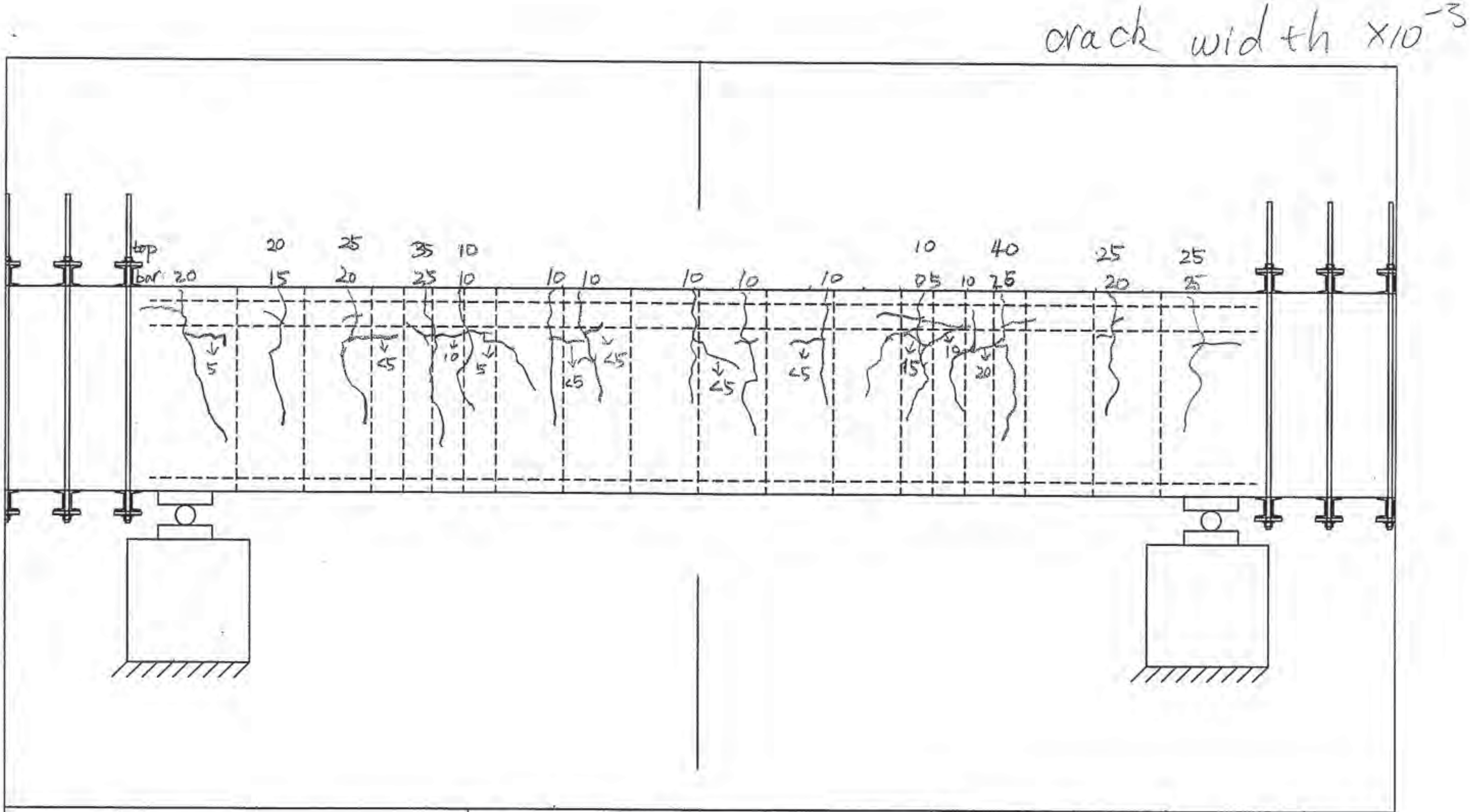
crack width measured at the level of steel. crack width $\times 10^{-3}$



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-1	**Sheet:**	1	of	1
	Average Load: 24.0 K	**Drawn by:**	Y. W.	**Checked by:**	
	Midspan Deflection: 1.08 in	**Date:**	05/10/12		

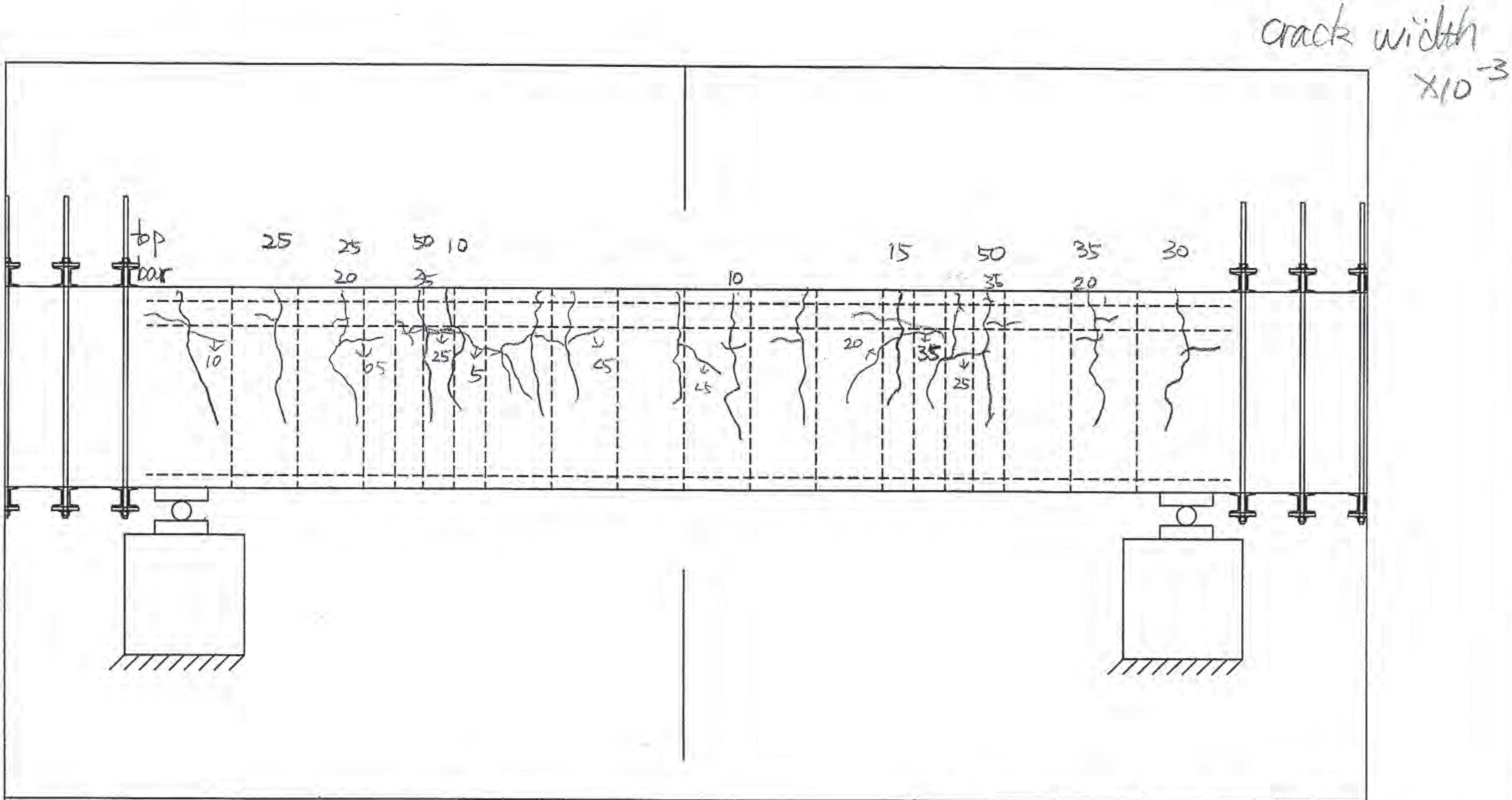
Avg.

5



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:**	B-1	**Sheet:**	1	of	1
	Average Load:	30.0 K	**Drawn by:**	Y.W.	**Checked by:**	
	~~**Midspan**~~ **Deflection:**	1.43	**Date:**	5/10/12		

Avg.

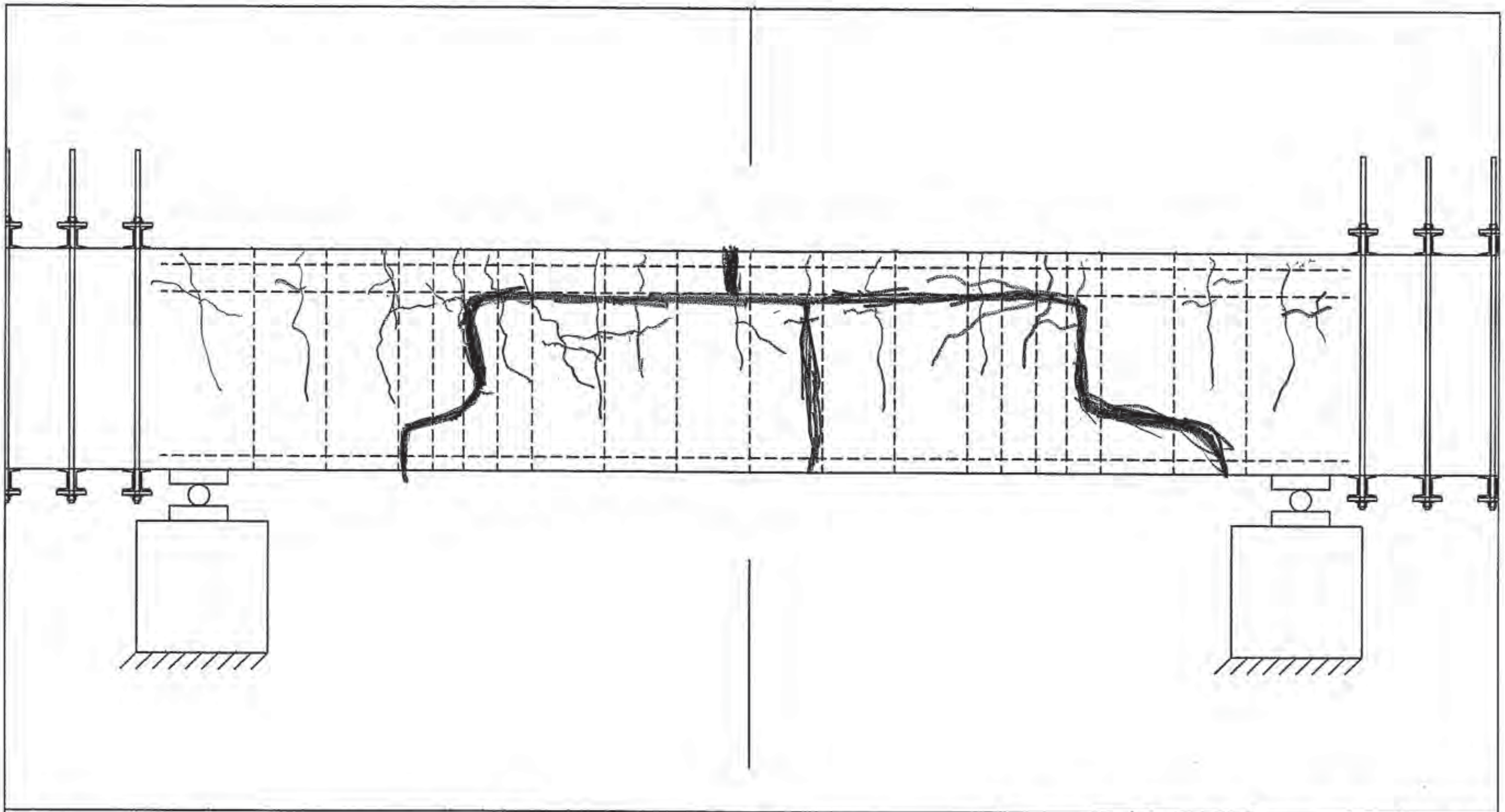


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-1	**Sheet:**	1	of	1
Average Load:	36.0 k	**Drawn by:**	Y. W.	**Checked by:**	
Midspan Deflection:	1.82 in	**Date:**	5/10/12		

Failure

crack width x10^{-3}

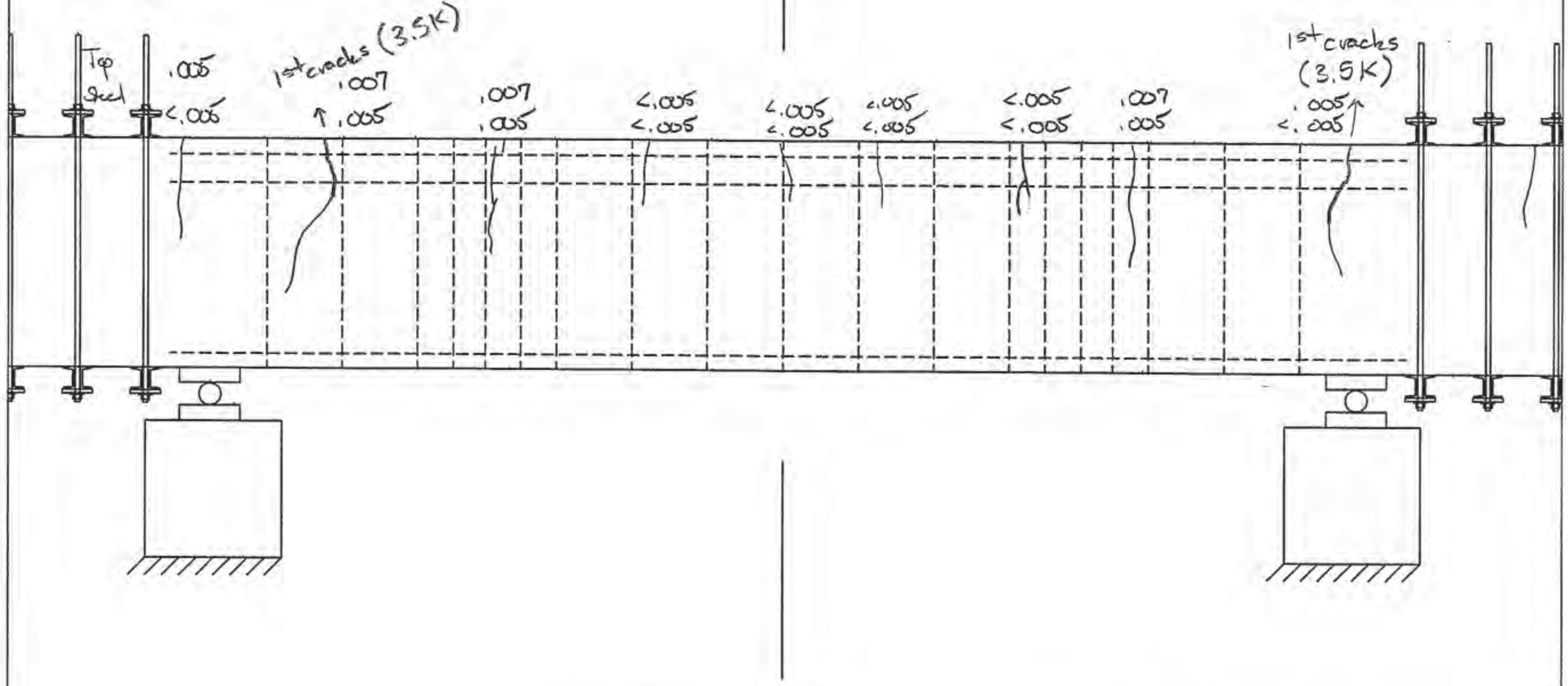


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: B-1	**Sheet:**	1	of	1
Average Load:	**Drawn by:**	Y.W.	**Checked by:**	
Midspan Deflection:	**Date:**	5/10/12		

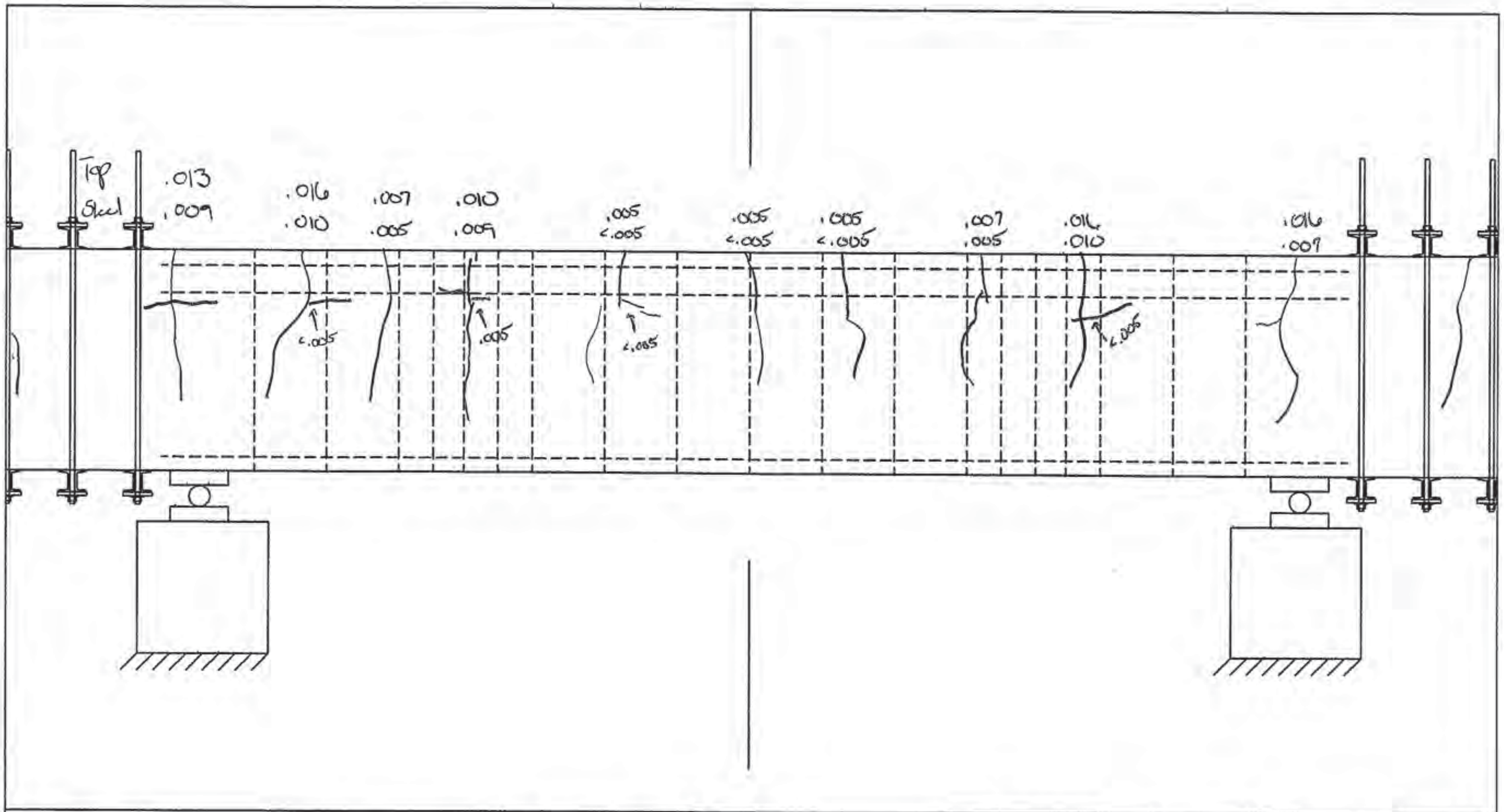
8

* CTL crack comparator used in this test



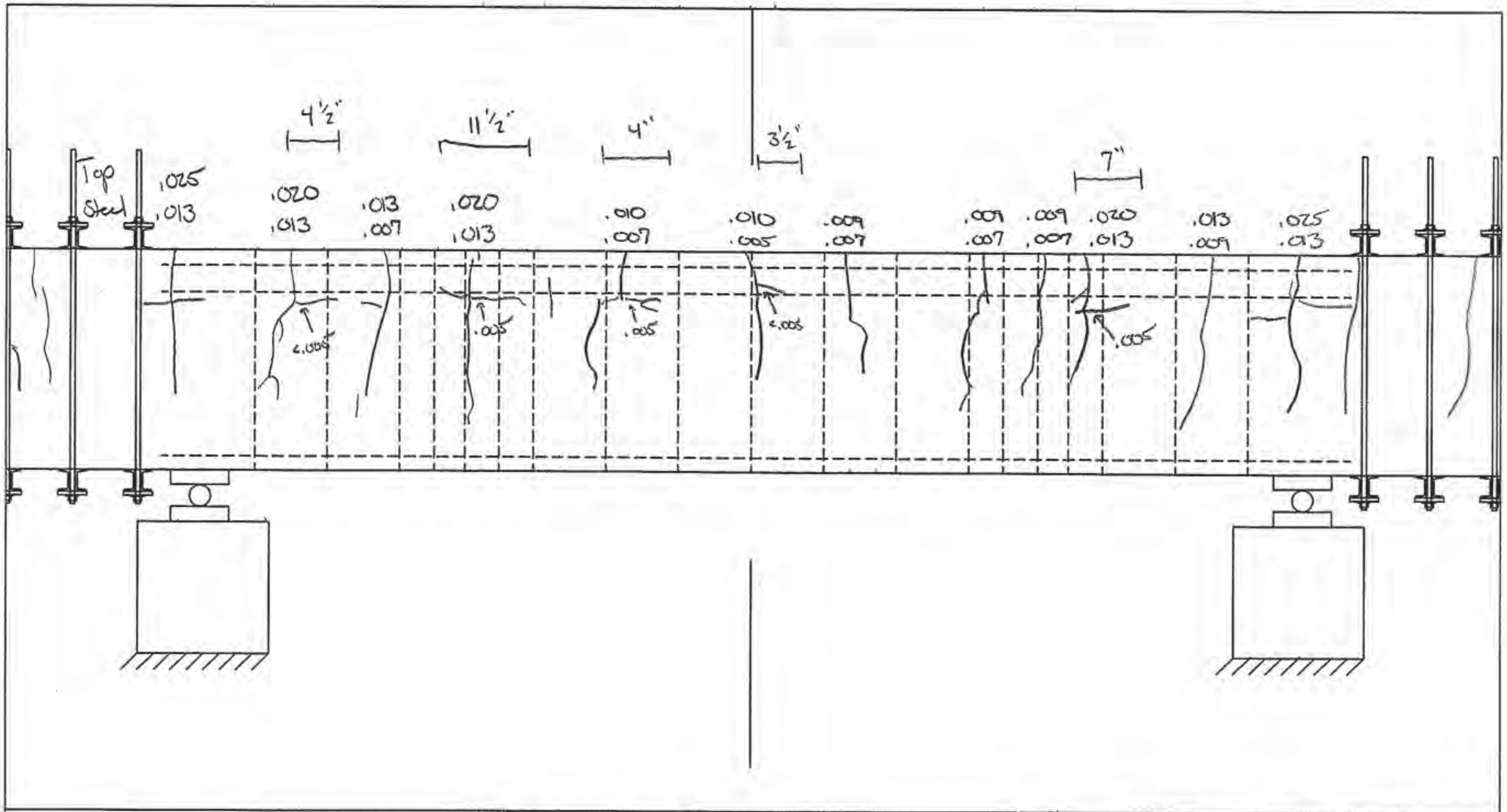
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-2	**Sheet:**	1	of	1
Average Load:	6K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	0.15"	**Date:**	5/23/12		



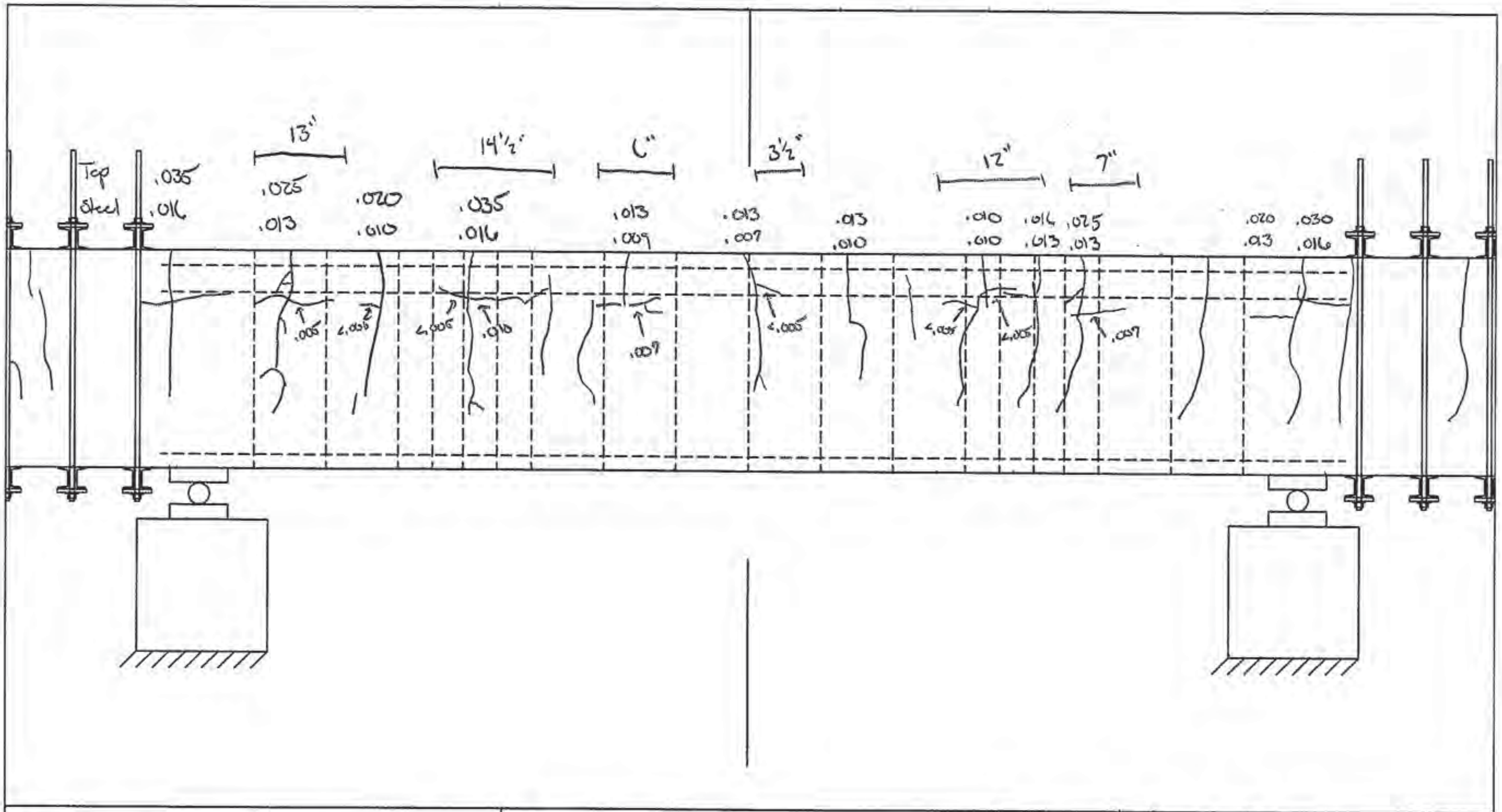
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-2	**Sheet:**	1	of	1
Average Load:	12K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	0.45"	**Date:**	5/23/12		



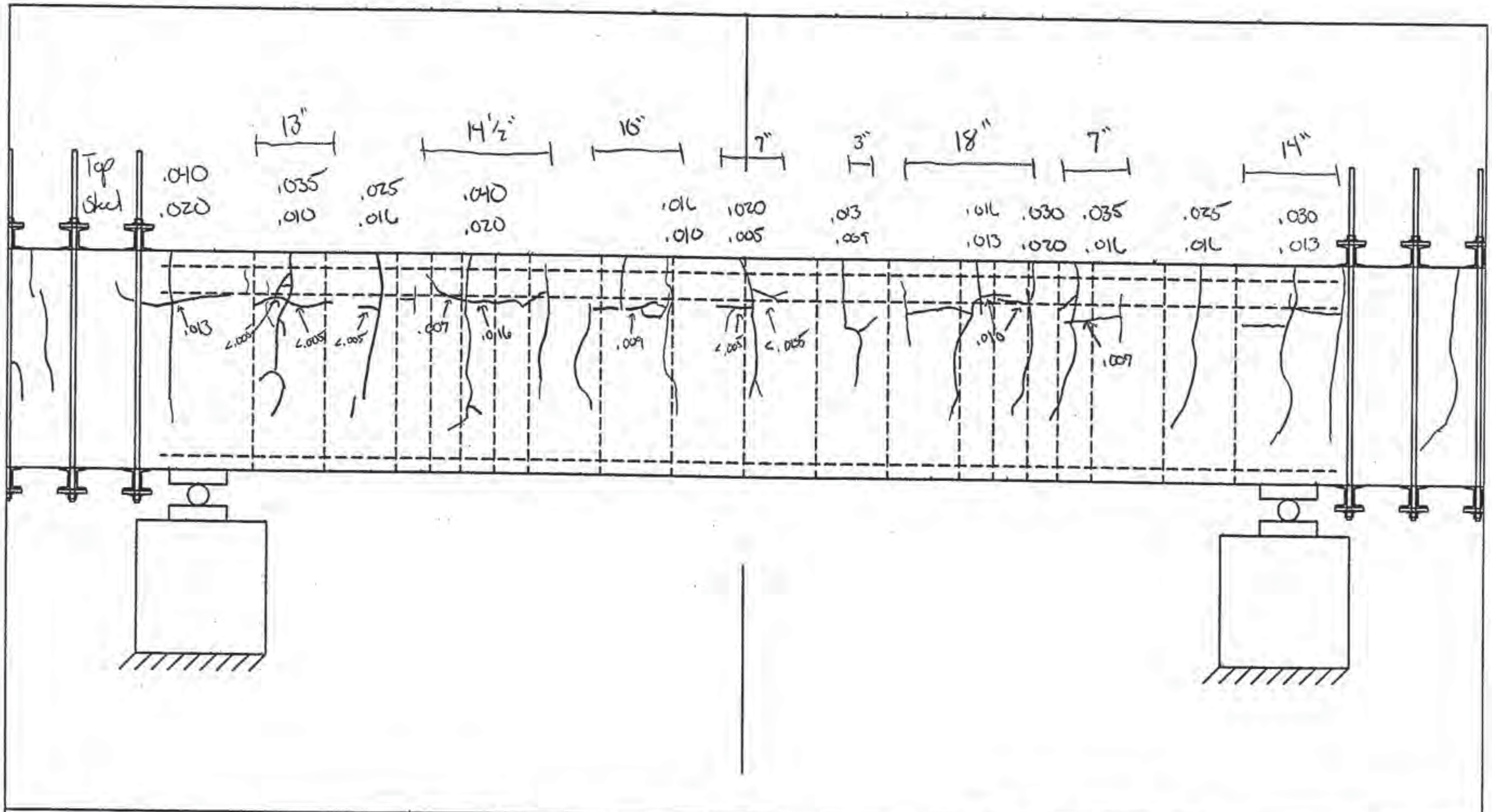
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-2	**Sheet:**	1	of	1
Average Load:	18K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	0.80"	**Date:**	5/23/12		

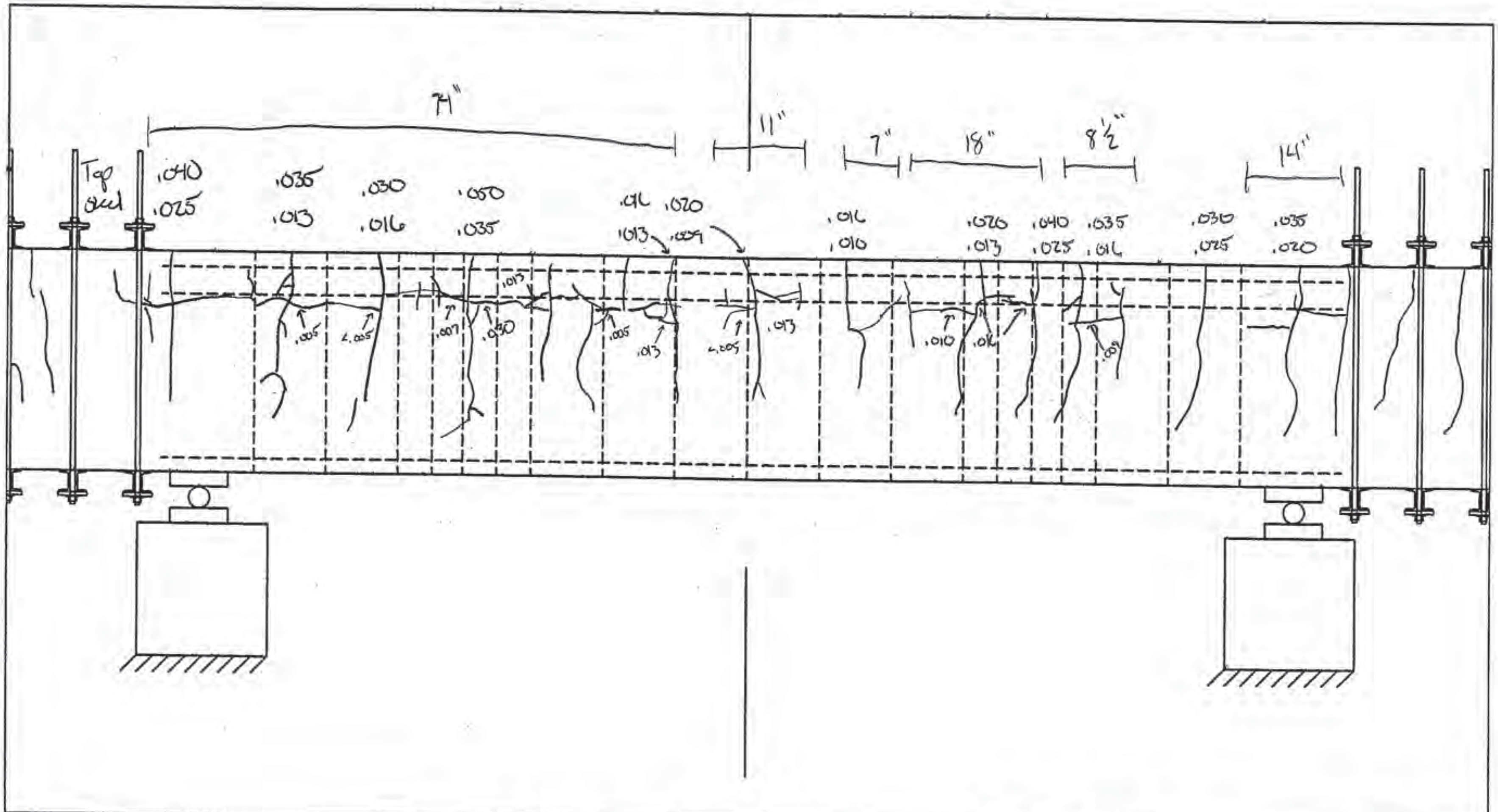


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-2	**Sheet:**	1	of	1
Average Load:	24K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	1.13"	**Date:**	5/23/12		

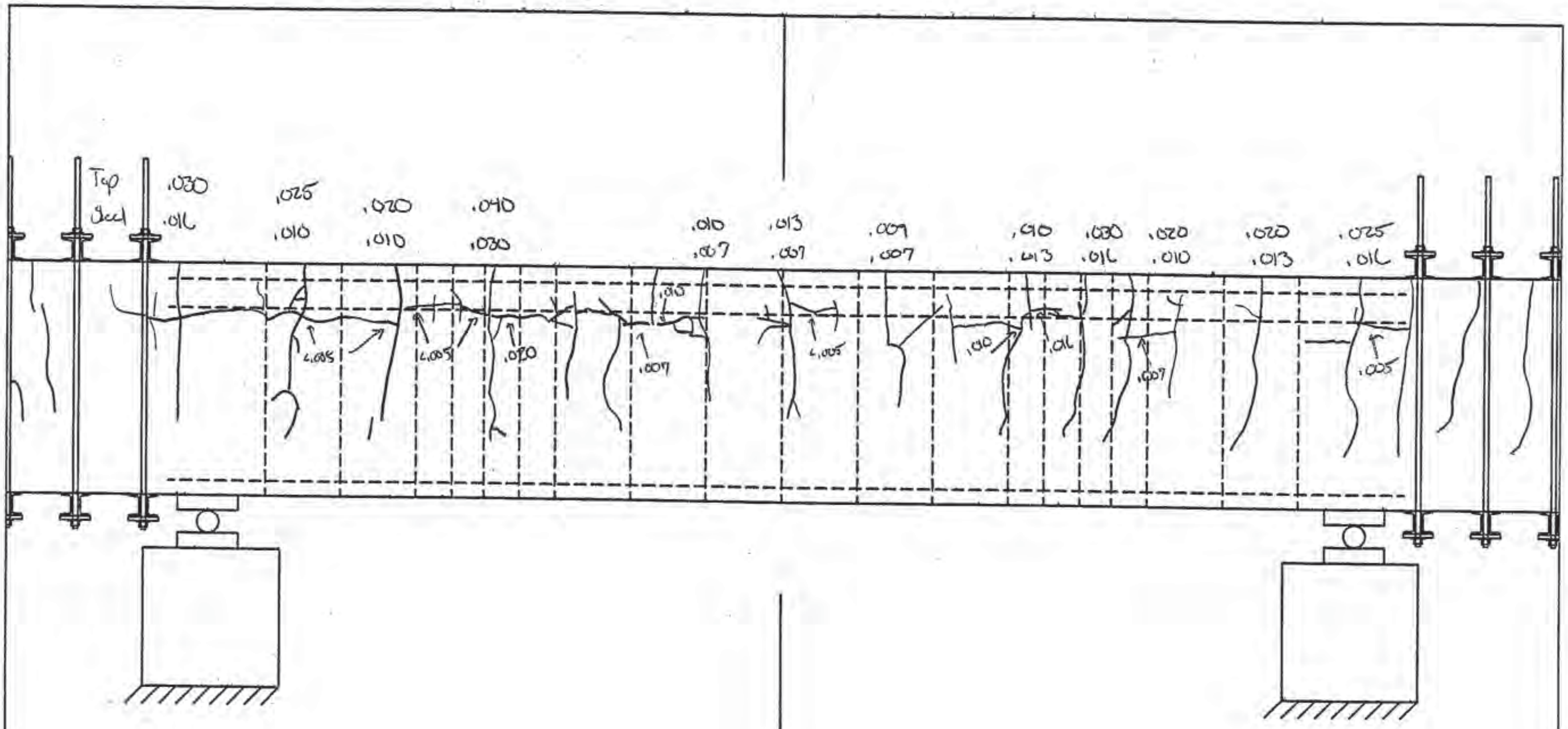


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-2	**Sheet:**	1	of 1
	Average Load: 30K	**Drawn by:**	BPR	**Checked by:**
	Average Deflection: 1.47"	**Date:**	5/23/12	



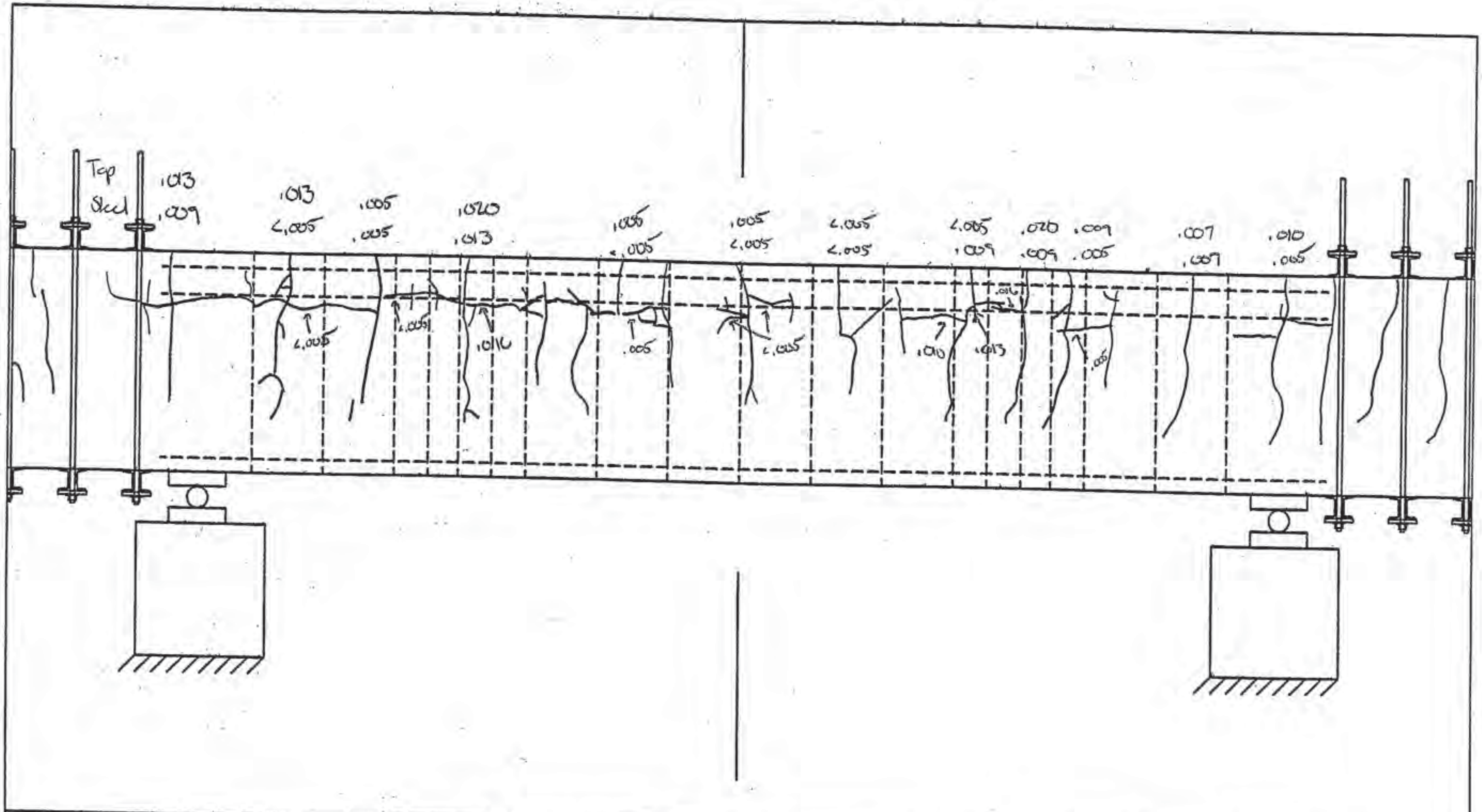
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-2	**Sheet:**	1	**of**	1
Average Load:	36K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	1.86"	**Date:**	5/23/12		

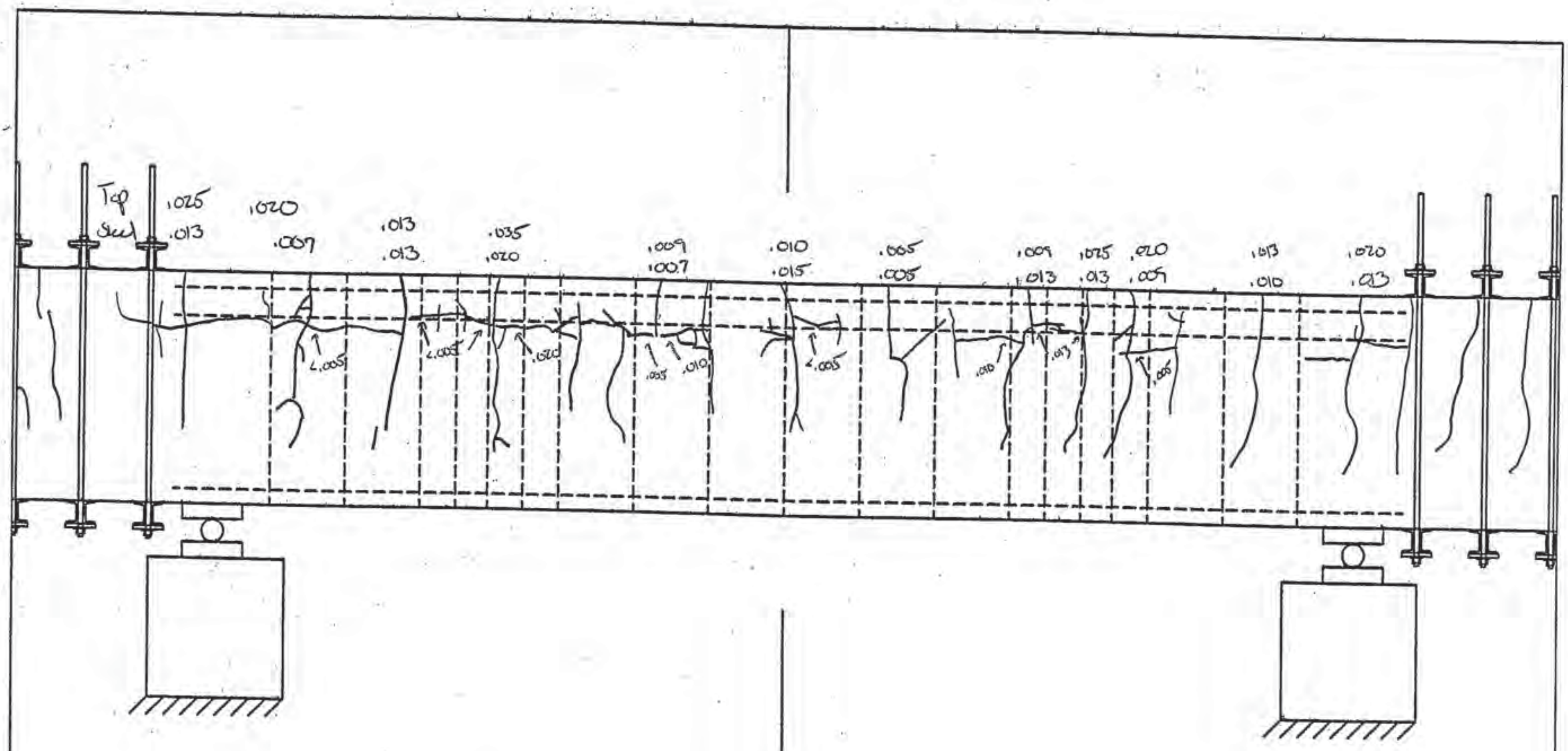


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-2	**Sheet:**	1	**of**	1
Average Load:	18K unload	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	1.25"	**Date:**	5/23/12		

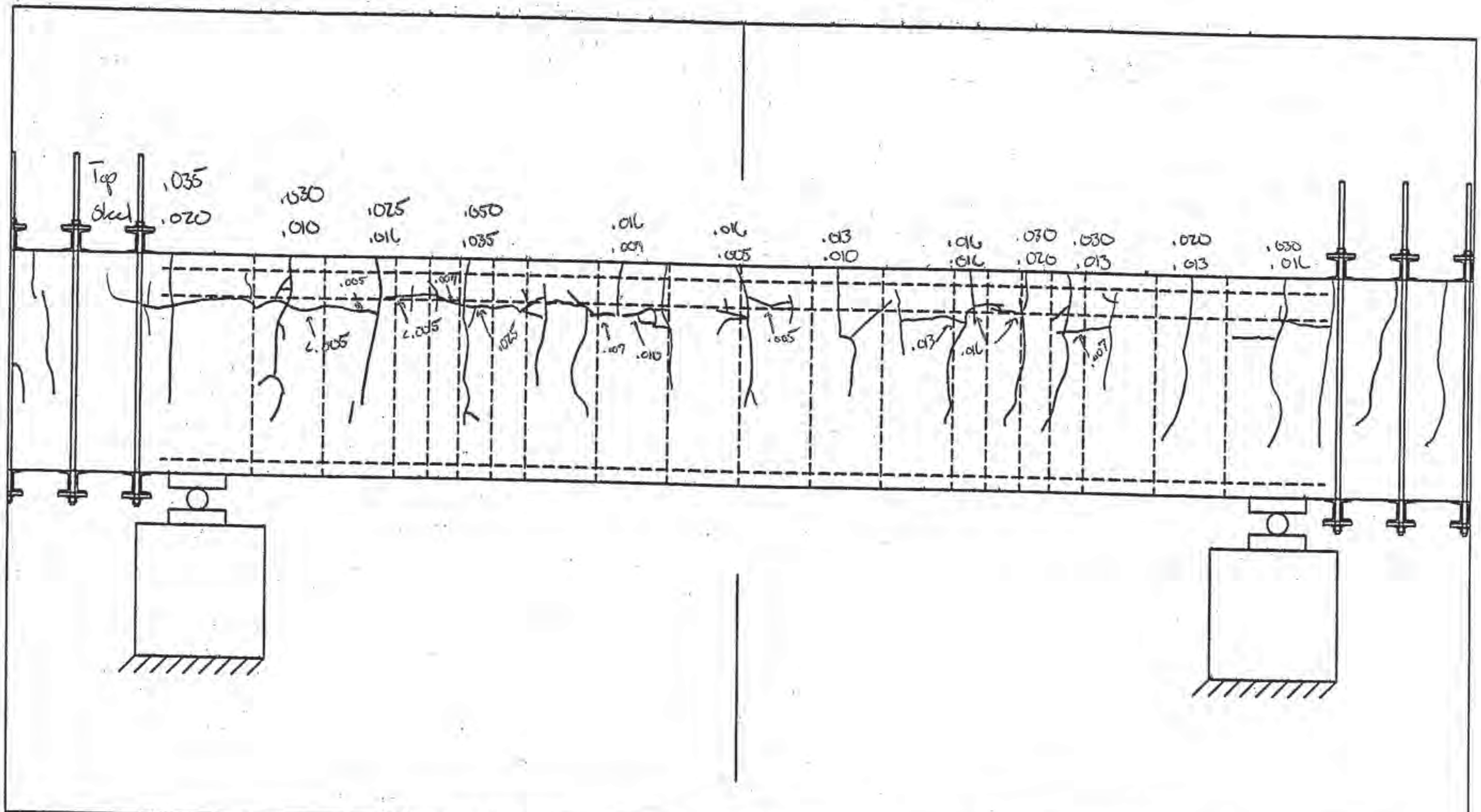


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-2	**Sheet:**	1	**of**	1
	Average Load: OK Unload	**Drawn by:**	BPR	**Checked by:**	
	Average Deflection: 0.48"	**Date:**	5/23/12		

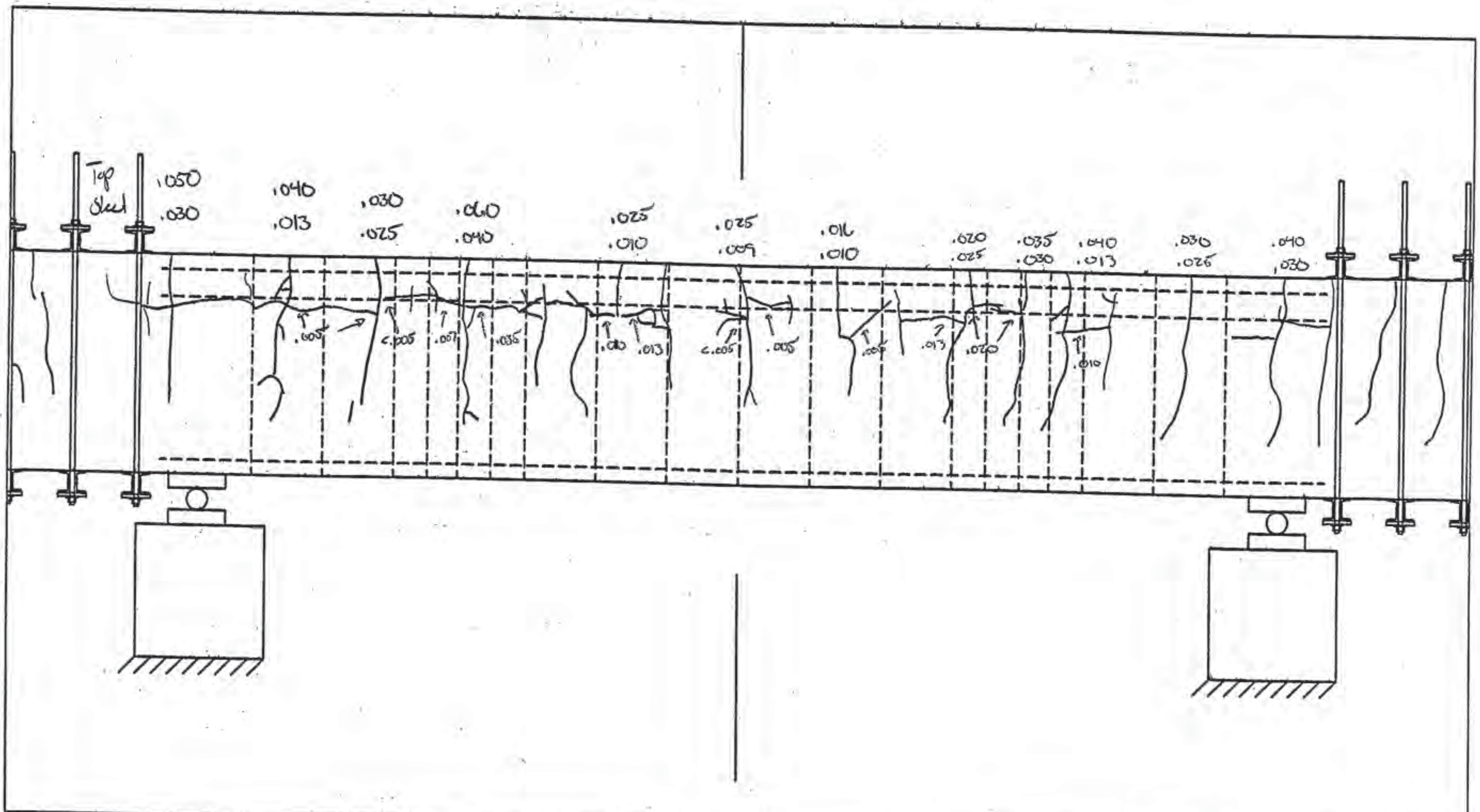


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-2	**Sheet:**	1	**of**	1
Average Load:	12 K Reload	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	0.88"	**Date:**	5/23/12		

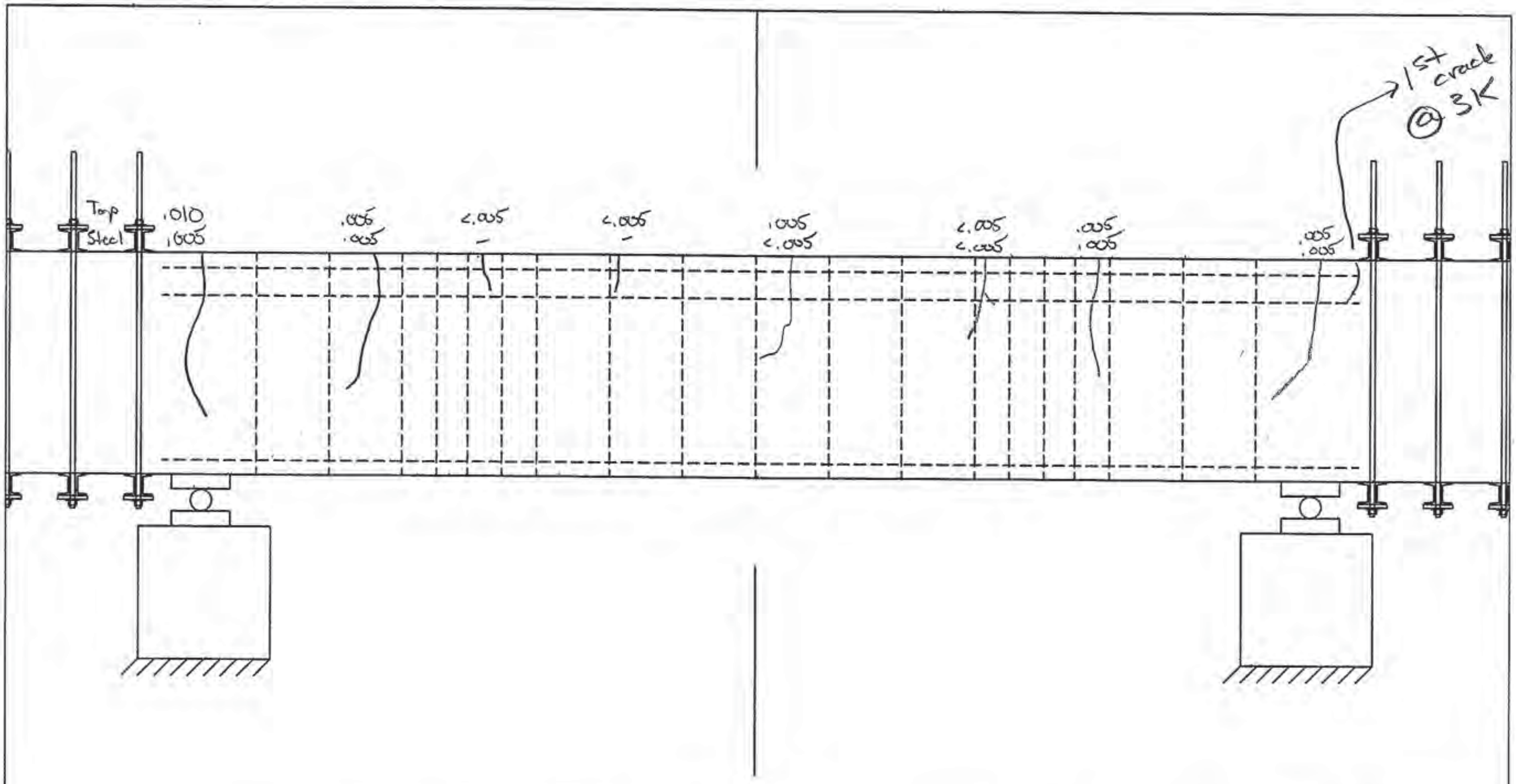


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-2	**Sheet:**	1	**of**	1
	Average Load: 24k	**Drawn by:**	BPR	**Checked by:**	
	Average Deflection: 1.41"	**Date:**	5/23/12		

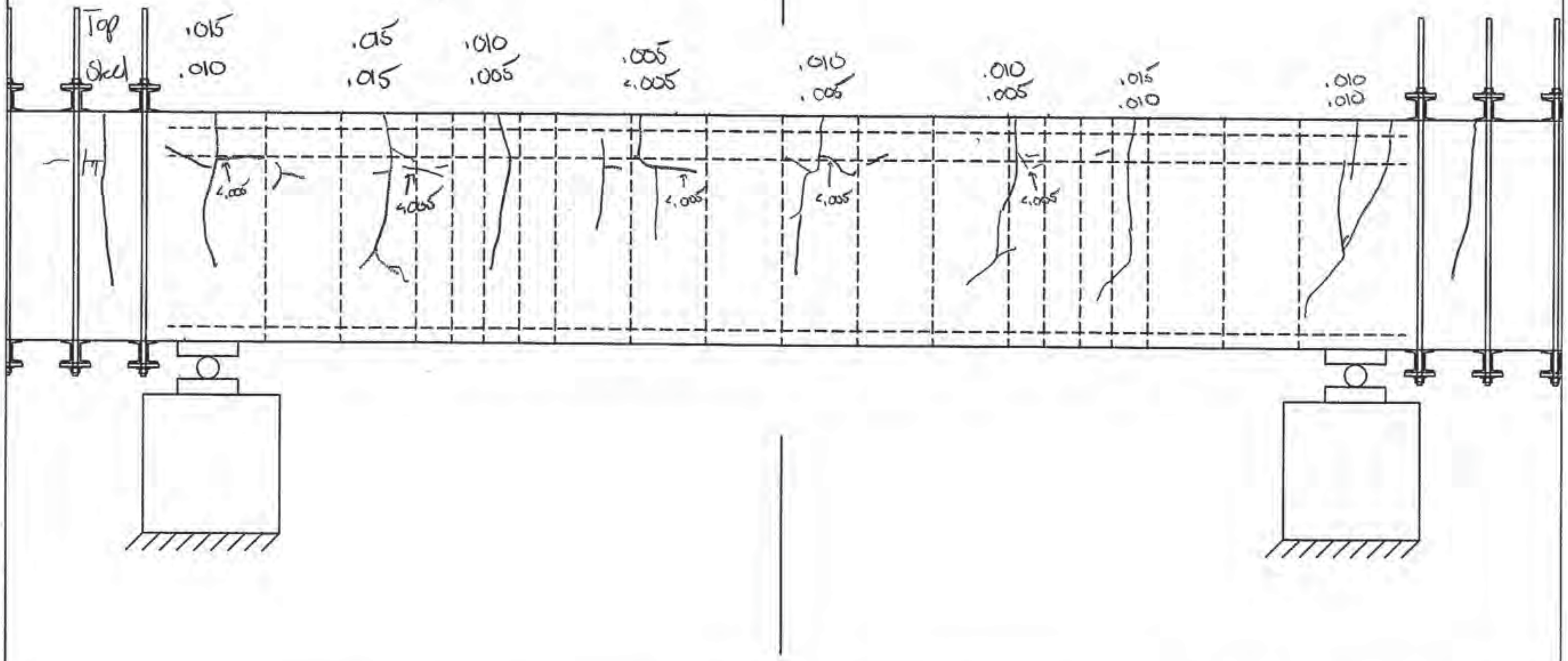


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-2	**Sheet:**	1	of	1
Average Load:	36K Reload	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	1.94"	**Date:**	5/23/12		

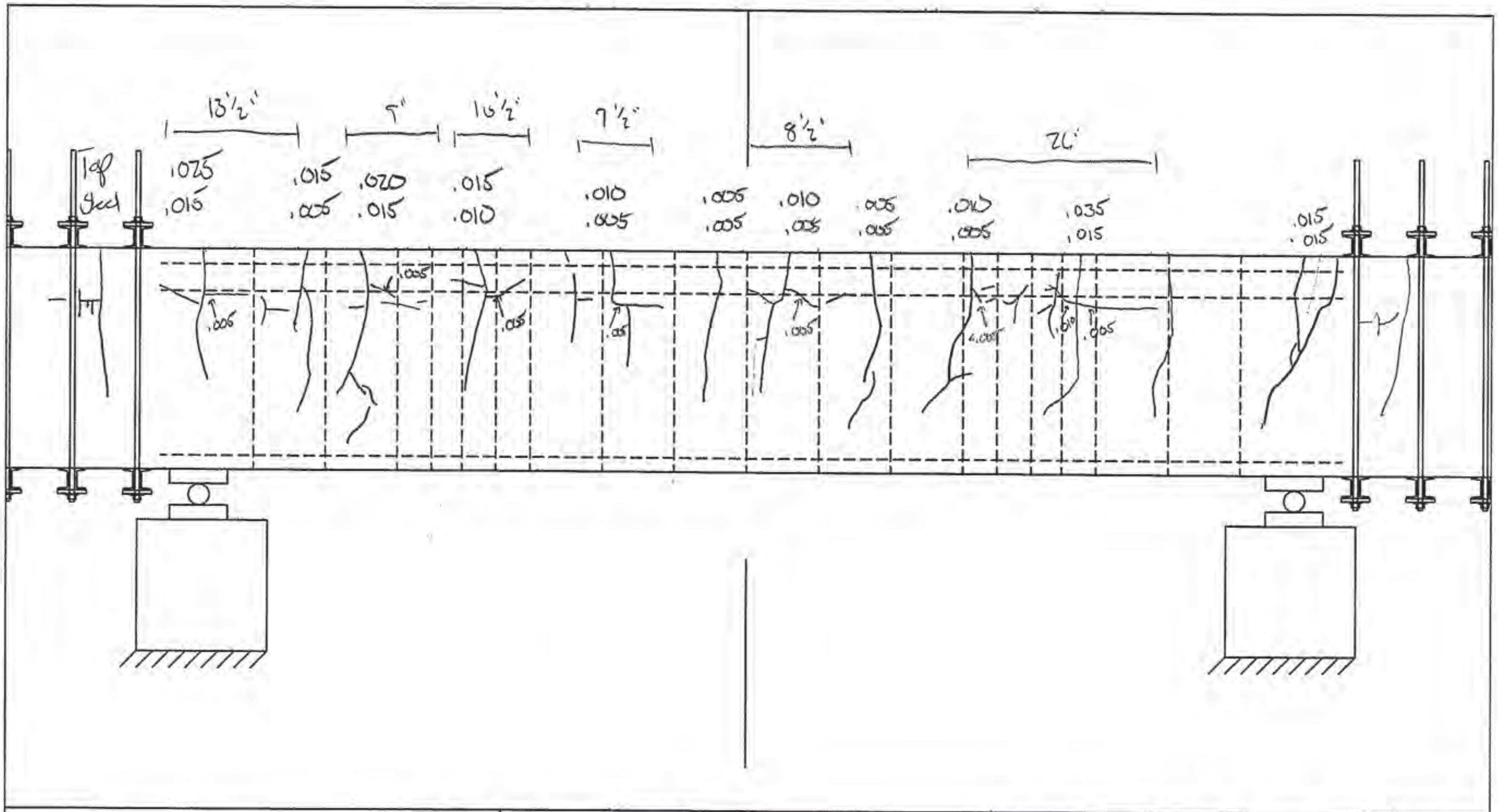


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-3	**Sheet:** 1	**of** 1
	Average Load: 6K	**Drawn by:** BPR	**Checked by:**
	Average Deflection: 0.14"	**Date:** 5/21/12	



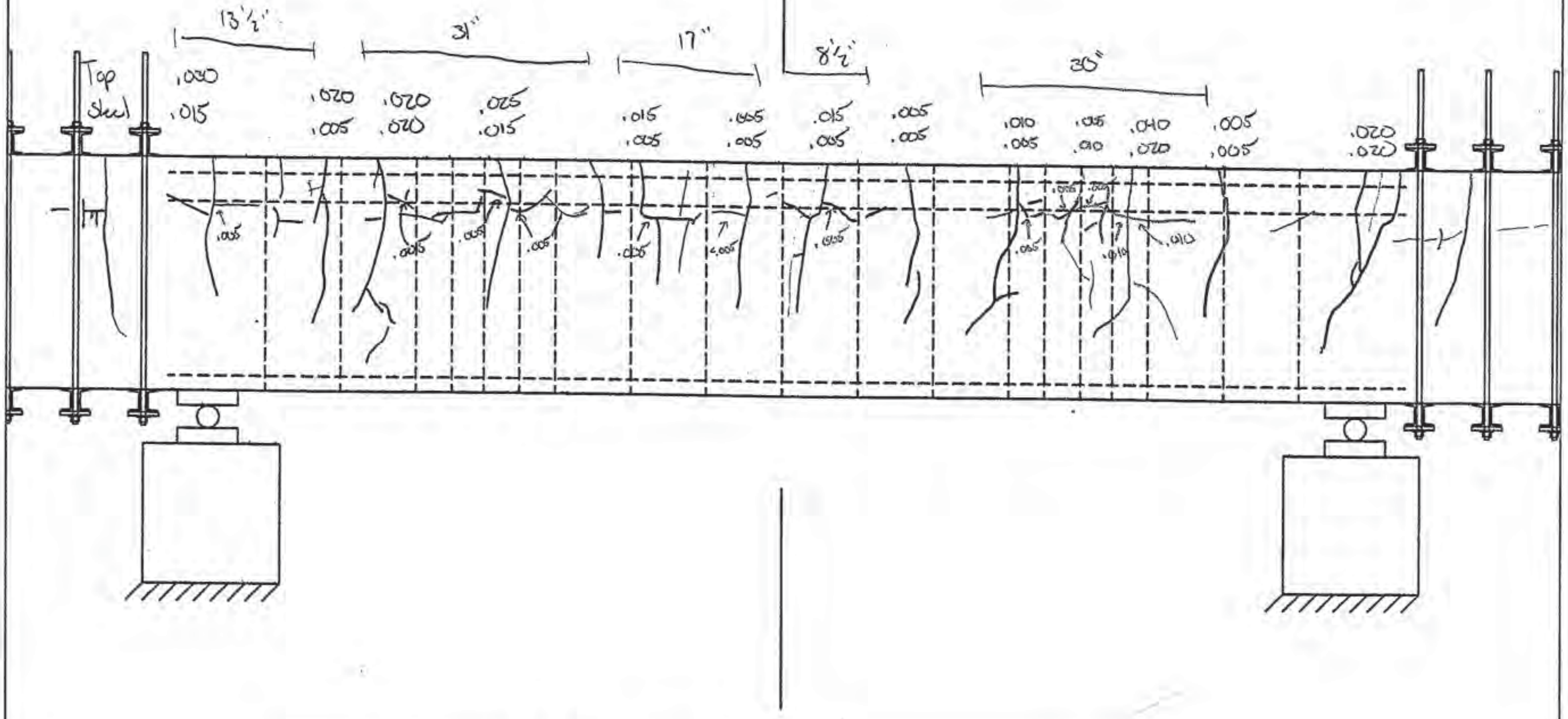
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-3	**Sheet:**	1	**of**	1
Average Load:	12K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	0.41"	**Date:**	5/21/12		



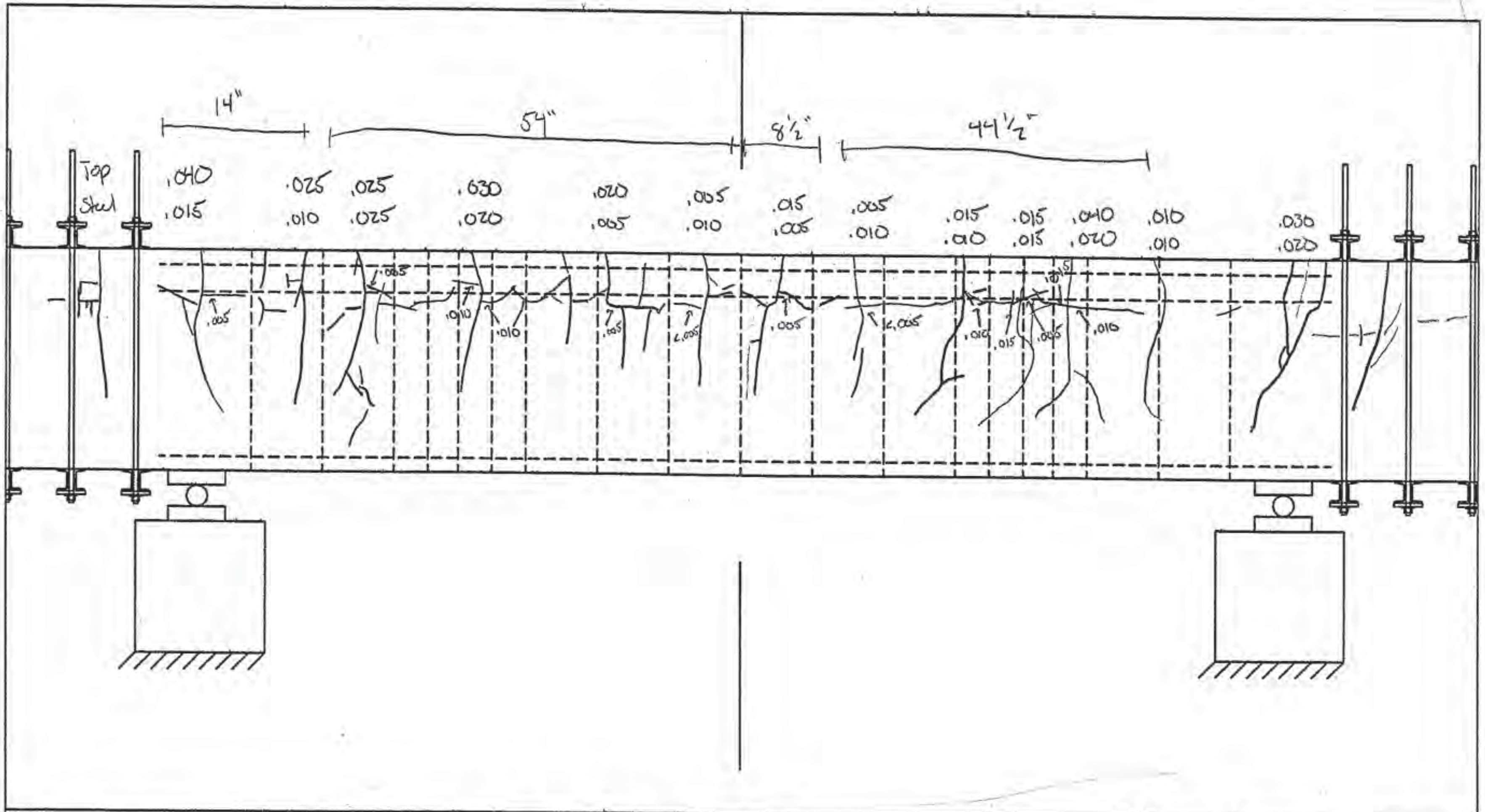
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: B - 3	**Sheet:**	1	of	1
Average Load: 18K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection: 0.76"	**Date:**	5/21/12		



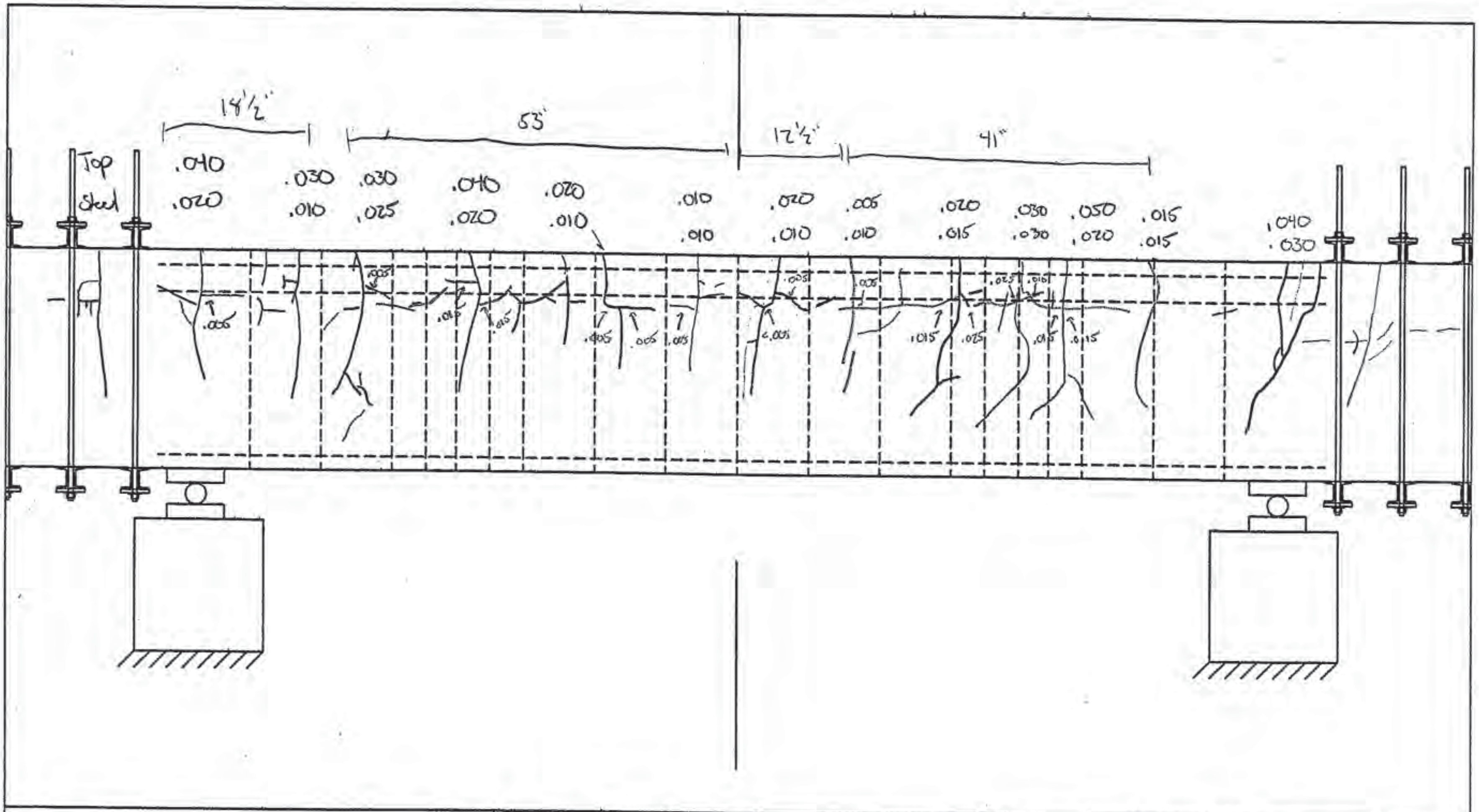
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B - 3	**Sheet:**	1	**of**	1
Average Load:	24K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	1,08"	**Date:**	5/21/12		



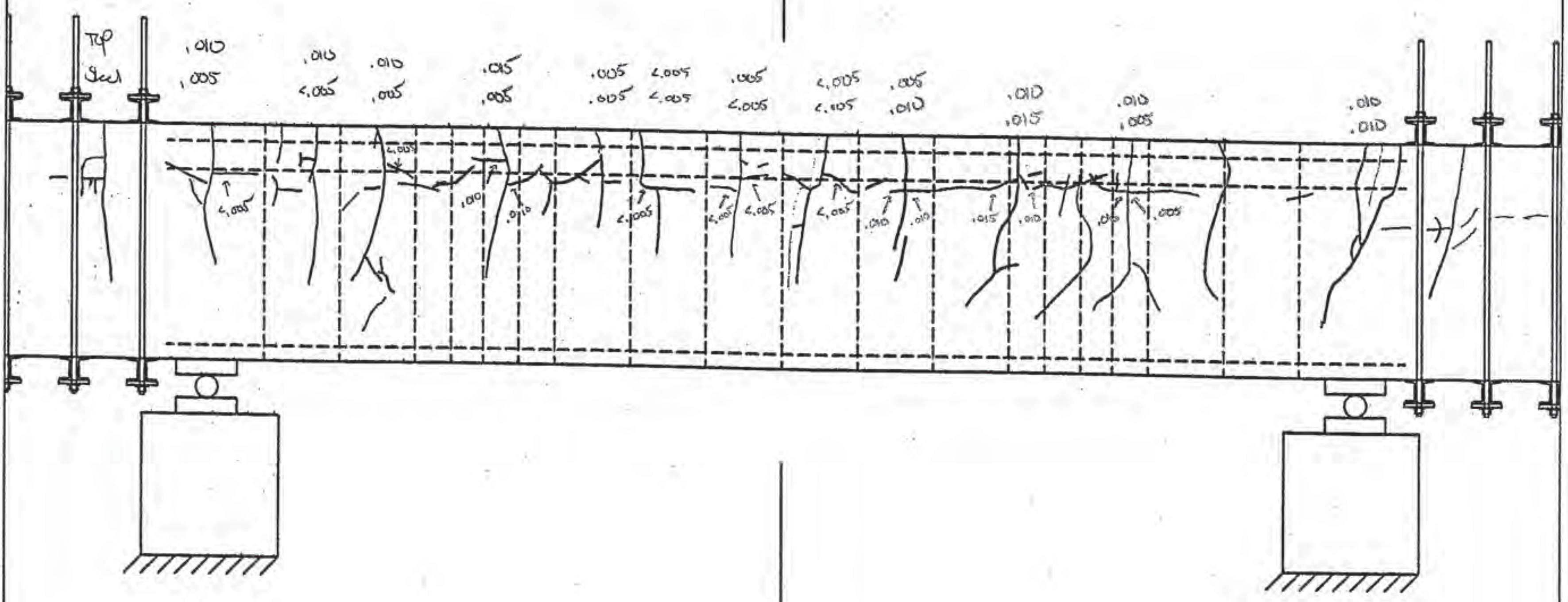
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: B-3	**Sheet:**	1	of	1
Average Load: 30K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection: 1.42"	**Date:**	5/21/12		



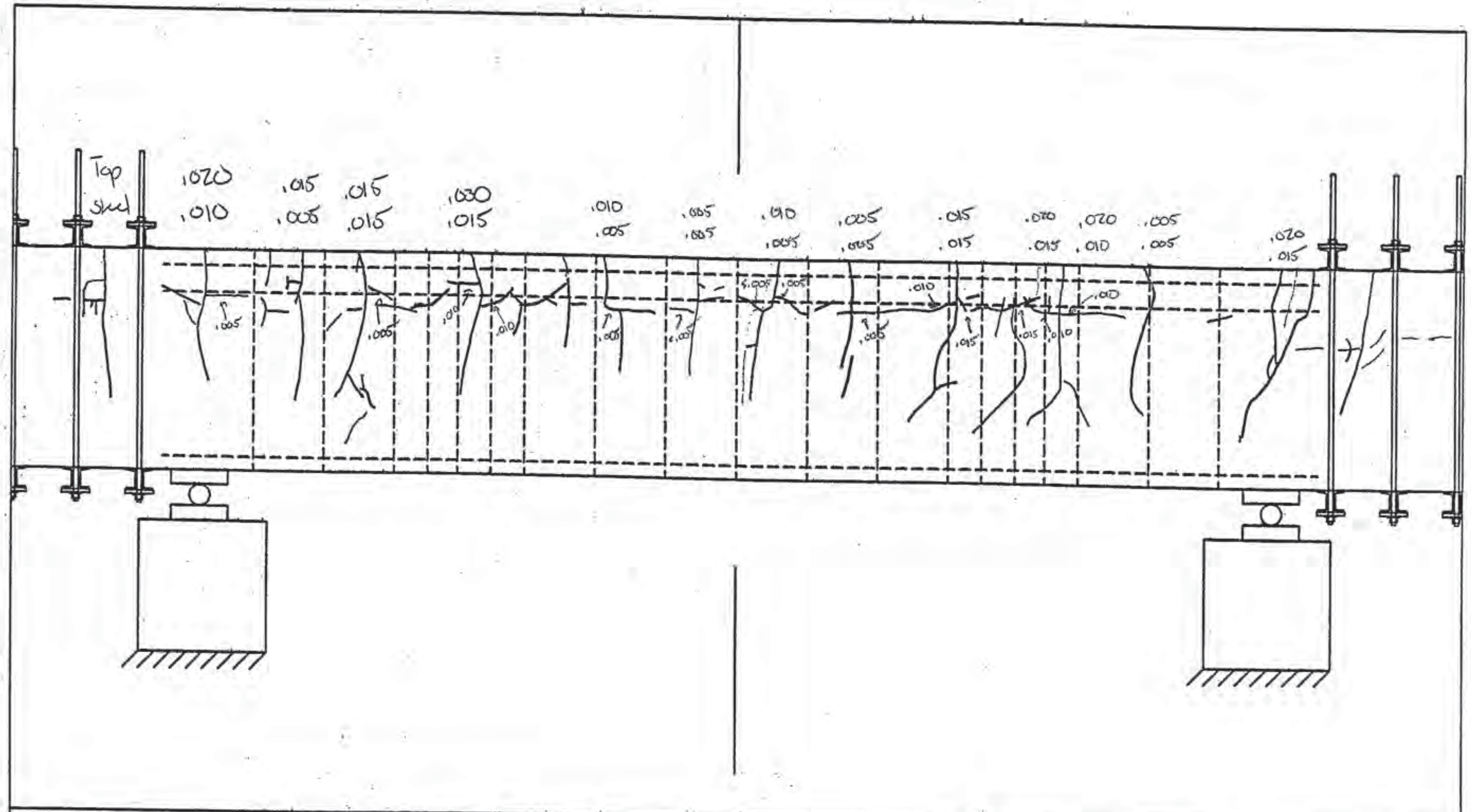
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: B - 3	**Sheet:**	1	of	1
Average Load: 36K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection: 1.79"	**Date:**	5/21/12		



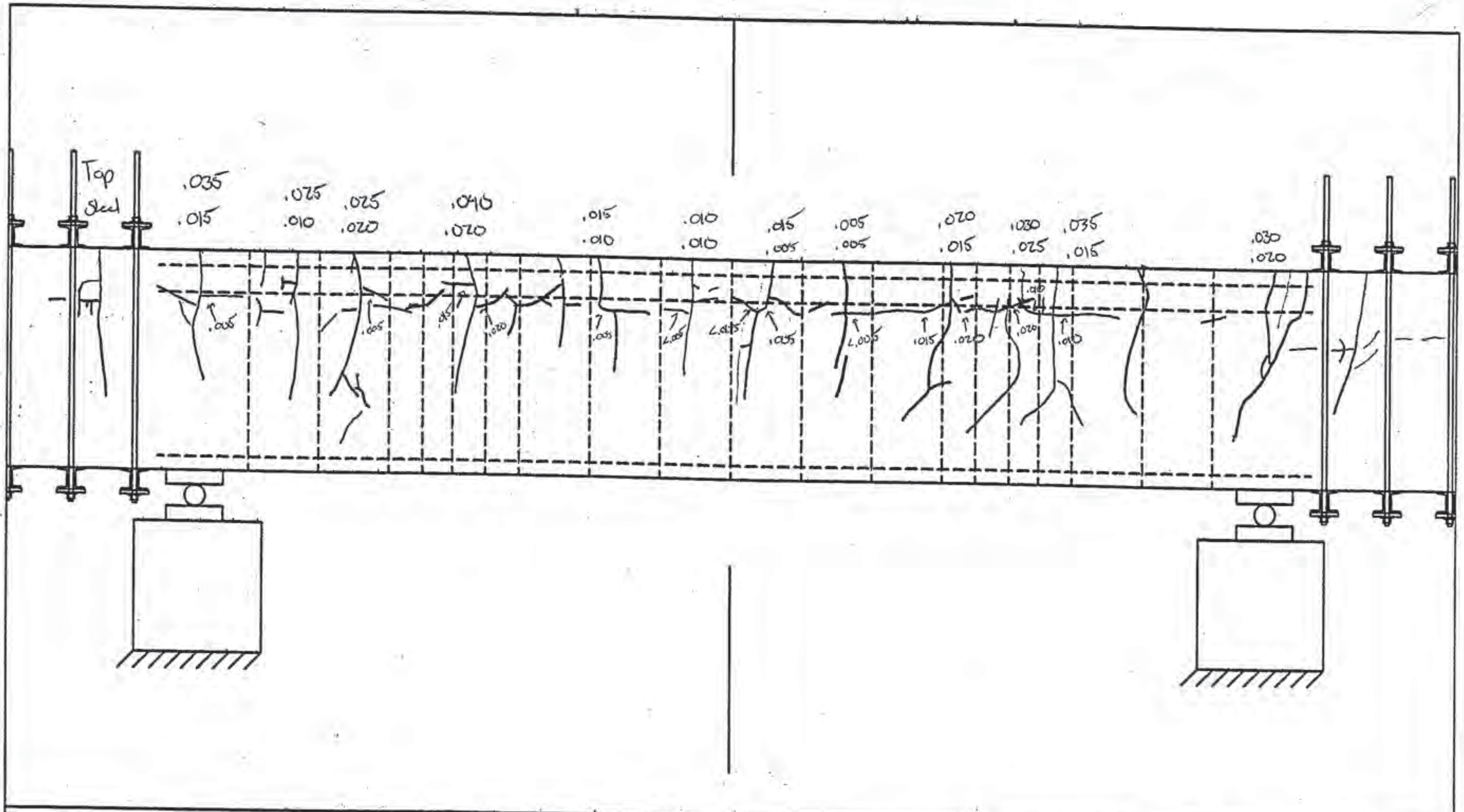
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-3	**Sheet:**	1	of	1
Average Load:	OK	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	0.45"	**Date:**	5/21/12		



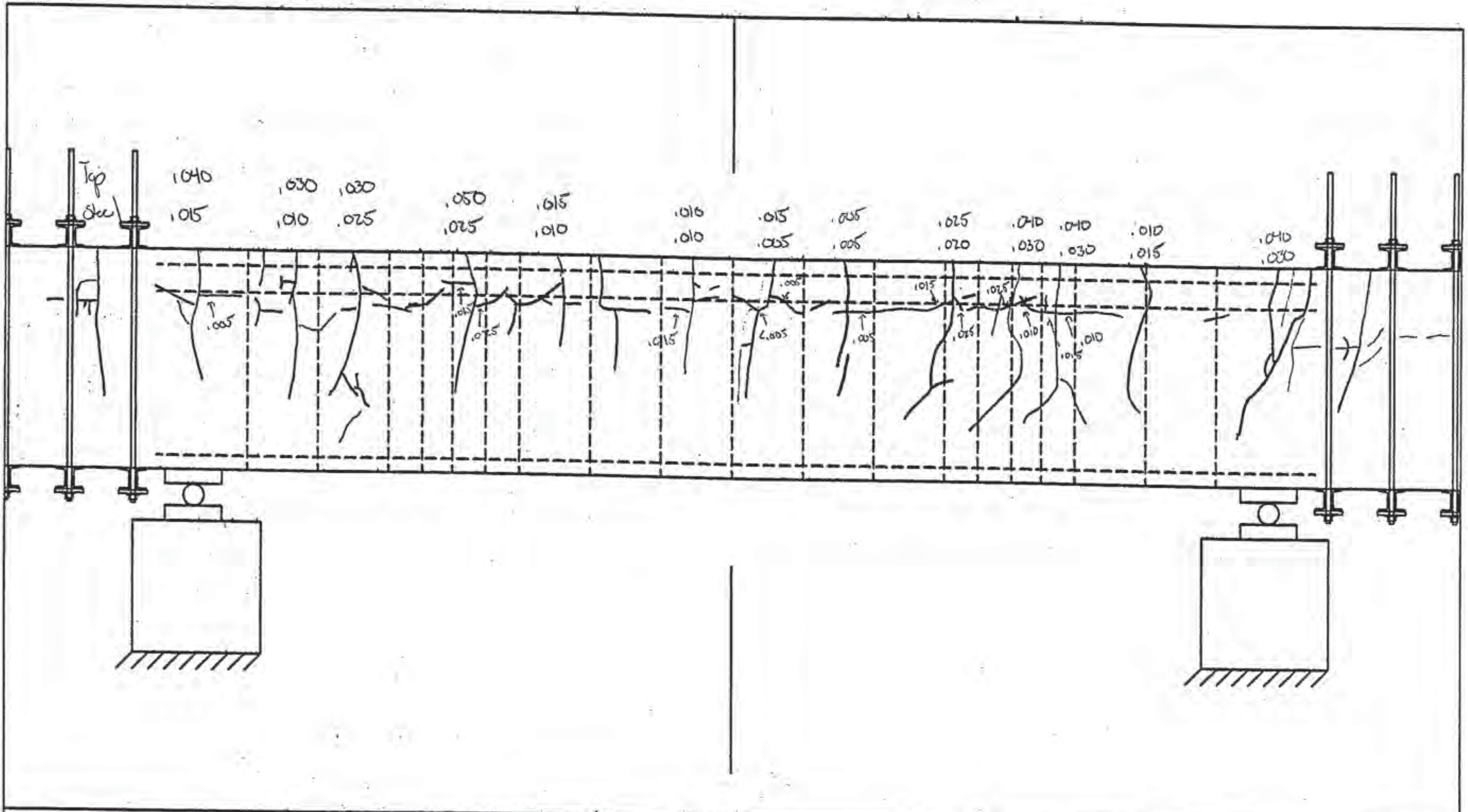
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-3	**Sheet:**	1	**of**	1
Average Load:	12K Reload	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	0.85"	**Date:**	5/21/12		



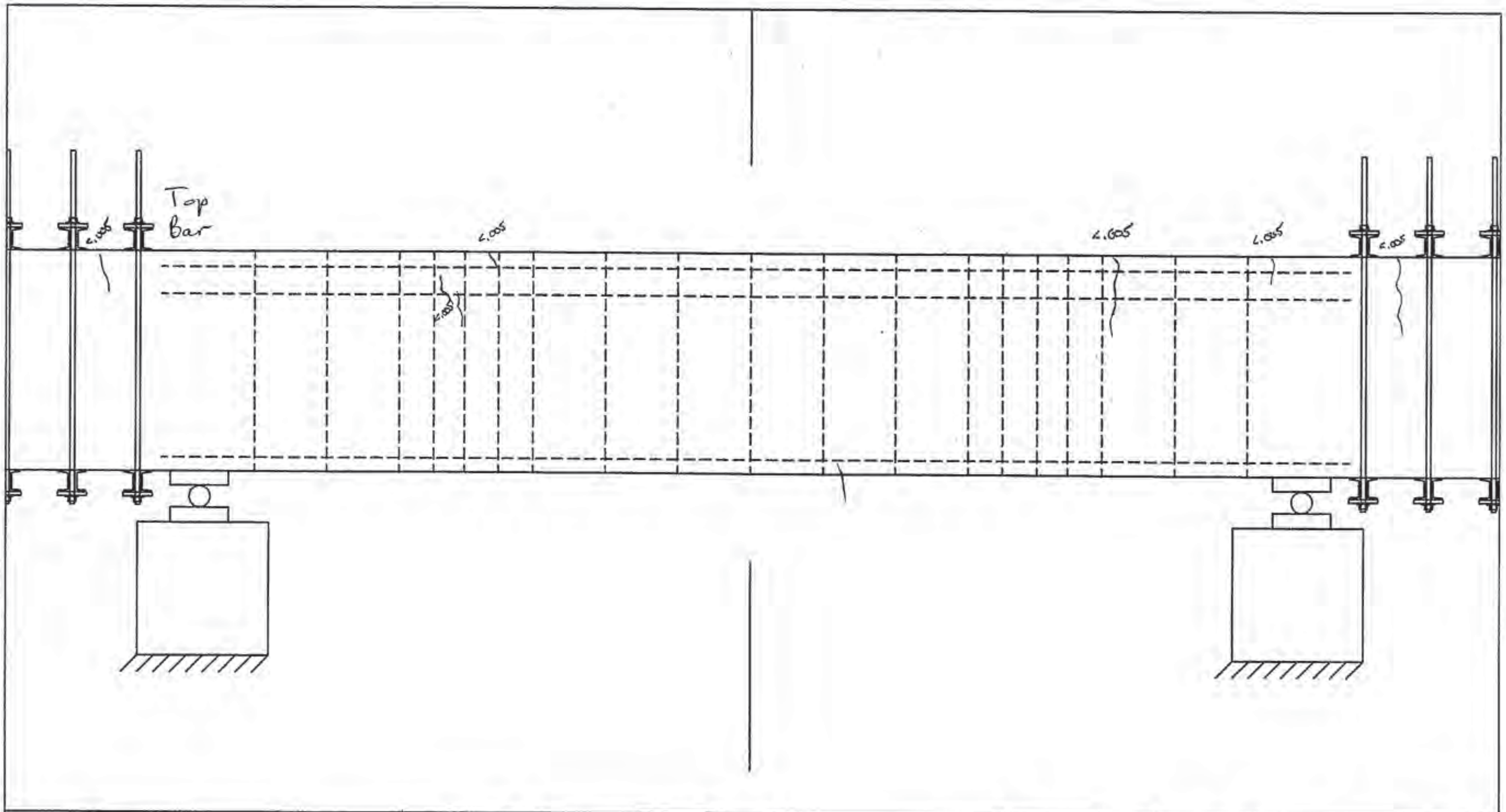
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-3	**Sheet:**	1	**of**	1
Average Load:	24K Reload	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	1.35"	**Date:**	5/21/12		



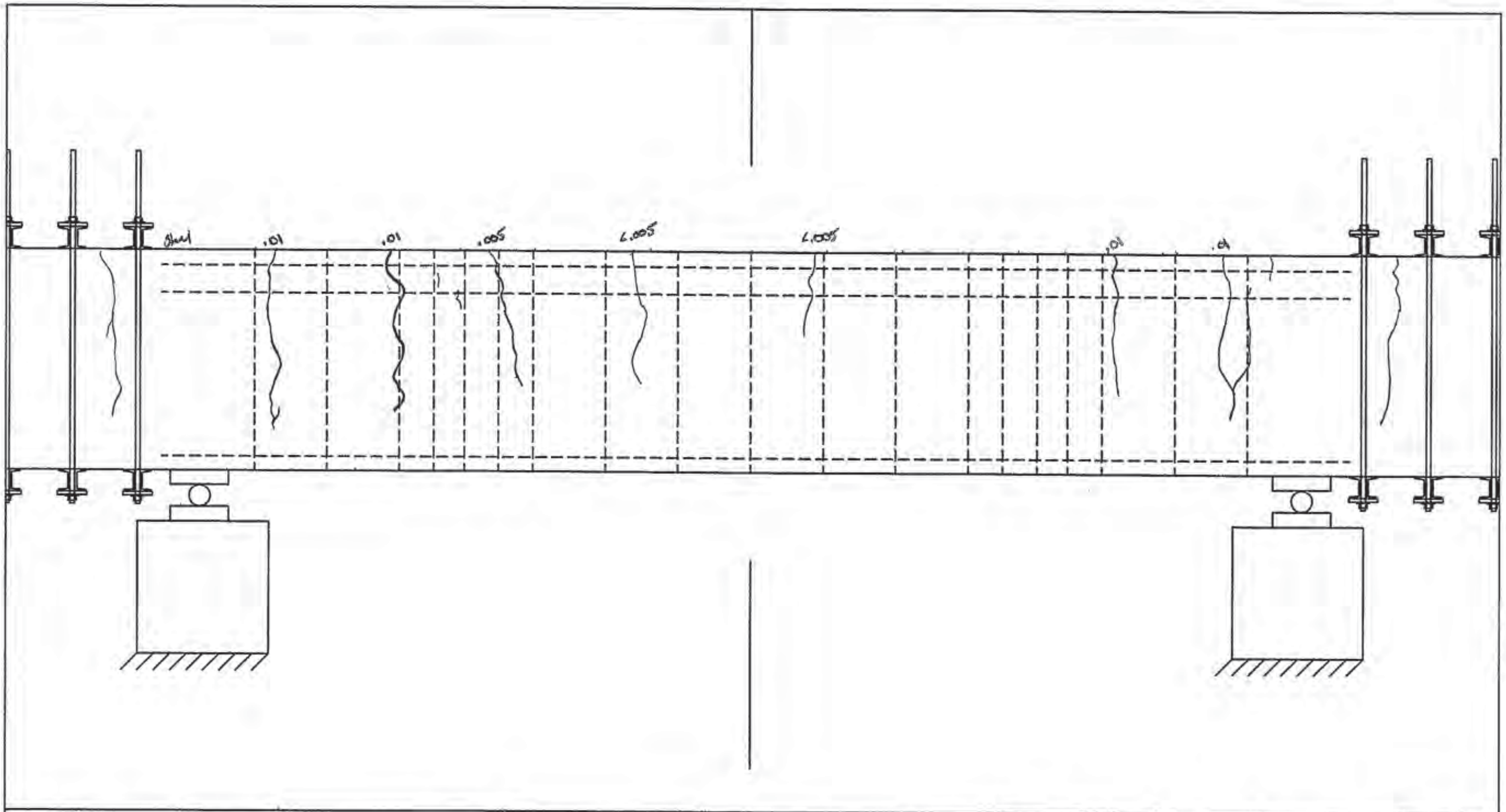
Specimen: B-3	**Sheet:**	1	of	1
Average Load: 36K Reload	**Drawn by:**	BPR	**Checked by:**	
Average Deflection: 1.86"	**Date:**	5/21/12		

BOWEN LABORATORY
PURDUE UNIVERSITY



Specimen: B-4	**Sheet:**	1	of	1
Average Load: 5.2K	**Drawn by:**	KM	**Checked by:**	
~~**Midspan**~~ **Deflection:** 0.046 Avg.	**Date:**	5-14-12		

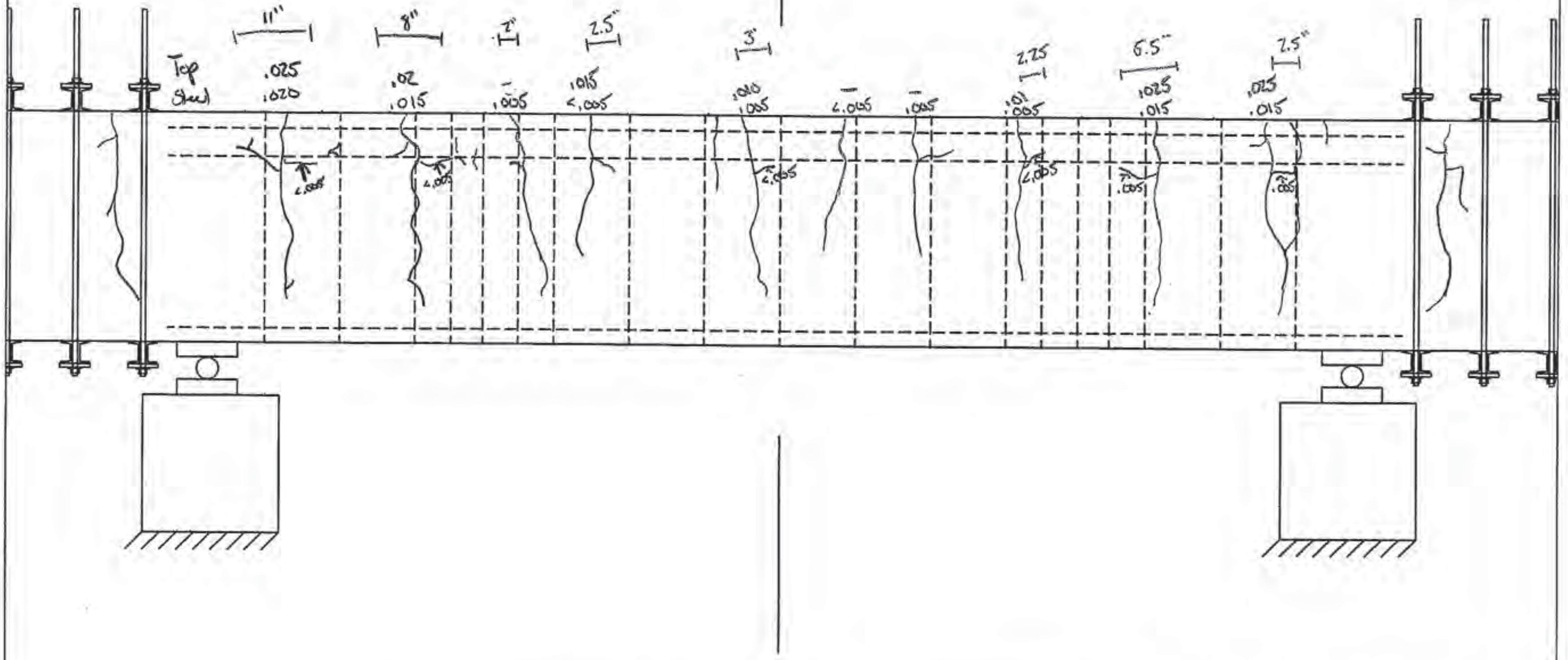
BOWEN LABORATORY
PURDUE UNIVERSITY



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: B-4	**Sheet:**	1	**of**	1
Average Load: 12	**Drawn by:**	KM	**Checked by:**	
Midspan Deflection: ,32	**Date:**	5-14-12		

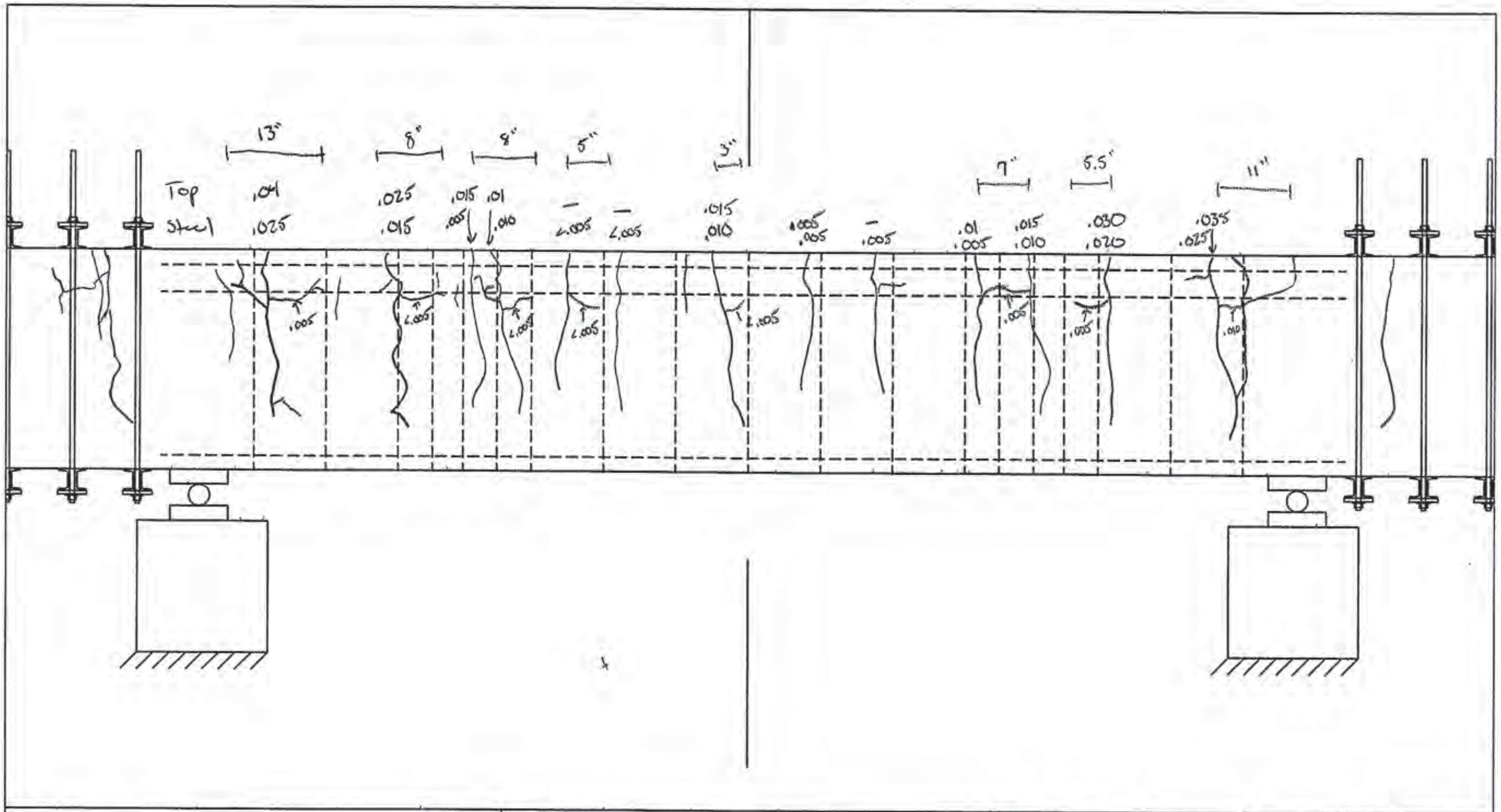
Avg.



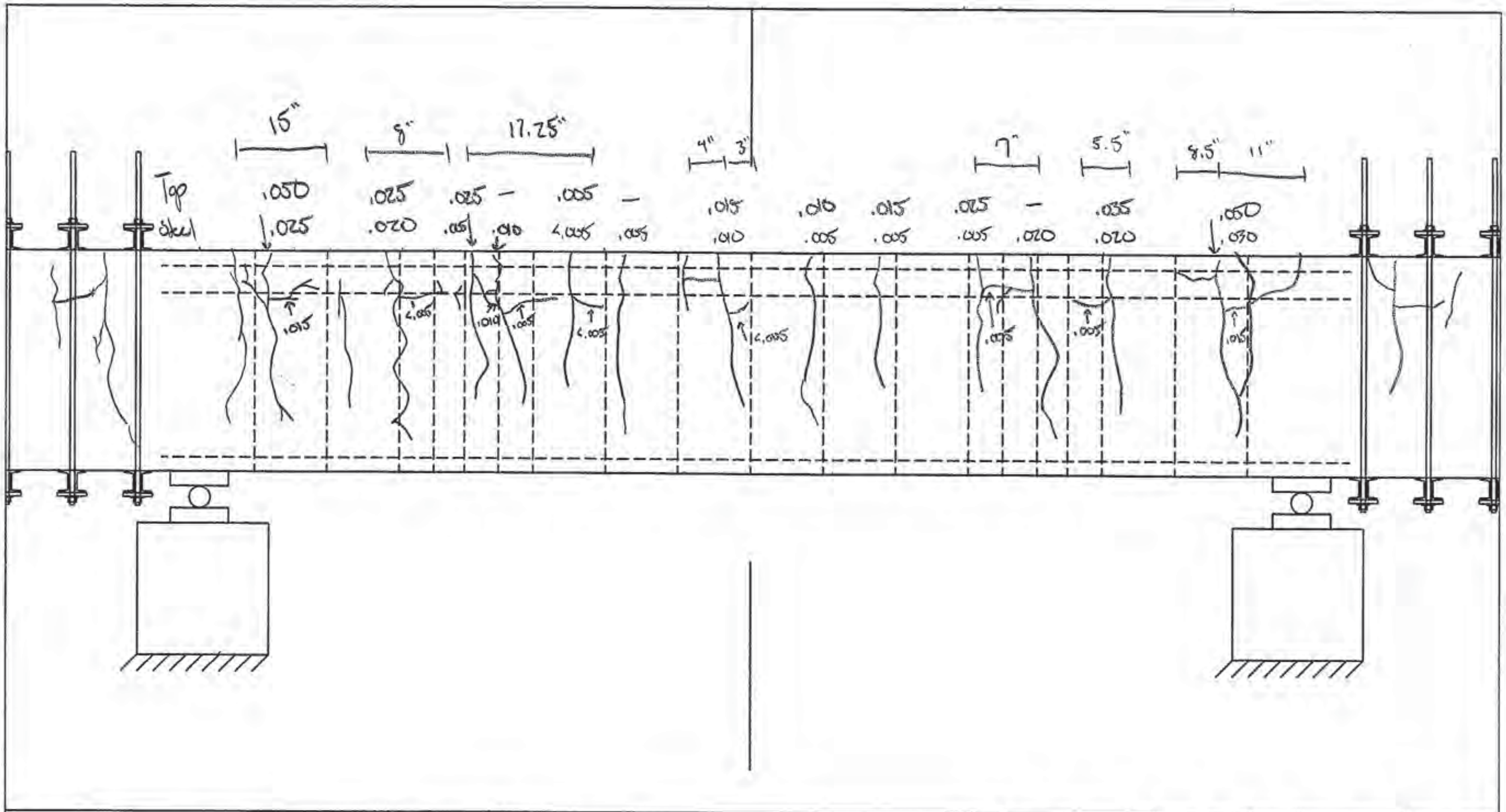
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: B-4	**Sheet:**	1	**of**	1
Average Load: 18"	**Drawn by:**	KM	**Checked by:**	
Midspan Deflection: 0.62	**Date:**	5-14-12		

Avg

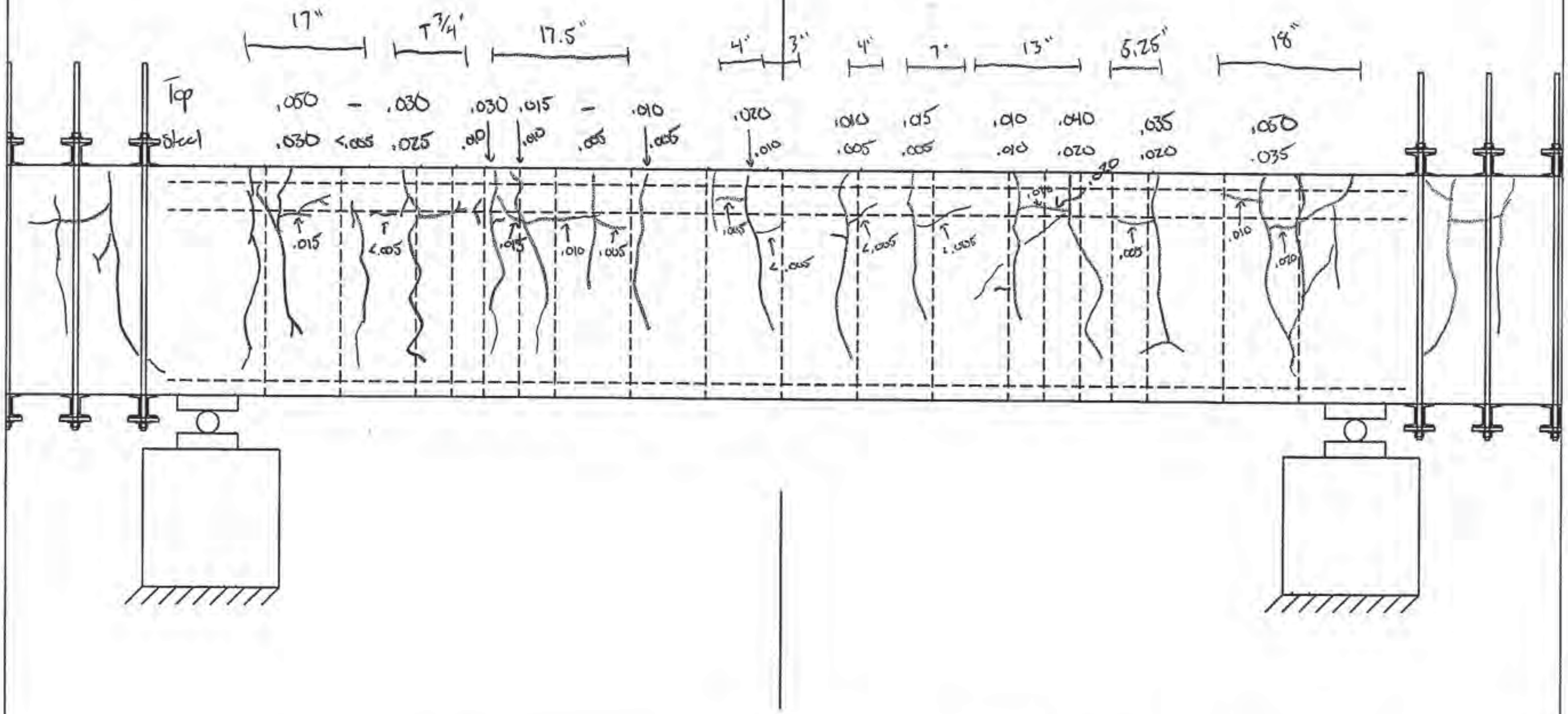


BOWEN LABORATORY PURDUE UNIVERSITY					
	Specimen: B-4	**Sheet:**	1	**of**	1
	Average Load: 24k	**Drawn by:**	KM	**Checked by:**	
	Midspan Deflection: 0.94	**Date:**	5-14-12		



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-4	**Sheet:**	1	of	1
	Average Load: 30k	**Drawn by:**	KM	**Checked by:**	
	Midspan Deflection: 1.25	**Date:**	5-14-12		

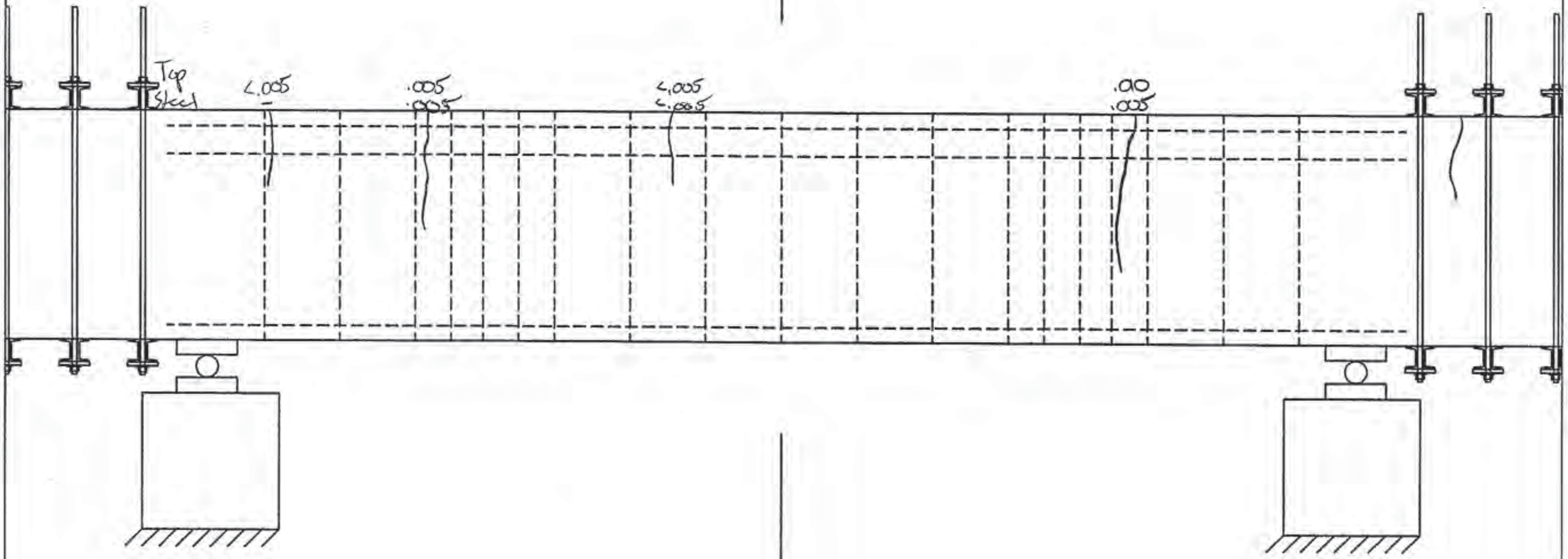
Avg



BOWEN LABORATORY
PURDUE UNIVERSITY

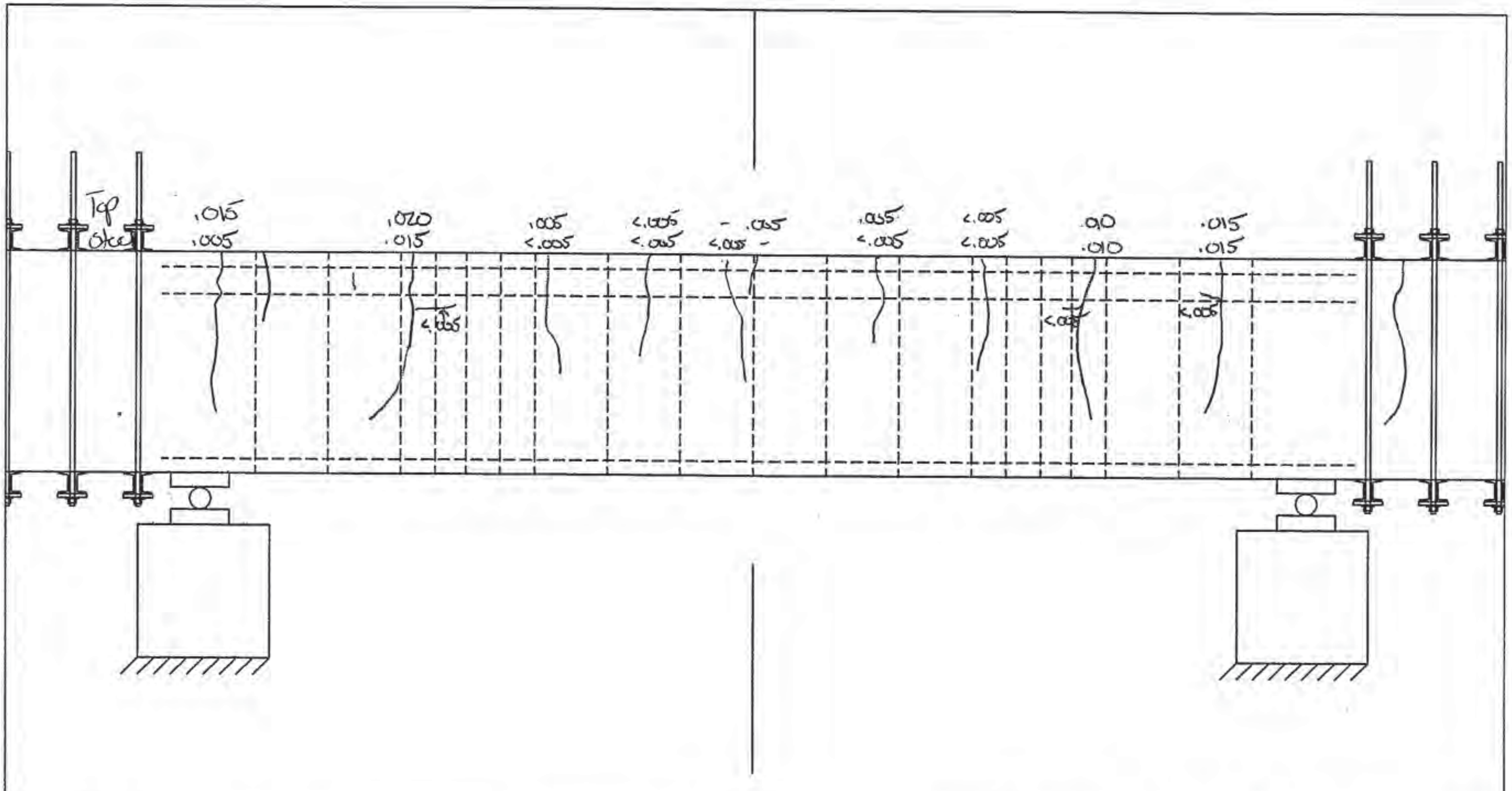
Specimen:	B-4	**Sheet:**	1	**of**	1
Average Load:	36 K	**Drawn by:**	KM	**Checked by:**	
Midspan Deflection:	1.62	**Date:**	5-14-12		

Avg

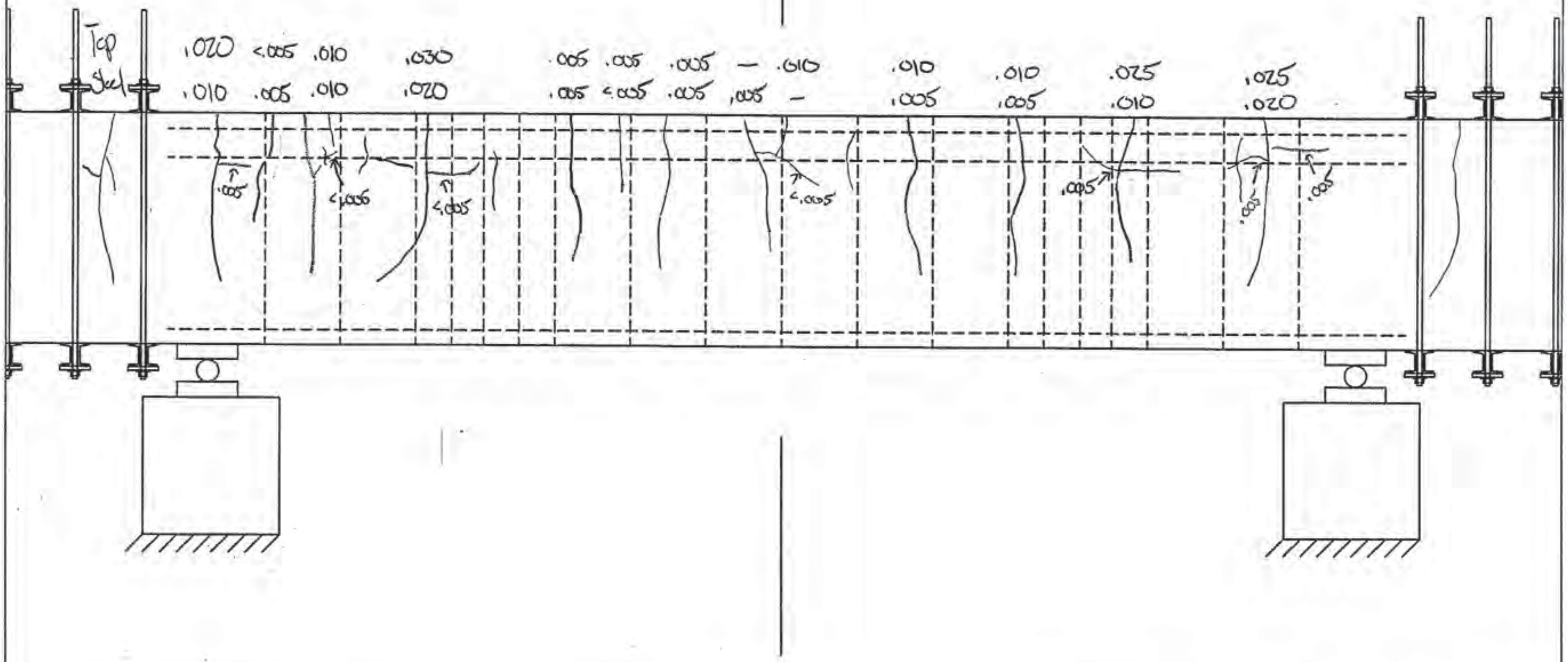


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-5	**Sheet:**	1	of	1
Average Load:	6K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	0.08"	**Date:**	5/17		

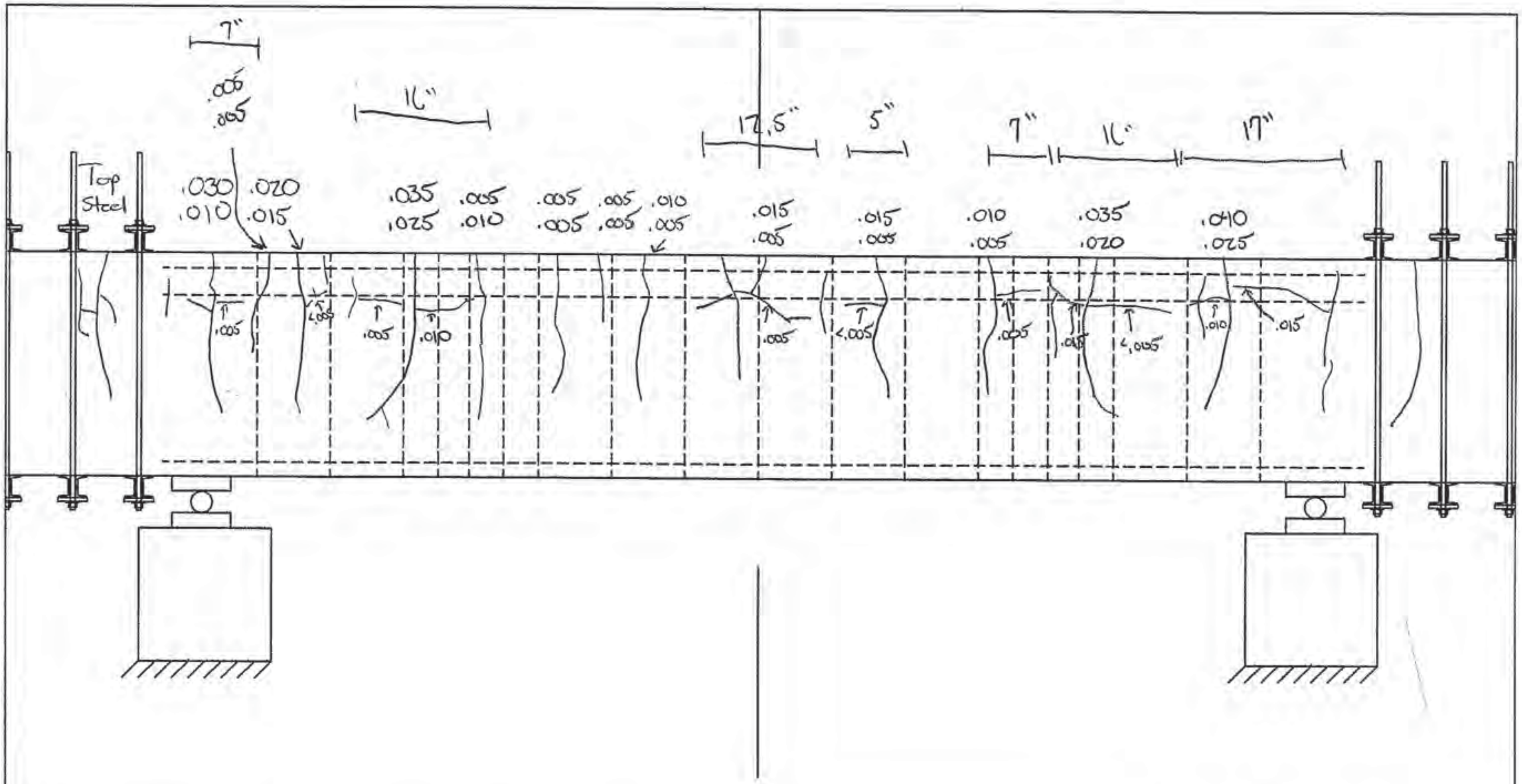


BOWEN LABORATORY PURDUE UNIVERSITY	Specimen: B-5	Sheet:	1	of 1
	Average Load: 12K	Drawn by:	BPR	Checked by:
	Average Deflection: 0.35"	Date:		



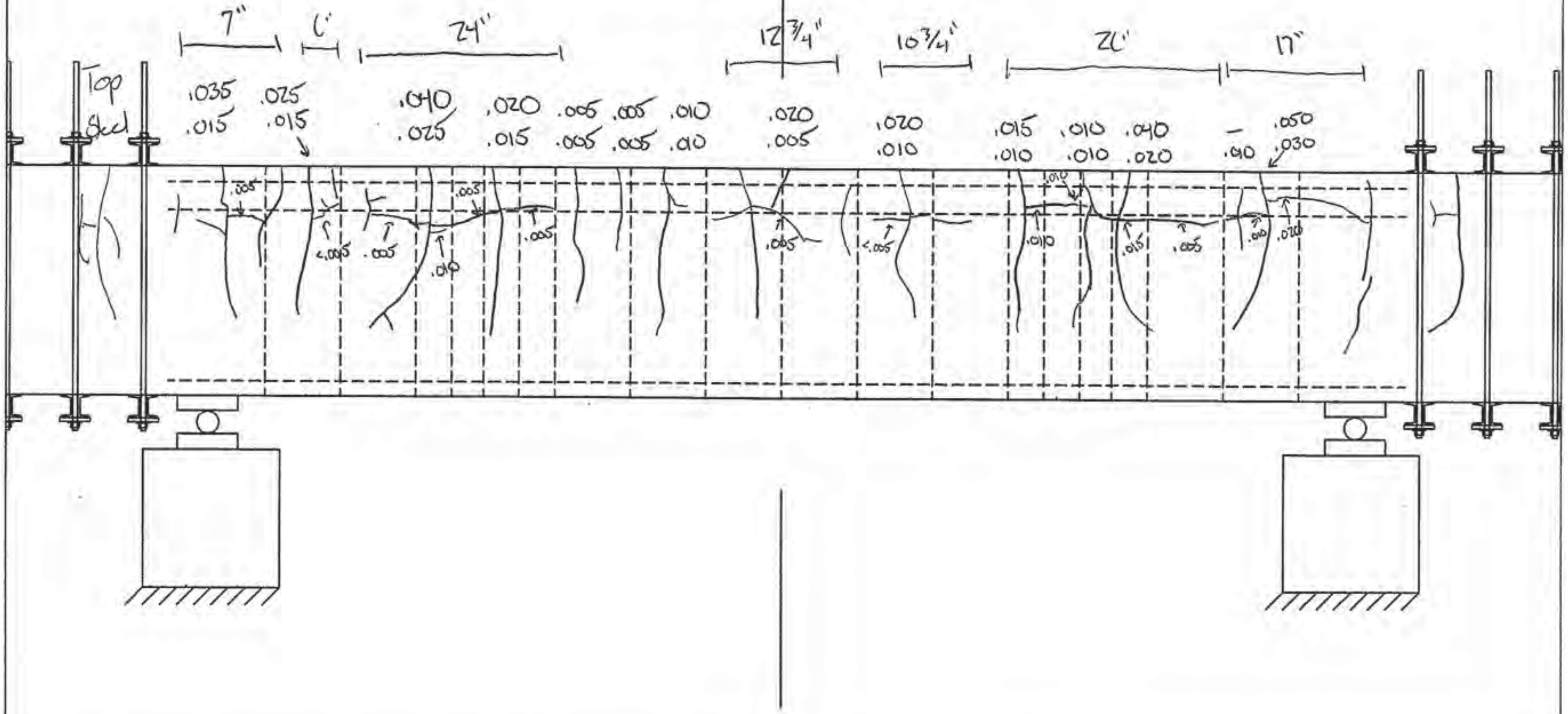
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-5	**Sheet:**	1	**of**	1
Average Load:	18K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	0.68"	**Date:**	5/17		



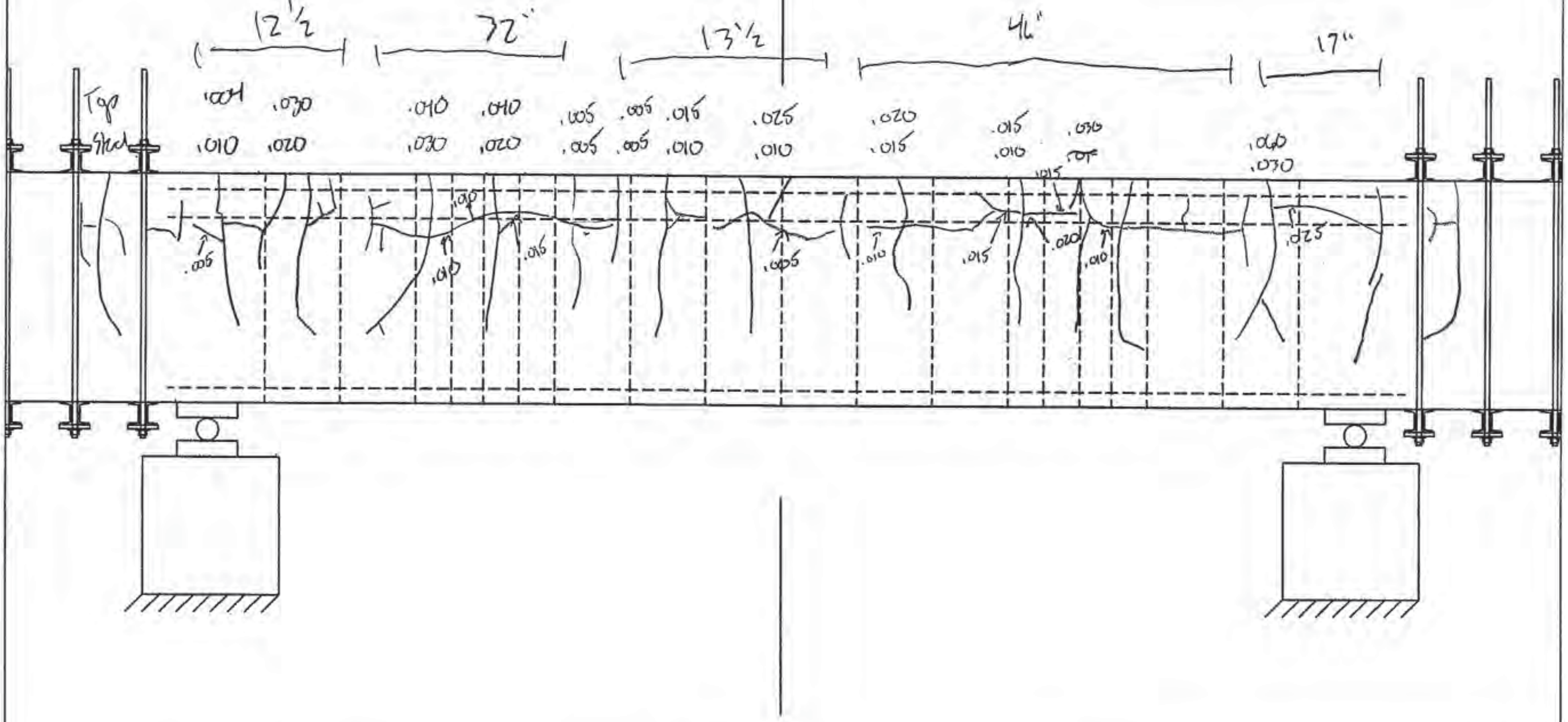
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: B-5	**Sheet:**	1	of	1
Average Load: 24 K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection: 1.0"	**Date:**	5/17		

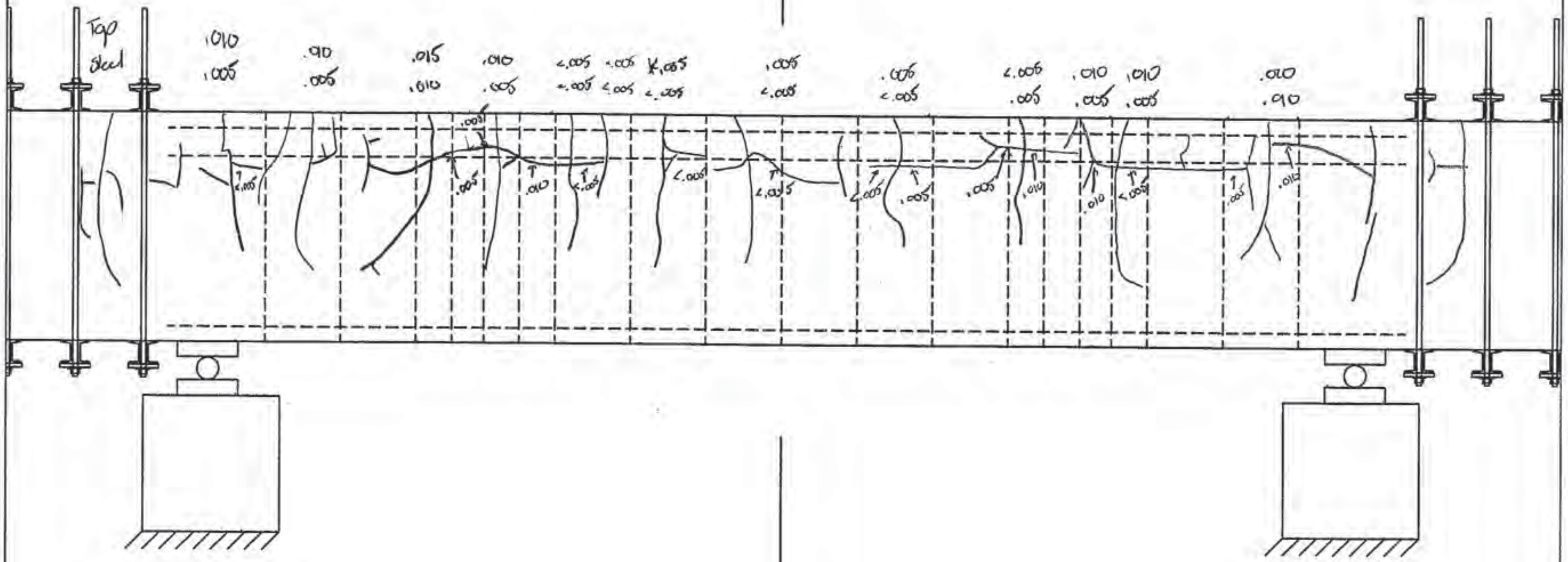


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-5	**Sheet:**	1	**of**	1
Average Load:	30K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	1.31"	**Date:**	5/17		

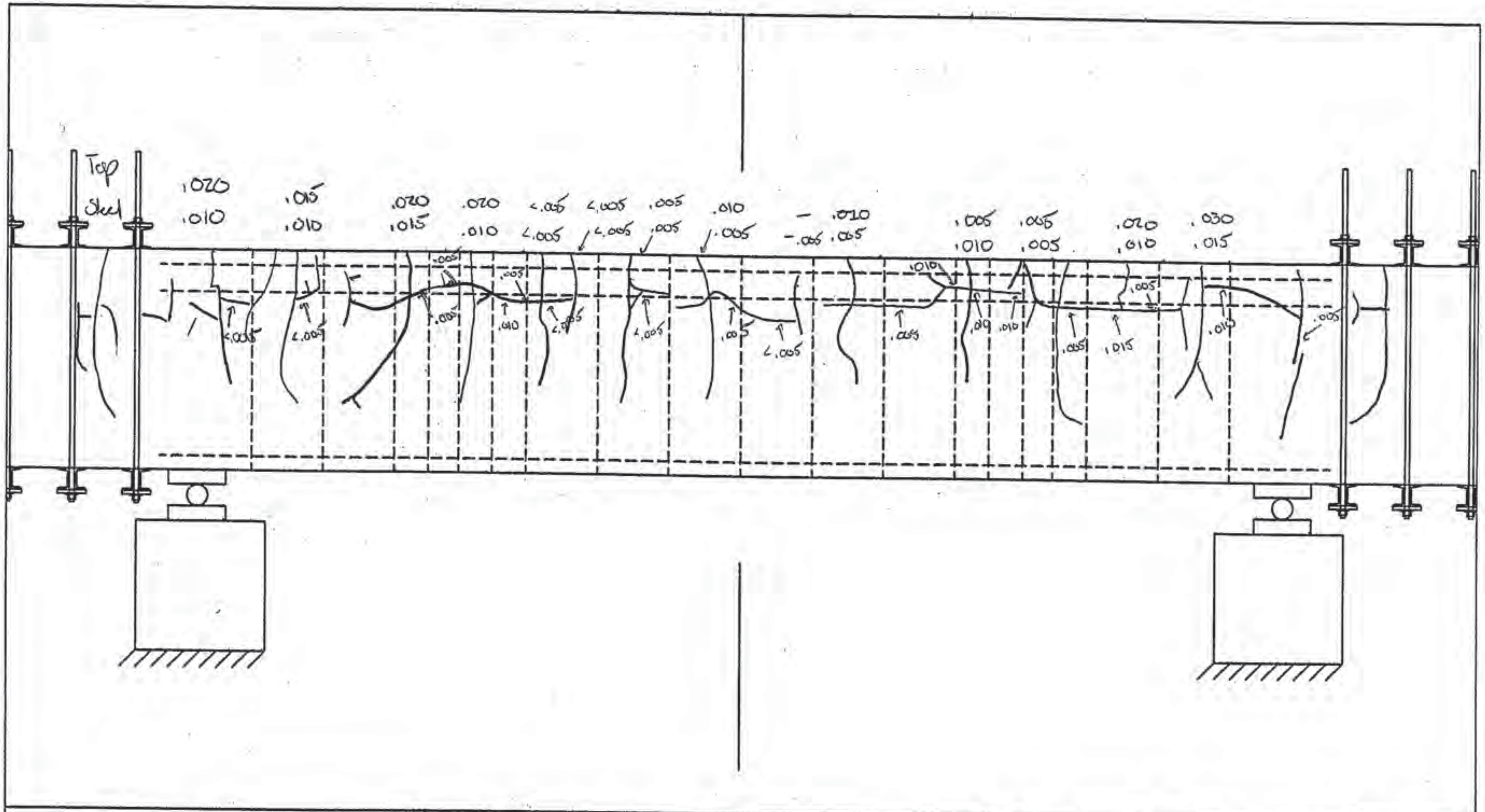


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-5	**Sheet:**	1	of	1
	Average Load: 361K	**Drawn by:**	BPR	**Checked by:**	
	Average Deflection: 1.66"	**Date:**	5/17		



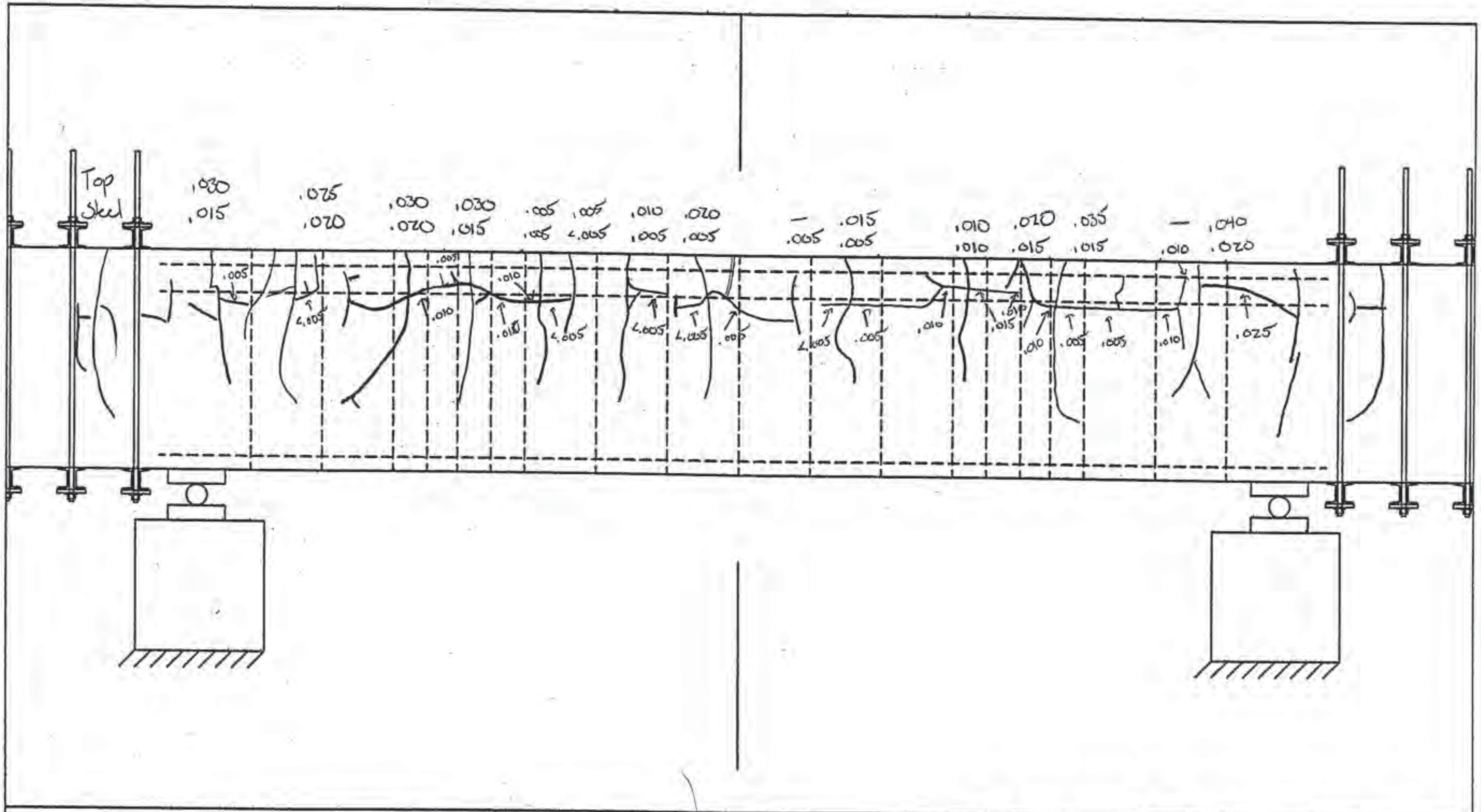
BOWEN
LABORATORY
PURDUE UNIVERSITY

Specimen:	B-5	**Sheet:**	1	**of**	1
Average Load:	0 K	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	0.39"	**Date:**	5/17/12		

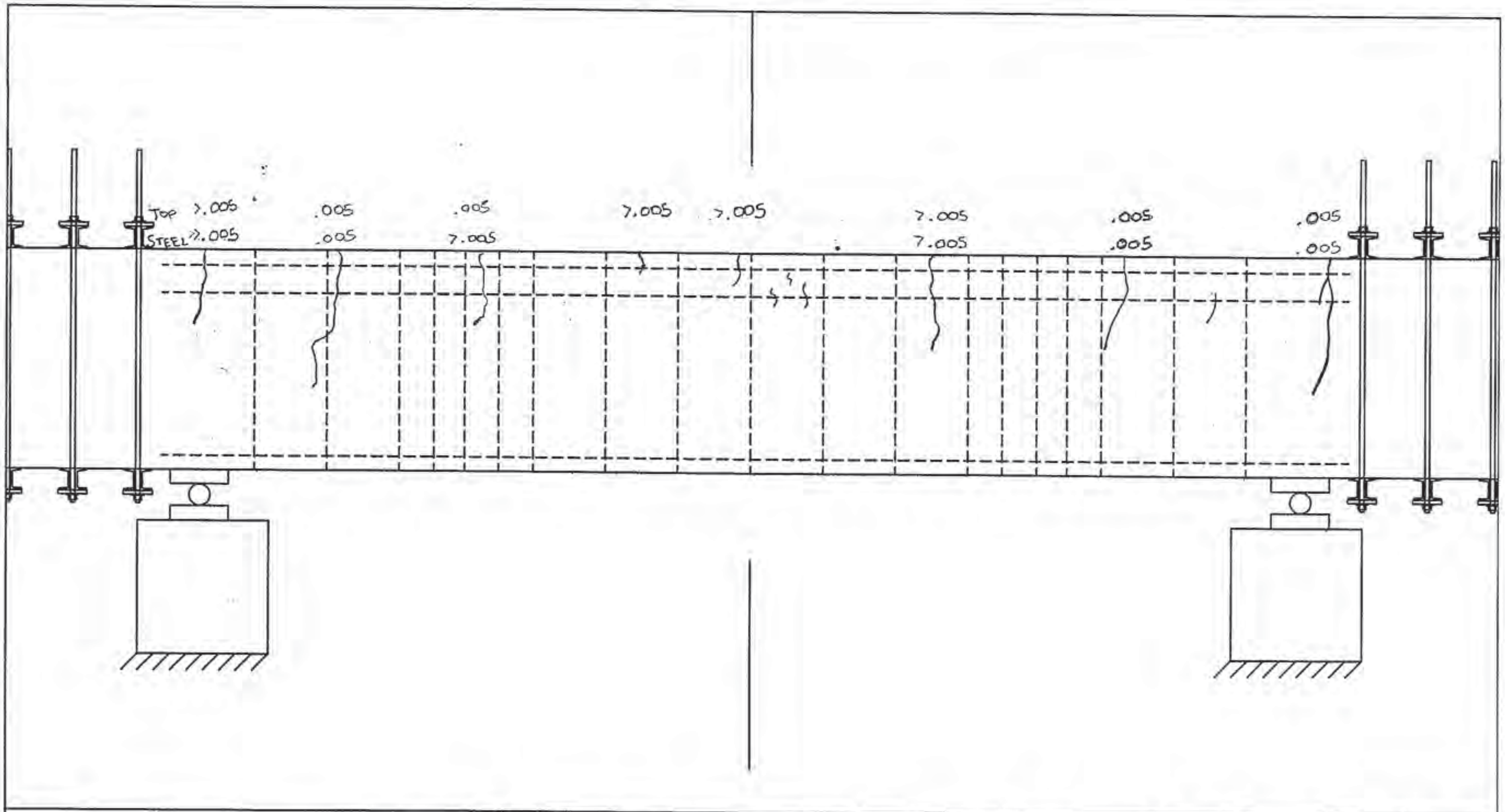


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-5	**Sheet:**	1	**of**	1
Average Load:	12K Reload	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	0.75"	**Date:**	5/17/12		

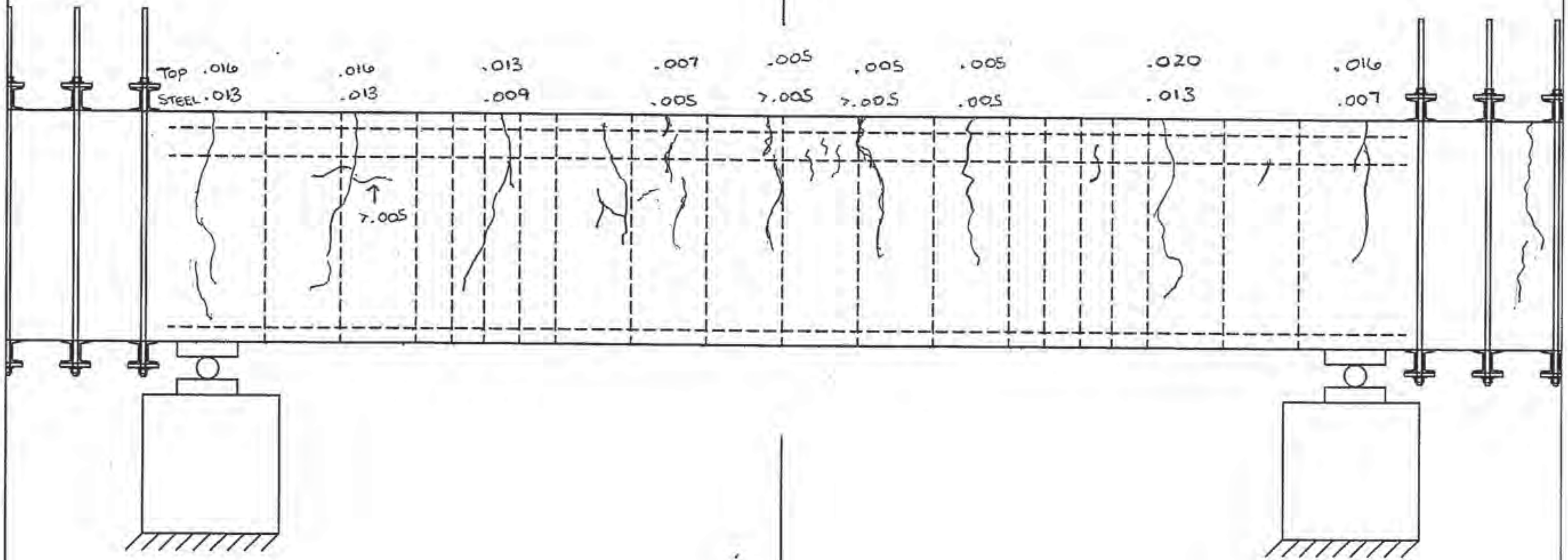


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-5	**Sheet:**	1	**of**	1
	Average Load: 24K Reload	**Drawn by:**	BPR	**Checked by:**	
	Average Deflection: 1.23"	**Date:**	5/17/12		



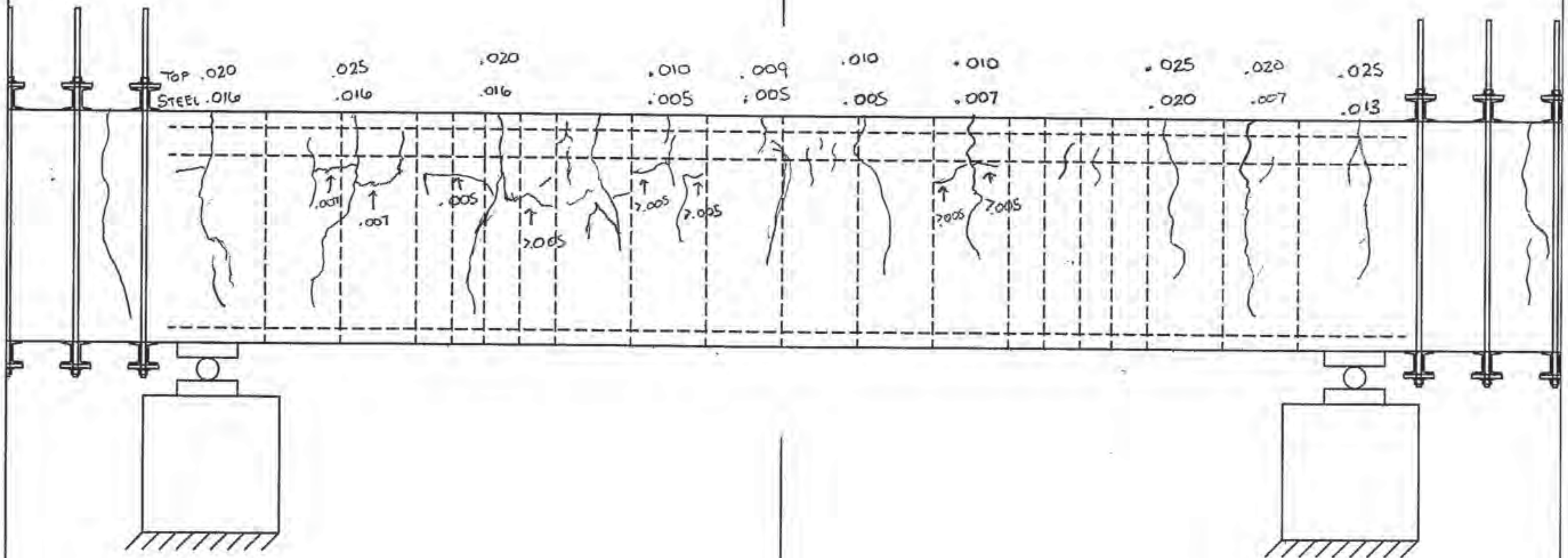
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-6	**Sheet:**	1	of	1
Average Load:	6 K	**Drawn by:**	BPR	**Checked by:**	MDN
Average Deflection:	0.11"	**Date:**	5/25/12		



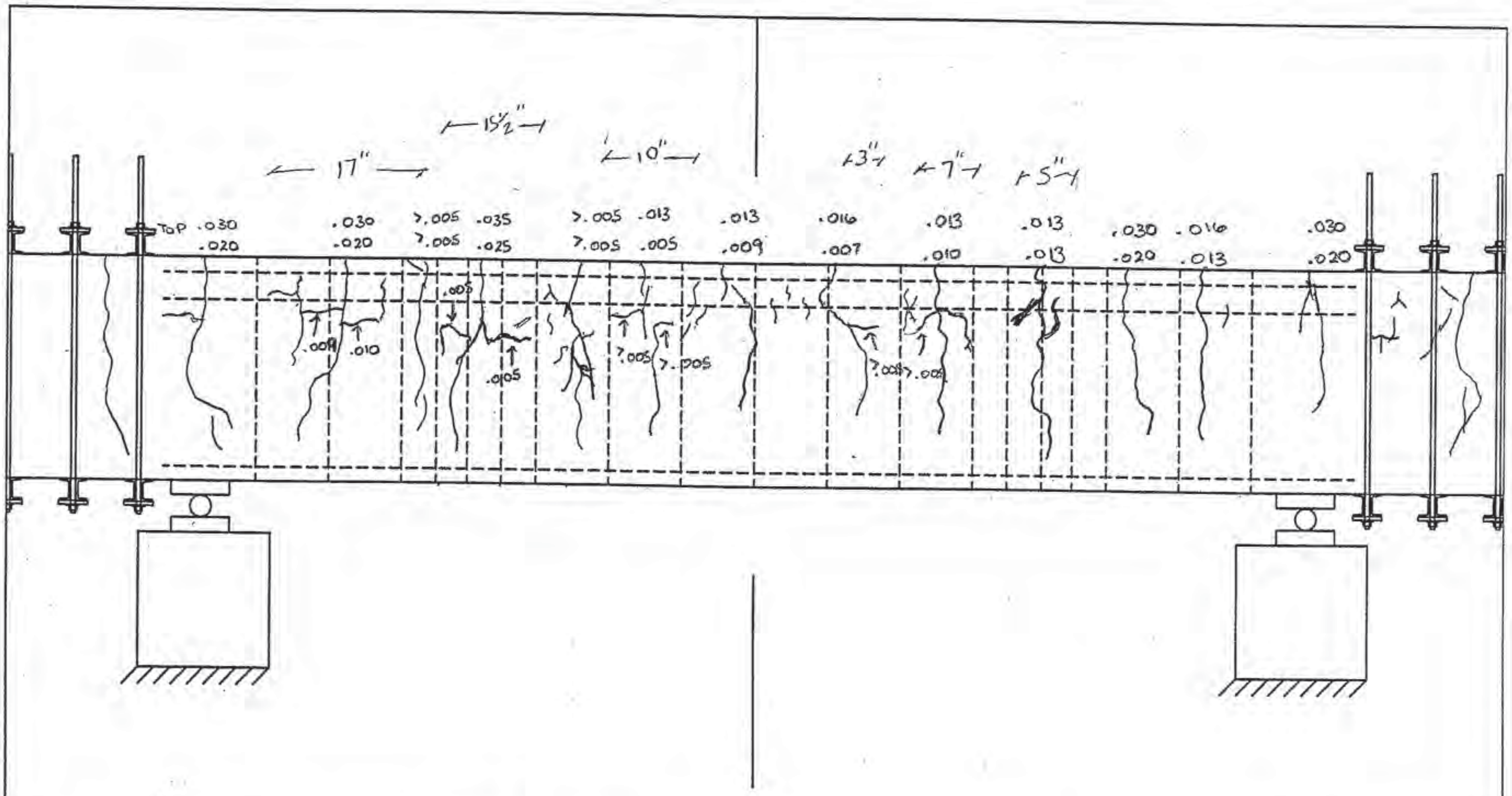
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-6	**Sheet:**	1	of	1
Average Load:	12 K	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	0.38"	**Date:**	5-25-12		



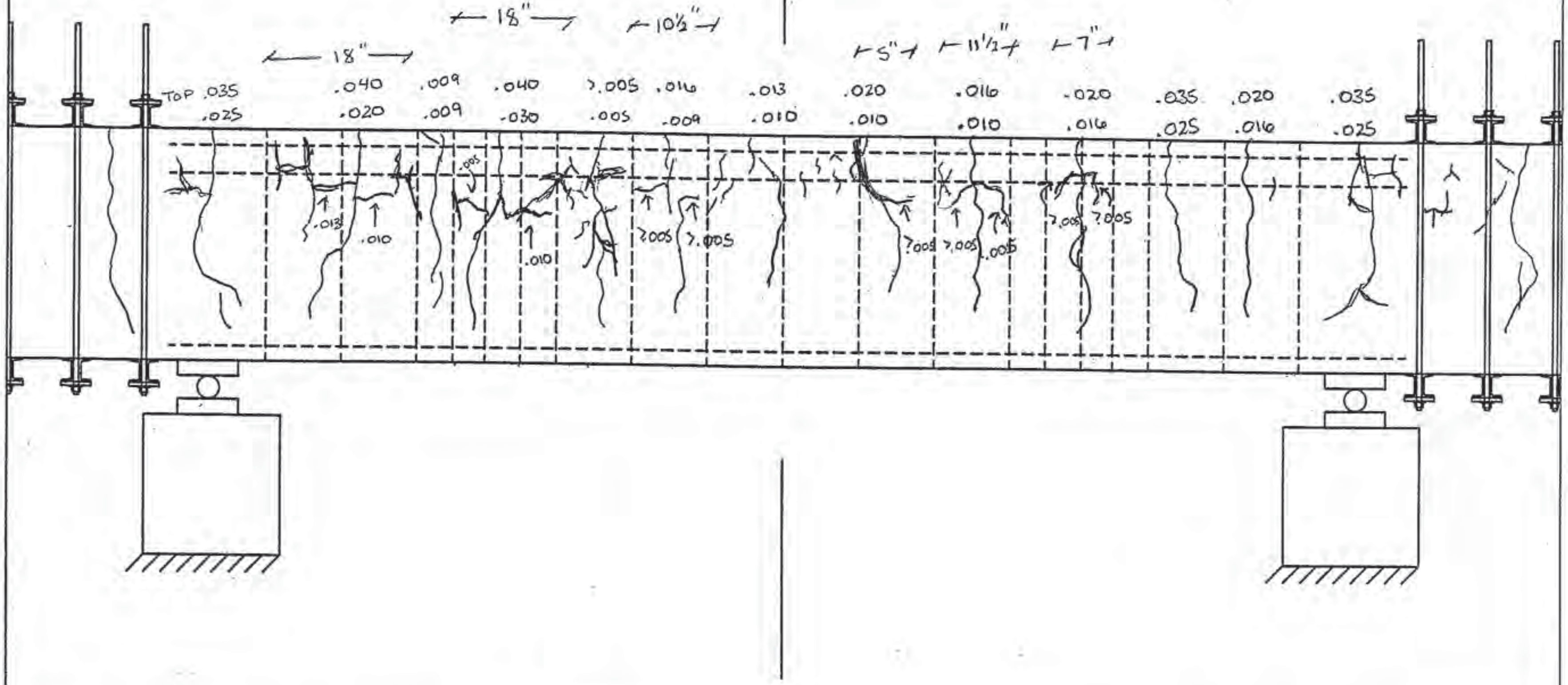
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: B - 6	**Sheet:**	1	of	1
Average Load: 18 K	**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 0.72"	**Date:**	5-25-12		



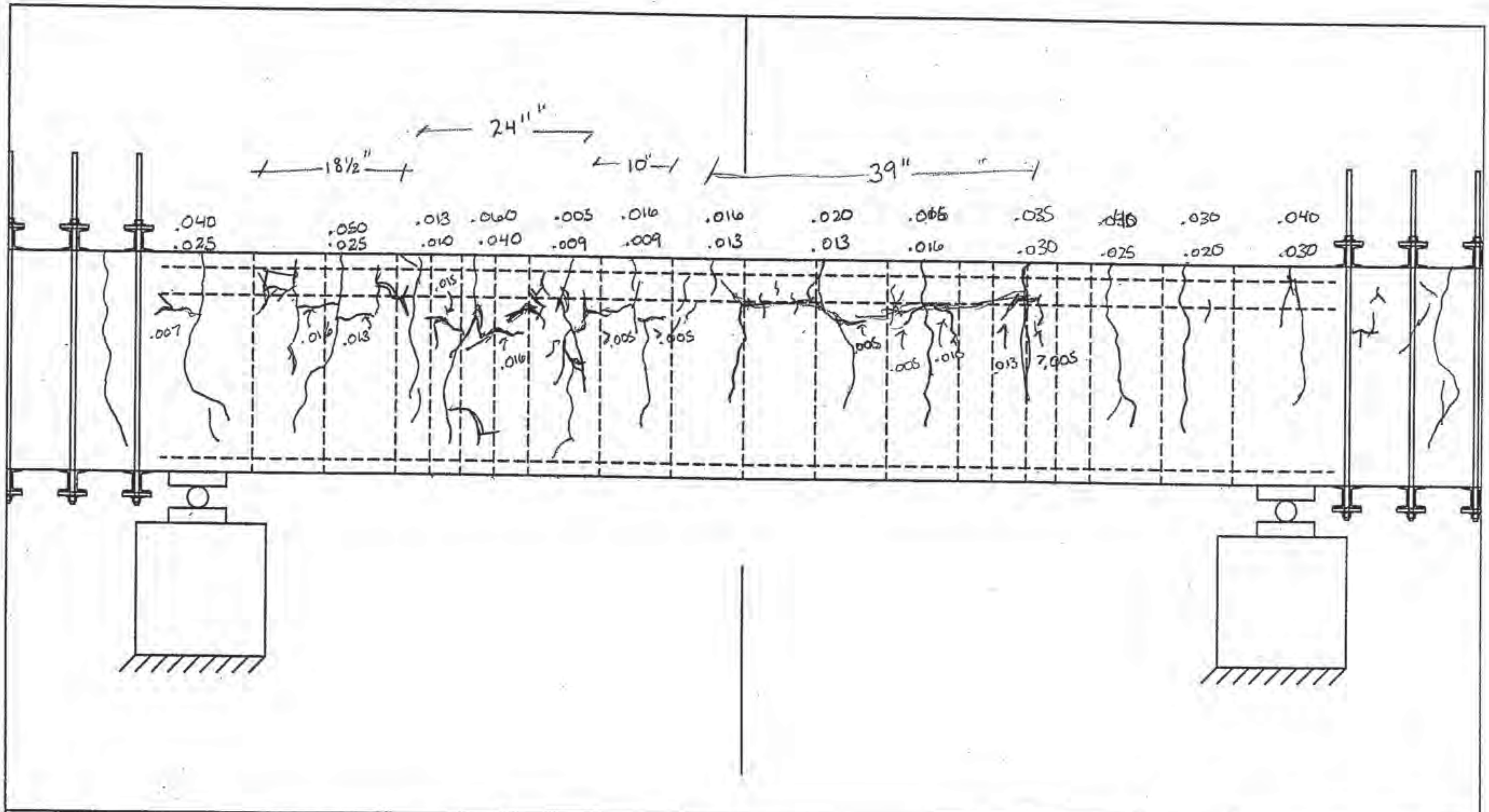
Specimen: B-6	**Sheet:**	1	of	1
Average Load: 24 K	**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 1.06"	**Date:**	5-25-12		

BOWEN LABORATORY
PURDUE UNIVERSITY

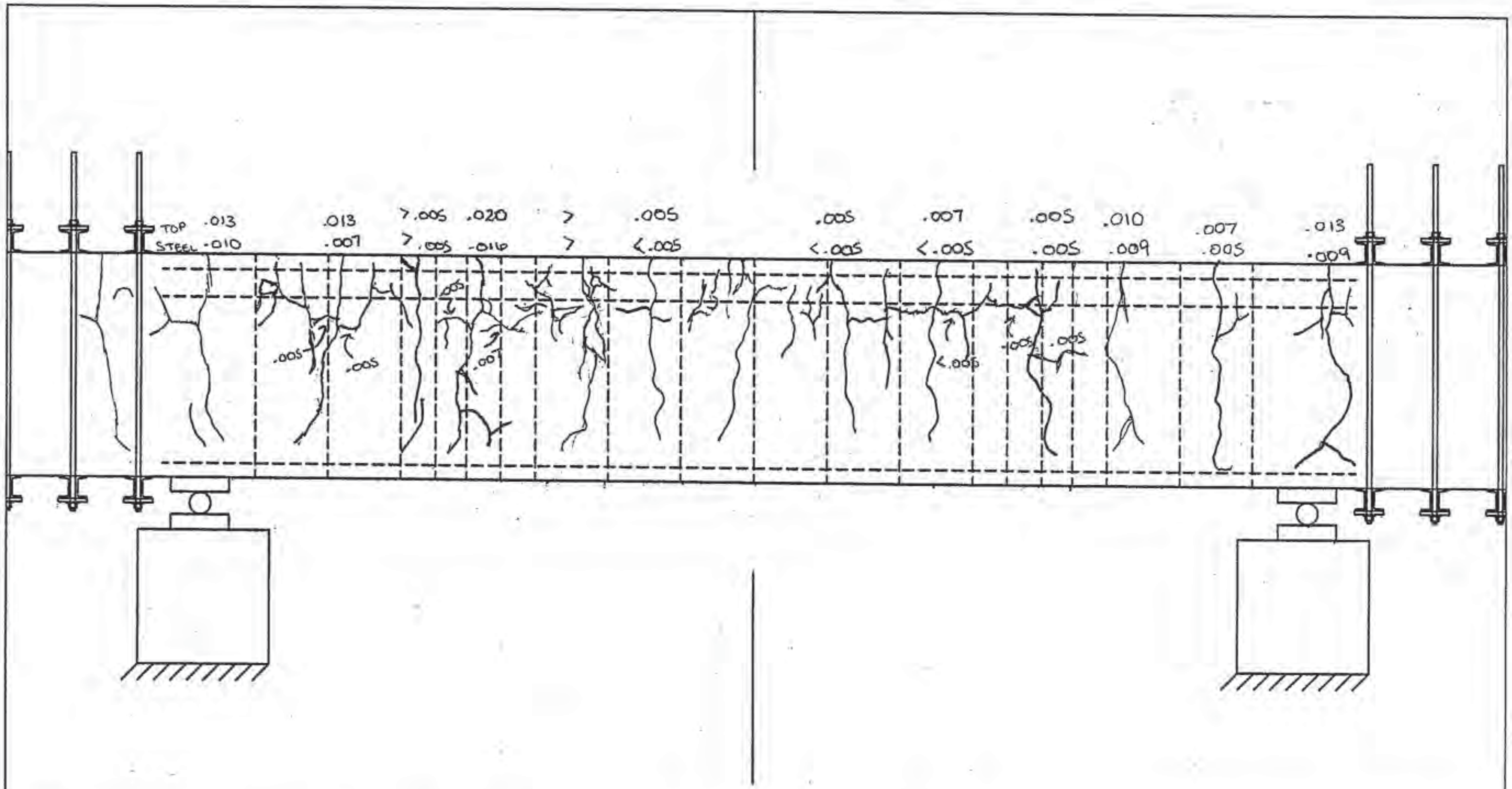


BOWEN LABORATORY
PURDUE UNIVERSITY

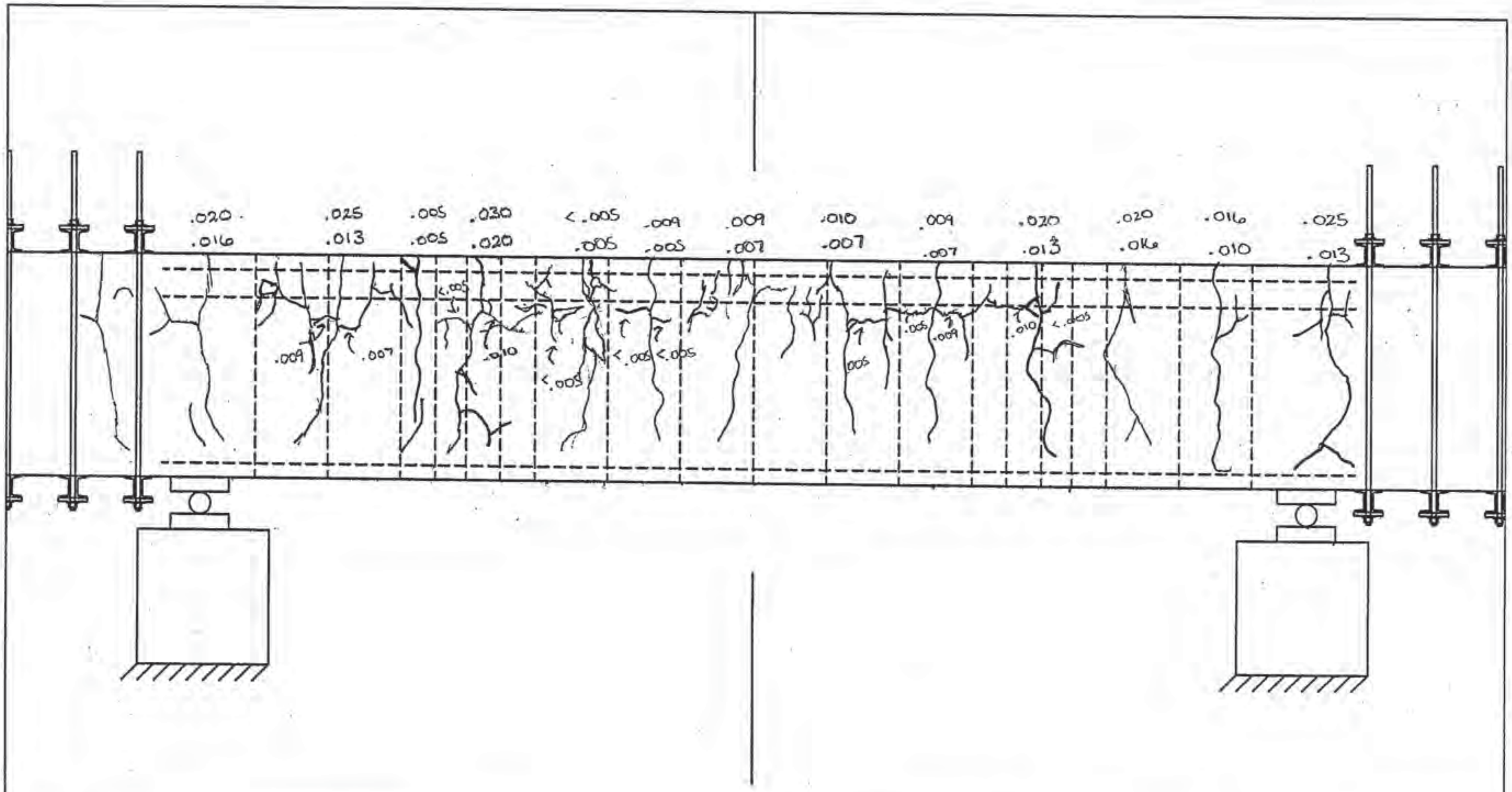
Specimen: B-6	**Sheet:**	1	**of**	1
Average Load: 30 K	**Drawn by:**	MDN	**Checked by:**	
Average Deflection: 1.39"	**Date:**	5-25-12		



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-6	**Sheet:**	1	of	1
	Average Load: 36 K	**Drawn by:**	MDN	**Checked by:**	
	Average Deflection: 1.73"	**Date:**	5-25-12		

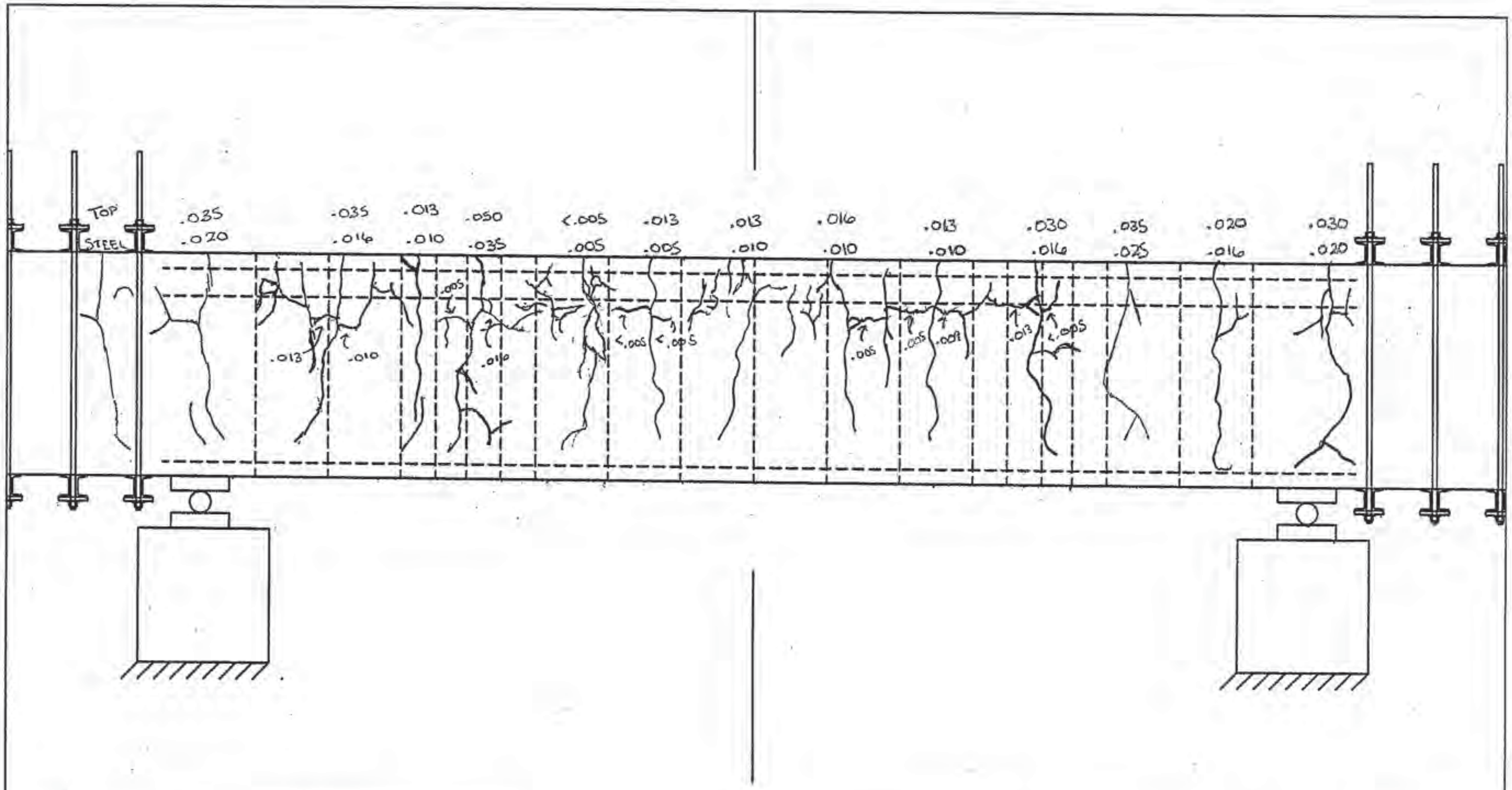


BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-6	**Sheet:**	1	**of**	1
	Average Load: 0 K (UNLOADING)	**Drawn by:**	MDN	**Checked by:**	
	Average Deflection: 0.44"	**Date:**			



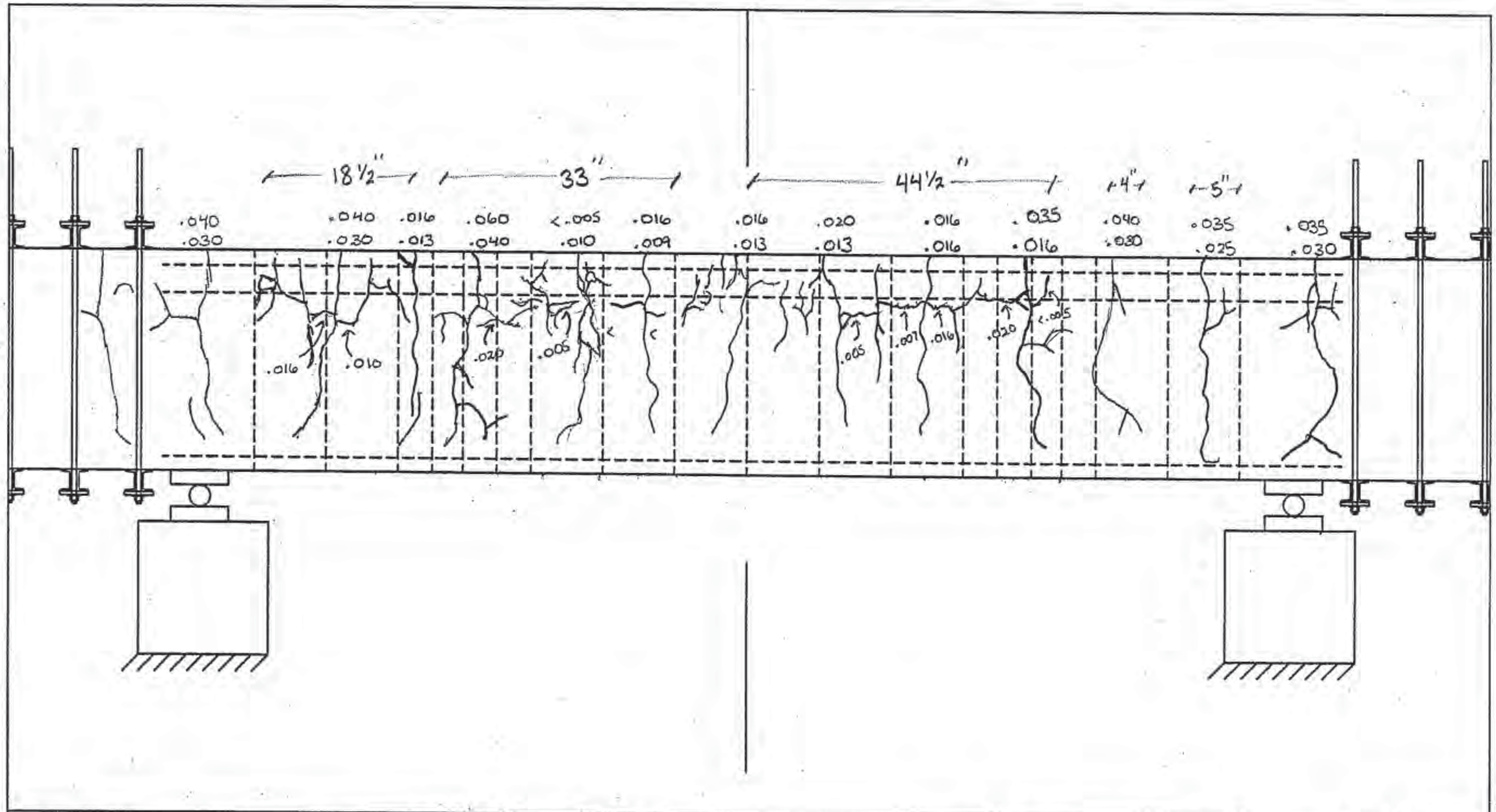
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-6	**Sheet:**	1	**of**	1
Average Load:	12 K (RELOADED)	**Drawn by:**		**Checked by:**	
Average Deflection:	0.81"	**Date:**			

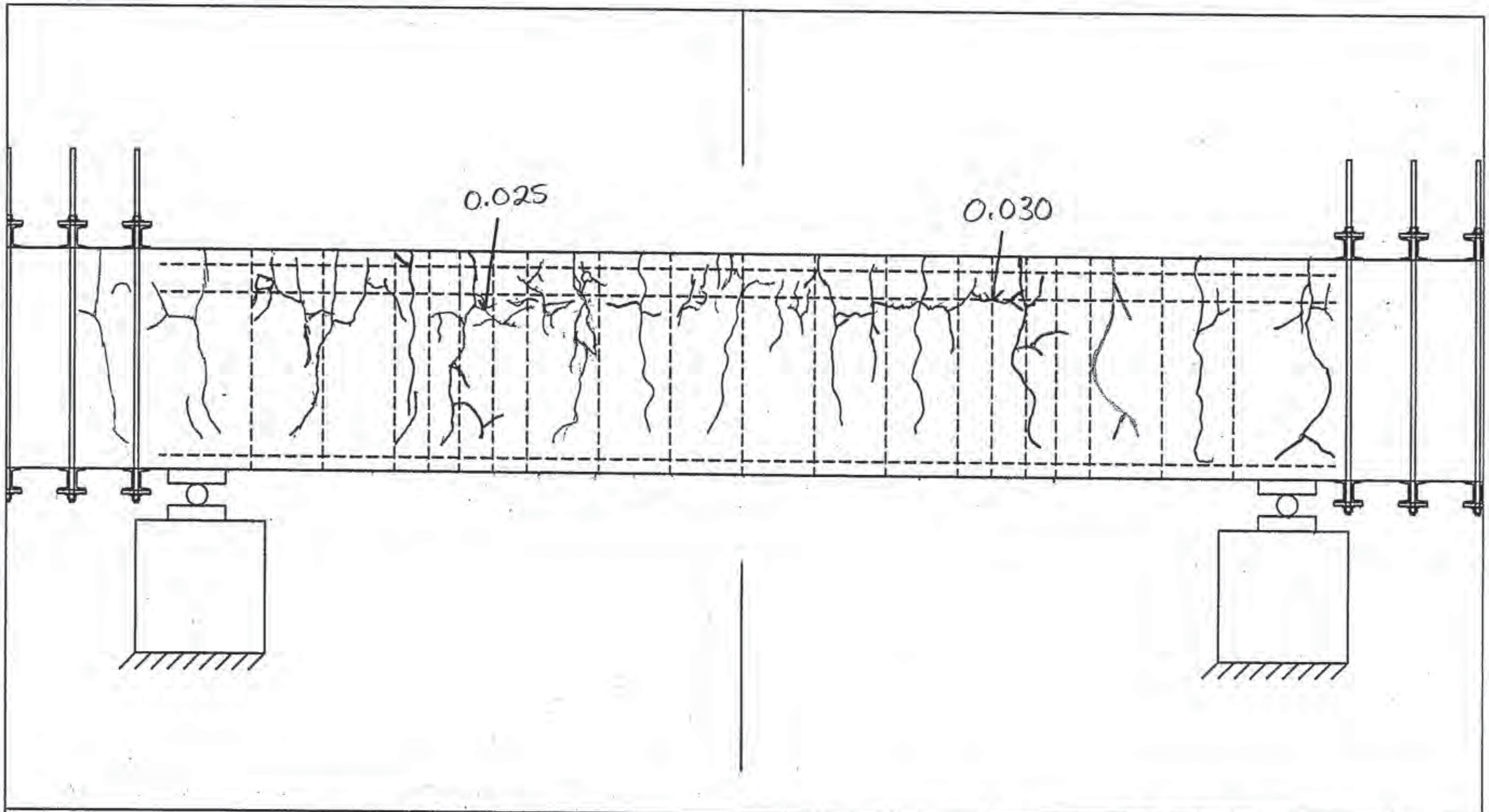


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	B-6	**Sheet:**	1	**of**	1
Average Load:	24 K (RELOADED)	**Drawn by:**	MDN	**Checked by:**	
Average Deflection:	1.30"	**Date:**			



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen:** B-6	**Sheet:**	1	of	1
	Average Load: 36 K (RELOADED)	**Drawn by:**	MDN	**Checked by:**	
	Average Deflection: 1.82"	**Date:**	5-25-12		



Specimen: B-6	**Sheet:**	1	**of**	1
Average Load: 38 K (Yield)	**Drawn by:**	BPR	**Checked by:**	
Average Deflection:	**Date:**	5/25/12		

BOWEN LABORATORY
PURDUE UNIVERSITY

Submittal #

BECHTEL POWER CORPORATION

SUPPLIER DOCUMENT REVIEW
CLASSIFICATION & STATUS

☐ Nuclear Safety_Related ☐ Augmented Quality ☒ Non-Safety-Related

STATUS CODE:
1 ☒ Work may proceed
1C ☐ Work may proceed. Editorial comments need only be incorporated if revised for other purposes.
2 ☐ Revise and resubmit. Work may proceed subject to incorporation of changes indicated
3 ☐ Rejected. Revise and Resubmit.
4 ☐ Review not required. Work may proceed.

Permission to proceed does not constitue acceptance or approval of design details, calculations, analysis, test methods, or materials developed or selected by the Supplier and does not relieve the Supplier from full compliance with contractural obligations.

Reviewed by	Arch	Civil	CS	Elect	Mech	MET	PD	Constr	Startup	STE
	N/A	RL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Status By:
Date: 6/13/12

Tests to Determine the Behavior of #11 Bars with Lap Splices

Bowen Laboratory
Purdue University
Spring 2012

Test Procedure

1. Fabrication

1.1 Formwork

The formwork shall be made using non-absorbent plywood. Its interior shall be caulked to prevent water leakage and it shall be covered with a thin layer of oil before casting. The dimensions of the formwork shall be checked and recorded using Form 1.

1.2 Reinforcement Cages

The steel reinforcement cages shall be built following the drawings attached. Reinforcing bars shall be supported by steel chairs placed away from lap splices. To ensure alignment, the bars shall be tied to chairs and to one another using gage-16 steel wire. The location of the reinforcement shall be recorded using Form 1. The locations of wire ties and rebar markings shall be recorded using Form 2.

Tolerances (within the test region) are:

3/16" for horizontal cover and horizontal spacing measured to the surface of the bar (excluding ribs)
1/4" for vertical distances shown in Form 1

1.3 Casting

Fresh concrete properties to be measured include:

Unit Weight
Slump
Air Content

These measurements shall be made following the Specifications and recorded using Form 3.

Slump shall be measured before any other activity related to casting takes place to make sure that the delivered mix has satisfactory workability. The mixing truck shall deliver a ticket with the batched mix weights. These weights shall be examined to corroborate that the delivered mix has the specified proportions. Concrete shall not be accepted if it arrives more than 45 min. after leaving the batching plant. No water shall be added to the mix after the truck leaves the plant.

Specimens and cylinders shall be cast and vibrated in two lifts following the Specifications. The vibrators to be used shall have the following cross-sectional dimensions:

For cylinders:	3/4" - 7/8"
For Larger Specimens:	1-3/4"

Their frequencies shall be between 50 and 200 Hz.

Excess concrete shall be removed off the formwork. The exposed surfaces of the specimens shall be finished using cast magnesium floats. Lifting inserts shall be inserted in the fresh concrete as soon as the finishing is completed.

Each test beam shall be cast using concrete from a single mixing truck. A complete set of concrete samples (cylinders) shall be obtained from each truck. Test beams and samples shall be marked with a number referring to the truck from which they were cast and the date of casting. In each casting day, trucks shall be numbered sequentially starting at 1. The number assigned to a truck shall be written clearly on the mix ticket describing the mix proportions for the batch. Test beams shall be cast and tested oriented in the North-South axis of the laboratory. During finishing, the north end of each beam shall be marked with the letter N.

These activities shall be documented using Form 3

1.4 Curing

As soon as casting is completed all specimens shall be covered with impermeable sheets. When the concrete surface sets, wet burlap shall be inserted between these sheets and the exposed concrete. All formwork and molds shall be struck no later than three days after the cast.

All exposed concrete surfaces shall be covered by wet burlap and impermeable sheets for a total of at least seven days after casting.

Burlap shall be doused with water at least every other day during the curing period.

Curing activities shall be logged using Form 4.

Test cylinders shall be stored and cured next to the test specimens and under similar conditions of temperature and humidity.

The variation of concrete strength with time shall be monitored as specified in the Specifications. The results of cylinder tests shall be recorded using Form 5.

2. Calibration

Three types of measurements will be made: displacement, force, air content.

The apparatuses to be used to calibrate sensors to measure these quantities are:

Displacement Sensors: INSTRON Universal Testing Machine (S.N.:)
Load Sensors: INSTRON Universal Testing Machine (S.N.:)
Air Content: Calibrated Cylinder (S.N.)

Load and displacement sensors will be calibrated following steps listed below:

1) Connect the sensor to the data-acquisition system that is going to be used in the test
2) Set and record the excitation voltage to the maximum possible value (not exceeding the maxima specified for the data-acquisition system and the sensor)
3) Set the data-acquisition equipment to record voltage
4) Set the gain of the data-acquisition system to the first available level lower than the ratio of the maximum range of the system to the maximum expected output from the sensor.
5) Mount the sensor on the universal testing machine
6) Apply a series of known displacement or force increments to the sensor ranging between 10% and 90% of the rated capacity of the sensor
7) Record the voltage read on the data-acquisition system at each known displacement or force increment
8) Create a plot of change in output voltage vs. change in force or displacement
9) Fit a line to the plot from 7) using “least squares”
10) Record the slope of the line from 8) (sensor sensitivity)
11) Label the cable used in the calibration with the serial number of the sensor

Sensors shall be calibrated before the first test and after the final test.

The apparatus used to measure air content of the fresh concrete shall be calibrated following the procedure described in ASTM standard 231. Form 6B shall be used to document the calibration.

All calibrations shall be performed by at least two persons: one leading each step and the other checking the work of the first independently. A log of each calibration shall be made using Form 6 and it shall include an estimate of the accuracy of the sensor.

Sensors for which the sensitivity obtained in 9) above deviates by more than 10% from the nominal sensitivity (as reported by the manufacturer) shall not be used in any of the tests.

3. Setup

Each test beam shall be placed on two roller supports as described in the attached proposal. The final location of the supports shall be measured ~~(~~to the nearest 1/16 in.~~)~~ with maximum deviation of ¼ in and reported using Form 7. As-built external dimensions of each test beam shall be recorded using the same form. The maximum deviation from nominal dimensions in the test region shall be ¼ in.

The test beam shall be placed with the reinforcement facing up as shown in the attached proposal.

The shear spans shall be reinforced with external stirrups (pairs of 5/8-in threaded rods) installed at a spacing not exceeding 12 in. The locations of the stirrups shall be measured. The measurements shall be recorded using Form 7.

The loading rigs (consisting of a loading tube, two hydraulic rams, two threaded rods, plates and nuts, and one load cell per rig) shall be placed on the test specimen and connected to "the strong floor" of the laboratory (without applying load to the specimen other than the weight of the rigs) as described in the attached proposal. The rams in each rig shall be connected to a single manifold and pump using 10,000-psi hydraulic hoses. All hoses and other hydraulic hardware shall be inspected visually and replaced –if defective- before testing.

4. Instrumentation

Displacement sensors shall be installed at midspan, at each support, and at each load point. They shall be secured to the strong floor of the laboratory directly below the point where displacement is to be measured.

All sensors (displacement and force) shall be connected to the data acquisition system using the same cables used during calibration. The excitation voltage and gain shall also be set to the value used in calibration. The data acquisition system shall be set to record voltage changes caused by loading. Before applying load with the hydraulic rams, all sensors shall be set to read a voltage value between 10% and 90% of the voltage output of the sensor at its rated capacity. These voltages shall be referred to as the "zero offsets" of the sensors. If a sensor is set to have an initial voltage exceeding 20% of its output at rated capacity, the sign of the initial "zero offset" shall be opposite to the sign of the expected change in its signal.

Set the data acquisition system to scan all sensors and save at least one record per sensor every 1 sec.

Record a file of "zero offsets" capturing at least 10 min. of data before any load is applied with the hydraulic system.

Means of initial voltages for all sensors (mean "zero offsets"), sensor serial numbers, the most recent sensitivity constants, excitation voltages, and the channels of the data-acquisition system used for each sensor shall be recorded using Form 8. The pairing of channels and sensors shall be checked by a second person working independently from the person making the initial connections.

Infrared targets to be used to measure displacements as described in the attached proposal shall be glued to one face of the test beam using epoxy adhesive. The numbering sequence of these targets shall be recorded using Form 9.

Video cameras (one for long-time lapse video and one for high-speed video) will be positioned to capture the response of the mid third of each specimen. To the extent possible, the location of the cameras shall be the same in all tests.

5. Testing

The following actions shall take place during each test:

At the end of each loading increment:

Mark Cracks: all visible cracks shall be marked using black permanent markers. Cracks shall be marked by drawing lines parallel to them and with an offset of approximately 0.25 in.

Measure Crack Widths: Crack widths shall be measured using crack comparators or graduated handheld microscopes.

Measure coordinates of infrared coordinates: A set of coordinates shall be obtained using an OptoTrack System 600 Pro. A set of four targets shall be attached to the strong floor. They shall be located at approximately the same distance to the OptoTrack cameras as targets attached to the test beam. Coordinates for these reference targets shall be obtained at each loading increment. They are to be used to monitor the stability of the Optotrack system by computing the variation in the distances between reference targets.

In-Test Data Backup: At every loading increment the data being produced by the data-acquisition system shall be copied to an external hard drive.

Photographs: a set of high-resolution photographs shall be obtained after cracks are marked at each loading increment. The photographs shall includes views of both elevations of the test beam and the top concrete surface above lap splices.

The following data shall be recorded throughout each test:

Sensor readings: to be recorded on a hard drive in volts. Conversion to engineering units shall be done after the test as follows:

-Subtract zero offsets
-Divide the result by the sensitivity obtained in the most recent calibration

Lapse video photographs: to be obtained every 5 min.

Actions to be taken at failure

Trigger high-speed camera to record breaking away of the concrete cover and relative movement of the bars.

Actions to be taken after test

Generate a record of sensors that may have malfunctioned or been accidentally moved during the test

Remove from all files recordings from sensors for which the results of the after-test calibration differ by more than 5% from the before-test calibration.

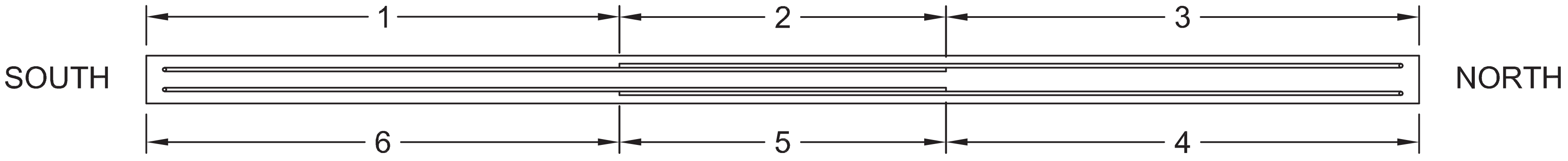
6. Reporting and Backup

Produce all the captured data in two ways:

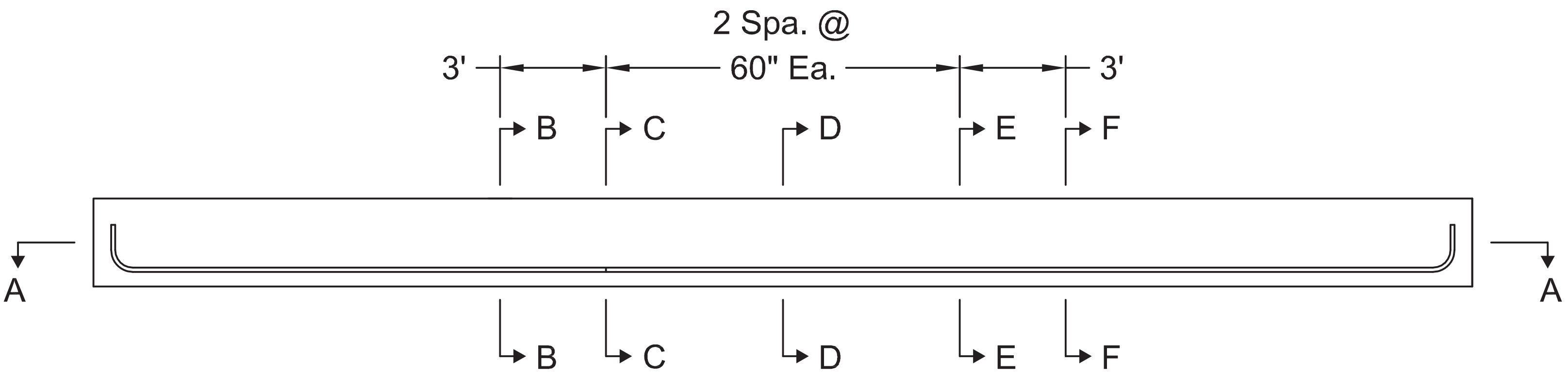
By uploading data, photos, and video to a private project at nees.org.
By recording all data, photos, and video on a magnetic hard drive

Reports shall be produced as described in the Specifications.

Form 1



Section A-A



*For section B-B through F-F see Sheet 3 of 3

Series A

Drawing:	Series A Formwork As-builts	Sheet:	1	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

BOWEN LABORATORY
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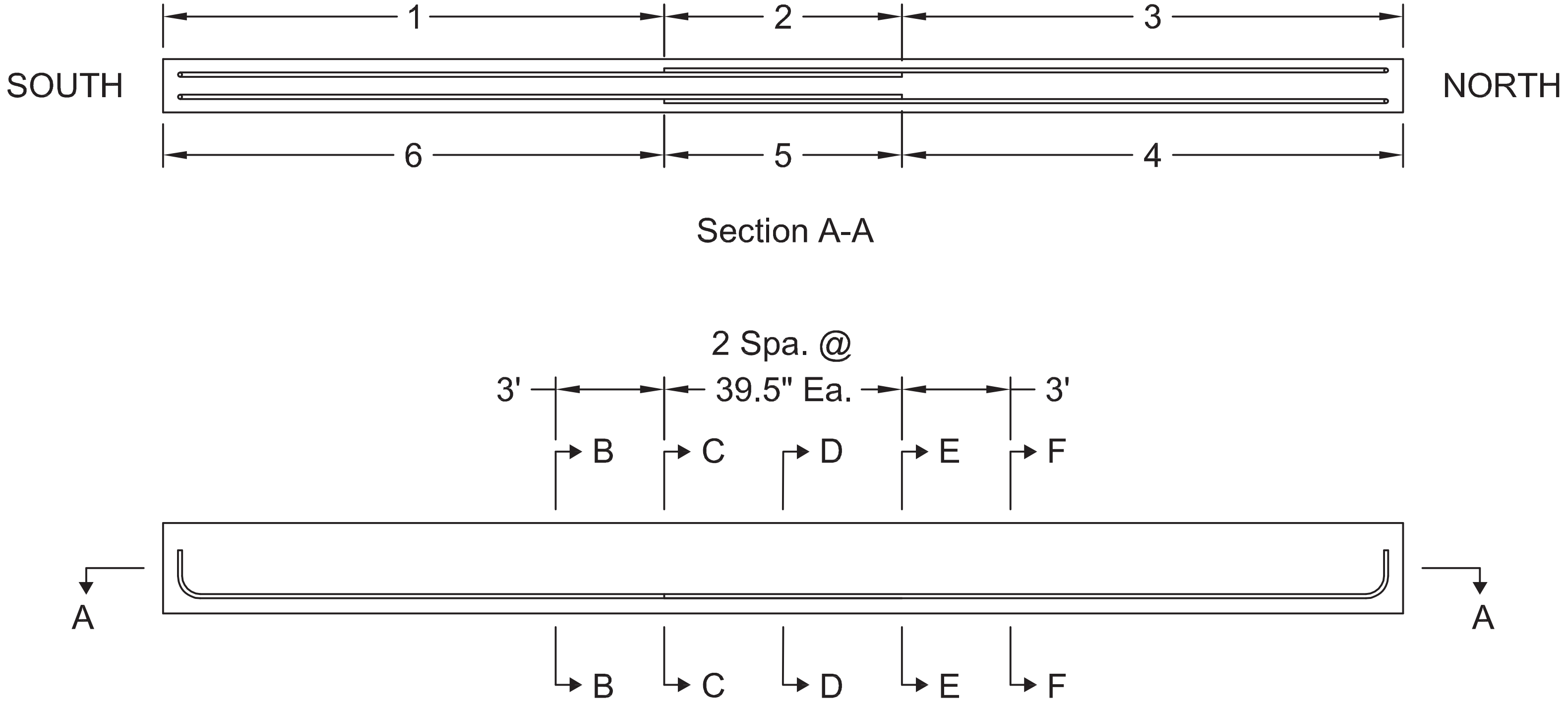
Form 1

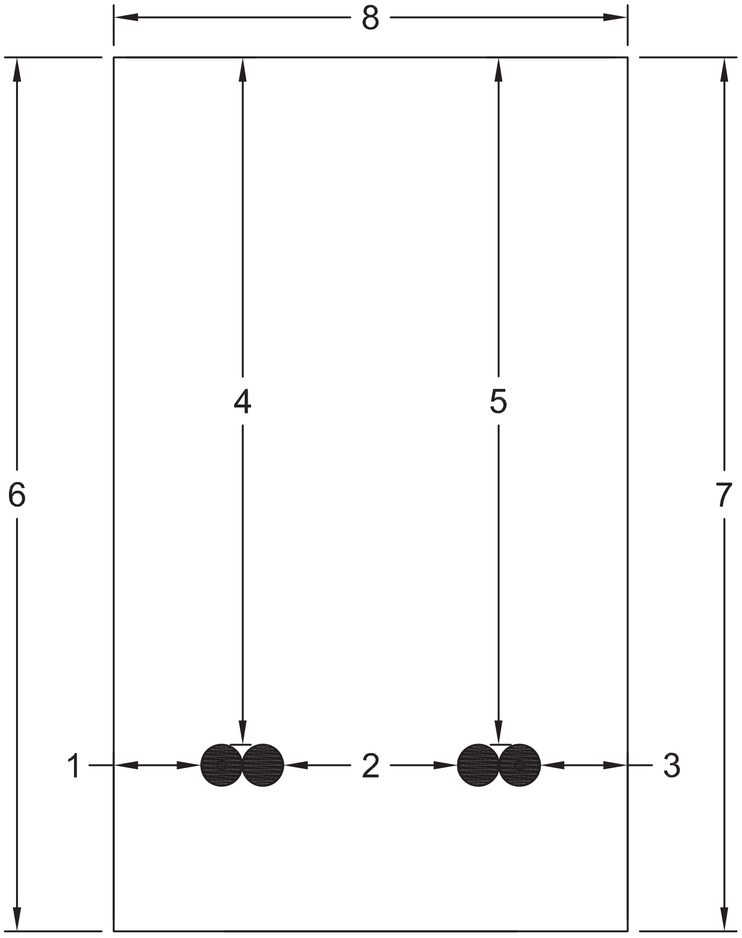


*For section B-B through F-F see Sheet 3 of 3

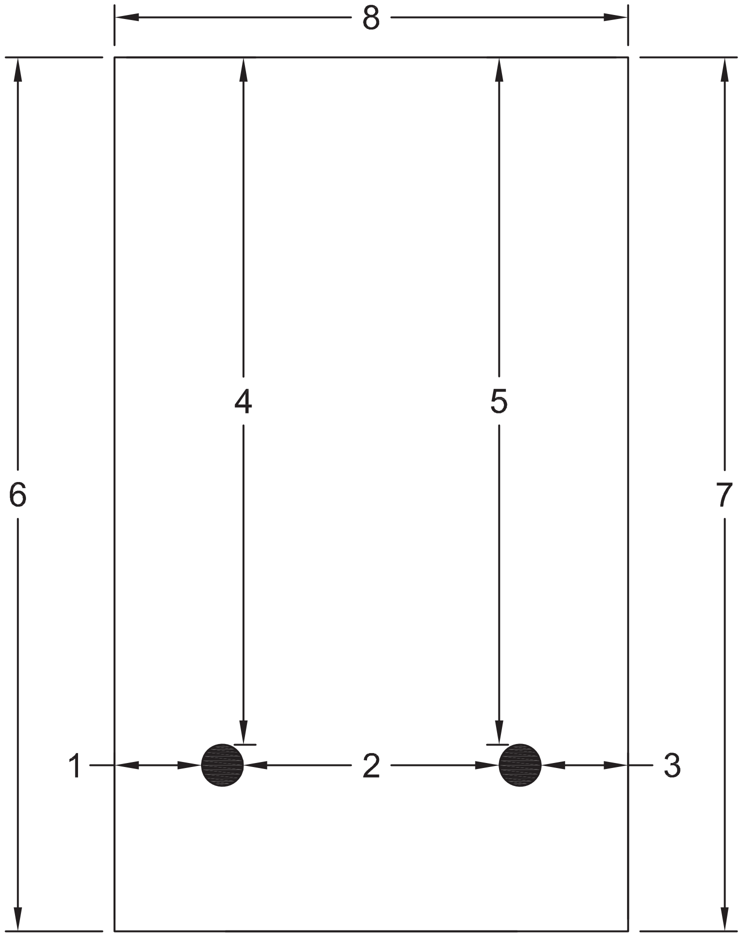
Series B

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Formwork As-builts	Sheet:	2	of 3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	

Form 1



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Formwork As-built Sections	Sheet:	3	of 3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	

Form 1

Project: Tests to Determine the
Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen:________________________

Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A								
B-B								
C-C								
D-D								
E-E								
F-F								

Recorded by:	Signature	Date	Time
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*See formwork as-built drawings for dimension locations

Form 1

Project: Tests to Determine the
Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen:________________________________

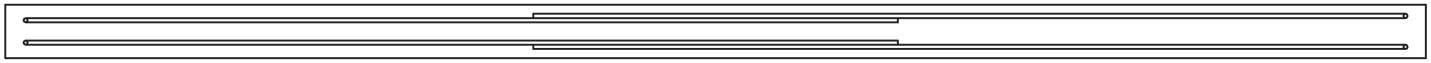
Sheet 2 of 2

Section	Formwork As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
A-A	14'-6"	10'-0"	14'-6"	14'-6"	10'-0"	14'-6"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Section	Formwork As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
A-A	13'-10.5"	6'-7"	13'-10.5"	13'-10.5"	6'-7"	13'-10.5"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Form 2

Wire Ties



Bar Marks

Specimen:					
Project:	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:		Checked by:	
		Date:			

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen:________________________

Sheet 1 of 1

General Information					
Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
Measurements made upon arrival of concrete					
Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**			
Time_1	Result_1	Time_1	Result_1	S/N of Air Meter	
Time_2	Result_2	Time_2	Result_2	S/N of Scale	
Unit Weight (ASTM C138 - 10b)					
Time_1	Wt. of Cont._1	Total Wt. $_1$	Wt. of Conc._1	Result_1 = Wt. of Conc./Vol. of Cont.	
Time_2	Wt. of Cont._2	Total Wt. $_2$	Wt. of Conc._2	Result2 = Wt. of Conc./Vol. of Cont.	
Times of actions during and after casting					
Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
Recorded by		Signature		Date	Time
Checked by		Signature		Date	Time
Checked by		Signature		Date	Time

Comments:

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

Form 4

Project: Tests to Determine the Behavior of Spliced #11 Bars	Curing Documentation v.1 (Rev. 03/30/2012)	Purdue University - Bowen Laboratory Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
	Time Beginning	Time Ending
	Temperature inside Lab (deg. F)	

Description of Work Performed

Recorded by	Signature	Date	Time
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Form 5

Project: Tests to Determine the Behavior of Spliced #11 Bars

Cylinder Compression Tests Documentation v.2
(Rev. 04/01/2012)

Specimen: ______________________

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
1										
2										
3										
4										
5										
6										

S/N of Testing Machine:			
Recorded by:	Signature	Date	Time
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Form 5

Project: Tests to Determine the Behavior of Spliced #11 Bars

Cylinder Compression Tests Documentation v.2
(Rev. 04/01/2012)

Specimen: ______________________

Sheet 2 of 2

Specimen	Date	Age	Time of Test	Wet/Dry	Average Measured Dia. [in.]	Cross-sectional Area [in2]	P_{max} [lb_f]	f'$_c$ [psi]	Fracture Type (1-6)
1	0-Jan		12:00 AM	0	#DIV/0!	#DIV/0!	0	#DIV/0!	0
2	0-Jan		12:00 AM	0	#DIV/0!	#DIV/0!	0	#DIV/0!	0
3	0-Jan		12:00 AM	0	#DIV/0!	#DIV/0!	0	#DIV/0!	0
4									
5									
6									

S/N of Testing Machine:			
Recorded by:	Signature	Date	Time
0		0	0
Checked by:	Signature	Date	Time
0		0	0
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lbf/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Recorded data is shown on sheet 1 of 2.

Form 6

Project: Tests to Determine the Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	
Data Acquisition System:	
Gain:	
Excitation Voltage:	
Channel:	
Sensor:	
Sensor S.N.:	

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage

Operator	Signature	Date	Time
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Results	Sensitivity	Accuracy

Notes:

Form 6B

Project: Tests to Determine the Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/06/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

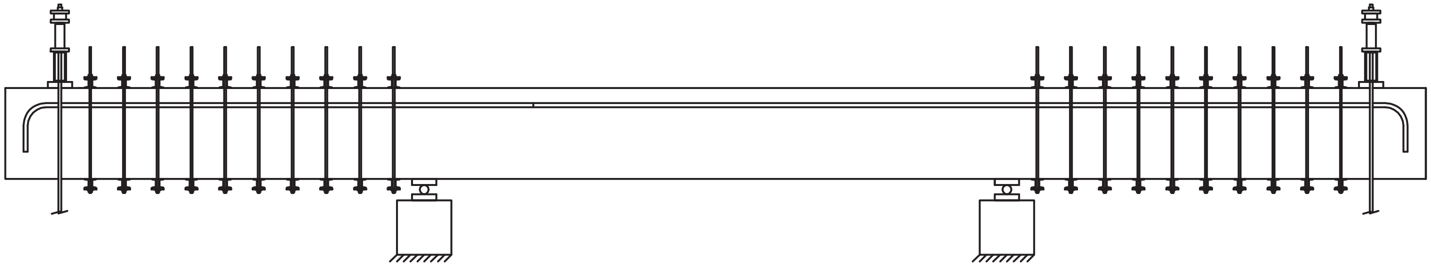
Meter S.N.	
Type of Meter	
Meter Brand Name	
Ambient Temperature	

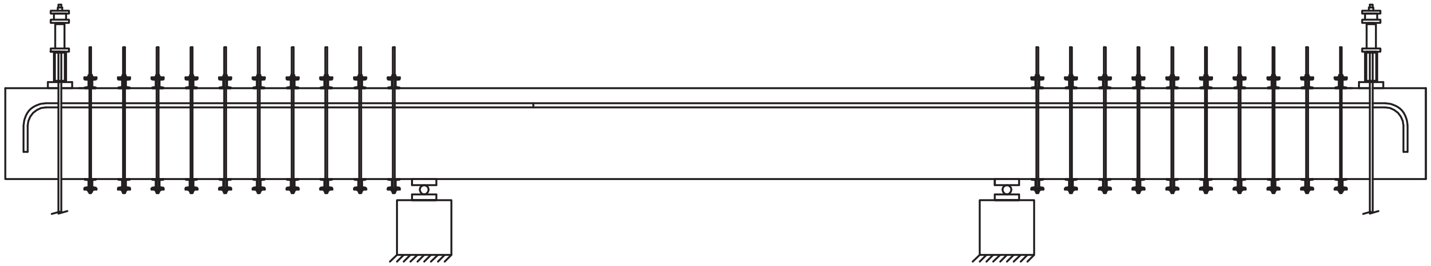
Target Air Content	Measured Air Content

Operator	Signature	Date	Time
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

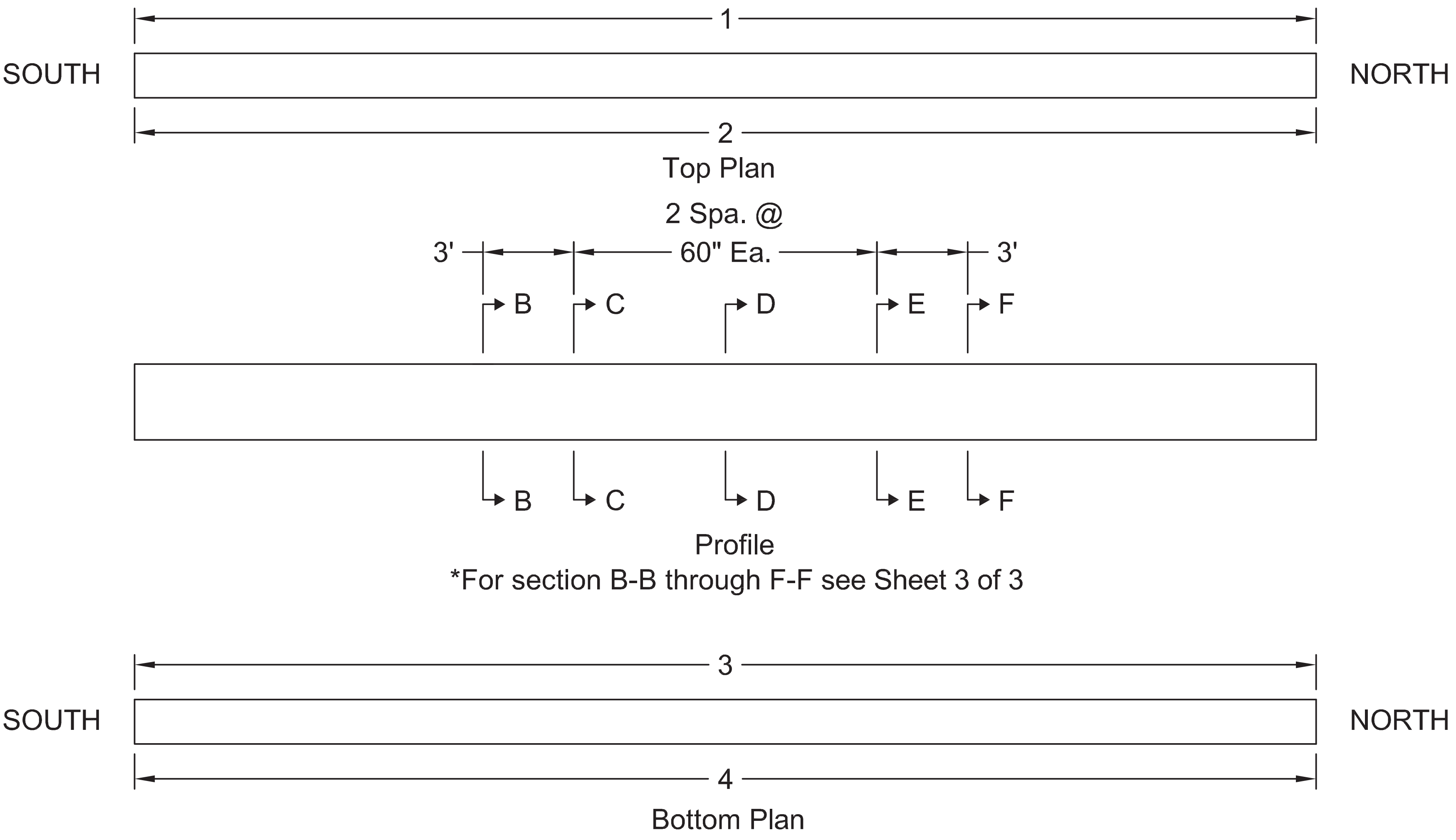
Form 7





BOWEN LABORATORY PURDUE UNIVERSITY	Specimen	Sheet:	1	of	4
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:		Checked by:	
		Date:			

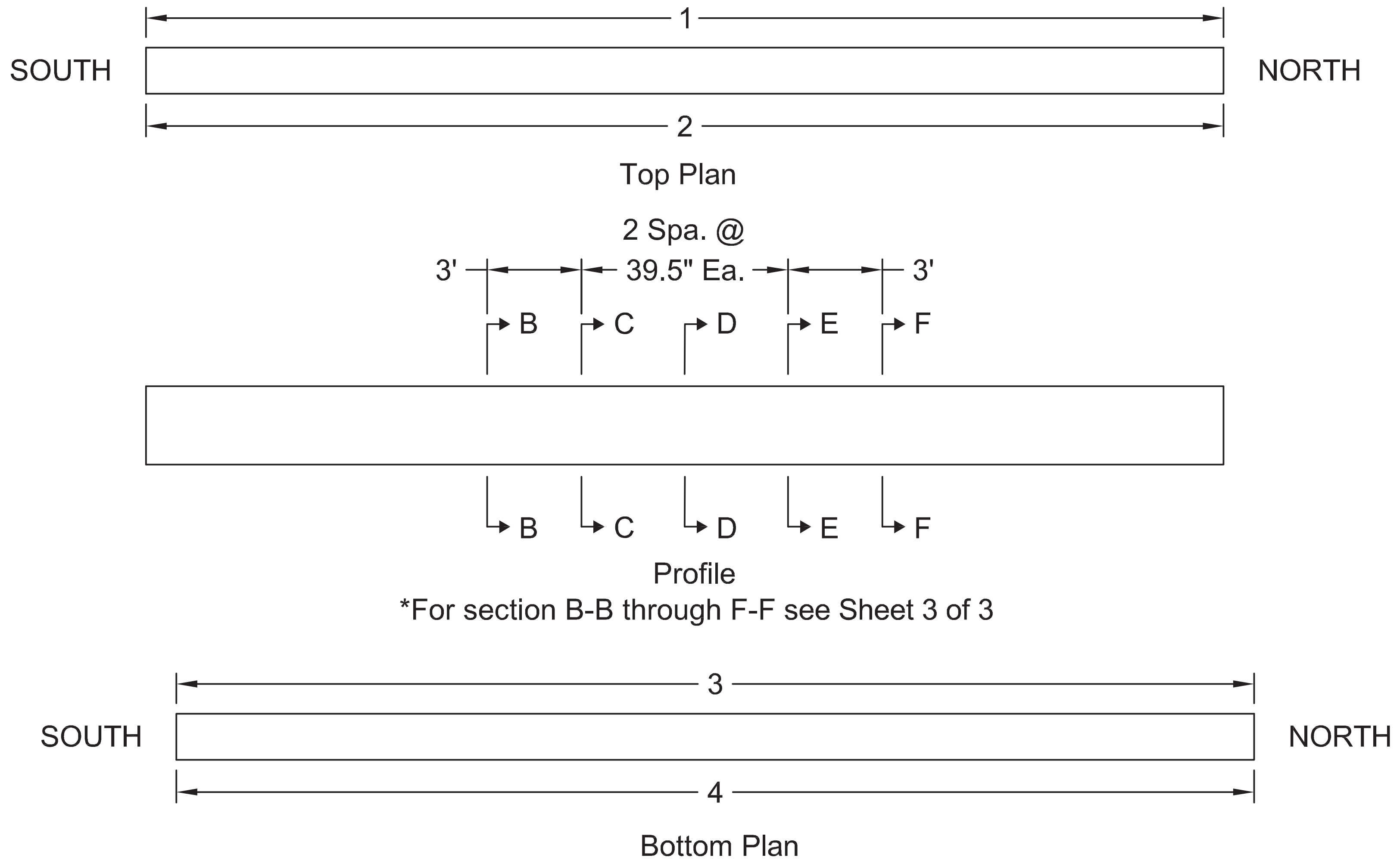
Form 7



BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

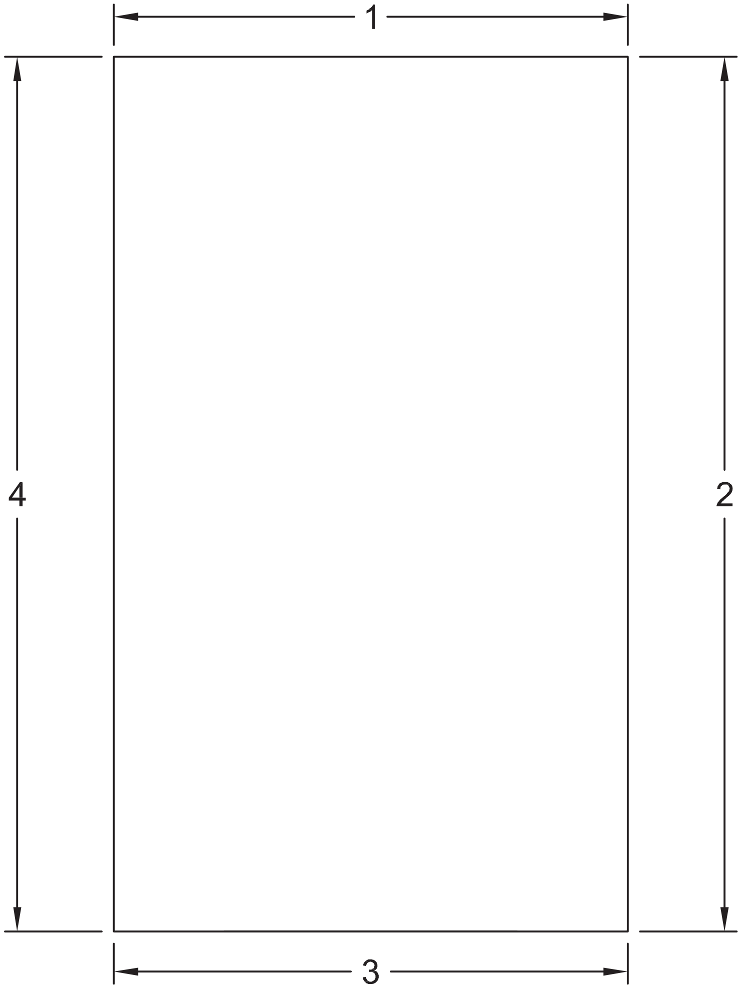
Form 7



*For section B-B through F-F see Sheet 3 of 3

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		

Form 7



Section B-B, C-C, D-D, E-E & F-F
*Facing North

Drawing:	Concrete As-built Sections	Sheet:	4	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

BOWEN LABORATORY
PURDUE UNIVERSITY

Form 7

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen:______________________________
Sheet 1 of 2

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan								
B-B								
C-C								
D-D								
E-E								
F-F								

Recorded by:	Signature	Date	Time
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Form 7

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen:______________________________

Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

Form 8

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

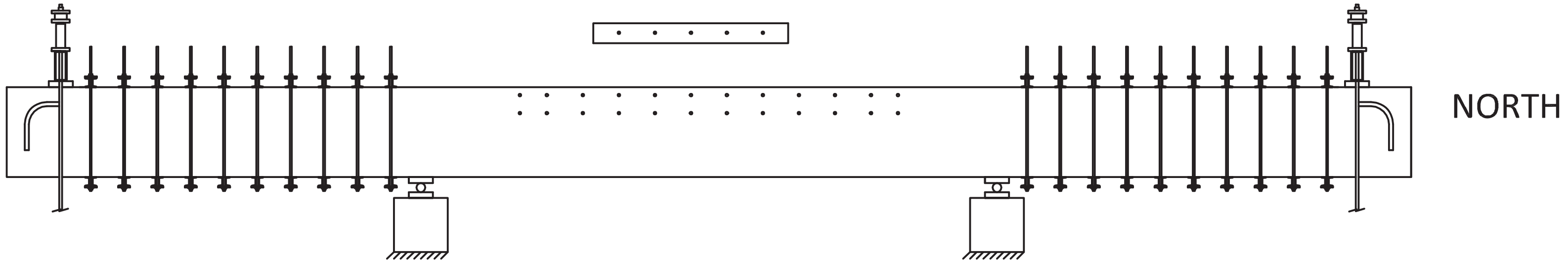
Specimen: ______________________________
Sheet _______ of _______

Data Acquisition System:								
Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity	Zero Offset	Location	Comments

Operator	Signature	Date	Time
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Form 9



BOWEN LABORATORY PURDUE UNIVERSITY	Specimen			
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:		Checked by:
		Date:		

Purdue University Specimen : A-1 Date: 6/4/12

	Average Load (~~lbf~~) k	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (~~lbf~~) k	South Load Cell (~~lbf~~) k	DG North Overhang (in)	DG South Overhang (in)	Time
1	0.2	0.01	0.01	0.00	-0.00	-0.00	0.000	-0.000	~~0.02~~ 0.2	0.2 ~~0.1~~	~~0.300~~ 0.100	0.000	7:44A
2	3.6	first crack											
3	6	0.20	0.19	0.03	0.04	0.02	0.000	-0.000	6	6	0.294	0.171	8:16A
4	12	0.52	0.51	0.08	0.11	0.07	-0.000	-0.000	12	12	0.614	0.500	8:38A
5	18	0.87	0.90	0.13	0.19	0.13	-0.000	0.000	18	18	0.960	0.897	9:01A
6	24	1.23	1.27	0.18	0.28	0.19	-0.001	-0.001	24	24	1.329	1.268	9:35A
7	30	1.64	1.67	0.24	0.36	0.25	-0.002	-0.001	30	30	1.738	1.668	10:00A
8	N+S	DG reset									0.800	0.900	10:26A
9	36	2.05	2.09	0.31	0.46	0.31	-0.002	-0.001	36	36	1.236	1.338	10:28A
10	37.3	yield											
11	38	2.36	2.51	0.35	0.53	0.38	-0.003	-0.001			1.554	1.755	10:54A
12	40.5	3.87	4.14	0.65	0.90	0.68	-0.005	-0.004	40.7	40.3			~~10~~ 11:33A
13	20.2	3.03	3.30	0.52	0.70	0.55	-0.005	-0.005	20.2	20.2			~~10~~ 11:58A
14	0.2	1.91	2.14	0.33	0.43	0.36	-0.005	-0.004	0.2	0.2			12:05P
15	12	2.42	2.68	0.42	0.55	0.44	-0.005	-0.004	12.0	12.0			12:20P
16	24	3.05	3.34	0.52	0.70	0.55	-0.005	-0.004	24.0	24.0			12:37P
17	36	3.70	3.99	0.62	0.86	0.65	-0.004	-0.004	36.0	36.0			12:54P
18	40.7	4.33	4.67	0.73	1.01	0.77	-.0005	-0.005	40.1	40.0			1:22p
19	41.9	5.34	5.67	0.90	1.23	0.95	-0.006	-0.004	41.4	41.2			1:36p
20	43	6.34	6.67	1.09	1.48	1.13	-.010	-.010	42.2	42.1			1:44p

Purdue University Specimen : A-2 Date: 6/1/12

	Average Load (lbf)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	DG North Overhang (in)	DG South Overhang (in)	Time
1	0.28	0	0	-0.01	0	-0.01	-0.001	-0.001	0.3	0.3	0.2	0.2	8:01A
2	1st crack	at	2.7k						~~6~~	~~6~~			8:~~07~~A
3	6	0.14	0.11	0.01	0.03	0.01	-0.001	-0.001	6	6	0.340	0.312	8:07A
4	12	0.44	0.44	0.06	0.10	0.06	.0.000	-0.001	12	12	0.638	0.632	8:35A
5	18	0.79	0.78	0.11	0.18	0.11	-0.001	-0.001	18	18	0.985	0.968	8:54A
6	24	1.16	1.17	0.17	0.26	0.17	-0.001	-0.001	24	24	1.355	1.367	9:21A
7	30	1.56	1.53	0.22	0.34	0.22	-0.002	-0.001	30	30	1.765	1.720	9:55A
8	N + S	DG	reset								0.~~8~~900	0.800	
9	36	1.93	1.89	0.27	0.42	0.28	-0.002	-0.001	36	36	1.274	1.165	10:29A
10	38.4	2.29	2.22	0.33	0.48	0.32	-0.001	-0.000			1.~~499~~635	1.499	10:59A
11	40.8	3.63	3.39	0.55	0.72	0.53	-0.002	-0.001	40.6	41			11:32A
12	Max. Load ~44.5k.												
13													
14													
15													
16													
17													
18													
19													
20													

Purdue University

Specimen : A-3

Date: 5/30/12

	Average Load (~~lbf~~) k	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (~~lbf~~) k	South Load Cell (~~lbf~~) k	DG North Overhang (in)	DG South Overhang (in)	Time
1	0.16	0.00	0.00	0.00	0.00	0.00	-0.002	-0.002	0.2	0.1	0.1	0.1	8:06
2	6.2	0.13	0.15	0.02	0.03	0.02	-0.002	-0.002	6.2	6.2	~~6.2~~ 0.234	0.248	8:13
3	12	0.44	0.47	0.07	0.1	0.07	-0.002	-0.001	12	12	0.538	0.57	8:33
4	18	0.80	0.83	0.12	0.18	0.12	-0.003	0.000	17.9	18	0.894	0.932	9:03
5	24	1.19	1.19	0.18	0.26	0.17	-0.003	0.001	24	24	1.289	1.284	9:32
6	30	1.55	1.57	0.23	0.33	0.23	-0.003	0.002	30	30	1.657	1.657	10:11
7	36	1.93	1.96	0.29	0.42	0.29	-0.004	0.004	36	36	/	/	10:40
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													

Purdue University Specimen : A-4 Date: 6/8/12

	Average Load (lbf)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	DG North Overhang (in)	DG South Overhang (in)	Time
1	0.3	-0.01	-0.01	-0.00	-0.00	0.00	-0.001	-0.001	0.3	0.3	0.000	0.000	7:43A
2	2.2	first crack											
3	6.0	0.17	0.16	0.02	0.04	0.03	-0.001	-0.001	6.0	6.0	0.169	0.171	7:52A
4	12.0	0.49	0.51	0.07	0.11	0.07	-0.001	-0.002	12.0	12.0	0.494	0.519	8:11A
5	18.0	0.96	0.92	0.14	0.21	0.14	-0.001	-0.001	18.0	18.0	0.963	0.929	8:36A
6	24.1	1.33	1.29	0.19	0.29	0.19	-0.001	-0.001	24.1	24.1	1.328	1.299	9:04A
7	29.9	1.73	1.69	0.25	0.38	0.26	-0.000	-0.001	29.9	29.9	1.740	1.706	9:24A
8	N+S	DG reset									0.000	0.000	
9	36.0	2.15	2.13	0.32	0.48	0.32	-0.000	0.001	36.0	36.0	0.428	0.~~5~~439	9:51A
10	N+S	DG reset									0.000	0.000	
11	36.8	yield							36.8	36.7			
12	37.8	2.66	2.67	0.40	0.58	0.42	-0.001	0.002	37.8	37.8	0.520	0.538	10:20A
13	40.0	3.97	4.04	0.61	0.85	0.66	-0.003	0.003	39.9	40.1	1.825	~~2~~1.922	10:54A
14	20.2	3.13	3.25	0.49	0.66	0.54	-0.003	0.003	20.2	20.2	0.983	1.110	11:25A
15	0.3	1.97	2.09	0.31	0.40	0.35	-0.003	0.001	0.3	0.3			11:30A
16	12.0	2.49	2.60	0.37	0.51	0.43	-0.003	0.001	12.0	12.0			11:46A
17	24.0	3.16	3.26	0.49	0.66	0.54	-0.003	0.002	24.1	24.0			11:59A
18	36.0	3.83	3.93	0.59	0.82	0.64	-0.003	0.003	36.0	36.0			12:16P
19	40.4	4.44	4.56	0.69	0.96	0.75	-0.003	0.005	40.5	40.4			12:35P
20	41.7	5.47	5.55	0.86	1.17	0.93	-0.003	0.005	41.6	41.9			12:53P

Purdue University Specimen : A-5 Date: 6/7/12

	Average Load (lbf)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	DG North Overhang (in)	DG South Overhang (in)	Time
1	0.22	~~0.3~~ 0.00	~~0.2~~ 0.00	~~0~~ 0.01	0.01	0.00	-0.002	-0.002	0.3	0.2	0.000	0.000	7:35A
2	3.2	first crack											
3	6.0	0.17	0.15	0.03	0.05	0.03	-0.002	-0.002	5.9	6.1	0.169	0.151	8:00A
4	12.0	0.49	0.49	0.07	0.11	0.07	-0.002	-0.001	12.0	12.0	0.488	0.488	8:21A
5	18.0	0.86	0.84	0.13	0.20	0.13	-0.002	-0.001	18.0	18.0	0.860	0.846	8:45A
6	24.0	1.23	1.25	0.18	0.28	0.18	-0.001	0.000	24.0	24.0	1.231	1.257	9:11A
7	30.0	1.61	1.63	0.25	0.37	0.24	-0.001	0.001	30.0	30.0	1.623	1.645	9:38A
8	N+S	DG reset									0.000	0.000	
9	36.0	2.07	2.10	0.31	0.47	0.32	-0.000	0.001	36.0	36.0	0.450	0.464	10:06A
10	37.5	yield											
11	~~2.4~~38	2.44	2.61	0.37	0.55	0.39	-0.000	0.001	37.7	37.5	0.875	0.987	10:32A
12	N+S	DG reset									0.000	0.000	
13	40.2	3.90	4.12	0.63	0.85	0.66	-0.000	-0.001	40.2	40.2	1.540	1.531	10:58A
14	20.3	3.08	3.29	0.50	0.66	0.52	-0.000	-0.001	20.3	20.2	0.622	0.767	11:32A
15	0.2	1.95	2.12	0.32	0.40	0.34	-0.002	-0.001	0.2	0.2			11:38A
16	12.0	2.47	2.67	0.40	0.51	0.42	-0.002	-0.001	11.9	12.0			11:51A
17	24.0	3.11	3.34	0.50	0.67	0.53	-0.001	-0.001	24.1	24.0			12:04P
18	36.0	3.77	4.01	0.61	0.82	0.64	-0.000	-0.001	36.0	36.0			12:19P
19	40.7	4.38	4.62	0.71	0.97	0.75	0.000	-0.001	40.8	40.6			12:41P
20	42.2	5.39	5.63	0.88	1.20	0.94	0.000	-0.003	42.3	42.0			12:58P

Purdue University Specimen : A-6 Date: 6/5/12

	Average Load (~~lbf~~) k	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (~~lbf~~) k	South Load Cell (~~lbf~~) k	DG North Overhang (in)	DG South Overhang (in)	Time
1	0.23	0.00	0.00	0.00	-0.00	0.00	-0.000	-0.000	0.3	0.2	0.000	0.000	1:04 P
2	3.14	first crack											
3	6	0.15	0.15	0.02	0.03	0.03	0.001	-0.000	6.0	6.0	0.144	0.154	1:12 P
4	12	0.45	0.45	0.07	0.09	0.07	0.004	0.000	12.0	12.1	0.447	0.450	1:30 P
5	18	0.86	0.86	0.13	0.18	0.13	0.007	-0.001	18.0	17.9	0.851	0.845	1:55 P
6	24	1.27	1.23	0.18	0.27	0.18	0.008	-0.001	24.0	24.0	1.268	1.219	2:25P
7	30	1.64	1.64	0.24	0.36	0.25	0.009	-0.002	30.0	30.0	1.639	1.651	2:48P
8	N+S	DG reset									0.000	0.000	2:56P
9	36	2.09	2.12	0.31	0.47	0.33	0.009	-0.003	36	36	0.458	0.475	3:51 P
10	37	Yield											
11	38	2.63	2.79	0.41	0.59	0.44	0.009	-0.004	37	37	1.003	1.163	3:55p
12	~~N+S~~	~~DG reset~~									1.021	1.181	
13											0.000	0.000	4:26 P
14	39.8	3.84	4.19	0.62	0.86	0.68	0.009	-0.007	39.9	39.7	1.173	1.400	4:31 P
15	20.2	3.00	3.37	0.49	0.66	0.54	0.008	-0.007	20.1	20.3	0.333	0.556	4:57 P
16	0.22	1.86	2.20	0.31	0.40	0.35	0.007	-0.007	0.2	0.2			5:06 P
17	12	2.39	2.74	0.39	0.52	0.44	0.007	-0.007	12.0	12.0			5:22 P
18	24	3.04	3.40	0.50	0.67	0.55	0.008	-0.007	24.0	24.0			5:36 P
19	36	3.71	4.07	0.60	0.83	0.66	0.009	-0.007	36.0	36.0			5:49 P
20	40.3	4.32	4.70	0.70	0.97	0.77	0.009	-0.009	40.7	39.9			6:13 P

Purdue University Specimen : A-6 Date: 6.5.12

	Average Load (lbf)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	DG North Overhang (in)	DG South Overhang (in)	Time
21	41.1	5.07	5.44	0.83	1.15	0.93	0.008	-0.011	41.1	41.2			6:23P
22	Max	Load	:~42.k										
23													
24													
25													
26													
27													
28													
29													
30													
31													
32													
33													
34													
35													
36													
37													
38													
39													
40													

Purdue University **Specimen :** B-1 **Date:** 5/10/12

	Average Load kip (~~lbf~~)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	TIME
1	0.2	0.01	-0.01	0	0	0	-0.001	-0.000	0.2	0.2	12:10
2	DGs	0	0								
3	3.5	0.05	0.04	0.01	0	0	0	0	3.5	3.5	
4	DGs	0.035	0.045								
5	2.3	0.04	0.04	0.01	0	0	-0.001	0.	2.2	2.3	2PM
6	DGs	0.033	0.044								
7	6	0.13	0.14	0.02	0.02	0.02	0.001	0.001	6	6	2:04
8	DGs	0.122	0.146								
9	12	0.44	0.42	0.05	0.07	0.06	0.003	0.001	12	12	2:21
10	DGs	0.414	0.429								
11	18	0.79	0.76	0.1	0.13	0.1	0.004	0.002	18	18	2:53
12	DGs	0.762	0.770								
13	24	1.1	1.07	0.15	0.18	0.14	0.007	0.002	24	24	3:16
14	DGs	1.069	1.079								
15	30	1.43	1.42	0.19	0.24	0.19	0.008	0.003	30	30	3:43
16	DGs.	1.401	1.432	→ REMOVED							
17	36	1.82	1.81	0.25	0.31	0.25	0.009	0.003	36	36	4:16
18	~40 :	Failure.									
19											
20											

Purdue University

Specimen : B-2

Date: 5/23/12

	Average Load ~~(lbf)~~ k	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell ~~(lbf)~~ kip	South Load Cell ~~(lbf)~~ kip	DG North Overhang (in)	DG South Overhang (in)	Time
1	0.2	0	0.01	0	0	-0.01	-0.005	0.001	0.3	0.2	+0.100	0.100	7:57A
2	3.4	1ST CRACK											
3	6.0	0.14	0.16	0.02	0.02	0.01	-0.005	0.001	6	6	0.238	0.244	8:30 A
4	12	0.47	0.42	0.06	0.07	0.05	-0.004	0.002	12	12	0.571	0.510	8:54A
5	18	0.81	0.78	0.11	0.13	0.10	-0.003	0.002	18	18	0.897	0.871	9:11 A
6	24	1.14	1.11	0.15	0.19	0.15	-0.002	0.003	24	24	1.217	1.206	9:35 A
7	30	1.48	1.46	0.2	0.25	0.2	-0.001	0.004	30	30	1.558	1.548	10:00A
8	36	1.88	1.85	0.26	0.33	0.26	-0.001	0.004	36	36	N.A.	1.945	10:26 A
9											Reset: @ 1.9	RELATIVE MEASUREMENTS	
10	18	1.27	1.23	0.18	0.22	0.17	-0.002	0.005	18	18	1.296 ↓	1.320	11:10 A
11	0.2	0.48	0.48	0.07	0.08	0.06	-0.004	0.001	0.2	0.2	0.500	0.550	11:15A
12	12	0.89	0.87	0.12	0.15	0.11	-0.002	0.002	12	12	0.914	0.960	11:30 A
13	24	1.43	1.39	0.2	0.24	0.19	-0.001	0.004	24	24	1.444	1.480	11:45A
14	36	1.96	1.91	0.28	0.34	0.27	-0.001	0.006	36	36	—	2.009	12:00 N.
15	DG's	Removed	@ 36 k										
16	Max	Load =	39k										
17													
18													
19													
20													

Purdue University Specimen : B-3 Date: 5/21/12

	Average Load ~~(lbf)~~ k	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell ~~(lbf)~~ k	South Load Cell ~~(lbf)~~ k	DG North Overhang (in)	DG South Overhang (in)	Time
1	0.2	0	0	0	0	0	-0.001	-0.003	0.2	0.2	0	0	8A
2	3k	: 1st	crack										
3	6.2	0.14	0.14	0.02	0.03	0.02	-0.001	-0.002	6.2	6.2	0.143	0.132	8:10A
4	12	0.42	0.40	0.05	0.07	0.05	-0.003	-0.002	12	12	0.429	0.407	8:35A
5	18	0.78	0.74	0.10	0.13	0.10	-0.004	-0.002	18	18	0.780	0.747	9:04A
6	24	1.09	1.07	0.14	0.19	0.15	-0.004	-0.002	24	24	1.087	1.080	9:27A
7	30	1.43	1.41	0.19	0.25	0.2	-0.004	-0.001	30	30	1.420	1.423	9:57A
8	36	1.79	1.78	0.25	0.32	0.25	-0.004	0.000	36	36	1.780	1.795	10:28A
9	0.2	0.44	0.44	0.06	0.09	0.06	-0.004	-0.006	0.2	0.2	0.435	0.436	11:05A
10	12	0.86	0.84	0.12	0.15	0.12	-0.004	-0.004	12.1	11.9	0.854	0.840	11:14A
11	24	1.36	1.34	0.18	0.24	0.19	-0.004	-0.002	24	24	1.352	1.352	11:25A
12	36	1.87	1.8~~4~~5	0.26	0.34	0.26	-0.004	-0.001	36	36	1.855	1.864	11:47A
13	MAX	LOAD :	39.8k										
14													
15													
16													
17													
18													
19													
20													

Purdue University Specimen : B-4 Date: 5/~~14~~ 12

	Average Load (lbf)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	DG North Overhang (in)	DG South Overhang (in)	Time
21	0.2	0	0	0	0	0	0	0	0.2	0.2	0.2	0.2	4:10 P
22	3.5	0.02	0.03	0	0	0	0	0.001	3.5	3.5	0.225	0.228	4:17 P
23	0.2	0	0	0	0	0	0	0.001	0.2	0.2	0.202	0.202	4:27 P
24													
25													
26													
27													
28													
29													
30													
31													
32													
33													
34													
35													
36													
37													
38													
39													
40													

Purdue University **Specimen :** B-4 **Date:** 5/14

	Average Load (lbf)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	DG North Overhang (in)	DG South Overhang (in)	Time
1	0.2	0	0	0	0	0	-0.002	-0.001	0.2	0.2	0.203	+0.205	1:20
2	5.2	0.04	0.05	0	0	0	-0.001	0	5.2	5.2	0.245	0.255	~1:35
3	↳	1ST CRACK											
4	12	0.31	0.33	0.04	0.05	0.05	0	0.001	12	12	0.514	0.535	1.58
5	18	0.62	0.63	0.08	0.11	0.08	0.003	0.002	18	18	0.811	0.833	2:20
6	↳	1ST SPLIT. CRACK							24	24			
7	24	0.95	0.94	0.13	0.16	0.13	0.004	0.003	24	24	1.131 ✓	1.148 ✓	2:57
8	30	1.26	1.25	0.17	0.21	0.17	0.006	0.004	30	30	1.439 ✓	1.459 ✓	3:33
9	36	1.62	1.61	0.21	0.27	0.22	0.006	0.004	36	36	1.~~8~~798	1.824	4:07
10	DGs	Removed.											
11	38	1.77	1.76	0.23	0.3	0.24	.008	.005	38	38	—	—	4:56
12													
13													
14													
15													
16													
17													
18													
19													
20													

Purdue University

Specimen : B-5

Date: 5/17/12

	Average Load (lbf)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell ~~(lbf)~~ k	South Load Cell ~~(lbf)~~ k	DG North Overhang (in)	DG South Overhang (in)	Time
1	0.2	0	0	0	0	0	0	0	0.2	0.2	0	0.300	12:20 PM
2	0.2	0	0	0	0	0	0.001	0.001	0.2	0.2	0	0.300	1:25PM
3	6	0.08	0.08	0	0.02	0.01	0.002	0.002	6	6	0.076	0.380	1:37PM
4	↳ 1ST CRACK OBSERVED												
5	12	0.33	0.36	0.04	0.06	0.05	0.004	0.002	11.9	12	—	0.660	1:56 PM
6	18	0.70	0.65	0.08	0.11	0.09	0.004	0.003	18	18	0.691	0.948	2:20PM
7	24	1.01	0.98	0.12	0.17	0.13	0.004	0.003	24	24	0.997	1.275✓	2:48PM
8	30	1.33	1.30	0.17	0.22	0.17	0.005	0.003	30	30	1.303	1.593	3:16PM
9	RESET DGS:										1.000	1.000	
10	36	1.68	1.63	0.22	0.28	0.22	0.005	0.004	36	36	1.343	1.342	3:44 PM
11	0	0.39	0.39	0.05	0.07	0.05	0.003	0.002	0	0	0.082	0.085	4:14PM
12	12	0.76	0.74	0.09	0.13	0.10	0.004	0.002	12	12	0.444	0.441	4:42 PM
13	24	1.25	1.21	0.15	0.21	0.16	0.004	0.003	24	24	0.918	0.915	4:49 PM
14	32	1.56	1.53	0.2	0.27	0.21	0.005	0.004	32	32	—	—	5:30 PM
15													
16													
17													
18													
19													
20													

Purdue University Specimen : B-6 Date: 5/25/12

	Average Load ~~(lbf)~~ kip	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell ~~(lbf)~~ k	South Load Cell ~~(lbf)~~ k	DG North Overhang (in)	DG South Overhang (in)	Time
1	0.18	·0	0.02	0	0	0	-0.006	0	0.2	0.2	0.	0.100	8:22 A
2	3.9 k:	1st crack											
3	6	0.1	0.12	0.01	0.01	0.01	-0.005	0.002	6	6	0.105	0.207	8:29A
4	12	0.37	0.39	0.05	0.06	0.04	-0.004	0.003	12	12	0.368	0.470	8:57 A
5	18	0.73	0.71	0.09	0.11	0.08	-0.003	0.003	18	18	0.718	0.805	9:06A
6	24	1.09	1.04	0.14	0.17	0.13	-0.002	0.004	24	23.9	1.068	1.130	9:30A
7									30	30			
8	30	1.42	1.36	0.19	0.22	0.17	-0.001	0.005	30	30	1.392	1.457	9:54 A
9	36	1.76	1.70	0.24 ~~1.70~~	0.29	0.23	0.001	0.006	36	36	1.734	1.795	10:14A
10	18.5	1.18	1.16	0.16	0.19	0.15	-0.001	0.005	18.5	18.5	1.169	1.256	10:39 A
11	0	0.43	043	0.06	0.07	0.05	-0.004	0.004	0.2	0.2	0.404	0.505	10:50A
12	12	0.81	0.80	0.11	0.13	0.10	-0.002	0.004	12	12	0.805	0.892	11:06 A
13	24	1.33	1.29	0.18	0.21	0.17	-0.000	0.005	24	24	1.303	1.381	11:18A
14	36	1.85	1.78	0.25	0.30	0.24	0.001	0.006	36	36.1	1.820	1.876	11:34A
15	38	2.02	1.93								NO DGs		
16	MAX	LOAD:	~41.6										
17													
18													
19													
20													

TAKING ACCURATE THERMOMETER READINGS

COMMON TYPES OF THERMOMETERS AND FACTORS AFFECTING THEIR USE

TOTAL IMMERSION thermometers are designed with scales calibrated to indicate the true temperature when the bulb and the portion of the thermometer that contains the mercury column are exposed to the temperature to be measured (practically, less than an inch is permitted to extend above the surface, to permit the reading to be made). Most total immersion thermometers can also be used in a condition of complete immersion, in which case the entire thermometer is exposed to the temperature being measured, such as in a freezer.

PARTIAL IMMERSION thermometers are designed with scales calibrated to indicate the true temperature when the thermometers are immersed to specified depths. The portion that should be immersed is indicated on the back of each thermometer.

COMPUTATION OF EMERGENT STEM CORRECTION

When total immersion thermometers are used only partially immersed, a stem correction may he calculated and applied to the reading for precision results. To compute an emergent stem correction, the following variables must be defined:

T = the reading of the thermometer in situ.
N = the number of degrees on the thermometer scale between the liquid surface and the top of the mercury column.
A = the average temperature of the emergent mercury column. To find value A, suspend alongside the subject thermometer a secondary or auxiliary thermometer with its bulb centered between the liquid level and the temperature indicated on the subject. thermometer. The temperature indicated on this auxiliary thermometer will he value A.

Find the stem correction (SC) by computation from the following formula:
SC = 0.00016 x (N x (T-A)) for Celsius temperatures, or
SC = 0.00009 x (N x (T-A)) for Fahrenheit temperatures.

Example: A thermometer graduated from -1° to 101°C., immersed to 20°C on its scale, reading 90°C. The auxiliary thermometer reads 42C. Hence, T=90, N=70 (90.20). A=42

Working the formula, SC =.00016 x (70 x (90 - 42)) yields a value for SC of +.537. This value must he added to the observed indication of the subject thermometer to determine the true temperature of the liquid. Hence, the true temperature of the liquid is 90° + .54° (rounded result) = 90.54°

GENERAL CONSIDERATIONS FOR MAKING AN ACCURATE READING

The error due to parallax may be eliminated by taking care that the reflection of the scale can be seen in the mercury thread, and by adjusting the line of sight so that the graduation of the scale nearest the meniscus exactly hides its own image: the line of sight will then be normal to the stem at that point. In reading thermometers, account must be taken of the fact that the lines are of appreciable width. The best practice is to consider the position of the lines as defined by their middle parts.

PERFORMING A CALIBRATION AT THE ICE POINT (0 DEGREES CELSIUS OR 32 DEGREES FAHRENHEIT)

Select clear pieces of ice, preferably made from relatively pure water. Discard any cloudy or unsound portions. Rinse the ice with distilled water and shave or crush into small pieces, avoiding direct contact with the hands or any chemically unclean objects. Fill a Dewar or other insulated vessel with the crushed ice and add sufficient distilled (and preferably precooled) water to form a slush, but not enough to float the ice. Insert the thermometer, packing the ice gently about the stem, to a depth sufficient to cover the 0°C (32°F) graduation. As the ice melts, drain off some of the water and add more crushed ice.

Raise the thermometer a few millimeters after at least 3 minutes have elapsed, tap the stem gently and observe the reading. Successive readings taken at least one minute apart should agree within one tenth of one graduation.

APPLYING THE CORRECTION AT ICE POINT

Record readings and compare with previous readings. If the readings are found to be higher or lower than the reading corresponding to a previous calibration, readings at all other temperatures will he correspondingly increased or decreased.

Reproduced in part from ASTM E77.

KESSLER **KESSLER THERMOMETER CORP.**

Precision and Reliability . . . from a name you can trust.

CALSER CORPORATION 302 N. BELT EAST SWANSEA, IL 62226 (618)277-0329

TESTING MACHINE CERTIFICATE OF CALIBRATION

Owner : Purdue University
Location : 1040 South River Rd. - Bowen Lab
West Lafayette, IN 47907
Machine : Forney 600,000lbf Model F-600-DFM/1
Serial No. : 99058
w/ Forney DFM/1 Digital R/O #9902182
w/ Dynisco P/T #02-23-990747

Report # : VN# 6560
Page : 2 of 2
Date of Service: 06/06/11

This is to certify that the testing machine listed above has been calibrated by Calser Corporation personnel.
The method of verification and listed data are in accordance with ASTM E 4-09.
Accuracy of all calibration devices is traceable to the National Institute of Standards and Testing (NIST)
and all calculations have been corrected for temperature where applicable.

Capacity Range	Loading Range	Max. Error
Run 1 600,000lbf Range	5,000 - 600,000	1.20 %
Run 2 600,000lbf Range	5,000 - 600,000	0.10 %
Run 3 600,000lbf Range	5,000 - 600,000	0.08 %

Verification Equipment Used:

(400,000 Load Cell Set)
Admet Gage Buster Digital Readout, Serial # GB-9911092,
and Load Cell(s) Listed Below:

Serial #	Range	Calib. Date	Uncertainty
901120B	716.99 -10,000 lbf	08/19/2009	1.792 lbf
090716C (LO)	5,572.38 - 100,000 lbf	08/10/2010	13.931 lbf
090716C (HI)	39,281.95 - 400,000 lbf	08/10/2010	98.205 lbf

This certificate is issued as a statement of the fact that on the above date the listed testing machine has an accuracy as indicated. It should not be construed or regarded as a Guarantee or Warranty of any kind (in favor of the client, the client's customers, or the public at large) that the testing machine will continue to retain the same percentage (%) of accuracy or efficiency as determined on the date when the calibration, and adjustments if required, was performed and reported by "Calser Corporation" since the calibrator has absolutely no control over the future operation, damage, maintenance, repairs, and overall condition of the testing machine and hereby expressly disclaims any and all liability for damage or loss sustained by all parties arising or resulting from the deterioration, obsolescence, malfunction or substandard performance of said testing machine; which shall remain the sole responsibility of the machine's regular custodian, owner, and/or user. This certificate shall not be reporoduced except in full, without the written approval of Calser Corporation.

CALSER CORPORATION

Quality Control Director

Thomas R. Gagen

Form # 104-01-Rev 3

CALSER CORPORATION 302 N. Belt East, Swansea, IL 62226 (618) 277-0329

TESTING MACHINE CALIBRATION DATA AND REPORT

Report #: VN# 6560

Page 1 of 2

Customer	Purdue University
Location	1040 South River Rd. - Bowen Lab West Lafayette, IN 47907
Machine	Forney 600,000lbf Model F-600-DFM/1
Serial No.	99058
Auxilary Equipment:	w/ Forney DFM/1 Digital R/O #9902182 w/ Dynisco P/T #02-23-990747

Date of Service	06/06/11
Cust Order No.	Verbal
Order Date	06/02/11
Temp.	74° F
Date Last Done	05/19/10

Applied Force	*	Indicated Force	Error	%	*	Indicated Force	Error	%	*	Indicated Force	Error	%
Run #1		Run #1	"As Found" Condition			Run #2	"As Left" Condition			Run #3	"As Left" Condition	
600,000lbf Range	*	10lbf / DIV			*				*			
0	6C	0	0	0.00	6C	0	0	0.00	6C	0	0	0.00
5,000	6C	4,940	-60	1.20	6C	5,000	0	0.00	6C	5,000	0	0.00
10,000	7	9,880	-120	1.20	7	9,990	-10	0.10	7	10,000	0	0.00
20,000	7	19,790	-210	1.05	7	19,990	-10	0.05	7	19,990	-10	0.05
40,000	8	39,530	-470	1.18	8	40,000	0	0.00	8	40,000	0	0.00
60,000	8	59,340	-660	1.10	8	60,010	10	0.02	8	60,000	0	0.00
80,000	8	79,150	-850	1.06	8	80,050	50	0.06	8	80,030	30	0.04
100,000	8	98,940	-1,060	1.06	8	100,060	60	0.06	8	100,070	70	0.07
125,000	8	123,600	-1,400	1.12	8	125,090	90	0.07	8	125,100	100	0.08
150,000	8	148,330	-1,670	1.11	8	150,150	150	0.10	8	150,120	120	0.08
200,000	8	197,650	-2,350	1.18	8	199,980	-20	0.01	8	200,010	10	0.01
300,000	8	296,650	-3,350	1.12	8	300,060	60	0.02	8	300,040	40	0.01
400,000	8	395,880	-4,120	1.03	8	400,120	120	0.03	8	400,090	90	0.02
500,000	8	495,110	-4,890	0.98	8	500,260	260	0.05	8	500,210	210	0.04
600,000	8	593,770	-6,230	1.04	8	600,310	310	0.05	8	600,290	290	0.05
0	8	0	20	0.00	8	0	-10	0.00	8	0	-30	0.00

Notes:

Calibration in accordance with ASTM E4-09, and Calser Corporation Procedure # 1-01, Rev 1.

***CALIBRATION EQUIPMENT**

All verification equipment-including dead weights, proving rings, load cells, etc. is calibrated and traceable to the latest procedures stipulated by the National Institute of Standards and Test'ing (NIST) and ASTM E74-06. All equipment is traceable under guidelines set forth in ISO/IEC 17025. All instrument readings have been corrected for temperature where necessary.

ACCURACY SUMMARY

Capacity Range	Loading Range	Max. Error
Run 1		
600,000lbf Range	5,000 - 600,000	1.20 %
Run 2		
600,000lbf Range	5,000 - 600,000	0.10 %
Run 3		
600,000lbf Range	5,000 - 600,000	0.08 %

VERIFICATION EQUIPMENT

Manufacturer & Serial #	* L/C	Class A Range (in LBs) and Uncertainty (LBF)	Agency & Date
Strainsense	6C	716.99 -10,000 lbf	Morehouse
901120B		1.792 lbf	08/19/09
Strainsense	7	5,572.38 - 100,000lbf	Morehouse
090716C (LO)		13.931 lbf	08/10/10
Strainsense	8	39,281.95 - 400,000 lbf	Morehouse
090716C (HI)		98.205 lbf	08/10/10

Calibration Technician Jerry Parker

This report shall not be copied except in its entirety without express written approval of Calser Corp.

Form# 103-01-Rev 3

CERTIFICATE OF CALIBRATION

ISSUED BY: INSTRON CALIBRATION LABORATORY

DATE OF ISSUE: 30-Jan-12 CERTIFICATE NUMBER: **340013012113643**

NVLAP®
Lab code: 200301-0

Instron
825 University Avenue
Norwood, MA 02062-2643
Telephone: (800) 473-7838
Fax: (781) 575-5750
Email: service_requests@instron.com

Page 1 of 3 pages

APPROVED SIGNATORY

Richard Binford
Digitally signed by Richard Binford
DN: cn=Richard Binford, c=US, l=Norwood, st=MA, ou=OVR
Date: 2012.01.30 12:01:16 -05'00'

Type of Calibration:	**Strain**
Relevant Standard:	**ASTM E83-10**
Date of Calibration:	**30-Jan-12**

Customer

Name:	PURDUE UNIVERSITY
Address:	550 STADIUM MALL DR. WEST LAFAYETTE,IN 47907 KBROWER@PURDUE.EDU
P.O./Contract No.:	
Contact:	KEVIN BROWER

Machine

Manufacturer:	BALDWIN
Serial Number:	120BTEC502040
System ID:	120BTEC502040
Range Type:	Single

Transducer

Manufacturer:	INSTRON
Transducer ID:	2630-115/590
Extensometer Type:	Type 1
Travel (Tension):	1 in
Travel (Compression):	0.1 in
Gauge Length:	2 in
Mode:	Static (Tension/Compression)

Classification

The following indicators of the extensometer system were verified and classed:

Indicator Type	Description	Indicator Units	Range Full Scale (%)	System Class
1. Digital Readout		strain	100	B-1

Certification Statement

All indicators listed above were verified on-site at customer location by Instron in accordance with ASTM E83.

The verification and equipment used conform to a controlled Quality Assurance program which meets the specifications outlined in ANSI/NCSL Z540-1, ISO 10012, ISO 9001:2008 and ISO/IEC 17025:2005.

The testing machine was verified in the 'as found' condition.

Instron Calpro Version 3.23

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340013012113643

Page 3 of 3 pages

Data

Indicator 1. - Digital Readout (strain)

% of Range	Run 1 Indicated (strain)	Run 1 Applied (in)	Run 2 Indicated (strain)	Run 2 Applied (in)
100% Range (Full Scale: 1.00016 in)				
	Run Temperature: 70.0 °F		Run Temperature: 70.1 °F	
40	0.19991	0.400580	0.1995	0.400013
70	0.34995	0.700010	0.349987	0.700023
100	0.49985	1.000162	0.49899	1.000050

Verification Equipment and Usage

Verification Equipment:

Make/Model	Serial Number	Description	Calibration Agency	Measurement Range	Cal Date	Cal Due
Extech 445580	1003552	temp. indicator	Tektronix	NA	12-Feb-11	12-Feb-13
Epsilon 3590VHR	A5010 (ASTM)	disp. indicator	Instron Ltd	2.00 in	14-Feb-11	14-Feb-12
* Instron US Gauge Bar	I902	gauge bar	AA Jansson	NA	11-May-10	11-May-12
* HBM ML38	90630412	force indicator	Instron	NA	21-Jan-11	21-Jan-13
* Epsilon 3590VHR	A5010 (ASTM)	(Note: Also used for displacement measurements and listed above.)				

* *Equipment used for gauge length measurements.*

Verification Equipment Usage:

Measurement Type	Serial Number	Range (% Full Scale)	Percent(s) of Range
Displacement	A5010 (ASTM)	100	0/10/20/40/70/100

Instron standards are traceable to NIST and/or other National standards.

Comments

Verified by: Rich Binford
Field Service Engineer

NOTE: Clause 9 of ASTM E-83 states; It is recommended that extensometer systems be verified annually or more frequently if required. In no case shall the time interval between verifications exceed 18 months (unless an extensometer is being used in a long-time test running beyond the 18 month period). An extensometer system shall not be used after an adjustment or repair that could affect its accuracy without first verifying its accuracy utilizing the procedure described in this practice.

Instron Calpro Version 3.23

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Instron® Service
825 University Avenue ■ Norwood, MA 02062-2643
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www.Instron.com

Field Service Report

Company: Purdue University
Address: 550 Stadium Mall Drive
Civil Room G151
West Lafayette, IN 47907
USA
Contact: Brower Kevin
Service Order #: SV1201120017@@1
PO #: Credit Card
Field Engineer: Richard Binford
Reference #:
Service Notes: Contract Total Amount: $2330.
Verified force,displcement and the extensometer. Keep a regular check on the pressure transducer oil capsule gap regularly to insure the .030" gap for accurate force readings.

Labor Activities

Work Date	Product/SN	Tag Number	Work Hours	Charge Code	Description
01/30/2012		120BTEC502040	0.02	S1400-003-A	Zone 3 For Tensile Service
01/30/2012		120BTEC502040	1.00	S1460-011-A	Crosshead Displacement Verification
01/30/2012		120BTEC502040	2.00	S1481-017-C-A	Force Verification, 68K lb- 300K lb Compression
01/30/2012	2630-115/590	120BTEC502040	1.00	S1490-003-A	Strain Verification, Static Ext or Deflectometer

Materials

Part Number	Part Number Description	Qty	Serial #

CERTIFICATE OF CALIBRATION

ISSUED BY : INSTRON CALIBRATION LABORATORY

DATE OF ISSUE : **30-Jan-2012** CERTIFICATE NUMBER: **340013012110833**

Lab code: 200301-0

Page 1 of 3

Instron
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APPROVED SIGNATORY

Richard Binford

Digitally signed by Richard Binford
DN: cn=Richard Binford, c=US, l=Norwood, st=MA, ou=OVR
Date: 2012.01.30 11:36:28 -05'00'

Type of Calibration: **Displacement**
Relevant Standard: **astm e2309**
Date of Calibration: **30-Jan-2012** **Customer Requested Due Date: 30-Jan-2013**

Customer

PURDUE UNIVERSITY
550 STADIUM MALL DR.
WEST LAFAYETTE, IN 47907

Machine

Serial No : C502040
Make : BALDWIN
Model : 120BTE

P.O. Number :
Contact : HARRY TIDRICK

Readout Verified

1. Digital Readout (in)

Certification Statement

This certifies that the displacements verified with machine indicator 1 (listed above) were verified by Instron in accordance with ASTM E2309-05 (Follow-the-Displacement Method) and Instron work instruction ICA-8-07.

The testing machine was verified on-site at customer location. Adjustments are noted in the comments section of this report with a reference to the "As Found" data.

The verification and equipment used conform to a controlled Quality Assurance program which meets the specifications outlined in ANSI/NCSL Z540-1, ISO 10012, ISO 9001:2000, and ISO/IEC 17025:2005. The Instron measurement equipment used for verification is traceable to NIST.

Summary of Results

Indicator 1- Digital Readout (in)

Verified Range (in)	Max Error (in)	Max Error (%)	Max Repeat Error (in)	Max Repeat Error (%)	System Class*	Resolution (in)	Resolution Class	ASTM Lower Limit (in)
0.2 - 1	-0.00268	-0.355	0.00112	0.257	B	.001	B	0.2

**System Class is derived from assessment of the following: error, repeatability, resolution, and standard device classification.*

The results indicated on this certificate and report relate only to the items verified. If there are methods or data included that are not covered by the NVLAP accreditation it will be identified in the comments. Any limitations of use as a result of this verification will be indicated in the comments. This report must not be used to claim product endorsement by NVLAP or the United States government. This report shall not be reproduced, except in full, without the approval of Instron.

CalproSDS version 3.3

CERTIFICATE OF CALIBRATION

ISSUED BY : INSTRON CALIBRATION LABORATORY

DATE OF ISSUE : **30-Jan-2012** CERTIFICATE NUMBER: **340013012110833**

Direction of Displacement : Ascending

Datapoint Summary - Indicator 1 - Digital Readout (in)

Suggested Value (in)	Run 1 Error (in)	Run 1 Error (%)	Run 2 Error (in)	Run 2 Error (%)	Run 3 Error (in)	Run 3 Error (%)	Repeat Error (in)	Uncertainty (in)*	Coverage Factor = k
0.2	0.00007	0.035	-0.00045	-0.222	-0.00026	-0.129	0.00052	0.00081	2.26
0.4	-0.00110	-0.276	-0.00086	-0.213	-0.00091	-0.227	0.00024	0.00070	2.26
0.6	-0.00105	-0.153	-0.00214	-0.355	-0.00176	-0.292	0.00109	0.00150	2.78
0.8	-0.00268	-0.331	-0.00156	-0.189	-0.00162	-0.203	0.00112	0.00165	2.78
1	-0.00168	-0.164	-0.00142	-0.142	-0.00198	-0.196	0.00056	0.00086	2.26

**The reported expanded uncertainty of measurement is based on a combined uncertainty multipied by a coverage factor k to provide a level of confidence of approximately 95 %.*

Runs 1 and 2 are performed to comply with the requirements of ASTM E2309, run 3 is performed to calculate the uncertainty of measurement.

Data - Indicator 1 - Digital Readout (in)

Temperature at start of verification : 67.9 °F

	Run 1			**Run 2**			**Run 3**	
Suggested Value	Applied	Indicated	Error Class	Applied	Indicated	Error Class	Applied	Indicated
0.2	0.19993	0.200	A	0.20245	0.202	A	0.20126	0.201
0.4	0.39810	0.397	A	0.40286	0.402	A	0.40091	0.400
0.6	0.68605	0.685	A	0.60314	0.601	A	0.60176	0.600
0.8	0.80968	0.807	A	0.82356	0.822	A	0.79962	0.798
1	1.02568	1.024	A	1.00142	1.000	A	1.00798	1.006

For runs 1 and 2: the worst Resolution Class is B and the worst Repeatability Class is A.

Temperature at end of verification : 70 °F

Starting Point of crosshead : 0 in

Verification Equipment

Make/Model	Serial No.	Description	Cal Agency	Uncertainty of Calibration	Resolution	Cal Date	Due Date
Instron LDS-10	06105014	Linear Gage	AA JANSSON	.000013 in	.00001 in	3-Aug-10	3-Aug-12
EXTECH 445580	1003552	Thermometer	TEKTRONIX	1 °F	.1 °F	12-Feb-11	12-Feb-13

The standards used for this verification are traceable to NIST.

CERTIFICATE OF CALIBRATION

ISSUED BY : INSTRON CALIBRATION LABORATORY

DATE OF ISSUE : **30-Jan-2012** CERTIFICATE NUMBER: **340013012110833**

Comments

Verified By: RICHARD BINFORD
SNR.SERV.ENGR,

CERTIFICATE OF CALIBRATION

ISSUED BY: INSTRON CALIBRATION LABORATORY

DATE OF ISSUE: 30-Jan-12 CERTIFICATE NUMBER: **340013012095410**

Lab code: 200301-0

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Page 1 of 4 pages

APPROVED SIGNATORY

Richard Binford

Digitally signed by Richard Binford
DN: cn=Richard Binford, c=US, l=Norwood, st=MA, ou=OVR
Date: 2012.01.30 11:08:19 -05'00'

Type of Calibration: Force
Relevant Standard: ASTM E4-10
Date of Calibration: 30-Jan-12

Customer Requested Due Date: 30-Jan-13

Customer

Name:	PURDUE UNIVERSITY
Address:	550 STADIUM MALL DR. WEST LAFAYETTE,IN 47907 KBROWER@PURDUE.EDU
P.O./Contract No.:	
Contact:	KEVIN BROWER

Machine

Manufacturer:	BALDWIN
Serial Number:	120BTEC502040
System ID:	120BTEC502040
Range Type:	Single

Transducer

Manufacturer:	BALDWIN
Transducer ID:	120BTEC502040
Capacity:	120000 lbf
Type:	Compression

Classification

1. Digital Readout - PASSED

Certification Statement

This certifies that the forces verified with machine indicator(s) (listed above) that passed are WITHIN ± 1 % accuracy, 1 % repeatability, and zero return tolerance.

All machine indicators were verified on-site at customer location by Instron in accordance with ASTM E4.

The certification is based on runs 1 and 2 only. A third run is taken to satisfy uncertainty requirements according to ISO 17025 specifications.

The verification and equipment used conform to a controlled Quality Assurance program which meets the specifications outlined in ANSI/NCSL Z540-1, ISO 10012, ISO 9001:2008 and ISO/IEC 17025:2005.

Method

The testing machine was verified in the 'as found' condition with no adjustments carried out.

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340013012095410

Page 2 of 4 pages

Summary of Results

Temperature at start of verification: 67.00 °F.

Indicator 1. - Digital Readout (lbf)

Range Full Scale (%)	Tested Force Range (lbf)	Mode	ASTM E4 Max Error (%)	ASTM E4 Max Repeat Error (%)	Zero Return	Resolution (lbf)	ASTM E4 Lower Limit (lbf)
100	-1194.4 to -119044.9	C	0.88	0.11	Pass	1	200

Temperature at end of verification: 67.80 °F.

Data Point Summary - Indicator 1. - Digital Readout (lbf)

COMPRESSION

% of Range	Run 1 Error (%)	Run 2 Error (%)	Run 3 Error (%)	ASTM E4 Repeat Error (%)	Relative Uncertainty* (%)	Uncertainty of Measurement* (± lbf)
100% Range (Full Scale: -119044.9 lbf)						
1	0.47	0.43	0.43	0.04	0.14	1.661
2	0.41	0.48	0.49	0.07	0.14	3.321
4	0.42	0.46	0.45	0.04	0.13	6.213
7	0.77	0.76	0.77	0.01	0.14	11.254
10	0.82	0.75	0.76	0.07	0.14	16.908
20	0.88	0.77	0.78	0.11	0.15	36.187
40	0.81	0.81	0.80	0.00	0.14	64.283
70	0.81	0.80	0.81	0.01	0.14	112.494
100	0.80	0.81	0.81	0.01	0.14	160.702

** The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%.*

Data - Indicator 1. - Digital Readout (lbf)

COMPRESSION

	Run 1		Run 2		Run 3	
% of Range	Indicated (lbf)	Applied (lbf)	Indicated (lbf)	Applied (lbf)	Indicated (lbf)	Applied (lbf)
100% Range (Full Scale: -119044.9 lbf)						
0 Return	1		0		-1	
1	-1200	-1194.4	-1200	-1194.9	-1200	-1194.85
2	-2400	-2390.3	-2400	-2388.5	-2400	-2388.2
4	-4800	-4780.1	-4800	-4777.95	-4800	-4778.5
7	-8400	-8335.52	-8400	-8336.7	-8400	-8336.11
10	-12000	-11902.07	-12000	-11910.33	-12000	-11909.74
20	-24000	-23789.98	-24000	-23815.94	-24000	-23815.35
40	-48000	-47615.95	-48000	-47615.36	-48000	-47618.9
70	-84000	-83326.29	-84000	-83333.37	-84000	-83327.47
100	-120000	-119044.89	-120000	-119034.86	-120000	-119034.86

CERTIFICATE OF CALIBRATION

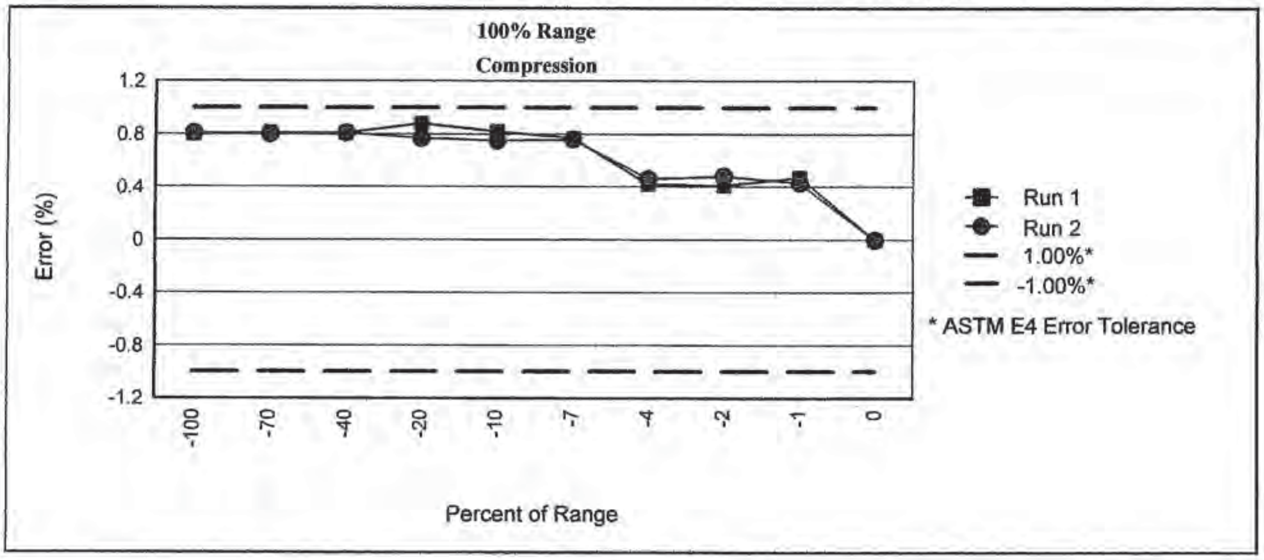
NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340013012095410

Page 3 of 4 pages

The Return to Zero tolerance is ± the indicator resolution, 0.1 % of the maximum force verified in the range, or 1% of the lowest force verified in the range, whichever is greater.

Graphical Data - Indicator 1. - Digital Readout (lbf)


100% Range
Compression

Verification Equipment

Make/Model	Serial Number	Description	Calibration Agency	Capacity	Cal Date	Cal Due
Extech 445580	1003552	temp. indicator	Tektronix	NA	12-Feb-11	12-Feb-13
HBM ML38	90630412	force indicator	Instron	NA	21-Jan-11	21-Jan-13
Strainsense 050530	050530	load cell	Instron	120000 lbf	10-Dec-10	10-Dec-12
HBM 10KFRR	688077	load cell	Instron	12000 lbf	24-Apr-10	24-Apr-12

Verification Equipment Usage

Range Full Scale (%)	Standard Serial Number	Mode	Percent(s) of Range	Lower Limit for Standard Class A / A1 (lbf)
100	050530	C	7/10/20/40/70/100	5000 / 5000
100	688077	C	1/2/4	200 / 200

Instron standards are traceable to NIST.

The standard Class A lower limit is used for systems with an accuracy of +/- 1.0% and the standard Class A1 lower limit is used for systems with an accuracy of +/- 0.5%.

Standard forces have been temperature compensated as necessary.

Comments

CERTIFICATE OF CALIBRATION

ISSUED BY: INSTRON CALIBRATION LABORATORY

DATE OF ISSUE: 12-Apr-12 CERTIFICATE NUMBER: **516041212091759**

Lab code: 200301-0

Instron
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Norwood, MA 02062-2643
Telephone: (800) 473-7838
Fax: (781) 575-5750
Email: service_requests@instron.com

Page 1 of 3 pages

APPROVED SIGNATORY

Jimmy Warner

Digitally signed by Jimmy Warner
DN: cn=Jimmy Warner, c=US, l=Norwood, st=MA, ou=OVR
Reason: I attest to the accuracy and integrity of this document
Date: 2012.04.12 09:51:28 -04'00'

Type of Calibration:	**Strain**
Relevant Standard:	**ASTM E83-10**
Date of Calibration:	**12-Apr-12**

Customer Requested Due Date: 23-Mar-13

Customer

Name:	Purdue University
Address:	550 Stadium Mall Drive Civil Room G151 West Lafayette IN 47907 sarahh@purdue.edu
P.O./Contract No.:	
Contact:	Kevin Brower

Machine

Manufacturer:	BALDWIN
Serial Number:	120BTEC502040
System ID:	120BTEC502040
Range Type:	Single

Transducer

Manufacturer:	EPSILON
Transducer ID:	3543-0800-200T-ST/E89895
Extensometer Type:	Type 1
Travel (Tension):	2 in
Gauge Length:	8 in
Mode:	Static (Tension)

Classification

The following indicators of the extensometer system were verified and classed:

Indicator Type	Description	Indicator Units	Range Full Scale (%)	System Class
1. Digital Readout		strain	100	B-1

Certification Statement

All indicators listed above were verified on-site at customer location by Instron in accordance with ASTM E83.

The verification and equipment used conform to a controlled Quality Assurance program which meets the specifications outlined in ANSI/NCSL Z540-1, ISO 10012, ISO 9001:2008 and ISO/IEC 17025:2005.

The testing machine was verified in the 'as found' condition.

Instron Calpro Version 3.23

The results indicated on this certificate and the following report relate only to the items verified. If there are methods or data included that are not covered by the NVLAP accreditation it will be identified in the comments. Any limitations of use as a result of this verification will be indicated in the comments. This report must not be used to claim product endorsement by NVLAP or the United States government. This report shall not be reproduced, except in full, without the approval of the issuing laboratory.

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
516041212091759

Summary of Results

Indicator 1. - Digital Readout (strain)

Range Full Scale (%)	Tested Range (in)	Mode	System Class*	Resolution (strain)	Resolution Class	ASTM E83 Lower Limit (in)
100	0.2 to 2	Tension	B-1	0.000001	A	0.0008

** System Class for a range is the worst of the following classes: gauge length class, resolution class, individual point error class, repeatability class and is also based on the measurement capability of the laboratory.*

Gauge Length Measurement and Classification

Nominal Gauge Length (in)	Actual Gauge Length (in)	Measurement Type	Error in Gauge Length (%)	ASTM E83 Gauge Length Class	Uncertainty of Measurement* (in)
8	7.9897	Direct	-0.13	B-1	0.0062

** The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%.*

Data Summary and Classification

Indicator 1. - Digital Readout (strain)

% of Range	Run 1 Error Fixed (strain)	Run 1 Error Relative (% of strain)	Run 2 Error Fixed (strain)	Run 2 Error Relative (% of strain)	Repeat Error (strain)	Worst Class	Uncertainty of Measurement* (strain)
100% Range (Full Scale: 2 in)							
10	0.00000	0.012	-0.00001	-0.037	0.00001	A	0.000025
20	-0.00003	-0.054	0.00000	-0.004	0.00003	A	0.000042
40	0.00003	0.028	0.00003	0.034	0.00000	A	0.000079
70	0.00001	0.005	0.00005	0.028	0.00004	A	0.000137
100	-0.00016	-0.064	-0.00019	-0.074	0.00003	A	0.000195

** The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%.*

Data

Indicator 1. - Digital Readout (strain)

% of Range	Run 1 Indicated (strain)	Run 1 Applied (in)	Run 2 Indicated (strain)	Run 2 Applied (in)
100% Range (Full Scale: 2 in)				
	Run Temperature: 73.0 °F		Run Temperature: 73.3 °F	
0	0.000001	0.000000	0.000006	0.000000
10	0.025004	0.200000	0.024998	0.200010
20	0.049975	0.400010	0.050004	0.400000

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
516041212091759

Data

Indicator 1. - Digital Readout (strain)

	Run 1		**Run 2**	
% of Range	Indicated (strain)	Applied (in)	Indicated (strain)	Applied (in)
100% Range (Full Scale: 2 in)				
	Run Temperature: 73.0 °F		Run Temperature: 73.3 °F	
40	0.100030	0.800010	0.100040	0.800000
70	0.175010	1.400000	0.175060	1.400040
100	0.249840	2.000000	0.249820	2.000000

Verification Equipment and Usage

Verification Equipment:

Make/Model	Serial Number	Description	Calibration Agency	Measurement Range	Cal Date	Cal Due
Extech 445580	984437	temp. indicator	Tektronix	NA	28-Dec-11	28-Dec-13
Boeckeler Micrometer 1398	20641 (ASTM)	disp. indicator	A.A. Jansson	2.00 in	07-Oct-11	07-Oct-12
* Fowler Economy Electronic	SH9J2879982	disp. indicator	AA Jansson	NA	20-Apr-10	20-Apr-12

** Equipment used for gauge length measurements.*

Verification Equipment Usage:

Measurement Type	Serial Number	Range (% Full Scale)	Percent(s) of Range
Displacement	20641 (ASTM)	100	0/10/20/40/70/100

Instron standards are traceable to NIST and/or other National standards.

Comments

none

Verified by: James Warner
Field Service Engineer

NOTE: Clause 9 of ASTM E-83 states; It is recommended that extensometer systems be verified annually or more frequently if required. In no case shall the time interval between verifications exceed 18 months (unless an extensometer is being used in a long-time test running beyond the 18 month period). An extensometer system shall not be used after an adjustment or repair that could affect its accuracy without first verifying its accuracy utilizing the procedure described in this practice.

CALIBRATION CERTIFICATE

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Amityville, NY 11701
Website
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KESSLER THERMOMETER CORPORATION

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KesslerUSA@aol.com

CALIBRATION REPORT FOR THERMOMETER

THIS REPORT OF CALIBRATION SHALL DOCUMENT THAT THE INSTRUMENT DESCRIBED HEREIN WAS EXAMINED AND TESTED IN KESSLER'S CALIBRATION LABORATORY AGAINST NIST TRACEABLE REFERENCE STANDARDS, IN ACCORDANCE TO KESSLER'S PROCEDURE T-2008, WHICH IS BASED ON ASTM E-77-98 (2003) AND NIST PIBLICATION 250-23. THIS CALIBRATION MEETS THE REQUIREMENTS OF ISO/IEC 17025, ANSI/NCLS Z2540-1-1994 AND THE ISO 9000 AND QS 9000 SERIES OF QUALITY STANDARDS.

CUSTOMER INFORMATION: GILSON COMPANY, INC.

Purchase Order Number: PO00096475

Date Calibrated: September 20, 2011

Next Recommended Due Date: October 20, 2012

INSTRUMENT DESCRIPTION:

Serial No.: 689373

Marked: KESSLER USA

Catalog No.: 6340-FC

Scale Range: 30/124°F

Divisions: 0.2°F

Immersion: 3"

RESULTS OF PHYSICAL EXAMINATION:
This instrument was examined under a polarized lens and strains in the glass, if any, were judged to be minimal and of no detriment to the function of the instrument. The capillary was examined under magnification and no irregularities or foreign material was discovered. It was determined that this instrument was suitable for calibration.

RESULTS OF CALIBRATION:

TEST TEMP	READING	CORRECTION	UNCERTAINTY
32.00	32.04	-0.04	+/-0.06
60.00	60.00	0.00	+/-0.06
80.00	80.20	-0.20	+/-0.06
100.00	100.20	-0.20	+/-0.06
120.00	120.20	-0.20	+/-0.06

- The above readings were made under magnification and resolved to one tenth of one scale division.
- The indications of this instrument cannot be adjusted or modified by ordinary means: accordingly, the readings given in the table above should be considered, in effect to be both "As Found" and "As Left" readings
- Laboratory Environment Conditions: Temperature: 25°C ± 5°C / Relative Humidity: Between 40% and 60%
- All temperatures given in this report are based on the International Scale of 1990 (ITS-90)

TRACEABILITY INFORMATION:
NIST Primary Standard: Rosemount Model 162CE Serial No. 5058
Transfer Standard: Hart Scientific 1502A Serial No. A14422 / 547027

Calibration Performed By: Barbara Plaza

Approved By:
John Lewis

Calibration Report Prepared By: RP

Report No.: 092011-03

CALIBRATION REPORT

PI TAPE®

Report Number:	02221223040412
Date Issued:	Apr-04-12
Pi Tape Corporation Serial Number:	02221223
Tape Size:	2" – 12" O.D.

About this Calibration

Temperature	68 Degrees F ± 2 Degrees	▨
Relative Humidity	45% ± 15%	▨
Tension	Five Pounds	▨
Tape Tolerance	Within .001"	Within Mfg Tolerance of .001"
Uncertainty of Measurement	±.00025 Inches	▨

Calibration Performed by: Jerry Mathis

Actual Findings and Procedure Numbers

Tape Reads	4.9000	Over 4.9000"	Procedure 1

Remarks: New Gage

Calibration Equipment Used

Gage	Serial Number	Test Date	Due Date	NIST Traceable Report Number
4.9"	102098	May-12-11	May-12-12	86903-1

This tape has been checked at one or more points over a calibrated measuring standard. Calibration performed in accordance with ANSI/NCSL Z540-1-1994, ISO/IEC 17025 and the former MIL-STD 45662A.

All standards are traceable to the National Institute of Standards and Technology

Jerry Mathis, Quality Assurance Manager

This calibration report shall not be reproduced, except in full, without the written approval of the issuing laboratory. Results listed relate only to the item being calibrated.

Pi Tape Corporation
344 N. Vinewood St. Escondido, CA 92029 USA
Phone (760) 746-9830 Fax (760) 746-9196
www.pitape.com

CERTIFICAT D'ETALONNAGE
KALIBRIER-ZERTIFIKAT
CALIBRATION CERTIFICATE

N° 26594

Date
Datum 13.10.2009
Date

Objet Gegenstand Object	Instrument vertical Vertikal- Messgerät Vertical instrument
Type Typ Model	V1004+ ✓
Numéro de série Serien-Nummer Serial number	10473 / A
Date d'émission du certificat Ausgabedatum des Zertifikates Certificate issue date	13.10.2009

7 6 8
2 1

Déclaration de confirmité	**Konformitätserklärung**	**Conformity declaration**
L'instrument de mesure auquel se réfère ce certificat a été réalisé conformément aux données techniques de TRIMOS contenues dans les documents de vente (prospectus, manuels d'utilisation).	Das Messgerät, auf welches sich dieses Zertifikat bezieht, wurde entsprechend den von TRIMOS in den Verkaufs-unterlagen (Prospekte, Gebrauchsanleitung) angegebenen technischen Daten hergestellt.	The measuring instrument to which this certificate refers to has been manufactured in acordance with the given TRIMOS specifications stated in sale documents (leaflets, instructions for use).

Responsable département qualité: Leiter der Qualitätsabteilung: Manager of quality department:	Gilbert Villard	Contrôleur: Prüfer: Inspector:	Philippe Desponds

CERTIFICAT D'ETALONNAGE ***KALIBRIER-ZERTIFIKAT*** ***CALIBRATION CERTIFICATE***	***N° 26594***	***Date*** ***Datum*** ***Date***	***13.10.2009***

Caractéristique de l'objet mesuré
Merkmale des Gegenstander der Kalibrierung
Features of the calibrated object

Nombre d'axes de mesures Anzahl der Messachsen Number of measuring axis	1
Etendue de mesure Messbereich Measuring range	0 - 990 mm 0 - 38.976 in
Coefficient de dilatation linéaire Linearer Ausdehnungskoeffizient Linear expansion coefficient	11.5 µm/m

Etalonnage
Kalibrierung
Calibration

Accessoire(s) utilisé(s) Verwendete Zubehöre Used accessories	V-1
Pas de mesure Messstufen Measuring steps	20 mm (.787in)
Nombre de série de mesures Anzahl von Messreihen Number of measurement series	3
Principe de mesure Messprinzip Principle of measurement	En montant Antastung aufwärts Upwards direction

Condition de référence
Referenzbedingungen
Reference conditions

Températures / Temperatur / Temperature	20°C +/- 0.5°C
Humidité relative / Relative Luftfeuchtigkeit / Relativ humidity	50% +/- 5%
Pression d'air / Luftdruck / Air pressure	722 mm Hg

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Date
Datum
Date
13.10.2009

Etalon de référence et traçabilité
Bezugsnormal und Rückverfolgbarkeit
Reference standard and tracability

Les résultats de mesure contenus dans ce certificat d'étalonnage se réfèrent, par une traçabilité documentée, aux étalons reconnus sur le plan national et dont la conformité avec le système international d'unité (SI) est démontrée. L'étalon de référence est composé des éléments suivants :

Die in diesem Kalibrierzertifikat erhaltenen Ergebnisse von Messungen sind über Bezugsnormale bsw. Einrichtungen auf national Normale rückverfolgbar. Deren Übereinstimmung ist durch das Internationale Einheitensystem (SI) nachgewiesen. Das Bezugsnormal besteht aus folgenden Elementen :

All measurement results contained in this calibration certificate maintain a link of tracability recognized by national standards. Their accordance with the international unity system (SI) is proved. The reference standard is composed of the following components:

Etalon de référence Bezugsnormal Reference standard	N° de série Serien-Nr. Serial no.	N° du certificat Zertifikat-Nr. Certificate no.	Etalonné par Kalibriert durch Calibrated by
Check-Master	800002	81228	Fabricant
Equerre	215-904	E310Z106	Kunz SCS
Marbre 2000x1800	1644	R402B028	Kunz SCS

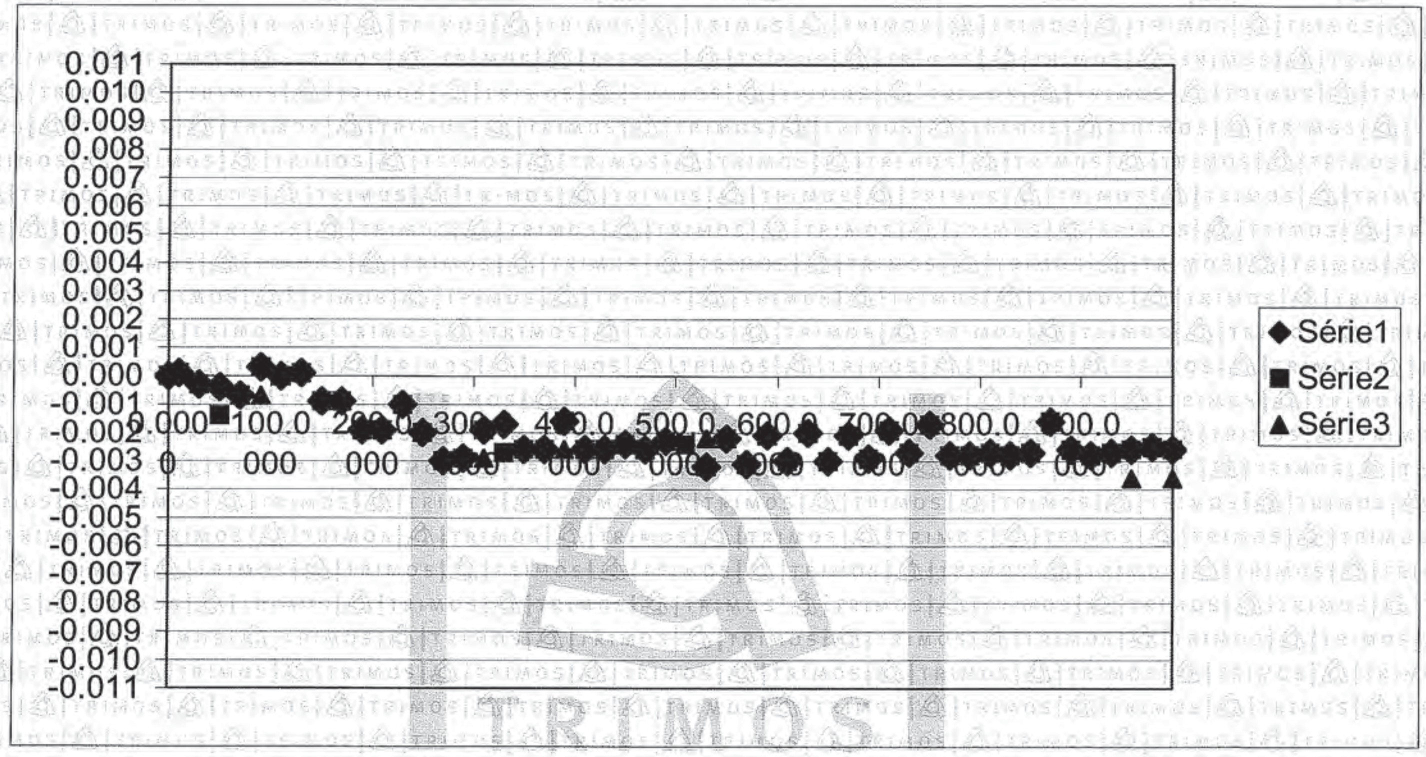
* Métrologie et accréditation suisse

CERTIFICAT D'ETALONNAGE
KALIBRIER-ZERTIFIKAT
CALIBRATION CERTIFICATE

N° 26594

Date
Datum ***13.10.2009***
Date

Justesse
Richtigkeit
Freedom from bias



Valeur réelle Wahrer Wert True value mm	Série 1 Serie 1 Series 1 mm	Série 2 Serie 2 Series 2 mm	Série 3 Serie 3 Series 3 mm	Moyenne Mittenwert Average mm	Ecart moyen Mittenabweichung Average deviation µm
0.0000	0.000	0.000	0.000	0.000	**0.0**
9.9999	10.000	10.000	10.000	10.000	**0.1**
30.0003	30.000	30.000	30.000	30.000	**-0.3**
50.0004	50.000	49.999	49.999	49.999	**-1.1**
70.0007	70.000	70.000	70.000	70.000	**-0.7**
90.0007	90.001	90.001	90.000	90.001	**0.0**
110.001	110.001	110.001	110.001	110.001	**0.0**
130.0009	130.001	130.001	130.001	130.001	**0.1**
150.0009	150.000	150.000	150.000	150.000	**-0.9**
170.0009	170.000	170.000	170.000	170.000	**-0.9**
190.0009	189.999	189.999	189.999	189.999	**-1.9**

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Valeur vraie Wahrer Wert True value mm	Série 1 Serie 1 Series 1 mm	Série 2 Serie 2 Series 2 mm	Série 3 Serie 3 Series 3 mm	Moyenne Mittenwert Average mm	Ecart moyen Mittenabweichung Average deviation µm
210.0009	209.999	209.999	209.999	209.999	**-1.90**
230.001	230.000	230.000	230.000	230.000	**-1.00**
250.001	249.999	249.999	249.999	249.999	**-2.00**
270.001	269.998	269.998	269.998	269.998	**-3.00**
290.0009	289.998	289.998	289.998	289.998	**-2.90**
310.0009	309.999	309.999	309.998	309.999	**-2.23**
330.0007	329.999	329.998	329.998	329.998	**-2.37**
350.0006	349.998	349.998	349.998	349.998	**-2.60**
370.0006	369.998	369.998	369.998	369.998	**-2.60**
390.0006	389.999	389.999	389.998	389.999	**-1.93**
410.0006	409.998	409.998	409.998	409.998	**-2.60**
430.0006	429.998	429.998	429.998	429.998	**-2.60**
450.0004	449.998	449.998	449.998	449.998	**-2.40**
470.0006	469.998	469.998	469.998	469.998	**-2.60**
490.0003	489.998	489.998	489.998	489.998	**-2.30**
510.0004	509.998	509.998	509.998	509.998	**-2.40**
530.0002	529.997	529.997	529.998	529.997	**-2.87**
550.0002	549.998	549.998	549.998	549.998	**-2.20**
570.0001	569.997	569.997	569.997	569.997	**-3.10**
590.0001	589.998	589.998	589.998	589.998	**-2.10**
610	609.997	609.997	609.997	609.997	**-3.00**
630	629.998	629.998	629.998	629.998	**-2.00**
650	649.997	649.997	649.997	649.997	**-3.00**
670.0001	669.998	669.998	669.998	669.998	**-2.10**
689.9999	689.997	689.997	689.997	689.997	**-2.90**
709.9999	709.998	709.998	709.998	709.998	**-1.90**
729.9997	729.997	729.997	729.997	729.997	**-2.70**
749.9997	749.998	749.998	749.998	749.998	**-1.70**
769.9998	769.997	769.997	769.997	769.997	**-2.80**
789.9998	789.997	789.997	789.997	789.997	**-2.80**
809.9997	809.997	809.997	809.997	809.997	**-2.70**
829.9998	829.997	829.997	829.997	829.997	**-2.80**
849.9997	849.997	849.997	849.997	849.997	**-2.70**
869.9996	869.998	869.998	869.998	869.998	**-1.60**
889.9996	889.997	889.997	889.997	889.997	**-2.60**
909.9998	909.997	909.997	909.997	909.997	**-2.80**
929.9997	929.997	929.997	929.997	929.997	**-2.70**
949.9996	949.997	949.997	949.996	949.997	**-2.93**
969.9995	969.997	969.997	969.997	969.997	**-2.50**
989.9996	989.997	989.997	989.996	989.997	**-2.93**

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Date
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Date
13.10.2009

Résultas de mesure
Messergebnisse
Measurement results

Erreur maximale autorisée Max. Fehlergrenze Maximum permissible error	5.8 µm
Erreur maximale mesurée Grösste gemessene Abweichung Maximum error measured	3.2 µm
Fidélité Wiederholpräzision Repeatability	+/- 2s < 2 µm

Incertitude de mesure
Messunsicherheit
Uncertainty of measurement

L'incertitude de mesure "U" indiquée ci-après pour la détermination des erreurs de mesures englobe : l'objet étalonné, l'étalon de référence, l'étendue de mesure et les conditions de référence.

Die nachstehend angegebene Messunsicherheit "U" für die Ermittlung der Messabweichungen umfasst folgende Komponente: das kalibrierte Objekt, das Bezugsnormal, den Messbereich und die Referenzbedingungen.

The uncertainty of measurement "U" for the determination of the errors of measurement given hereafter includes the calibrated object, the reference standard, the measuring range and the reference conditions.

le niveau de confiance est de 95% Das Vertrauensniveau beträgt 95% Confidence probability is 95%	**K** = 2
Incertitude de mesure Messunsicherheit Uncertainty of measurement	**U** 95 = 2.5µm + (L(mm) / 300)

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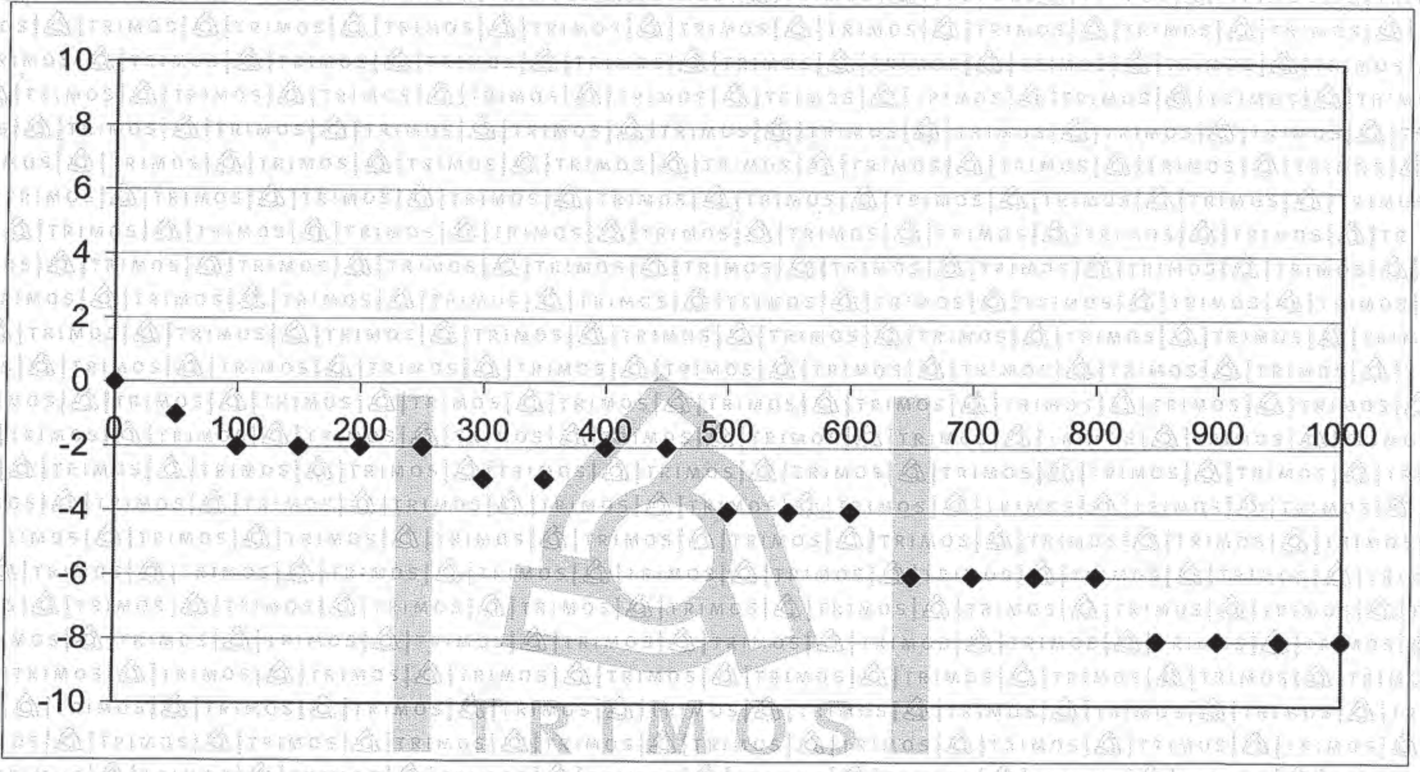
Date
Datum **13.10.2009**
Date

Contrôle de la perpendicularité (direction de mesure)
Kontrolle der Rechtwinkligkeit (Messrichtung)
Checking of the squareness (measuring direction)



Hauteur Höhe Height mm	Ecart Abweichung Deviation µm
0	0.0
50	-1.0
100	-2.0
150	-2.0
200	-2.0
250	-2.0
300	-3.0
350	-3.0
400	-2.0
450	-2.0
500	-4.0

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Date
Datum **13.10.2009**
Date

Hauteur Höhe Height **mm**	Ecart Abweichung Deviation **µm**
550	-4.0
600	-4.0
650	-6.0
700	-6.0
750	-6.0
800	-6.0
850	-8.0
900	-8.0
950	-8.0
1000	-8.0

Resultats du contrôle de la perpendicularité (dans la direction de mesure) :
Ergebnisse der Rechtwinkligkeitsprüfung (in Messrichtung) :
Resullts of squareness checking (in measuring direction) :

Erreur maximale autorisée Max. angegebene Fehlergrenze Maximum permissible error	12.0 µm
Erreur de la perpendicularité mesurée Gemessene Rechtwinkligkeitsabweichung Squareness error measured	8.0 µm

TROEMNER
Henry Troemner LLC

Calibration Certificate

NVLAP
Accredited by the National Voluntary Laboratory Accreditation Program for the specific scope of accreditation under Lab Code 105013

201 Wolf Drive • P.O. Box 87 • Thorofare, NJ 08086-0087 • Phone: 856-686-1600 • Fax: 856-686-1601 • www.troemner.com • e-mail: troemner@troemner.com

Page 1 of 7 Pages
Weight

Certificate Number 663364-1
Date of Calibration 30-APR-2012

SECTION 1: NAME AND ADDRESS OF CUSTOMER

End user
Purdue University
1040 S. River Road
Bowen Laboratory
West Lafayette IN 47907

Client
Precision Weighing Balances
30 South Cross Road
Bradford MA 01835-8232

SECTION 2: APPROVED SIGNATORY

Joseph Moran, Metrology Manager

SECTION 3: PERSON PERFORMING WORK

Daniel Foglio

SECTION 4: CERTIFICATE INFORMATION

Description of Masses: Grip Handle

Accuracy Class : NIST 105-1 Class F
Order Number : 100001369
Construction : Two Piece
Material : Cast Iron

Date Received : 30-APR-2012
Date of Calibration : 30-APR-2012
Date of Issue : 30-APR-2012
Weight Range : 100 lb

SECTION 5: ENVIRONMENTAL CONDITIONS DURING TEST

Temperature: 21.84°C Pressure: 769.06 mm Hg Relative Humidity: 48%

SECTION 6: PERTINENT INFORMATION

The Weights listed on this calibration report have been compared to reference mass standards that are directly traceable to the National Institute of Standards and Technology under Test No. 822-275872-11.

Reference standards and balances used to perform the calibration are listed in Section 10.

The weights calibrated for this report have been calibrated in accordance with Troemner's calibration process. The calibration performed meets Level III criteria as described in the NIST/NVLAP Technical Guide 150-2.

This calibration also meets specifications as outlined in ISO 9001, ISO/IEC 17025, ANSI/NCSL Z540-1-1994, NRC Document 10CFR50 Appendix B, and applicable documents.

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Weight

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SECTION 7: TRUE MASS (MASS IN VACUUM) CALIBRATION DATA

Nominal Mass Value	Serial Number	True Mass	Density[1] of Weight	Uncertainty (+ or -)
100 lb		45362.709 g	7.2000 g/cm^3	450 mg

---

[1] Density is assumed unless otherwise stated

TROEMNER
Henry Troemner LLC

NVLAP
Accredited by the National Voluntary Laboratory Accreditation Program for the specific scope of accreditation under Lab Code 105013

Calibration Certificate

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SECTION 8: MASS IN AIR CALIBRATION VALUE VS. REFERENCE DENSITY 8000 kg m^{-3}

Nominal Mass Value	Serial Number	Conventional Mass Value	Uncertainty (+ or -)	Tolerance (+ or -)
100 lb		45361.953 g	450 mg	4.5000 g

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SECTION 9: MASS IN AIR CALIBRATION DATA VS. REFERENCE DENSITY 8000 kg m^{-3}

Nominal Mass Value	Serial Number	Conventional Mass Correction	Uncertainty (+ or -)	Tolerance (+ or -)
100 lb		2716 mg	450 mg	4.5000 g

Calibration Certificate

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Weight

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SECTION 10: CALIBRATION PROCEDURE DATA

Nominal Mass Value	Serial Number	Standard Set No.	Cal Due	Balance Used	Cal Due	Procedure Used
100 lb		S1104	05/31/12	XP64003L-A01	11/30/12	Multi A-B

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Weight
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SECTION 11: GENERAL INFORMATION

This calibration was performed in Troemner's High Precision Level I Mass Metrology Laboratory at 201 Wolf Drive, Thorofare, New Jersey 08086 unless otherwise noted on page one. The internal procedures used are CAL-CLASSI and NIST HB145.

SECTION 12: DEFINITIONS AND TERMS

MASS IN A VACUUM - The mass of a weight as if it were measured in a vacuum. Also known as True Mass.

MASS IN AIR - The conventional value of the result of weighing in air, in accordance to International Recommendation OIML D 28. For a weight taken at 20° C, the conventional mass is the mass of a reference weight of a density of 8000 kg·m^{-3} which it balances in air of a density of 1.2 kg·m^{-3}.

AS FOUND MASS IN A VACUUM - The measured value of the mass(es) as they were received by Troemner.

AS LEFT MASS IN A VACUUM - The measured value of the mass(es) after they were adjusted, repaired or replaced when necessary. The As Found Mass in a Vacuum will equal the As Left Mass in a Vacuum if the mass(es) did not require adjustment, repair or replacement.

NOMINAL MASS - The mass value as marked on the weight.

CORRECTION - The difference between the mass value of a weight and its nominal value. A positive correction indicates that the mass value is greater than the nominal value by the amount of the correction.

AS FOUND CONVENTIONAL MASS CORRECTION - The conventional correction of the result, as it was received by Troemner, of weighing in air in accordance to International Recommendation D 28. For a weight taken at 20° C, the conventional mass is the mass of a reference weight of density 8000 kg·m^{-3} which it balances in air density of 1.2 kg·m $^{-3}$. If the customer requires cleaning prior to calibration, the after cleaning correction would be reported.

AS LEFT CONVENTIONAL MASS CORRECTION - The conventional correction of the result, after adjust-, ment repair, or replacement of weighing in air in accordance to International Recommendation D 28. For a weight taken at 20° C, the conventional mass is the mass of a reference weight of density 8000 kg·m^{-3} which it balances in air density of 1.2 kg·m^{-3}. The As Found will equal the As Left Conventional Mass Correction if the mass(es) did not require adjustment, repair or replacement.

(continued on next page)

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Weight
Certificate Number 663364-1
Date of Calibration 30-APR-2012

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SECTION 12: DEFINITIONS AND TERMS (continued)

UNCERTAINTY - The standard deviation associated with the result of the measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand. The uncertainty is calculated in accordance with NIST TechNote 1297 / UKAS M3003 using a coverage factor of $k = 2$ ($k = 2$ defines an interval having a level of confidence of approximately 95 percent). The uncertainty does not include possible effects of magnetism.

TOLERANCE - Defines the limits in which the correction value and the uncertainty must fall to meet the tolerance specification for the given Class.

AS FOUND CONVENTIONAL MASS VALUE - The measured value of the mass(es) as they were received by Troemner, of weighing in air in accordance to International Recommendation OIML D 28. For a weight taken at 20° C, the conventional mass is the mass of a reference weight of density 8000 $kg{\cdot}m^{-3}$ which it balances in air density of 1.2 $kg{\cdot}m^{-3}$. If the customer requires cleaning prior to calibration, the after cleaning value would be reported. F denotes Out of Tolerance Weight.

AS LEFT CONVENTIONAL MASS VALUE - The measured value of the mass(es) after they were adjusted, repaired or replaced when necessary, of weighing in air in accordance to International Recommendation OIML D 28. For a weight taken at 20° C, the Conventional Mass is the mass of a reference weight of density 8000 $kg{\cdot}m^{-3}$ which it balances in air density of 1.2 $kg{\cdot}m^{-3}$. The As Found will equal the As Left Conventional Mass Value if the mass(es) did not require adjustment, repair or replacement.

ASTM E617-97 - Weights meet the tolerance specification for ASTM E617-97. Weights 2kg - 1g screened for magnetism using a Gaussmeter.

Project: Tests to Determine the Behavior of Spliced #11 Bars

Calibration Documentation v.1 (Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 2

Calibration Instrument Name and S.N.:	Instron 1044172
Data Acquisition System:	OptroTrack Pro Series 600
Gain:	NA
Excitation Voltage:	NA
Channel:	NA
Sensor:	OptroTrack Pro Series 600
Sensor S.N.:	OptroTrack Pro Series 600

Input [in.]	Output [in.]		Input [in.]	Output [in.]	
0	0		6.5	6.507	
0	0		6.5	6.507	
1	1.001		4	3.999	
1	1.001		4	3.999	
4	3.998		1.5	1.499	
4	3.997		1.5	1.498	
6.5	6.502				
6.5	6.502				
9	9.007				
9	9.007				

Operator	Signature	Date	Time
S.P.		6/13/12	10 AM
Checked by	**Signature**	**Date**	**Time**
BPR		6/13/12	10:15 AM
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	1	0.007 in.

Notes: The accuracy of the INSTRON sensor is 0.003 in.

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI-SCXI-1000 PCI 6289
Gain:	1
Excitation Voltage:	3.333
Channel:	M1-0
Sensor:	PA-20-NJC-DS-L3M
Sensor S.N.:	37100980

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
~~0.611~~	~~1.498~~				
0.611	0.038				
2.602	0.362				
4.553	0.675				
6.560	1.001				
8.630	1.332				

Operator	Signature	Date	Time
S.P.		5/9/12	
Checked by	**Signature**	**Date**	**Time**
BPR		5/9/12	
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	6.197 in/V	0.1 %

Notes:

Project: Tests to Determine the Behavior of Spliced #11 Bars

Calibration Documentation v.1 (Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI-SCXI-1000 PCI 6289
Gain:	1
Excitation Voltage:	3.333
Channel:	M1-1
Sensor:	PA-20-NJC-DS-L3M
Sensor S.N.:	37100981

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
8.630	1.335				
6.618	1.011				
4.640	0.691				
2.655	0.369				
0.651	0.041				

Operator	Signature	Date	Time
S.P.		5/9/12	
Checked by	**Signature**	**Date**	**Time**
BPR		5/9/12	
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	6.167 in/V	0.1%

Notes:

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI SCXI-1000 PCI 6289
Gain:	1
Excitation Voltage:	3.333
Channel:	M1-02
Sensor:	PA-10-DS
Sensor S.N.:	40010980

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
8.594	2.578				
6.647	1.965				
4.600	1.323				
2.603	0.696				
0.642	0.071				

Operator	Signature	Date	Time
S.P.		5/9/12	
Checked by	**Signature**	**Date**	**Time**
BPR		5/9/12	
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	3.175 in/V	0.2%

Notes:

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI SCXI-1000 PCI 6289
Gain:	1
Excitation Voltage:	3.333
Channel:	M1-03
Sensor:	PA-10-DS
Sensor S.N.:	40010985

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
0.610	0.056				
2.578	0.682				
4.625	1.328				
6.566	1.939				
8.620	2.584				

Operator	Signature	Date	Time
S.P.		5/9/12	
Checked by	**Signature**	**Date**	**Time**
BPR		5/9/12	
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	3.169 in/v	0.2%

Notes:

Project: Tests to Determine the Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI SCXI-1000 PCI 6289
Gain:	1
Excitation Voltage:	3.333
Channel:	M2-0
Sensor:	PA-10-DS
Sensor S.N.:	40010977

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
8.620	2.590				
6.602	1.957				
4.607	1.331				
2.604	0.699				
0.611	0.065				

Operator	Signature	Date	Time
S.P.		5/9/12	
Checked by	**Signature**	**Date**	**Time**
BPR		5/9/12	
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	3.173 in/V	0.2%

Notes: M2-0

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	Instron 1094172
Data Acquisition System:	NI-SCXI-1000 PCI 6289
Gain:	100
Excitation Voltage:	10V
Channel:	M2-02
Sensor:	3175-50K
Sensor S.N.:	443

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
0	0				
6.1	-0.00240				
11.9	-0.00466				
15.3	-0.00600				
20.2	-0.00790				
25.3	-0.00990				
30.4	-0.01190				

Operator	Signature	Date	Time
S.P.		5/9/12	
Checked by	**Signature**	**Date**	**Time**
BPR		5/9/12	
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	-2556 K/V	0.1%

Notes:

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Calibration Documentation v.1
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Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	Instron 1044172
Data Acquisition System:	NI - SCXI - 1000 PCI 6289
Gain:	100
Excitation Voltage:	10V
Channel:	M2-3
Sensor:	3175-50K
Sensor S.N.:	442

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
0	0				
5.5	-0.00215				
10.4	-0.00407				
15.5	-0.00605				
20.5	-0.00799				
25.5	-0.00996				
30.5	-0.01190				
0	+0.000010				

Operator	Signature	Date	Time
S.P.		5/9/12	
Checked by	**Signature**	**Date**	**Time**
BPR		5/9/12	
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	-2563 K/V	0.1%

Notes:

Project: Tests to Determine the Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI SCX1-1000 PCI 6289
Gain:	1
Excitation Voltage:	30
Channel:	M3-0
Sensor:	LUCAS DCEC-2000
Sensor S.N.:	J7250

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
1.835	-4.272				
1.500	-2.655				
1.000	-0.253				
0.500	2.133				
0.125	3.953				

Operator	Signature	Date	Time
S.P.		5/9/12	
Checked by	**Signature**	**Date**	**Time**
BPR		5/9/12	
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	-0.208 in/V	0.1%

Notes:

Project: Tests to Determine the Behavior of Spliced #11 Bars

Calibration Documentation v.1 (Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI SCXI-1000 PCI 6289
Gain:	1
Excitation Voltage:	30
Channel:	M3-1
Sensor:	LUCAS DCEC-2000
Sensor S.N.:	J7251

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
0.125	4.150				
0.507	2.318				
0.999	-0.020				
1.500	-2.414				
1.835	-4.025				

Operator	Signature	Date	Time
S.P.		5/9/12	
Checked by	**Signature**	**Date**	**Time**
BPR		5/9/12	
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	-0.209 in/V	0.1%

Notes:

Project: Tests to Determine the Behavior of Spliced #11 Bars

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Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON PUID 1044172
Data Acquisition System:	NI SCXI 1000 SN 1188607
Gain:	1
Excitation Voltage:	3.333V
Channel:	M1-0
Sensor:	PA-20
Sensor S.N.:	37100980

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
0.5″	0.307				
2.5″	0.627				
4.5″	0.952				
6.5″	1.271				
8.5″	1.594				

Operator	Signature	Date	Time
S.P.		6/13/12	3 PM
Checked by	**Signature**	**Date**	**Time**
BPR		6/13	3:10PM
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	0.0483 V/V/in	0.1%

Notes: Deviation from sensitivity computed before test*: 0.3% ✓ ok

*0.0484 V/V/in

Project: Tests to Determine the Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI SCXI 1000 SN 1188607
Gain:	1
Excitation Voltage:	3.333V
Channel:	M1-1
Sensor:	PA-20
Sensor S.N.:	37100981

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
8.5"	1.612				
6.5	1.291				
4.5	0.968				
2.5	0.646				
0.5	0.320				

Operator	Signature	Date	Time
S.P.		6/13/12	3:20 P.
Checked by	**Signature**	**Date**	**Time**
BPR		6/13	3:30PM
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	0.0484	0.1%

Notes:

Deviation = 0.4%

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

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Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI SCXI 1000 1188607
Gain:	1
Excitation Voltage:	3.333V
Channel:	M1-2
Sensor:	PA-10
Sensor S.N.:	40010980

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
0.5"	0.584				
2.5	1.212				
4.5	1.839				
6.5	2.467				
8.0	2.942				

Operator	Signature	Date	Time
S.P		6/13/12	3:30 P.
Checked by	**Signature**	**Date**	**Time**
BPR		6/13	3:40PM
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	0.0943 V/V/in	0.1%

Notes: Deviation: 0.2%

Project: Tests to Determine the Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

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Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	SCXI 1000 1188607
Gain:	1
Excitation Voltage:	3.333 V
Channel:	M1-3
Sensor:	PA-10
Sensor S.N.:	40010985

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
8 "	2.934				
6.5	2.462				
4.5	1.835				
2.5	1.207				
0.5	0.577				

Operator	Signature	Date	Time
S.P.	AP	6/13/12	3:40 P.
Checked by	**Signature**	**Date**	**Time**
BPR		6/13	3:50PM
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	0.0943 V/V/in	0.03%

Notes:
Deviation: 0.4%

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI SCXI 1000 1188607
Gain:	1
Excitation Voltage:	3.333V
Channel:	M2-0
Sensor:	PA-10
Sensor S.N.:	40010977

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
0.5"	0.584				
2.5"	1.215				
4.5"	1.841				
6.5"	2.469				
8.0"	2.939				

Operator	Signature	Date	Time
S.P.		6/13/12	3:55 P.
Checked by	**Signature**	**Date**	**Time**
BPR		6/13/12	4:00PM
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	0.0942 V/V/in	0.1%

Notes:
Deviation = 0.4%

Project: Tests to Determine the Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

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Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI SCXI 1000 1188607
Gain:	100
Excitation Voltage:	10V
Channel:	M2-2
Sensor:	LEBOW 50K -443
Sensor S.N.:	443

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
-0.4+0.4=0	0				
5k +0.4	-0.00211				
10k+0.4	-0.00410				
14.6k+0.4	-0.00588				
19.7k +0.4	-0.00787				
24.7k+0.4	-0.00984				
29.7k +0.4	-0.01178				

Operator	Signature	Date	Time
S.P.		6/13/12	4:45P
Checked by	**Signature**	**Date**	**Time**
BPR		6/13	4:50PM
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	-1.957 mV/V @FSV	0.1%

Notes:
DEVIATION from prev. cal (5/4/12): 0.1%

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI SCXI 1000 1188607
Gain:	100
Excitation Voltage:	10V
Channel:	M2-3
Sensor:	LEBOW 50k - 442
Sensor S.N.:	442

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
−0.4+0.4k	0.00001				
$4.65^{k}+0.4$	−0.00196				
$9.67^{k}+0.4$	−0.00392				
$14.6^{k}+0.4$	−0.00584				
$19.7^{k}+0.4$	−0.00785				
25.25k+0.4	−0.01001				
$29.6^{k}+0.4$	−0.01172				

Operator	Signature	Date	Time
S.P.		6/13/12	5:05P.
Checked by	**Signature**	**Date**	**Time**
BPR		6/13	5:10PM
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	−1.955 mV/V @ 50k	0.1%

Notes: Deviation : 0.2%

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NI SCXI 1000 1188607
Gain:	1
Excitation Voltage:	30V
Channel:	M3-0
Sensor:	LUCAS DCDT ±2"
Sensor S.N.:	J7250

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
0.125"	4.288				
0.5"	2.477				
1.0"	0.106 ✓				
1.5"	-2.271 ✓				
2.0"	-4.663				
1.0	0.112				
0.5"	2.480				
0.125"	4.289				

Operator	Signature	Date	Time
S.P.		6/13/12	5:50 P
Checked by	Signature	Date	Time
BPR		6/13	6:00PM
Checked by	Signature	Date	Time

Results	Sensitivity	Accuracy
	-4.769 V/in	0.2%

Notes: Deviation from 5/4/12 cal = 0.7%

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

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Sheet 1 of 1

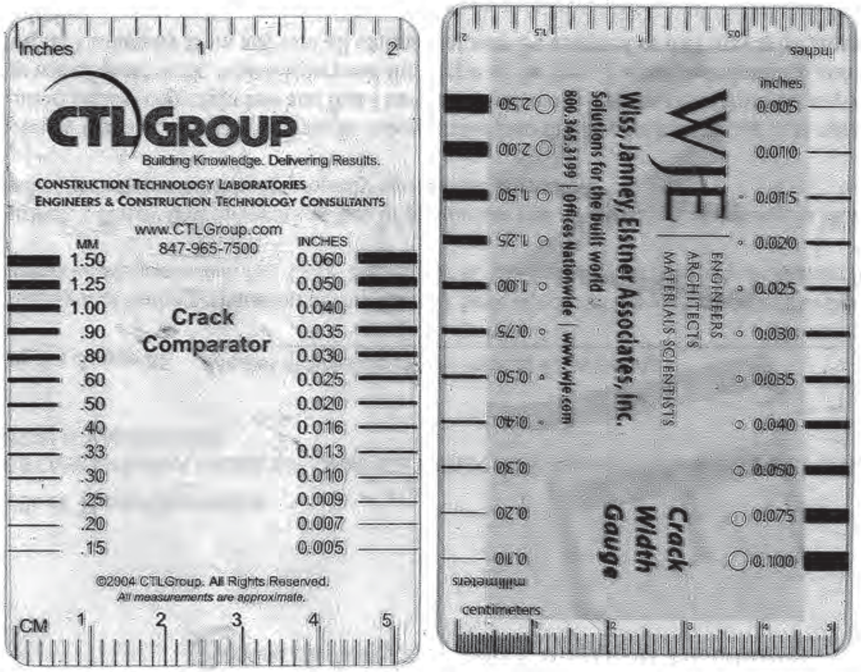
Calibration Instrument Name and S.N.:	INSTRON 1044172
Data Acquisition System:	NISCXI 1000 1188607
Gain:	1
Excitation Voltage:	30V
Channel:	M3-1
Sensor:	LUCAS DCDT ±2"
Sensor S.N.:	J7251

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage
0.125"	4.293				
0.500"	2.496				
1.0"	0.140				
1.5"	-2.232				
2.0"	-4.606				

Operator	Signature	Date	Time
S.P.		6/13/12	6PM
Checked by	**Signature**	**Date**	**Time**
BPR		6/13	6:10PM
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy
	-4.742 V/in	0.2%

Notes: Deviation = 0.7%.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0.050
0.075
0.100
2.50
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millimeters
centimeters

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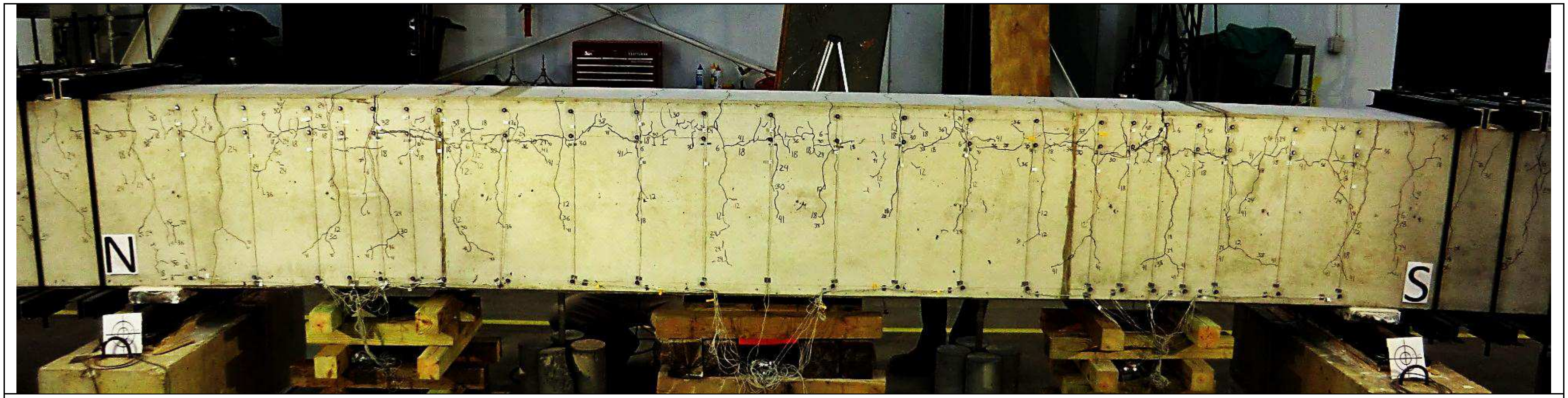
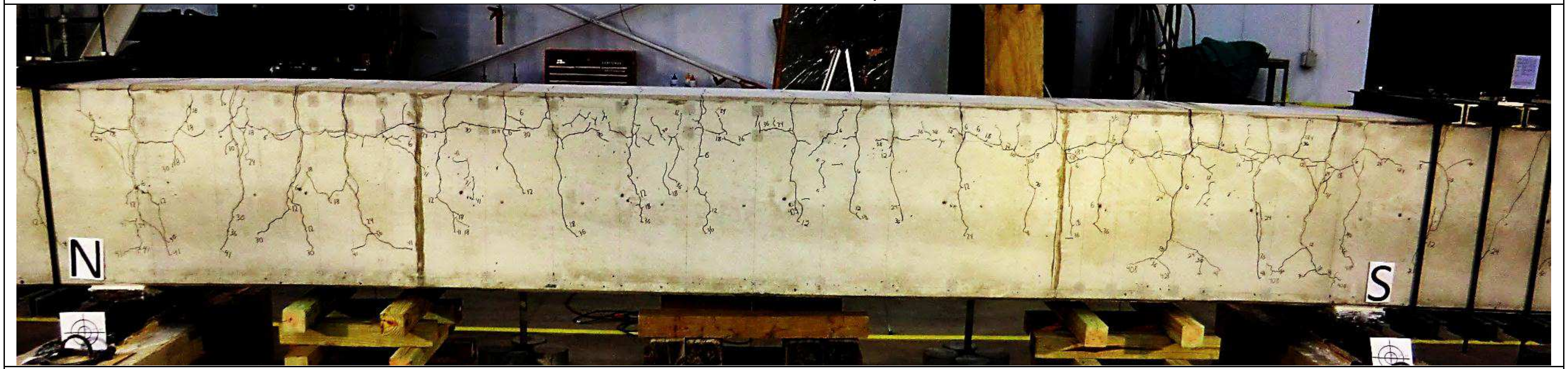
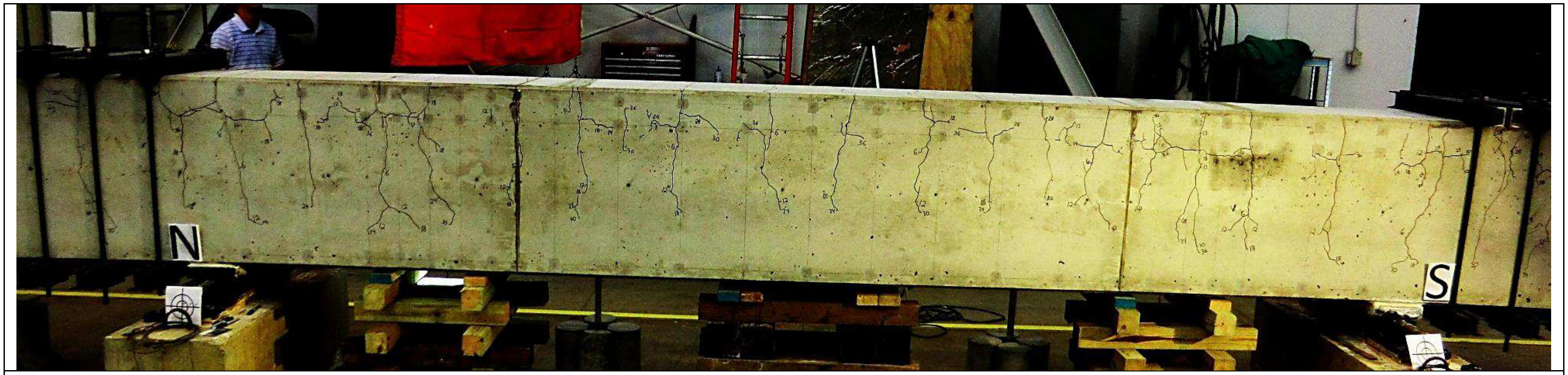


GIRDER A1 – 41 kip

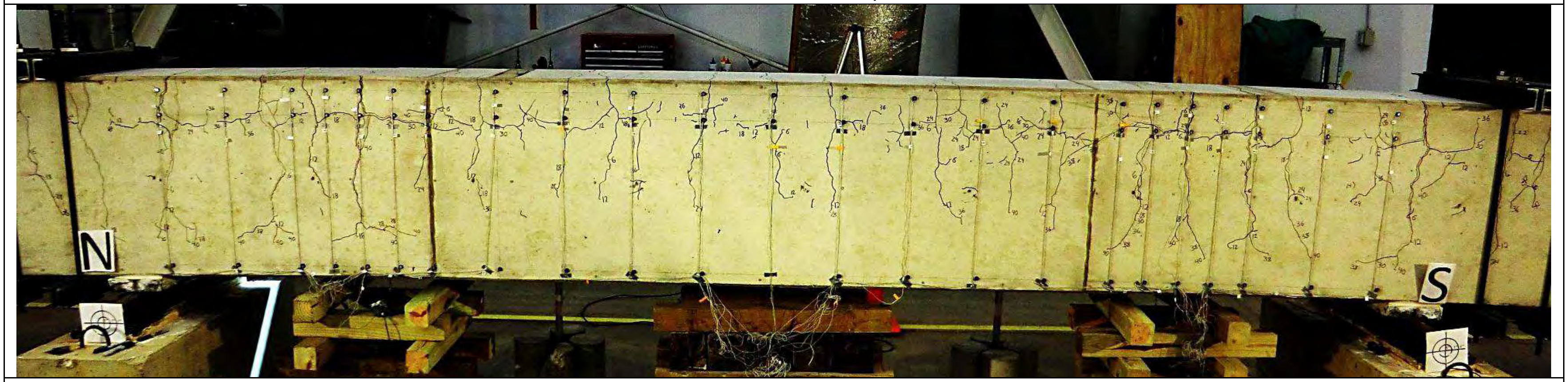


GIRDER A2 – 41 kip

FIRST LOADING

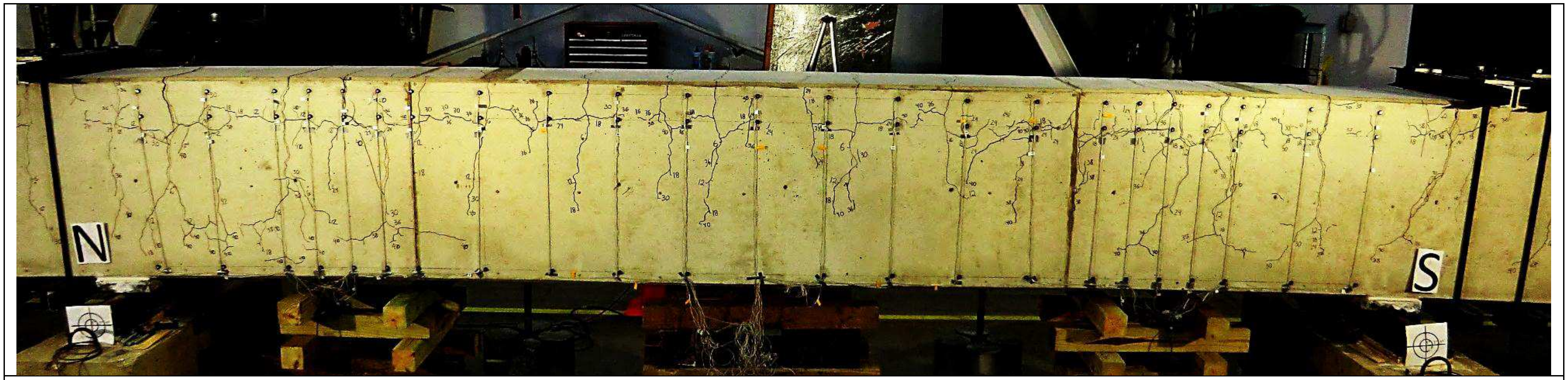


GIRDER A3 – 36 kip

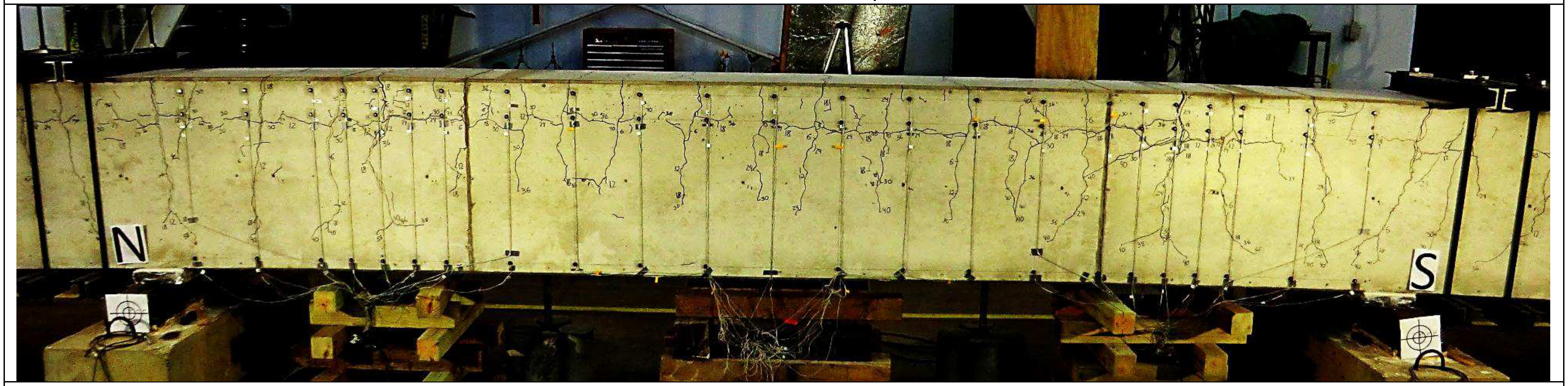


GIRDER A4 – 40 kip

FIRST LOADING



GIRDER A5 – 40 kip



GIRDER A6 – 40 kip

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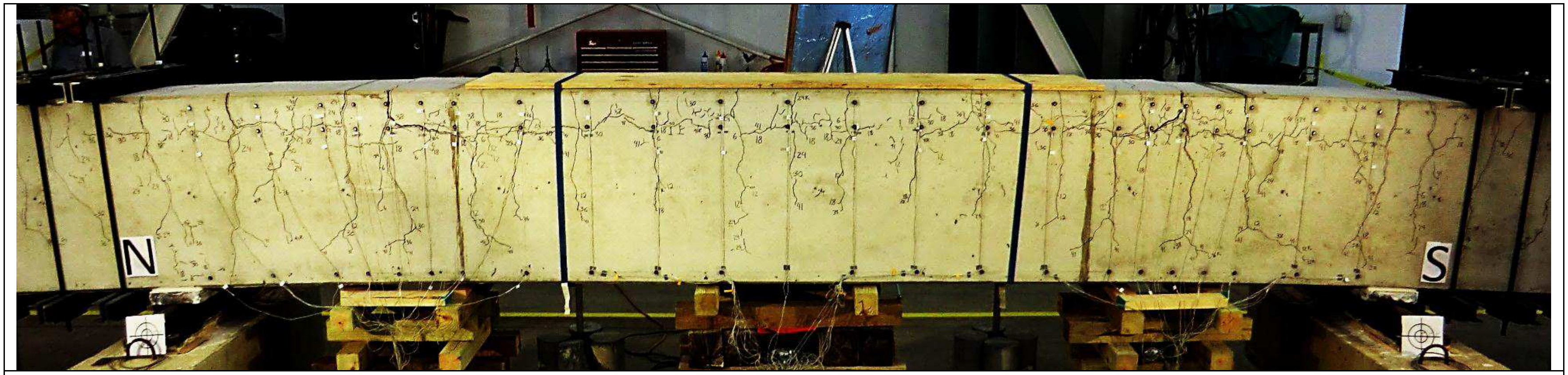


GIRDER A1 – 42 kip

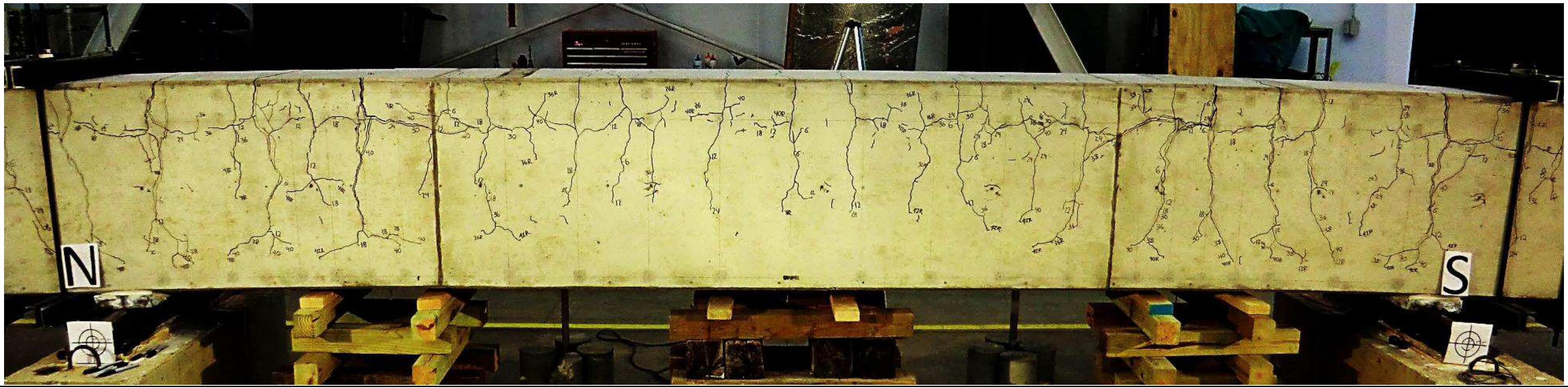
No reload

GIRDER A2

RELOADING

No reload

GIRDER A3



GIRDER A4 – 42 kip

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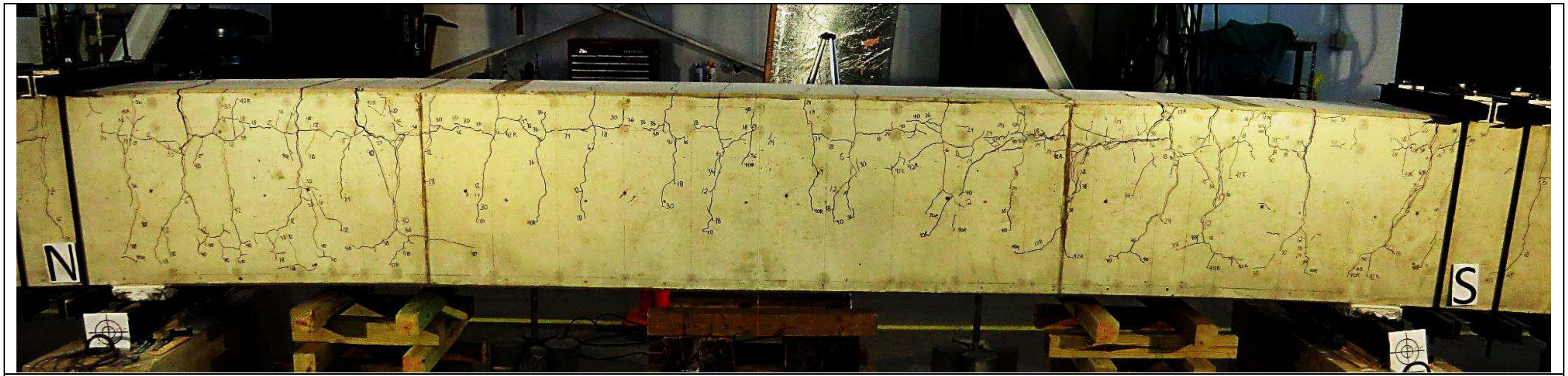
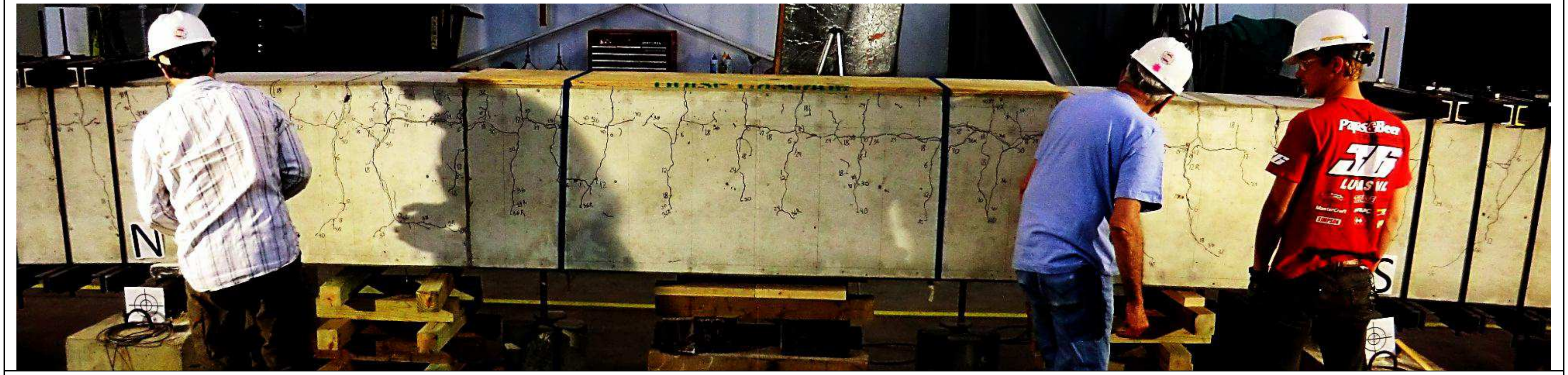


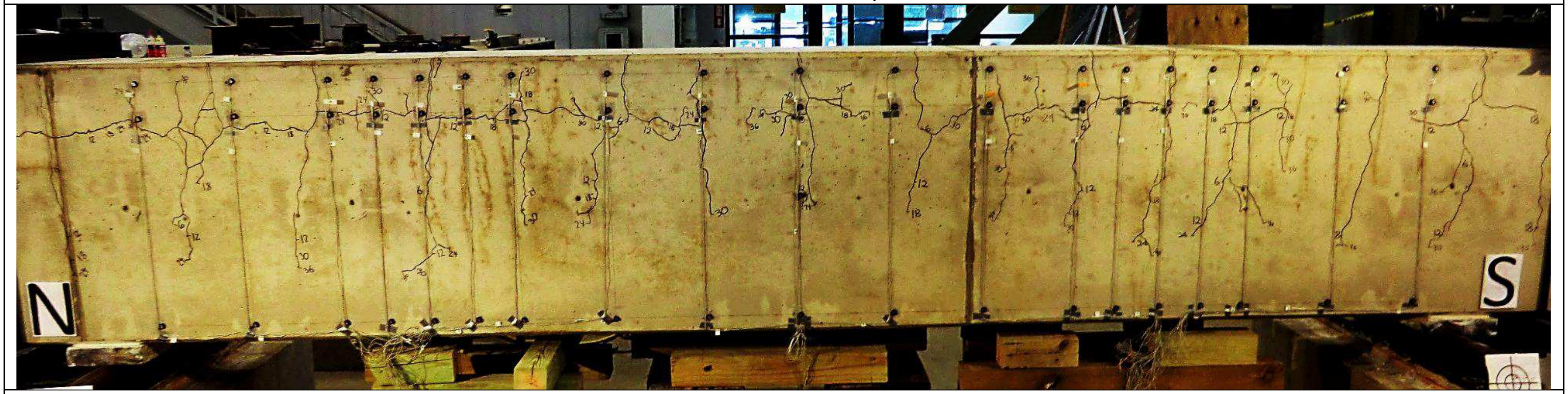
GIRDER A5 – 42 kip



GIRDER A6 – 41 kip

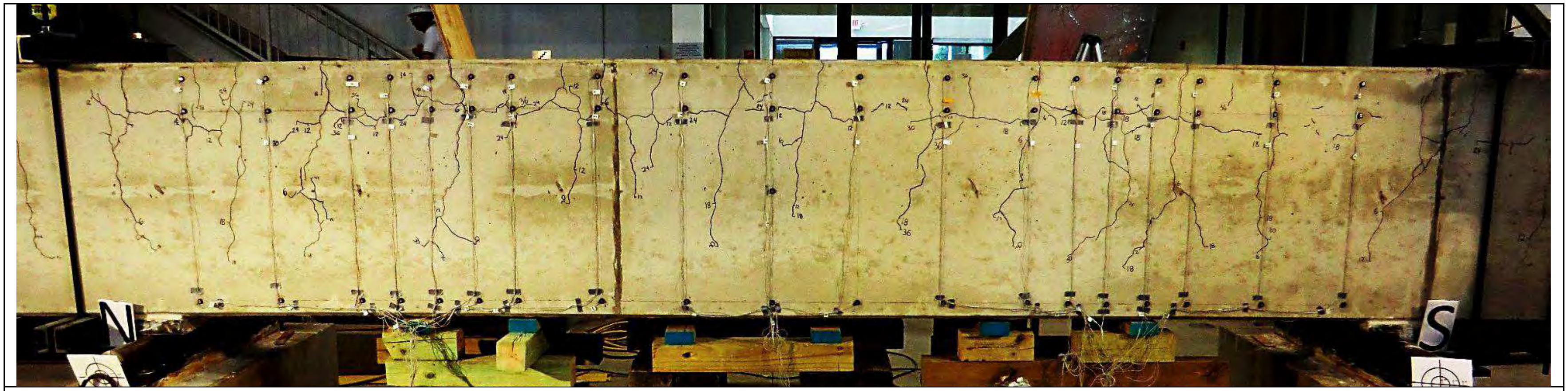
FIRST LOADING

GIRDER B1 – 36 kip

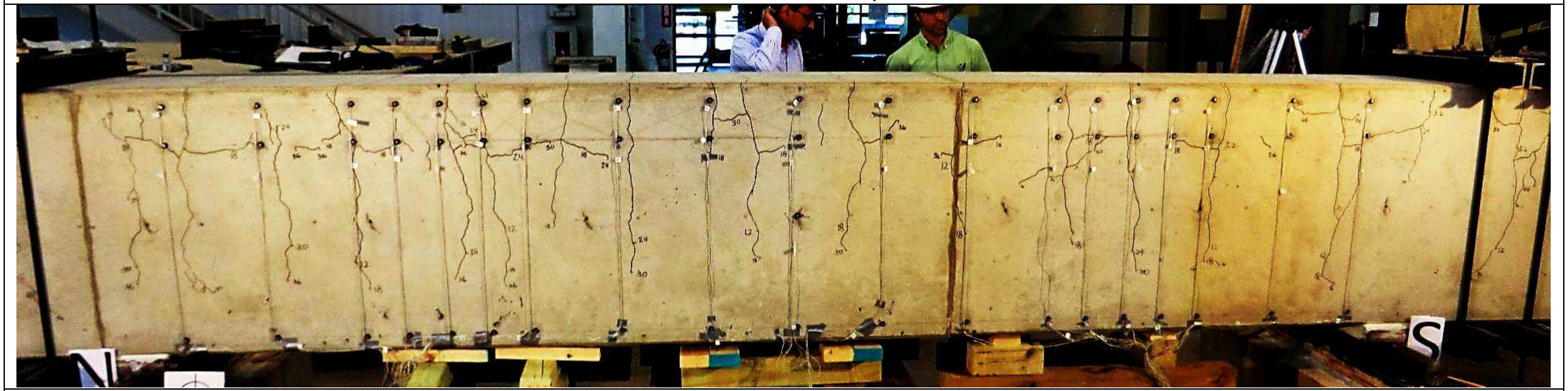


GIRDER B2 – 36 kip

FIRST LOADING

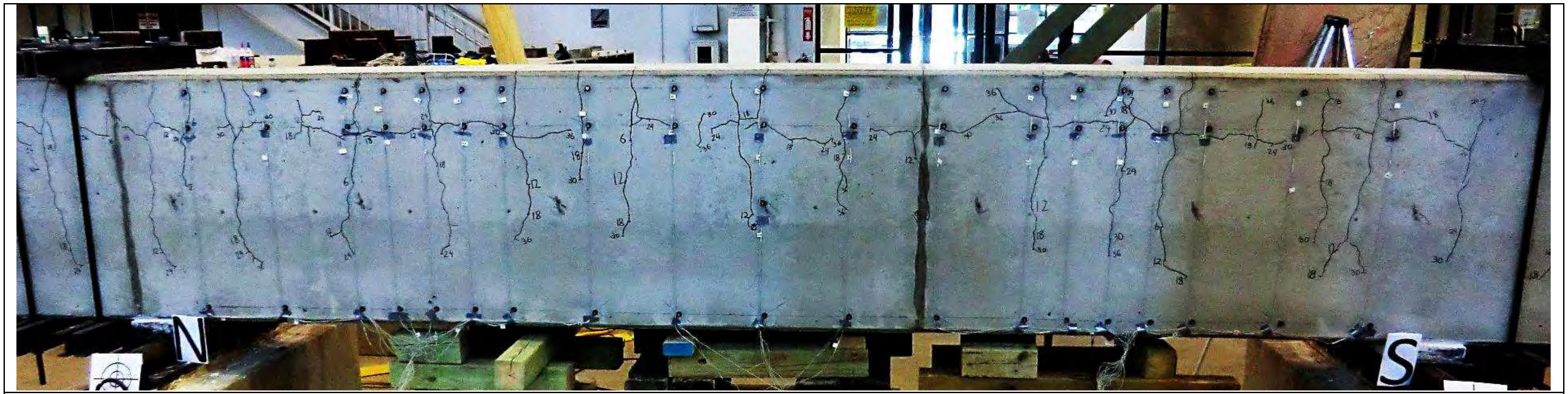


GIRDER B3 – 36 kip

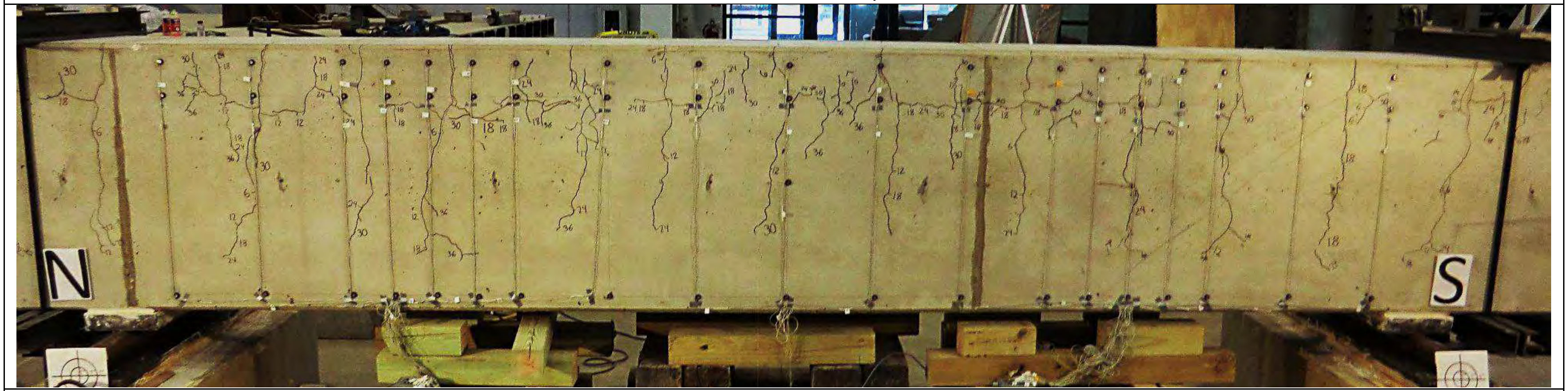


GIRDER B4 – 36 kip

FIRST LOADING



GIRDER B5 – 36 kip



GIRDER B6 – kip

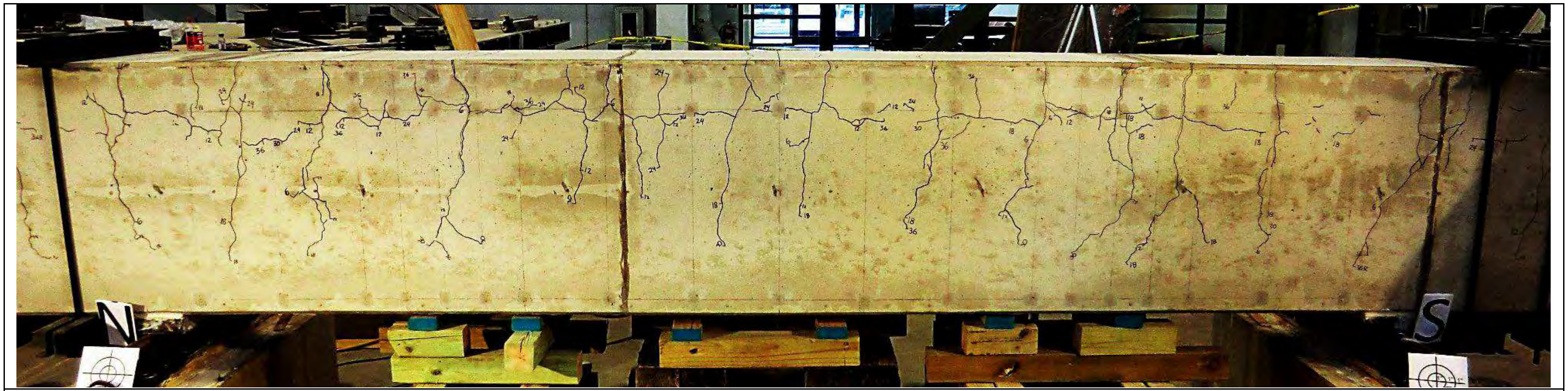
RELOADING

No reload

GIRDER B1 – kip

GIRDER B2 – Load = 36 kip.

RELOADING

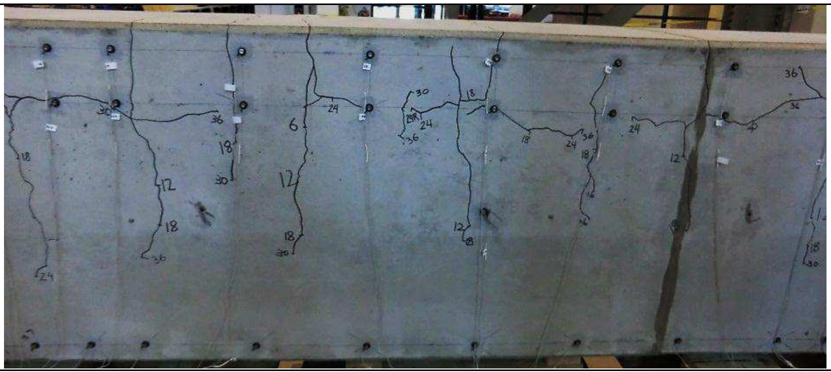


GIRDER B3 – Load = 36 kip

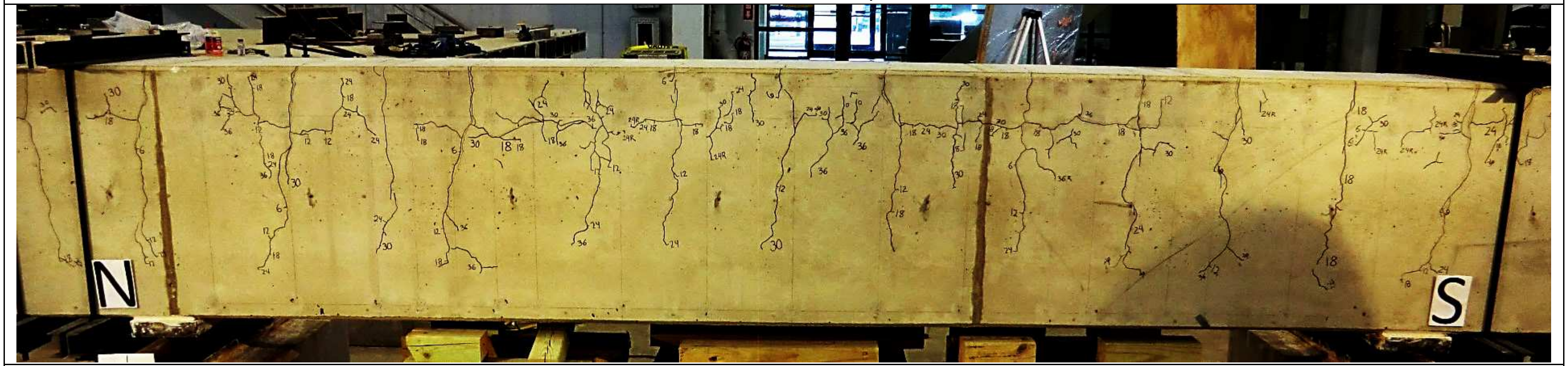
No reload

GIRDER B4

RELOADING



GIRDER B5 – 24 kip.



GIRDER B6 – 36 kip.

Project: Tests to Determine the Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

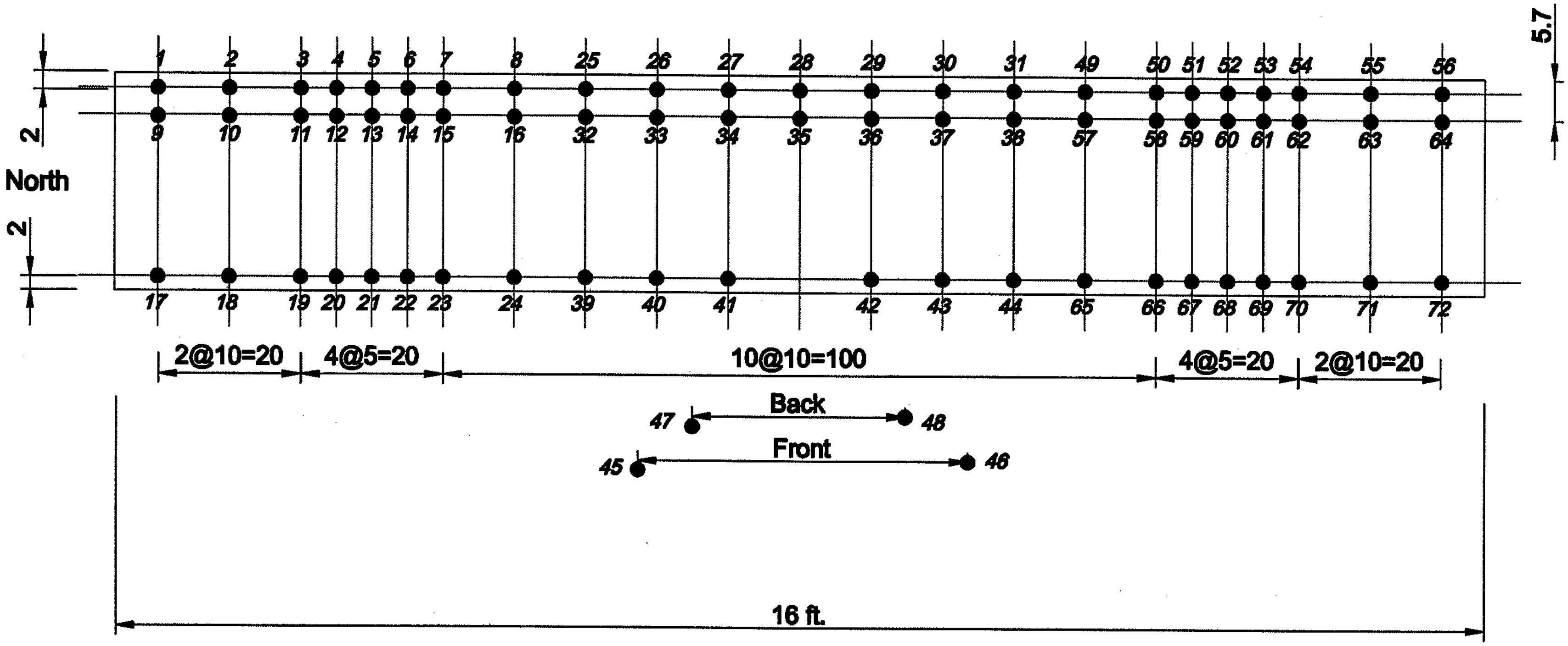
Specimen: A-1
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	[in/V] Sensitivity	[in] Zero Offset	Location	Zeroes [V] Comments
0 M1-0	1	3.333	PA-20	37100980	-6.197	-17.26	N. Overhang	2.785
1 M1-1	1	"	"	37100981	-6.167	-17.02	S. "	2.759
2 M1-2	1	"	PA-10	40010986	3.175	1.18	N. Splice End	0.372
3 M1-3	1	"	"	40010991	3.169	0.87	Midspan	0.274
4 M2-0	1	"	"	40010988	3.173	1.08	S. Splice End	0.339
5 M2-2	100	10	Lebow 50K	443	-2556	0.2 [K]	N. End	-0.000044
6 M2-3	100	10	"	442	-2563	0.2 [K]	S. "	-0.000033
7 M3-0	1	30	Lucas 2	J7250	0.208	0.005	N. Support	0.027
8 M3-1	1	30	"	J7251	0.209	0.000	S. "	0.000

Operator	Signature	Date	Time
BPR		6/2/12	2:40 PM
Checked by	**Signature**	**Date**	**Time**
KAN		6-2-12	2:40 pm
Checked by	**Signature**	**Date**	**Time**

Notes:



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen A-1			
Behavior of Lap Splices of No. 11 Reinforcing Bars	**Drawn by:**	BPR	**Checked by:** KAM
	Date:	6/2/12	

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

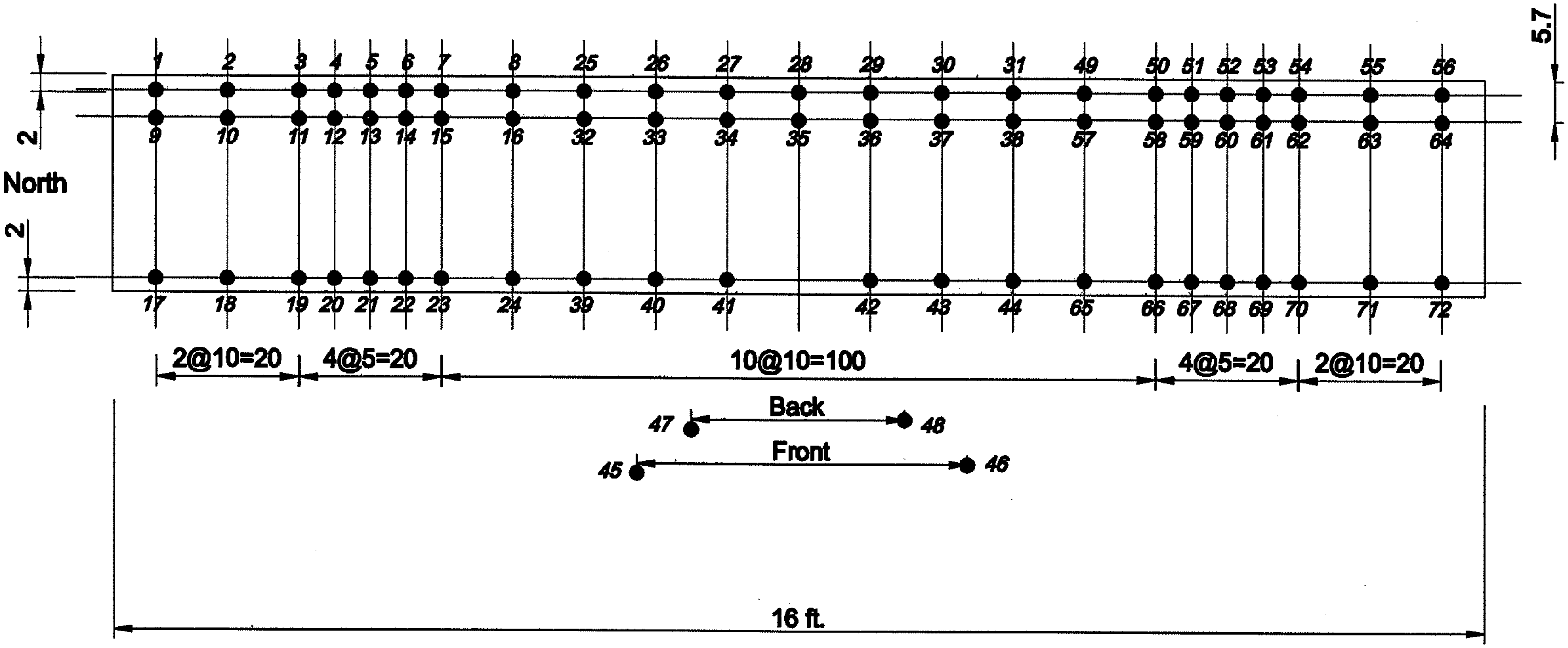
Specimen: A-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	(in/v) Sensitivity	(in) Zero Offset	Location	Zeroes (v) Comments
0 M1-0	1	3.333	PA-20	37100980	-6.197	-17.04	N. Overhang	2.750
1 M1-1	1	"	"	37100981	-6.167	-17.31	S. "	2.807
2 M1-2	1	"	PA-10	40010986	3.175	1.26	N. Splice End	0.396
3 M1-3	1	"	"	40010991	3.169	0.82	Midspan	0.260
4 M2-0	1	"	"	40010988	3.173	0.99	S. Splice End	0.311
5 M2-2	100	10	Lebow 50K	443	-2556	0.3 [K]	N. End	-0.000060
6 M2-3	100	10	"	442	-2563	0.2 [K]	S. "	-0.000036
7 M3-0	1	30	Lucas 2	J7250	0.208	0.004	N. Support	0.013
8 M3-1	1	30	"	J7251	0.209	-0.004	S. "	-0.025

Operator	Signature	Date	Time
BPR		5/31/12	5:10 PM
Checked by	Signature	Date	Time
KAM		5-31-12	5:30 pm
Checked by	Signature	Date	Time

Notes:



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen A-2

Behavior of Lap Splices of No. 11 Reinforcing Bars

Drawn by: BPR **Checked by:** dAM

Date: 5/31/12

Project: Tests to Determine the Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

Specimen: A-3
Sheet 1 of 1

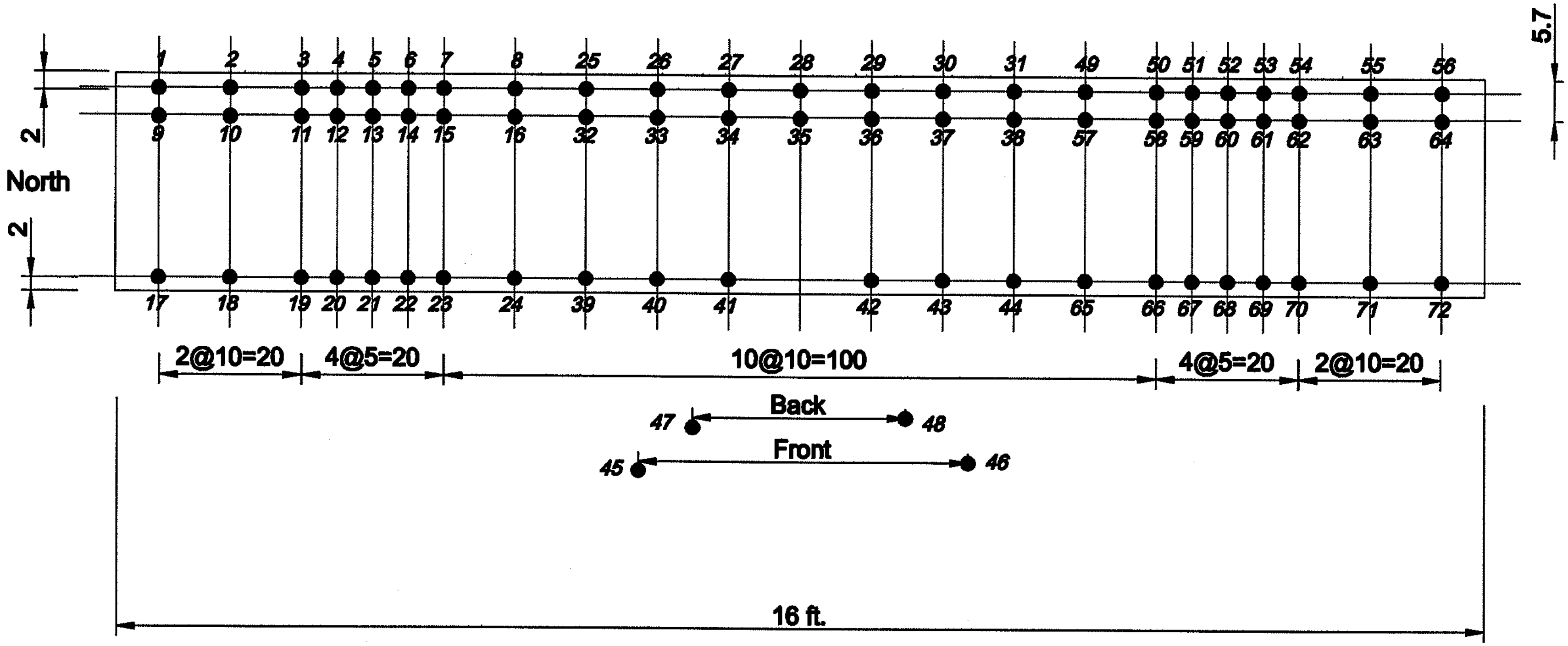
Data Acquisition System:

BPR 5/29/12

Channel #	Gain	Excitation V.	Sensor	S.N.	[in/V] Sensitivity	[in] Zero Offset	Location	~~Zeroes~~ [V] Comments
0 M1-0	1	3.333	PA-20	37100980	-6.197	~~18.~~ -17.43	N. Overhang	2.813
1 M1-1	1	"	"	37100981	-6.167	-17.13	S. "	2.777
2 M1-2	1	"	PA-10	40010986	3.175	1.19	N. Splice End	0.376
3 M1-3	1	"	"	40010991	3.169	0.90	Midspan	0.283
4 M2-0	1	"	"	40010988	3.173	1.15	S. Splice End	0.362
5 M2-2	100	10	Lebow 50K	443	-2556	0.2 [K]	N. End	-0.000034
6 M2-3	100	10	"	442	-2563	0.2 [K]	S. "	-0.000031
7 M3-0	1	30	Lucas 2	J7250	0.208	-0.003	N. Support	-0.016
8 M3-1	1	30	"	J7251	0.209	-0.001	S. "	-0.007

Operator	Signature	Date	Time
BPR		5/29/12	9:20 PM
Checked by	Signature	Date	Time
J.N.H.		5.29.12	9:20
Checked by	Signature	Date	Time

Notes:



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen A-3

Behavior of Lap Splices of No. 11 Reinforcing Bars

Drawn by: BPR **Checked by:** KAM

Date: 5/29/12

Project: Tests to Determine the Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

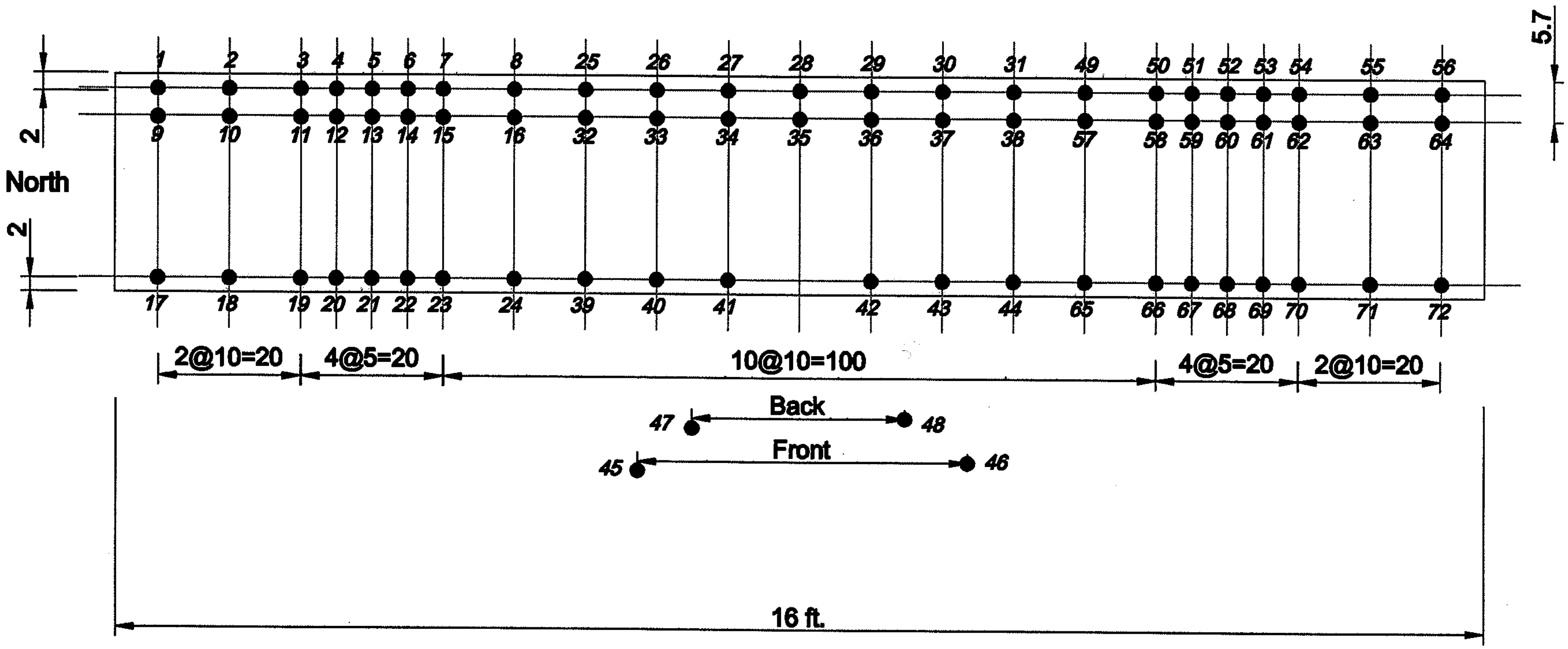
Specimen: A-4
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	(in/v) Sensitivity	[in] Zero Offset	Location	Zeroes [v] Comments
0 M1-0	1	3.333	PA-20	37100980	-6.197	-17.08	N. Overhang	2.757
1 M1-1	1	"	"	37100981	-6.167	-17.45	S. "	2.830
2 M1-2	1	"	PA-10	40010986	3.175	1.22	N. Splice E.	0.383
3 M1-3	1	"	"	40010991	3.169	0.86	Midspan	0.271
4 M2-0	1	"	"	40010988	3.173	1.05	S. Splice E.	0.332
5 M2-2	100	10	Lebow 50K	443	-2556	BPR 6/7 ~~0.007~~ 0.3 [K]	N. End	-0.000056
6 M2-3	100	10	"	442	-2563	0.3 [K]	S. End	-0.000055
7 M3-0	1	30	Lucas 2	J7250	0.208	0.007	N. Support	0.035
8 M3-1	1	30	"	J7251	0.209	-0.007	S. "	-0.034

Operator	Signature	Date	Time
BPR		6/7/12	10:30 PM
Checked by	**Signature**	**Date**	**Time**
KAM		6-7-12	10:30 pm
Checked by	**Signature**	**Date**	**Time**

Notes:



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen A-4			
Behavior of Lap Splices of No. 11 Reinforcing Bars	**Drawn by:** BPR	**Checked by:** KAM	
	Date: 6/7/12		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

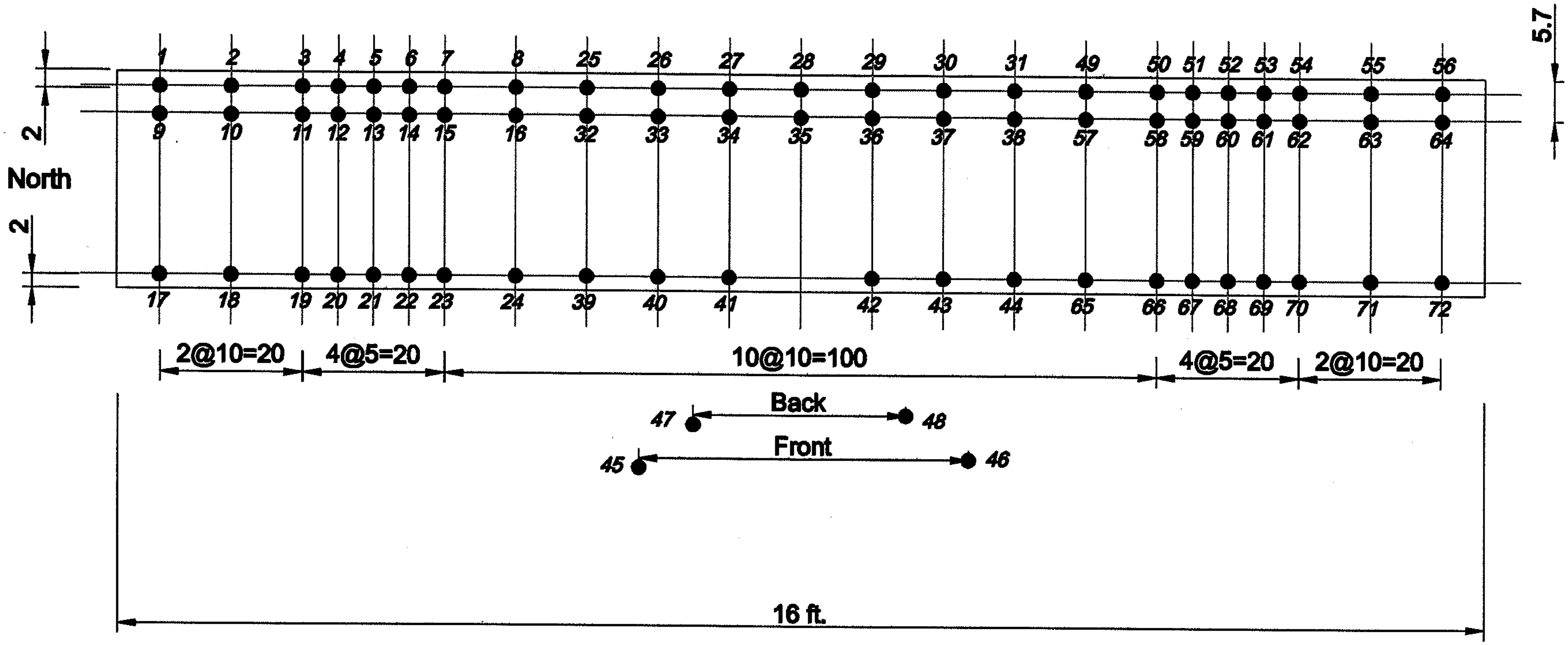
Specimen: A-5
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	(in/v) Sensitivity	[in] Zero Offset	Location	Zeroes (V) Comments
0 M1-0	1	3.333	PA-20	37100980	-6.197	-17.40	N. Overhang	2.808
1 M1-1	1	"	"	37100981	-6.167	-16.96	S. "	2.750
2 M1-2	1	"	PA-10	40010986	3.175	1.10	N. Splice End.	0.349
3 M1-3	1	"	"	40010991	3.169	0.72	Midspan	0.230
4 M2-0	1	"	"	40010988	3.173	0.98	S. Splice End	0.310
5 M2-2	100	10	Lebow 50K	443	-2556	0.2 [K]	N. End	-0.000038
6 M2-3	100	10	"	442	-2563	0.2 [K]	S. "	-0.000037
7 M3-0	1	30	Lucas 2	J7250	0.208	0.006	N. Support	0.027~~7~~ BPR 6/6
8 M3-1	1	30	"	J7251	0.209	-0.005	S. "	-0.026~~8~~ BPR 6/6

Operator	Signature	Date	Time
BPR		6/6/12	5:30 PM
Checked by	**Signature**	**Date**	**Time**
J.N.H.		6.6.12	5:45 P
Checked by	**Signature**	**Date**	**Time**

Notes:



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen A-5			
Behavior of Lap Splices of No. 11 Reinforcing Bars	**Drawn by:**	BPR	**Checked by:** KAM
	Date:	6/6/12	

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

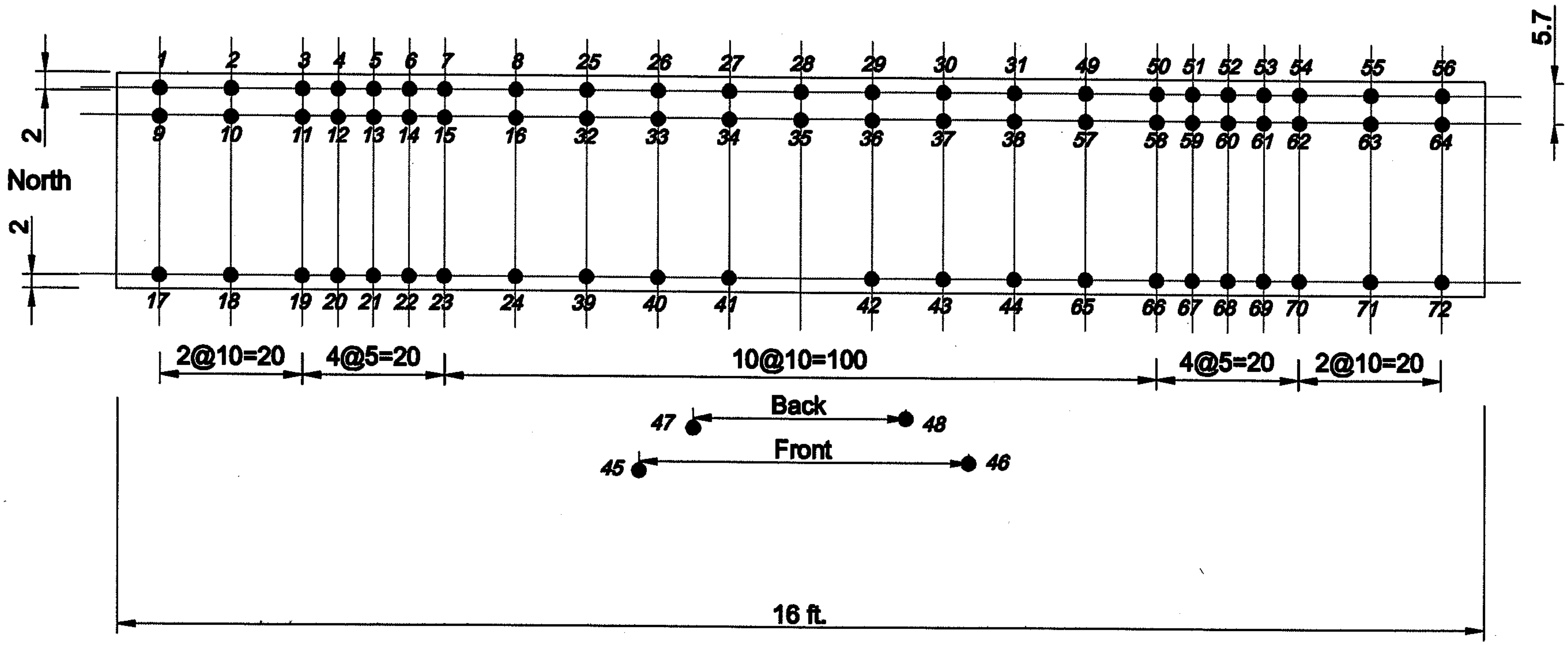
Specimen: A-6
Sheet 1 of 1

Data Acquisition System:

Channel #	Gain	Excitation V.	Sensor	S.N.	(in/v) Sensitivity	[in] Zero Offset	Location	~~Zeroes~~ (v) Comments
0 M1-0	1	3.333	PA-20	37100980	-6.197	BPR 6/5 ~~2.78~~ -17.23	N. Overhang	2.780
1 M1-1	1	"	"	37100981	-6.167	-17.01	S. "	2.758
2 M1-2	1	"	PA-10	40010986	3.175	1.10	N. Splice End	0.347
3 M1-3	1	"	"	40010991	3.169	0.84	Midspan	0.264
4 M2-0	1	"	"	40010988	3.173	1.00	S. Splice End	0.316
5 M2-2	100	10	Lebow 50K	443	-2556	BPR 6/5 ~~0.006~~ 0.3 [K]	N. End	-0.000057
6 M2-3	100	10	"	442	-2563	BPR 6/5 ~~-0.007~~ 0.2 [K]	S. End	-0.000036
7 M3-0	1	30	Lucas 2	J7250	0.208	0.006	N. Support	0.029
8 M3-1	1	30	"	J7251	0.209	-0.007	S. "	-0.034

Operator	Signature	Date	Time
BPR		6/4/12	11:00 AM
Checked by	**Signature**	**Date**	**Time**
KAM		6-4-12	11:00 am
Checked by	**Signature**	**Date**	**Time**

Notes:



BOWEN LABORATORY PURDUE UNIVERSITY	**Specimen** A-6		
	Behavior of Lap Splices of No. 11 Reinforcing Bars	**Drawn by:** BPR	**Checked by:** KAM
		Date: 6/4/12	

Project: Tests to Determine the Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

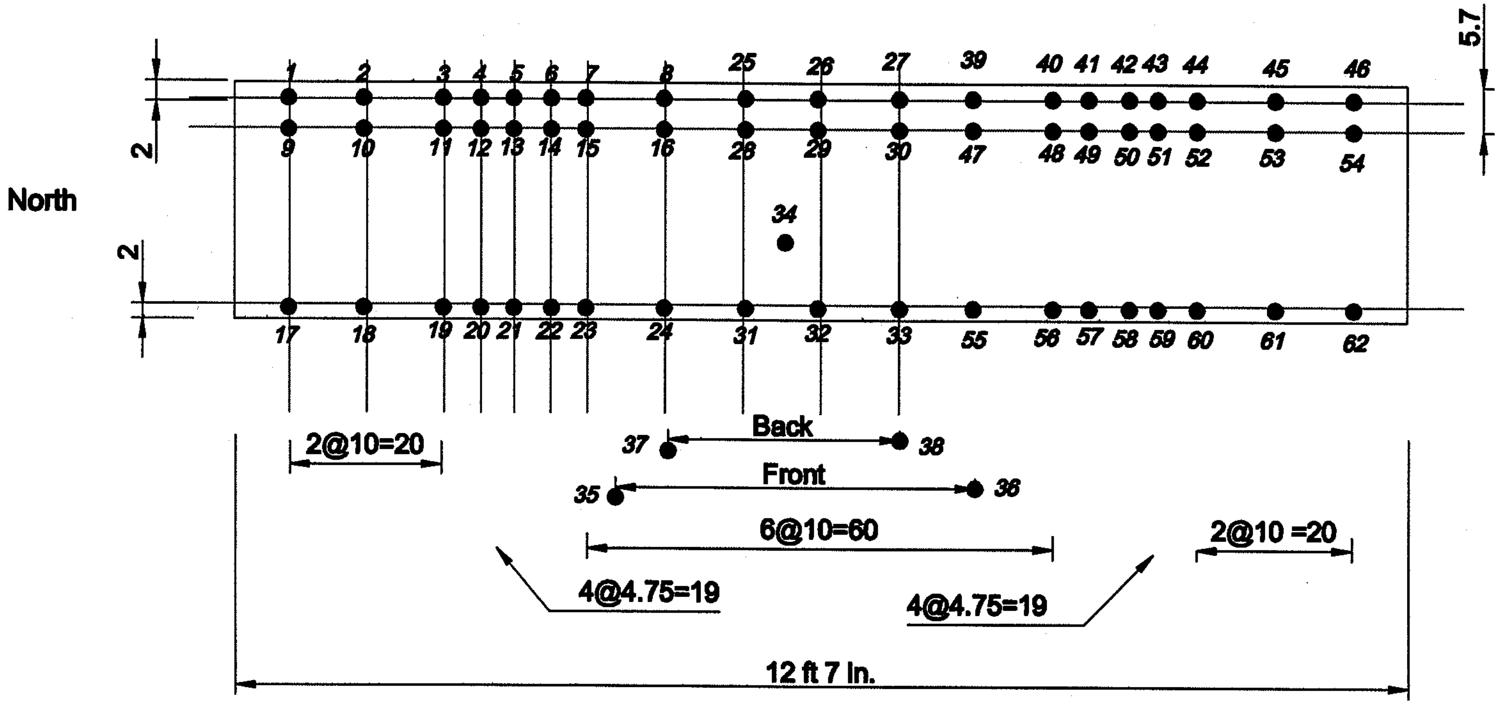
Specimen: B-1
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	(in./V) Sensitivity	(in.) Zero Offset	Location	Zeros (V.) Comments
0 M1-0	1	3.333	PA-20	371 00980	-6.197 ✓	-18.68	N. Overhang	3.013
1 " 1	1	"	"	371 00981	-6.167	-17.01	S. "	2.745
2 " 2	1	"	PA-10	400 10980 ✓	3.175 ✓	0.74	N. Splice end	0.235
3 " 3	1	"	"	400 10985 ✓	3.169 ✓	0.54	Midspan	0.170
4 M2-0	1	"	"	400 10977 ✓	3.173 ✓	0.91	S. Splice end	0.287
5 M2-2	100	10	Lebow 50k	443	-2556	0.2	N. End	-0.000042
6 " -3	100	10	"	442	-2563	0.2	S. End	-0.000029
7 M3-0	1	30V	Lucas 2"	J7250	0.208 ✓	-0.008	N. Support	-0.041
8 M3-1	1	30V	" 2"	J7251	0.209 ✓	-0.006	S. "	-0.027

Operator	Signature	Date	Time
S.P.		5/10/12	11 AM
Checked by	**Signature**	**Date**	**Time**
A.J.C.		5/10/12	11 am
Checked by	**Signature**	**Date**	**Time**

Notes:



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen B-1				
Behavior of Lap Splices of No. 11 Reinforcing Bars	**Drawn by:**	BPR	**Checked by:**	KM
	Date:	5/10/12		

Project: Tests to Determine the Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

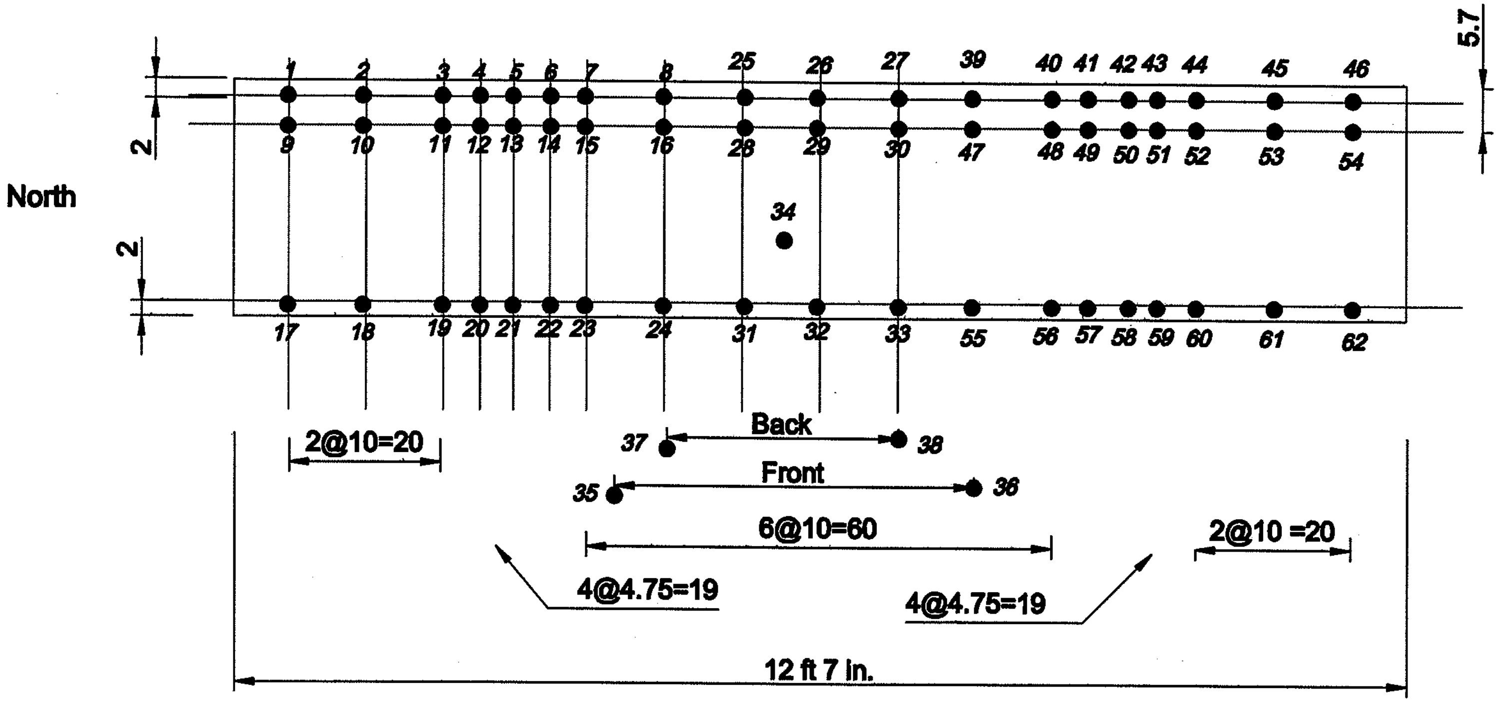
Specimen: B-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity	[in] Zero Offset	Location	Zeroes (V) Comments
0 M1-0	1	3.333	PA-20	37100980	-6.197	-18.60	N. Overhang	3.002
1 M1-1	1	"	"	37100981	-6.167	-17.13	S. Overhang	2.778
2 M1-2	1	"	PA-10	40010986	3.175	+0.74	N. Splice End	0.234
3 M1-3	1	"	"	40010991	3.169	+0.56	Midspan	0.177
4 M2-0	1	"	"	40010988	3.173	+1.12	S. Splice End	0.352
5 M2-2	100	10V	Lebow 50K	443	-2556	0.2 [K]	N. End	-0.000041
6 M2-3	100	10V	"	442	-2563	0.2 [K]	S. End	-0.000036
7 M3-0	1	30V	Lucas 2	J7250	0.208	+0.010	N. Support	0.051
8 M3-1	1	30V	"	J7251	0.209	-0.005	S. Support	-0.024

Operator	Signature	Date	Time
BPR		5/22/12	6:15PM
Checked by	**Signature**	**Date**	**Time**
J.N.H.		5.22.12	6:25 PM
Checked by	**Signature**	**Date**	**Time**

Notes:



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen B-2				
Behavior of Lap Splices of No. 11 Reinforcing Bars	**Drawn by:**	BPR	**Checked by:**	KAM
	Date:	5/22/12		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

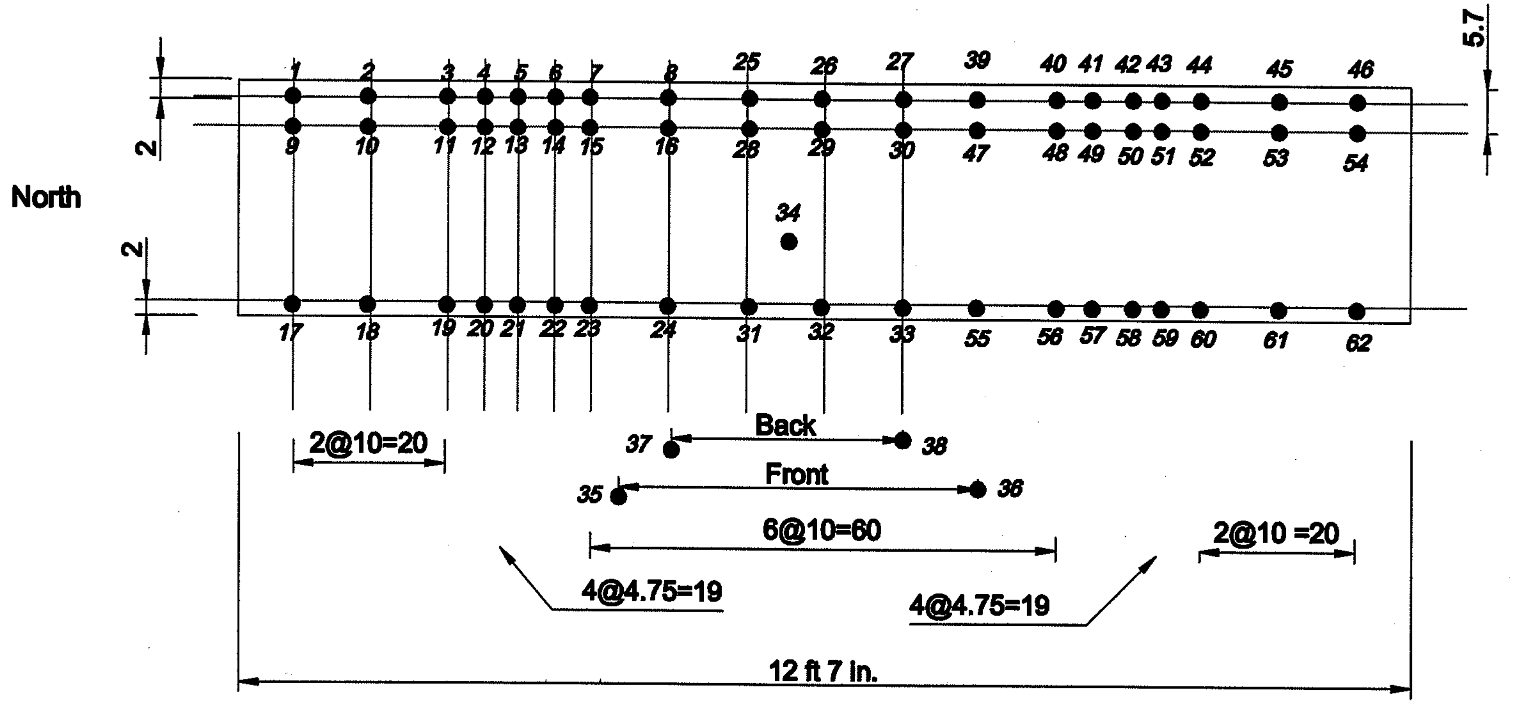
Specimen: B-3
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity	[in] Zero Offset	Location	Zeroes (V) Comments
0 M1-0	1	3.333	PA-20	37100980	-6.197	-18.99	N. Overhang	3.064 ✓
1 M1-1	1	"	"	37100981	-6.167	-16.99	S. " "	2.755 ✓
2 M1-2	1	"	PA-10	40010986	3.175	0.97	N. Splice End	0.305 ✓
3 M1-3	1	"	"	40010991	3.169	0.64	Midspan	0.203 ✓
4 M2-0	1	"	"	40010988	3.173	1.07	S. Splice End	0.336 ✓
5 M2-2	100	10	Lebow 50K	443	-2556	0.3 [K]	N. End	-0.000060 ✓
6 M2-3	100	10	"	442	-2563	0.2 [K]	S. End	-0.000040 ✓
7 M3-0	1	30	Lucas 2	J7250	0.208	0.014	N. Support	0.067 ✓
8 M3-1	1	30	"	J7251	0.209	-0.006	S. "	-0.028 ✓

Operator	Signature	Date	Time
BPR		5/19/12	5:25 PM
Checked by	**Signature**	**Date**	**Time**
SP		5/19/12	7:15 PM
Checked by	**Signature**	**Date**	**Time**

Notes:



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen B-3				
Behavior of Lap Splices of No. 11 Reinforcing Bars	**Drawn by:**	BPR	**Checked by:**	LHM
	Date:	5/19/12		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

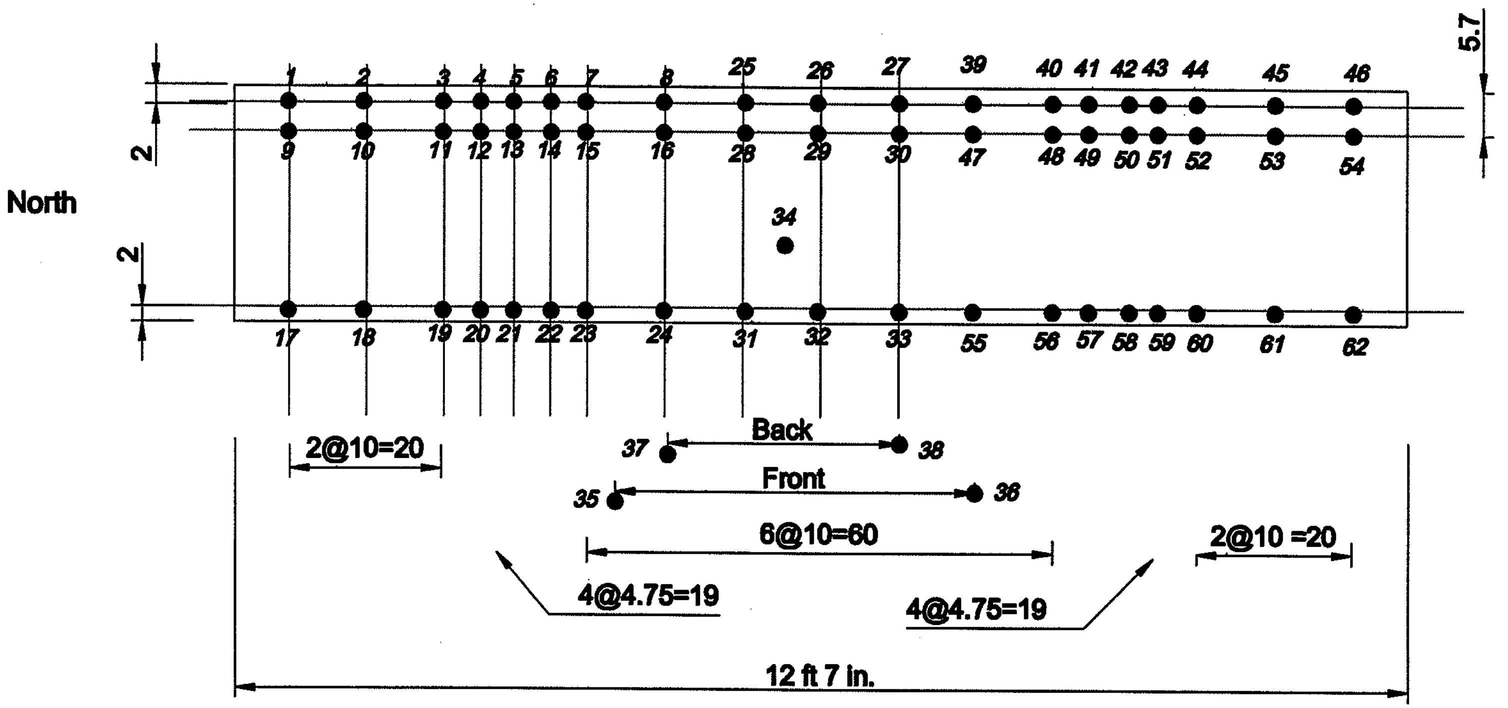
Instrumentation Documentation v.1
(Rev. 04/01/2012)

Specimen: B-4
Sheet 1 of 1

Data Acquisition System:								
Channel #	Gain	Excitation V.	Sensor	S.N.	(in/V) Sensitivity	in. Zero Offset	Location	Zero Offset V. Comments
0 M1-0	1	3.333	PA-20	37100980	-6.197	-18.37	N. Overhang	2.965
1 M1-1	1	"	"	37100981	-6.167	-17.04	S. "	2.764
2 M1-2	1	"	PA-10	40010986	3.175	0.62	N. Splice End	0.195
3 M1-3	1	"	"	40010991	3.169	0.46	Midspan	0.146
4 M2-0	1	"	"	40010988	3.173	0.99	S. Splice End	0.312
5 M2-2	100	10V	LC443	443	-2556	0.2	N. End	-0.000042
6 M2-3	100	10V	LC442	442	-2563	0.2	S. End	-0.000040
7 M3-0	1	30V	LVDT	J7250	0.208	-0.005	N. Support	-0.026
8 M3-1	1	30V	LVDT	J7251	0.209	-0.003	S. "	-0.014

Operator	Signature	Date	Time
S.P.		5/12/12	3:46 PM.
Checked by	Signature	Date	Time
BPR		5/12	4:00 PM
Checked by	Signature	Date	Time

Notes: All instruments & settings as in B-1



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen B-4

Behavior of Lap Splices of No. 11 Reinforcing Bars

Drawn by: BPR **Checked by:** KM

Date: 5/14/12

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

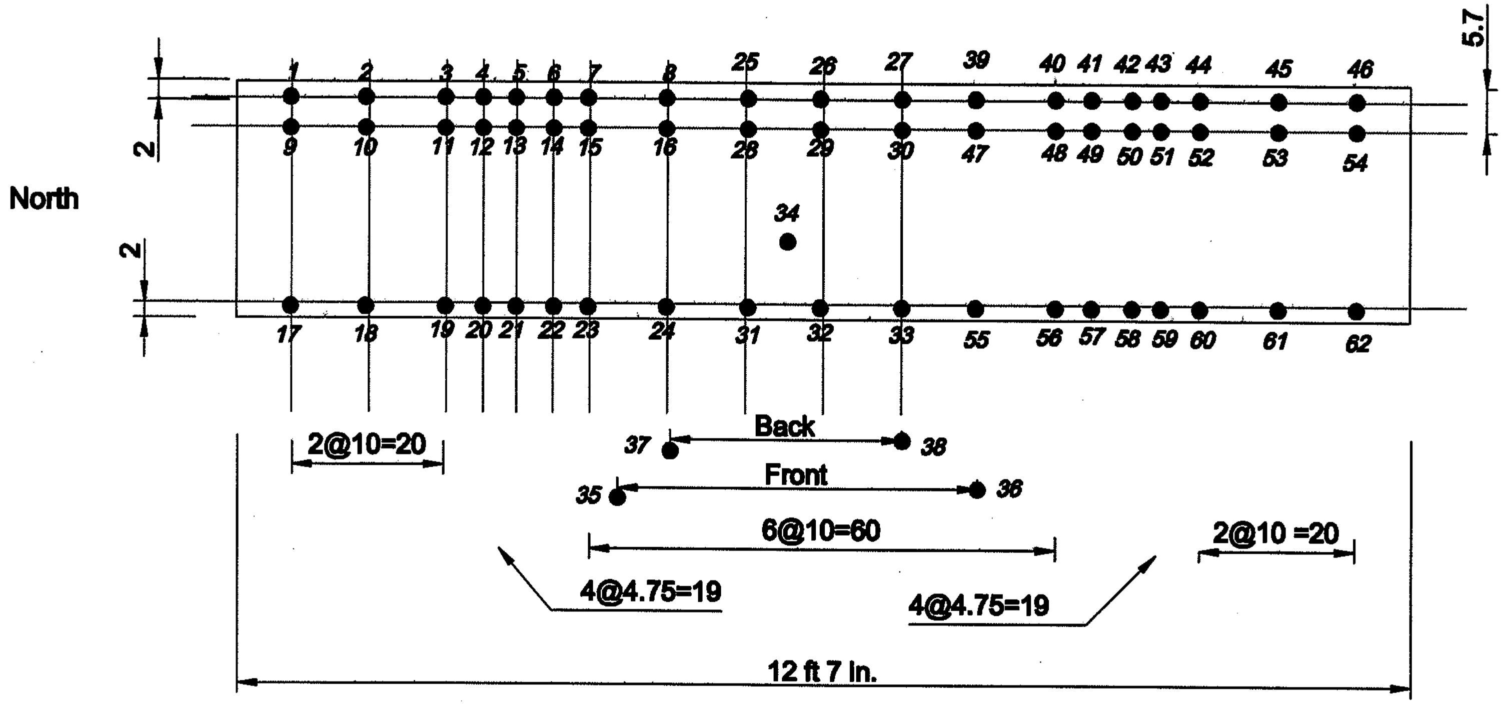
Specimen: B-5
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	(in/V) Sensitivity	[in] Zero Offset	Location	Zeroes(V) Comments
0 M1-0	1	3.333	PA-20	37100980	-6.197	-18.73	N. Overhang	3.022 ✓
1 M1-1	1	"	"	37100981	-6.167	-16.89	S. "	2.739 ✓
2 M1-2*	1	"	PA-10	40010986*	3.175	+0.72	N. Splice end	0.225 ✓
3 M1-3	1	"	"	40010991	3.169	+0.48	Midspan	0.153 ✓
4 M2-0	1	"	"	40010988	3.173	+0.97	S. Splice end	0.305
5 M2-2	100	10V	Lebow 50K	443	-2556	0.2[K]	N. End	-0.000048
6 M2-3	100	10V	"	442	-2563	0.2[K]	S. End	-0.000039
7 M3-0	1	30V	Lucas 2	J7250	0.208	-0.005	N. Support	-0.022
8 M3-1	1	30V	"	J7251	0.209	+0.011	S. "	0.054

Operator	Signature	Date	Time
S. PUJOL			
Checked by	Signature	Date	Time
BPR		5/17/12	12:20PM
Checked by	Signature	Date	Time

Notes: * Cable Replaced.



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen B-5

Behavior of Lap Splices of No. 11 Reinforcing Bars

Drawn by:	BPR	**Checked by:**	Km
Date:	5/16/12		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

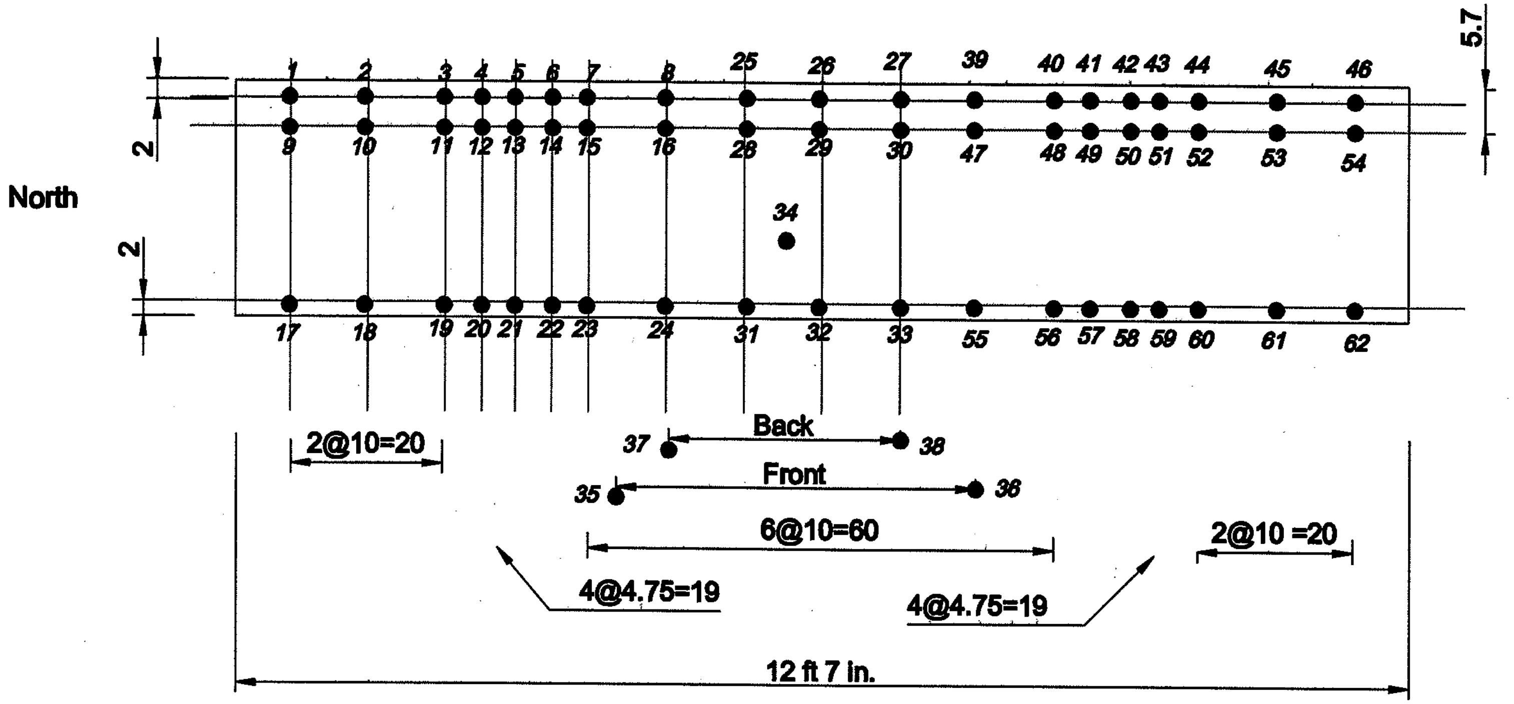
Specimen: B-6
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity	[in] Zero Offset	Location	~~Zeroes~~ [V] Comments
0 M1-0	1	3.333	PA-20	37100980	-6.197	-18.86	N. Overhang	3.043
1 M1-1	1	"	"	37100981	-6.167	-17.11	S. Overhang	2.774
2 M1-2	1	"	PA-10	40010986	3.175	0.86	N. Splice End	0.271
3 M1-3	1	"	"	40010991	3.169	0.59	Midspan	0.185
4 M2-0	1	"	"	40010988	3.173	1.15	S. Splice End	0.362
5 M2-2	100	10V	Lebow 50K	443	-2556	0.2 [K]	N. End	-0.000033
6 M2-3	100	10V	"	442	-2563	0.2 [K]	S. End	-0.000036
7 M3-0	1	30V	Lucas 2	J7250	0.208	0.000	N. Support	0.000
8 M3-1	1	30V	"	J7251	0.209	0.002	S. Support	0.013

Operator	Signature	Date	Time
BPR		5/24	5:30PM
Checked by	**Signature**	**Date**	**Time**
KAM		5-24	5:30pm
Checked by	**Signature**	**Date**	**Time**

Notes:



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen B-~~2~~6				
Behavior of Lap Splices of No. 11 Reinforcing Bars	**Drawn by:**	BPR	**Checked by:**	KAM
	Date:	5/24/12		

25884-000-30R-C01R-00002, Rev. 000

APPENDIX B

“Purdue Phase II Test Report”

AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS

A REPORT Submitted to

First Energy Nuclear Operating Company
Oak Harbor, Ohio

by
Mete A. Sozen

Mete A Sozen

and
Santiago Pujol

Pujol.

08 June 2016
Bowen Laboratory
West Lafayette, IN

SUMMARY

Six girders containing pairs of 79-inch unconfined lap splices of #11 reinforcing bars were tested by loading them to a deflection beyond yield load to develop laminar cracks, unloading, and then loading them to failure. Concrete compressive strength ranged from 5200 to 5900 psi at time of test. Measured yield stress of the bars was 65 ksi.

The testing showed that crack widths of as a much as 0.05 inches can be achieved while maintaining the full yield capacity of the #11 reinforcement with 79-inch long splices.

OBJECT AND SCOPE

A series of six reinforced concrete girders with unconfined 79-inch lap splices of Grade-60 #11 bars were tested to failure to:

- determine the effect of existing laminar cracks (cracks on or near the plane of the splice), on the capability of the splice to develop the yield stress of the reinforcing bar, and

- to try to establish the maximum crack width that can be reached while maintaining the yield capacity of the spliced reinforcing bars.

METHOD

Each test girder was initially loaded to beyond yield load to develop laminar cracks, unloaded, and then reloaded to failure. This report documents the measured load-deflection relationships, the initial and final widths of the laminar cracks, observed crack patterns, and the reinforcement stresses developed by the splices. The geometry of the specimens and the test setup were the same as those used in test Series B documented in our report from 2012 [Sozen and Pujol, 2012] to produce complementary test results. In the tests done in 2012, longer splices performed better in the presence of existing laminar cracks. For this reason, the tests described here do not include replicas of specimens in Test Series A from 2012.

The testing procedure used was similar to the procedure used in 2012. The loading sequences used were modified (by increasing peak deflection reached before unloading) to create (and measure) laminar cracks wider than the laminar cracks observed in the initial loading of comparable specimens tested in 2012. Initial loading was stopped at deflections deemed safe for personnel and instrumentation. Reloading to failure was conducted with reduced instrumentation and from a safe distance.

The profile and cross-sectional dimensions of the 34-foot 4-inch long test girders are shown in Fig. 1. They measured 17-5/8 inches by 30 inches in cross section. Each test girder contained two contiguous (i.e. not staggered) splices of length 6 feet 7 inches (56 bar diameters) with a side cover of 3 inches.

Each test girder was placed on two simple supports at a distance of 12 feet 7 inches from one another leaving two overhangs beyond each support. Loads were applied on the overhangs at 9 feet 8 ½ inches from the support leading to bending moment distribution shown qualitatively in Fig.2.

The test girders were tested statically with test durations ranging from 3.5 to 5.5 hours and had measured compressive strengths not exceeding 5900 psi. Yield stress of the reinforcement was determined to be 65ksi. Unit stresses developed in the reinforcement (at splice end) ranged from 73 to 75 ksi.

MATERIALS

The cross section in Fig.1 shows the arrangement of the spliced bars. Concrete was cast with the bars near the bottom of the form (and not as shown in the figure that refers to the positon of the bars during the test) to make certain that the wet concrete would not settle away from the bars. Top cover, as shown in Fig. 1, was 5 inches and the side cover was 3 inches to have the laminar crack develop in the horizontal plane affecting the strength of both splices.

All test girders were cast on 2 February 2016 using normal-weight aggregate. Mix proportions by weight are shown in Table 1. Each girder and associated cylinders were cast using concrete from a single truck. After casting, the girders were kept under burlap cover for one week. Target air entrainment was 5%. The age of the concrete and measured concrete strengths at time of test are listed in Table 2.

All reinforcement came from the same heat. As mentioned above the measured yield stress of the reinforcement was 65 ksi (Table 3).

INSTRUMENTATION

The applied load was measured by load cells with an accuracy of 80 lbf as listed in Table 4.

Longitudinal and vertical deformations of the concrete surface were measured using OPTOTRAK (a coordinate tracking system) that had an accuracy of 0.005 inches. The locations of the OPTOTRAK targets are shown in Fig. 4.

Crack development was recorded by visual inspection. Laminar crack widths were determined using OPTOTRAK targets at 4 and 8 inches below the top surface of the test girder.

OBSERVED LOAD-DEFLECTION RELATIONSHIPS

The variations of the deflection at mid-span with applied load are shown in Fig. 5 through 10. Initial loading was continued to a mid-span deflection of 0.4 inches, approximately 4/3 of the deflection at yield, for test girders C1, C2, C3, and C5 and to 0.5 inches, approximately 5/3 of the deflection at yield, for test girders C4 and C6. The maximum deflection was observed to be approximately three times that at yield. Table 5 lists maximum loads and deflections.

CRACK PATTERNS AT END OF FIRST LOADING

Figures 11 to 16 illustrate the crack patterns observed during the tests. Each figure contains two photographs. The photograph on top of the page shows the test girder from the south support to mid-span. The lower one shows the test girder from mid-span to the north support.

HORIZONTAL DEFORMATIONS ALONG LENGTH OF SPLICE

Horizontal deformations along the middle 80 inches at the level of the reinforcement (between contiguous targets) of the test girders obtained by OPTOTRAK measurements are shown in Fig. 17 through 22. Each figure contains the measurements made during the first loading and to an indicated load level (not to the maximum load) during reloading. Despite the presence of laminar cracks near each end of each splice, the increases in deformation indicate that most of the force transfer by bond developed near the splice ends.

VERTICAL DEFORMATIONS ALONG LENGTH OF SPLICE

Vertical deformations measured over a gage length of 4 inches (using targets above and below the plane of the bars) and along the central 80 inches of the test girders are shown in Fig. 23 through 28. Figure 25 contains only the data obtained in the south 40 inches because the sensors for the north 40 inches did not function.

From these plots it is inferred that the stress transfer from bar to bar in the splice took place primarily over lengths at splice ends of approximately 15-bar diameters. (Once these parts of the splice started losing their strength and transferring the force towards the remaining portion of the splice, failure initiated because there was not sufficient remaining length to develop the required force).

Crack widths inferred from the data in Figures 23 to 28 are listed in Table 6. Figure 29 compares the load-deflection relationships measured for specimens C1 to C6. Whatever the size of the “existing” crack, all specimens responded in the same manner and developed more than the yield stress.

CONCLUSION

The test results summarized in Table 6 showed that crack widths of as a much as 0.05 inch can be achieved while maintaining the full yield capacity of the #11 reinforcement with 79” long splices.

REFERENCES

Sozen M., Pujol S., 2012, “An Investigation of the Effect of Laminar Cracks on Strength of Unconfined Lap Splices of #11 Reinforcing Bars.” Report to FENOC, Oak Harbor, Ohio.

TABLES

Table 1 Concrete Mix Proportions

Component	Weight of Component / Weight of Cement
Cement	1
Fine Aggregate	2.4
Coarse Aggregate (max. size = 1¼ in.)	2.6
Water	0.55

Table 2 Concrete Strength

Test Girder	Cast Date	Test Date	Concrete Compressive Strength* (psi)	Concrete Splitting Cylinder Strength (psi)	Age of Specimen (days)
C1	2/2/2016	3/21/2016	5300	500	48
C2		3/28/2016	5200	450	55
C3		4/4/2016	5900	500	62
C4		4/11/2016	5700	500	69
C5		4/12/2016	5600	500	70
C6		4/14/2016	5300	400	72

*mean of six cylinder tests

Table 3 Reinforcement

Bar Designation	#11
Nominal Diameter, in.	1.41
Nominal Area, in^2	1.56
Nominal Perimeter, in.	4.43
Unit Weight, lbf/ft	5.31
Yield Stress*, ksi	65

*Note: means from tests of three coupons

Table 4 Sensors

Sensor Type	**Manufacturer**	**Model Number**	**Serial Number**	**Location**	**Range**	**Accuracy**
Load Cell	Lebow	3175 50K	1176585	North Load Point	50 kip	80 lbf
		3175 50K	442	South Load Point		
String Potentiometer	Unimeasure	PA 20	36030715	North Overhang	20 in.	0.05 in.
		PA 20	45110640	South Overhang		
		PA 10	40010981	North Splice End	10 in.	0.02 in.
		PA 10	40010984	Mid-span*		
		PA 10	40010987			
		PA 10	40010979	South Splice End		
LVDT	Schaevitz	DC EC 250	22439	North Support	+/-0.25 in.	0.001 in.
	Schaevitz	DC EC 250	22461	South Support		
Optotrak	Northern Digital Inc.	PRO Series 600	-	-	-	0.005 in.
Dial Gage	Federal	1 in. Dial Gage		North Overhang	1 in.	0.001 in.
				Mid-span		
				South Overhang		

*Sensor 40010981 was used for C1 and C2, sensor 40010987 was used for C3-C6

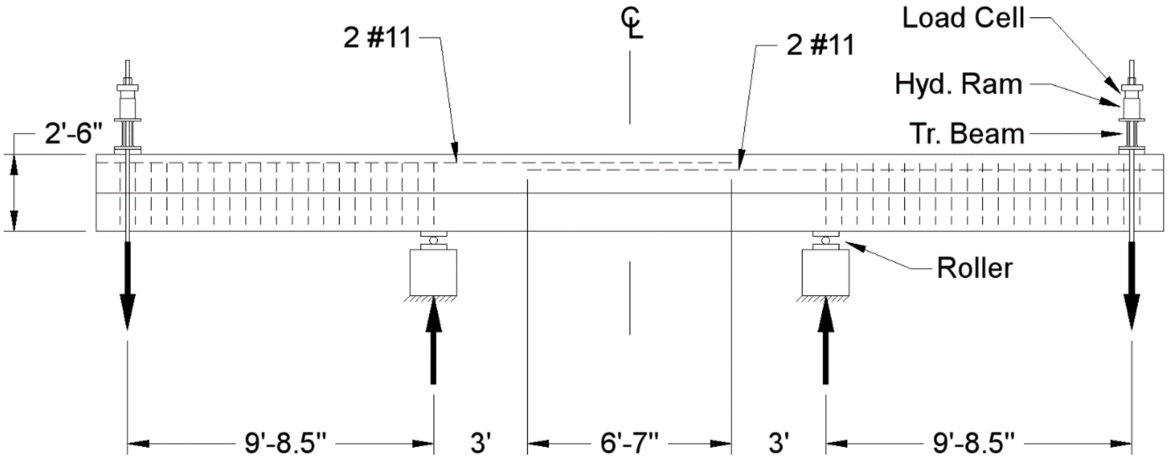
Table 5 Summary of Results

Test Girder Designation	Concrete Compressive Strength (psi)	Concrete Splitting Strength (Tensile) (psi)	Maximum Applied Load (kip)	Maximum Midspan Deflection (in.)	Maximum Moment at Support (kip-ft)	Maximum Moment at Splice End (kip-ft)	Calc. Reinf. Stress at Support (ksi)	Calc. Reinf. Stress at Splice End (ksi)
C1	5300	500	39.7	0.70	427	419	74	73
C2	5200	450	40.0	0.85	430	422	75	74
C3	5900	500	40.4	0.79	434	426	76	74
C4	5700	500	40.9	0.83	439	431	76	75
C5	5600	500	40.2	0.82	432	424	75	74
C6	5300	400	40.7	0.92	437	429	76	75

Table 6 Summary of Laminar Crack Widths and Lengths

Test Girder Designation	From Optotrak				From Crack Maps	
	Max. Mid-span Deflection at Initial Loading (in.)	Max. Crack Width at Initial Loading (10^-3 in)	Mid-span Deflection at last reading during reload (in.)	Max. Crack Width at last reading during reload (10^-3 in)	Maximum Crack Length at South Splice End (in.)	Maximum Crack Length at North Splice End (in.)
C1	0.42	42	0.70	90	27	23
C2	0.40	21	0.41	25	22	27
C3	0.41	39	0.41	42	23	11
C4	0.52	52	0.50	53	28	24
C5	0.43	54	0.42	57	24	18
C6	0.52	30	0.52	33	22	0

FIGURES



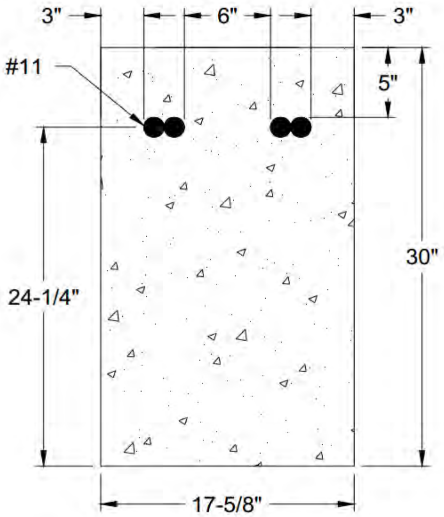


Figure 1 Test Girder Profile and Cross-Sectional Dimensions

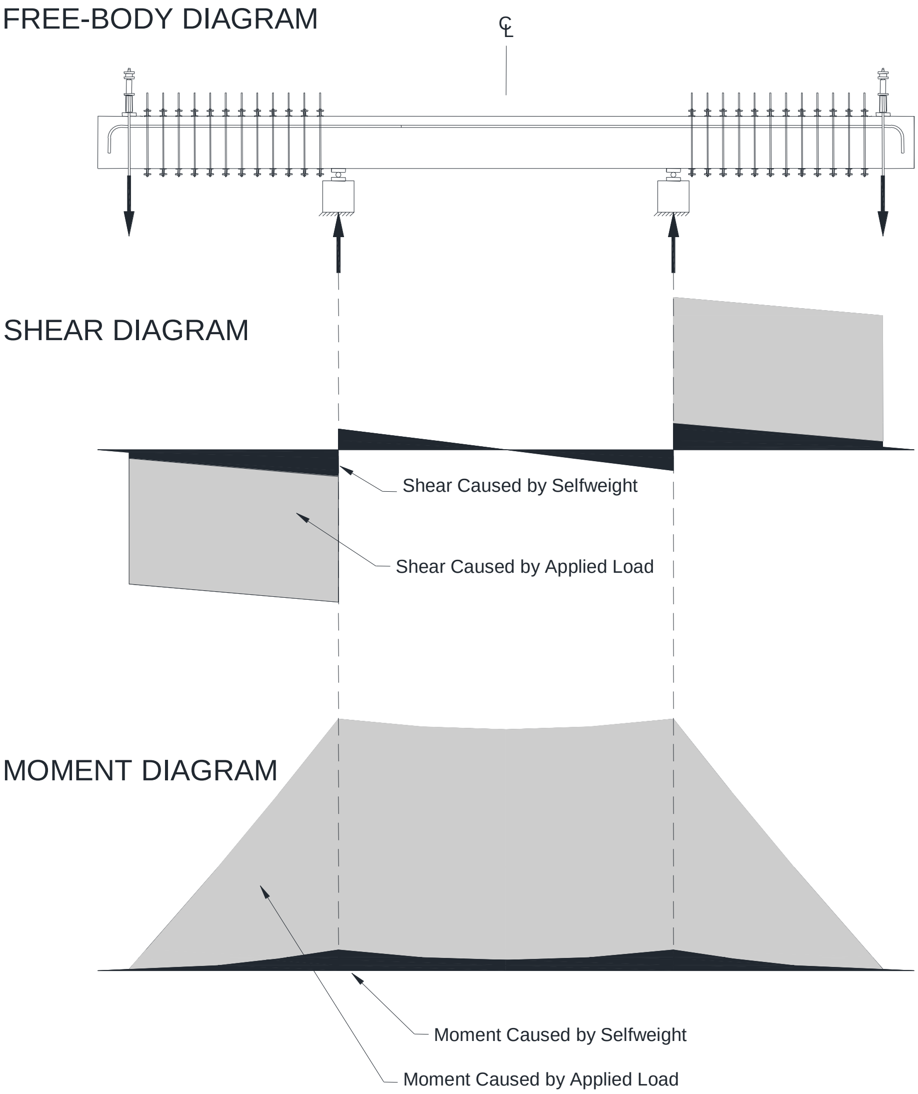


Figure 2 Moment and Shear Diagrams

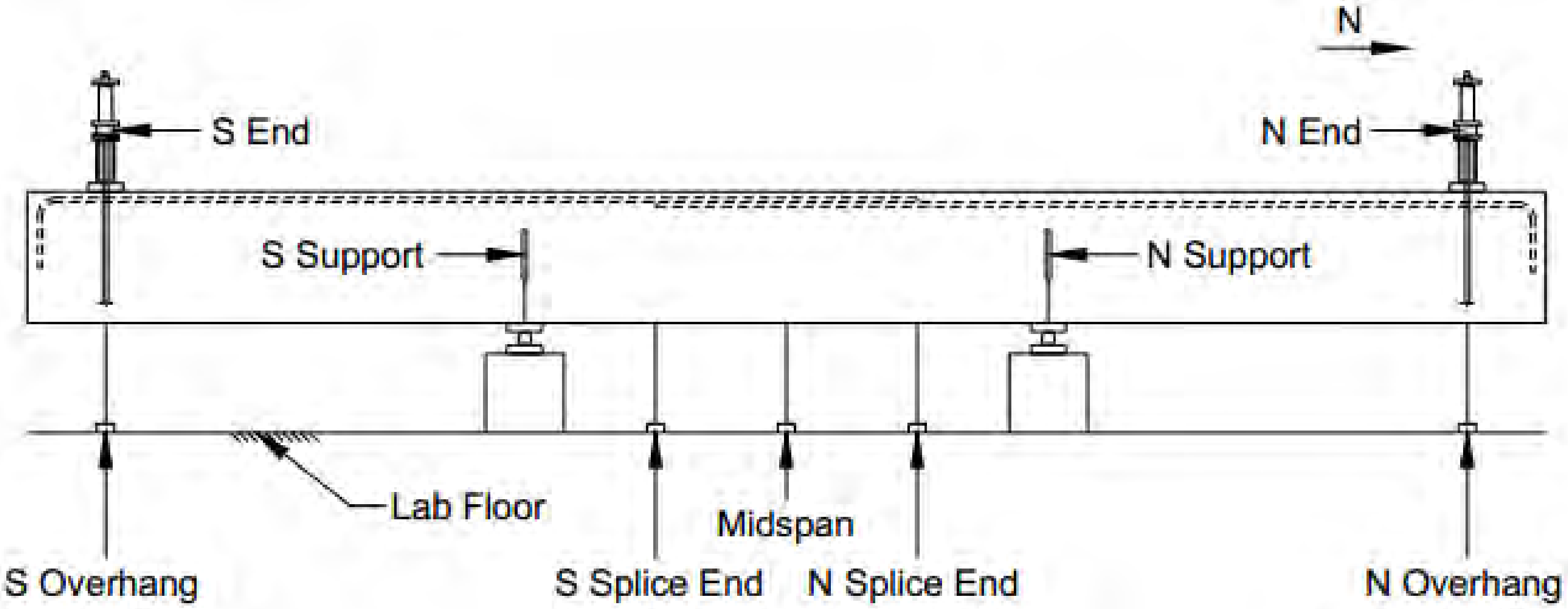


Figure 3: Locations of Deflection Measurements

- String Potentiometers were used to measure displacement at N Overhang, N Splice End, Midspan, S Splice End and S Overhang
- Displacement measurements were checked using dial gages at N Overhang, Midspan and S Overhang
- Linear Variable Differential Transformers (LVDTs) were used to measure displacement at N Support and S Support

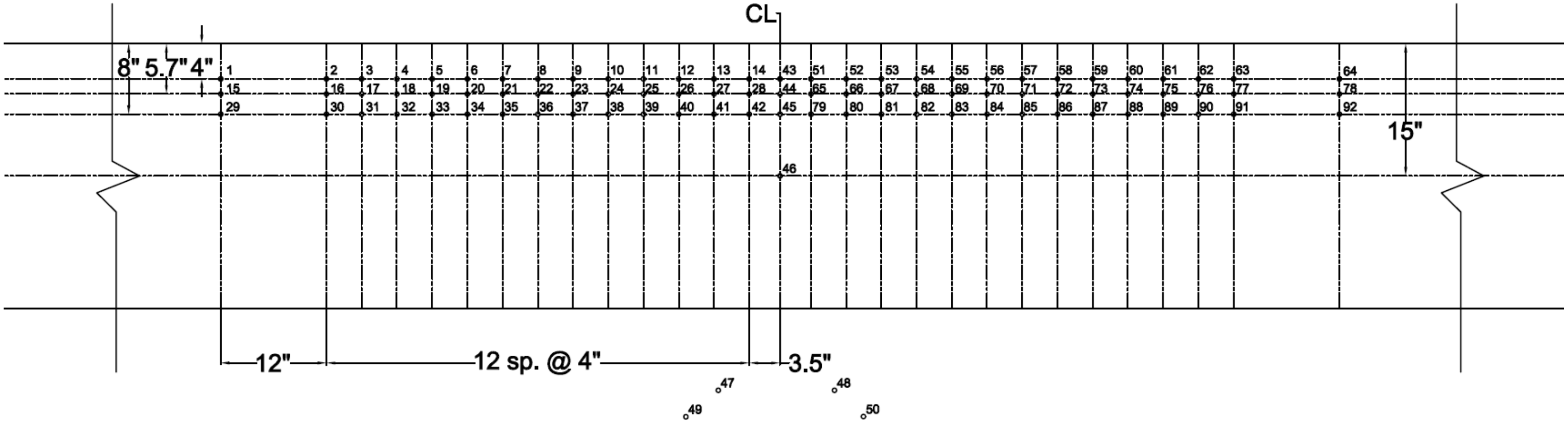


Figure 4 Arrangement of Optotrak Targets

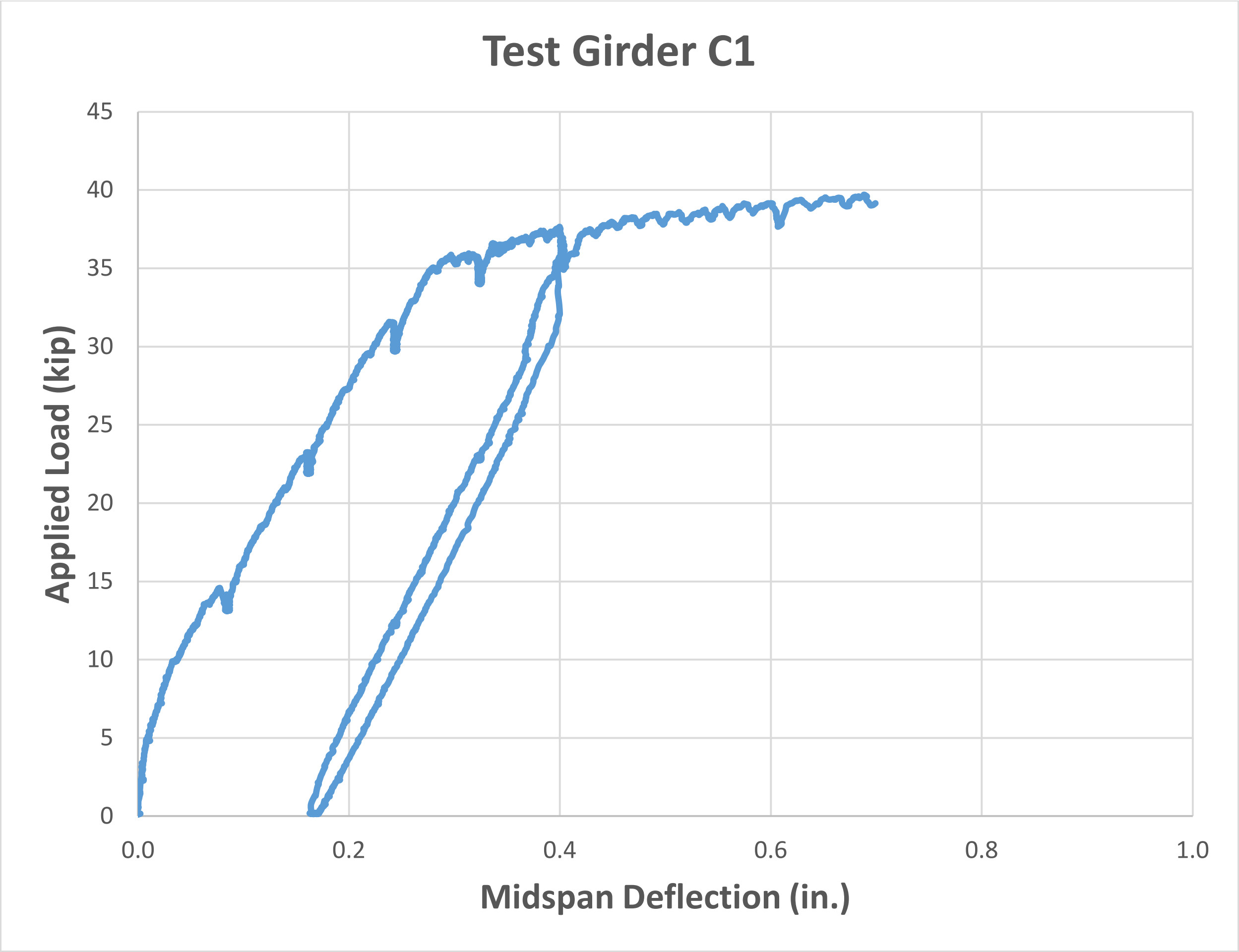


Figure 5 Load-Deflection Plot, C1

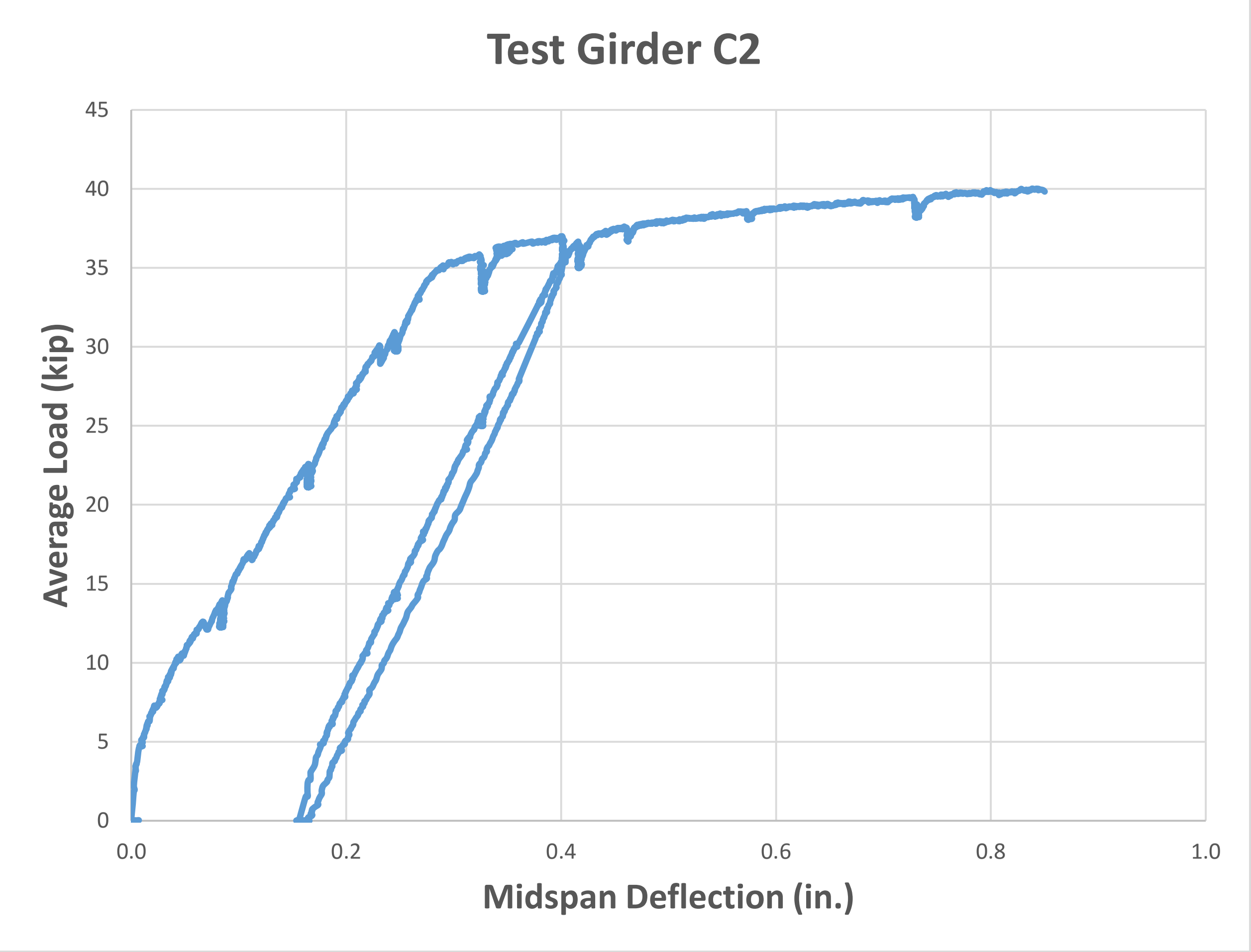


Figure 6 Load-Deflection Plot, C2

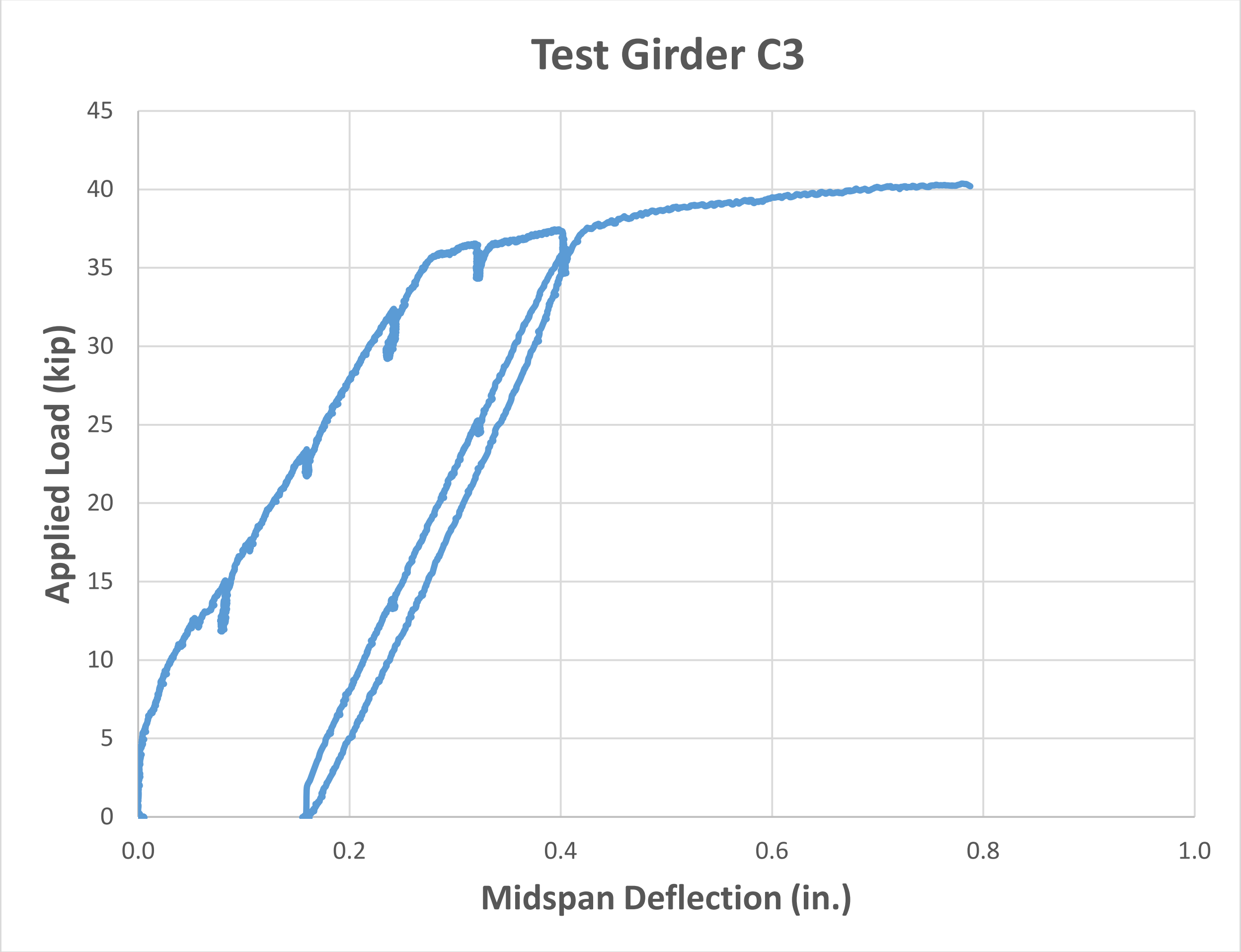


Figure 7 Load-Deflection Plot, C3

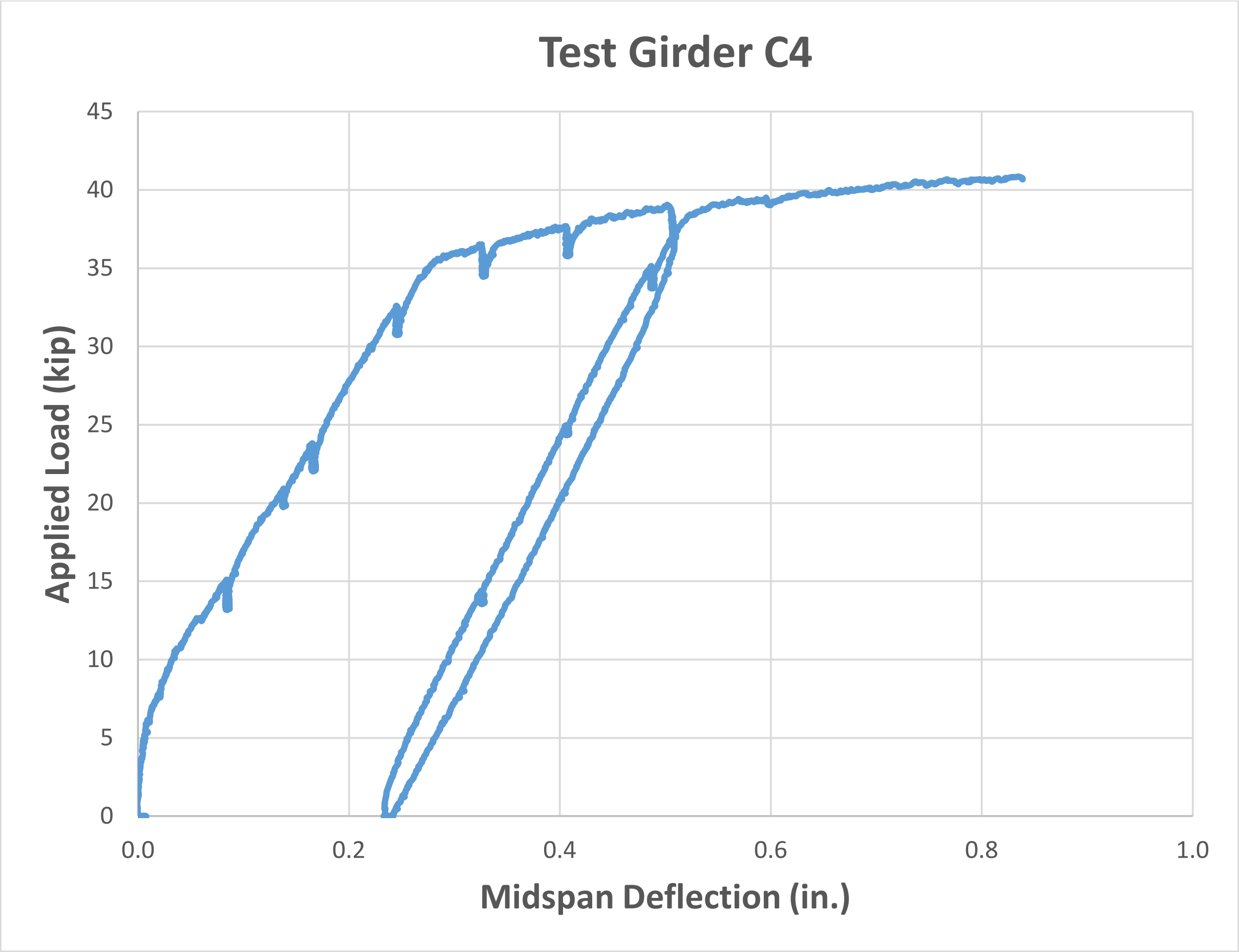


Figure 8 Load-Deflection Plot, C4

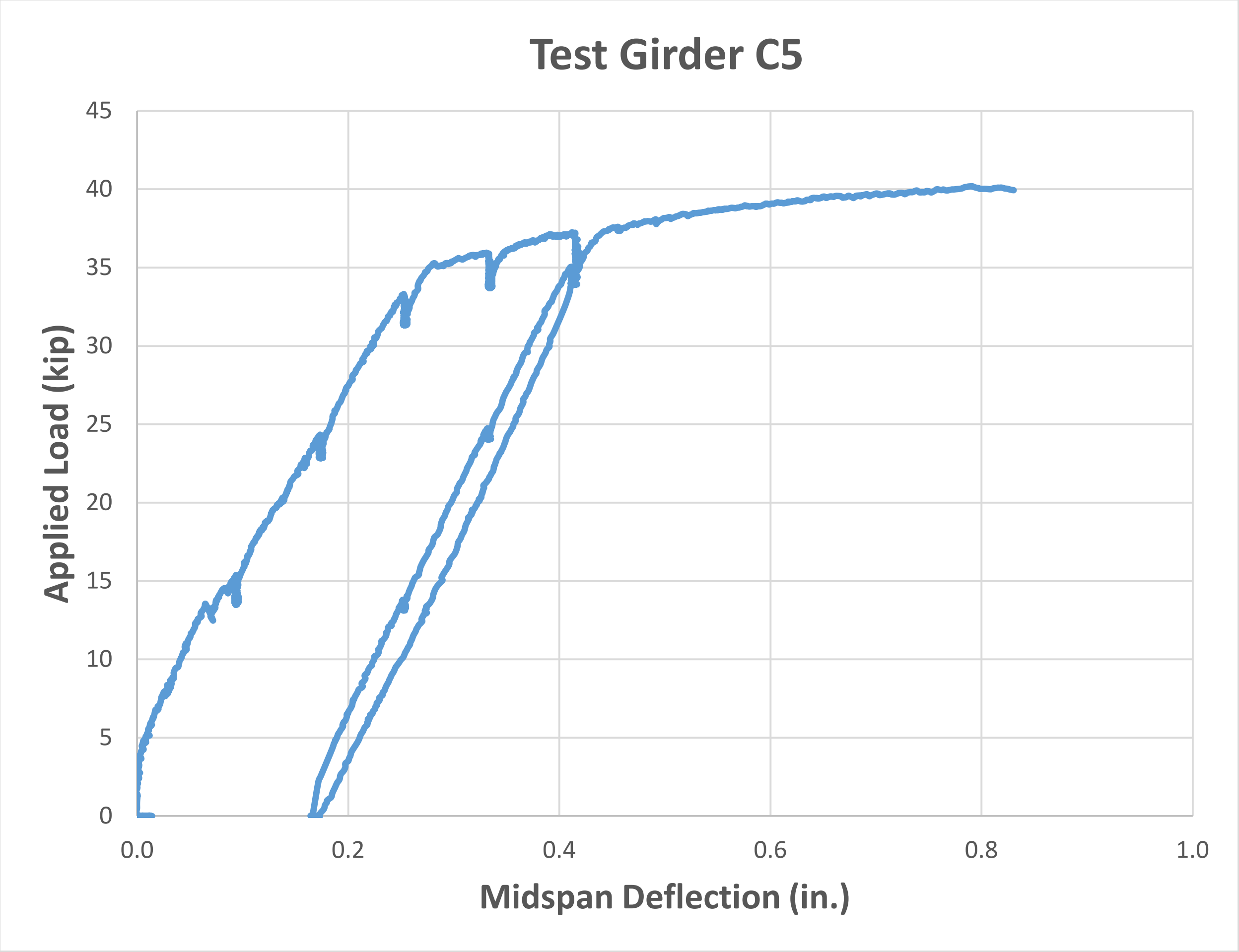


Figure 9 Load-Deflection Plot, C5

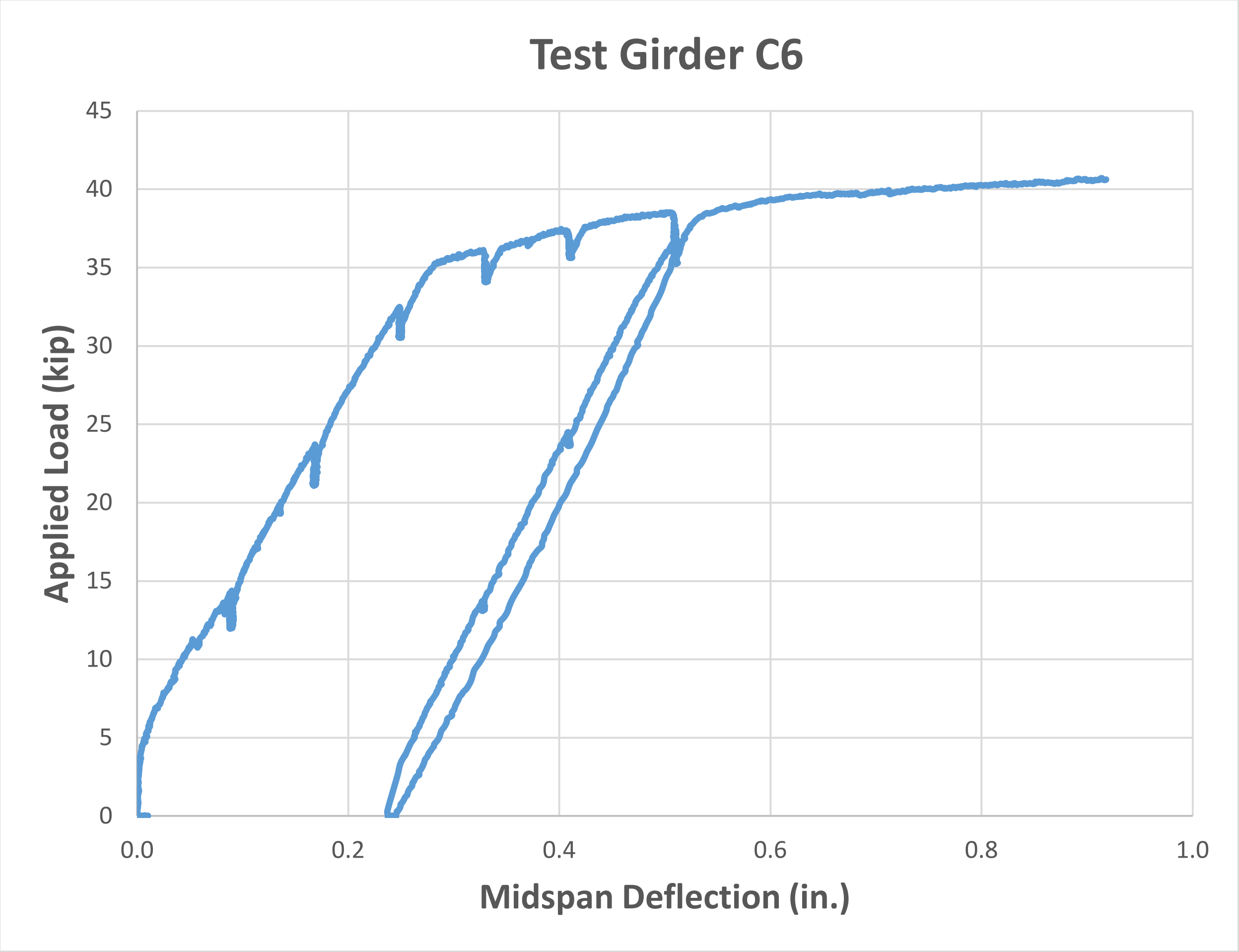


Figure 10 Load-Deflection Plot, C6

Figure 11 Photo C1

Figure 12 Photo C2

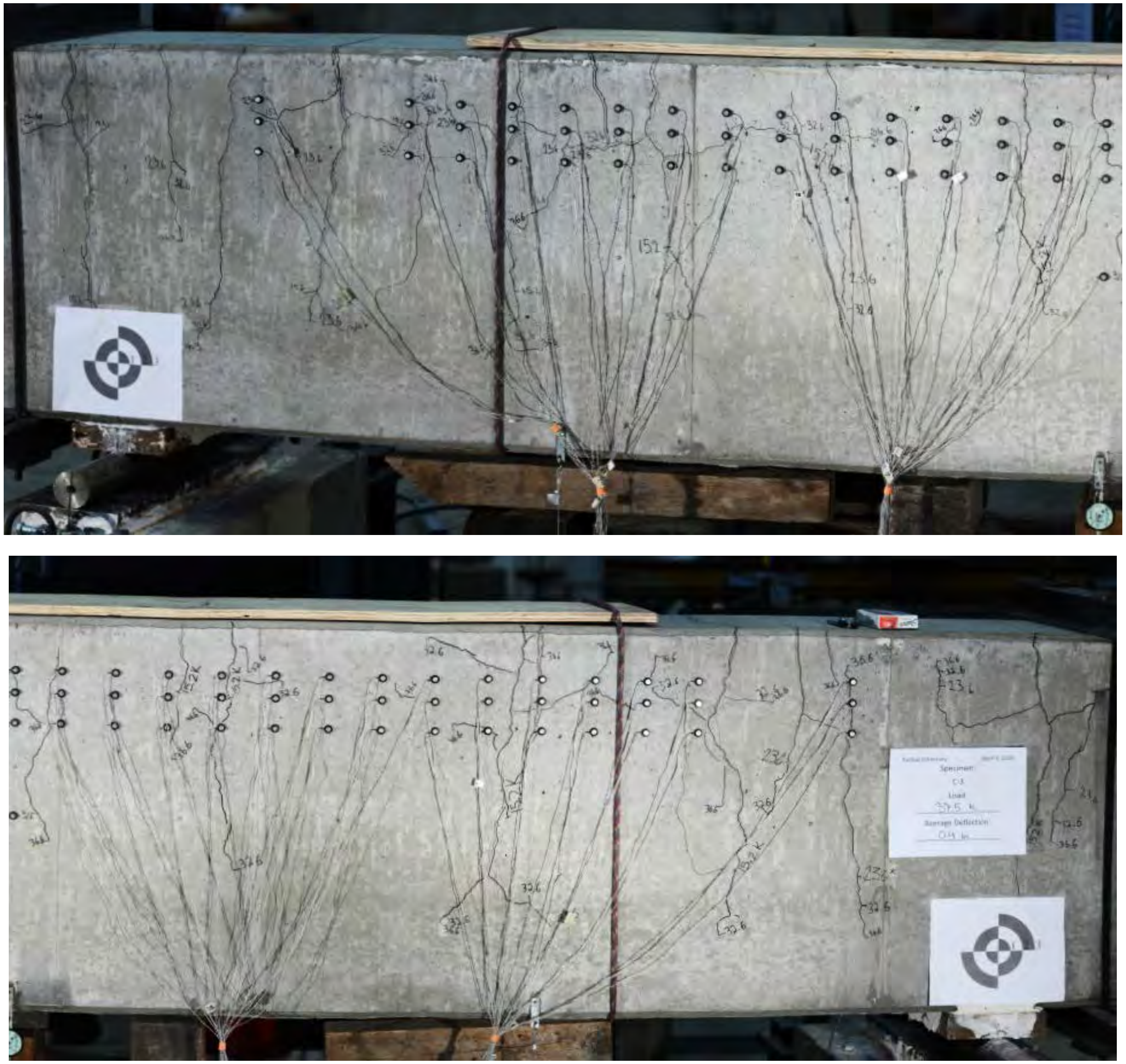


Figure 13 Photo C3

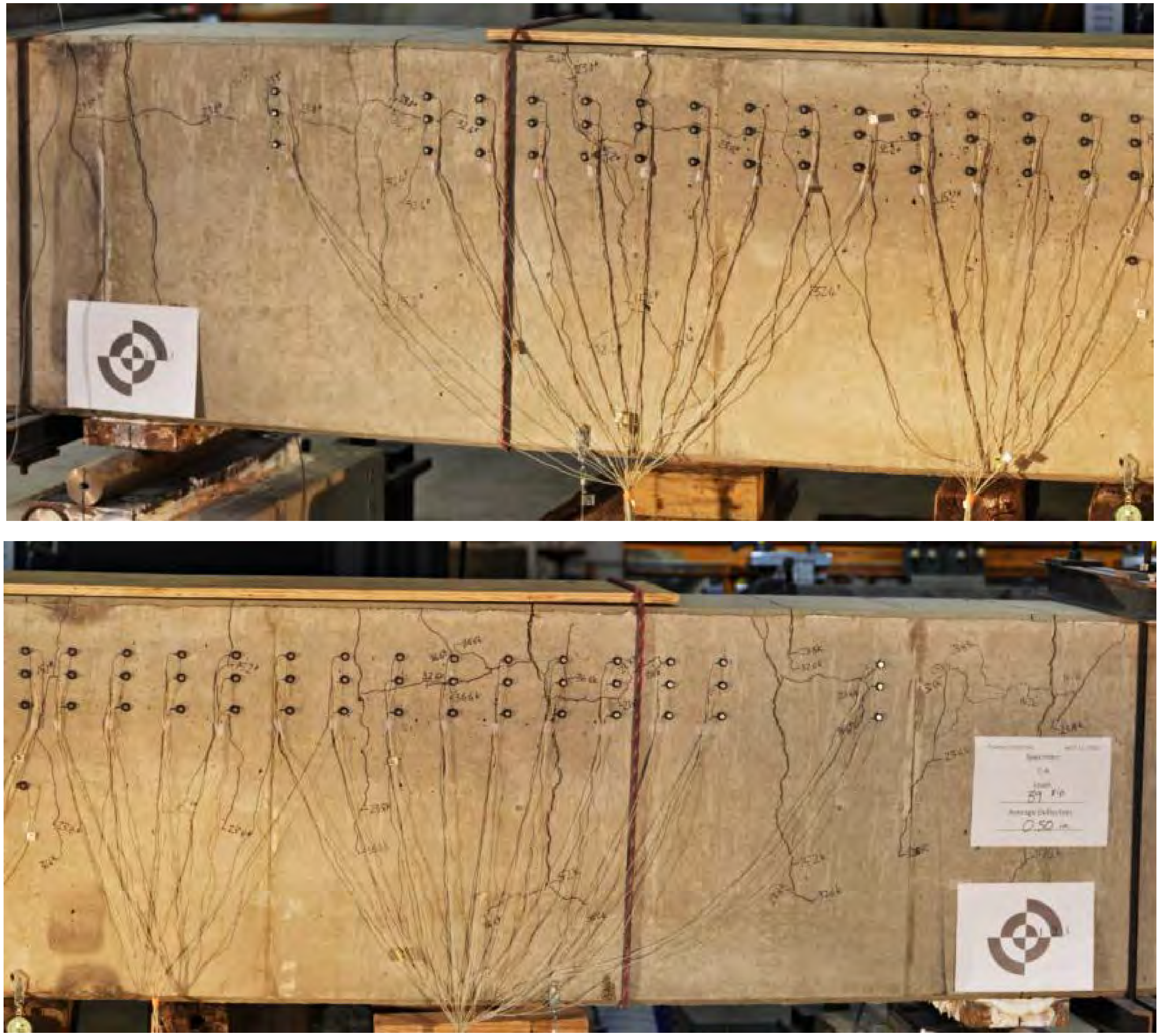


Figure 14 Photo C4

Figure 15 Photo C5

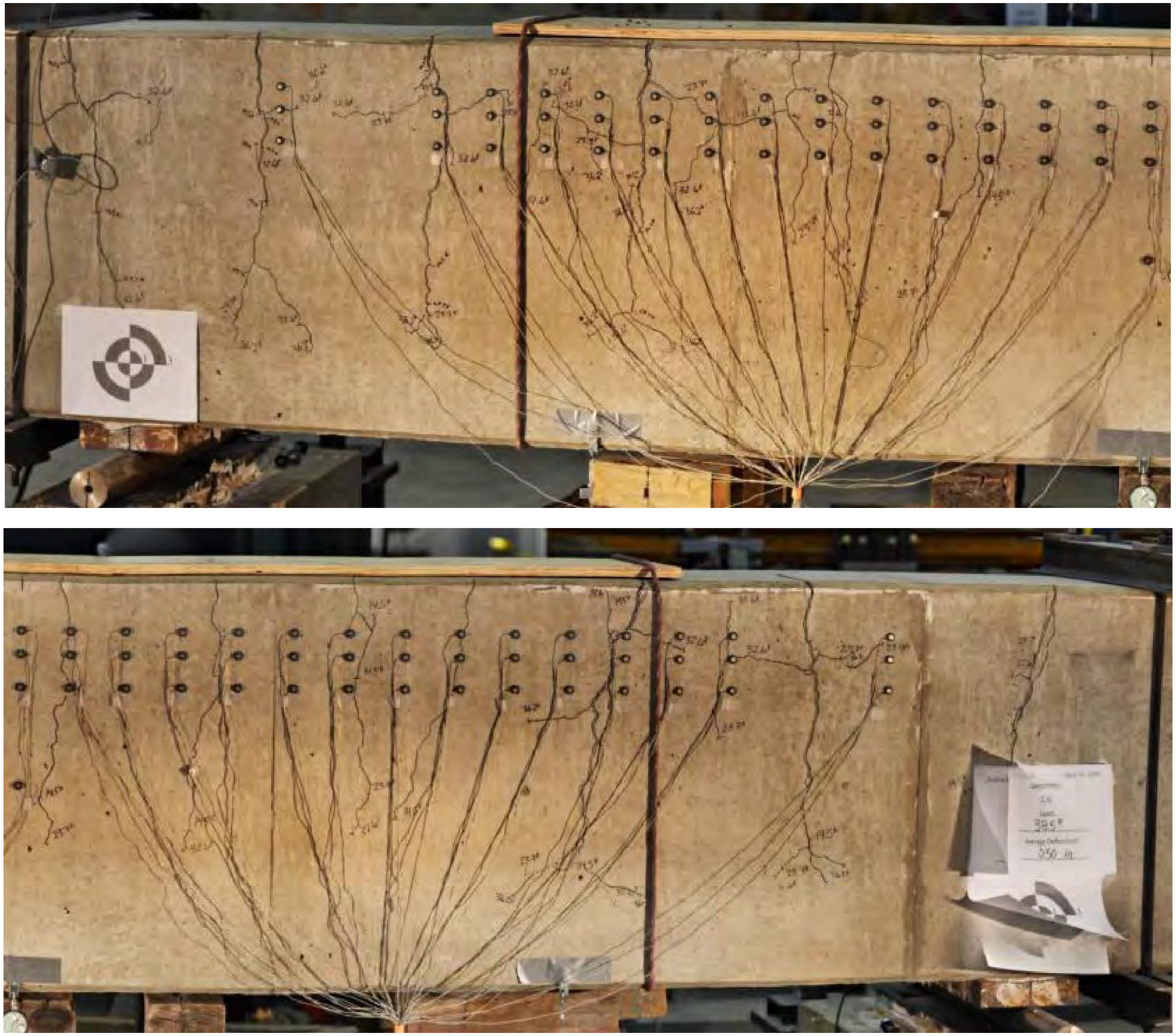
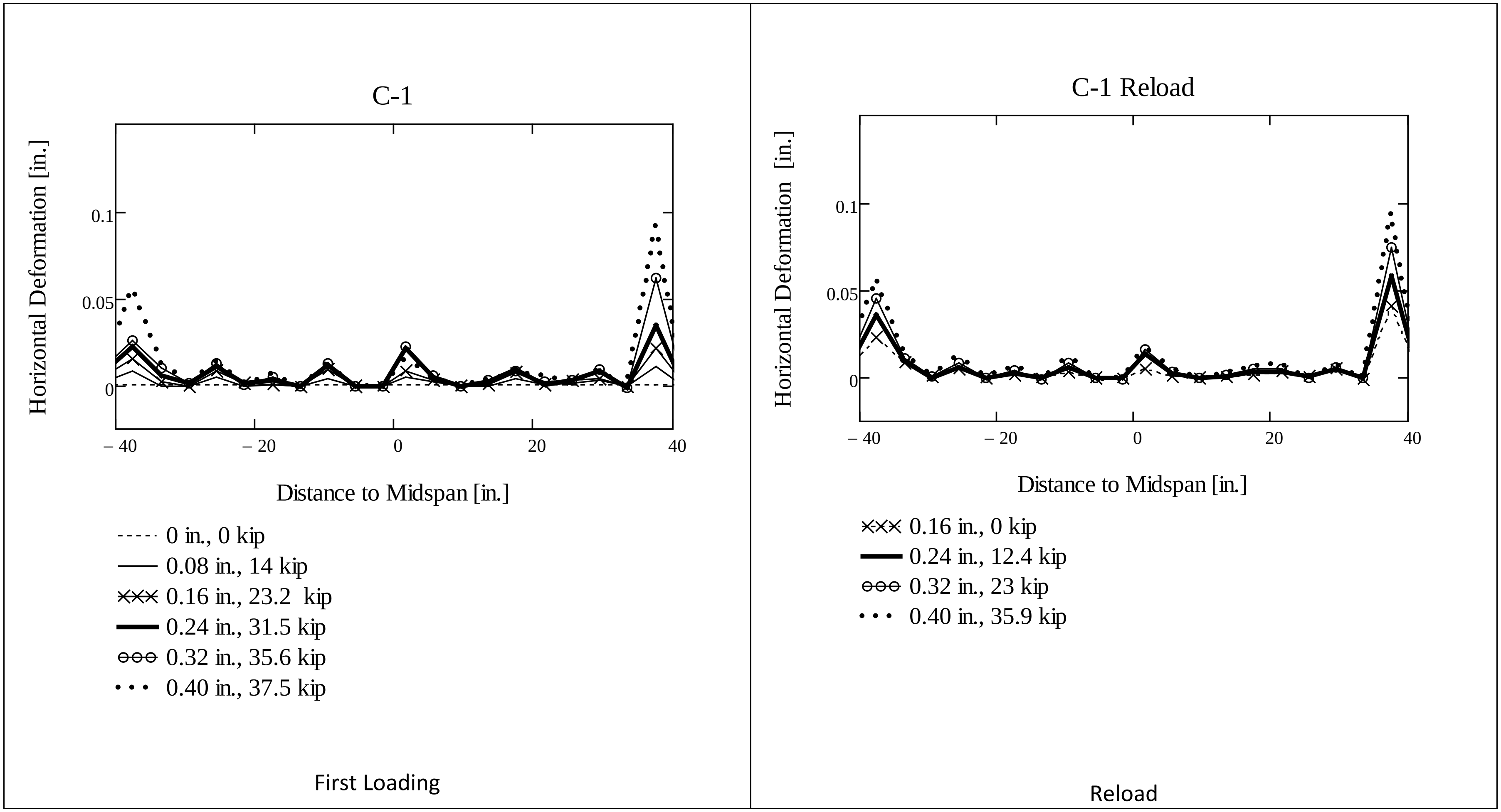


Figure 16 Photo C6



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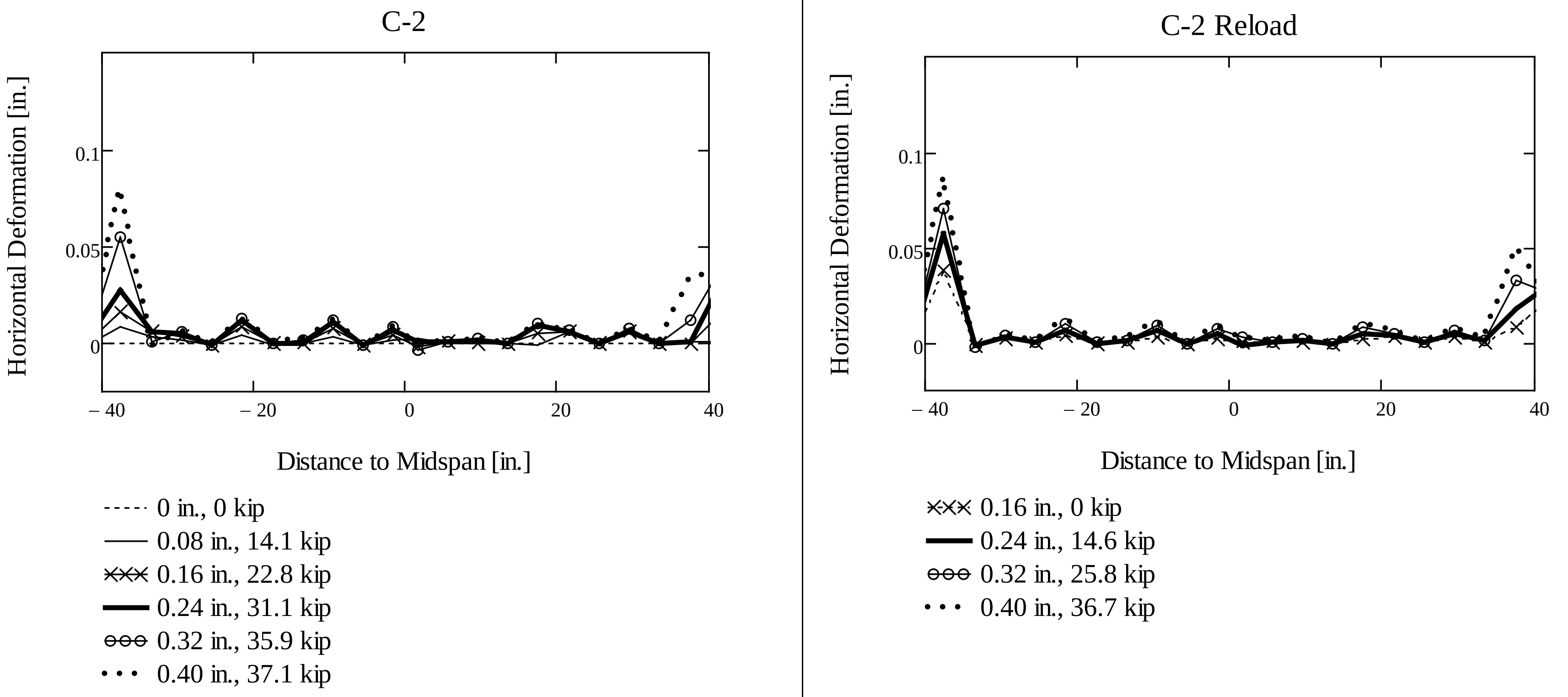
Reload

Figure 17 Horizontal Deformations, Load and Reload, C1

Note: Data series are labeled using midspan deflection and average load applied at ends



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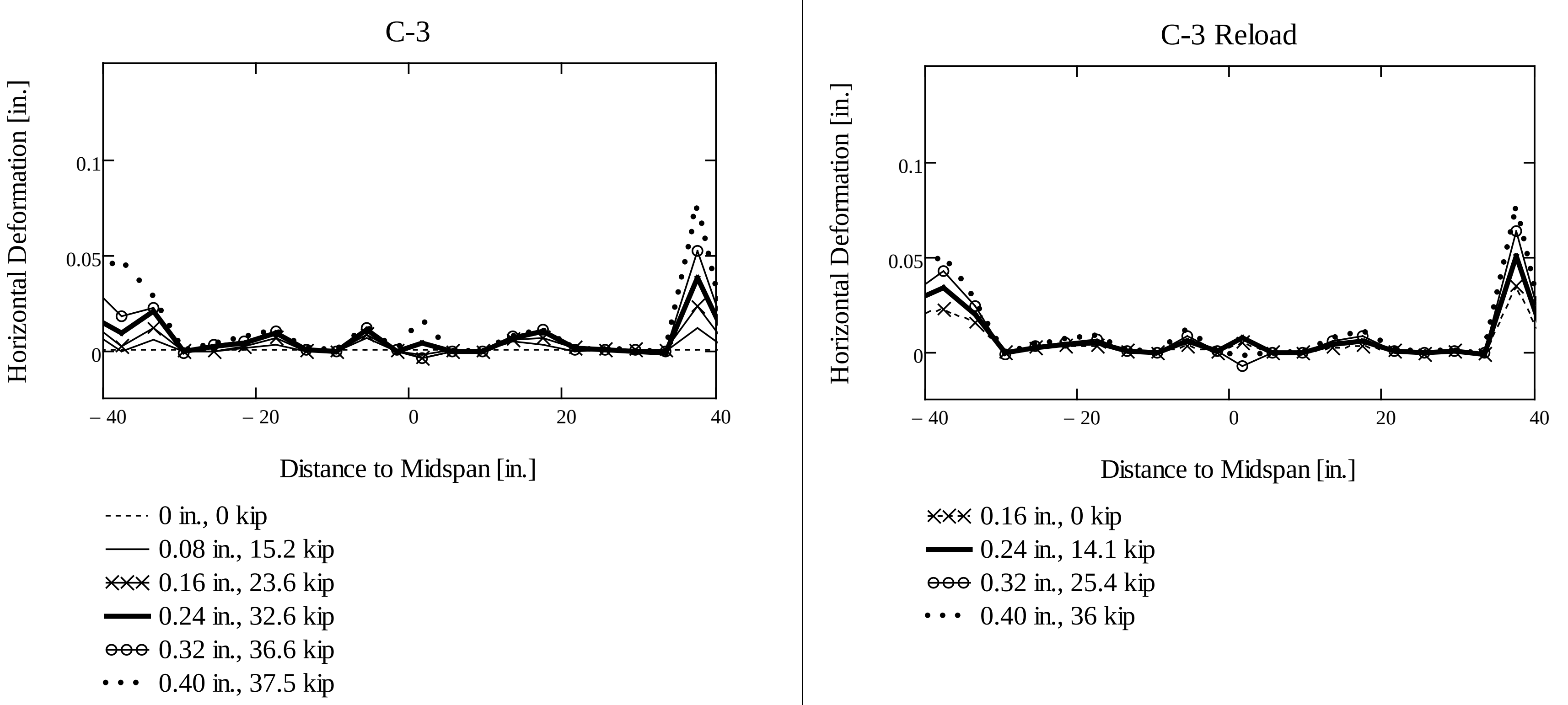
Reload

Figure 18 Horizontal Deformations, Load and Reload, C2

Note: Data series are labeled using midspan deflection and average load applied at ends



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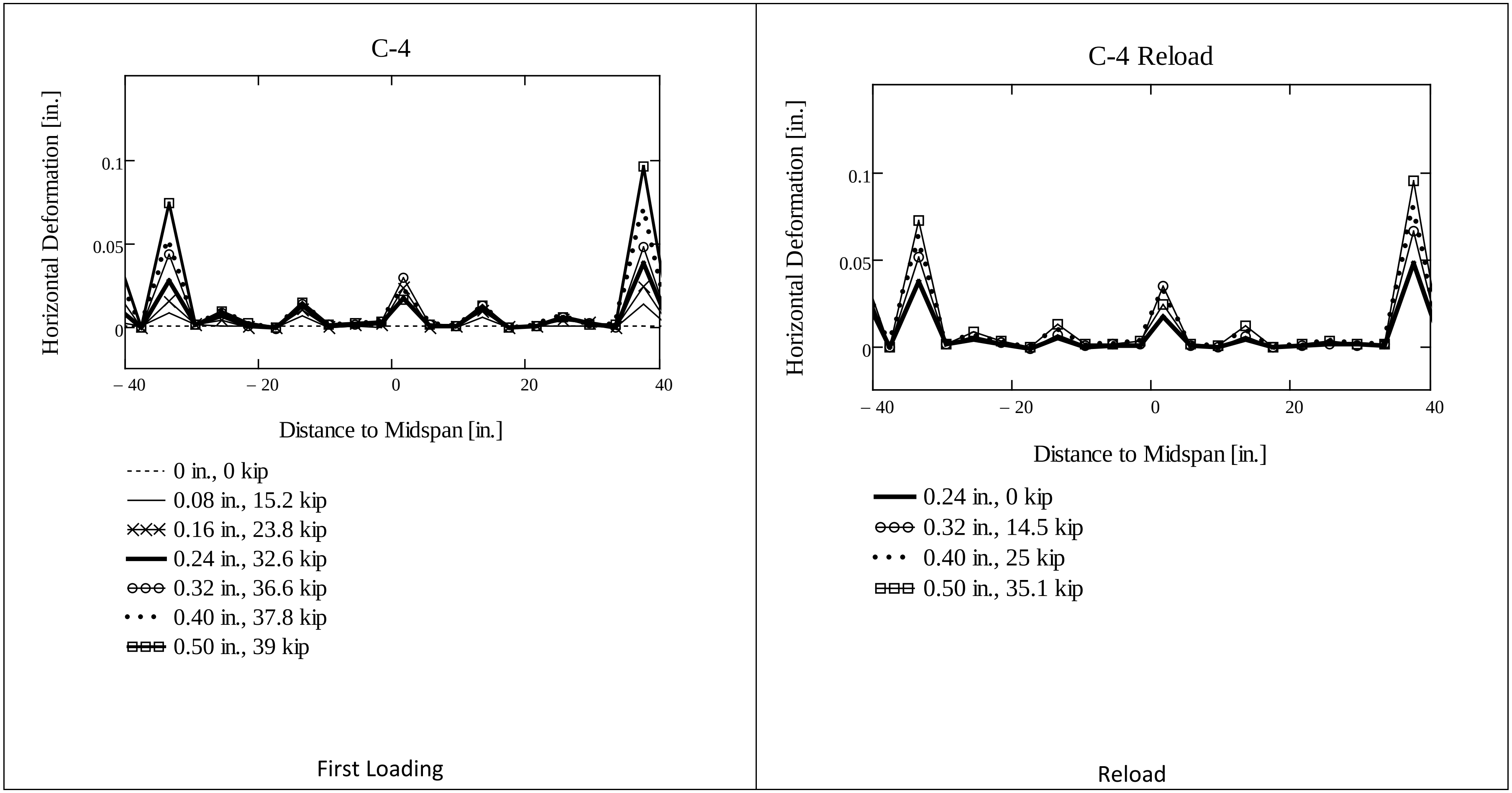
Reload

Figure 19 Horizontal Deformations, Load and Reload, C3

Note: Data series are labeled using midspan deflection and average load applied at ends



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Reload

Figure 20 Horizontal Deformations, Load and Reload, C4

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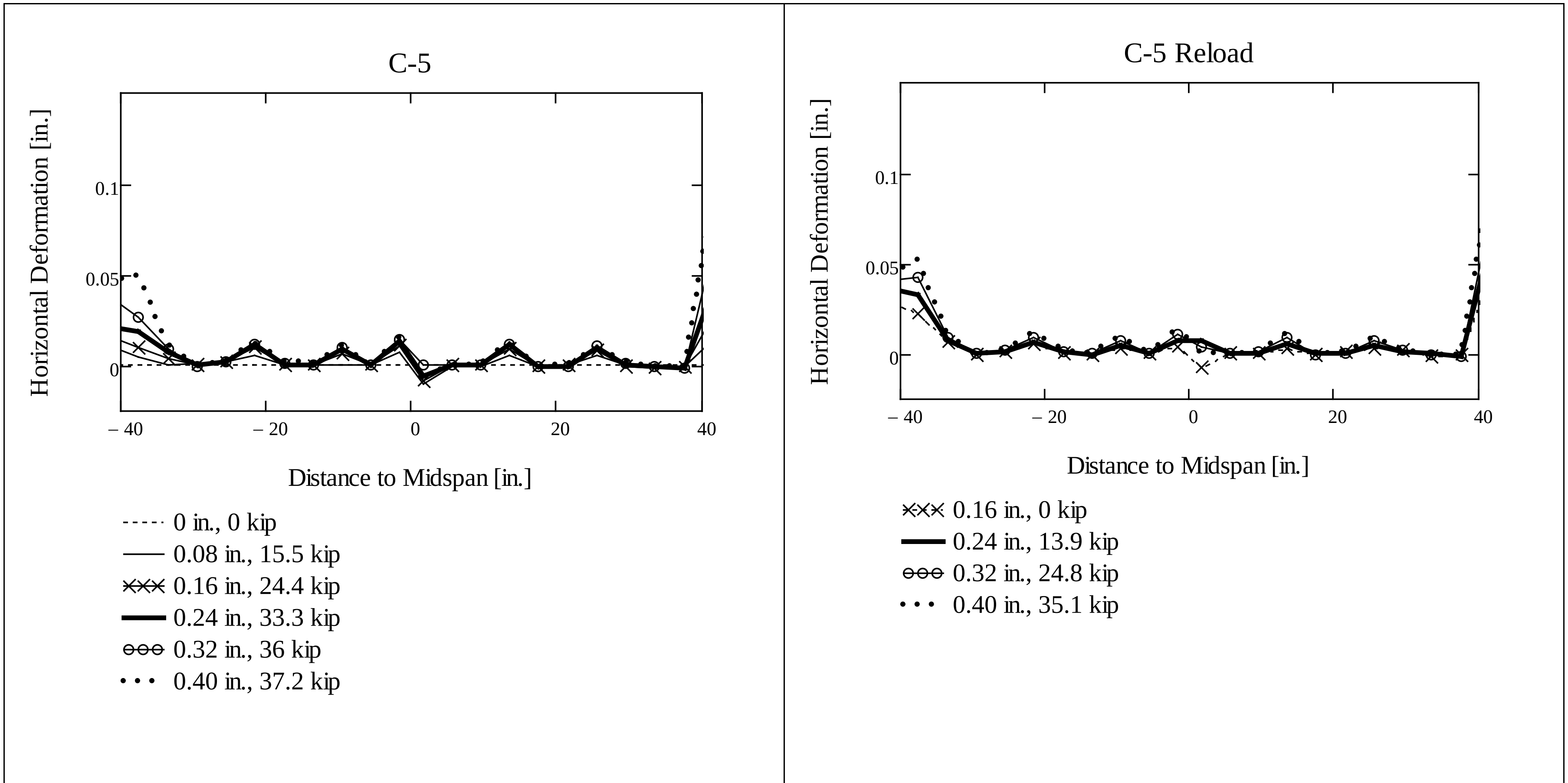

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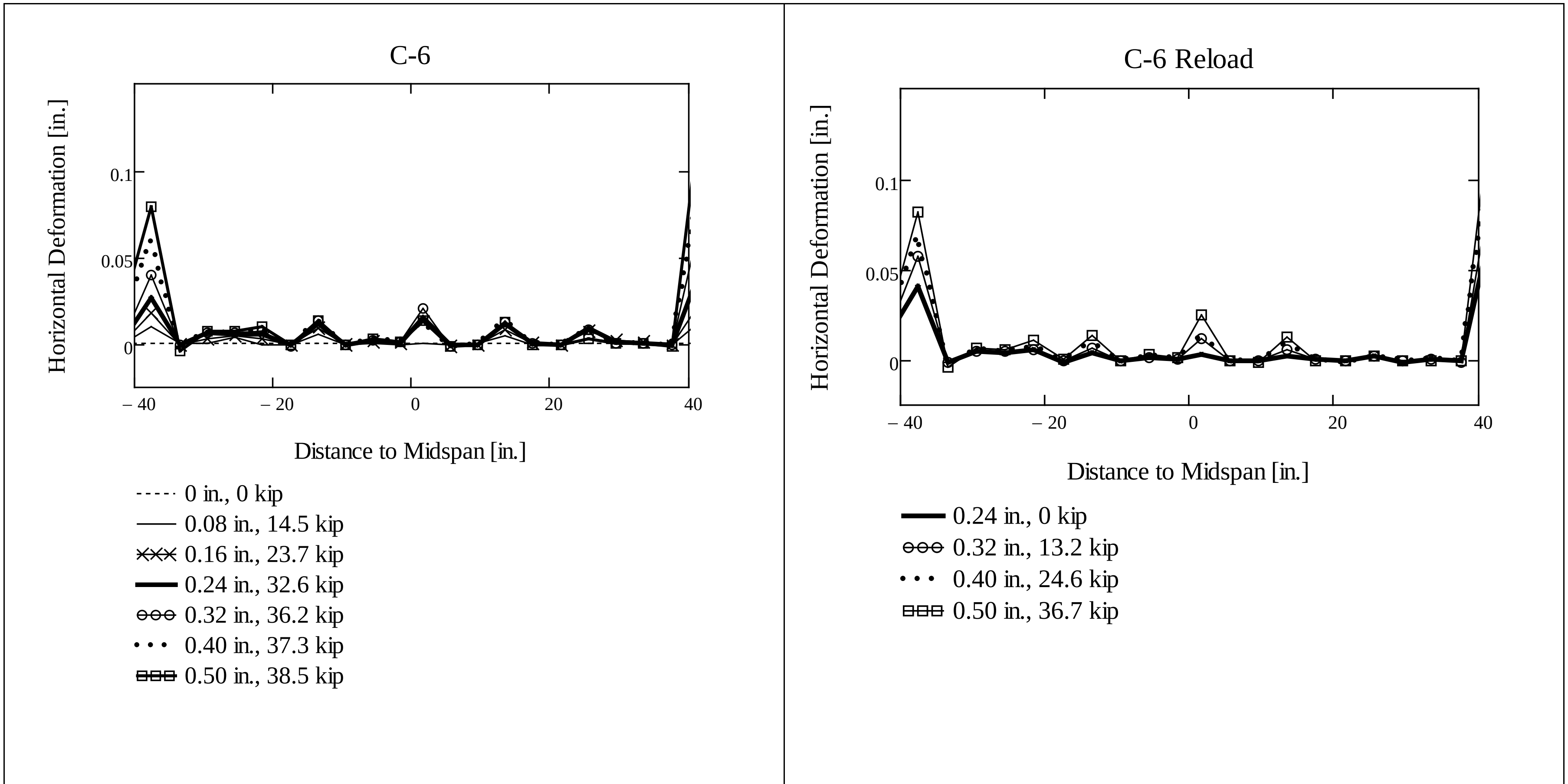
Reload

Figure 21 Horizontal Deformations, Load and Reload, C5

Note: Data series are labeled using midspan deflection and average load applied at ends



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Reload

Figure 22 Horizontal Deformations, Load and Reload, C6

Note: Data series are labeled using midspan deflection and average load applied at ends

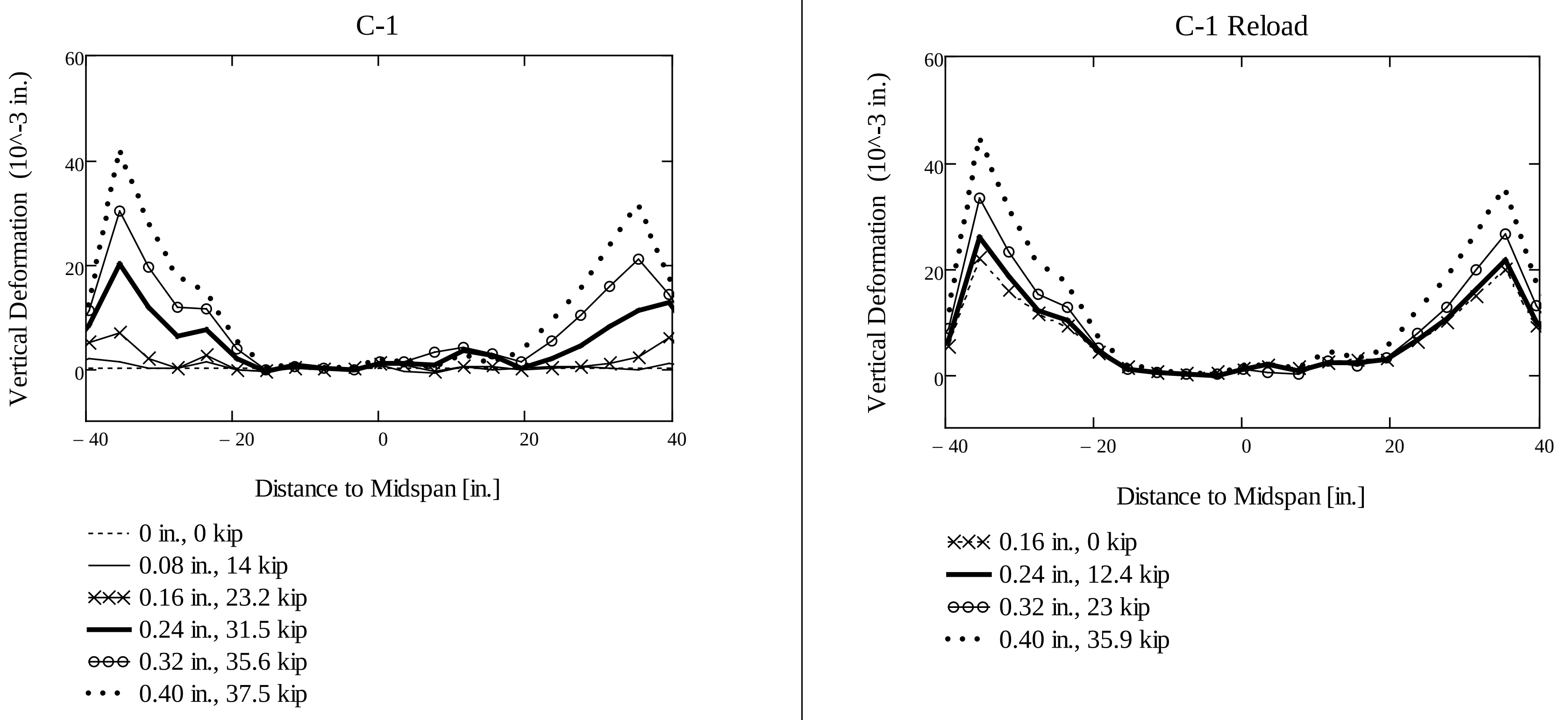

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Figure 23 Vertical Deformations, Load and Reload, C1

Note: Data series are labeled using midspan deflection and average load applied at ends

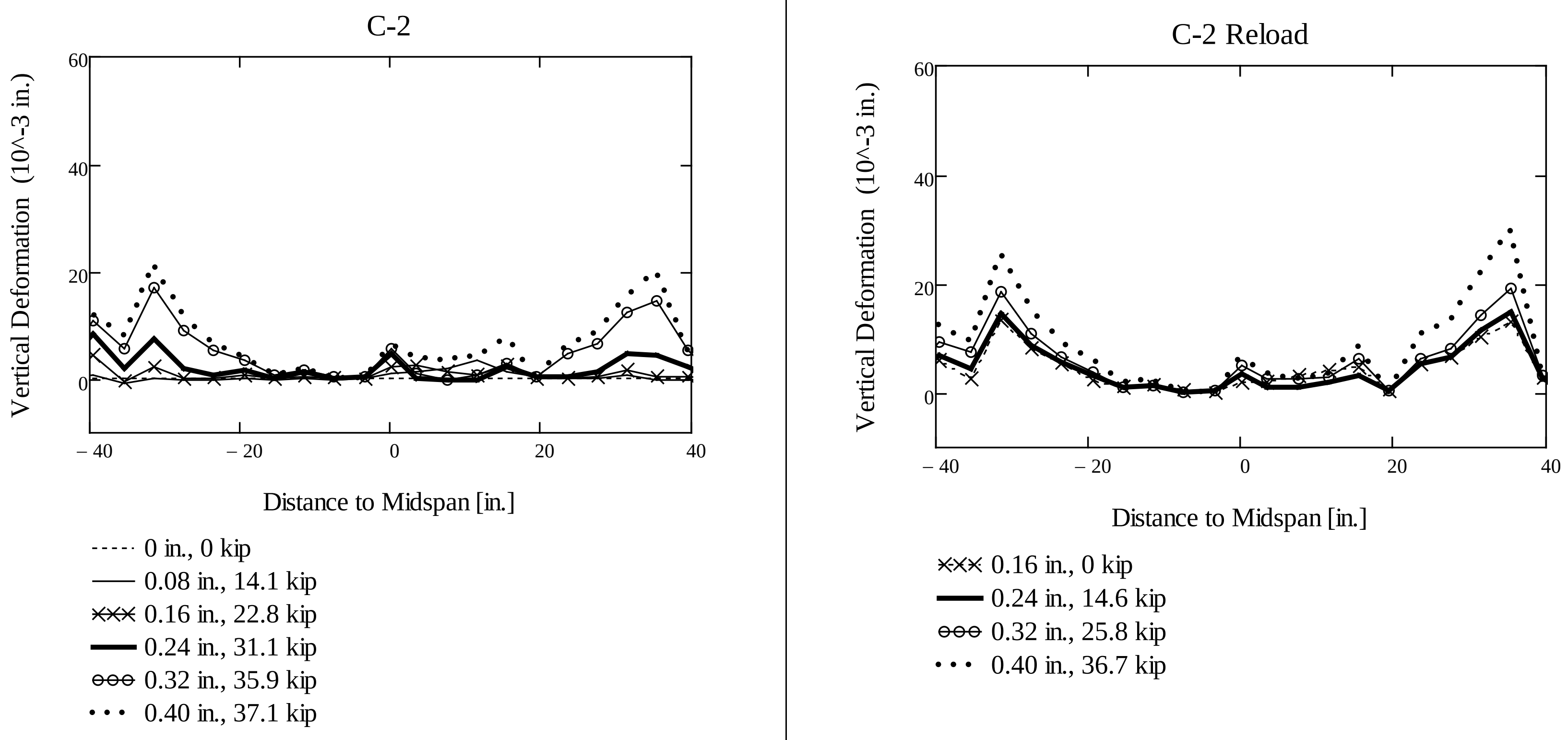

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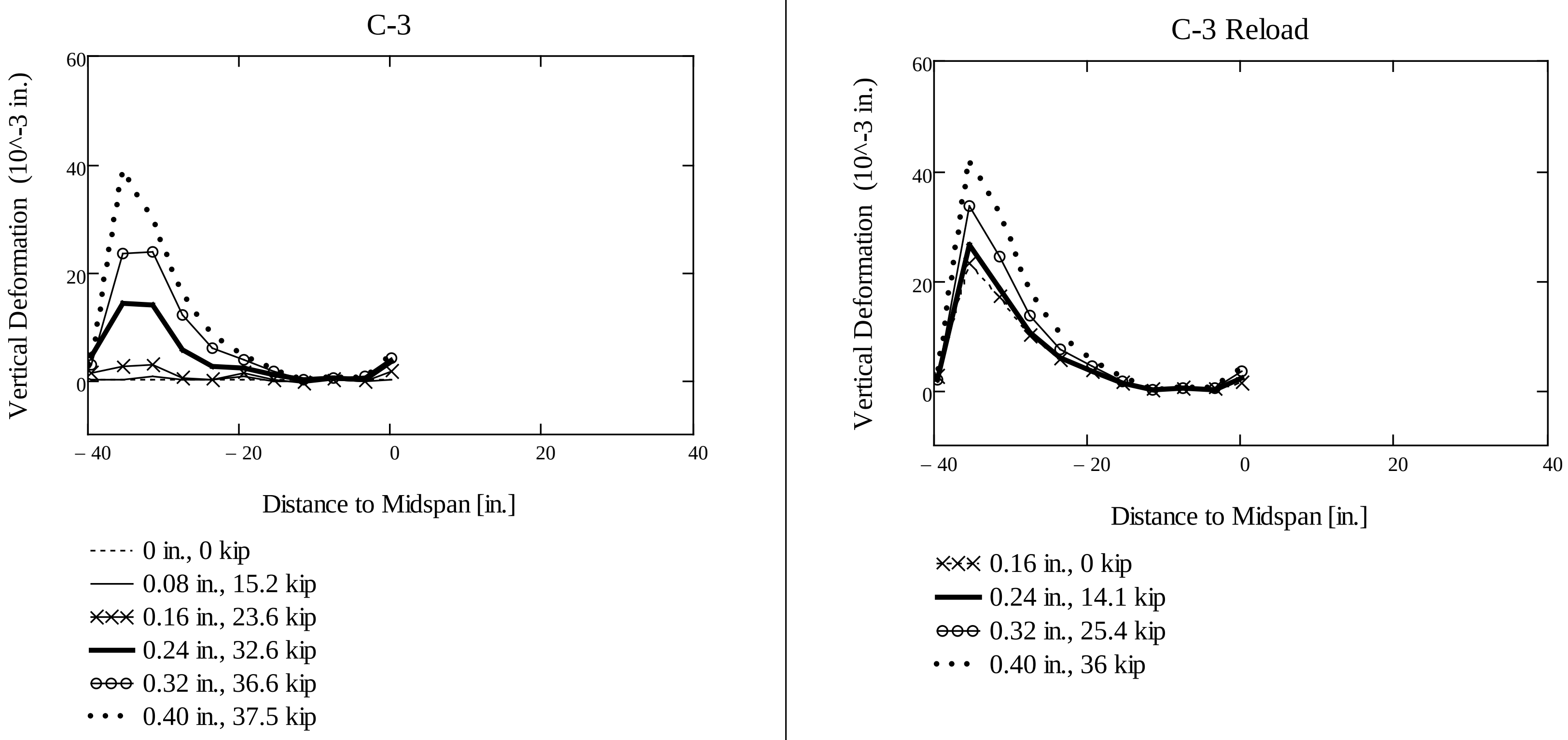
Figure 24 Vertical Deformations, Load and Reload, C2

Note: Data series are labeled using midspan deflection and average load applied at ends



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Reload

Figure 25 Vertical Deformations, Load and Reload, C3

Note: Data series are labeled using midspan deflection and average load applied at ends

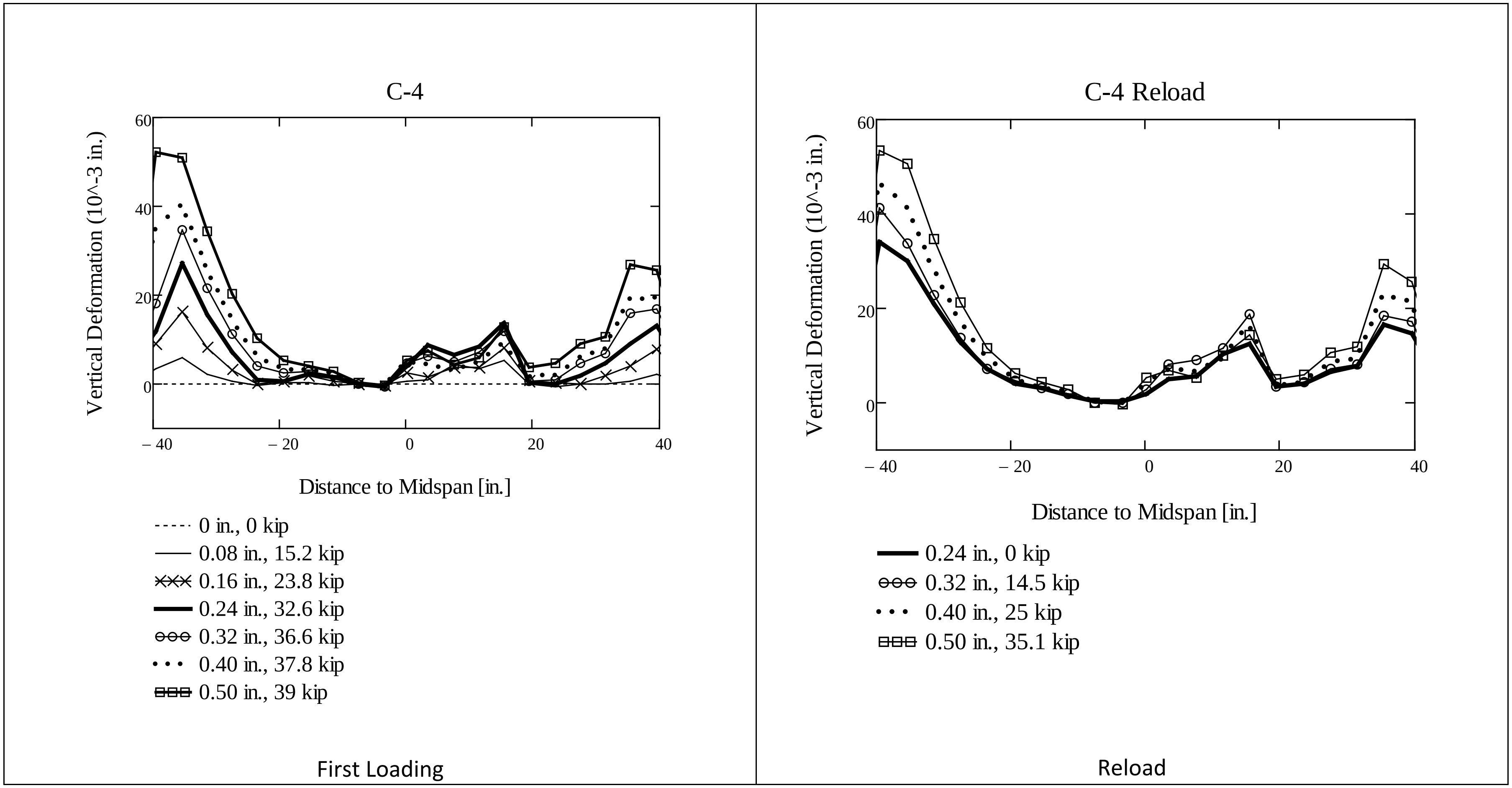

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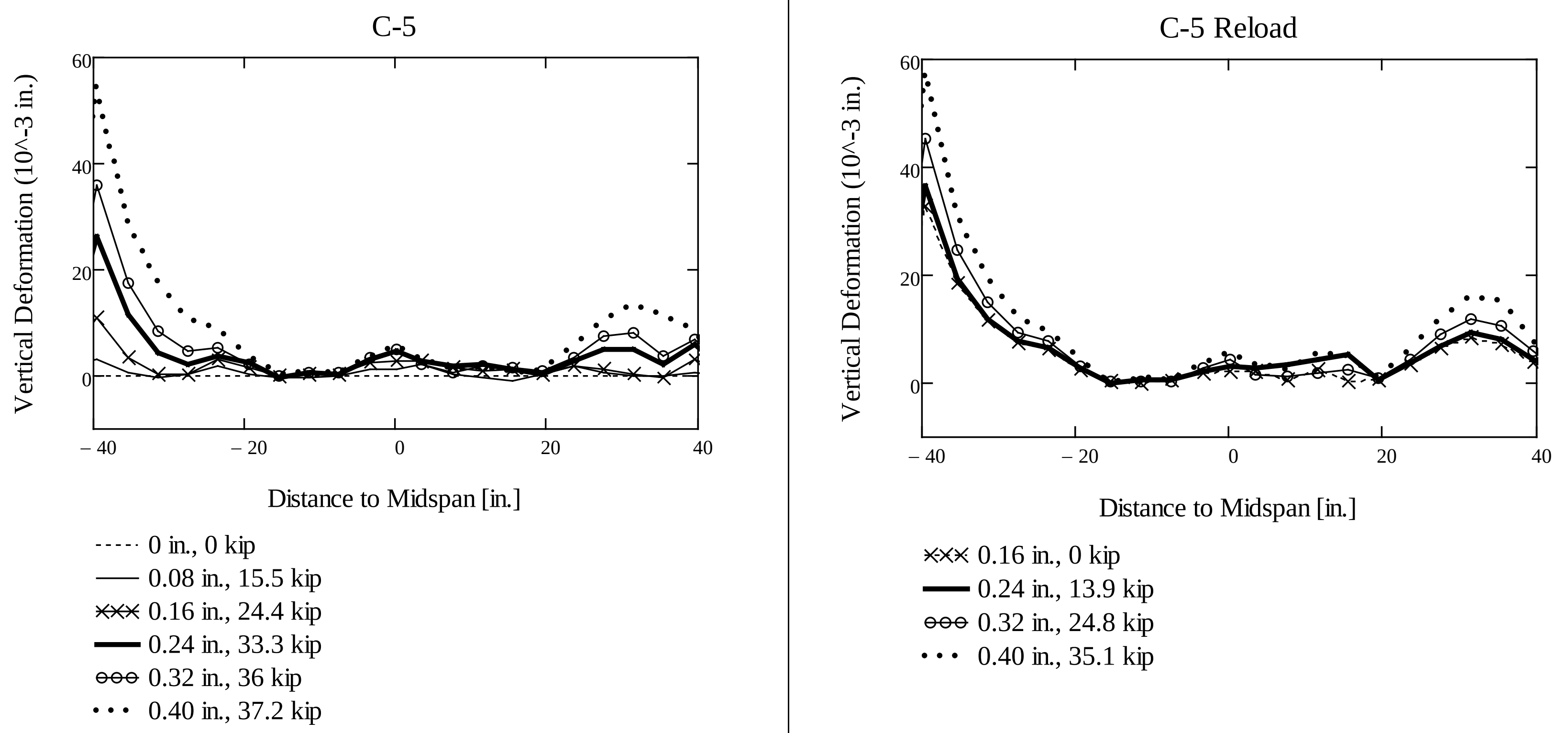
Figure 26 Vertical Deformations, Load and Reload, C4

Note: Data series are labeled using midspan deflection and average load applied at ends



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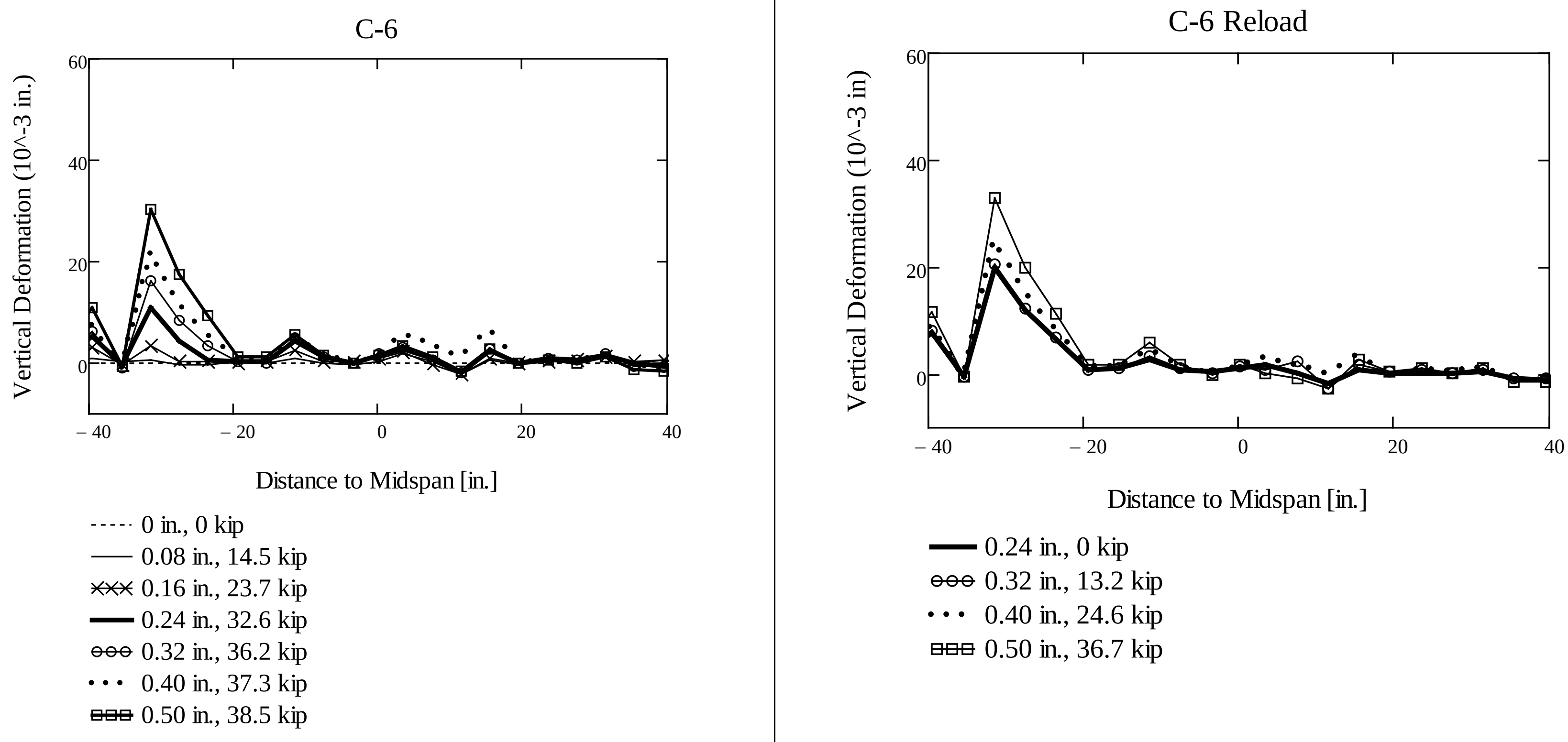
Reload

Figure 27 Vertical Deformations, Load and Reload, C5

Note: Data series are labeled using midspan deflection and average load applied at ends



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Reload

Figure 28 Vertical Deformations, Load and Reload, C6

Note: Data series are labeled using midspan deflection and average load applied at ends

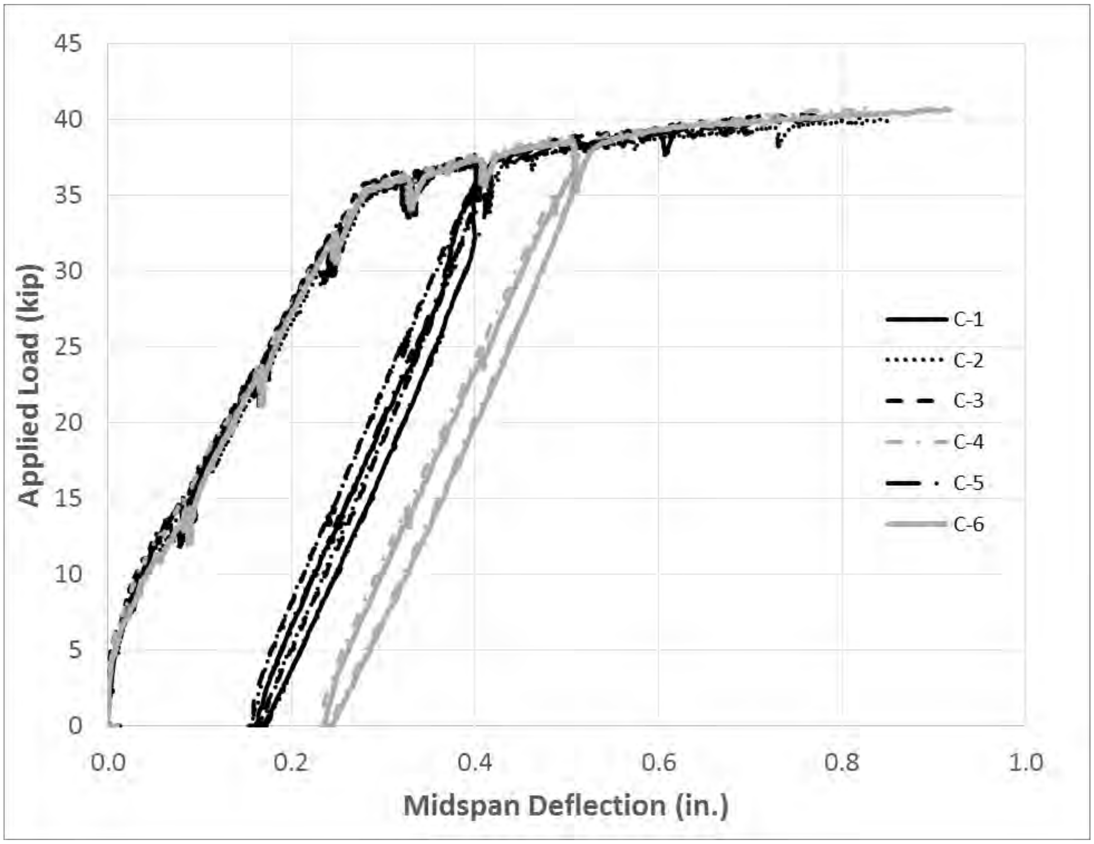


Figure 29 Comparison of Load-Deflection Relationships

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Cylinder Compression Tests Documentation v.2
(Rev. 04/01/2012)

Specimen: C1 test day

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
1	3/21/16	11:55	Dry	5.93	6.05	12.00	12.00	12.00	151,608	5
2	3/21/16	11:59	Dry	5.93	6.05	12.00	12.00	12.00	151,425	4
3	3/21/16	12:03	Dry	5.93	6.05	12.00	12.00	12.00	144,778	3
4	3/21/16	12:07	Dry	5.93	6.04	12.00	12.00	12.00	149,386	5
5	3/21/16	12:12	Dry	5.93	6.02	12.00	12.00	12.00	150,020	5
6	3/21/16	12:15	Dry	5.93	6.04	12.00	12.00	12.00	153,955	4

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		3/21/16	12:19
Checked by:	Signature	Date	Time
JASPAL S SAINI	JSSaini	03/21/16	12:19
Checked by:	Signature	Date	Time
S. PUJOL	S Pujol	3/22/16	9 AM.

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'$_c$) calculated on sheet 2 of 2.

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Cylinder Split Tensile Tests Documentation v.1
(Rev. 05/14/2012)

Specimen: C1 test day

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb$_f$]	Fracture Sketch
				end	middle	end	1	2		
1	3/21/16	9:51	Dry	5.93	6.05	6.06	12.00	12.01	59,765	
2	3/21/16	10:05	Dry	5.92	6.02	6.06	12.00	12.02	52,335	
3	3/21/16	10:11	Dry	5.93	5.97	6.04	12.01	12.05	57975	
4	3/21/16	10:17	Dry	5.91	5.97	6.04	12.00	12.01	63546	
5	3/21/16	10:23	Dry	5.93	5.98	6.06	11.99	12.01	44959	
6	3/21/16	10:32		5.93	5.98	6.04	12.02	12.06	43976	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		3/21/16	10:33
Checked by:	Signature	Date	Time
Will Pollalis	Will Pollalis	3/21/16	10:35
Checked by:	Signature	Date	Time
S. PUJOL	S Pujol	3/22/16	9AM

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb$_f$/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Tests to Determine the Behavior of Spliced #11 Bars

Cylinder Compression Tests Documentation v.2
(Rev. 04/01/2012)

Specimen: C2 test day

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
1	3/28/16	10:54	Dry	5.93	6.04	12.00	11.95	12.00	145,661	6
2	3/28/16	10:58	Dry	5.94	6.05	11.95	12.00	12.00	147489	5
3	3/28/16	11:01	Dry	5.93	6.05	11.95	12.00	12.00	148412	5
4	3/28/16	11:07	Dry	5.93	6.03	12.00	12.00	12.00	143739	5
5	3/28/16	11:11	Dry	5.93	6.05	11.95	12.00	12.00	150473	5
6	3/28/16	11:16	Dry	5.93	6.05	11.95	12.00	11.95	150433	5

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		3/28/16	11:16
Checked by:	Signature	Date	Time
Henrik Skovgaard		3/30/16	8:48
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Cylinder Split Tensile Tests Documentation v.1
(Rev. 05/14/2012)

Specimen: C2 test day
(56 day)

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
1	3/28/16	8:32	Dry	5.94	6.04	6.05	12.00	12.00	57,696	
2	3/28/16	8:37	Dry	5.93	6.04	6.05	12	12	55,073	
3	3/28/16	8:42	Dry	5.93	6.03	6.05	12	12	42,134	
4	3/28/16	8:46	Dry	5.93	6.02	6.05	12	12	50,648	
5	3/28/16	8:52	Dry	5.93	6.05	6.05	12	12	54369	
6	3/28/16	8:56	Dry	5.93	6.03	6.04	12	12	45287	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		3/28/16	9:02
Checked by:	Signature	Date	Time
Henrik Skaagaard		3/30/16	8:47
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Tests to Determine the Behavior of Spliced #11 Bars

Cylinder Compression Tests Documentation v.2
(Rev. 04/01/2012)

Specimen: C3

Sheet 1 of 3

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
1	4/5/16	7:17	Dry	5.94	6.02	12.05	12.00	12.00	166509	6
2	4/5/16	7:25	Dry	5.93	6.04	12.00	11.95	12.00	165239	5
3	4/5/16	7:33	Dry	5.94	6.05	12.00	11.95	11.95	168307	6
4	4/5/16	7:37	Dry	5.94	6.03	12.00	11.95	11.95	163382	5
5	4/5/16	7:41	Dry	5.93	6.04	12.05	12.00	12.05	162122	6
6	4/5/16	7:46	Dry	5.94	6.04	12.00	12.00	12.05	167221	5

S/N of Testing Machine:	Forney		
Recorded by:	Signature	Date	Time
Kinsey Skiller		4/5/16	7:50
Checked by:	Signature	Date	Time
Sam Worthy	SWorthy	4/5/16	0746
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Cylinder Split Tensile Tests Documentation v.1
(Rev. 05/14/2012)

Specimen: C3

Sheet 1 of 3

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
1	4/5/16	7:49	Dry	5.93	6.02	6.04	12.00	12	76206	
2	4/5/16	8:03	Dry	5.94	6.02	6.05	12	12	68902	
3	4/5/16	8:05	Dry	5.94	6.03	6.06	12	12	53916	
4	4/5/16	8:08	Dry	5.95	6.00	6.04	12	12	42549	
5	4/5/16	8:11	Dry	5.93	6.01	6.03	12	12	53347	
6	4/5/16	8:18	Dry	5.94	6.00	6.02	12	12	50127	

S/N of Testing Machine:	Forney		
Recorded by:	Signature	Date	Time
Kinsey Skiller		4/5/16	8:18
Checked by:	Signature	Date	Time
Sam Worthy	SWorthy	4/5/16	0722
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Tests to Determine the Behavior of Spliced #11 Bars

Cylinder Compression Tests Documentation v.2
(Rev. 04/01/2012)

Specimen: C4

Sheet 1 of 3

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
1	4/11/16	9:20	Dry	5.94	6.04	12.00	12.00	11.95	161352	3
2	4/11/16	9:27	Dry	5.94	6.05	12.00	12.00	11.95	165941	5
3	4/11/16	9:34	Dry	5.93	6.06	12.00	12.10	12.05	162517	5
4	4/11/16	9:40	Dry	5.94	6.03	11.95	12.00	12.00	160794	5
5	4/11/16	9:46	Dry	5.94	6.02	11.95	12.00	11.95	151473	3
6	4/11/16	9:52	Dry	5.94	6.04	12.05	12.00	11.95	160,170	3

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen		4/11/16	9:55
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Cylinder Split Tensile Tests Documentation v.1
(Rev. 05/14/2012)

Specimen: C4

Sheet 1 of ~~2~~ 3

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
1	4/11/16	10:11	Dry	6.04	6.01	5.95	12	12	54504	⦶
2	4/11/16	10:17	Dry	6.03	5.99	5.94	12	12	46887	⦶
3	4/11/16	10:24	Dry	6.04	5.99	5.93	12	12	62431	⦶
4	4/11/16	10:29	Dry	6.03	5.99	5.94	12	12	60959	⦶
5	4/11/16	10:35	Dry	6.04	5.96	5.93	12	12	62507	⦶
6	4/11/16	10:40	Dry	6.04	5.99	5.93	12	12	41,151	⦶

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen		4/11/16	10:50
Checked by:	Signature	Date	Time
Tom SPRAGG		4/12/16	10:50
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Cylinder Compression Tests Documentation v.2
(Rev. 04/01/2012)

Specimen: C5

Sheet 1 of 3

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
1	4/12/16	8:45	Dry	6.04	5.93	12.00	11.95	11.95	157909	5
2	4/12/16	8:50	Dry	6.03	5.95	11.95	11.95	11.95	145422	5
3	4/12/16	8:56	Dry	6.02	5.94	12.00	12.00	12.00	160573	5
4	4/12/16	9:04	Dry	6.03	5.93	12.05	12.00	12.05	162401	5
5	4/12/16	9:10	Dry	6.04	5.94	11.95	12.00	12.00	161391	3
6	4/12/16	9:15	Dry	6.02	5.93	12.05	12.1	12.05	158,264	6

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen		4/12/16	9:22 AM
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

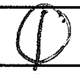
*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'$_c$) calculated on sheet 2 of 2.

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Cylinder Split Tensile Tests Documentation v.1
(Rev. 05/14/2012)

Specimen: C5

Sheet 1 of ~~2~~ 3

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
1	4/12/16	7:45	Dry	6.04	5.97	5.93	12.60	12.00	55507	
2	4/12/16	8:00	Dry	6.02	5.98	5.94	12.00	12.00	51940	
3	4/12/16	8:07	Dry	6.04	5.96	5.93	12.00	12.00	64451	
4	4/12/16	8:13	Dry	6.03	5.98	5.94	12.00	12.00	62706	
5	4/12/16	8:20	Dry	6.04	5.99	5.95	12.00	12.00	54167	
6	4/12/16	8:26	Dry	6.03	5.99	5.94	12.00	12.00	40823	

S/N of Testing Machine:	Forney 99658	[redacted]	
Recorded by:	Signature	Date	Time
Kinsey Skillen		4/12/16	8:30 AM
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Tests to Determine the Behavior of Spliced #11 Bars

Cylinder Compression Tests Documentation v.2
(Rev. 04/01/2012)

Specimen: CC test day

Sheet 1 of 3

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
1	4/14/16	9:42	Dry	6.04	5.95	12.00	12.00	12.00	143979	5
2	4/14/16	9:48	Dry	6.03	5.94	11.95	12.00	11.95	152771	4
3	4/14/16	9:52	Dry	6.03	5.93	12.05	12.00	12.00	150,079	3
4	4/14/16	9:56	Dry	6.04	5.92	12.00	12.05	12.05	154850	5
5	4/14/16	9:59	Dry	6.03	5.94	11.95	11.95	11.95	147712	5
6	4/14/16	10:05	Dry	6.05	5.94	12.05	12.00	12.00	153686	5

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		4/14/16	10:10 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Cylinder Split Tensile Tests Documentation v.1
(Rev. 05/14/2012)

Specimen: CC test day

Sheet 1 of 3

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
1	4/14/16	9:10	Dry	6.05	5.99	5.93	12	12	53328	
2	4/14/16	9:15	Dry	6.03	6.00	5.94	12	12	54417	
3	4/14/16	9:18	Dry	6.03	6.01	5.94	12	12	43763	
4	4/14/16	9:23	Dry	6.04	5.98	5.94	12	12	51448	
5	4/14/16	9:28	Dry	6.03	5.99	5.94	12	12	35520	
6	4/14/16	9:32	Dry	6.02	5.98	5.93	12	12	40360	

S/N of Testing Machine:	Forney 79058	[redacted]	
Recorded by:	Signature	Date	Time
Kinsey Skiller		4/14/16	9:40
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb$_f$/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Form 3
Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: C1

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
FEB 02, 2016	11822021	1982	09:47	10:02	52

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		Air Content (ASTM C231 - 10)		
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter
10:13	7½"	10:21	4.3%	5431265256 / LAF2
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale
10:45	7½"	10:39	4.1%	H 3802360

Unit Weight (ASTM C138 - 10b)

Time$_1$	Wt. of Cont.$_1$	Total Wt. $_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.
10:19	8.45 lb	45.15 lb	36.70 lb	$36.70\# / 0.25\,ft^3 = 146.8\,\frac{lbf}{ft^3}$
Time$_2$	Wt. of Cont.$_2$	Total Wt. $_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.
10:38	8.45 lb	45.00 lb	36.55 lb	$36.55\# / 0.25\,ft^3 = 146.2\,\frac{lbf}{ft^3}$

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
10:28	10:30	10:46	10:48	10:59	10:56
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
10:59	2:55	4:55	5:00 *	5:05 *	

Recorded by	Signature	Date	Time
JASPAL S SAINI	JSaini	02/02/16	4 PM
Checked by	Signature	Date	Time
S. PUJOL		2/2/16	4 PM
Checked by	Signature	Date	Time

Comments:

CONC TEMP @ 10:12 = 70°F

* cylinders done @ 5:50 pm & 5:55 pm

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

C1
Appendix 2, Pg 2 of 18

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1982	1076	user	11822021	0	9:47	2/2/16

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
5.75 CYDS	4000CC				D	32409

Description	Design Qty	Adj.T	Required	Batched	Actual Wat
Batch: 1 -----	Start: 9:47:03		End:	-------	Time (hh:mm:ss): : : -----
Buzzi	588 lb		3381 lb	3425 lb >	
STONE-8	940 lb		5416 lb	5420 lb	1 gl
STONE-4	620 lb		3583 lb	3580 lb	2 gl
SAND-23	1435 lb		8623 lb	8600 lb	44 gl
WATER	322.9 lb		1456.7 lb	1450.0 lb	173.8 gl
MICROAIR	1.10 /C		37.19 oz	37.00 oz	

Actual Num Batches: 1
Load 22477 lb Design W/C: 0.549 Water/Cement: 0.542 T Design 222.5 gl Actual 221.6 gl To Add: 0.9 gl
Slump: 6.00 in # Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

CL

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
110	11022021	1982	5.75cy	4000CC	6.00	TEST	02/02/16	116

Sold To	Tax Code	Driver	Project No.	Order No.
BOB BOWEN LAB		DOUG PHEBUS		[illegible]

Delivery Address	P.O. Number
ON SOUTH RIVER ROAD AT THE LAB 3 YARD TEST LOAD 1ST THEN 5.75 406-697-1743 TRUCK RELEASE	

Job No.

Time Printed 09:39

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	5.75cy	34.50cy	4000CC	4000-A-C-LSTONE-CC	115.00	661.25
				WINTER FEE		23.00
				ENVIRONMENTAL FEE		12.00

imi
www.irvmat.com

Water Added At Customer's Request					Total No. Gallons	Slump Meter Reading				

On Job Time	Finish Pour Time

AUTH.#: Grand Total: 744.99

Subtotal	696.25
Tax	48.74
Total	744.99

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

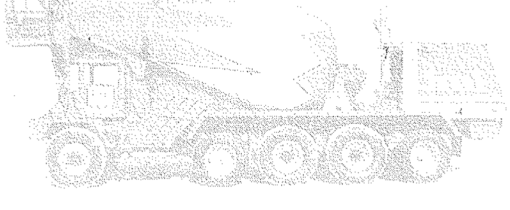
PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

3253215



11022021

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" General Office (317) 326-3101

CUSTOMER COPY

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Form 3
Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: C2

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
FEB 02, 2016	11822029	1693	10:45	11:06	57

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**		
Time_1	Result_1	Time_1	Result_1	S/N of Air Meter
11:16	$7\frac{1}{2}''$	11:22	4.3%	5431265256 / LAF 2
Time_2	Result_2	Time_2	Result_2	S/N of Scale
11:43	$6\frac{1}{2}''$	11:38	4.7%	H 3802360

Unit Weight (ASTM C138 - 10b)

Time_1	Wt. of Cont._1	Total Wt._1	Wt. of Conc._1	Result_1 = Wt. of Conc./Vol. of Cont.
11:21	8.45 lb	45.00 lb	36.55 lb	$36.55^{\#}/0.25\,ft^3 = 146.2\,\frac{lbf}{ft^3}$
Time_2	Wt. of Cont._2	Total Wt._2	Wt. of Conc._2	Result2 = Wt. of Conc./Vol. of Cont.
11:36	8.45 lb	44.15 lb	35.70 lb	$35.70^{\#}/0.25\,ft^3 = 142.8\,\frac{lbf}{ft^3}$

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
11:25	11:30	11:46	11:48	11:53	11:50
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
12:00	2:55	4:55	5:00 *	5:05 *	

Recorded by	Signature	Date	Time
JASPAL S SAINI	JSaini	02/02/16	4:15PM
Checked by	Signature	Date	Time
S. PUJOL		2/2/16	4:15PM
Checked by	Signature	Date	Time

Comments:

CONC TEMP @ 11:17 = 70°F

* Cylinders covered @ 5:55pm

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

C2

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1693	2774	user	11822029	0	10:54	2/2/16

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
5.75 CYDS	4000CC				D	32416

Batch: 1 ----- Start: 10:54:11 End: ------- Time (hh:mm:ss): : : -----

Description	Design Qty	Adj.T	Required	Batched	Actual Wat
Buzzi	588 lb		3381 lb	3375 lb	
STONE-8	940 lb		5416 lb	5400 lb	1 gl
STONE-4	620 lb		3583 lb	3620 lb	2 gl
SAND-23	1435 lb		8664 lb	8660 lb	49 gl
WATER	322.9 lb		1415.5 lb	1406.0 lb	168.5 gl
MICROAIR	1.10 /C		37.19 oz	37.00 oz	

Actual Num Batches: 1

Load 22463 lb Design W/C: 0.549 Water/Cement: 0.550 T Design 222.5 gl Actual 221.4 gl To Add: 1.1 gl

Slump: 6.00 in # Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
119	11822029	1693	5.75cy	4000CC	6.00	TEST	02/02/16	116 C2

Sold To	Tax Code	Driver	Project No.	Order No.
COD BOWEN LAB	7	RON HOWARD	0	1022

Delivery Address	P.O. Number
ON SOUTH RIVER ROAD AT THE LAB 3 YARD TEST LOAD 1ST THEN 5.75 406-697-1743 TRUCK RELEASE	

Job No.

Time Printed 10:45

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	11.50cy	34.50cy	4000CC	4000-A-C-LSTONE-CC	115.00	661.25
				WINTER FEE		23.00
				ENVIRONMENTAL FEE		12.00

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Water Added At Customer's Request					Total No. Gallons	**Slump Meter Reading**		9 0 0	Subtotal 696.25

On Job Time	**Finish Pour Time**

AUTH.#:

Grand Total: 1,489.98

Tax 48.74
Total 744.99

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

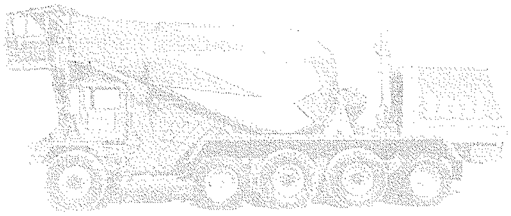
PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

3253223



11822029

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

CUSTOMER COPY

Project: Tests to Determine the Behavior of Spliced #11 Bars

Form 3
Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: C3

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
FEB 02, 2016	11822035	1967	11:52	12:08	57

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		Air Content (ASTM C231 - 10)		
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter
12:17	$5\frac{1}{2}$"	12:22	4.2%	5431265256/LAF2
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale
12:48	$5\frac{3}{4}$"	12:42	4.2%	H 3802360

Unit Weight (ASTM C138 - 10b)

Time$_1$	Wt. of Cont.$_1$	Total Wt. $_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.
12:20	8.45 lb	45.55 lb	37.10 lb	$\frac{37.10\#}{0.25ft^3}$ = 148.4 $\frac{lbf}{ft^3}$
Time$_2$	Wt. of Cont.$_2$	Total Wt. $_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.
12:41	8.45 lb	44.85 lb	36.40 lb	$\frac{36.40\#}{0.25ft^3}$ = 145.6 $\frac{lbf}{ft^3}$

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
12:27	12:30	12:40	12:43	12:52	12:47
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
12:57	4:20	5:45	5:50	5:55	6:00

Recorded by	Signature	Date	Time
JASPAL S SAINI	JSaini	02/02/16	4:15PM
Checked by	Signature	Date	Time
S. PUJOL		2/2/16	4:15 PM
Checked by	Signature	Date	Time

Comments:

CONC TEMP @ 12:18 = 71°F

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

C3

Appendix 2, Pg 8 of 18

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1967	3002	user	11822035	0	11:52	2/2/16

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
5.75 CYDS	4000CC				D	32422

Description	Design Qty	Adj.T	Required	Batched	Actual Wat
Batch: 1 -----	Start: 11:52:23		End:	------- Time (hh:mm:ss): : : -----	
Buzzi	588 lb		3381 lb	3390 lb	
STONE-8	940 lb		5416 lb	5420 lb	1 gl
STONE-4	620 lb		3583 lb	3620 lb	2 gl
SAND-23	1435 lb		8664 lb	8660 lb	49 gl
WATER	317.9 lb		1386.7 lb	1372.0 lb	164.4 gl
MICROAIR	1.10 /C		37.19 oz	37.00 oz	

Actual Num Batches: 1

Load 22464 lb Design W/C: 0.541 Water/Cement: 0.539 T Design 219.0 gl Actual 217.3 gl To Add: 1.8 gl

Slump: 6.00 in # Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

C3

imi Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
118	11822035	1967	5.75cy	4000CC	6.00	TEST	02/02/16	116

Sold To	Tax Code	Driver	Project No.	Order No.
COD BOWEN LAB	Z	JOE MOREHOUSE	0	1022

Delivery Address	P.O. Number
ON SOUTH RIVER ROAD AT THE LAB 3 YARD TEST LOAD 1ST THEN 5.75 406-697-1743 TRUCK RELEASE	

Job No.

Time Printed 11:49

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	17.25cy	34.50cy	4000CC	4000-A-C-LSTONE-CC	115.00	661.25
				WINTER FEE		23.00
				ENVIRONMENTAL FEE		12.00

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Water Added At Customer's Request					Total No. Gallons	Slump Meter Reading				

On Job Time	Finish Pour Time

AUTH.#: Grand Total: 2,234.97

Subtotal	696.25
Tax	48.74
Total	744.99

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

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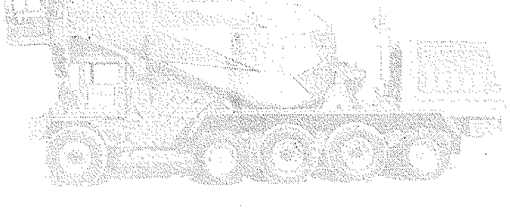
DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:

X

3253229



11822035

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Form 3
Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: C4

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
FEB 02, 2016	11822042	1693	12:45	1:05	56

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**		
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter
1:12	$5\frac{1}{2}$"	1:18	3.9 %	5431265256 / LAF2
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale
1:42	6"	1:35	3.8 %	H3802360

Unit Weight (ASTM C138 - 10b)

Time$_1$	Wt. of Cont.$_1$	Total Wt.$_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.
1:16	8.45 lb	45.60 lb	37.15 lb	$37.15\#/0.25ft^3 = 148.6\ lbf/ft^3$
Time$_2$	Wt. of Cont.$_2$	Total Wt.$_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.
1:34	8.45 lb	44.50 lb	36.05 lb	$36.05\#/0.25ft^3 = 144.2\ lbf/ft^3$

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
1:25	1:28	1:40	1:44	1:50	1:44
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
2:00	4:20	5:55	6:05	6:10	6:15

Recorded by	Signature	Date	Time
JASPAL S SAINI	JSSaini	02/02/16	4:15 PM
Checked by	Signature	Date	Time
S. PUJOL		2/2/16	4:15 PM
Checked by	Signature	Date	Time

Comments:

CONC TEMP @ 1:13 = 70°F

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

C4

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1693	2774	user	11822042	0	12:45	2/2/16
Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
5.75 CYDS	4000CC				D	32429

Description	Design Qty	Adj.T	Required	Batched	Actual Wat
Batch: 1 -----	Start:	12:45:26	End:	------- Time (hh:mm:ss):	: : -----
Buzzi	588 lb		3381 lb	3365 lb	
STONE-8	940 lb		5416 lb	5400 lb	1 gl
STONE-4	620 lb		3583 lb	3580 lb	2 gl
SAND-23	1435 lb		8664 lb	8680 lb	50 gl
WATER	317.9 lb		1386.7 lb	1376.0 lb	164.9 gl
MICROAIR	1.10 /C		37.19 oz	37.50 oz	

Actual Num Batches: 1
Load 22403 lb Design W/C: 0.541 Water/Cement: 0.543 T Design 219.0 gl Actual 217.8 gl To Add: 1.2 gl
Slump: 6.00 in # Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

4

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
110	11822042	1693	5.75cy	4000CC	6.00	TEST	02/02/16	116

Sold To	Tax Code	Driver	Project No.	Order No.
BOB BOWEN LAB	C	RON HOWARD	0	1022

Delivery Address	P.O. Number
ON SOUTH RIVER ROAD AT THE LAB 3 YARD TEST LOAD 1ST THEN 5.75 406-697-1743 TRUCK RELEASE	

Job No.

Time Printed 12:45

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	23.00cy	34.50cy	4000CC	4000-A-C-LSTONE-CC	115.00	661.25
				WINTER FEE		23.00
				ENVIRONMENTAL FEE		12.00

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Water Added At Customer's Request					Total No. Gallons	**Slump Meter Reading**		9	0	0

Subtotal	696.25
Tax	48.74
Total	744.99

On Job Time	**Finish Pour Time**

AUTH.#: Grand Total: 2,979.96

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

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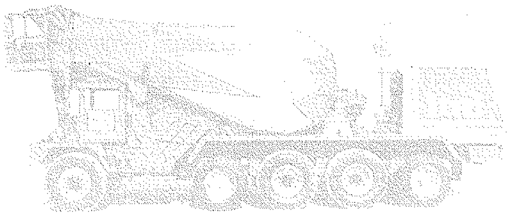
DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X Bowen LAB

3253236



11822042

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

CUSTOMER COPY

Form 3

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: C5

Sheet 1 of 1

General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
FEB 02, 2016	11822044	1677	1:47	2:03	57

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		Air Content (ASTM C231 - 10)		
Time_1	Result_1	Time_1	Result_1	S/N of Air Meter
2:18	7 1/4"	2:16	4.4%	5431265256/LAF2
Time_2	Result_2	Time_2	Result_2	S/N of Scale
2:48	6 1/2"	2:47	4.9%	H 3802360

Unit Weight (ASTM C138 - 10b)

Time_1	Wt. of Cont._1	Total Wt._1	Wt. of Conc._1	Result_1 = Wt. of Conc./Vol. of Cont.
2:15	8.45 lb	45.15 lb	36.7 lb	$36.7\#/0.25ft^3 = 146.8 \frac{lbf}{ft^3}$
Time_2	Wt. of Cont._2	Total Wt._2	Wt. of Conc._2	Result2 = Wt. of Conc./Vol. of Cont.
2:46	8.45 lb	44.55 lb	36.1 lb	$36.1\#/0.25ft^3 = 144.4 \frac{lbf}{ft^3}$

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
2:35	2:39	2:50	2:52	3:04	2:51
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
3:10	5:45	6:35	6:40	6:45	6:50

Recorded by	Signature	Date	Time
JASPAL S SAINI		02/02/16	4:20 PM
Checked by	Signature	Date	Time
: S. PUJOL		2/2/16	4:25 PM
Checked by	Signature	Date	Time

Comments:

CONC TEMP @ 2:12 = 72°F

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

C5

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1677	3304	user	11822044	0	13:47	2/2/16
Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
5.75 CYDS	4000CC				D	32431

Batch: 1 ----- Start: 13:47:23 End: ------- Time (hh:mm:ss): : : -----

Description	Design Qty	Adj.T	Required	Batched	Actual Wat
Buzzi	588 lb		3381 lb	3375 lb	
STONE-8	940 lb		5416 lb	5400 lb	1 gl
STONE-4	620 lb		3583 lb	3600 lb	2 gl
SAND-23	1435 lb		8664 lb	8680 lb	50 gl
WATER	317.9 lb		1386.7 lb	1378.0 lb	165.1 gl
MICROAIR	1.10 /C		37.19 oz	37.00 oz	

Actual Num Batches: 1
Load 22435 lb Design W/C: 0.541 Water/Cement: 0.542 T Design 219.0 gl Actual 218.1 gl To Add: 0.9 gl
Slump: 6.00 in # Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
118	11022044	1677	5.75cy	4000CC	6.00	TEST	02/02/16	116

Sold To	Tax Code	Driver	Project No.	Order No.
[illegible] BOWEN LAB	2	[illegible]	0	[illegible]

Delivery Address	P.O. Number
ON SOUTH RIVER ROAD AT THE LAB 3 YARD TEST LOAD 1ST THEN 5.75 406-697-1743 TRUCK RELEASE	

Job No.

Time Printed 13:47

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	28.75cy	34.50cy	4000CC	4000-A-C-LSTONE-CC	115.00	661.25
				WINTER FEE		23.00
				ENVIRONMENTAL FEE		12.00

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Water Added At Customer's Request					Total No. Gallons	Slump Meter Reading				

On Job Time	Finish Pour Time

AUTH.#: Grand Total: 3,724.95

Subtotal	696.25
Tax	48.74
Total	744.99

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

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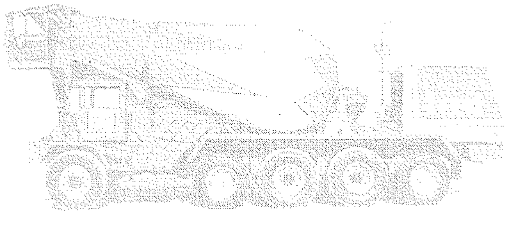
NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:

X

3253238



11022044

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

CUSTOMER COPY

Project: Tests to Determine the Behavior of Spliced #11 Bars

Form 3
Casting Documentation v.1
(Rev. 03/30/2012)

Specimen: C6

Sheet 1 of 1

General Information					
Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
FEB 02, 2016	11822046	1949	2:52	3:11	53
Measurements made upon arrival of concrete					
Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**			
$Time_1$	$Result_1$	$Time_1$	$Result_1$	S/N of Air Meter	
3:18	7"	3:22	4.3%	5431265256 | LAF2	
$Time_2$	$Result_2$	$Time_2$	$Result_2$	S/N of Scale	
3:52	6¼"	3:37	4.8%	H3802360	
Unit Weight (ASTM C138 - 10b)					
$Time_1$	Wt. of $Cont._1$	Total Wt. $_1$	Wt. of $Conc._1$	$Result_1$ = Wt. of Conc./Vol. of Cont.	
3:20	8.45 lb	45.30 lb	36.85 lb	$36.85\#/0.25 ft^3 = 147.4 lb/ft^3$	
$Time_2$	Wt. of $Cont._2$	Total Wt. $_2$	Wt. of $Conc._2$	Result2 = Wt. of Conc./Vol. of Cont.	
3:35	8.45 lb	44.55 lb	36.10 lb	$36.1\#/0.25 ft^3 = 144.4 lbf/ft^3$	
Times of actions during and after casting					
Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
3:32	3:37	3:50	3:55	4:04	3:53
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
4:10	6:45	7:25	7:30	7:35	7:40

Recorded by	Signature	Date	Time
JASPAL S SAINI		02/02/16	4:20 PM
Checked by	Signature	Date	Time
S. PUJOL		2/2/16	4:25 PM
Checked by	Signature	Date	Time

Comments:

CONC TEMP @ 3:18 = 70°F

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1949	1395	user	11822046	0	14:52	2/2/16

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
5.75 CYDS	4000CC				D	32433

Description	Design Qty	Adj.T	Required	Batched	Actual Wat
Batch: 1 -----	Start:	14:52:27	End:	------- Time (hh:mm:ss):	: : -----
Buzzi	588 lb		3381 lb	3370 lb	
STONE-8	940 lb		5416 lb	5400 lb	1 gl
STONE-4	620 lb		3583 lb	3640 lb	2 gl
SAND-23	1435 lb		8664 lb	8680 lb	50 gl
WATER	317.9 lb		1386.7 lb	1376.0 lb	164.9 gl
MICROAIR	1.10 /C		37.19 oz	37.00 oz	

Actual Num Batches: 1
Load 22468 lb Design W/C: 0.541 Water/Cement: 0.542 T Design 219.0 gl Actual 217.9 gl To Add: 1.2 gl
Slump: 6.00 in # Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 0.0 lb / CYD

C6

Appendix 2, Pg 18 of 18

Remit To: P.O. Box 7048, Group #2
Indianapolis, IN 46207-7048

Concrete Delivery Ticket

imi
Irving Materials, Inc.

Plant #	Ticket Number	Truck	Load Size	Mix	Slump	Use	Date	Customer
110	11822046	1949	5.75cy	4000CC	6.00	TEST	02/02/16	116

Sold To	Tax Code	Driver	Project No.	Order No.
[illegible] BOWEN LAB	[illegible]	JOE [illegible]	0	[illegible]

Delivery Address	P.O. Number
ON SOUTH RIVER ROAD AT THE LAB 3 YARD TEST LOAD 1ST THEN 5.75 406-697-1743 TRUCK RELEASE	

Job No.

Time Printed 14:51

Load Quantity	Total	Ordered Quantity	Product Code	Product Description	Unit Price	Amount
5.75	34.50cy	34.50cy	4000CC	4000-A-C-LSTONE-CC	115.00	661.25
				WINTER FEE		23.00
				ENVIRONMENTAL FEE		12.00

www.irvmat.com

Water Added At Customer's Request	8	Total No. Gallons	**Slump Meter Reading**	7.50
On Job Time	**Finish Pour Time**	AUTH.#:		

Grand Total: 4,469.94

Subtotal	696.25
Tax	48.74
Total	744.99

PROPERTY DAMAGE RELEASE / WARNING - Irritating To The Skin and Eyes

Dear Customer - The Seller is not responsible for slumps, strength or quality of concrete to which water or any other material has been added by the purchaser or at his request.

The undersigned hereby authorizes Irving Materials, Inc. to use private property for making the delivery shown here on and assumes full responsibility for any damage or injury due to the premises.

The undersigned agrees to reimburse said Company for loss of time and equipment by reason of such delivery and also to identify and save harmless said Company from any and all claims, demands and suits for or on account of or in any manner caused by or arising from private property delivery.

The undersigned assumes responsibility for a suitable roadway from public highway to point of delivery and is responsible for any needed wrecker service charges as a result.

SAFETY WARNING: Keep away from children. Contains Portland Cement. Irritating to the skin and eyes. Wear rubber boots, gloves and eye protection. Prolonged contact may cause burns. In case of contact with skin or eyes, flush thoroughly with water. If irritation persists, get medical attention. For additional information regarding the HAZARDS OF READY MIX CONCRETE, consult the Material Data Safety Sheet (MSDS) available upon request.

PRODUCT NOTICE: Seller will not be held responsible for the final appearance of exposed aggregate, integral coloring, stamped and decorative surfacing, and all other forms of architectural and design concrete.

DELIVERY NOTICE: Seller assumes no responsibility for deliveries beyond the public right of way. Buyer assumes responsibility for damages including but not limited to curb, sidewalk, driveway, or any property of the contractor or property owner or agents.

NOTICE: MY SIGNATURE BELOW INDICATES THAT I HAVE READ THE SAFETY AND HEALTH WARNING NOTICE AND ACCEPTANCE OF THE LOAD.

Release, Load and Terms Accepted By:
X

3253240

11822046

Concrete - Sand - Gravel - Stone "We're Proud Of Our Work" **General Office (317) 326-3101**

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Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
C1-C6 all cylinders	2/2/16	After directly casting
	Time Beginning	**Time Ending**
	5:24	6:10
	Temperature inside Lab (deg. F)	
	55	

Description of Work Performed

Specimens + cylinders covered w/ plastic sheeting

Recorded by	Signature	Date	Time
Kinsey Skiller		2/2/16	6:10
Checked by	**Signature**	**Date**	**Time**
Will Pollak		2/2/16	6:10
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
C1 - C6 all cylindes	2/2/16	After directly casting
	Time Beginning	**Time Ending**
	6:15	6:38
	Temperature inside Lab (deg. F)	
	55	

Description of Work Performed

Specimens & cylindes covered w/ damp burlap and plastic sheeting

Recorded by	Signature	Date	Time
Kinsey Sheller		2/2/16	6:40
Checked by	**Signature**	**Date**	**Time**
Will Pollalis		2/2/16	6:40
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
C1 - C6 all cylinders	2/3/16	1 day
	Time Beginning	**Time Ending**
	10:05 am	10:25 am
	Temperature inside Lab (deg. F)	
	60	

Description of Work Performed

Specimens + cylinders doused w/ water and recovered.

Recorded by	Signature	Date	Time
Kinsey Skiller		2/3/16	10:25

Checked by	Signature	Date	Time

Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
C1 - C6 all cylinders	2/4/16	2 day
	Time Beginning	Time Ending
	9:45 am	10:12 am
	Temperature inside Lab (deg. F)	
	60	

Description of Work Performed

Specimens + cylinders burlap doused w/ water and recovered w/ plastic sheeting

Recorded by	Signature	Date	Time
Kinsey Skiller		2/4/16	10:12
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
C1 - C6 all cylinders	2/5/16	3 day
	Time Beginning	**Time Ending**
	10:30 am	9:15 pm
	Temperature inside Lab (deg. F)	
	63	

Description of Work Performed

- ↦ Specimens + cylinders doused w/ water
- ↦ forms struck within casting times
- ↦ cylinders stripped, placed next to specimens on tarp
- ↦ Specimens + cylinders covered w/ burlap and sheeting post form striking

Recorded by	Signature	Date	Time
Kinsey Skillen		2/5/16	9:15
Checked by	**Signature**	**Date**	**Time**
Will Pollalis		2/5/16	9:16
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
C1 - C6 All cylinders	2/6/16	4 day
	Time Beginning	**Time Ending**
	2:00 pm	2:30
	Temperature inside Lab (deg. F)	
	62	

Description of Work Performed

Specimens + cylinders burlap doused w/ water and recovered w/ plastic sheeting

Recorded by	Signature	Date	Time
Kinsey Skillen		2/6/16	2:30

Checked by	Signature	Date	Time

Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
C1 - C6 all cylinders	2/8/16	6 day
	Time Beginning	Time Ending
	9:35 m	10:00 am
	Temperature inside Lab (deg. F)	
	58	

Description of Work Performed

Specimens + cylinders dozed w/ water and coverd w/ plastic sheeting.

Recorded by	Signature	Date	Time
Kinsey Skillen		2/8/16	10:00 am
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1 (Rev. 03/30/2012)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
C1 - C6 all cylinders	2/9/16	7 day
	Time Beginning	**Time Ending**
	3:00 pm	4:15 pm
	Temperature inside Lab (deg. F)	
	60	

Description of Work Performed

7 day Curing complete, Specimens and cylinders uncovered from wet burlap and plastic sheeting

Recorded by	Signature	Date	Time
Kinsey Skillen		2/9/16	4:15
Checked by	**Signature**	**Date**	**Time**
Will Pollalis		2/9/16	4:15
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

SOLD TO:
PRIMESOURCE BUILDING PRODUCTS
4316 W MINNESOTA ST
INDIANAPOLIS, IN 46241-

NUCOR
NUCOR STEEL MARION, INC.

CERTIFIED MILL TEST REPORT

SHIP TO:
PRIMESOURCE BUILDING PRODUCTS
J&K Supply
3515 Coleman Ct
LAFAYETTE, IN 47905-

Ship from:
MTR #: 0000046153
Nucor Steel Marion, Inc.
912 Cheney Avenue
Marion, OH 43302
7403834011

Date: 1-Dec-2015
B.L. Number: 402908
Load Number: 136352

Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 January 1, 2012

LOT # HEAT #	DESCRIPTION	PHYSICAL TESTS YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% DEF	CHEMICAL TESTS C Ni	Mn Cr	P Mo	S V	Si Cb	Cu Sn	C.E.
PO# => MR1510554501 MR15105545	1040-4500197870 Nucor Steel - Marion, Inc. 13/#4 Rebar 20' A615M GR420 (Gr60) ASTM A615/A615M-14 GR 60[420] AASHTO M31-07	67,100 463MPa	104,100 718MPa	12.0%	OK	-4.5% .031	.40 .14	1.04 .20	.018 .048	.043 .003 0	.21 .00	.36	
PO# => MR1510603601 MR15106036	1040-4500197870 Nucor Steel - Marion, Inc. 16/#5 Rebar 20' A615M GR420 (Gr60) ASTM A615/A615M-15 GR 60[420] AASHTO M31-07	66,900 461MPa	104,500 721MPa	13.2%	OK	-4.6% .038	.40 .13	1.07 .19	.015 .047	.031 .005	.15 .002	.35	
PO# => MR1510603701 MR15106037	1040-4500197870 Nucor Steel - Marion, Inc. 16/#5 Rebar 20' A615M GR420 (Gr60) ASTM A615/A615M-15 GR 60[420] AASHTO M31-07	65,800 454MPa	103,200 712MPa	12.0%	OK	-5.0% .038	.41 .13	1.03 .20	.017 .046	.038 .005	.20 .002	.34	

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.

1.) Weld repair was not performed on this material.
2.) Melted and Manufactured in the United States.
3.) Mercury, Radium, or Alpha source materials in any form have not been used in the production of this material.

QUALITY ASSURANCE: Ignatius Okafor

NUCOR STEEL KANKAKEE, INC.

Mill Certification
7/17/2015

MTR #: 0000080668
NUCOR STEEL KANKAKEE, INC.
One Nucor Way
Bourbonnais, IL 60914-4127
(815) 937-3131
Fax: (815) 939-5599

ld To:
AMBASSADOR STEEL FAB LLC
PO BOX 627
AUBURN, IN 46706
(260) 927-3075
Fax: (765) 455-4225

Ship To:
AMBASSADOR STEEL CORP
149 SYCAMORE LANE
MOORESVILLE, IN 46158
(317) 834-3434

Customer P.O.	0000161822	Sales Order	312954.23
Product Group	Rebar	Part Number	900000367204200
Grade	ASTM A615/A615M-14 GR 60[420] AASHTO M31-07	Lot #	KN1510386801
Size	36/#11 Rebar	Heat #	KN15103868
Product	36/#11 Rebar 60' A615M GR420 (Gr60)	B.L. Number	K1-505038
Description	A615M GR 420 (Gr60)	Load Number	K1-5161822
Customer Spec		Customer Part #	MARKET

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.

Roll Date: 6/30/2015 Melt Date: 6/25/2015 Qty Shipped LBS: 38,255 Qty Shipped Pcs: 120

Melt Date: 6/25/2015

C	Mn	P	S	Si	Cu	Ni	Cr	Mo	V	Cb	CEA706
0.38%	1.08%	0.013%	0.048%	0.20%	0.29%	0.18%	0.11%	0.057%	0.0165%	0.000%	0.58%

CEA706: A706 CARBON EQUIVALENT

Roll Date: 6/30/2015

ield 1: 69,379psi	Tensile 1: 105,322psi	Elongation: 13.25% in 8"(% in 203.3mm)
end OK	Weight Variation -004.0%	Avg Deformation Height: 0.077in

Specification Comments:

ALL MANUFACTURING PROCESSES OF THE STEEL MATERIALS IN THIS PRODUCT, INCLUDING MELTING, HAVE OCCURRED WITHIN THE UNITED STATES. ALL PRODUCTS PRODUCED ARE WELD FREE. MERCURY, IN ANY FORM, HAS NOT BEEN USED IN THE PRODUCTION OR TESTING OF THIS MATERIAL.

Matt Luymes

Matt Luymes
Division Metallurgist

Calculation of Moment and Stresses

$b := \left(17 + \frac{5}{8}\right) in$	Width
$h := 30 in$	Height
$c := 5.7 in$	Cover to centroid of reinforcement
$d := h - c = 24.3 \cdot in$	Effective depth
$A_s := 2 \cdot 1.56 in^2$	Area of steel outside the splice
$\rho := \frac{A_s}{b \cdot d} = 0.73 \cdot \%$	Reinforcement ratio outside splice region
$A_{sp} := 4 \cdot 1.56 in^2 = 6.24 \cdot in^2$	Area of steel in spliced region
$\rho_{sp} := \frac{A_{sp}}{b \cdot d} = 1.46 \cdot \%$	Reinforcement ratio inside splice region
$f'_c := 5500 psi$	Concrete compressive strength Assuming the average of the 6 tests which varied between 5200psi and 5900psi
$E_c := 57000 \cdot \sqrt{f'_c \cdot psi} = 4.2 \times 10^3 \cdot ksi$	Modulus of elasticity of concrete
$E_s := 29000 ksi$	Modulus of elasticity of steel
$n := \frac{E_s}{E_c} = 6.9$	Modular ratio

Calculating Moments

Contribution of self weight

$\gamma := 150\,\frac{\mathrm{lbf}}{\mathrm{ft}^3}$ Unit weight of concrete

$w := \gamma\cdot b\cdot h = 0.55\cdot\frac{\mathrm{kip}}{\mathrm{ft}}$ Self weight per foot

$L_T := 34\mathrm{ft} + 4\mathrm{in} = 412\cdot\mathrm{in}$ Total length of beam

$L_S := 151\mathrm{in}$ Span between supports

$L_{LP} := 9\mathrm{ft} + 8.5\mathrm{in} = 116.5\cdot\mathrm{in}$ Distance from support to load point

$L_{end} := \frac{L_T - L_S}{2} = 130.5\cdot\mathrm{in}$ Distance from end to support

$$M(x) := \frac{w\cdot L_T}{2}\cdot\left(x - L_{end}\right) - w\cdot\left(\frac{x^2}{2}\right)$$

$M_{supp\_SW} := -M\left(L_{end}\right) = 32.6\cdot\mathrm{kip}\cdot\mathrm{ft}$ Moment at support due to SW

$M_{sup\_SW} := \frac{1}{2}\cdot L_{end}\cdot\left(w\cdot L_{end}\right) = 32.6\cdot\mathrm{kip}\cdot\mathrm{ft}$ Check

$M_{splice\_SW} := -M\left(L_{end} + 36\mathrm{in}\right) = 24.7\cdot\mathrm{kip}\cdot\mathrm{ft}$ Moment at splice end due to SW

Applied Load

At load point

$P_{hw} := (2\cdot 42 + 118 + 79 + 52 + 2\cdot 65 + 2\cdot 31)\mathrm{lbf} = 0.53\cdot\mathrm{kip}$ Weight of hardware

$$P_{jack} := \begin{pmatrix} 39.7 \\ 40 \\ 40.4 \\ 40.9 \\ 40.2 \\ 40.7 \end{pmatrix}\mathrm{kip}$$

Load from hydraulic jacks

$P_{app} := P_{hw} + P_{jack}$ Total load applied at load point

Clamps

$$w_{clamp} := \frac{12\cdot 66lbf}{L_{end}} = 0.073\cdot\frac{kip}{ft}$$

Assume the weight of 12 clamps is distributed uniformly from end of beam to support

$$M_{clamp} := \frac{1}{2}L_{end}\cdot w_{clamp}\cdot L_{end} = 4.3\cdot kip\cdot ft$$

Constant between supports

Maximum moment at support and splice end

$$i := 0..5$$

$$M_{supp_i} := \left(P_{app_i}\right)\cdot L_{LP} + M_{supp\_SW} + M_{clamp}$$

$$M_{supp} = \begin{pmatrix} 427 \\ 430 \\ 434 \\ 439 \\ 432 \\ 437 \end{pmatrix}\cdot kip\cdot ft$$

$$M_{splice_i} := \left(P_{app_i}\right)\cdot L_{LP} + M_{splice\_SW} + M_{clamp}$$

$$M_{splice} = \begin{pmatrix} 419 \\ 422 \\ 426 \\ 431 \\ 424 \\ 429 \end{pmatrix}\cdot kip\cdot ft$$

Estimating Stress in Steel at Support and Splice End

$$k := \sqrt{\rho^2 \cdot n^2 + 2 \cdot \rho \cdot n} - \rho \cdot n = 0.27$$

$$j := 1 - \frac{k}{3} = 0.91$$

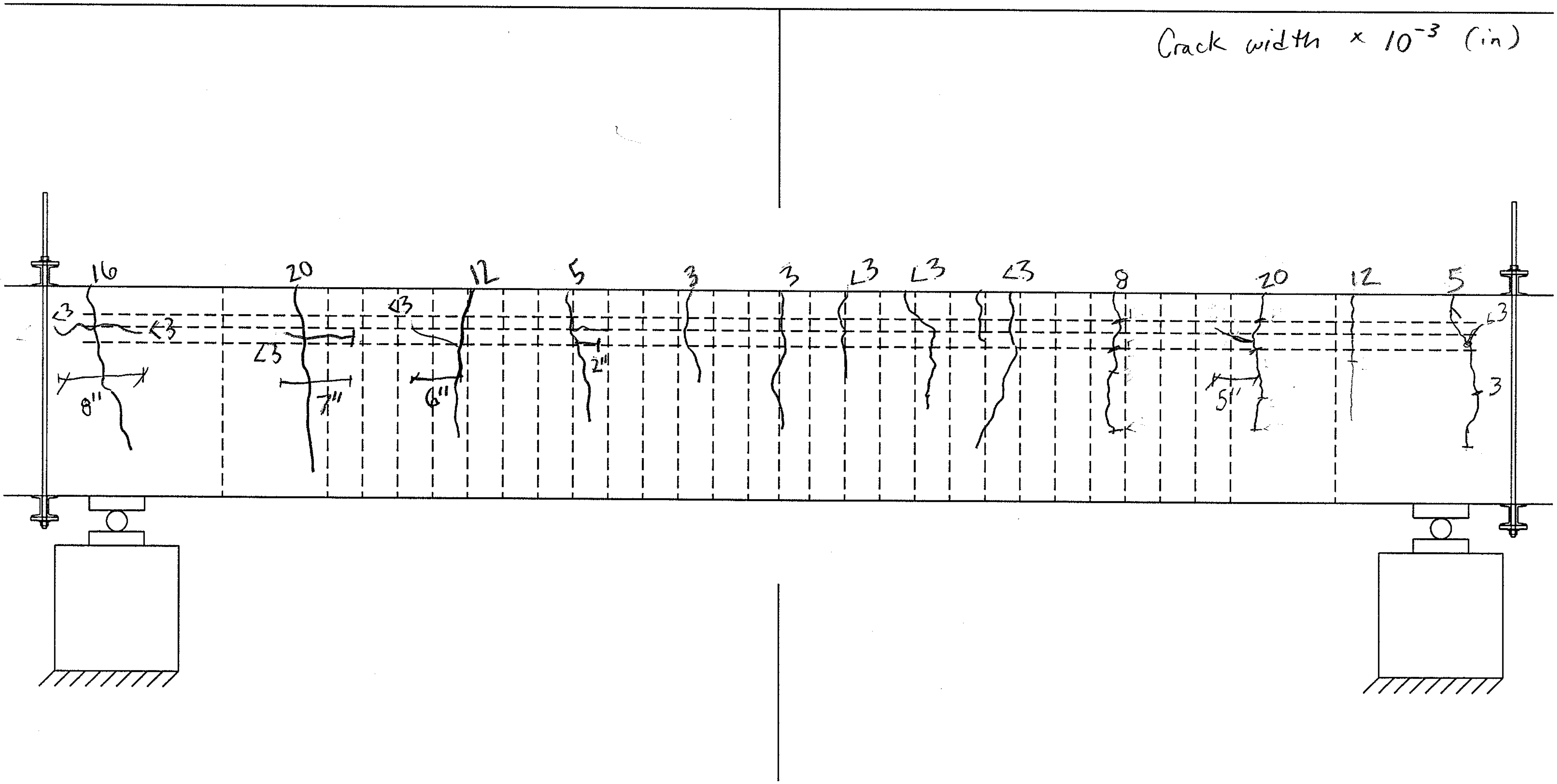
$$M = A_s \cdot f_s \cdot j \cdot d$$

$$f_s = \frac{M}{A_s \cdot j \cdot d}$$

$$f_{s\_supp_i} := \frac{M_{supp_i}}{A_s \cdot j \cdot d} \qquad f_{s\_sp_i} := \frac{M_{splice_i}}{A_s \cdot j \cdot d}$$

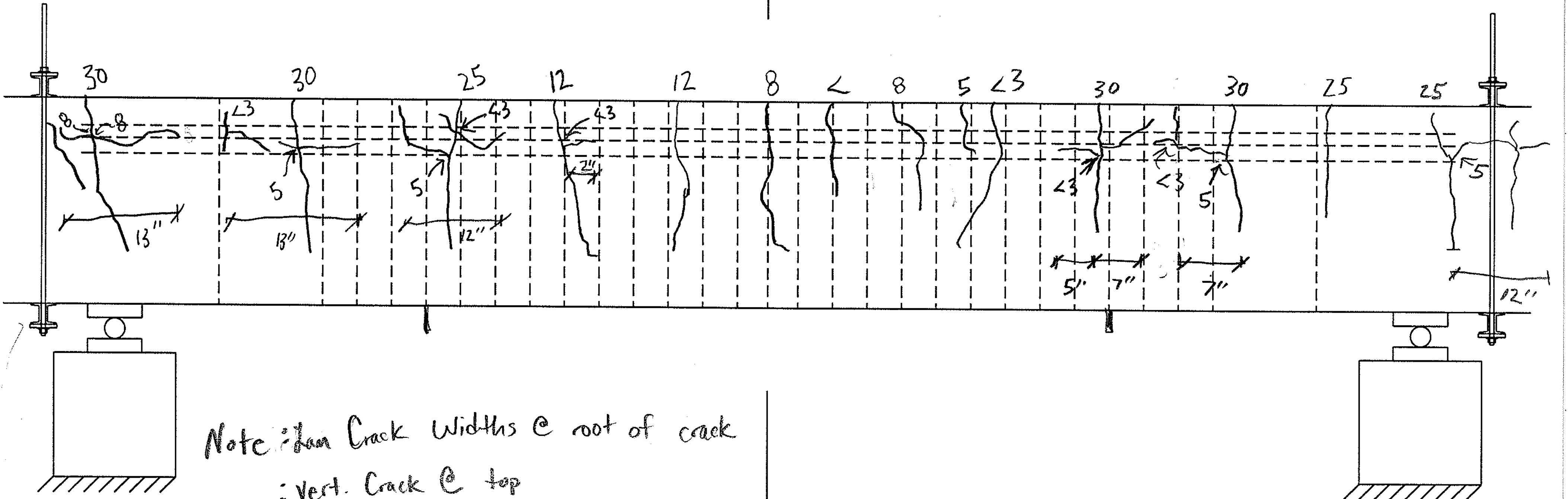
$$f_{s\_supp} = \begin{pmatrix} 74.3 \\ 74.8 \\ 75.5 \\ 76.4 \\ 75.2 \\ 76 \end{pmatrix} \cdot ksi \qquad f_{s\_sp} = \begin{pmatrix} 73 \\ 73.5 \\ 74.1 \\ 75 \\ 73.8 \\ 74.7 \end{pmatrix} \cdot ksi$$

Crack width × 10^{-3} (in)



Specimen: C1	Sheet:	1	of	1
Average Load: 14.5^{k}	Drawn by:	KS	Checked by:	
Average Deflection: .08"	Date:	3/21/16		

Crack width × 10^{-3} (in)



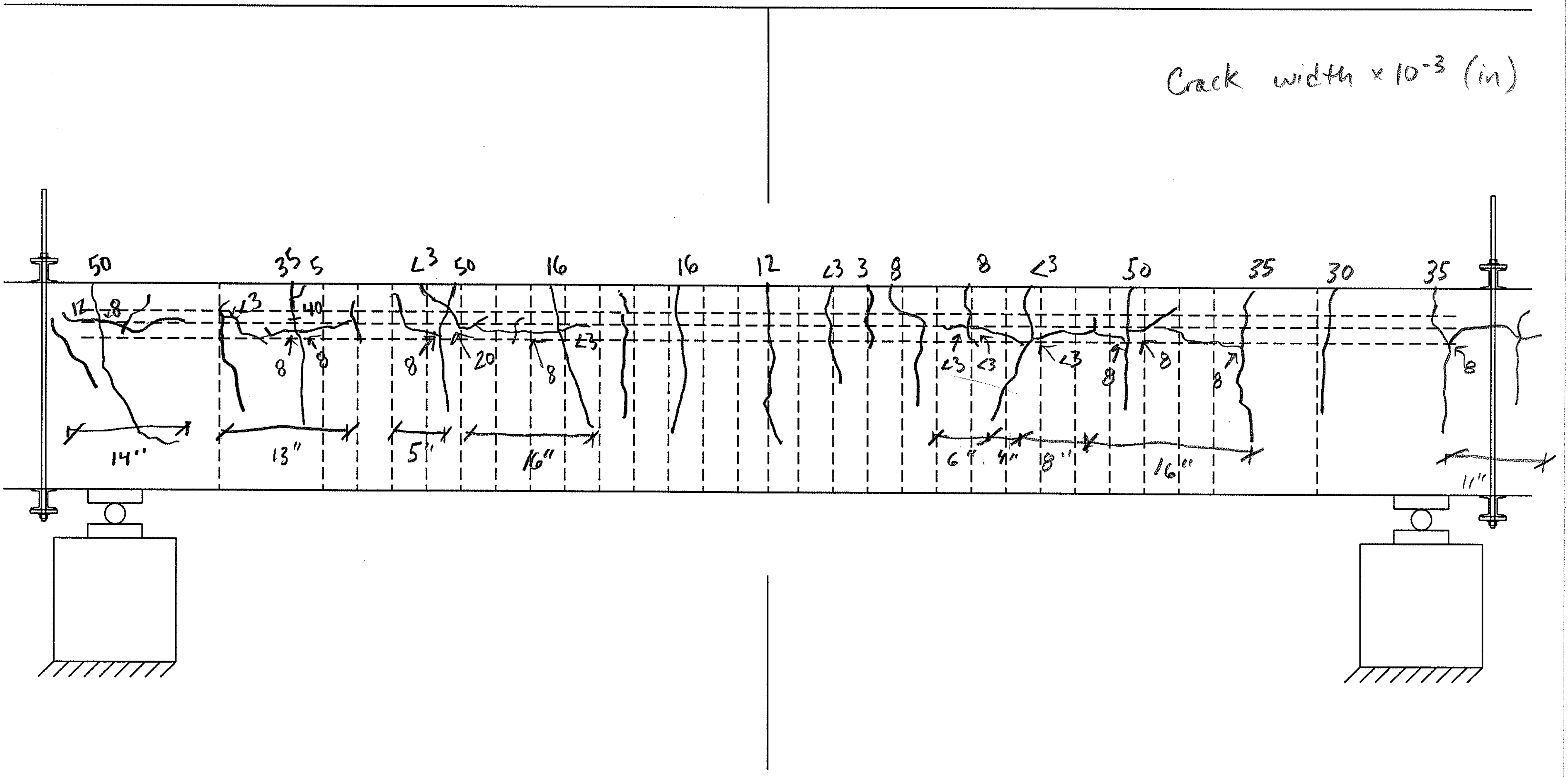
Note: Lam Crack Widths @ root of crack

: Vert. Crack @ top

BOWEN LABORATORY
PURDUE UNIVERSITY

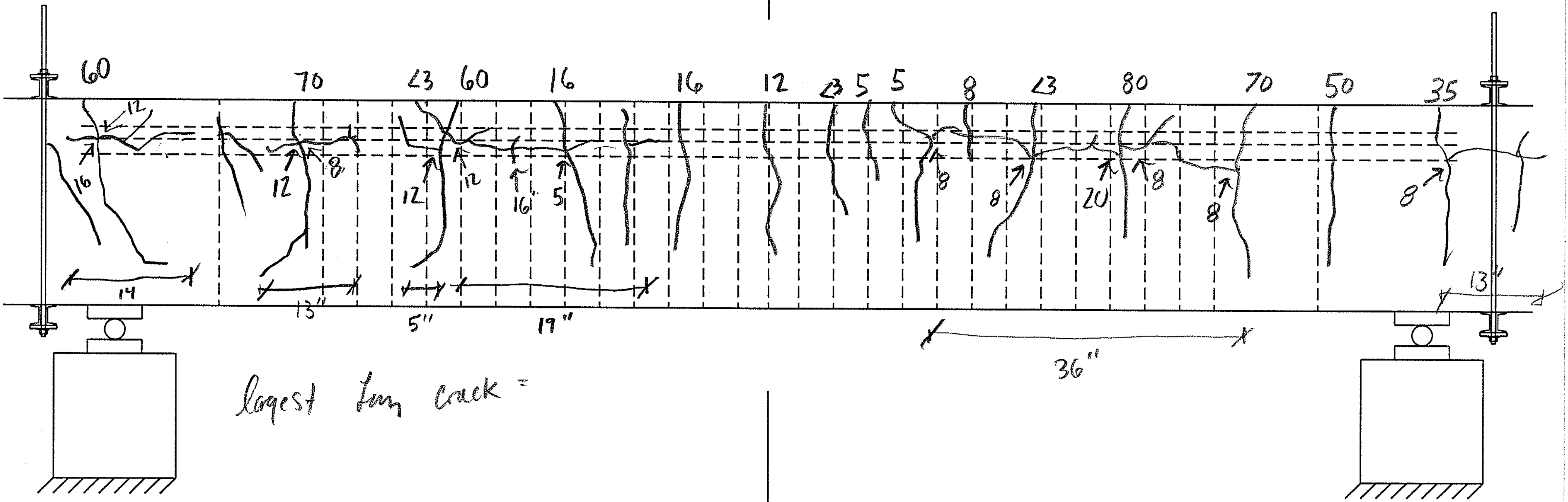
Specimen:	C1	Sheet:	1	of	1
Average Load:	23.2^{K}	Drawn by:	KS	Checked by:	
Average Deflection:	.16 in	Date:			

Crack width $\times 10^{-3}$ (in)



BOWEN LABORATORY
PURDUE UNIVERSITY

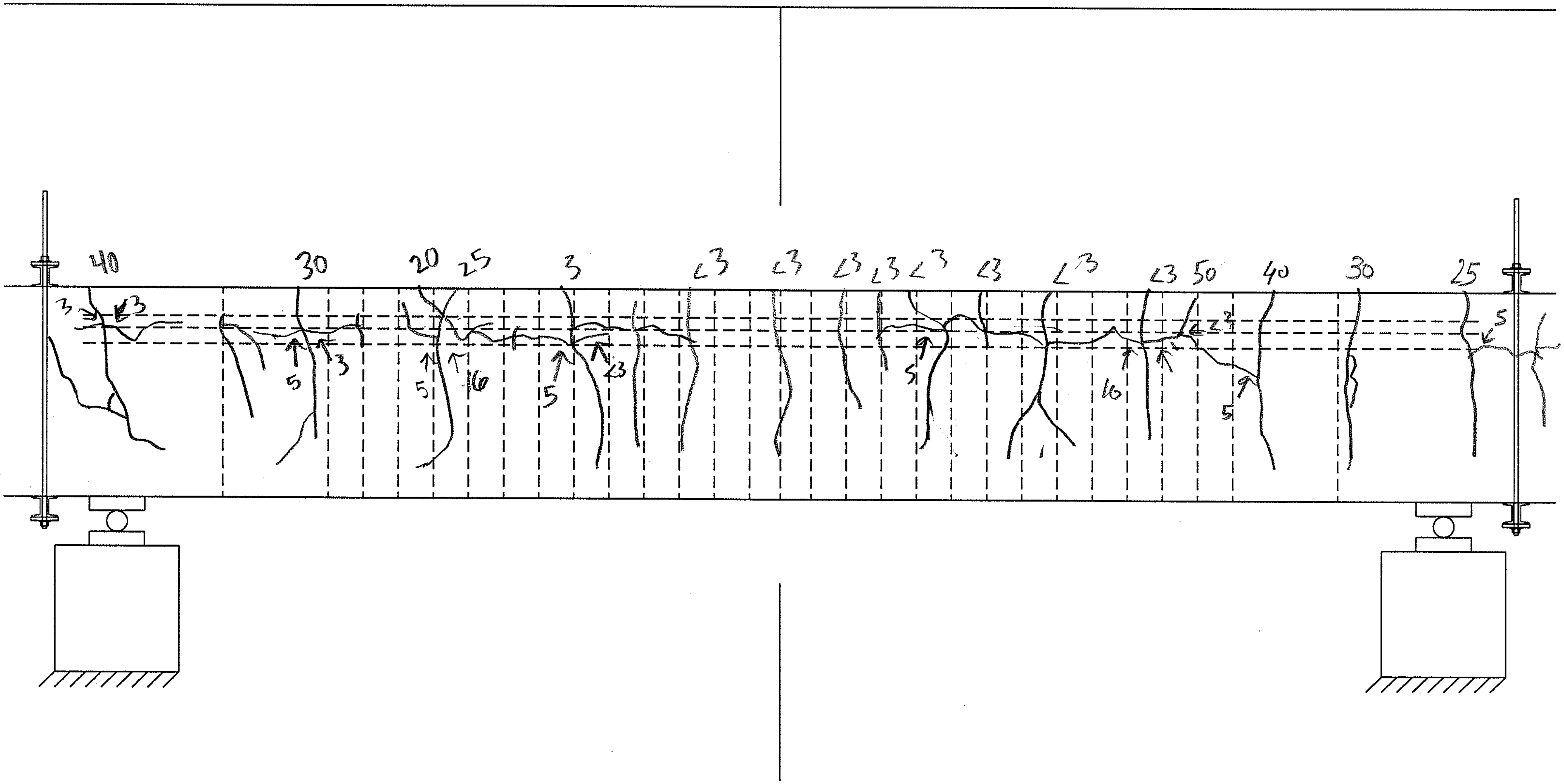
Specimen: C1		Sheet:	1	of	1
Average Load: 31.5k		Drawn by:	KS	Checked by:	LL
Average Deflection: .24 in		Date:			



largest fan crack =

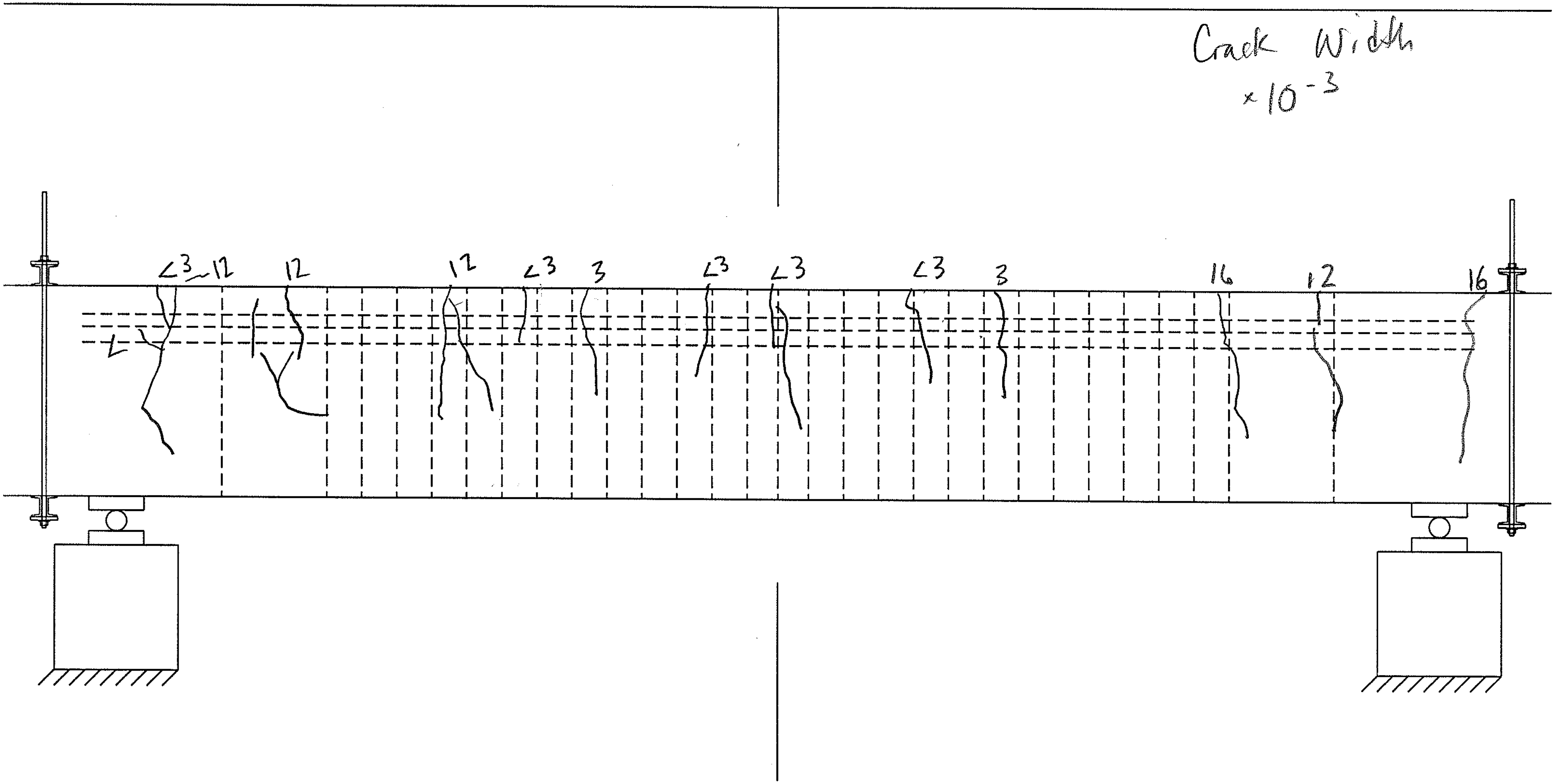
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C1	Sheet:	1	of	1
Average Load:	35.6^{K}	Drawn by:	KS	Checked by:	
Average Deflection:	.32 in	Date:			



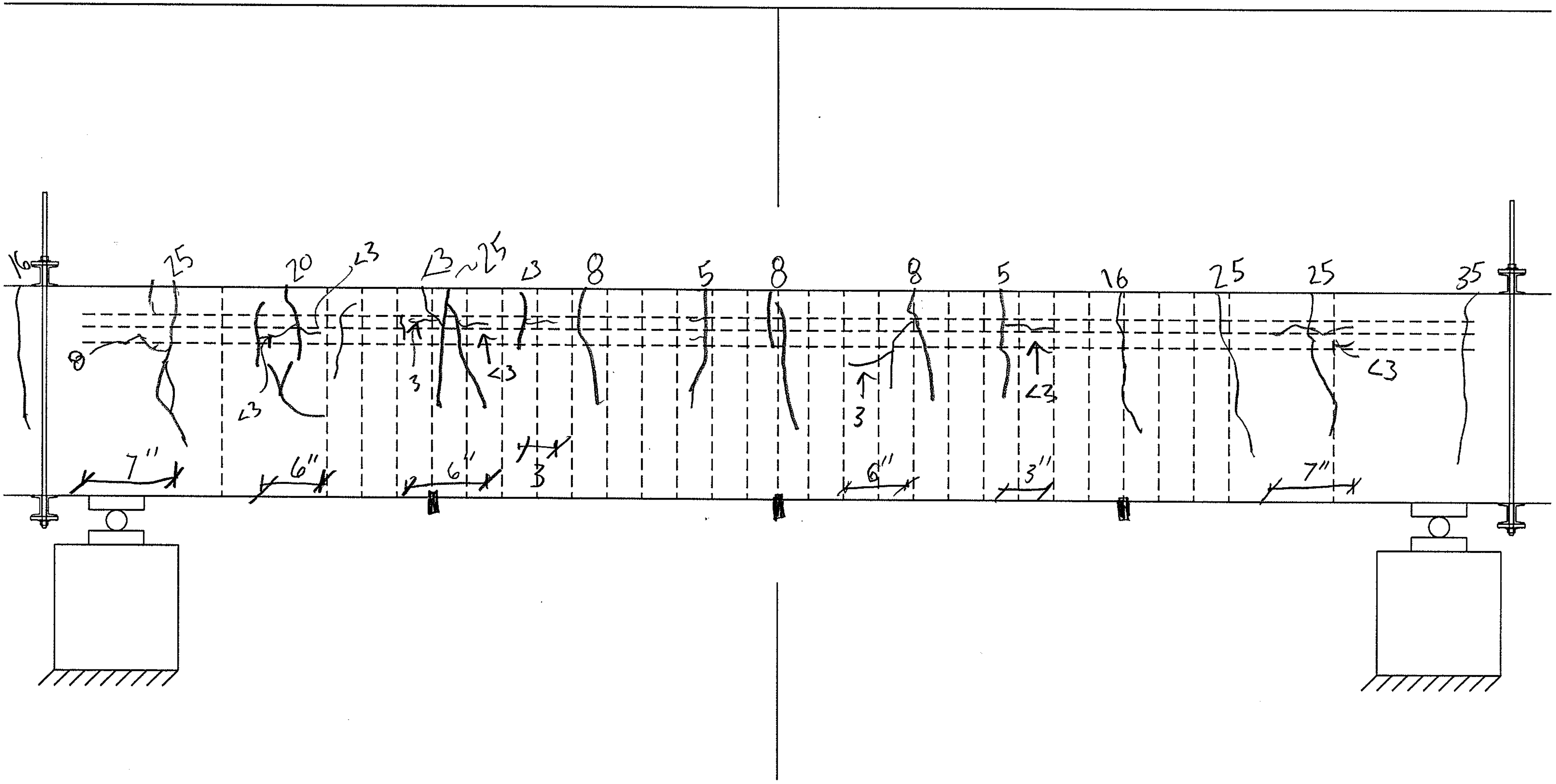
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: C1	Sheet:	1	of	1
Average Load: 0 K (unload)	Drawn by:	KS	Checked by:	
Average Deflection: .163 in	Date:			



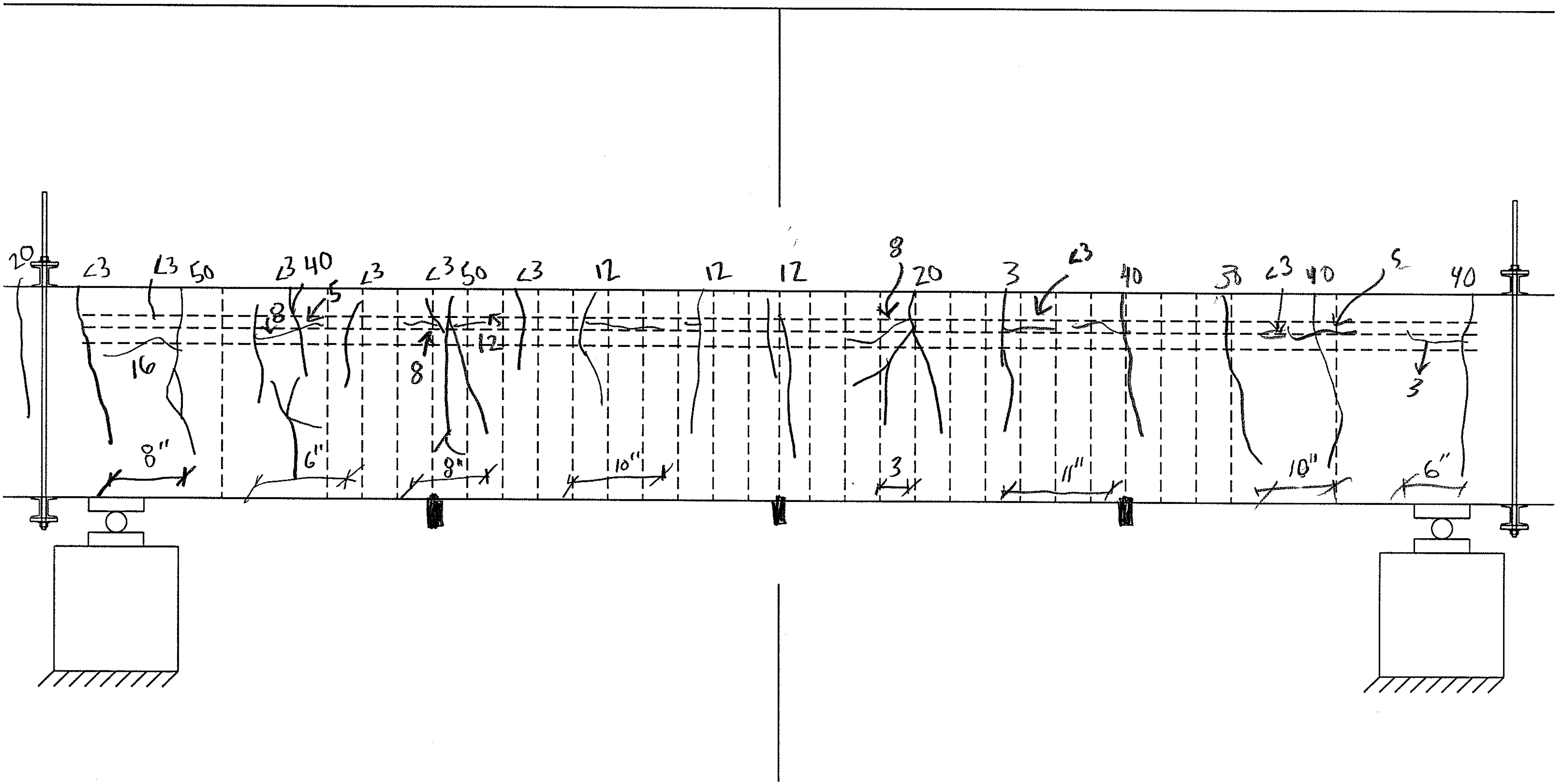
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C2	Sheet:	1	of	1
Average Load:	14.1^{k}	Drawn by:	KS	Checked by:	
Average Deflection:	0.08 in	Date:	3/28/16		



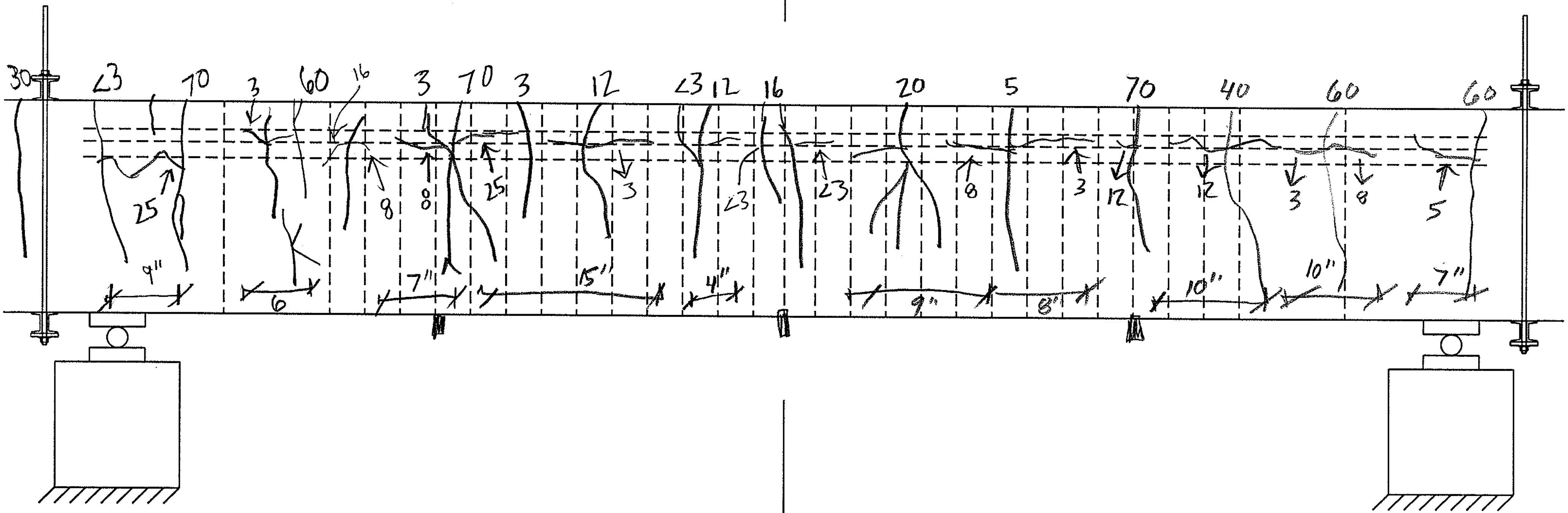
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C2	Sheet:	1	of	1
Average Load:	22,8 k	Drawn by:	KS	Checked by:	
Average Deflection:	.16 in	Date:	3/28/16		



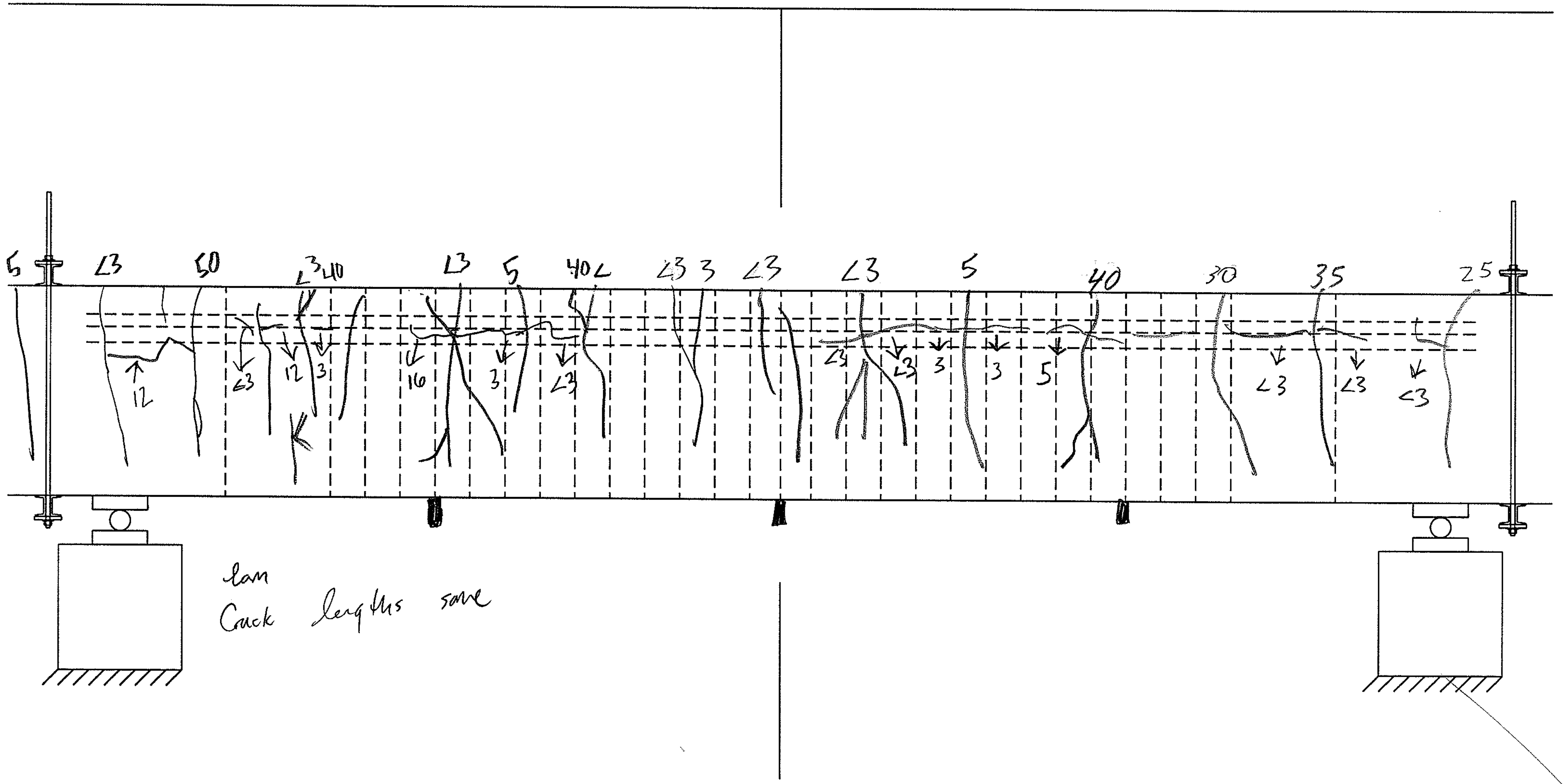
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C2	Sheet:	1	of	1
Average Load:	31.1 k	Drawn by:	KS	Checked by:	
Average Deflection:	.24 in	Date:	3/28/16		



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C2	Sheet:	1	of	1
Average Load:	35.9 K	Drawn by:	KS	Checked by:	
Average Deflection:	.32 in	Date:	3/28/16		

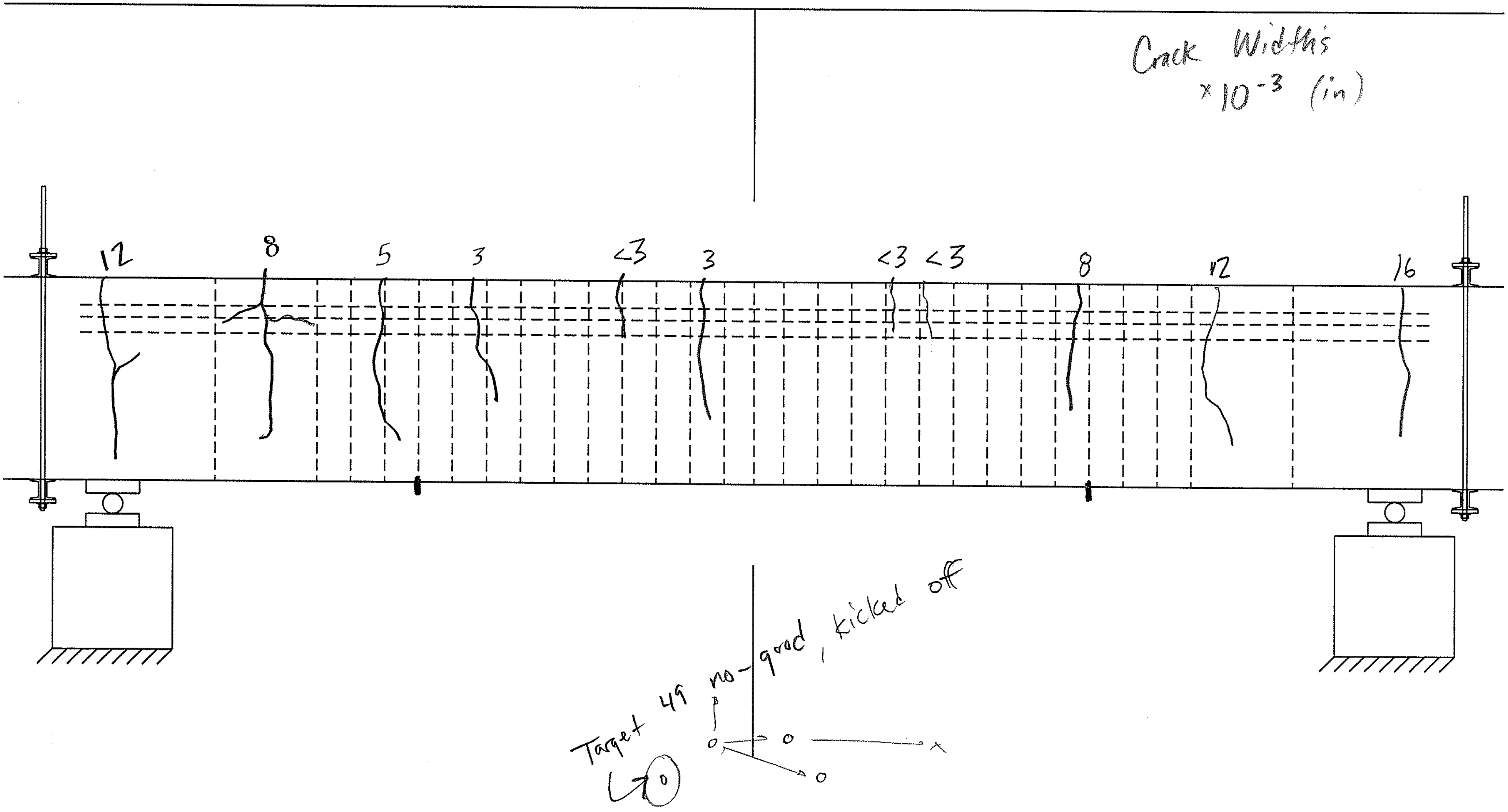


lam
Crack lengths same

BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C2	Sheet:	1	of	1
Average Load:	0k (unload)	Drawn by:	KS	Checked by:	
Average Deflection:	0.16 in	Date:	3/28/16		

Crack Widths
x10^{-3} (in)

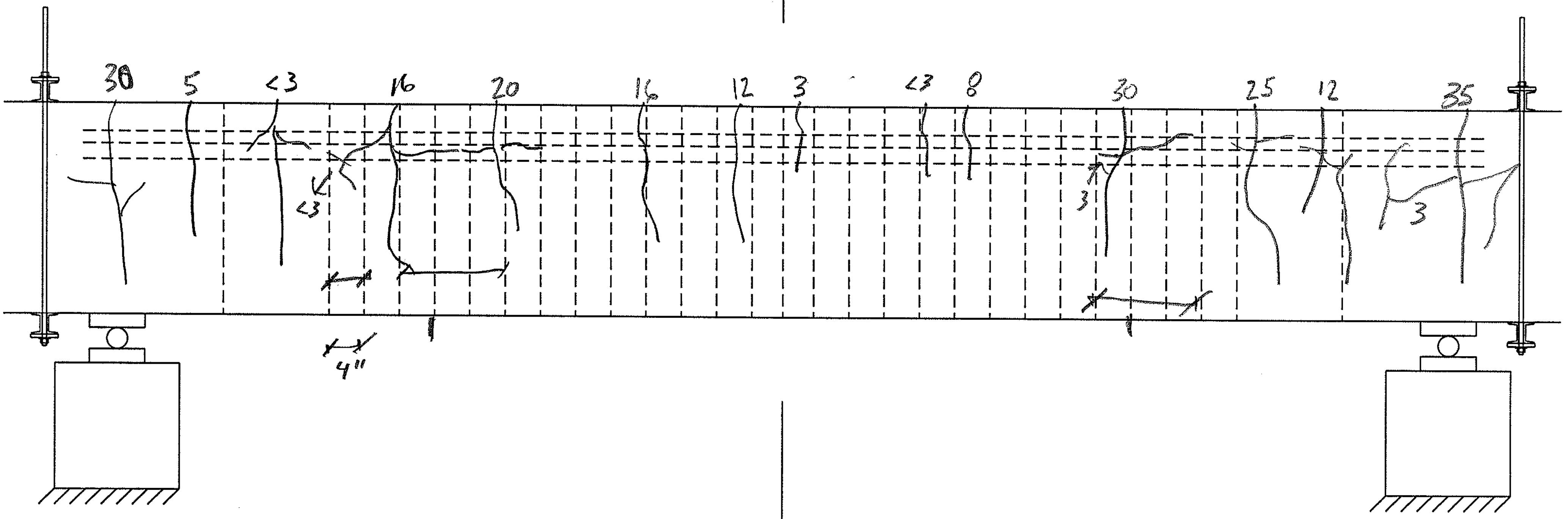


Target 49 no-good, kicked off
70

BOWEN LABORATORY
PURDUE UNIVERSITY

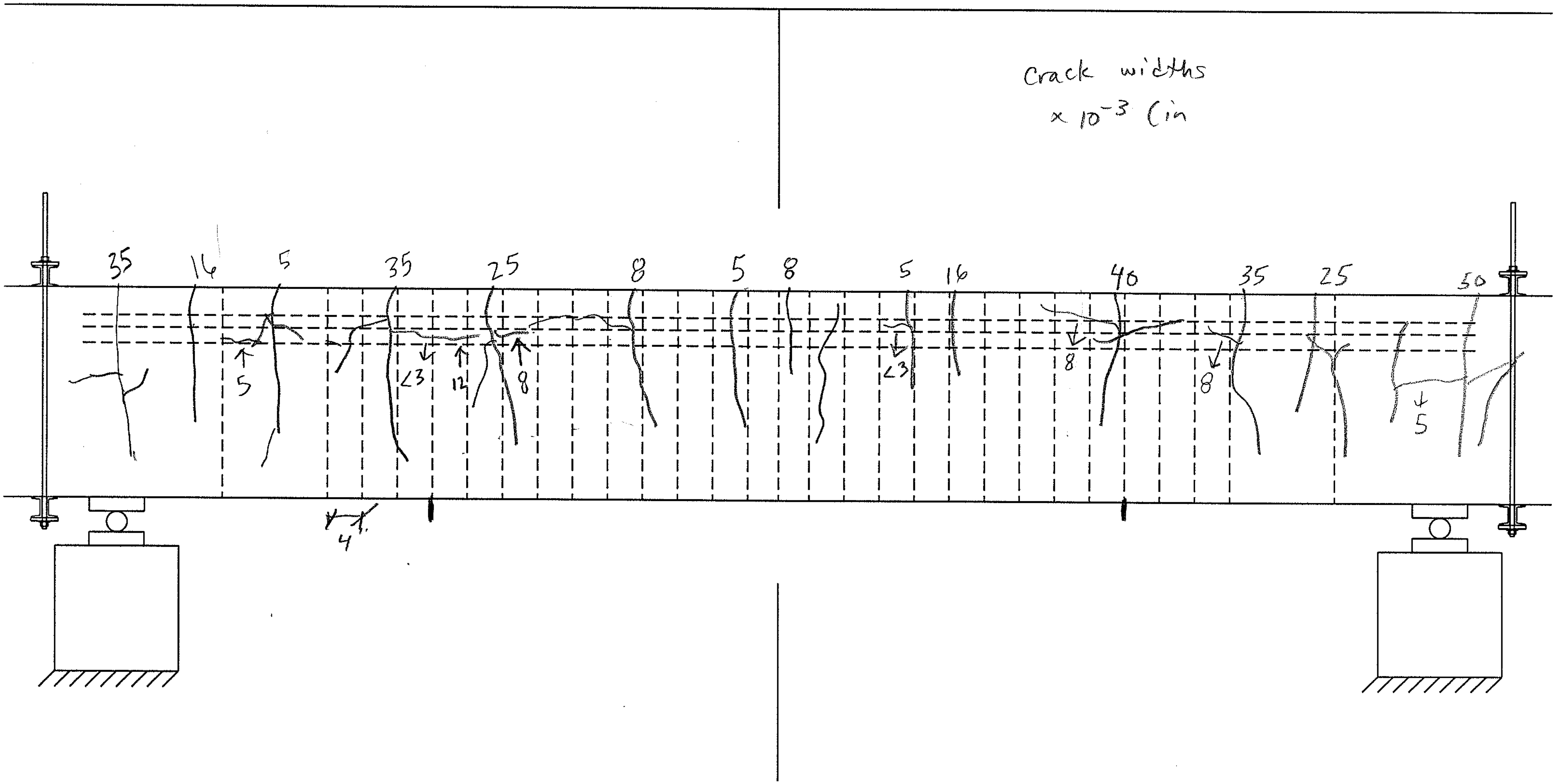
Specimen:	C3	Sheet:	1	of	1
Average Load:	15.2 K	Drawn by:	KS	Checked by:	
Average Deflection:	.08 in	Date:	4/4/16		

Crack Widths $\times 10^{-3}$ (in)



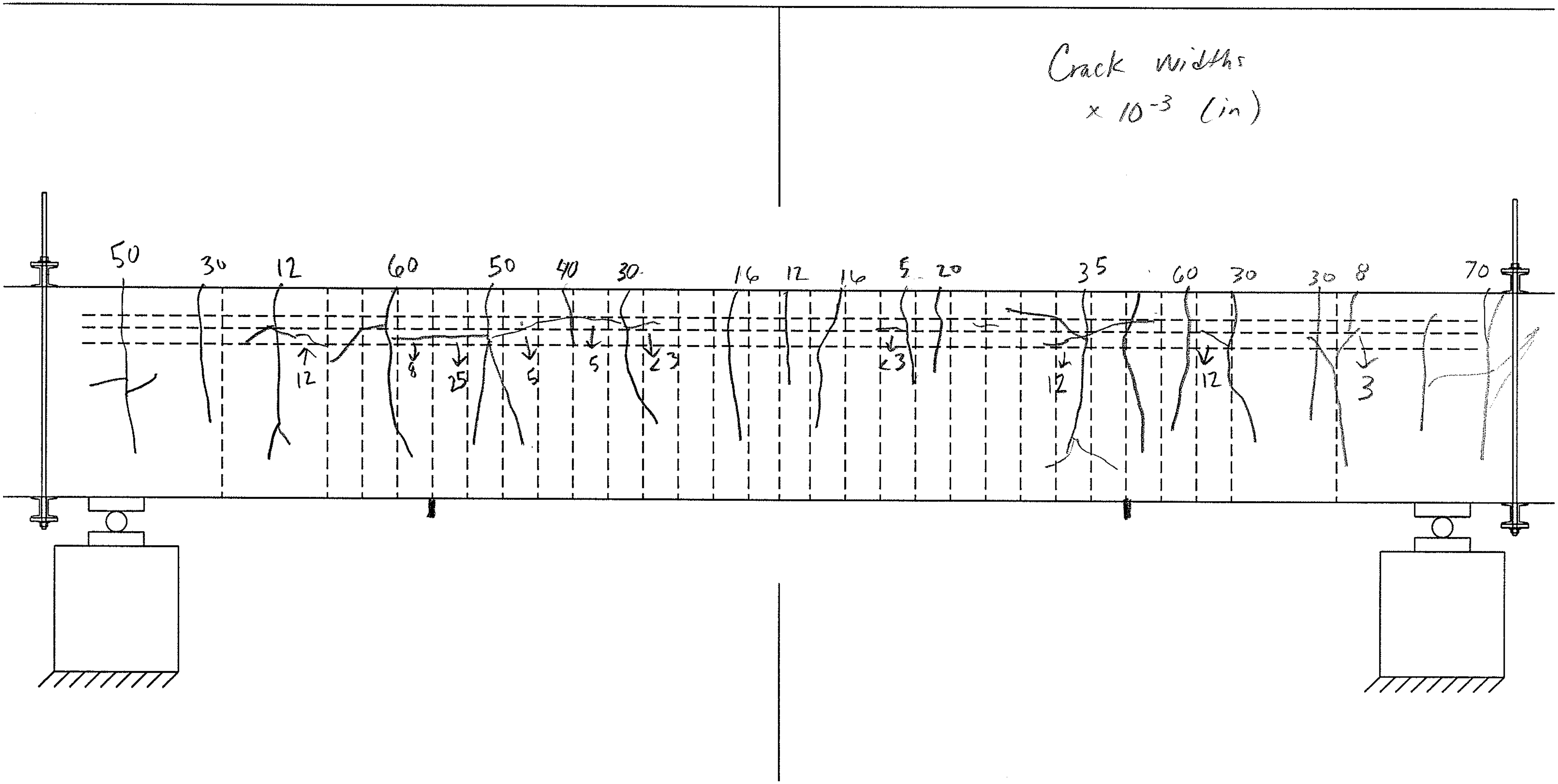
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C3	Sheet:	1	of	1
Average Load:	$23{,}6^{K}$	Drawn by:	KS	Checked by:	
Average Deflection:	0.16^{K}	Date:	4/4/16		


Crack widths $\times 10^{-3}$ (in

BOWEN LABORATORY
PURDUE UNIVERSITY

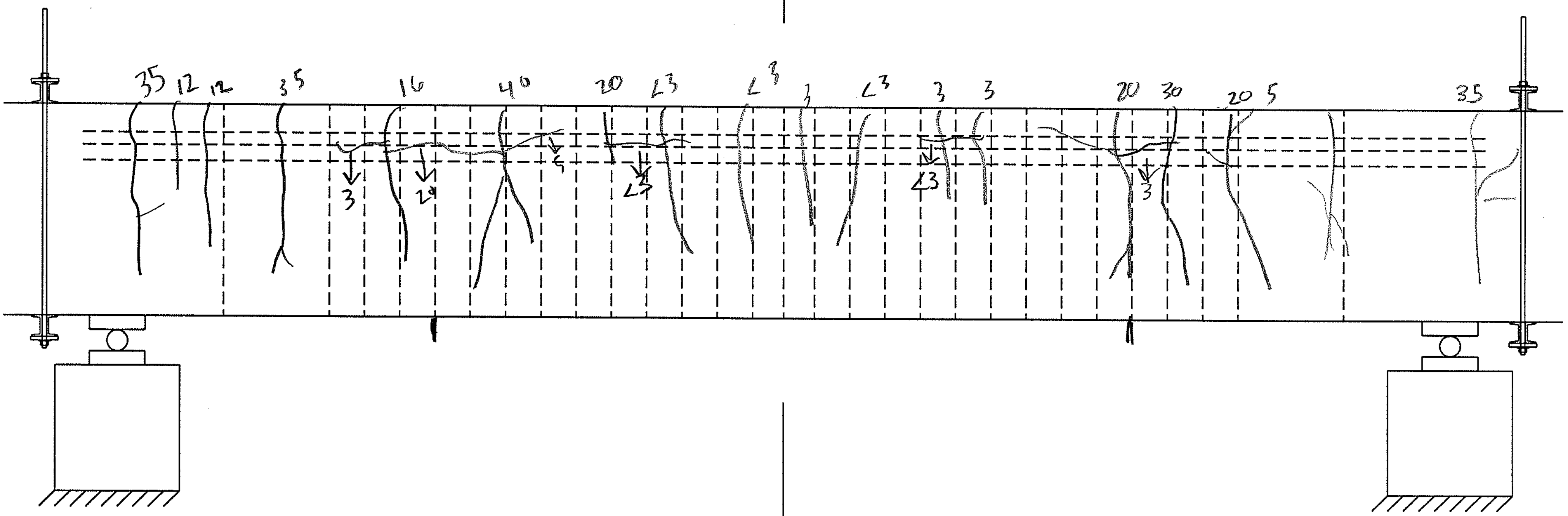
Specimen:	C3	Sheet:	1	of	1
Average Load:	32.6^K	Drawn by:	KS	Checked by:	
Average Deflection:	.24 in	Date:	4/4/16		



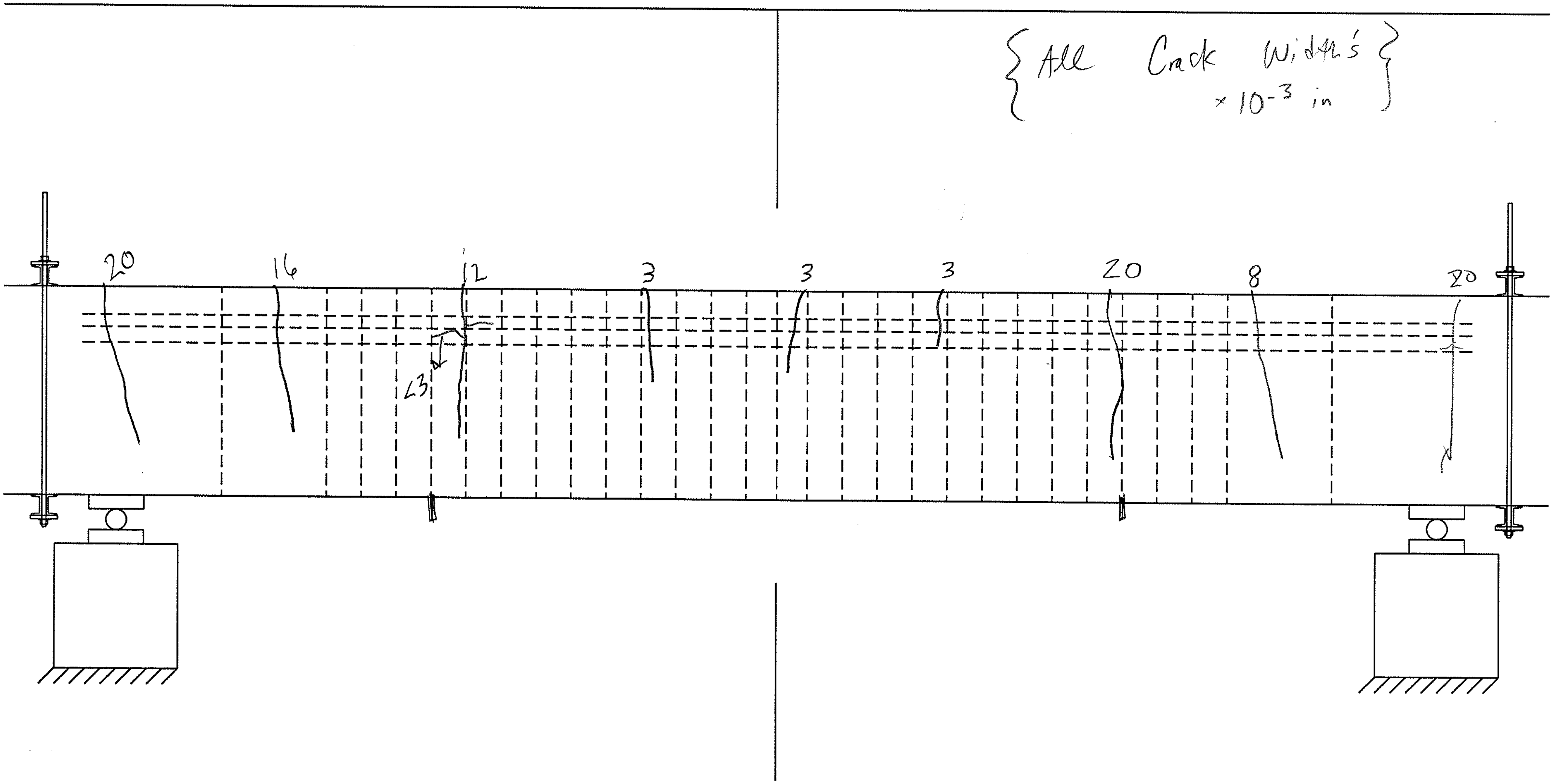
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C3	Sheet:	1	of	1
Average Load:	36.6 K	Drawn by:	KS	Checked by:	
Average Deflection:	.32 in	Date:	4/4/16		

Crack widths
x 10^{-3} (in)



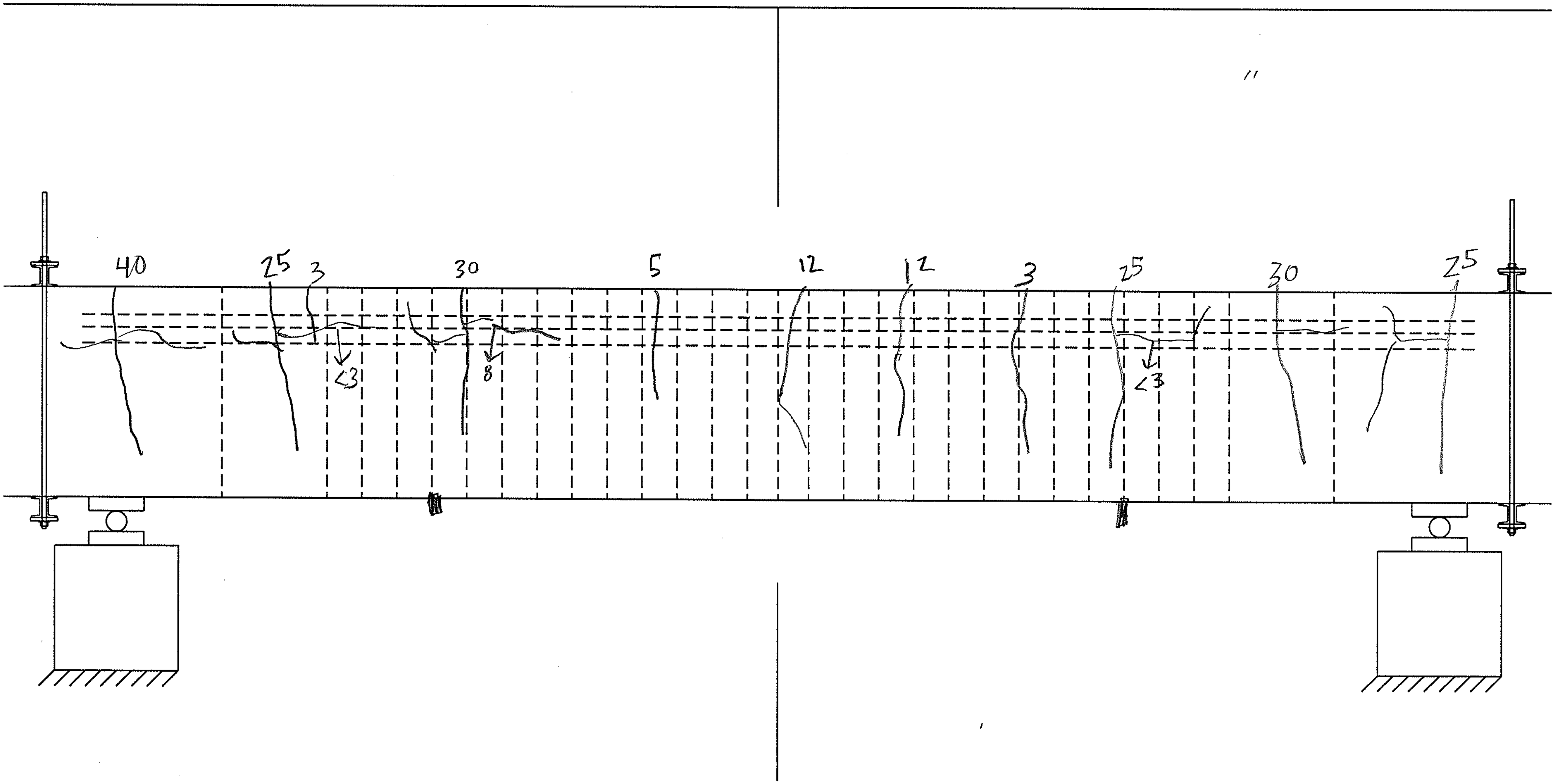
BOWEN LABORATORY PURDUE UNIVERSITY	Specimen: C3	Sheet:	1	of	1
	Average Load: 0k unload	Drawn by:		Checked by:	
	Average Deflection: .16 in	Date:	4/4/16		



{All Crack Widths ×10^{-3} in}

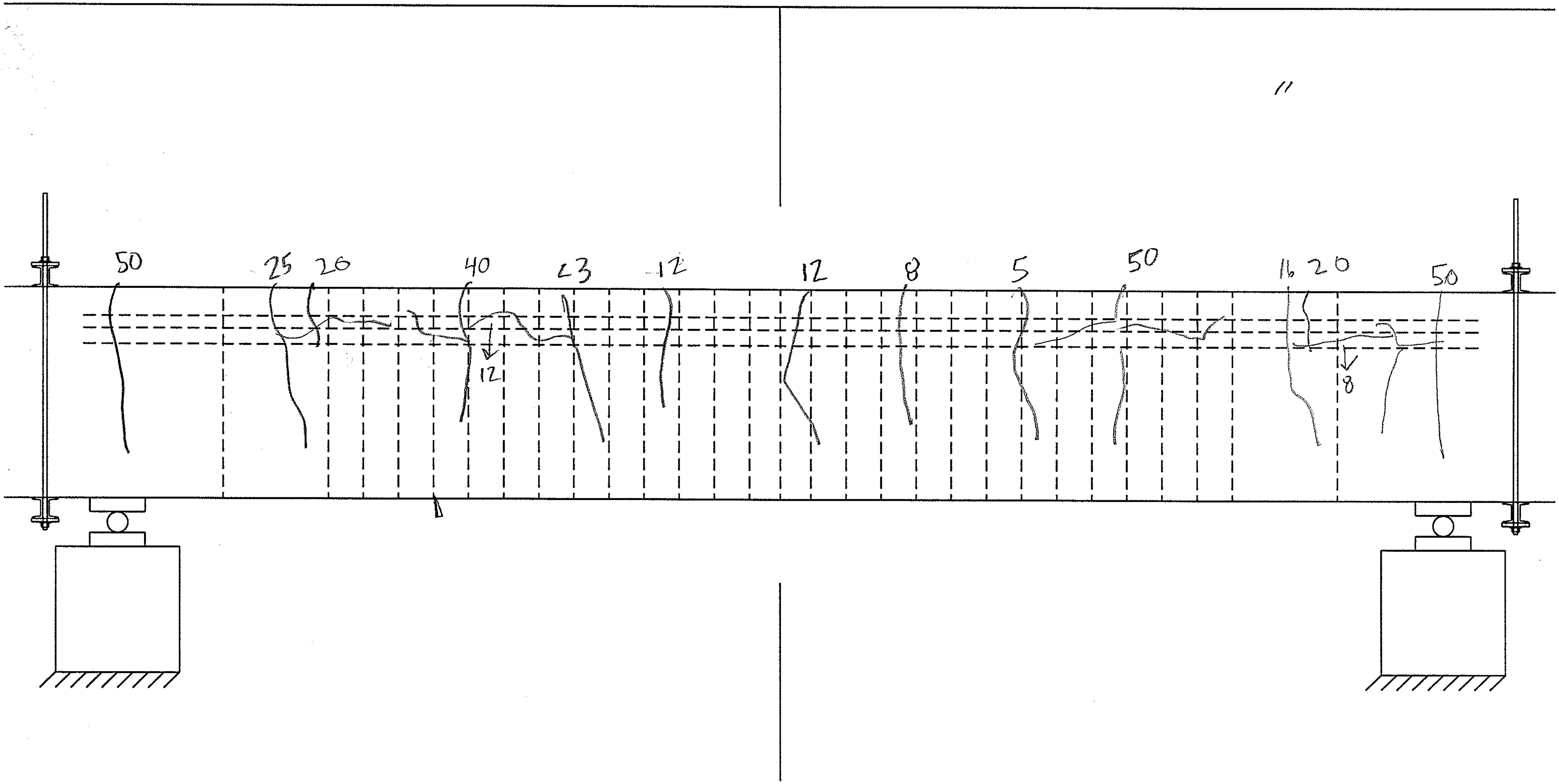
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C4	Sheet:	1	of	1
Average Load:	15.2 K	Drawn by:	KS	Checked by:	
Average Deflection:	0.08 in	Date:	4/11/16		



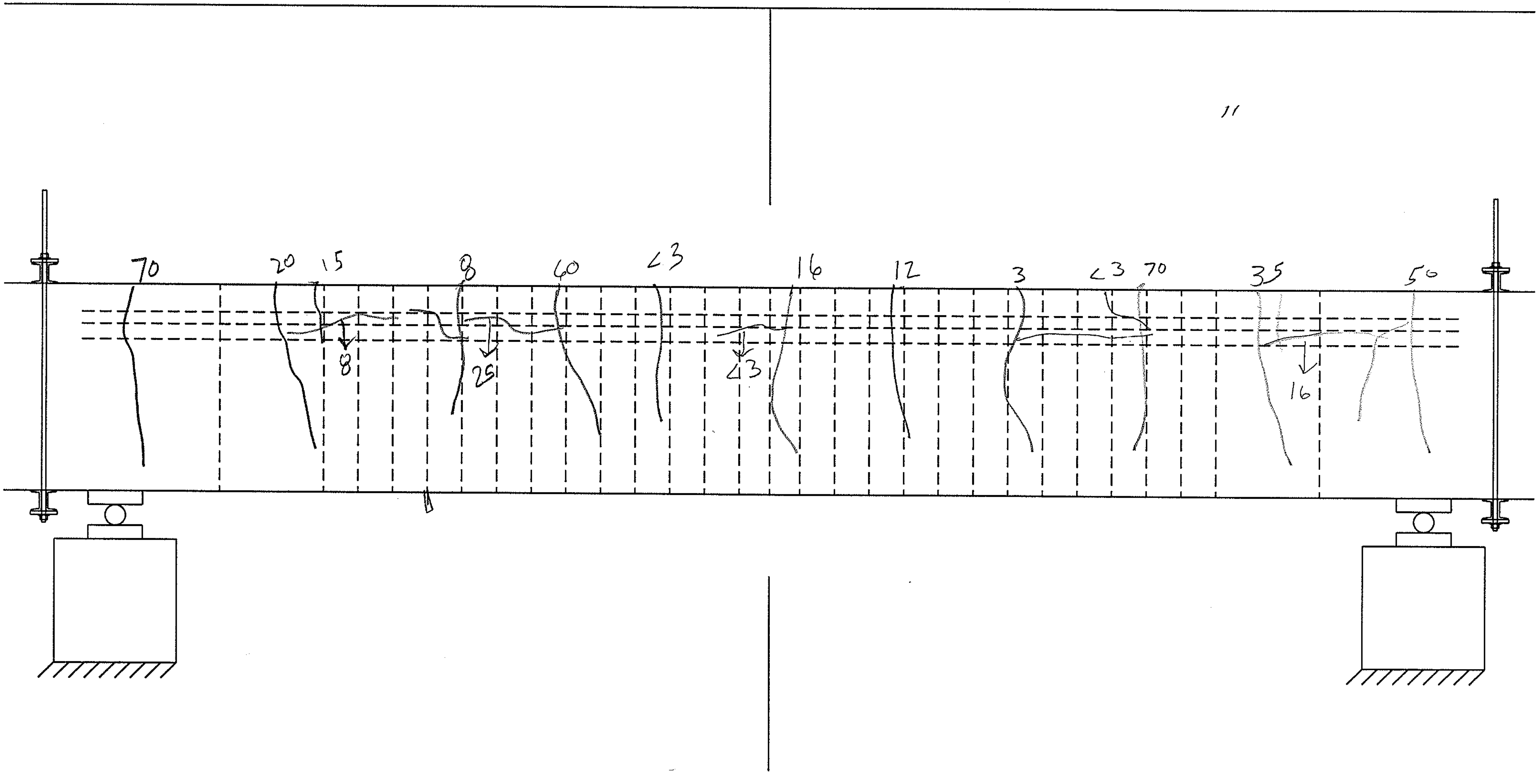
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C4	Sheet:	1	of	1
Average Load:	23.8^{k}	Drawn by:	KS	Checked by:	
Average Deflection:	0.16 in	Date:	4/11/16		



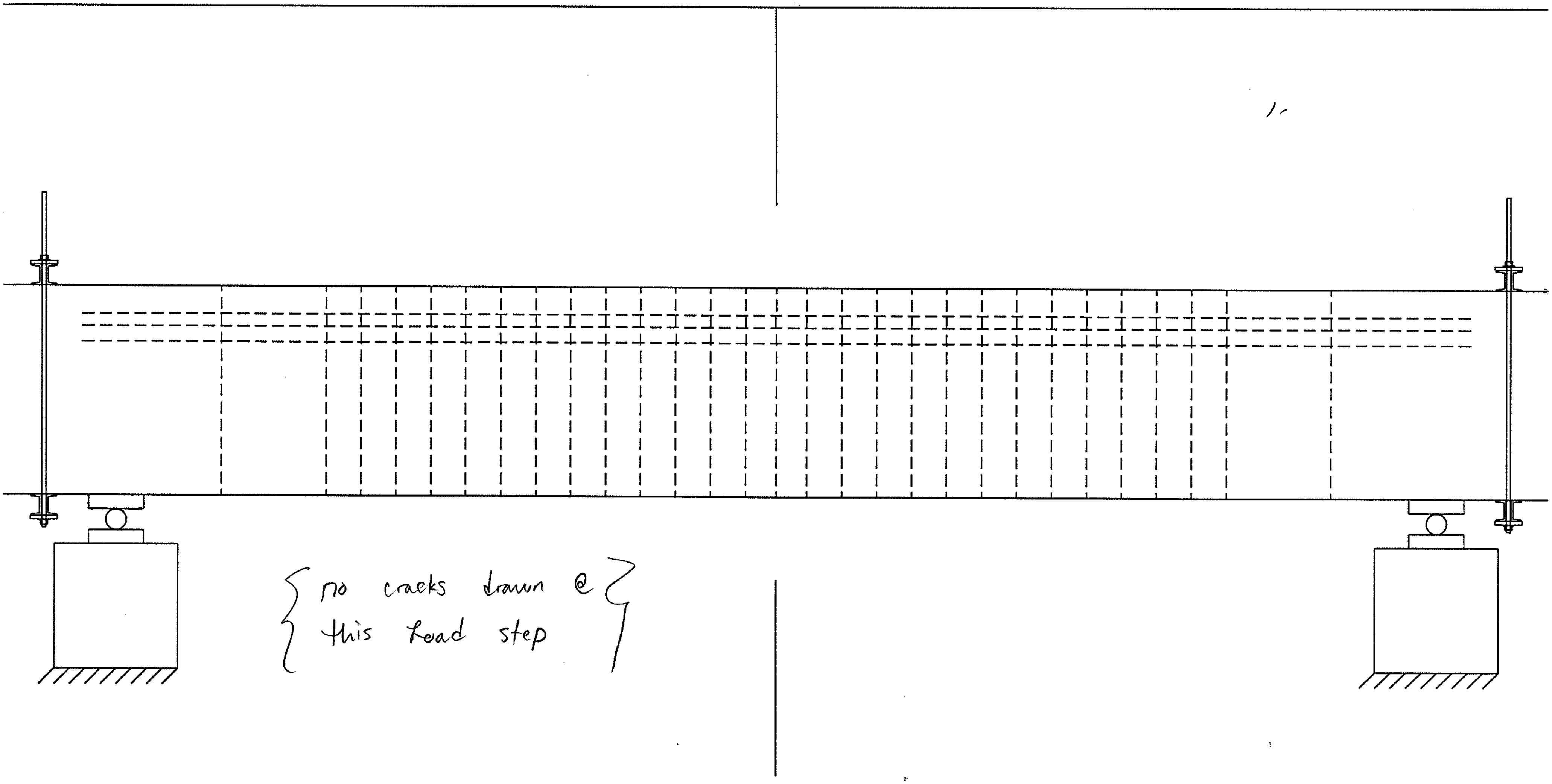
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C4	Sheet:	1	of	1
Average Load:	32.6^K	Drawn by:	KS	Checked by:	
Average Deflection:	0.24 in	Date:	4/11/16		



BOWEN LABORATORY
PURDUE UNIVERSITY

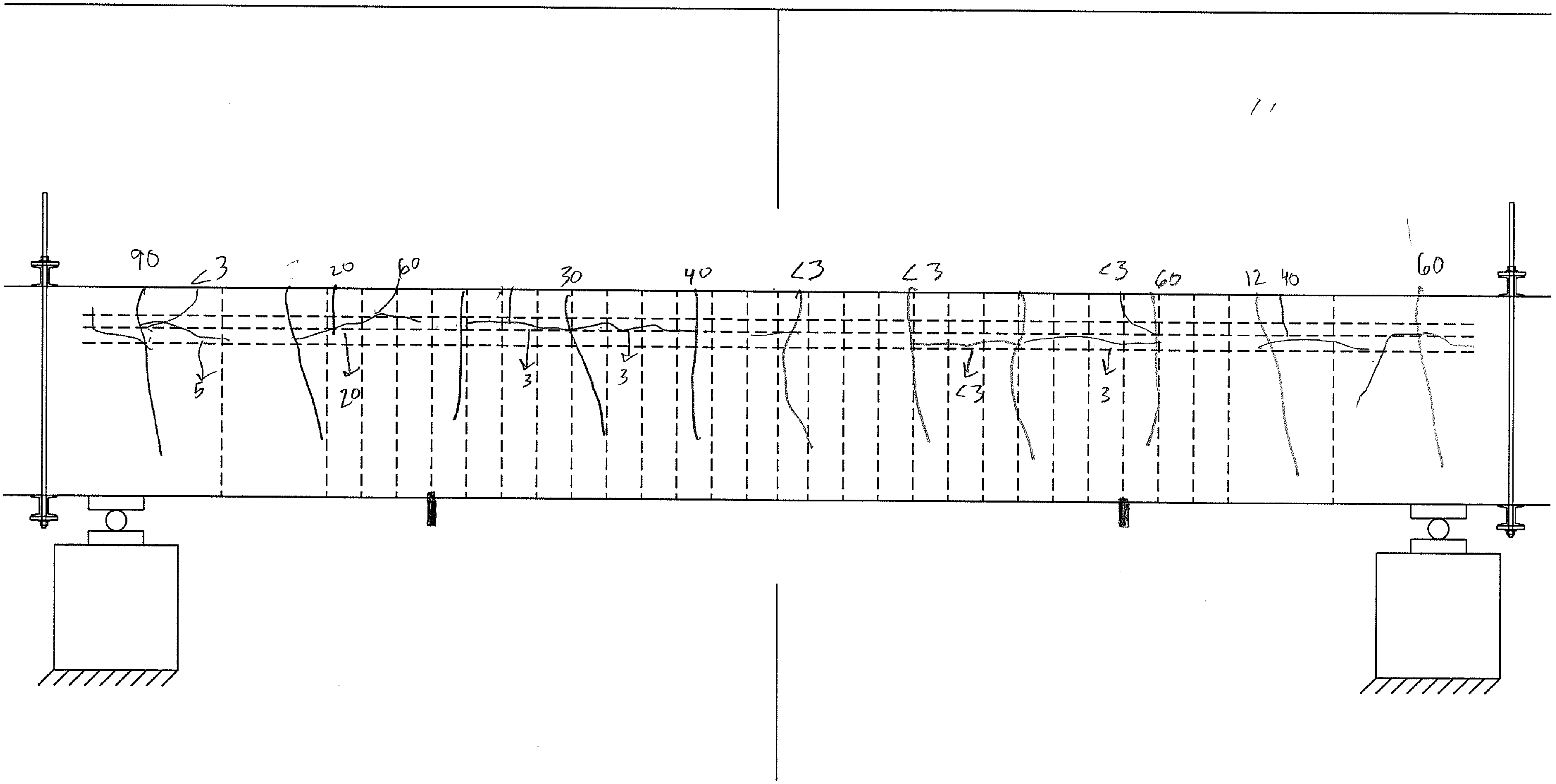
Specimen:	C4	Sheet:	1	of	1
Average Load:	36.6 K	Drawn by:	KS	Checked by:	
Average Deflection:	0.32 in	Date:	4/11/16		



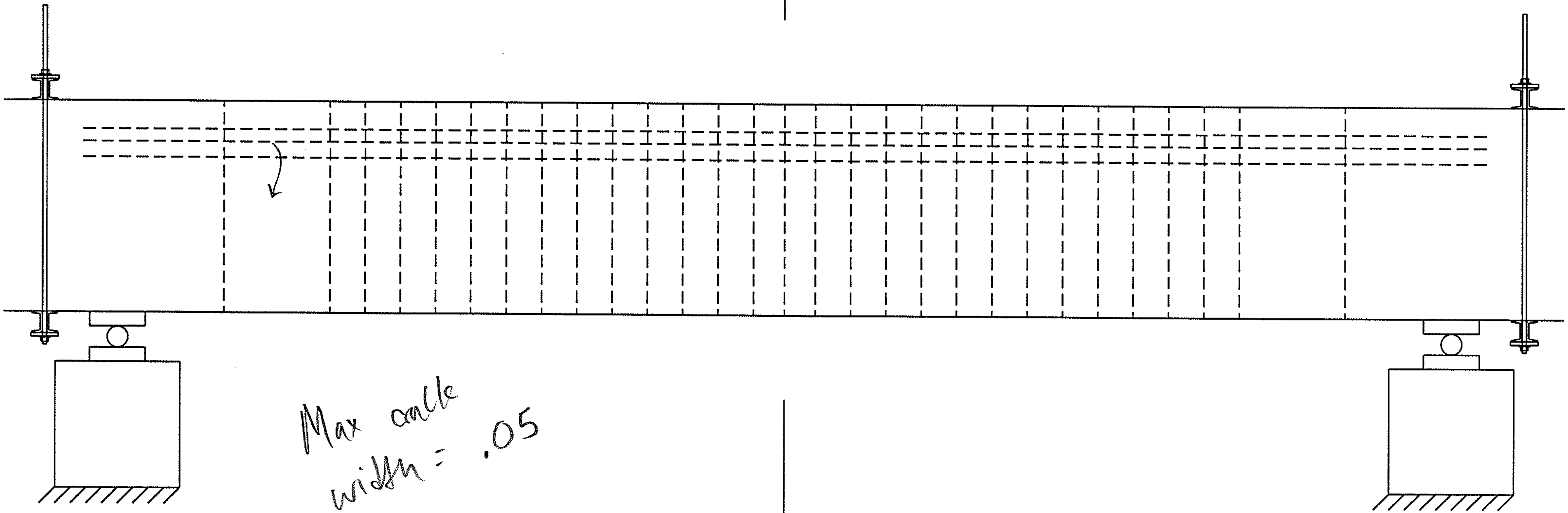
{no cracks drawn @ this load step}

BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C4	Sheet:	1	of	1
Average Load:	37.8K	Drawn by:	KS	Checked by:	
Average Deflection:	0.40 in	Date:	4/11/16		



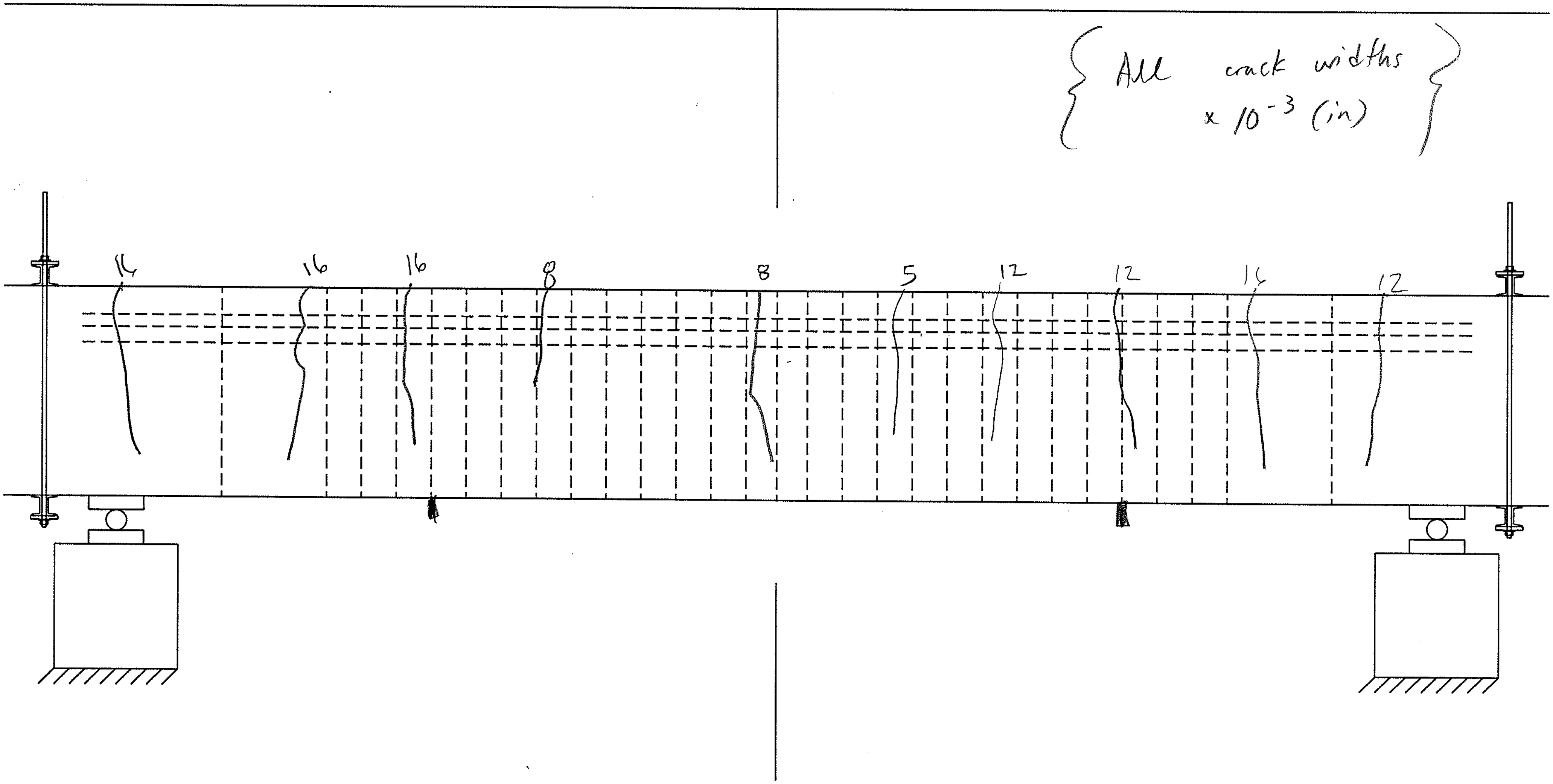
BOWEN LABORATORY PURDUE UNIVERSITY	Specimen:	C4	Sheet:	1	of	1
	Average Load:	$39^k \rightarrow 0^k$ Unload	Drawn by:	RS	Checked by:	
	Average Deflection:	.23 in	Date:	4/11/16		



Max crack width = .05

BOWEN LABORATORY
PURDUE UNIVERSITY

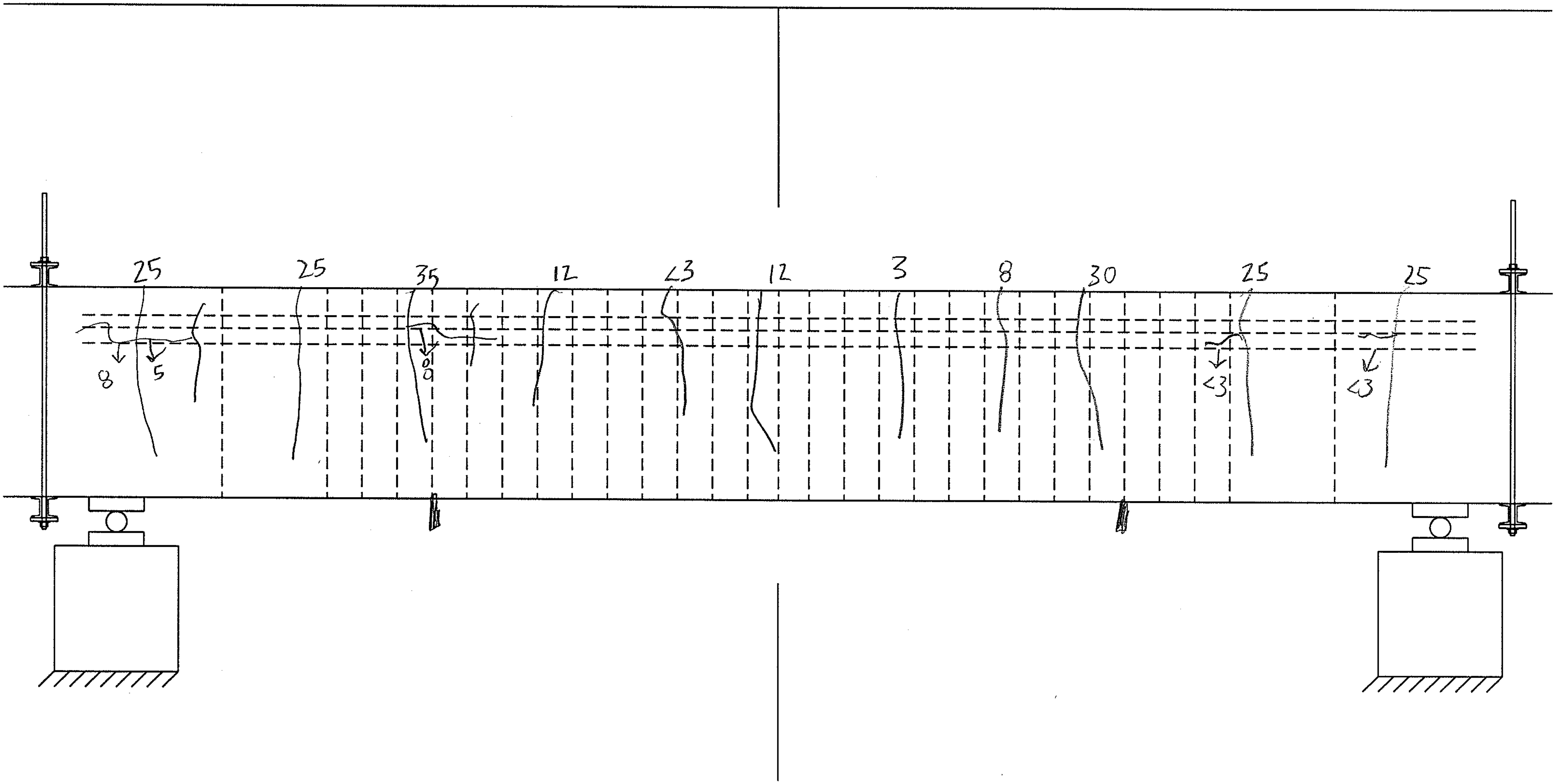
Specimen:	C4	Sheet:	1	of	1
Average Load:	35.1^{K} Reload	Drawn by:	KS	Checked by:	
Average Deflection:	0.48 in	Date:	4/11/16		



{All crack widths $\times 10^{-3}$ (in)}

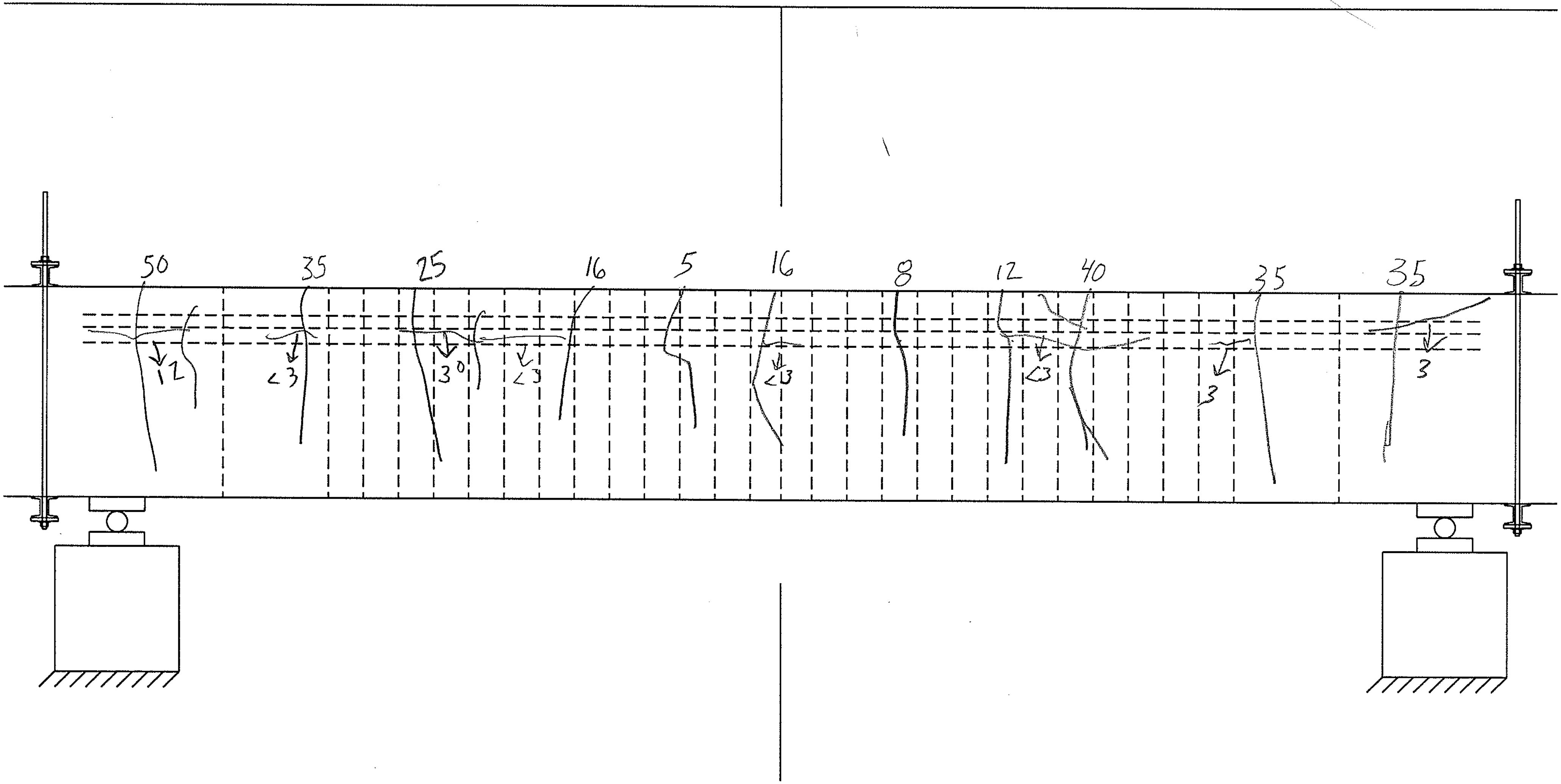
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C5	Sheet:	1	of	1
Average Load:	15.5^k	Drawn by:	KS	Checked by:	
Average Deflection:	0.08 in	Date:	4/12/16		



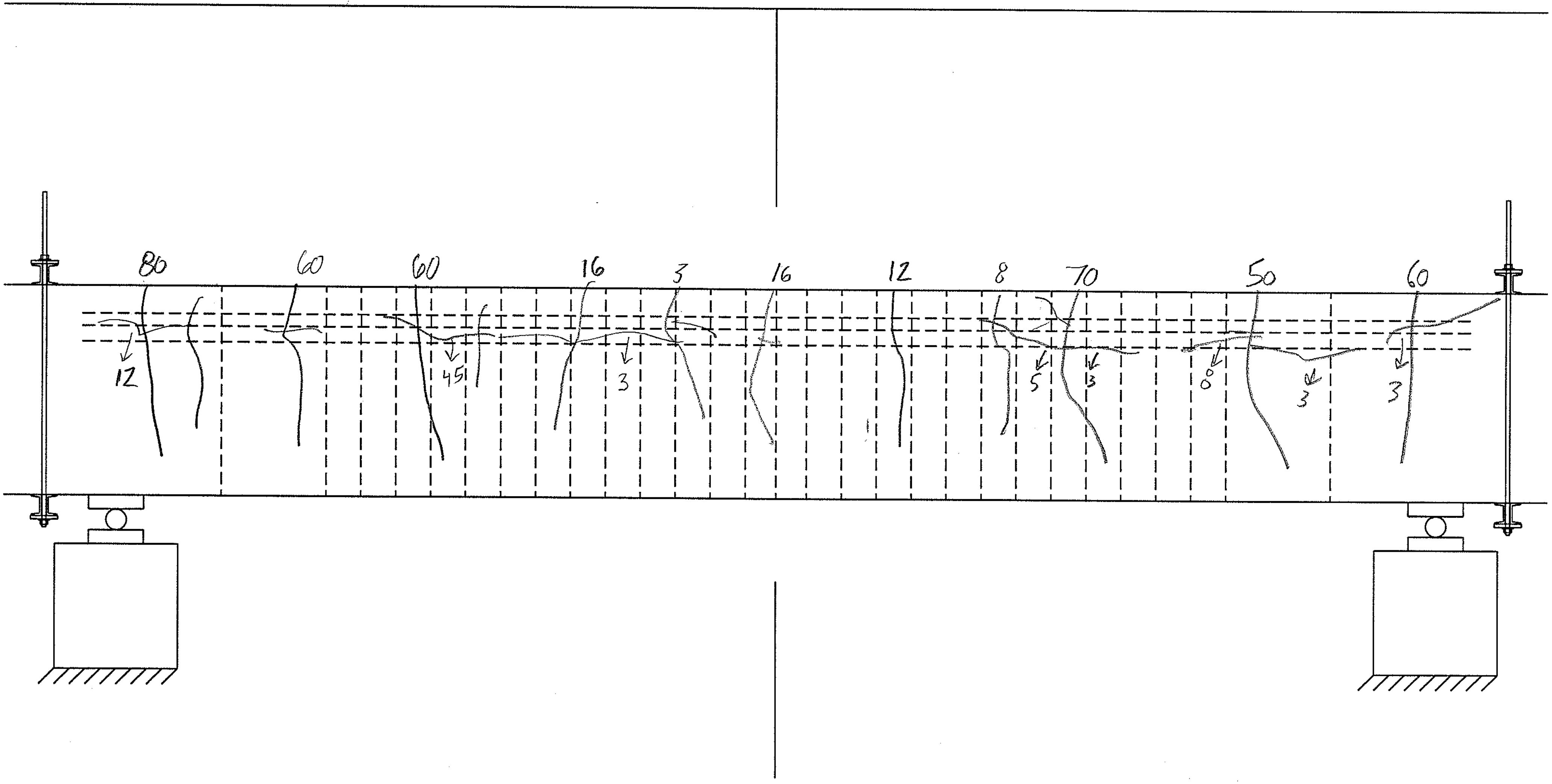
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C5	Sheet:	1	of	1
Average Load:	24.4K	Drawn by:	KS	Checked by:	
Average Deflection:	0.16 in	Date:	4/12/16		



BOWEN LABORATORY
PURDUE UNIVERSITY

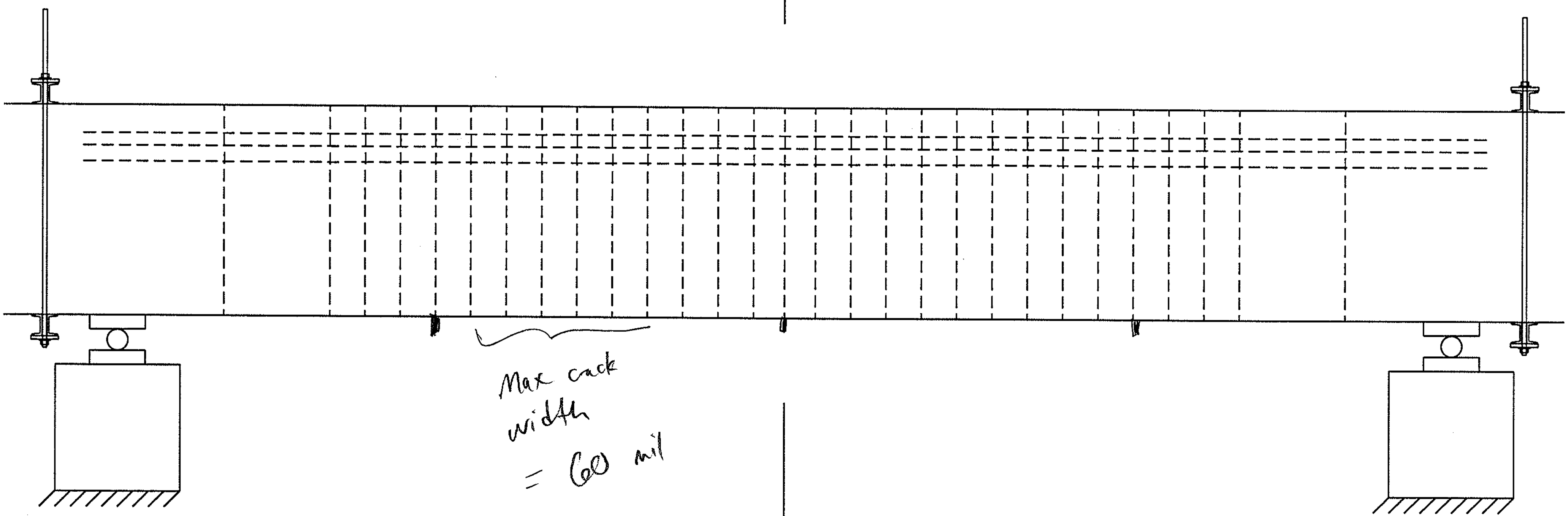
Specimen:	C5	Sheet:	1	of	1
Average Load:	33.3K	Drawn by:	KS	Checked by:	
Average Deflection:	0.24 in.	Date:	4/12/16		



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C5	Sheet:	1	of	1
Average Load:	36 K	Drawn by:	KS	Checked by:	
Average Deflection:	0.32 in	Date:	4/12/16		

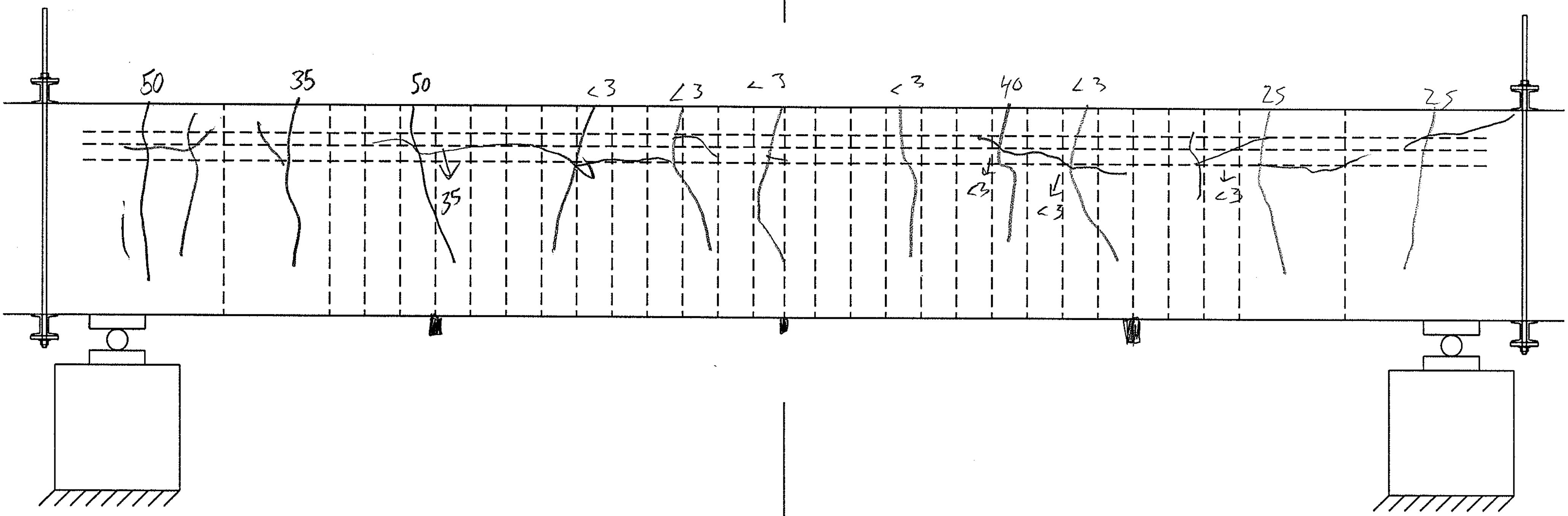
Crack width $\times 10^{-3}$ in



Max crack width = 60 mil

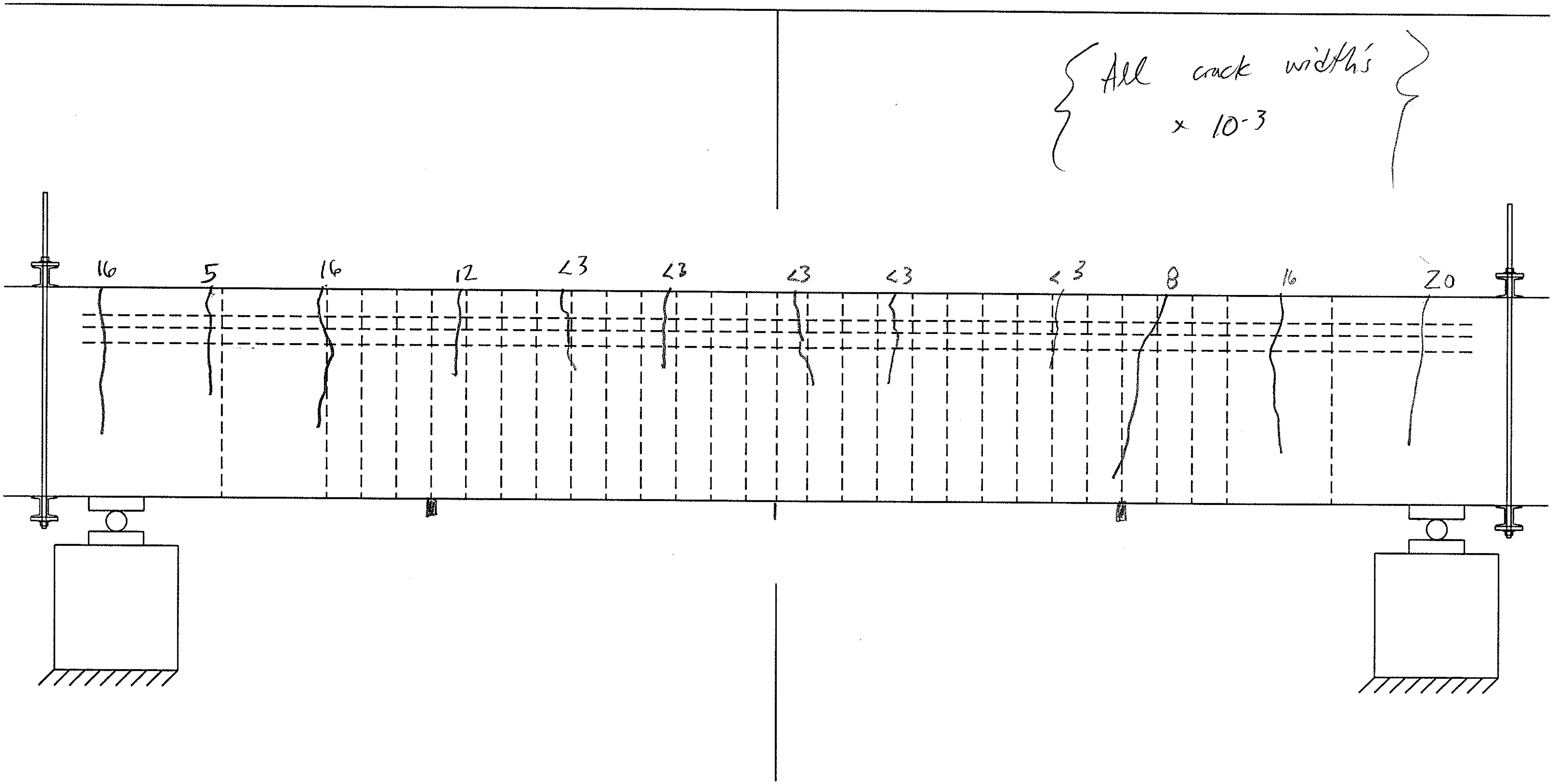
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C5	Sheet:	1	of	1
Average Load:	37.2^{K}	Drawn by:	KS	Checked by:	
Average Deflection:	0.40 in	Date:	4/12/16		



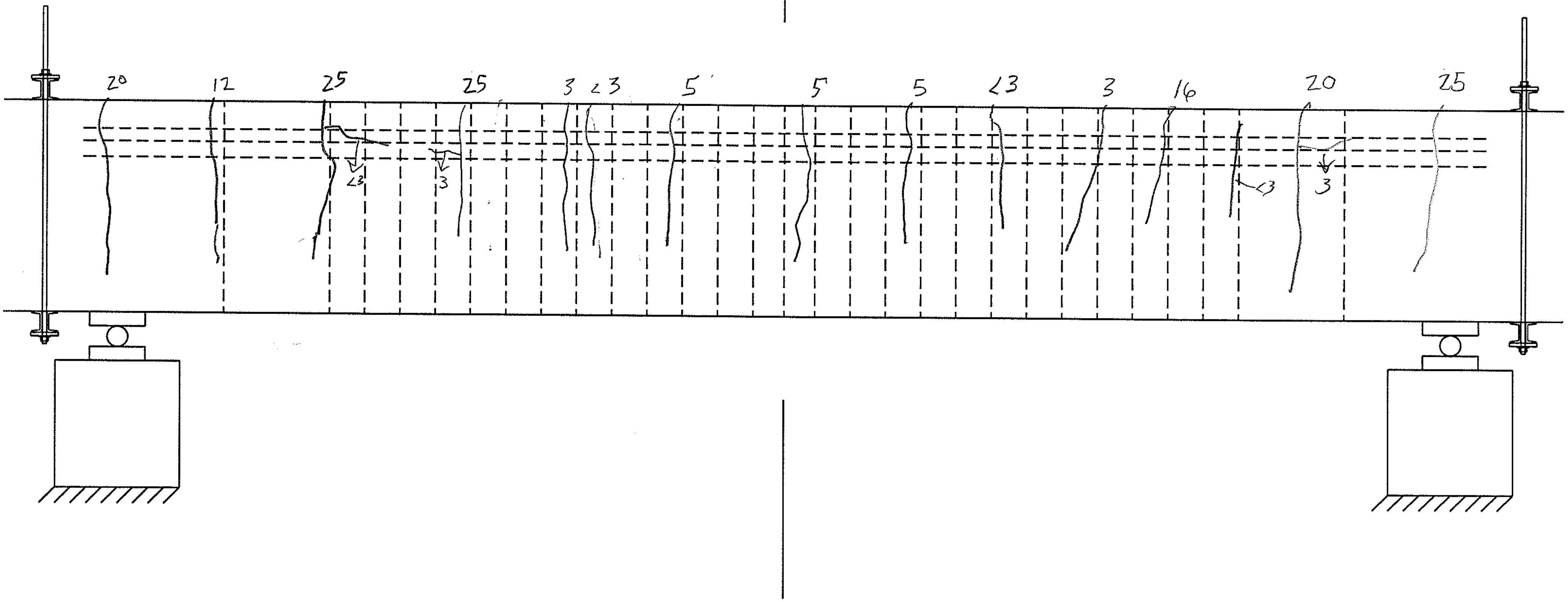
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen: C5	Sheet:	1	of	1
Average Load: 37.2 K → Unload	Drawn by:	KS	Checked by:	
Average Deflection: 0.16 in	Date:	4/12/16		


{All crack width's $\times 10^{-3}$}

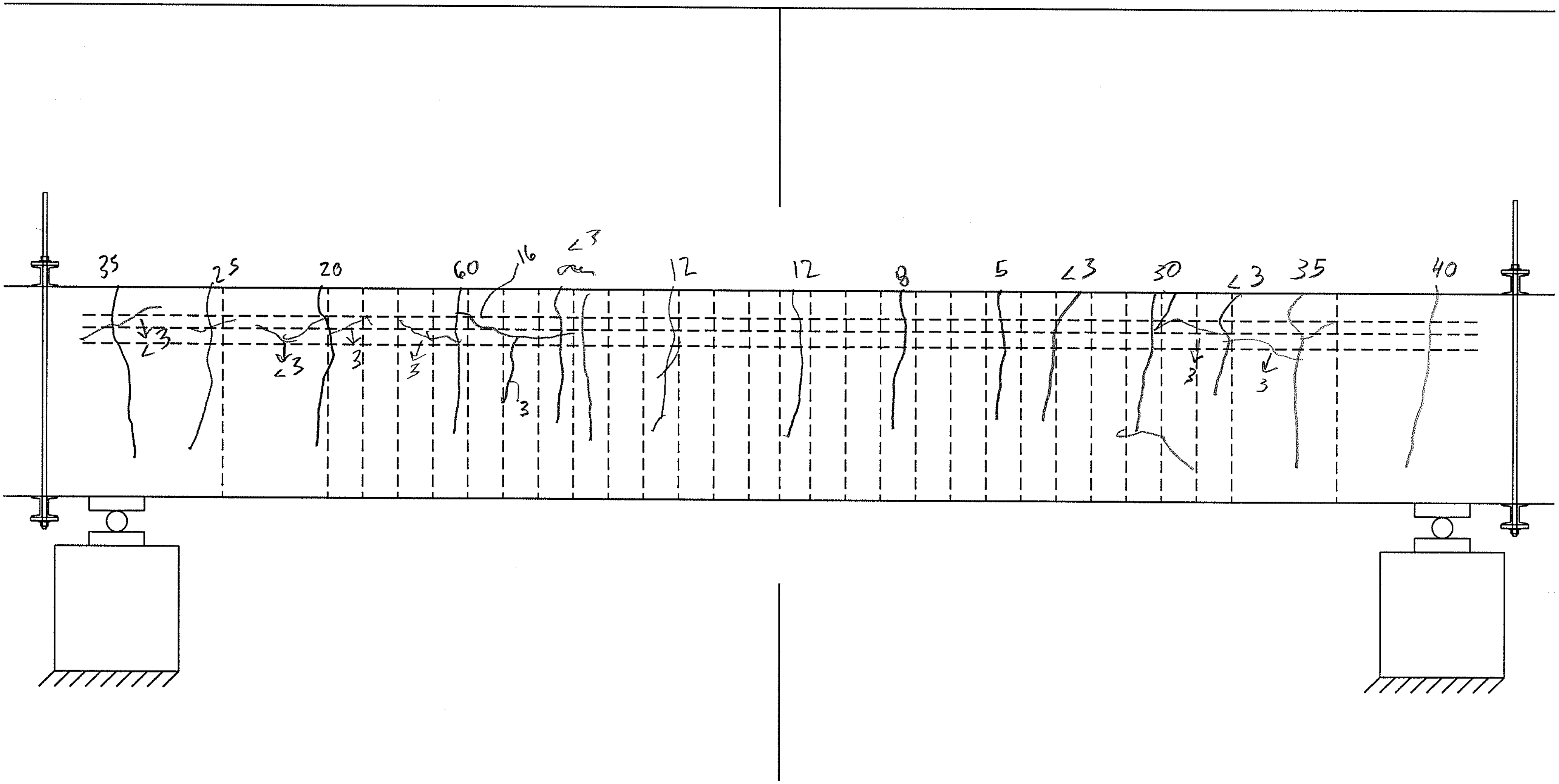
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C6	Sheet:	1	of	1
Average Load:	14.5^{k}	Drawn by:	KS	Checked by:	
Average Deflection:	0.08 in.	Date:	4/14/16		



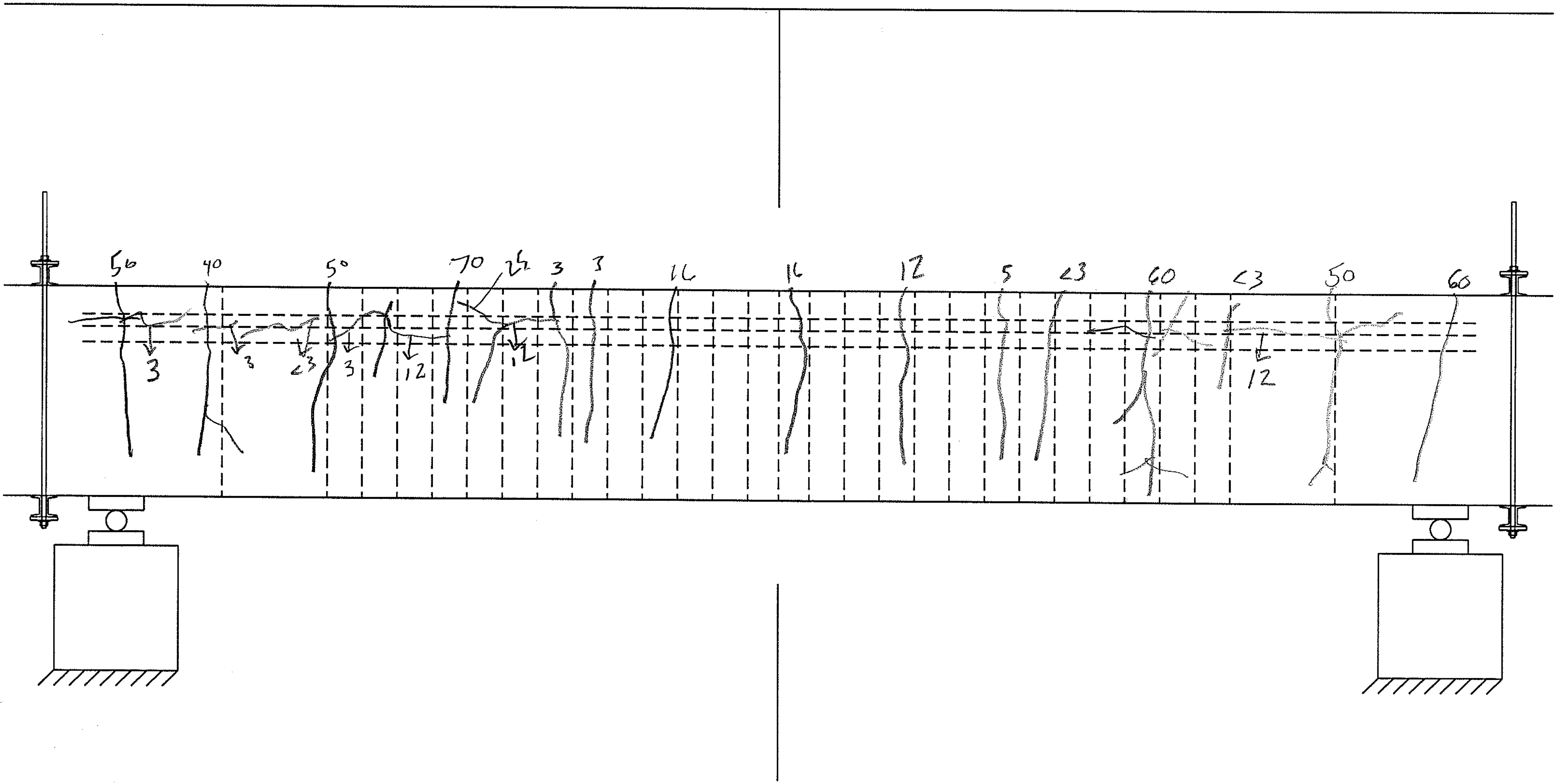
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C6	Sheet:	1	of	1
Average Load:	23.7 K	Drawn by:	KS	Checked by:	
Average Deflection:	0.16 in.	Date:	4/14/16		



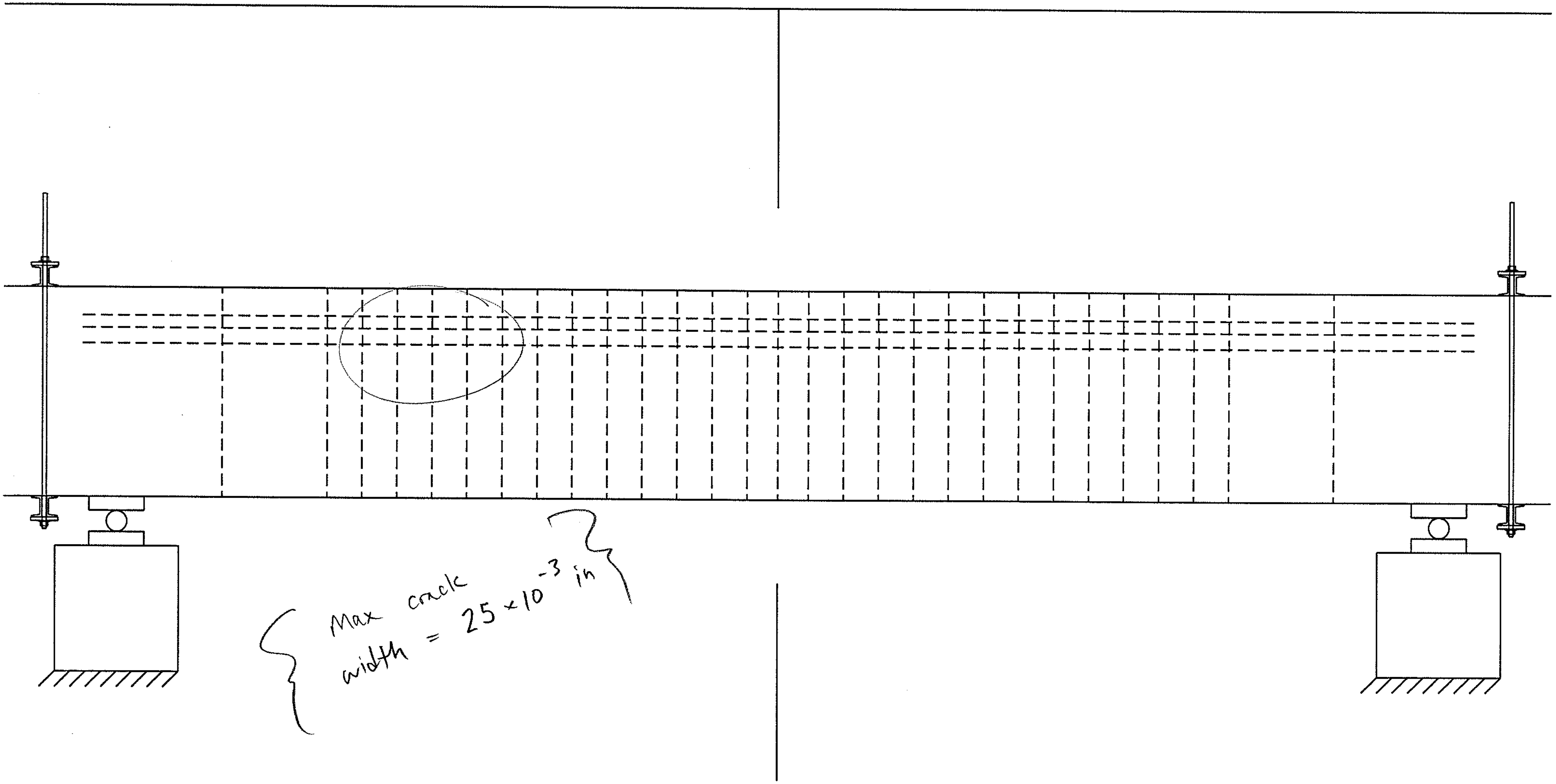
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C6	Sheet:	1	of	1
Average Load:	32.6 ^{K}	Drawn by:	KS	Checked by:	
Average Deflection:	.24 in.	Date:	4/4/16		



BOWEN LABORATORY
PURDUE UNIVERSITY

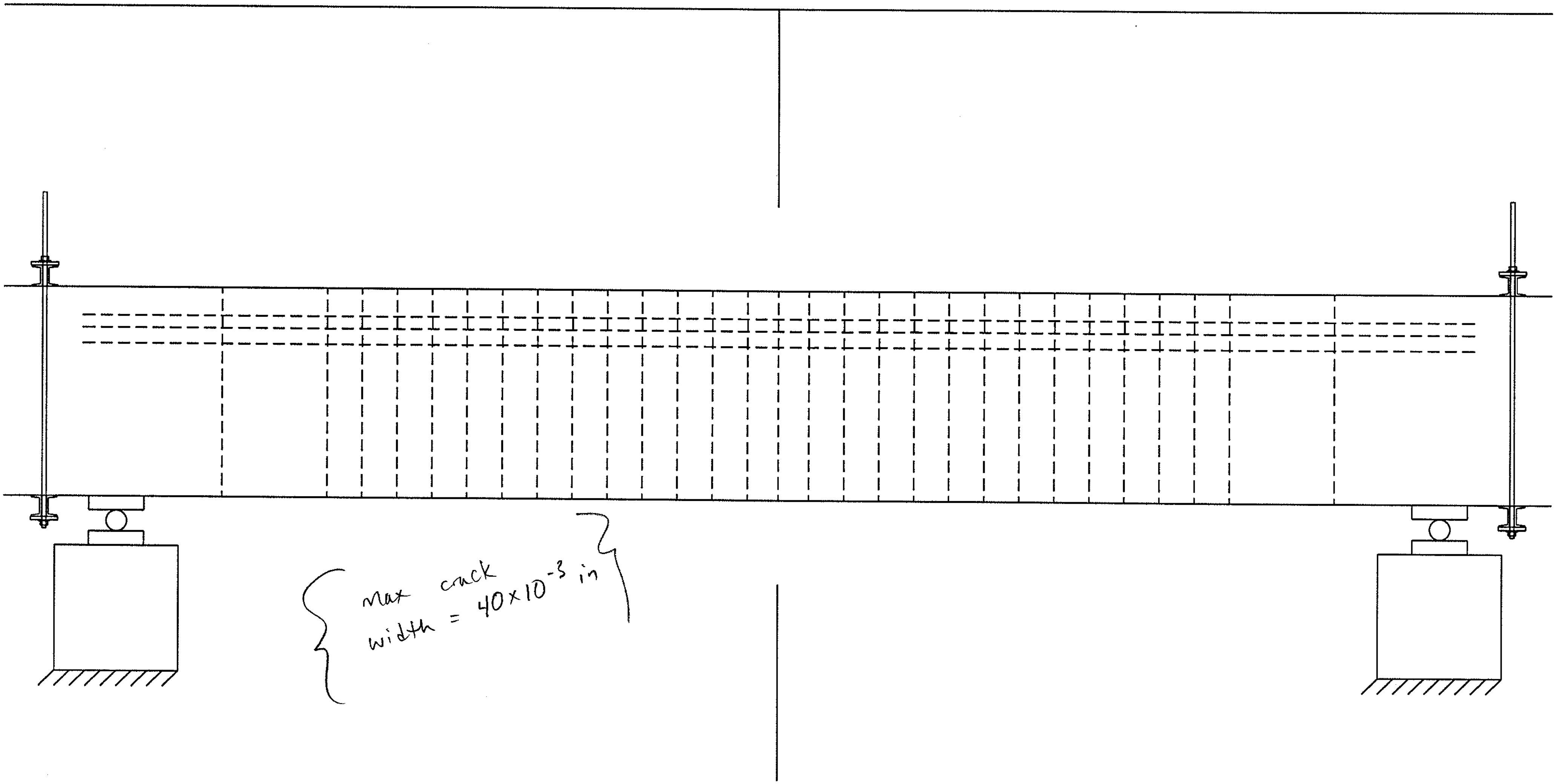
Specimen:	C6	Sheet:	1	of	1
Average Load:	36.2^{K}	Drawn by:	KS	Checked by:	
Average Deflection:	0.32^{K}	Date:	4/4/16		



Max crack width = 25×10^{-3} in

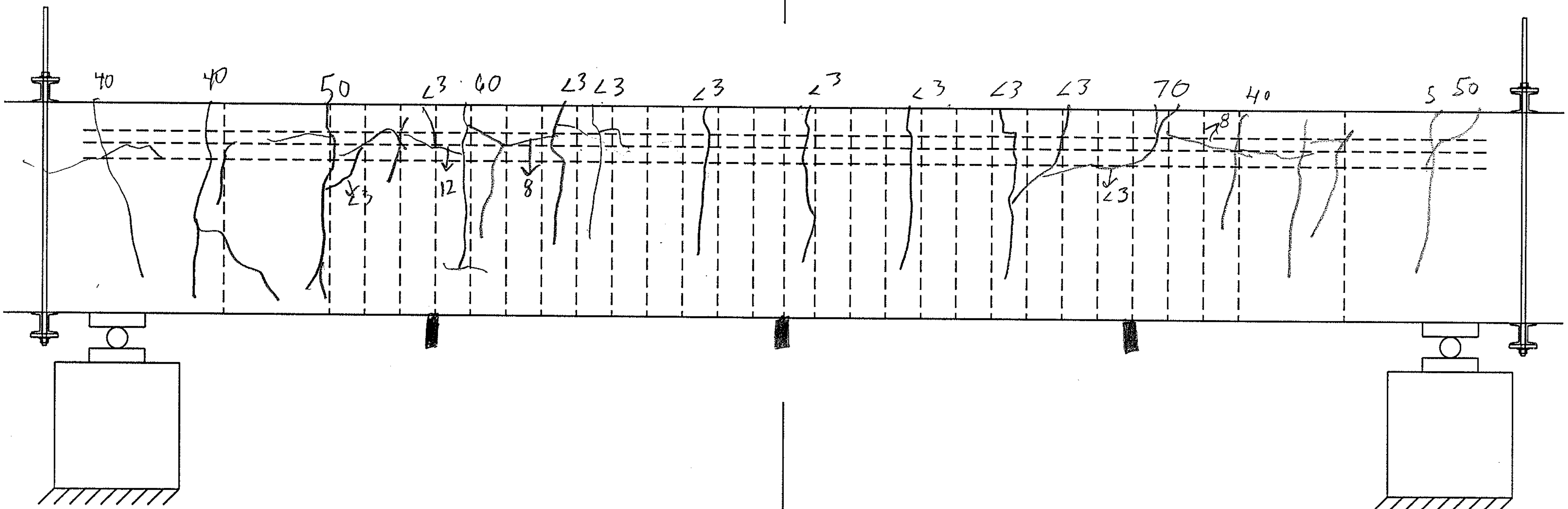
BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C6	Sheet:	1	of	1
Average Load:	37.3^{K}	Drawn by:	KS	Checked by:	
Average Deflection:	0.40 in	Date:	4/14/16		



BOWEN LABORATORY PURDUE UNIVERSITY

Specimen:	C6	Sheet:	1	of	1
Average Load:	38.5 K	Drawn by:	KS	Checked by:	
Average Deflection:	0.50 in	Date:	4/14/16		



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	C6	Sheet:	1	of	1
Average Load:	38.5^k → unload	Drawn by:	KS	Checked by:	
Average Deflection:	0.23 in	Date:	4/14/16		

REV 02

Tests to Determine the Behavior of #11 Bars with Lap Splices – TEST SERIES C

Bowen Laboratory
Purdue University
April 8, 2016

Test Procedure

This procedure refers to the test described in the proposal titled Experimental Study of The Effect of Laminar Cracks on Strength and Ductility 79-in Splices of #11 Reinforcing Bars submitted to First Energy Corporation. Parameters for performance of tests are specified in this document.

1. Fabrication

1.1 Formwork

The formwork shall be made using non-absorbent plywood. Its interior shall be caulked to prevent water leakage and it shall be covered with a thin layer of oil before casting. The dimensions of the formwork shall be checked and recorded using Form 1.

1.2 Reinforcement Cages

The steel reinforcement cages shall be built following the same drawings and forms used for test Series B (attached). Reinforcing bars shall be supported by steel chairs placed away from lap splices. To ensure alignment, the bars shall be tied to chairs and to one another using gage-16 steel wire. The location of the reinforcement shall be recorded using Form 1. The locations of wire ties and rebar markings shall be recorded using Form 2.

Tolerances (within the test region) are:

3/16" for horizontal cover and horizontal spacing measured to the surface of the bar (excluding ribs)
1/4" for vertical distances shown in Form 1

1.3 Casting

Fresh concrete properties to be measured include:

Unit Weight
Slump
Air Content

These measurements shall be made following the Specifications and recorded using Form 3.

Slump shall be measured before any other activity related to casting takes place to make sure that the delivered mix has satisfactory workability. The mixing truck shall deliver a ticket with the batched mix weights. These weights shall be examined to corroborate that the delivered mix has the specified proportions. Concrete shall not be accepted if it arrives more than 45 min. after leaving the batching plant. No water shall be added to the mix after the truck leaves the plant.

Specimens and cylinders shall be cast and vibrated in two lifts following the Specifications. The vibrators to be used shall have the following cross-sectional dimensions:

For cylinders:	3/4" - 7/8"
For Larger Specimens:	1-3/4"

Their frequencies shall be between 50 and 200 Hz.

Excess concrete shall be removed off the formwork. The exposed surfaces of the specimens shall be finished using cast magnesium floats. Lifting inserts shall be inserted in the fresh concrete as soon as the finishing is completed.

Each test beam shall be cast using concrete from a single mixing truck. A complete set of concrete samples (cylinders) shall be obtained from each truck. Test beams and samples shall be marked with a number referring to the truck from which they were cast and the date of casting. In each casting day, trucks shall be numbered sequentially starting at 1. The number assigned to a truck shall be written clearly on the mix ticket describing the mix proportions for the batch. Test beams shall be cast and tested oriented in the North-South axis of the laboratory.. Beam ends facing North during casting shall face North during testing. During finishing, the North end of each beam shall be marked with the letter N.

These activities shall be documented using Form 3.

1.4 Curing

As soon as casting is completed all specimens shall be covered with impermeable sheets. When the concrete surface sets, wet burlap shall be inserted between these sheets and the exposed concrete. All formwork and molds shall be struck no later than three days after the cast.

All exposed concrete surfaces shall be covered by wet burlap and impermeable sheets for a total of at least seven days after casting.

Burlap shall be doused with water at least every other day during the curing period.

Curing activities shall be logged using Form 4.

Test cylinders shall be stored and cured next to the test specimens and under similar conditions of temperature and humidity.

The variation of concrete strength with time shall be monitored as specified in the Specifications. The results of cylinder tests shall be recorded using Form 5.

2. Calibration

Three types of measurements will be made: displacement, force, air content.

The apparatuses to be used to calibrate sensors to measure these quantities are:

Displacement Sensors: INSTRON Universal Testing Machine (S.N.:__________)
Load Sensors: INSTRON Universal Testing Machine (S.N.: _________)
Air Content: Calibrated Cylinder (S.N.:___________)

Load and displacement sensors will be calibrated following steps listed below:

1) Connect the sensor to the data-acquisition system that is going to be used in the test
2) Set and record the excitation voltage to the maximum possible value (not exceeding the maxima specified for the data-acquisition system and the sensor)
3) Set the data-acquisition equipment to record voltage
4) Set the gain of the data-acquisition system to the first available level lower than the ratio of the maximum range of the system to the maximum expected output from the sensor.
5) Mount the sensor on the universal testing machine
6) Apply a series of known displacement or force increments to the sensor ranging between 10% and 90% of the rated capacity of the sensor
7) Record the voltage read on the data-acquisition system at each known displacement or force increment
8) Create a plot of change in output voltage vs. change in force or displacement
9) Fit a line to the plot from 7) using “least squares”
10) Record the slope of the line from 8) (sensor sensitivity)
11) Label the cable used in the calibration with the serial number of the sensor

Sensors shall be calibrated before the first test and after the final test.

The apparatus used to measure air content of the fresh concrete shall be calibrated following the procedure described in ASTM standard 231. Form 6B shall be used to document the calibration.

All calibrations shall be performed by at least two persons: one leading each step and the other checking the work of the first independently. A log of each calibration shall be made using Form 6 and it shall include an estimate of the accuracy of the sensor.

Sensors for which the sensitivity obtained in 9) above deviates by more than 10% from the nominal sensitivity (as reported by the manufacturer) shall not be used in any of the tests.

3. Setup

Each test beam shall be placed on two roller supports as described in the attached proposal. The final location of the supports shall be measured (to the nearest 1/16 in.) and reported using Form 7. The maximum deviation from nominal setup dimensions shall be ¼ in. As-built external dimensions of each test beam shall be recorded using the same form. The maximum deviation from nominal dimensions in the test region shall be ¼ in.

The test beam shall be placed with the reinforcement facing up as shown in the attached proposal.

The shear spans shall be reinforced with external stirrups (pairs of 5/8-in threaded rods) installed at a spacing not exceeding 12 in. The locations of the stirrups shall be measured. The measurements shall be recorded using Form 7.

The loading rigs (consisting of a loading tube, two hydraulic rams, two threaded rods, plates and nuts, and one load cell per rig) shall be placed on the test specimen and connected to “the strong floor” of the laboratory (without applying load to the specimen other than the weight of the rigs) as described in the attached proposal. The rams in each rig shall be connected to a single manifold and pump using 10,000-psi hydraulic hoses. All hoses and other hydraulic hardware shall be inspected visually and replaced –if defective- before testing.

4. Instrumentation

Displacement sensors shall be installed at midspan, at each support, and at each load point. They shall be secured to the strong floor of the laboratory directly below the point where displacement is to be measured.

All sensors (displacement and force) shall be connected to the data acquisition system using the same cables used during calibration. The excitation voltage and gain shall also be set to the value used in calibration. The data acquisition system shall be set to record voltage changes caused by loading. Before applying load with the hydraulic rams, all sensors shall be set to read a voltage value between 10% and 90% of the voltage output of the sensor at its rated capacity. These voltages shall be referred to as the "zero offsets" of the sensors. If a sensor is set to have an initial voltage exceeding 20% of its output at rated capacity, the sign of the initial "zero offset" shall be opposite to the sign of the expected change in its signal.

Set the data acquisition system to scan all sensors and save at least one record per sensor every 1 sec.

Record a file of "zero offsets" capturing at least 10 min. of data before any load is applied with the hydraulic system.

Means of initial voltages for all sensors (mean "zero offsets"), sensor serial numbers, the most recent sensitivity constants, excitation voltages, and the channels of the data-acquisition system used for each sensor shall be recorded using Form 8. The pairing of channels and sensors shall be checked by a second person working independently from the person making the initial connections.

Infrared targets to be used to measure displacements as described in the attached proposal shall be glued to one face of the test beam using epoxy adhesive. The numbering sequence of these targets shall be recorded using Form 9.

Video cameras (one for long-time lapse video and one for high-speed video) will be positioned to capture the response of the mid third of each specimen. To the extent possible, the location of the cameras shall be the same in all tests.

5. Testing

The following actions shall take place during each test:

At the end of each loading increment:

Mark Cracks: all visible cracks shall be marked using black permanent markers. Cracks shall be marked by drawing lines parallel to them and with an offset of approximately 0.25 in.

Measure Crack Widths: Crack widths shall be measured using crack comparators or graduated handheld microscopes.

Measure coordinates of infrared coordinates: A set of coordinates shall be obtained using an OptoTrak System 600 Pro. A set of four targets shall be attached to the strong floor. They shall be located at approximately the same distance to the OptoTrak cameras as targets attached to the test beam. Coordinates for these reference targets shall be obtained at each loading increment. They are to be used to monitor the stability of the OptoTrak system by computing the variation in the distances between reference targets.

In-Test Data Backup: At every loading increment the data being produced by the data-acquisition system shall be copied to an external hard drive or USB memory.

Photographs: a set of high-resolution photographs shall be obtained after cracks are marked at each loading increment. The photographs shall include views of both elevations of the test beam and the top concrete surface above lap splices.

The following data shall be recorded throughout each test:

Sensor readings: to be recorded on a hard drive in volts. Conversion to engineering units shall be done after the test as follows:

-Subtract zero offsets
-Divide the result by the sensitivity obtained in the most recent calibration
Lapse video photographs: to be obtained every 5 min..

Actions to be taken at failure

Trigger high-speed camera to record breaking away of the concrete cover and relative movement of the bars.

Actions to be taken after test

Generate a record of sensors that may have malfunctioned or been accidentally moved during the test

Remove from all files recordings from sensors for which the results of the after-test calibration differ by more than 5% from the before-test calibration.

The referenced proposal states:

"The first loading is planned to be to a deflection at mid-span of 0.4 in. Previous investigation has shown that at that deflection the laminar cracks are likely to exceed a width of 0.03 in. The load will then be taken off and reapplied until failure is obtained."

If deemed safe during testing, extending the first loading to a larger mid-span deflection shall be allowed.

6. Reporting and Backup

Produce all the captured data in two ways:

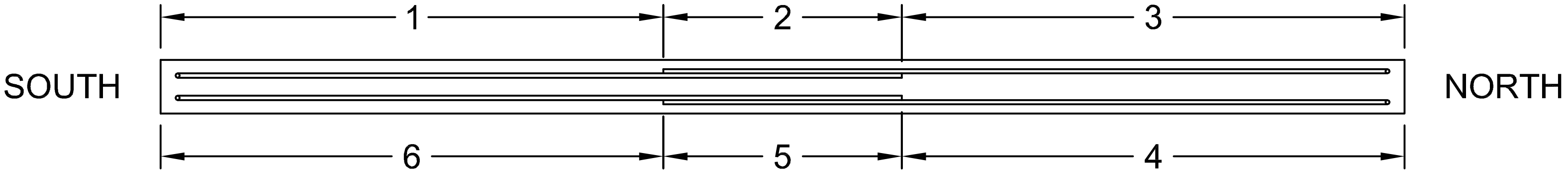
By uploading data, photos, and video to datacenterhub.org or ftp.ecn.purdue.edu.

By recording all data, photos, and video on a magnetic hard drive

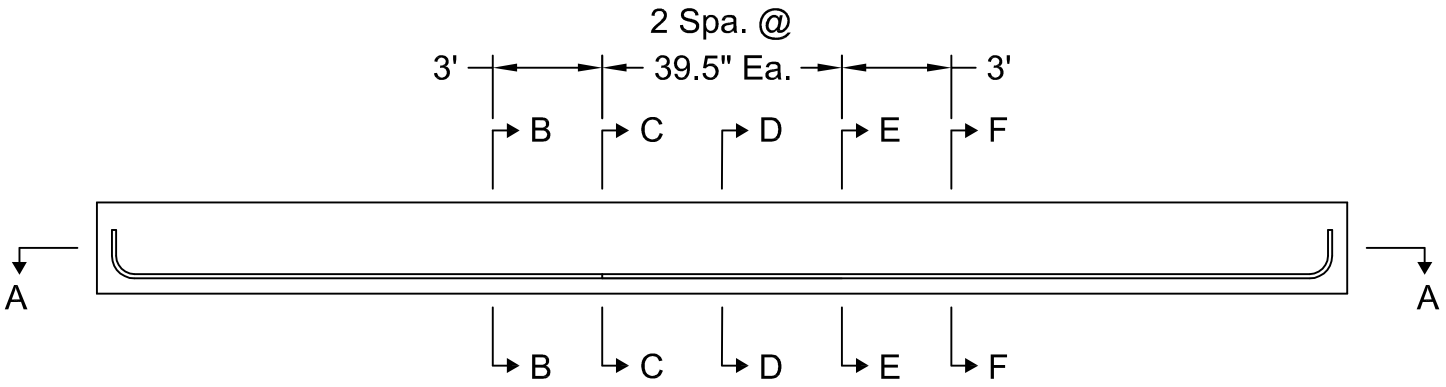
Reports shall be produced as described in the Specifications.

DRAWINGS AND FORMS

Form 1



Section A-A



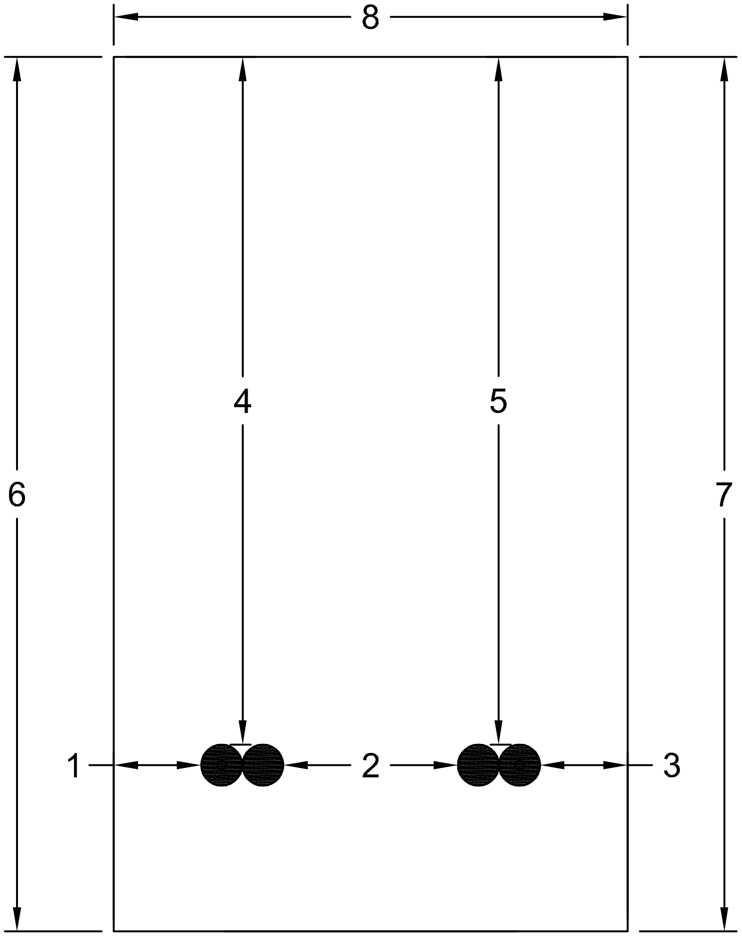
*For section B-B through F-F see Sheet 3 of 3

Series B

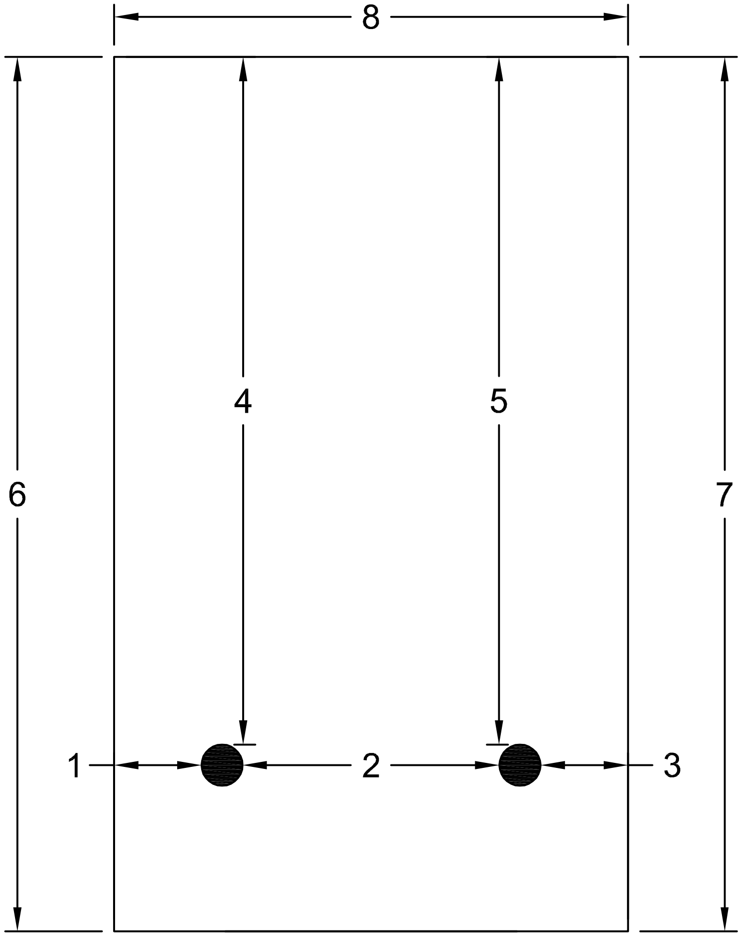
Drawing:	Series B Formwork As-builts	Sheet:	2	of	3
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

BOWEN LABORATORY
PURDUE UNIVERSITY

Form 1



Section C-C, D-D, & E-E
*Facing North



Section B-B & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Formwork As-built Sections	Sheet:	3	of 3
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by: SP
			Date:	04/04/2012	

Form 1

Project: Tests to Determine the
Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen:________________________________

Sheet 1 of 2

Section	Formwork As-built Dimensions							
	1	2	3	4	5	6	7	8
A-A								
B-B								
C-C								
D-D								
E-E								
F-F								

Recorded by:	Signature	Date	Time
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*See formwork as-built drawings for dimension locations

Form 1

Project: Tests to Determine the
Behavior of Spliced #11 Bars

As-built Dimensions v.1
(Rev. 04/04/2012)

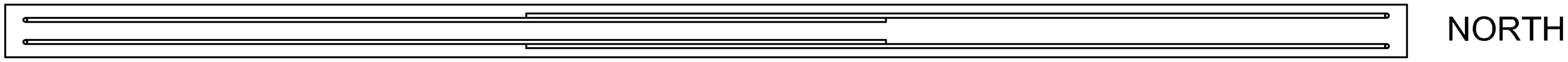
Specimen:________________________________
Sheet 2 of 2

Section	Formwork As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
A-A	14'-6"	10'-0"	14'-6"	14'-6"	10'-0"	14'-6"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

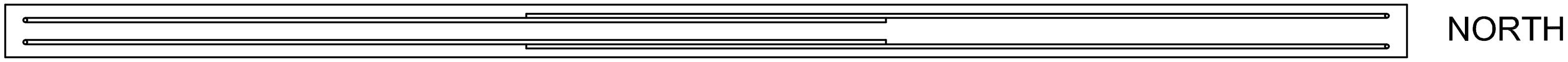
Section	Formwork As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
A-A	13'-10.5"	6'-7"	13'-10.5"	13'-10.5"	6'-7"	13'-10.5"	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
E-E	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
F-F	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Form 2

Wire Ties



Bar Marks



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:					
Project:	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:		Checked by:	
		Date:			

Project: Tests to Determine the Behavior of Spliced #11 Bars

Casting Documentation v.1
(Rev. 03/30/2012)

Specimen:________________________

Sheet 1 of 1

General Information					
Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
Measurements made upon arrival of concrete					
Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**			
Time$_1$	Result$_1$	Time$_1$	Result$_1$	S/N of Air Meter	
Time$_2$	Result$_2$	Time$_2$	Result$_2$	S/N of Scale	
Unit Weight (ASTM C138 - 10b)					
Time$_1$	Wt. of Cont.$_1$	Total Wt. $_1$	Wt. of Conc.$_1$	Result$_1$ = Wt. of Conc./Vol. of Cont.	
Time$_2$	Wt. of Cont.$_2$	Total Wt. $_2$	Wt. of Conc.$_2$	Result2 = Wt. of Conc./Vol. of Cont.	
Times of actions during and after casting					
Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
Recorded by		Signature		Date	Time
Checked by		Signature		Date	Time
Checked by		Signature		Date	Time

Comments:

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

Project: Tests to Determine the Behavior of Spliced #11 Bars

Curing Documentation v.1
(Rev. 03/30/2012)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information		
Specimen(s)	Date	Specimen Age
	Time Beginning	Time Ending
	Temperature inside Lab (deg. F)	

Description of Work Performed

Recorded by	Signature	Date	Time
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Form 5

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Cylinder Compression Tests Documentation v.2
(Rev. 04/01/2012)

Specimen: ______________________

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
1										
2										
3										
4										
5										
6										

S/N of Testing Machine:			
Recorded by:	Signature	Date	Time
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Form 5

Project: Tests to Determine the Behavior of Spliced #11 Bars

Cylinder Compression Tests Documentation v.2
(Rev. 04/01/2012)

Specimen: ____________________

Sheet 2 of 2

Specimen	Date	Age	Time of Test	Wet/Dry	Average Measured Dia. [in.]	Cross-sectional Area [in2]	P_{max} [lb_f]	f'$_c$ [psi]	Fracture Type (1-6)
1	0-Jan		12:00 AM	0	#DIV/0!	#DIV/0!	0	#DIV/0!	0
2	0-Jan		12:00 AM	0	#DIV/0!	#DIV/0!	0	#DIV/0!	0
3	0-Jan		12:00 AM	0	#DIV/0!	#DIV/0!	0	#DIV/0!	0
4									
5									
6									

S/N of Testing Machine:			
Recorded by:	Signature	Date	Time
0		0	0
Checked by:	Signature	Date	Time
0		0	0
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lbf/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Recorded data is shown on sheet 1 of 2.

Project: Tests to Determine the Behavior of Spliced #11 Bars

Calibration Documentation v.1
(Rev. 04/02/2012)

Bowen Lab - Purdue University
Sheet 1 of 1

Calibration Instrument Name and S.N.:	
Data Acquisition System:	
Gain:	
Excitation Voltage:	
Channel:	
Sensor:	
Sensor S.N.:	

Measurand	Voltage	Measurand	Voltage	Measurand	Voltage

Operator	Signature	Date	Time
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Results	Sensitivity	Accuracy

Notes:

Form 6B

Project: Tests to Determine the
Behavior of Spliced #11 Bars

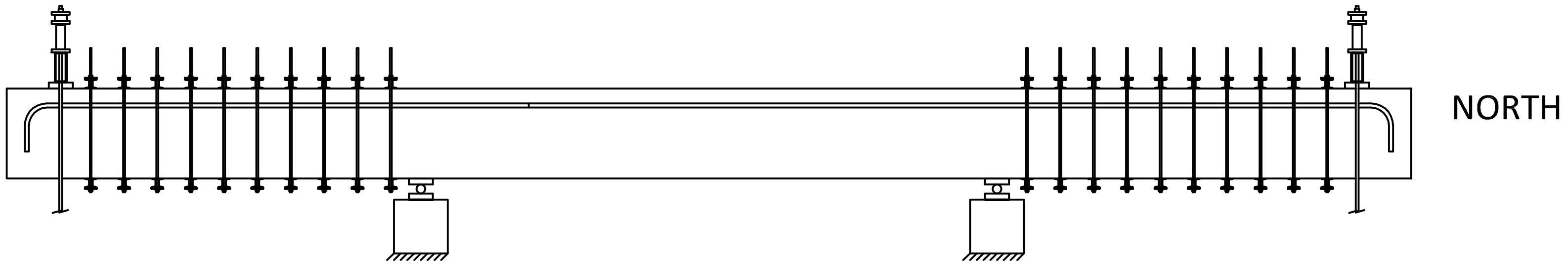
Calibration Documentation v.1
(Rev. 04/06/2012)

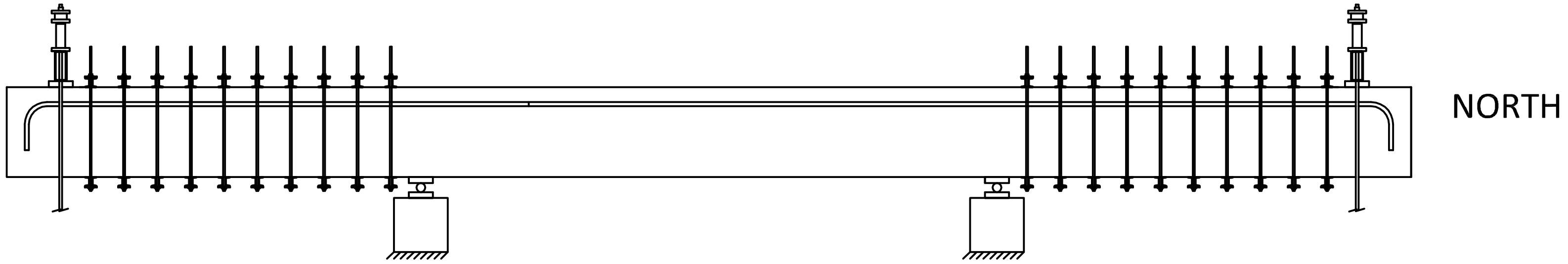
Bowen Lab - Purdue University
Sheet 1 of 1

Meter S.N.			
Type of Meter			
Meter Brand Name			
Ambient Temperature			
		Target Air Content	Measured Air Content
Operator	Signature	Date	Time
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

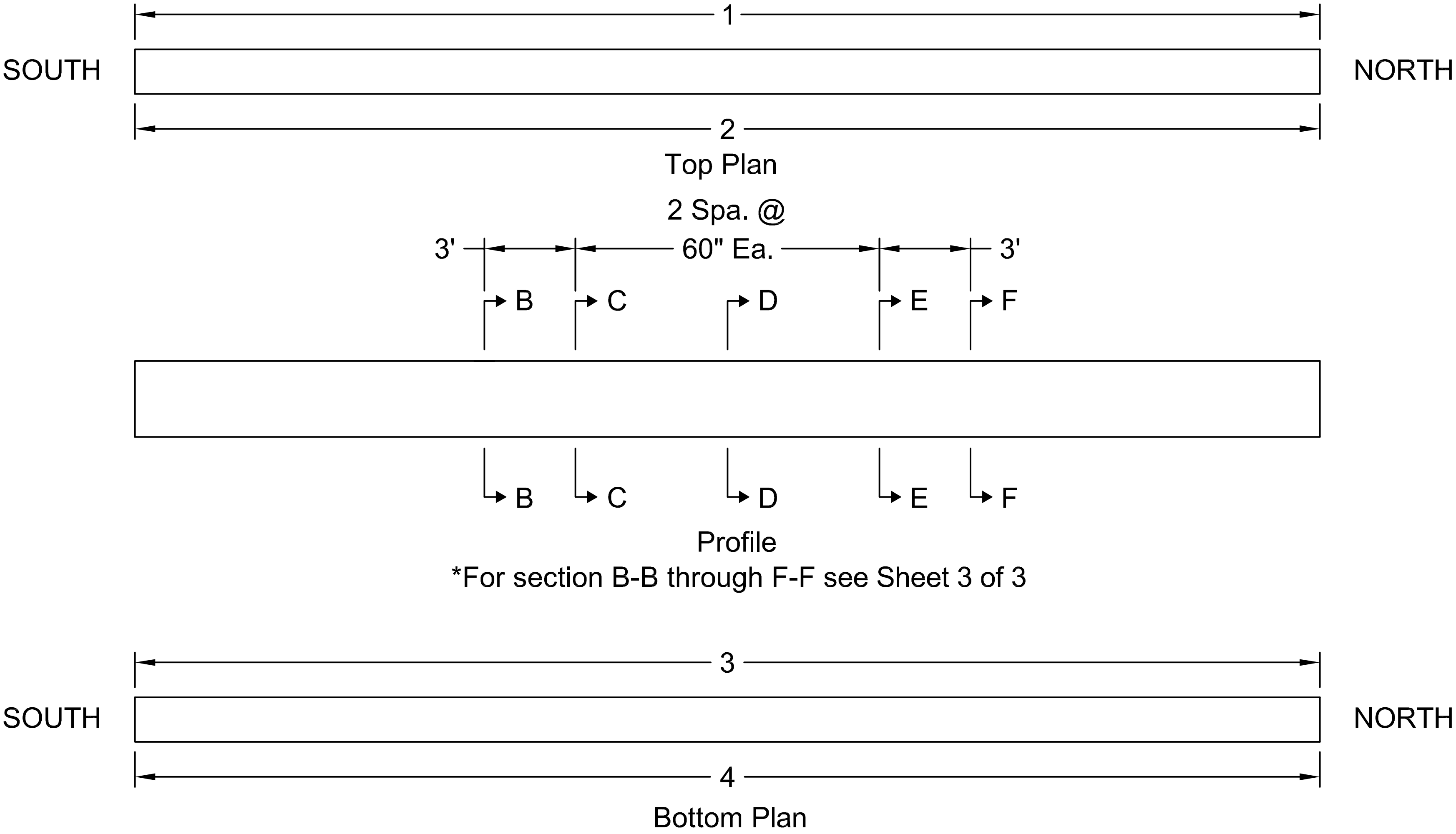
Form 7





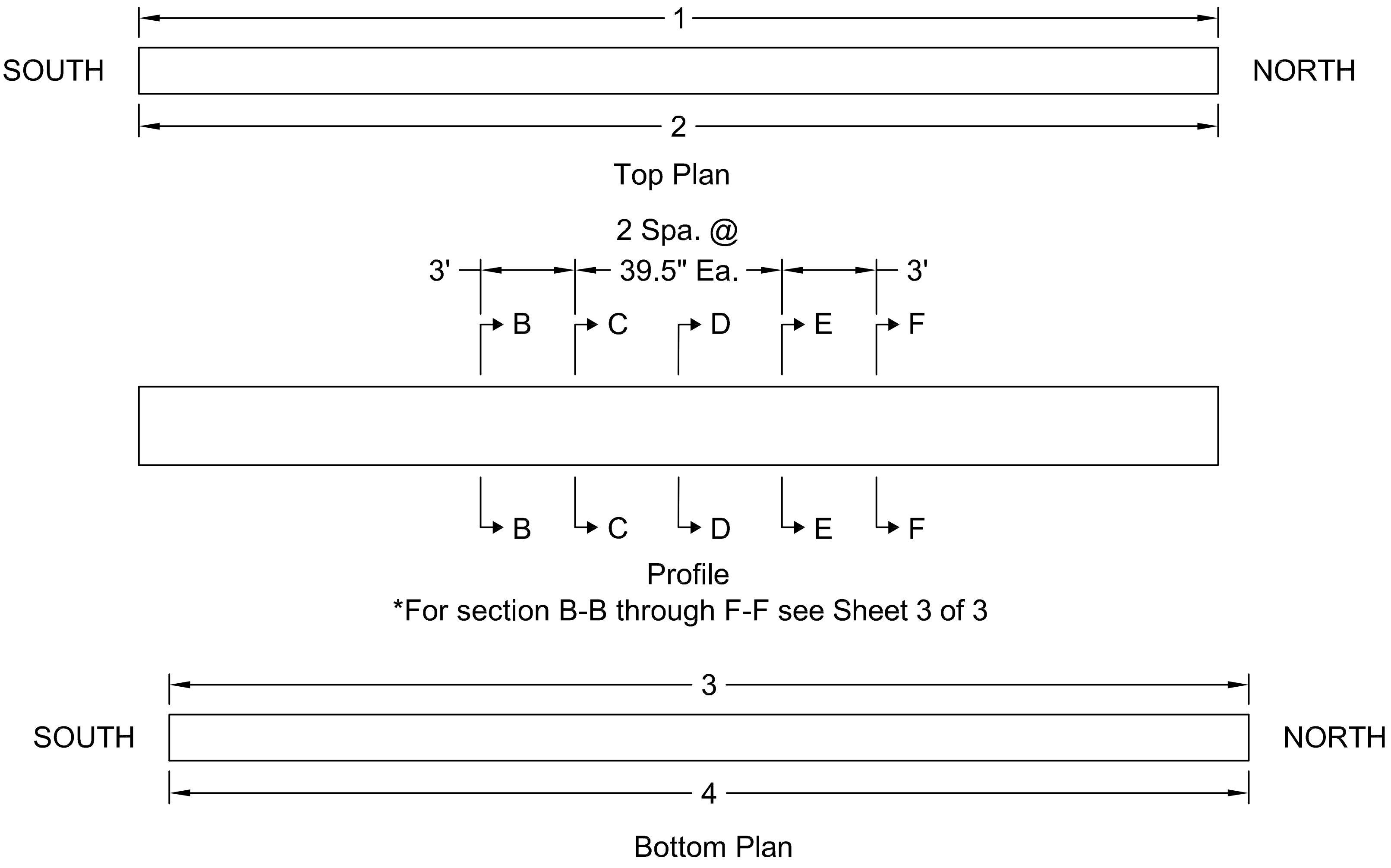
BOWEN LABORATORY PURDUE UNIVERSITY	Specimen	Sheet:	1	of	4
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:		Checked by:	
		Date:			

Form 7



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series A Concrete As-builts	Sheet:	2	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		

Form 7

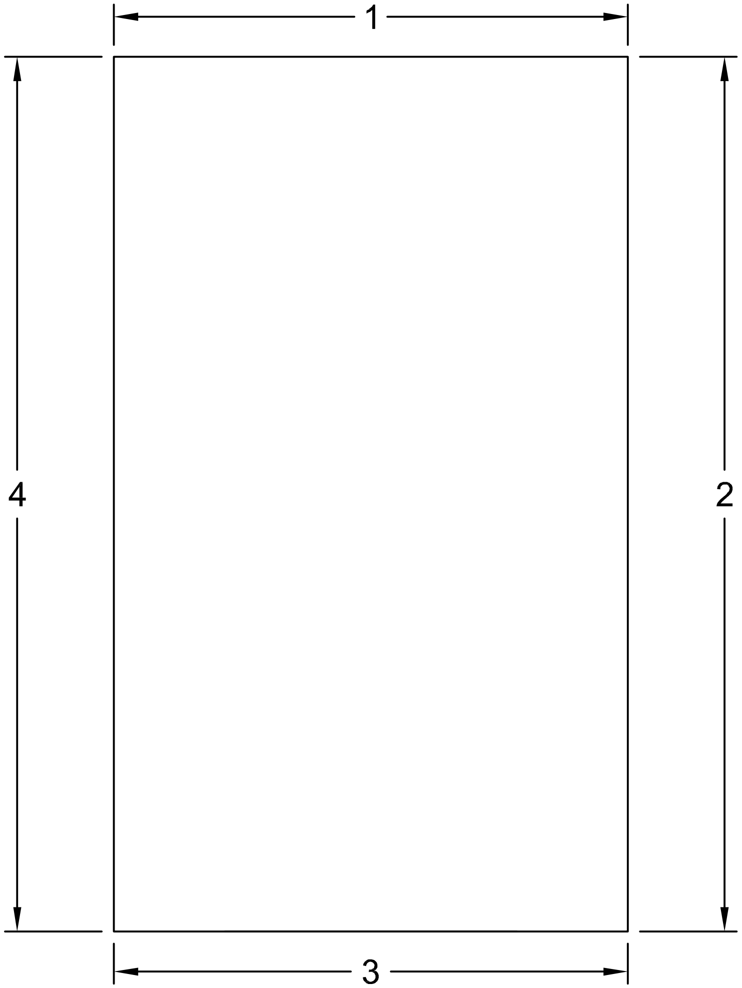


*For section B-B through F-F see Sheet 3 of 3

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series B Concrete As-builts	Sheet:	3	of	4
Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
		Date:	04/04/2012		

Form 7



Section B-B, C-C, D-D, E-E & F-F
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Concrete As-built Sections	Sheet:	4	of	4
	Project:	Experimental Investigation of Capacity of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	BPR	Checked by:	SP
			Date:	04/04/2012		

Form 7

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen:________________________________

Sheet 1 of 2

Section	Concrete As-built Dimensions							
	1	2	3	4	5	6	7	8
Plan								
B-B								
C-C								
D-D								
E-E								
F-F								

Recorded by:	Signature	Date	Time
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*See concrete as-built drawings for dimension locations

Form 7

Project: Tests to Determine the Behavior of Spliced #11 Bars

Setup and As-built Dimensions v.1
(Rev. 04/04/2012)

Specimen:________________________________

Sheet 2 of 2

Section	Concrete As-built Dimensions Key - Series A							
	1	2	3	4	5	6	7	8
Plan	39'-0"	39'-0"	39'-0"	39'-0"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

Section	Concrete As-built Dimensions Key - Series B							
	1	2	3	4	5	6	7	8
Plan	34'-4"	34'-4"	34'-4"	34'-4"	N/A	N/A	N/A	N/A
B-B	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
C-C	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
D-D	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
E-E	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A
F-F	17-5/8"	30"	17-5/8"	30"	N/A	N/A	N/A	N/A

Form 8

Project: Tests to Determine the Behavior of Spliced #11 Bars

Instrumentation Documentation v.1
(Rev. 04/01/2012)

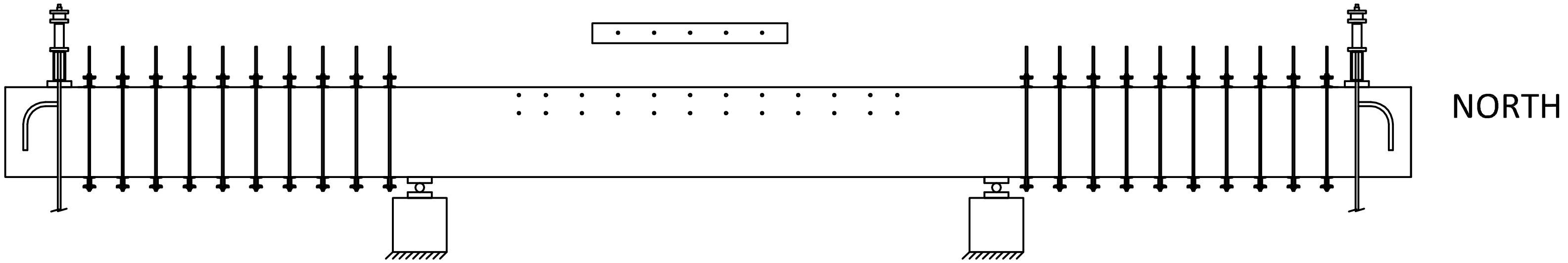
Specimen: ____________________________
Sheet _______ of _______

Data Acquisition System:								
Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity	Zero Offset	Location	Comments

Operator	Signature	Date	Time
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Form 9



BOWEN LABORATORY PURDUE UNIVERSITY	Specimen			
	Behavior of Lap Splices of No. 11 Reinforcing Bars	Drawn by:	Checked by:	
		Date:		

Purdue University

Specimen : C1

Date: 3/21/16

PC TIME

REVERSE

	Average Load (lbf)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	DG North Overhang (in)	DG South Overhang (in)	Time	DG Mid (in)
1	200	.014	-.007	-.003	-.003	.002	-.012	-.006	200	100	0.900	0.000	1:31	0.900
2	200	.013	-.007	-.003	-.002	.002	-.012	-.006	200	100	0.9	0	2:22	0.9
3	1ST CR	HEARD	AT 7.5	K MEAN	LOAD	S. SUPPORT			AFTER	DROP				
4	14500	.510	.445	.06	.081	.064	-.015	-.005	13700	14100	0.398	0.446	2 43	0.812
5					.082				13.0	13.2			3:24	
6	23200	.965	0.912	0.120	0.158	0.124	-.017	-.004	22800	22800	OFFSC.	0.915	3:30	0.734
7										RESET	1.000	0.000		
8	31500	1.415	1.363	0.183	0.240	0.191	-.020	-.005	31000	31500	0.559	0.455	4:08	0.653
9	29.8k	1.419	1.366	0.184	0.241	0.192	-.020	-.005	29700	29800	0.556	0.458	4:39	—
10										RESET	1.0	0		—
11	35.6k													
12	34.8k	1.918	1.767	0.259	0.321	0.253	-.021	-.005	34600	34900	0.500	0.403	4:53	0.574
13	34.4k	1.920	1.769								0.499	0.404		
14										RESET	1.0	0		
15	37.5k	2.465	2.269	.34	.399	.340	-.022	-.005	36800	36600	REMOVED		5:24	0.480
16	0.2k	1.018	0.872	.142	.167	.140	-.018	-.004	0.2k	0.1k	—	—	5:40	~~0.737~~
17					.164								5:46	0.737
18	0.19k				.162								6:12	0.739
19	12.4k	1.448	1.273	.200	.240	.196	-.02	-.004	12.5k	12.2k	—	—	6:17	0.[illegible]62
20	23k	1.897	1.718	.262	.320	.261	-.021	-.005	23k	23k	—	—	6:28	0.[illegible]
21	35.9k	2465	2.266	.341	.400	.340	-.022	-.005	35.6k	35.5k	—	—	6:40	~~0.~~
22	35.5				.400									0.480
23														Removed
24														

Purdue Un sity

Specimen : C-2

Date: MAR 28/2016

Comp.

	Average Load (lbf)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	DG North Overhang (in)	DG South Overhang (in)	Time	MID DG
1	0	.001	.002	-.001	-.001	0.000	-.000	-.000	0	0	1.0	0	12:00 N	0.100
2	0.2K	.002	.002	-.001	-.001	0	0	0	0.2	0.2	0.999	0.002	12:45PM	0.1
3	0.2	—	—	—	-.005	—	—	—	—	—	—	—	1:17	0.104
4	14.1	0.497	0.458	0.052	0.079	0.065	-.016	-.002	13.5	13.6	0.503	0.450	1:31 PM	0.021
5	—	—	—	—	0.080	—	—	—	—	—	—	RESET		0.900
6	22.8	0.949	0.913	0.115	0.160	0.128	-0.017	-.001	22.4	22.1	OFF	0.914	1:57PM	0.820
7	21.8	—	0.916	—	—	—	—	—	RESET			0.914	—	—
8	21.8	—	—	—	—	—	—	—	—	→		0.000	—	—
9	31.1	1.452	1.384	0.180	0.240	0.190	-0.019	-.003	31	30.7	—	0.471	2:37PM	0.739
10	35.9	1.812	1.866	0.243	0.320	0.265	-.019	-.003	35.1	35.1	—	0.055	3:09PM	—
11	34.5	←	1.871	—	—	—	—	—	RESET	→		0.057	3:14PM	0.657
12	—	—	—	—	—	—	—	—		→		0.000	3:15PM	—
13	37.1K	2.250	2.261	0.309	.397	.332	-.019	-.003	36.2	36.3	—	0.388	3:43PM	0.583
14	0.19	0.847	0.850	0.116	0.150	0.133	-.016	-.002	0.2	0.1	—	—	4:11PM	0.835
15	14.6k	1.382	1.370	0.187	0.241	0.204	-.018	-.002	14.6	14.4	—	—	4:26PM	—
16	25.8K	1.835	1.827	0.251	0.320	0.271	-.018	-.003	25.7	25.5	—	—	4:38PM	0.659
17	36.7K	2.337	2.332	0.322	0.411	0.343	-.018	-.003	36.1	36.1	—	—	4:53PM	0.568
18	↓ REMOVE OPTOTRAK TARGETS & D.G.													
19	LOAD TO FAILURE													
20														
21														
22														
23														
24														

Purdue University

Specimen : C3

Date: 4/4/16

	Average Load (lbf)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	DG North Overhang (in)	DG South Overhang (in)	P.C. Time	MID DG.
1	0.2	0.000	0.001	0	-0.001	-0.001	0	0	0.2	0.1	1.000	0.000	11:55A	0.900
2	15.2	0.489	0.472	0.057	-0.080	0.067	-0.017	-0.010	13.2	14.9	~~0.554~~	0.474	2:11 P	
3	13.0	0.442	0.472		0.078				11.2	14.9	0.560	0.472	2:15P	0.824
4	23.6	0.941	0.937	0.117	0.156	0.123	-.018	-0.011	22.6	22.8	0.052	0.945	2:42P	0.742
5		0.941									0.049			
6										RESET	1.000	0.945	2:48P	
7	OPTOT TARGET 49 WAS KICKED DURING TEST										RESET	0	2:49P	
8	32.6	1.403	1.400	0.180	0.239	0.188	-.018	-0.012	32.1	31.9			3:10P	
9	31.6								31.6	31.6	0.535	0.459	3:15P	0.658
10	36.6	1.816	1.890	0.243	0.318	0.262	-.019	-.014						
11	35.3	MAX CRCK : 0.025"							35.4	35.2	0.112	0.943	3:44	0.583
12	34.8									RESET	1.000	0	3:51	
13	37.5	2.216	2.367	0.311	0.4	0.339	-.019	-.015	37.1	36.7	0.592	0.469	4:10	0.502
14		MAX CRCK > 0.040"												
15				~0.050"										
16	0.12	0.883	0.969	0.123	0.157	0.145	-.017	-.010	0.2	0.1	REMOVED ——		4:30P	~~0.~~
17	0.13				0.154								4:34P	0.748
18	14.1	1.340	1.455	0.188	0.238	0.212	-.017	-0.013	13.8	13.9	——	——	4:49P	~~0.660~~
19	13.5													0.680
20	25.4	1.780	1.918	0.250	0.318	0.274	-.017	-.014	25.3	25.3	——	——	5:02	—
21	36	2.21	2.38	0.311	0.4	0.339	-.017	-.015	35.7	35.7	——	——	5:13	—
22			MOVED		0.400		MOVED						5:25	0.581
23	349	2.210	2.383	0.315	0.400	0.348							5:27	
24	↓ TEST TO FAILURE													

Purdue University

Specimen : C4

Date: 11 APR 16

	Average Load (lbf)	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	DG North Overhang (in)	DG South Overhang (in)	PC Time	MID DG
1	.12	0	0	0	0	0.001	0	0	0.2	0.1	0	1.0	8:04	0.9
2	.12	0.023	-.006	-.008	-.005	-.000	-.014	-.004	0.2	0.1	0.020	1.009	8:14	0.905
3	15.2	0.480	0.459	+.056	0.078	+.066	-.014	-.005	13	14.3	0.469	0.542	8:33	0.819
4	23.8	0.975	0.924	0.117	0.160	0.130	-0.014	-.007	22.6	22.9	OFF SCALE ~~1.077~~	0.072	8:58	0.736
5	~~32.6~~	~~1.441~~	~~1.405~~							RESET	0	1.000		
6	32.6	1.441	1.405	0.180	0.240	0.196	-.013	-.007	32.1	32.0	0.472	0.516	9:20	0.666
7	36.6	1.810	1.930	0.240	0.321	0.275	-.011	-.009	35.5	35.4	0.842	OFF SC.	9:47	
8	35.1	1.815	1.932		0.322					RESET	0	1.0		0.574
9	37.8	2,226	2,397	,308	,401 ✓	,344	-,01	-,01	37	36,4	0.409	0.535	10:22	0.493
10	39	2.697	3.089	.387	.501	.443	-.008	-.011	37.8	37.6	—	—	10:34	0.393
11	0.1	1.207	1.559	.177	.230	.225	-.012	-.008	0.2	0.1	—	—	10:59	0.671
12	14.5	1.701	2.095	.249	0.321	.298	-.011	-.009	13.3	14.4	—	—	11:22	0.577
13	24.7	2.156	2.543	.310	.4	.361	-.010	-.010	24.7	24.7	—	—	11:37	0.494
14	34.6	2.592	2.993	.373	.482	.428	-.008	-.010	34.4	34.6	—	—	11:50	0.413
15	↓			→	MAX SPLIT CRACK ~0.05"									—
16	↓ TEST TO FAILURE													
17														
18														
19														
20														
21														
22														
23														
24														

Purdue University

Specimen : C5

Date: 4/12/16

		Average Load ~~(lbf)~~ kip.	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	small-big DG North Overhang (in)	DG South Overhang (in)	Time	DG Mid
	1	.11	0	0	0	0	0	0	0	.2	.1	0	0.1	1:50	.9
Bolts removed	2	.11	.008	.02	-.014	-.013	-.012	-.002	-.005	.2	.1	.008	0.112	1:59	.91
↓ LOAD	3	15.5	0.556	0.575	0.058	0.081	0.063	-0.003	-0.009	13.9	14.8	0.451	0.562	2:00	0.815
	4	24.4	1.032	1.054	0.117	0.160	0.127	-0.003	-0.010	23.7	24.0	1.004	0.951	2:20	0.736
	5	33.3	1.508	1.532	0.181	0.240	0.193	-0.003	-0.011	32.8	32.8	OFF 1.004 RES. 0.700	OFF 0.951 Res 0.200	2:47	0.654
	6	36	1.911	2.023	0.248	0.320	0.267	-0.003	-0.010	35.3	35.1	0.301 RES 0.800	0.702 R0.300	3:14	0.575
S.side crack ~0.060 in. *	7	37.2	2.317	2.513	0.319	0.401	0.344	-0.003	-0.009	36.5	36.1	0.401	0.784	3:47	0.492
unloaded	8	0	0.913	1.094	0.126	0.156	0.146	-0.003	-0.009	0.1	0.1	OFF	OFF	4:06	0.744
	9	13.9	1.392	1.590	0.190	0.239	0.215	-0.002	-0.010	13.5	13.9	—	—	4:32	0.654
	10	24.8	1.848	2.042	0.253	0.320	0.278	-0.003	-0.009	24.8	24.6	—	—	4:46	0.573
S.side crack ~0.070 in.	11	35.1	2.290	2.497	0.316	0.399	0.342	-0.003	-0.009	34.9	34.9	—	—	5:00	0.494
	12														
	13														
	14														
	15														
	16														
	17														
	18														
	19														
	20														
	21														
	22														
	23														
	24														

Purdue University

Specimen : C6

Date: 4/14/16

		Average Load ~~(lbf)~~ Kip	North Overhang (in)	South Overhang (in)	North Splice End (in)	Midspan (in)	South Splice End (in)	LVDT North Support	LVDT South Support	North Load Cell (lbf)	South Load Cell (lbf)	DG North Overhang (in)	DG South Overhang (in)	Time	DG Mid
	1	0.13	-0.001	0.000	-.002	-.001	0.000	-0.001	-0.000	0.2	0.1	0.000	0.000	1:39	.900
	2	0.11	0.025	-0.004	-0.014	-0.008	-0.005	-0.021	-0.008	.1	.1	0.020	0.010	1:47	.894
	3	14.5	0.519	0.525	0.055	0.081	0.070	-0.021	-0.013	13.3	13.7	0.491	0.523	1:58	0.814
	4	23.7	1.007	0.988	0.114	0.160	0.133	-0.021	-0.015	23.3	23.2	1.012 RES. 0.800	0.958 RES. 0.100	2:20	0.735
	5	32.6	1.466	1.452	0.176	0.240	0.198	-0.020	-0.016	31.8	31.8	0.298 R 0.800	0.565 R 0.000	2:42	0.653
	6	36.2	1.861	1.922	0.243	0.321	0.268	-0.018	-0.017	35.2	35.1	0.391 R 0.700	0.474	3:05	0.574
did not mark cracks →	7	37.3	2.296	2.364	0.311	0.400	0.342	-0.016	-0.017	36.8	36.8	0.275 R 0.800	0.918 R 0.200	3:28	0.495
	8	↓→ Max	crack	width =	25 ×10^{-3}	in.									
→	9	38.5	2.796	2.920	0.398	0.500	0.433	-0.014	-0.017	37.6	37.7	0.297	0.747	3:44	0.395
	10	↓→ Max	crack	width =	40 ×10^{-3}	in.						—	—		
Unload	11	0.1	1.311	1.396	0.187	0.232	0.216	-0.017	-0.017	0.1	0.1	—	—	3:58	0.671
	12	13.8	1.791	1.896	0.256	0.320	0.284	-0.015	-0.017	13.3	13.8	—	—	4:18	0.581
	13	24.6	2.254	2.355	0.320	0.400	0.352	-0.014	-0.017	24.3	24.4	—	—	4:32	0.497
	14	36.7	2.791	2.916	0.398	0.501	0.433	-0.014	-0.017	36.4	36.3	—	—	4:46	0.395
	15														
	16														
	17														
	18														
	19														
	20														
	21														
	22														
	23														
	24														

CERTIFICATE OF CALIBRATION

ISSUED BY: INSTRON CALIBRATION LABORATORY

DATE OF ISSUE: 09-Dec-15 CERTIFICATE NUMBER: **340120915110036**

NVLAP Lab Code 200301-0

Instron
825 University Avenue
Norwood, MA 02062-2643
Telephone: (800) 473-7838
Fax: (781) 575-5750
Email: service_requests@instron.com

Page 1 of 4 pages

APPROVED SIGNATORY

Richard
Binford

Digitally signed by Richard Binford
DN: cn=Richard Binford, c=US, l=Norwood, st=MA, o=Instron, ou=OVR, Calibration Laboratory, A division of Illinois Tool Works, Inc. (ITW, Inc.), email=Richard_Binford@Instron.com
Reason: I attest to the accuracy and integrity of this document
Date: 2015.12.09 11:23:52 -05'00'

Date of Calibration: **09-Dec-15** **Customer Requested Due Date:** **31-Dec-16**

* * * CALIBRATION RESULTS * * *

Type of Calibration: Strain **Relevant Standard:** ASTM E83-10a
System ID: 120BTE502040 **Transducer ID:** 2630-115/590

Indicator 1. - Digital Readout (strain)
PASSED Class B-1 - 100% Range in Tension mode

Customer

Name:	PURDUE UNIVERSITY
Address:	US 231 BOWEN LABORATORY WEST LAFAYETTE,IN 47907 KBROWER@PURDUE.EDU
P.O./Contract No.:	
Contact:	KEVIN BROWER

Machine

Manufacturer:	SATEC
Serial Number:	120BTE502040
System ID:	120BTE502040
Range Type:	Single

Transducer

Manufacturer:	INSTRON
Transducer ID:	2630-115/590
Extensometer Type:	Type 1
Travel (Tension):	1 in
Travel (Compression):	0.1 in
Gauge Length:	2 in
Mode:	Static (Tension/Compression)

Certification Statement

All indicators listed above were verified on-site at customer location by Instron in accordance with ASTM E83.

The verification and equipment used conform to a controlled Quality Assurance program which meets the specifications outlined in ANSI/NCSL Z540-1, ISO 10012, ISO 9001:2008 and ISO/IEC 17025:2005.

The testing machine was verified in the 'as found' condition.

Instron Calpro Version 3.30

The results indicated on this certificate and the following report relate only to the items verified. If there are methods or data included that are not covered by the NVLAP accreditation it will be identified in the comments. Any limitations of use as a result of this verification will be indicated in the comments. This report must not be used to claim product endorsement by NVLAP or the United States government. This report shall not be reproduced, except in full, without the approval of the issuing laboratory.

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915110036

Summary of Results

Indicator 1. - Digital Readout (strain)

Range Full Scale (%)	Tested Range (in)	Mode	System Class*	Resolution (strain)	Resolution Class	ASTM E83 Lower Limit (in)
100	0.1002 to 1.00369	Tension	B-1	0.00001	A	0.002

** System Class for a range is the worst of the following classes: gauge length class, resolution class, individual point error class, repeatability class and is also based on the measurement capability of the laboratory.*

Gauge Length Measurement and Classification

Nominal Gauge Length (in)	Actual Gauge Length (in)	Measurement Type	Relative Error of Gauge Length for Each Measurement Made (%)			ASTM E83 Gauge Length Class	Uncertainty of Measurement* (in)
2	1.99865	Indirect	-0.229	-0.117	0.143	B-1	0.0032

** The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%.*

Data Summary and Classification

Indicator 1. - Digital Readout (strain)

% of Range	Run 1 Error Fixed (strain)	Run 1 Error Relative (% of strain)	Run 2 Error Fixed (strain)	Run 2 Error Relative (% of strain)	Repeat Error (strain)	Worst Class	Uncertainty of Measurement* (strain)
100% Range (Full Scale: 1.00369 in)							
10	-0.00018	-0.354	-0.00010	-0.199	0.00008	B-1	0.000093
20	-0.00043	-0.427	-0.00047	-0.466	0.00004	B-1	0.00017
40	-0.00082	-0.406	-0.00097	-0.482	0.00015	B-1	0.00033
70	-0.00059	-0.168	-0.00035	-0.101	0.00024	B-1	0.00058
100	-0.00184	-0.367	-0.00156	-0.311	0.00028	B-1	0.00082

** The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%.*

Data

Indicator 1. - Digital Readout (strain)

% of Range	Run 1 Indicated (strain)	Run 1 Applied (in)	Run 2 Indicated (strain)	Run 2 Applied (in)
100% Range (Full Scale: 1.00369 in)				
	Run Temperature: 67.6 °F		Run Temperature: 69.8 °F	
0	0	-0.000001	0	0.000000
10	0.050027	0.100410	0.05	0.100200
20	0.1	0.200858	0.1	0.200936
40	0.2	0.401631	0.2	0.401937

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915110036

Data

Indicator 1. - Digital Readout (strain)

100% Range (Full Scale: 1.00369 in)

	Run 1		**Run 2**	
% of Range	Indicated (strain)	Applied (in)	Indicated (strain)	Applied (in)
	Run Temperature: 67.6 °F		Run Temperature: 69.8 °F	
70	0.35	0.701182	0.35	0.700708
100	0.5	1.003686	0.5	1.003124

Verification Equipment

Make/Model	Serial Number	Description	Calibration Agency	Measurement Range	Cal Date	Cal Due
Extech 445580	1041758	temp. indicator	Masy Systems Inc.	NA	13-Feb-15	13-Feb-17
Epsilon 3590VHR	A5010 (ASTM)	disp. indicator	Epsilon Technology	2.00 in	29-Jan-15	29-Jan-16
Instron US Gauge Bar	I902 (ASTM)	gauge bar	A.A. Jansson	NA	29-May-14	29-May-16
Interface 9840	93112	force indicator	Instron	NA	24-Sep-14	24-Sep-16

Verification Equipment Usage

Measurement Type	Serial Number	Range (% of FS)	Mode	Percent(s) of Range	Accuracy (+/-)
Displacement	A5010 (ASTM)	100	T	10/ 20	0.00004 in
				40/ 70	0.000075 in
				100	0.00015 in
Gauge Length	93112	NA		NA*	0.015% of reading
	A5010 (ASTM)	NA		NA*	0.00004 in
	I902 (ASTM)	NA		NA*	0.00021 in
Temperature	1041758	All		All	1.8 °F

** Refer to Gauge Length Measurement and Classification section for usage.*

Instron standards are traceable to the SI (The International System of Units) through standards maintained by the National Institute of Standards and Technology (NIST) or other internationally recognized National Metrology Institutes (NMIs).

The accuracy of the verification equipment used was equal to or better than the accuracy indicated in the table above.

Comments

Verified by: Rich Binford
Field Service Engineer

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915110036

NOTE: Clause 9 of ASTM E-83 states; It is recommended that extensometer systems be verified annually or more frequently if required. In no case shall the time interval between verifications exceed 18 months (unless an extensometer is being used in a long-time test running beyond the 18 month period). An extensometer system shall not be used after an adjustment or repair that could affect its accuracy without first verifying its accuracy utilizing the procedure described in this practice.

CERTIFICATE OF CALIBRATION

ISSUED BY: INSTRON CALIBRATION LABORATORY

DATE OF ISSUE: 09-Dec-15 CERTIFICATE NUMBER: **340120915102905**

NVLAP Lab Code 200301-0

Instron
825 University Avenue
Norwood, MA 02062-2643
Telephone: (800) 473-7838
Fax: (781) 575-5750
Email: service_requests@instron.com

APPROVED SIGNATORY

Type of Calibration: **Force**
Relevant Standard: **ASTM E4-14**
Date of Calibration: **09-Dec-15**

Customer Requested Due Date: **31-Dec-16**

Customer

Name:	PURDUE UNIVERSITY
Address:	US 231 BOWEN LABORATORY WEST LAFAYETTE,IN 47907 KBROWER@PURDUE.EDU
P.O./Contract No.:	
Contact:	KEVIN BROWER

Machine

Manufacturer:	SATEC
Serial Number:	120BTE502040
System ID:	120BTE502040
Range Type:	Single

Transducer

Manufacturer:	SATEC
Transducer ID:	120BTE502040
Capacity:	120000 lbf
Type:	Compression

Classification

1. Digital Readout - PASSED**

Certification Statement

This certifies that the forces verified with machine indicator(s) (listed above) that passed are WITHIN ±1% accuracy, 1% repeatability, and zero return tolerance.
All machine indicators were verified on-site at customer location by Instron in accordance with ASTM E4.
The certification is based on runs 1 and 2 only. A third run is taken to satisfy uncertainty requirements according to ISO 17025 specifications.
The verification and equipment used conform to a controlled Quality Assurance program which meets the specifications outlined in ANSI/NCSL Z540-1, ISO 10012, ISO 9001:2008 and ISO/IEC 17025:2005.

**** within ±0.5% accuracy and 0.5% repeatability.**

Method

The testing machine was verified in the 'as found' condition with no adjustments carried out.

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915102905

Summary of Results

Temperature at start of verification: 71.20 °F.

Indicator 1. - Digital Readout (lbf)

Range Full Scale (%)	Tested Force Range (lbf)	Mode	ASTM E4 Max Error (%)	ASTM E4 Max Repeat Error (%)	Zero Return	Resolution (lbf)	ASTM E4 Lower Limit (lbf)
100	-1196.65 to -119941.1	C	0.28	0.19	Pass	1	200

Temperature at end of verification: 71.20 °F.

Data Point Summary - Indicator 1. - Digital Readout (lbf)

COMPRESSION

% of Range	Run 1 Error (%)	Run 2 Error (%)	Run 3 Error (%)	ASTM E4 Repeat Error (%)	Relative Uncertainty* (%)	Uncertainty of Measurement* (± lbf)
100% Range (Full Scale: -119941.1 lbf)						
1	0.28	0.26	0.29	0.02	0.14	1.6
2	0.15	0.16	0.16	0.01	0.13	3.1
4	0.03	0.03	0.03	0.00	0.13	6.1
7	-0.02	-0.01	-0.01	0.01	0.13	11
10	0.11	0.11	0.12	0.00	0.13	15
20	0.14	0.14	0.15	0.00	0.13	31
40	0.10	0.10	0.10	0.00	0.13	61
70	0.21	0.05	0.07	0.16	0.16	137
100	0.24	0.05	0.07	0.19	0.18	211

** The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%.*

Data - Indicator 1. - Digital Readout (lbf)

COMPRESSION

	Run 1		**Run 2**		**Run 3**	
% of Range	Indicated (lbf)	Applied (lbf)	Indicated (lbf)	Applied (lbf)	Indicated (lbf)	Applied (lbf)
100% Range (Full Scale: -119941.1 lbf)						
0 Return	4		3		12	
1	-1200	-1196.65	-1200	-1196.85	-1200	-1196.55
2	-2400	-2396.45	-2400	-2396.25	-2400	-2396.05
4	-4800	-4798.6	-4800	-4798.4	-4800	-4798.35
7	-8400	-8401.4	-8400	-8400.85	-8400	-8400.8
10	-12000	-11986.44	-12000	-11987.03	-12000	-11985.26
20	-24000	-23967.57	-24000	-23965.8	-24000	-23964.03
40	-48000	-47953.43	-48000	-47950.48	-48000	-47949.89
70	-84000	-83820.71	-84000	-83957	-84000	-83944.02
100	-120000	-119711	-120000	-119941.1	-120000	-119918.68

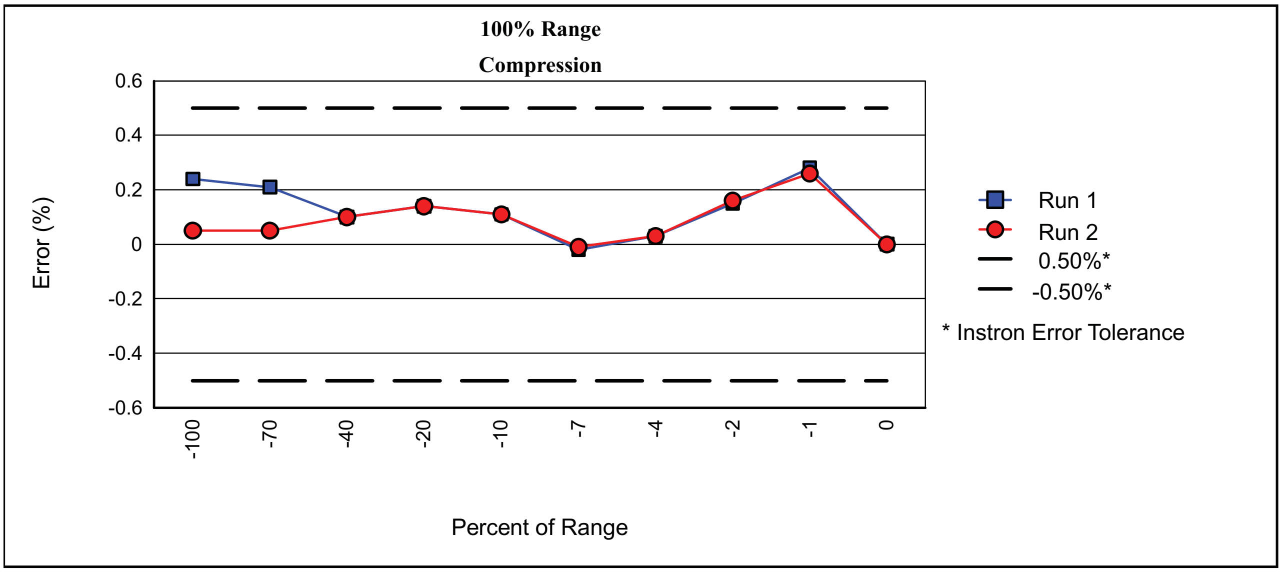
CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915102905

The Return to Zero tolerance is ± the indicator resolution, 0.1% of the maximum force verified in the range, or 1% of the lowest force verified in the range, whichever is greater.

Graphical Data - Indicator 1. - Digital Readout (lbf)



Verification Equipment

Make/Model	Serial Number	Description	Calibration Agency	Capacity	Cal Date	Cal Due
Extech 445580	1041758	temp. indicator	Masy Systems Inc.	NA	13-Feb-15	13-Feb-17
HBM 10KFRR	688077	load cell	Instron	12000 lbf	16-May-14	16-May-16
Interface 9840	93112	force indicator	Instron	NA	24-Sep-14	24-Sep-16
Strainsense 050530	050530	load cell	Instron	120000 lbf	16-Oct-14	16-Oct-16

Verification Equipment Usage

Range Full Scale (%)	Mode	Standard Serial Number	Percent(s) of Range	Lower Limit for Standard (lbf)	Accuracy (+/-)
100	C	688077	1/ 2/ 4/ 7	Class A1: 256	0.1% of reading
		050530	10/ 20/ 40/ 70/ 100	Class A1: 10552	0.1% of reading
All	C	1041758	All	NA	1.8 °F

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915102905

Instron standards are traceable to the SI (The International System of Units) through standards maintained by the National Institute of Standards and Technology (NIST) or other internationally recognized National Metrology Institutes (NMIs).

The standard Class A lower limit is used for systems with an accuracy of +/-1.0% and the standard Class A1 lower limit is used for systems with an accuracy of +/-0.5%.

The accuracy of the force indicator used with elastic devices is incorporated into the devices stated accuracy.

Standard forces have been temperature compensated as necessary.

The accuracy of the verification equipment used was equal to or better than the accuracy indicated in the table above.

Comments

Verified by: Rich Binford
Field Service Engineer

NOTE: Clause 19 of ASTM E4 states; It is recommended that testing machines be verified annually or more frequently if required. In no case shall the time interval between verifications exceed 18 months (except for machines in which long term test runs beyond the 18 month period). Testing machines shall be verified immediately after repairs that may in any way affect the operation of the weighing system or values displayed. Verification is required immediately after a testing machine is relocated and where there is a reason to doubt the accuracy of the force indicating system, regardless of the time interval since the last verification.

CALSER CORPORATION

302 N. Belt East, Swansea, IL 62226 (618) 277-0329

TESTING MACHINE CALIBRATION DATA AND REPORT

Report #: **VN# 10097**
Page 1 of 2

Customer	Purdue University		
Location	1040 South Rive Rd. - Bowen Lab	**Date of Service**	08/19/15
	West Lafayette, IN 47907	**Customer Order No.**	Verbal
Manufacturer	Forney **Model** F-600-DFM/I	**Order Date**	08/03/15
Serial No.	99058 **Capacity** 600,000 lbf	**Temp.**	71˚ F
Resolution	1 lbf / DIV	**Date Last Done**	06/04/14
Customer Asset No.	1009085	**Calibration Next Due**	08/19/16
Auxiliary Equipment:	w/ Forney CA-0396 Auto Digital R/O #15087	**Method of Verification**	Set the Force
	w/ Gefran P/T		

Applied Force	*	Indicated Force	Error	%	Applied Force	*	Indicated Force	Error	%
Run #1		"As Found" Condition			Run #2		"As Left" Condition		
600,000lbf Range	*	1lbf / DIV			600,000lbf Range	*	1lbf / DIV		
0	6C	0	0	0.00	0	6C	0	0	0.00
5,000	6C	5,002	2	0.04	5,000	6C	5,004	4	0.08
10,000	6C	10,012	12	0.12	10,000	6C	10,008	8	0.08
20,000	17S	20,034	34	0.17	20,000	17S	20,039	39	0.20
40,000	17S	40,058	58	0.15	40,000	17S	40,064	64	0.16
60,000	17S	60,066	66	0.11	60,000	17S	60,069	69	0.12
80,000	12	80,087	87	0.11	80,000	12	80,091	91	0.11
100,000	12	100,120	120	0.12	100,000	12	100,132	132	0.13
150,000	12	150,161	161	0.11	150,000	12	150,174	174	0.12
200,000	12	200,094	94	0.05	200,000	12	200,102	102	0.05
300,000	12	300,166	166	0.06	300,000	12	300,170	170	0.06
400,000	12	400,075	75	0.02	400,000	12	400,081	81	0.02
500,000	12	500,210	210	0.04	500,000	12	500,199	199	0.04
600,000	12	600,182	182	0.03	600,000	12	600,174	174	0.03
0	12	0	0	0.00	0	12	0	0	0.00

Notes:

Calibration in accordance with ASTM E4,
and Calser Corporation Procedure # 1-01, Rev 1.

***CALIBRATION EQUIPMENT**

All verification equipment-including dead weights, proving rings, load cells, etc, is calibrated and traceable to the latest procedures stipulated by the National Institute of Standards and Technology (NIST) and ASTM E74-06. All equipment is traceable under guidelines set forth in ISO/IEC 17025 . All instrument readings have been corrected for temperature where necessary.

ACCURACY SUMMARY

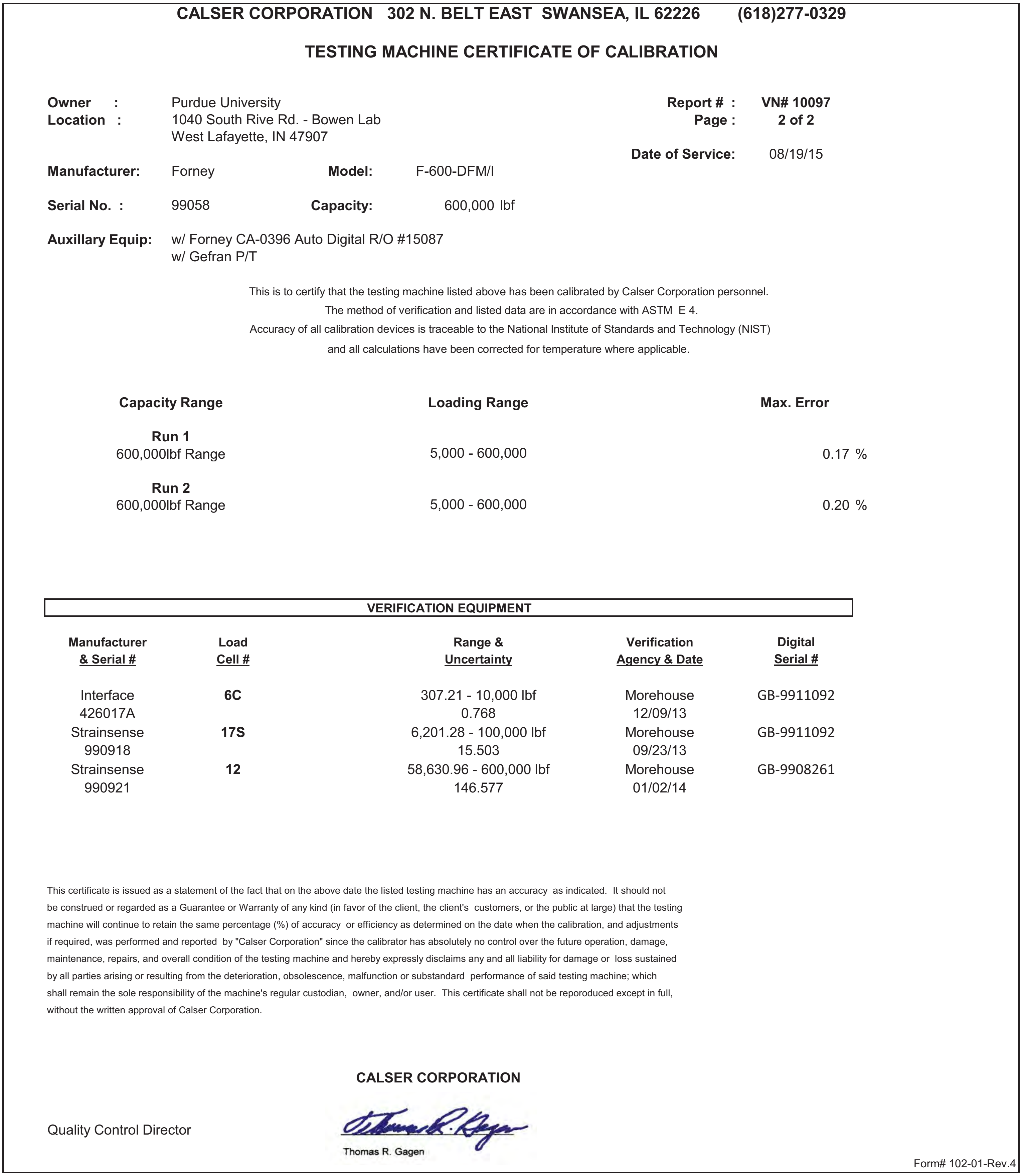
Capacity Range	Loading Range	Max. Error
Run 1		
600,000lbf Range	5,000 - 600,000	0.17 %
Run 2		
600,000lbf Range	5,000 - 600,000	0.20 %

Verification Equipment

Manufacturer and Serial #	* L/C	Range and uncertainty	Verification Agency and Date
Interface	6C	307.21 - 10,000 lbf	Morehouse
426017A		0.768	12/09/13
Strainsense	17S	6,201.28 - 100,000 lbf	Morehouse
990918		15.503	09/23/13
Strainsense	12	58,630.96 - 600,000 lbf	Morehouse
990921		146.577	01/02/14

Calibration Technician Jerry Parker

This report shall not be copied except in its entirety without express written approval of Calser Corp.



CALSER CORPORATION 302 N. BELT EAST SWANSEA, IL 62226 (618)277-0329

TESTING MACHINE CERTIFICATE OF CALIBRATION

Owner : Purdue University
Location : 1040 South Rive Rd. - Bowen Lab
West Lafayette, IN 47907

Report # : VN# 10097
Page : 2 of 2
Date of Service: 08/19/15

Manufacturer: Forney **Model:** F-600-DFM/I

Serial No. : 99058 **Capacity:** 600,000 lbf

Auxillary Equip: w/ Forney CA-0396 Auto Digital R/O #15087
w/ Gefran P/T

This is to certify that the testing machine listed above has been calibrated by Calser Corporation personnel. The method of verification and listed data are in accordance with ASTM E 4. Accuracy of all calibration devices is traceable to the National Institute of Standards and Technology (NIST) and all calculations have been corrected for temperature where applicable.

Capacity Range	Loading Range	Max. Error
Run 1 600,000lbf Range	5,000 - 600,000	0.17 %
Run 2 600,000lbf Range	5,000 - 600,000	0.20 %

VERIFICATION EQUIPMENT

Manufacturer & Serial #	Load Cell #	Range & Uncertainty	Verification Agency & Date	Digital Serial #
Interface 426017A	**6C**	307.21 - 10,000 lbf 0.768	Morehouse 12/09/13	GB-9911092
Strainsense 990918	**17S**	6,201.28 - 100,000 lbf 15.503	Morehouse 09/23/13	GB-9911092
Strainsense 990921	**12**	58,630.96 - 600,000 lbf 146.577	Morehouse 01/02/14	GB-9908261

This certificate is issued as a statement of the fact that on the above date the listed testing machine has an accuracy as indicated. It should not be construed or regarded as a Guarantee or Warranty of any kind (in favor of the client, the client's customers, or the public at large) that the testing machine will continue to retain the same percentage (%) of accuracy or efficiency as determined on the date when the calibration, and adjustments if required, was performed and reported by "Calser Corporation" since the calibrator has absolutely no control over the future operation, damage, maintenance, repairs, and overall condition of the testing machine and hereby expressly disclaims any and all liability for damage or loss sustained by all parties arising or resulting from the deterioration, obsolescence, malfunction or substandard performance of said testing machine; which shall remain the sole responsibility of the machine's regular custodian, owner, and/or user. This certificate shall not be reporoduced except in full, without the written approval of Calser Corporation.

CALSER CORPORATION

Quality Control Director

Thomas R. Gagen

Form# 102-01-Rev.4

CERTIFICATE OF CALIBRATION

ISSUED BY : INSTRON CALIBRATION LABORATORY

DATE OF ISSUE : **09-Dec-2015** CERTIFICATE NUMBER: **340120915130058**

Lab code: 200301-0

Page 1 of 3

Instron
825 University Avenue
Norwood, MA 02062-2643
Telephone: (800) 473 - 7838
Fax: (781) 575 - 5755
Email: service_requests@instron.com

APPROVED SIGNATORY

Type of Calibration: **Displacement**
Relevant Standard: **ASTM E2309/E2309M-05(2011)e1**
Date of Calibration: **09-Dec-2015** **Customer Requested Due Date: 31-Dec-2016**

Customer

PURDUE UNIVERSITY
CIVIL RM G151 550 STADIUM MALL DR
WEST LAFAYETTE, IN 47907

Machine

Serial No : 502040
Make : BALDWIN
Model : 120BTE

P.O. Number :
Contact : KEVIN BROWER

Readout Verified

1. Digital Readout (in)

Certification Statement

This certifies that the displacements verified with machine indicator 1 (listed above) were verified by Instron in accordance with ASTM E2309/E2309M (Follow-the-Displacement Method) and Instron work instruction ICA-8-07.

The verification and equipment used conform to a controlled Quality Assurance program which meets the specification outlined in ANSI/NCSL Z540-1, ISO 10012, ISO 9001:2008, and ISO/IEC 17025:2005. The Instron measurement equipment used for verification is traceable to NIST.

The testing machine was verified on-site at customer location. The testing machine was verified in the 'As Found' condition with no adjustments or repairs carried out. This is also the 'As Left' condition.

Summary of Results

Indicator 1- Digital Readout (in)

Verified Range (in)	Max Error (in)	Max Error (%)	Max Repeat Error (in)	Max Repeat Error (%)	System Class*	Resolution (in)	Resolution Class	ASTM Lower Limit (in)
0.6 - 3	-0.00883	-0.484	0.00224	0.117	A	.001	A	0.6

**System Class is derived from assessment of the following: error, repeatability, resolution, and standard device classification.*

The results indicated on this certificate and report relate only to the items verified. If there are methods or data included that are not covered by the NVLAP accreditation it will be identified in the comments. Any limitations of use as a result of this verification will be indicated in the comments. This report must not be used to claim product endorsement by NVLAP or the United States government. This report shall not be reproduced, except in full, without the approval of Instron.

CalproSDS version 3.10

CERTIFICATE OF CALIBRATION

ISSUED BY : INSTRON CALIBRATION LABORATORY

DATE OF ISSUE : **09-Dec-2015** CERTIFICATE NUMBER: **340120915130058**

Direction of Displacement : Ascending

Datapoint Summary - Indicator 1 - Digital Readout (in)

Suggested Value (in)	Run 1 Error (in)	Run 1 Error (%)	Run 2 Error (in)	Run 2 Error (%)	Run 3 Error (in)	Run 3 Error (%)	Repeat Error (in)	Uncertainty (in)*	Coverage Factor = k
0.6	-0.00167	-0.278	-0.00103	-0.173	-0.00166	-0.273	0.00064	0.00098	2.31
1.2	-0.00545	-0.454	-0.00449	-0.368	-0.00499	-0.414	0.00096	0.0013	2.57
1.8	-0.00581	-0.484	-0.00667	-0.367	-0.00805	-0.446	0.00224	0.0031	3.18
2.4	-0.00710	-0.296	-0.00883	-0.356	-0.00828	-0.345	0.00173	0.0026	3.18
3	-0.00467	-0.155	-0.00352	-0.117	-0.00537	-0.178	0.00185	0.0027	3.18

**The reported expanded uncertainty of measurement is based on a combined uncertainty multipied by a coverage factor k to provide a level of confidence of approximately 95 %.*

Runs 1 and 2 are performed to comply with the requirements of ASTM E2309/E2309M, run 3 is performed to calculate the uncertainty of measurement.

Data - Indicator 1 - Digital Readout (in)

Temperature at start of verification : 71.3 °F

	Run 1			**Run 2**			**Run 3**	
Suggested Value	Applied	Indicated	Error Class	Applied	Indicated	Error Class	Applied	Indicated
0.6	0.60167	0.6	A	0.59603	0.595	A	0.60766	0.606
1.2	1.19945	1.194	A	1.21849	1.214	A	1.20499	1.2
1.8	1.19981	1.194	A	1.81667	1.81	A	1.80505	1.797
2.4	2.40210	2.395	A	2.48083	2.472	A	2.40228	2.394
3	3.00467	3	A	3.00652	3.003	A	3.01537	3.01

For runs 1 and 2: the worst Resolution Class is A and the worst Repeatability Class is A.

Temperature at end of verification : 71.2 °F

Starting Point of crosshead : 0 in

Verification Equipment

Make/Model	Serial No.	Description	Cal Agency	Cal Date	Due Date
Instron LDS-10	06105014	Linear Gage	AA JANNSON	21-Jul-15	21-Jul-17
EXTECH 445580	1041758	Thermometer	MASY	13-Feb-15	13-Feb-17

CERTIFICATE OF CALIBRATION

ISSUED BY : INSTRON CALIBRATION LABORATORY

DATE OF ISSUE : **09-Dec-2015** CERTIFICATE NUMBER: **340120915130058**

Verification Equipment Specifications

Serial No.	Resolution	Accuracy (+/-)
06105014	0.00001 in	0.0002 in
1041758	0.1 °F	2 °F

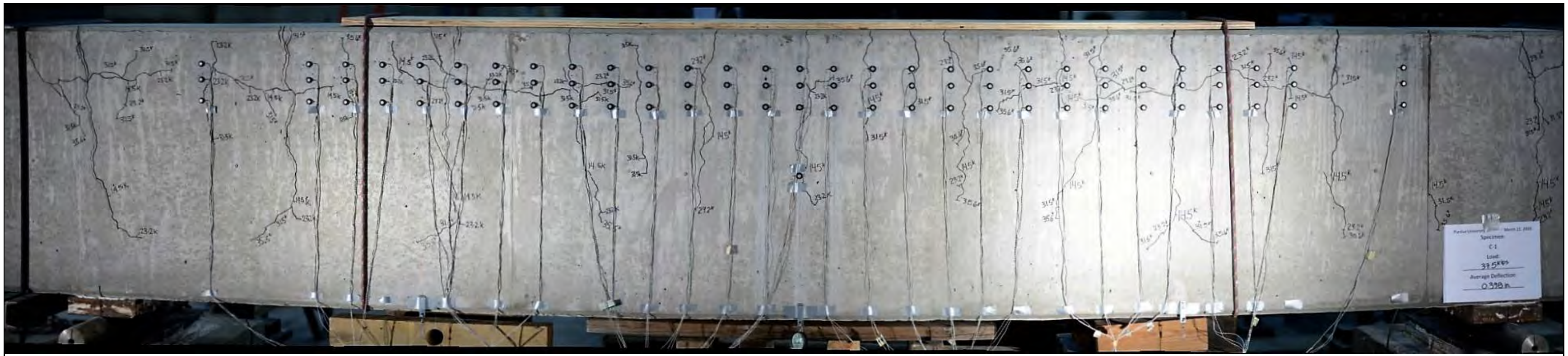
Instron standards are traceable to the SI (The International System of Units) through standards maintained by the National Institute of Standards and Technology (NIST) or other internationally recognized National Metrology Institutes (NMIs).

The accuracy of the verification equipment used was equal to or better than the accuracy indicated in the table above.

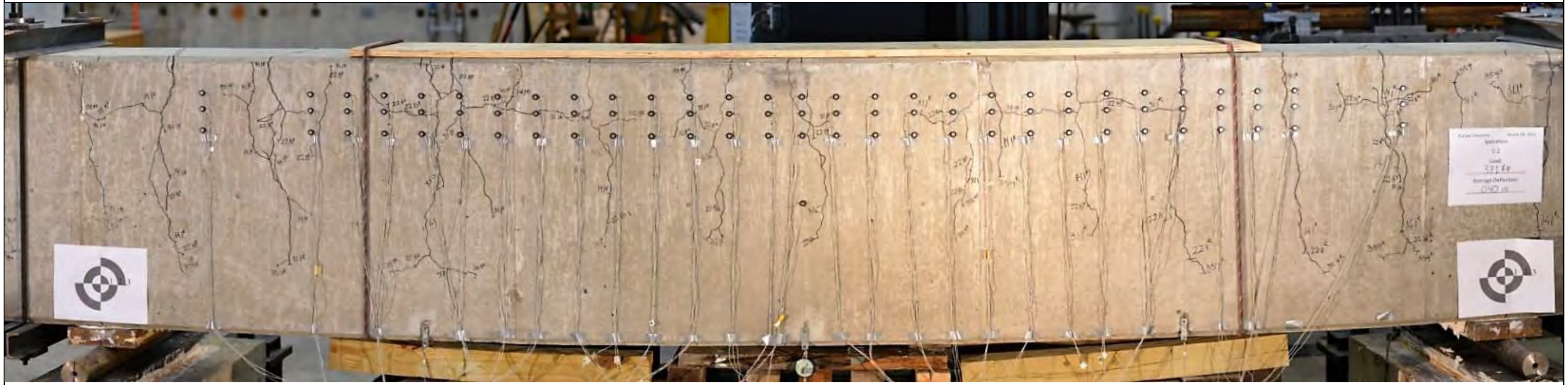
Comments

Verified By: RICHARD BINFORD
FIELD SYSTEMS ENGINEE

FIRST LOADING

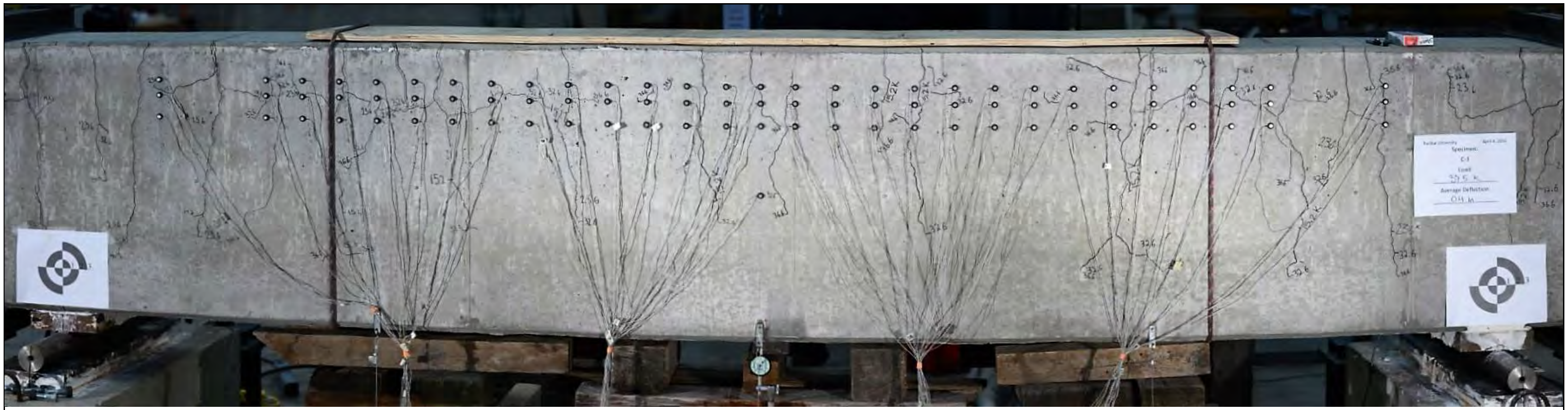


GIRDER C1: Midspan deflection = 0.4 in., Load = 37.5 kips

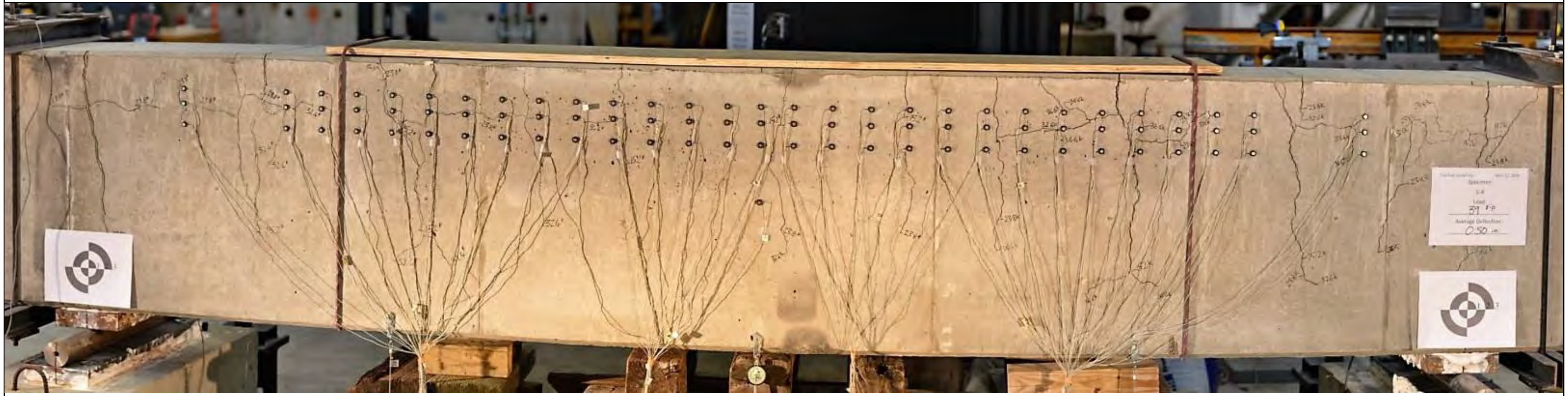


GIRDER C2: Midspan deflection = 0.4 in., Load = 37.1 kips

FIRST LOADING

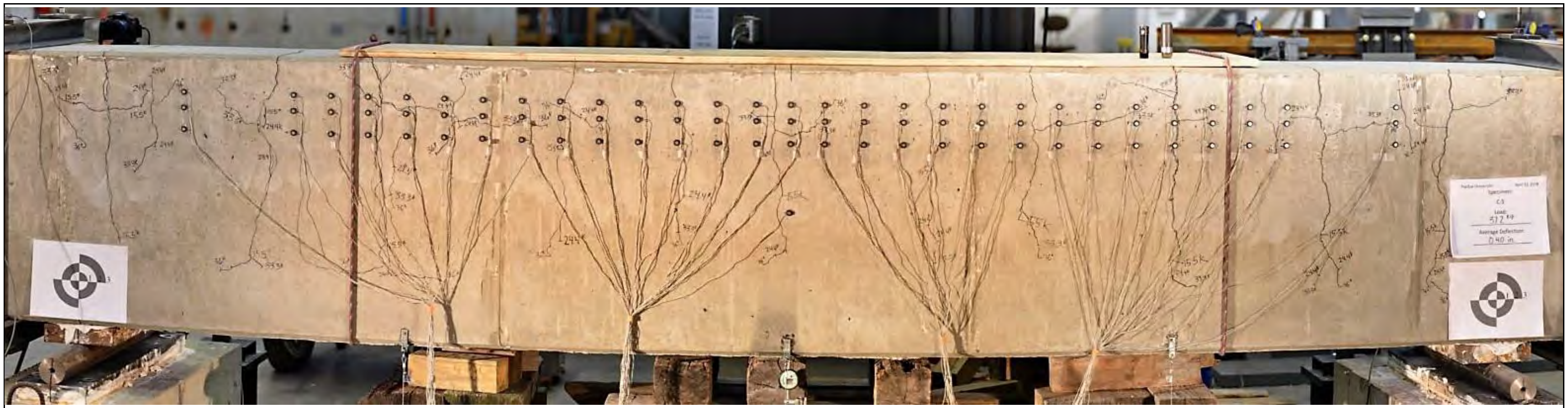


GIRDER C3: Midspan deflection = 0.4 in., Load = 37.5 kips

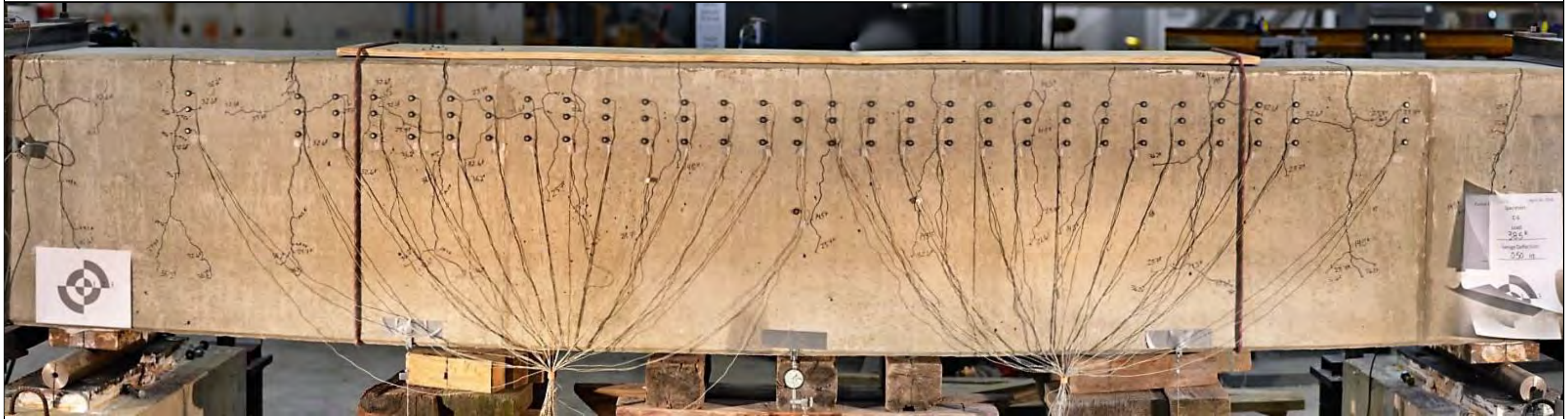


GIRDER C4: Midspan deflection = 0.5 in., Load = 39 kips

FIRST LOADING

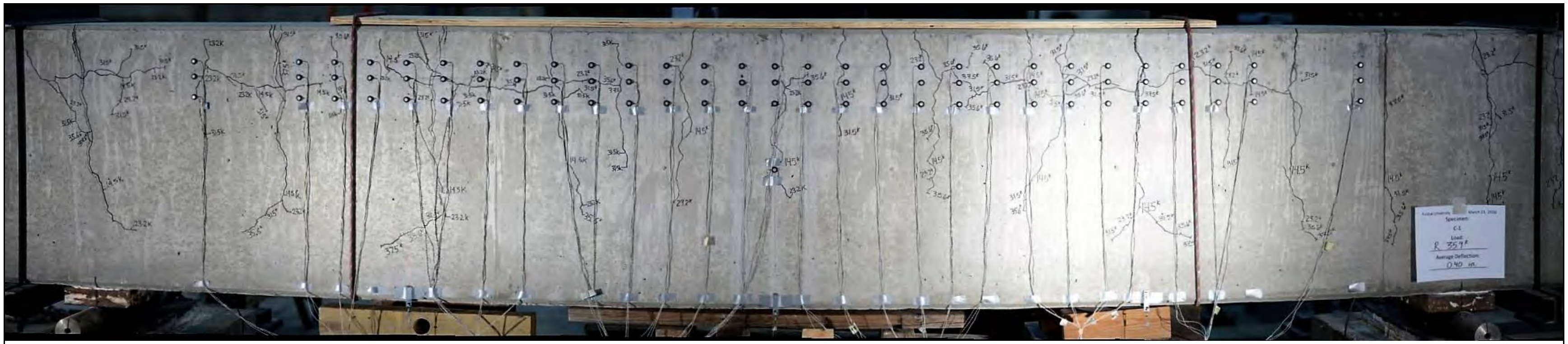


GIRDER C5: Midspan Deflection = 0.4 in., Load = 37.2 kips

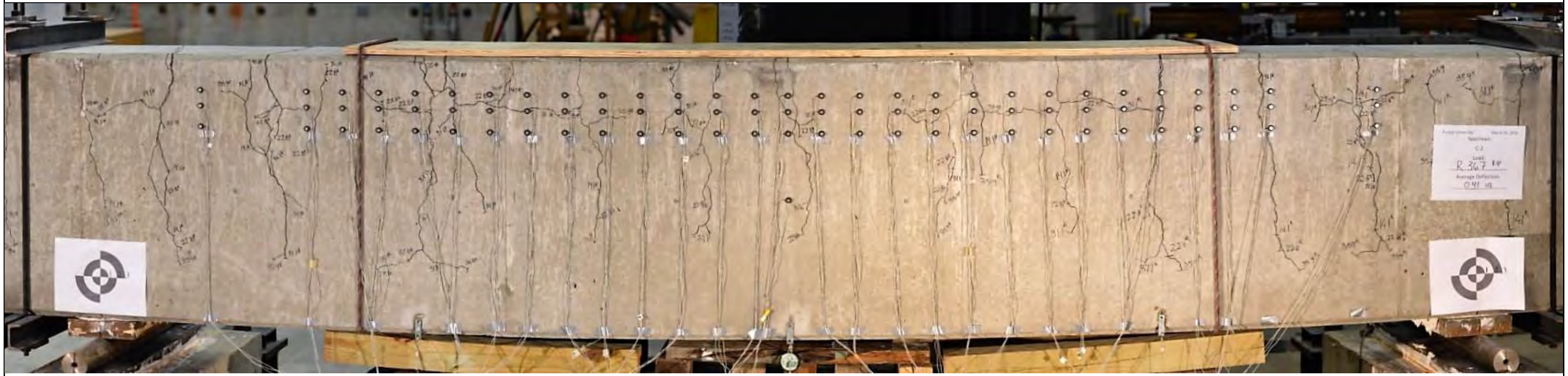


GIRDER C6: Midspan deflection = 0.5 in., Load = 38.5 kips

RELOADING

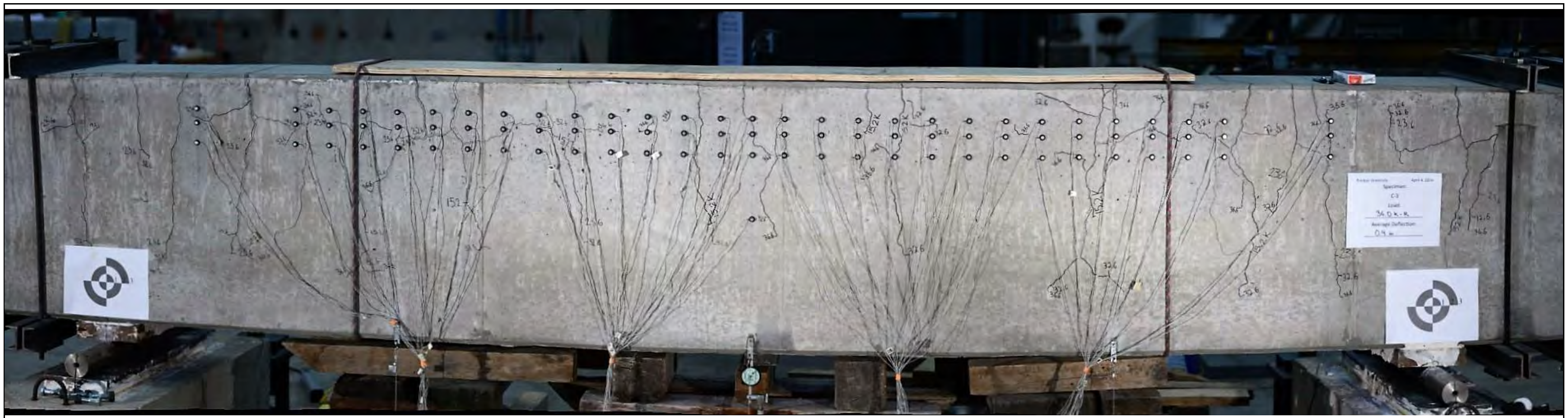


GIRDER C1: Midspan deflection = 0.4 in., Load = 35.9 kips

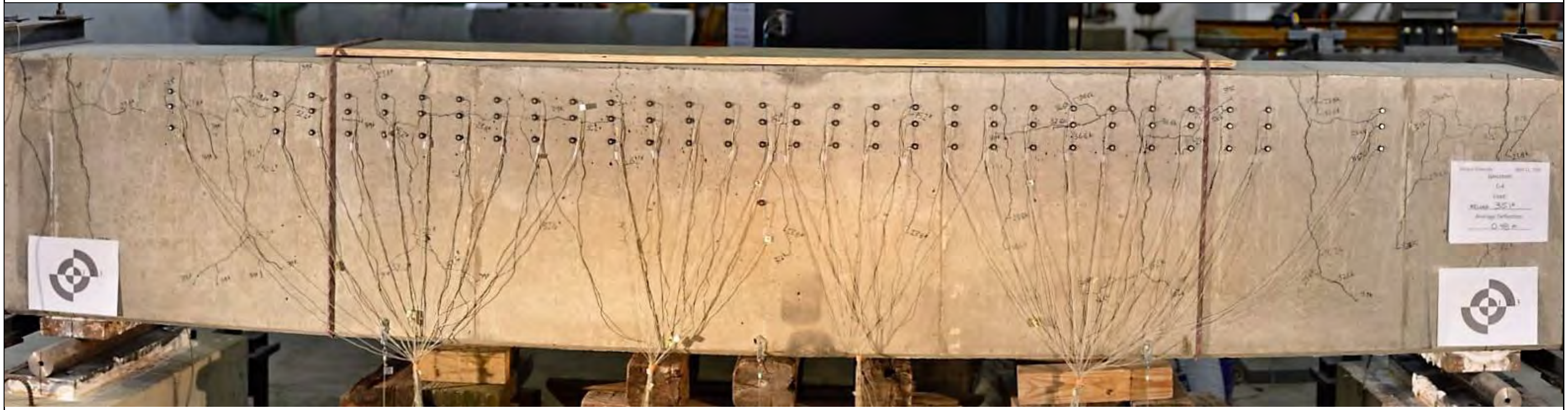


GIRDER C2: Midspan deflection = 0.4 in., Load = 36.7 kips

RELOADING

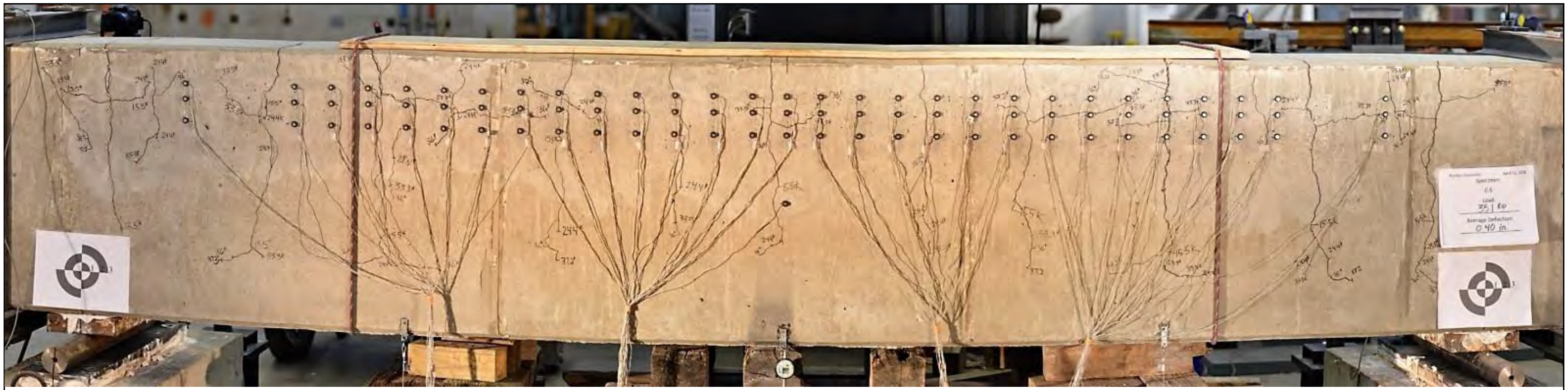


GIRDER C3: Midspan deflection = 0.4 in., Load = 36 kips

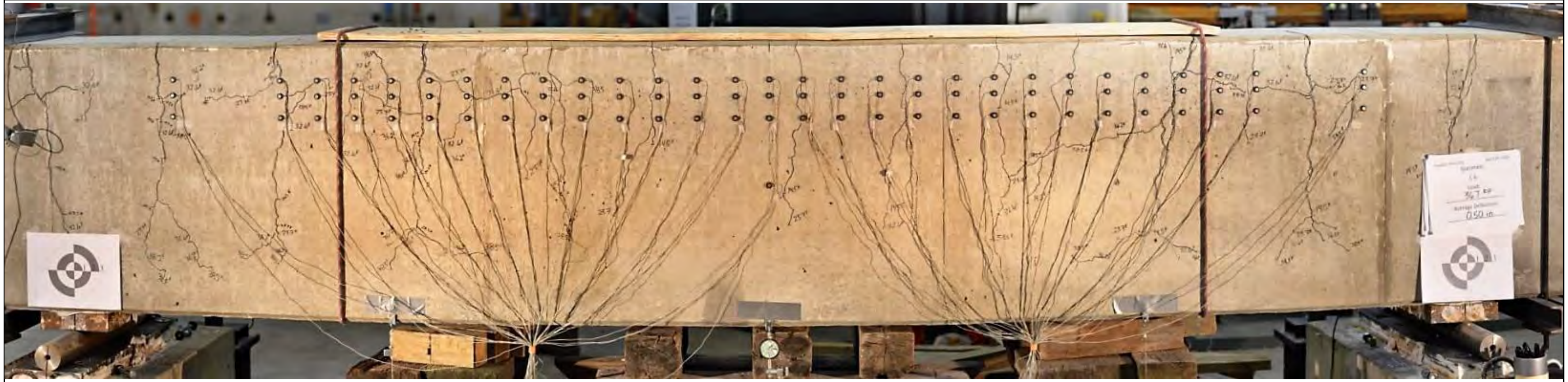


GIRDER C4: Midspan deflection = 0.5 in., Load = 35.1 kips

RELOADING



GIRDER C5: Midspan deflection = 0.4 in., Load = 35.1 kips



GIRDER C6: Midspan deflection = 0.5 in., Load = 36.7 kips

25884-000-30R-C01R-00002, Rev. 000

APPENDIX C

“Purdue Phase III Test Report”

AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF 79-IN. LAP SPLICES OF #11 REINFORCING BARS WITH POST-INSTALLED TRANSVERSE REINFORCEMENT.

A REPORT Submitted to

First Energy Nuclear Operating Company
Oak Harbor, Ohio

by

Mete A. Sozen

Mete A Sozen

and

Santiago Pujol

Pujol.

27 September 2017
Bowen Laboratory
West Lafayette, IN

SUMMARY

Eighteen test specimens containing two 79 in. lap splices of #11 reinforcing bars were tested by subjecting them to tensile forces applied directly to the spliced bars. The bars were stressed beyond their yield stress to develop laminar cracks, unloaded, and then reloaded to failure.

Three series of tests were conducted. In the Series 1 (specimens D1-D3, D9, D11, D17), splices were unconfined. They confirmed results from beam tests reported earlier indicating that laminar cracks with widths of up to 0.05 in. did not affect the ability of the lap splice to develop yielding in the spliced bars. In the other two series of tests, lap splices were confined by transverse reinforcement installed after initial laminar cracks of widths of at least 0.06 in. were developed. Transverse reinforcement was installed using ASTM A193 ¾’’diameter threaded rod drilled and epoxied into the concrete in the direction perpendicular to the plane of the bars. In Series 2 (D4-D7), transverse reinforcement had embedment lengths of 5 in. measured below the surface of the spliced reinforcing bars. In Series 3 (D8, D10, D12-D16, D18), all anchors had an embedment length of 12 in. below the spliced bars and bearing plates, washers and nuts at the concrete surface (Figure 6). Specimen dimensions and threaded rod spacings are shown and listed in Figures 4-6 and Table 5. Maximum initial crack widths reached before unloading and reloading are listed in Table 5.

Concrete compressive strength ranged from 4000 psi to 4500 psi at time of test. Measured yield stress of the ASTM 615 reinforcing bars was 67 ksi. The measured yield stress of the ASTM A193 threaded rod was 120 ksi.

In specimens D4-D8, D10, and D12, anchors were installed at an ambient temperature of approximately 55° F. In specimens D13-D16, and D18, anchors were installed at an ambient temperature of approximately 75° F. Epoxy was cured for 24 hours prior to reloading, except in specimen D7, in which epoxy was cured for 48 hours. The curing of epoxy and anchor installation was performed indoors in laboratory conditions.

Test results confirmed that crack widths as large as 0.05 in. can be achieved while maintaining the full yield capacity of the #11 reinforcement with 79 in. long splices. Test results also showed that crack widths of nearly 1/8 in. or wider (and bar stresses of approximately 80 ksi) can be reached before failure in lap splice pairs confined by at least three epoxied ASTM A193 ¾’’ diameter threaded rods with an embedment length of 12 in. below the surface of the splice, spaced at no more than 26.5 in. in the direction of the splice, and fastened to the concrete surface with a bearing plate and nut (Series 3).

OBJECT AND SCOPE

Eighteen reinforced concrete specimens with 79 in. lap splices of ASTM 615 Gr. 60 #11 bars were tested to failure to:

1) Examine splices with wider laminar cracks than those produced in previous tests (An Experimental Investigation Of The Effects Of Laminar Cracks On Strength Of Unconfined 79-in. Lap Splices Of #11 Reinforcing bars, Series C, Submitted 5/10/16).
2) Evaluate the effects of transverse reinforcement (that can be provided in the field by post-installed threaded rods installed after development of laminar cracks) on the response of splices with laminar cracks.

METHOD

The test specimens are depicted in Figure 1. They had the same cross sections and materials as the specimens used previous tests (30” x 17-5/8” with top cover of 5” and side cover of 3”), but their length was 80 in.

Each specimen had a pair of lap spliced bars with a length of 79 in. Test specimens were subjected to tensile forces applied directly to the spliced bars to produce effects similar to the effects that bending would produce in a structural element. Force was applied through the “self-reacting” loading frame shown in Figure 1. The loading frame and the specimen rested on the laboratory floor during the tests (Figure 100).

Six specimens (D1, D2, D3, D9, D11, D17) were tested without any transverse reinforcement. The remaining twelve specimens were reinforced in their transverse direction.

Transverse reinforcement was installed (after formation of laminar cracks) by using ASTM A193 ¾’’ - diameter threaded rods drilled and epoxied into the concrete in the direction perpendicular to the plane of the bars. These anchor bolts were centered along the specimen and had two different embedment lengths: 5 in. and 12 in. (measured below the spliced reinforcing bars) (Figures 4, 5, 6 and Table 5). Transverse reinforcement spacing *s* was 40’’ for specimen D4, 53’’ for specimen D6, and 26.5’’ for specimens D5, D7-D18 (Figures 4, 5, 6).

The test specimens were tested statically. Initial cracks were first caused by applying tension up to the stresses shown in Table 5. Maximum initial crack widths are listed in Table 5. After formation of these cracks, specimens were unloaded and reloaded to failure (when possible). In test Series 2 and 3, unloading was followed by installation of threaded anchor rods and curing of the epoxy.

Test durations ranged from 1 to 2 hours (after installation of anchors). Measured concrete compressive strengths ranged from 4000 to 4500 psi. The yield stress of the ASTM 615 reinforcement was measured to be 67 ksi. Measured yield stress of the ASTM A193 threaded rod was 120 ksi. Maximum unit stresses developed in the reinforcement (at the splice end) ranged from 71 to 81 ksi in Series 1, 73 to 79 ksi in Series 2, and 78 to 83 ksi in Series 3 (Table 5) with mean values of 75, 75, and 80 ksi.

MATERIALS

The cross section in Figure 1 shows the arrangement of the spliced bars. Concrete was cast with the bars near the bottom of the form (and not as shown in the figure that refers to the positon of the bars during the test) to make certain that the wet concrete would not settle away from the bars. Top cover, as shown in Figure 1, was 5 in. and the side cover was 3 in. to have the laminar crack develop in the horizontal plane affecting the strength of both splices.

Test specimens were cast using normal-weight aggregate on the dates listed in Table 2. Mix proportions by weight are shown in Table 1. All specimens fabricated on each of the dates in Table 2 and the associated cylinders were fabricated using concrete from a single mixing truck. After casting, the specimens were kept under wet burlap cover for one week. Target air entrainment was 5%. The age of the concrete and measured concrete strengths at time of test are listed in Table 2.

All reinforcement came from the same heat. As mentioned above the measured yield stress of the ASTM 615 reinforcement was 67 ksi (Table 3). ASTM A193 threaded rod yield stress was 120 ksi.

Square bearing plates were installed after insertion of the threaded anchors immediately after the application of the epoxy. Bearing plates, washer and nuts were installed on Series 3 (specimens D8, D10, D12-D16, D18). The plates were made of A36 steel with the dimensions shown in Figure 8. After curing the epoxy for at least 24 hours, a nut with a washer was torqued to 100 ft-lbf to ensure contact between the bearing plate and the concrete surface.

A Hilti TE70 hammer drill was used to drill holes for the transverse reinforcement. The drill bit diameter was ⅞''. A hole cleaning method using compressed air, a steel wire brush, and vacuum was used to clean each hole. All holes were cleaned by vacuuming, brushing, and blowing compressed air into each hole. The cleaning sequence was performed six times before installation of the threaded rods. Hilti HIT-RE 500 V3 epoxy was injected into each hole, starting from the bottom of the hole and withdrawing the epoxy dispenser upward. The hole was filled to mid-height before insertion of the threaded rod. The ASTM A193 ¾'' threaded rods were inserted into the hole and given a half turn once the threaded rod made contact with the bottom of the hole. Epoxy glue was cured for at least 24 hours in laboratory conditions. In Series 3, bearing plates were placed over the anchor right after the anchor was placed into the drilled and epoxied hole. Torque was applied to a washer and nut after epoxy curing.

In specimens D4-D8, D10, and D12, anchors were installed at an ambient temperature of approximately 55° F. In specimens D13-D16, and D18, anchors were installed at an ambient temperature of approximately 75° F. Epoxy was cured for 24 hours prior to reloading, except in specimen D7, in which epoxy was cured for 48 hours. The curing of epoxy and anchor installation was performed indoors in laboratory conditions.

INSTRUMENTATION

Bar forces were measured using two force transducers (one per bar) opposite to the hydraulic jacks used to apply load (Figure 1). Infrared targets were installed on the west faces of the specimens, above and below the plane of the spliced bars to measure horizontal and vertical deformation of the concrete surface (Figure 2). Displacement sensors (LVDTs) were installed across the plane of the lap splices to measure the widths of laminar cracks forming near the ends of each splice at each of the four corners of each specimen –in plan view- (Figure 3). Table 4 lists the instrumentation details.

MAXIMUM STRESSES AND CRACK WIDTHS REACHED

In all specimens initial loading produced cracks with widths exceeding 0.05 in. and as large as 0.13 in. Maximum crack widths reached during initial loading and at failure are listed in Table 5.

In Series 1, the spliced bars in unconfined specimens D1 to D3 (with initial crack widths exceeding 0.05 in.) were able to reach stresses larger than the yield stress after unloading and reloading them to failure. Specimens D9, D11 and D17, nevertheless, failed during initial loading at stresses exceeding the yield stress and crack widths ranging from 0.06 in. to 0.13 in.

Specimens in Series 2, reached bar stresses at failure ranging from 73 to 79 ksi (mean = 75 ksi). Maximum laminar crack width at failure exceeded 0.08 in. in Series 2. Specimens in Series 3 reached stresses at failure ranging from 78 to 83 ksi (mean = 80 ksi). Maximum laminar crack width at failure exceeded 0.1 in. in Series 3.

The measurements indicate that the use of at least three ASTM A193 ¾’’ diameter threaded rods with an embedment length of 12 in. below the surface of the splice, spaced at 26.5 in. in the direction of the splice, and furnished with bearing plates and nuts, was effective in increasing the ability of the lap splices to reach stresses beyond the yield stress of the bars.

OBSERVATIONS

Figures 64 to 81 show measured force-elongation curves. Reported elongations are measured changes in the distance between the outer infrared targets mounted on the bars closer to the East face of the specimen and the infrared targets mounted on the center of the specimen (Figure 2). The curves show that specimens in Series 3 (with anchors with 12 in. embedment, 26.5 in. spacing, and bearing plates, washers and nuts) were more ductile than other specimens.

Crack patterns photographed near failure are shown in Figures 82 to 99. Force-crack width curves are shown in Figures 10 to 27. Four LVDTs were used in each specimen to measure laminar crack width near splice ends (one LVDT at each corner of the specimen –in a plan view-). The reported laminar crack widths are measurements from the LVDT producing the largest reading at failure.

Measured force-crack width curves confirm that specimens in Series 3 reached larger laminar crack widths at failure.

Vertical and horizontal deformations measured with infrared targets (Figure 2) are shown in Figures 28 to 63. They were calculated as the changes in distances between adjacent targets. Comparisons between LVDT readings and Optotrak readings at the same load point are shown in Table 6.

CONCLUSIONS

The tests of 79-in. lap splices of #11 reinforcing bars resulted in the following three conclusions:

1. If the existing laminar crack does not exceed 0.05 in., the test splices developed a minimum tensile stress of 67 ksi and a maximum tensile stress of 80 ksi.
2. If the existing laminar crack width was more than 0.05 in. and did not exceed 0.08 in., the transverse reinforcement as described in Figure 6 made it possible to develop a minimum tensile stress of 78 ksi and a maximum tensile stress of 83 ksi. Transverse reinforcement was installed using ASTM A193 ¾’’diameter threaded rod drilled and epoxied into the concrete in the direction perpendicular to the plane of the bars.
3. The observed increase in strength was associated with increased ductility.

TABLES

Table 1 Concrete Mix Proportions

Component	Weight of Component / Weight of Cement
Type 1 Portland Cement	1
Fine Aggregate (#23 sand, max. size = 1/20 in.)	2.4
Coarse Aggregate (#4 and #8 stone, max. size = 1¼ in.)	2.6
Water	0.55

Table 2 Concrete Strength

Test Specimen	Cast Date	Test Date	Concrete Compressive Strength* (psi)	Concrete Splitting Cylinder Strength* (psi)	Age of Specimen (days)
D1	1/11/2017	2/13/2017	3900	450	33
D2		2/15/2017	3900	450	35
D3		2/15/2017	3900	450	35
D4		2/20/2017	4000	350	40
D5		2/22/2017	4000	350	42
D6		2/23/2017	4000	350	43
D7		2/26/2017	4200	400	46
D8		3/6/2017	4100	450	54
D9		3/10/2017	4100	400	58
D10		3/14/2017	4200	450	62
D11		3/17/2017	4300	400	65
D12		3/22/2017	4100	450	70
D13	4/27/2017	6/14/2017	4400	450	48
D14		6/19/2017	4300	450	53
D15		6/22/2017	4500	400	56
D16		6/29/2017	4300	400	63
D17		7/5/2017	4400	450	69
D18		7/6/2017	4300	450	70

*Mean from 3 tests

Table 3 Reinforcement

Bar Designation	#11
Nominal Diameter, in.	1.41
Nominal Area, in^2	1.56
Nominal Perimeter, in.	4.43
Unit Weight, lbf/ft	5.31
Yield Stress*, ksi	67

*Note: mean from tests of twelve coupons

Table 4 Sensors

Sensor Type	Manufacturer	Model Number	Serial Number	Location	Range	Accuracy
Load Cell	Tokyo Sokki	KCB-500KNA	ALU03006	East	112 kip	400 lbf
		KCB-500KNA	ALU03005	West		
LVDT	Schaevitz	DE EC 250	12838	NE	+/-0.25 in.	0.002 in.
		DC EC 500	23618	SE	+/-0.50 in.	0.001 in.
		DC EC 1000	8702*	NE	+/-1.00 in.	0.004 in.
		DC EC 1000	J4914*	SE		
		DC EC 1000	X00598	NW		
		DC EC 1000	J4913	SW		
Optotrak	Northern Digital Inc.	PRO Series 600	-	-	-	0.005 in.

*12838 was changed to 8702 starting from test D2, 23618 was changed to J4914 starting from test D11

Table 5 Summary of Results

Test Series	ID	Concrete Comp. Strength (psi)	Concrete Splitting Strength (Tensile) (psi)	Threaded anchor spacing (in)	Number of Anchors	Threaded rod embedment depth below bottom of splice (in)	Bearing Plate Y/N	Max reinf. Stress at Splice Ends During Initial Loading (ksi)	Max Reinf. Stress at Splice End (ksi)	Max Lam. Crack Width During Initial Loading** (in)	Max Lam. Crack Width at Failure** (in)
1	D1	3900	450	N/A	0	N/A	N	72	73	0.07	0.08
1	D2	3900	450	N/A	0	N/A	N	71	71	0.06	0.07
1	D3	3900	450	N/A	0	N/A	N	80	81	0.11	0.18
2	D4	4000	350	40	2	5	N	75	79	0.06	0.08
2	D5	4000	350	26.5	2	5	N	70	74	0.07	0.24
2	D6	4000	350	53	2	5	N	71	75	0.06	0.09
2	D7	4200	400	26.5	3	5	N	71	73	0.06	0.10
3	D8	4100	450	26.5	3	12	Y	69	83	0.08	0.18
1	D9*	4100	400	N/A	0	N/A	N	76	76	0.09	0.09*
3	D10	4200	450	26.5	3	12	Y	72	79	0.06	0.13
1	D11*	4300	400	N/A	0	N/A	N	71	71	0.06	0.06*
3	D12	4100	450	26.5	3	12	Y	71	78	0.06	0.11
3	D13	4400	450	26.5	3	12	Y	71	80	0.06	0.24
3	D14	4300	450	26.5	3	12	Y	67	79	0.06	0.23
3	D15	4500	400	26.5	3	12	Y	74	81	0.06	0.23
3	D16	4300	400	26.5	3	12	Y	71	80	0.08	0.22
1	D17*	4400	450	N/A	0	N/A	N	77	77	0.13	0.13*
3	D18	4300	450	26.5	3	12	Y	67	80	0.06	0.25

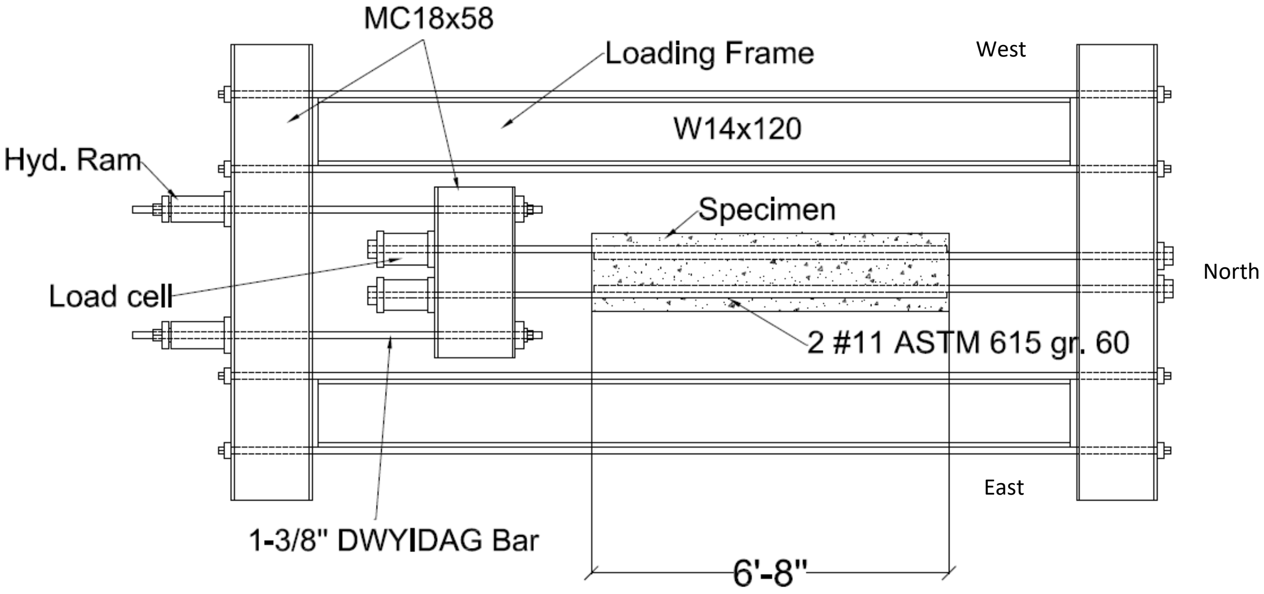
*Note: Denotes initial loading splice failure prior to anchor installation.

**Note: Crack widths based on LVDT measurement.

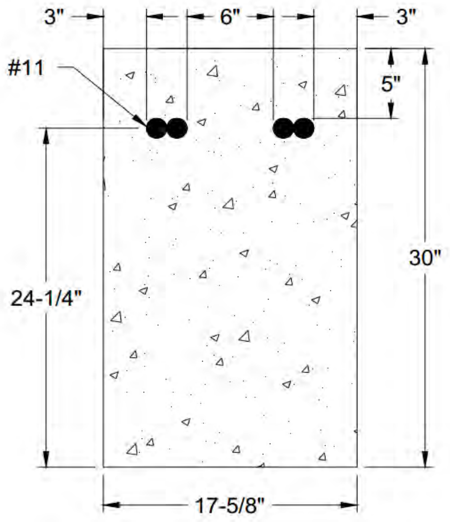
Table 6 Comparison of Crack Width Measurements Made at NW and SW Corners

Specimen	Load Step (kip)	NW crack width (in)		SW crack width (in)	
		LVDT reading	Mean of two closest Optotrak readings	LVDT reading	Mean of two closest Optotrak readings
D1	110	0	0	0.04	0.04
D2	110	0.01	0.02	0.02	0.02
D3	110	0	0	00	0
D4	110	0	0	0	0
D5	110	0	0	0	0
D6	110	0.02	0.03	0.02	0.02
D7	110	0.04	0.04	0.03	0.03
D8	110	0	0	0.03	0.03
D9	110	0.02	0.02	0	0.01
D10	110	0	0	0.02	0.02
D11	110	0.04	0.04	0.02	0.02
D12	110	0.01	0.01	0.01	0.01
D13	105	0.04	0.04	0.04	0
D14	100	0.05	0.05	0.02	0.04
D15	110	0.04	0.04	0.04	0.04
D16	110	0.03	0.03	0.03	0
D17	110	0.03	0.03	0.02	0.02
D18	110	0.01	0	0.01	0.02

FIGURES



Plan View



Cross Section

Figure 1 Test Specimen Loading Frame Setup and Cross-Sectional Dimensions

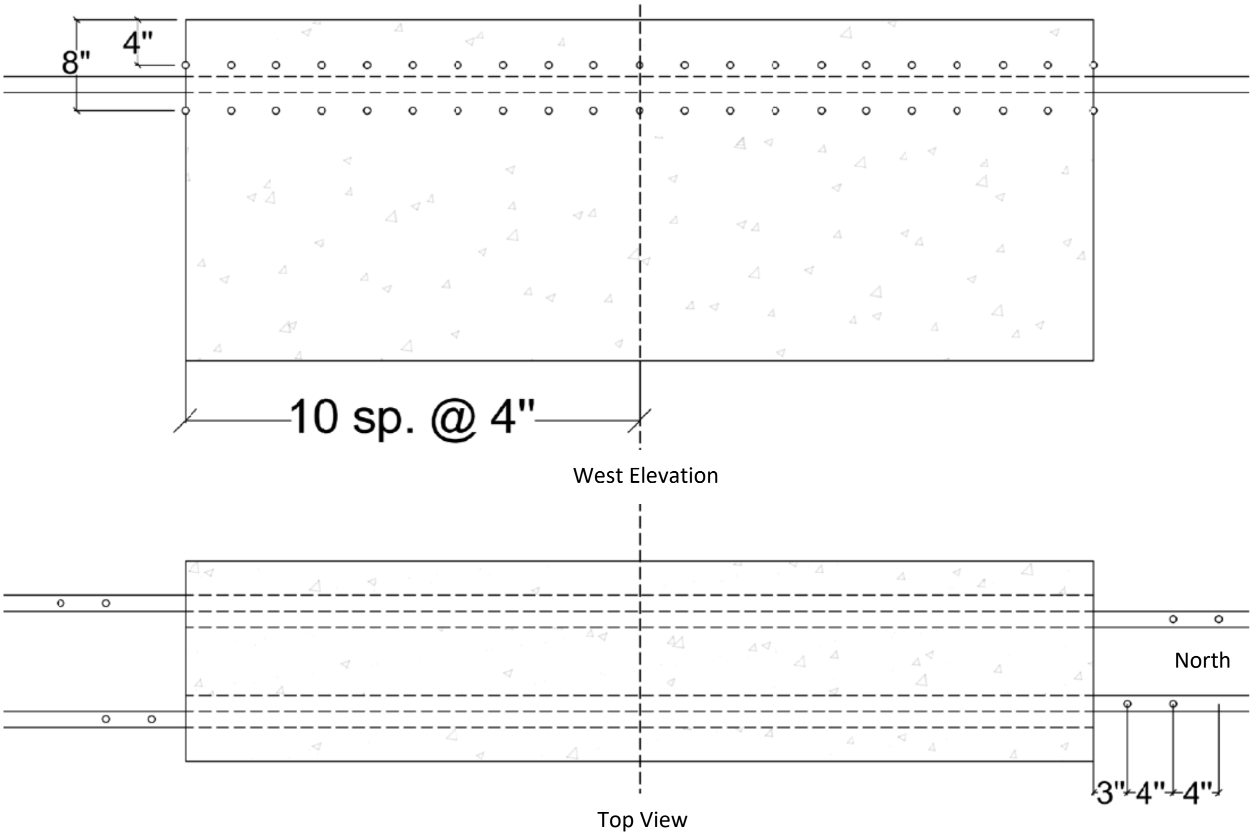


Figure 2 Optotrak Target Layout

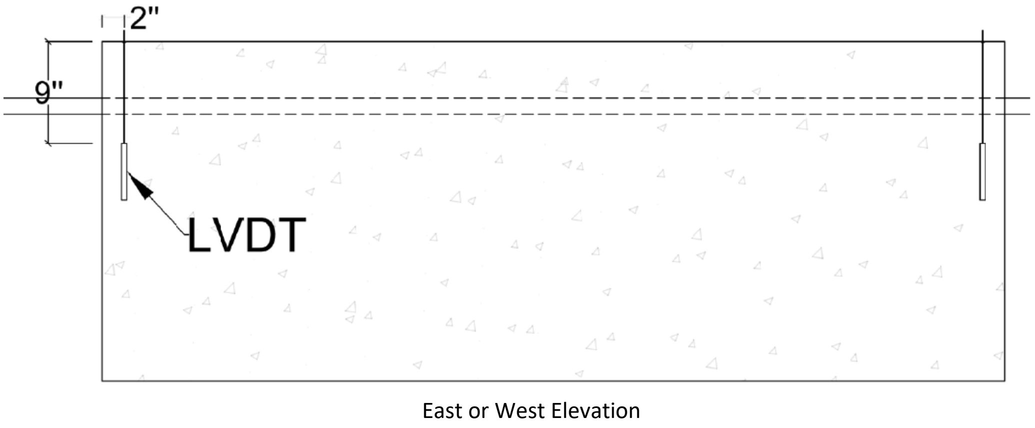
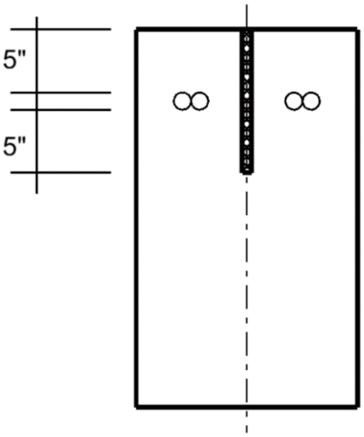
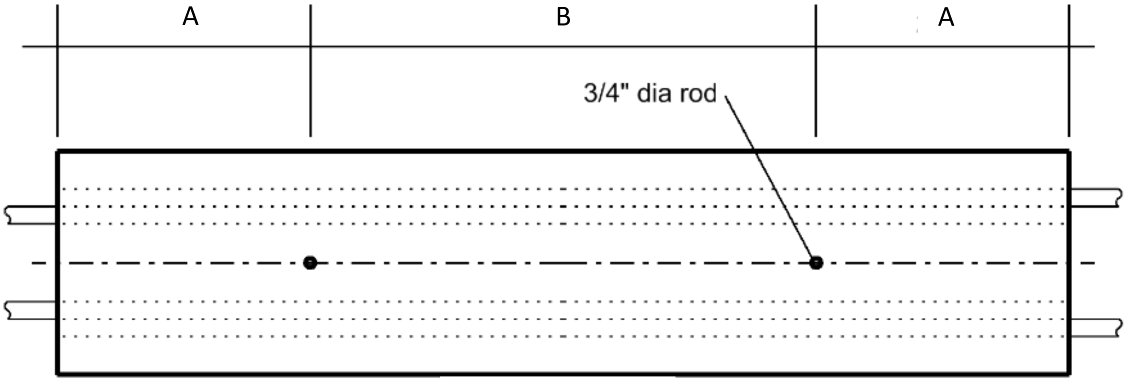


Figure 3 LVDT Layout

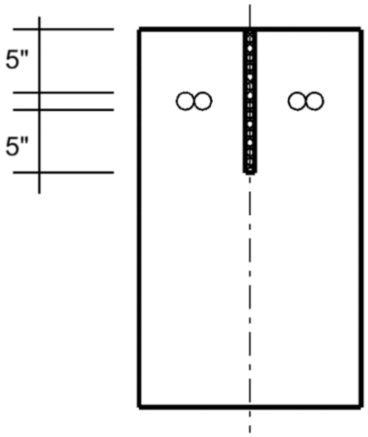


X-SECTION

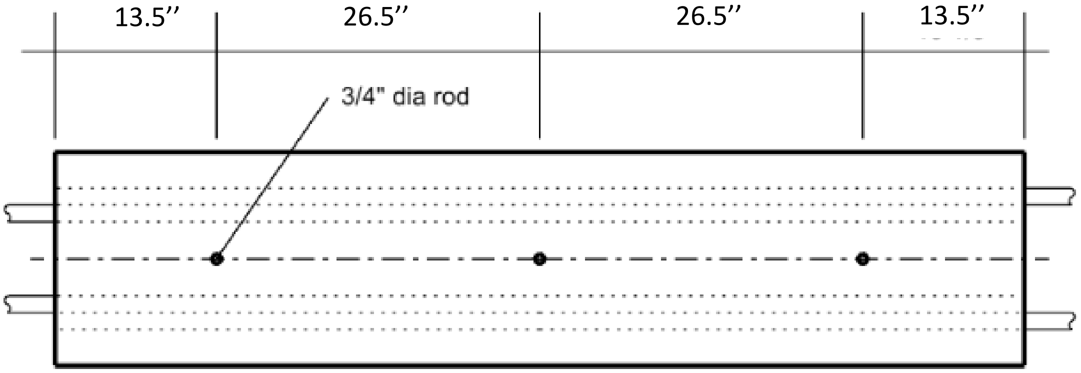


Top View

Figure 4 Anchor Configuration for Specimens D4 and D6 (Series 2). Dimension A was 20’’ for Specimen D4 and 13.5’’ for Specimen D6. Dimension B was 40’’ for Specimen D4 and 53’’ for Specimen D6.

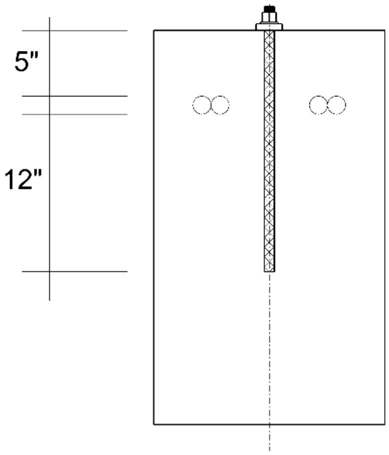


X-SECTION

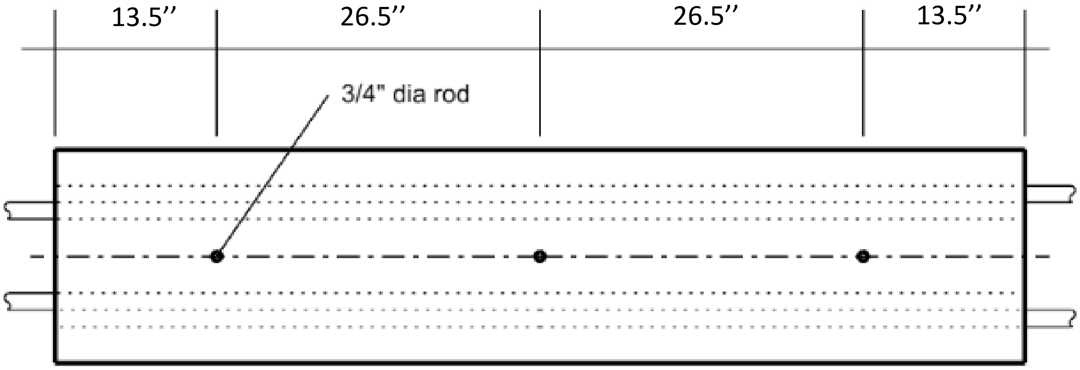


Top View

Figure 5 Anchor configuration for Specimens D5 and D7 (Series 2)



X-SECTION



Top View

Figure 6 Anchor Configuration for Specimens D8, D10, D12-D16, D18 (Note: Plates, nuts and washers were used in specimens D8, D10, D12-D16, D18 –Series 3)

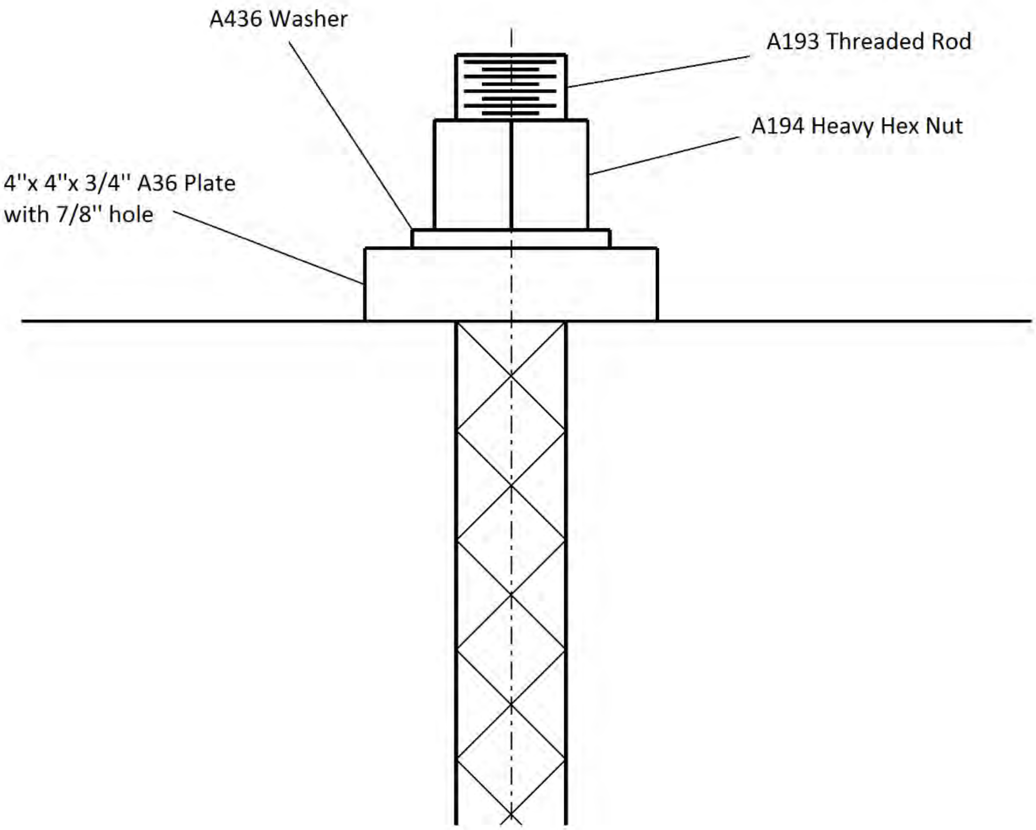


Figure 7 Anchor Plate Assembly for Specimens D8, D10, D12-D16, D18 (Series 3)

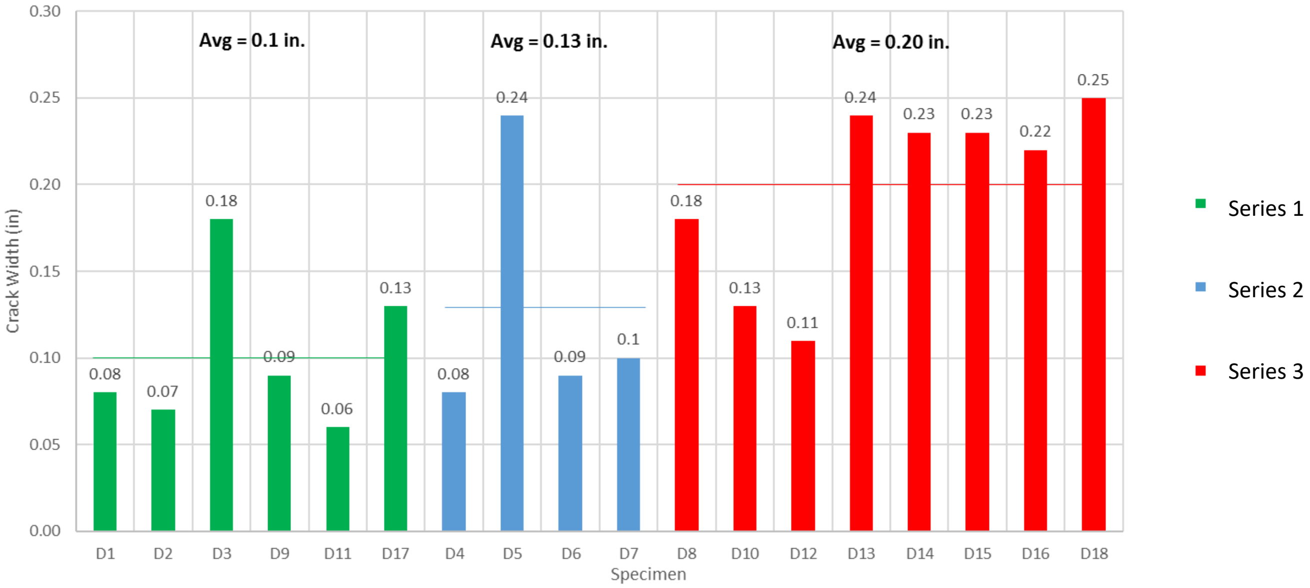


Figure 8 Maximum Crack Width at Splice Ends at Failure

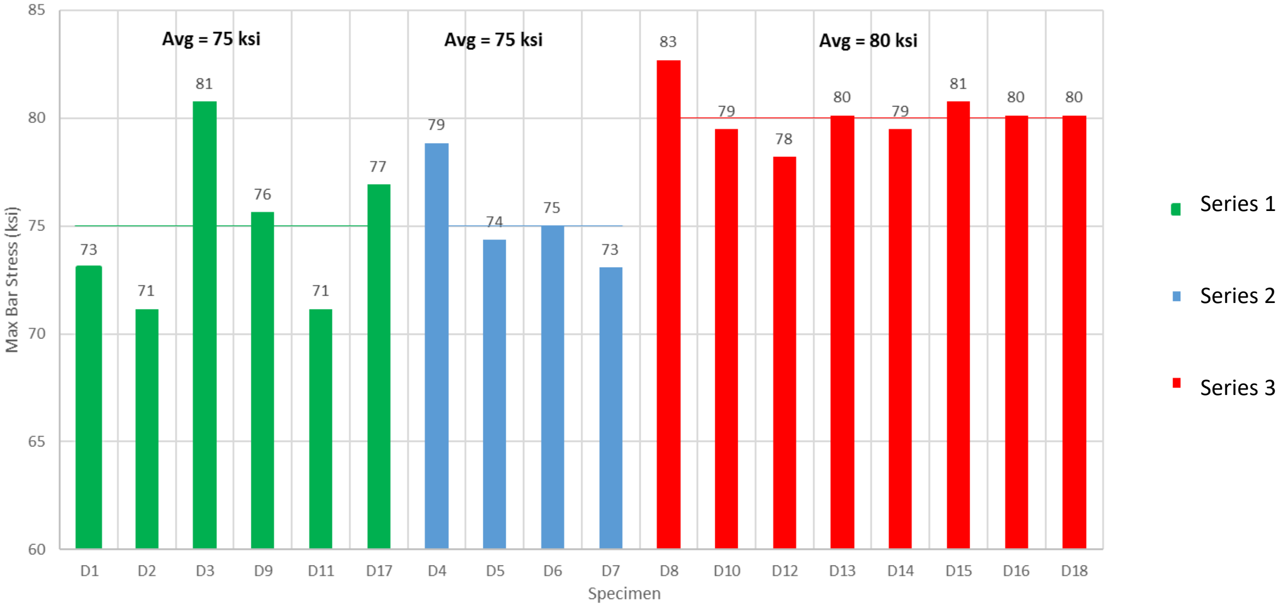


Figure 9 Maximum Reinforcement Stress at Splice Ends at Failure

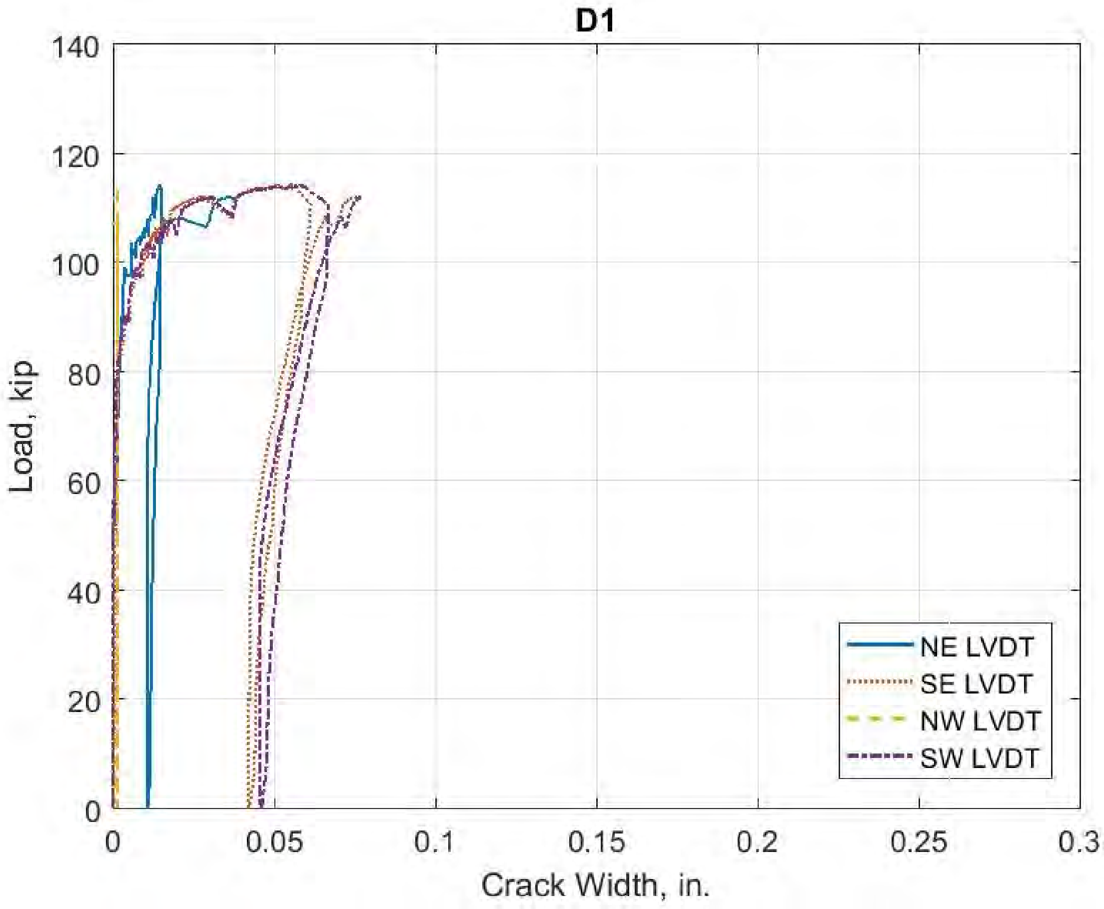


Figure 10 D1 Load vs. Crack Width Plot

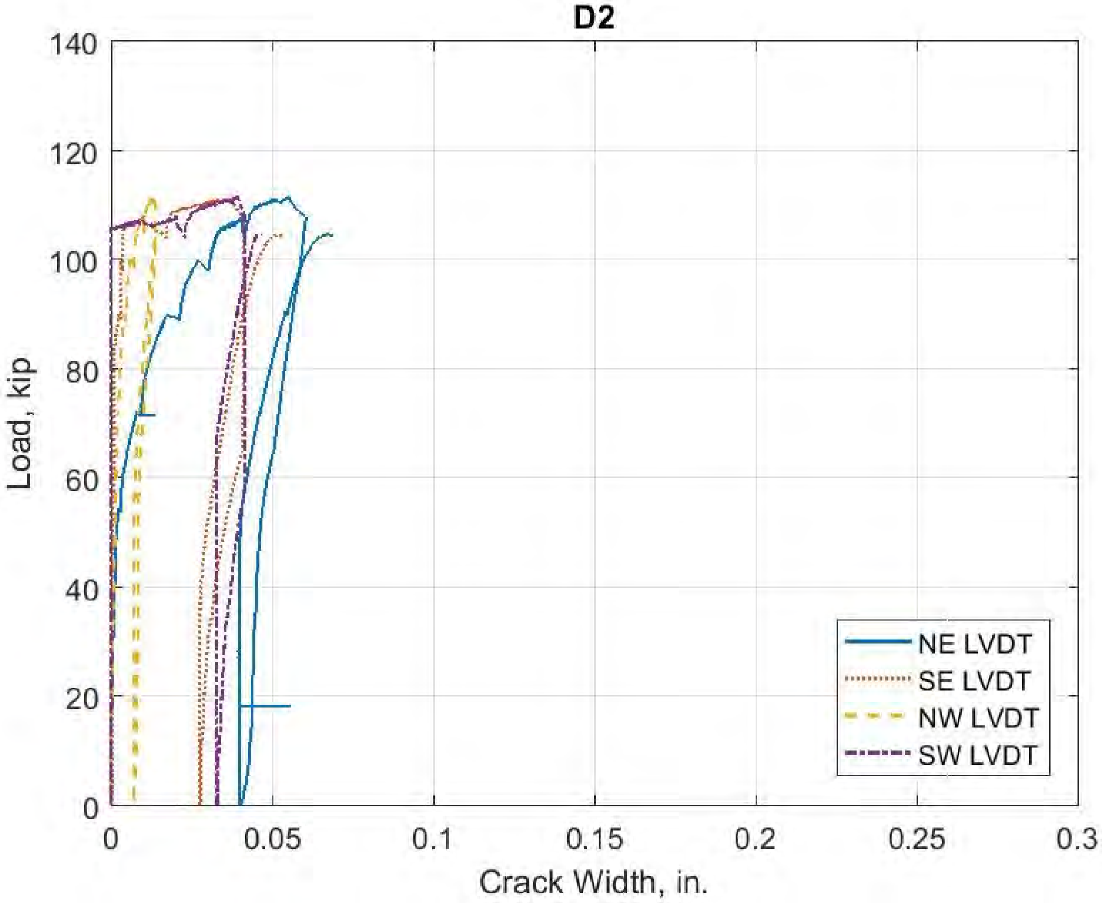


Figure 11 D2 Load vs. Crack Width 1

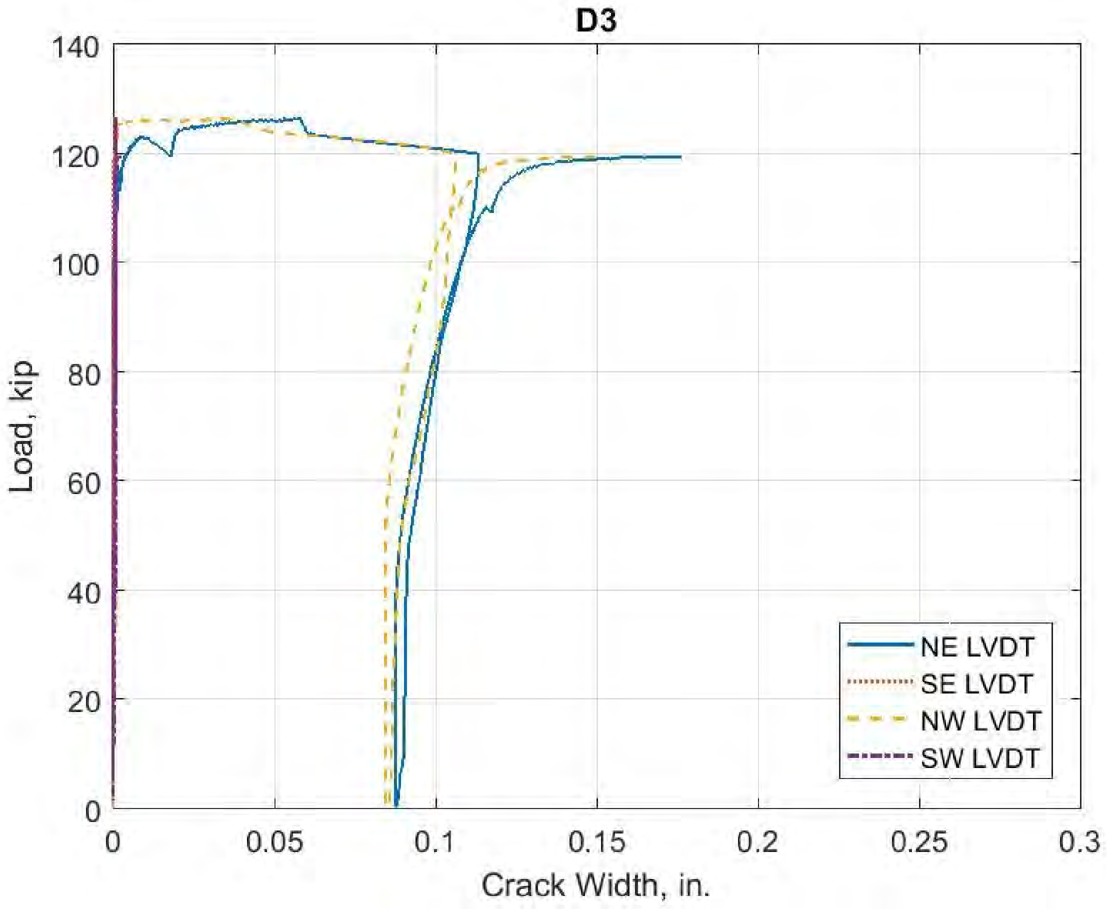


Figure 12 D3 Load vs. Crack Width

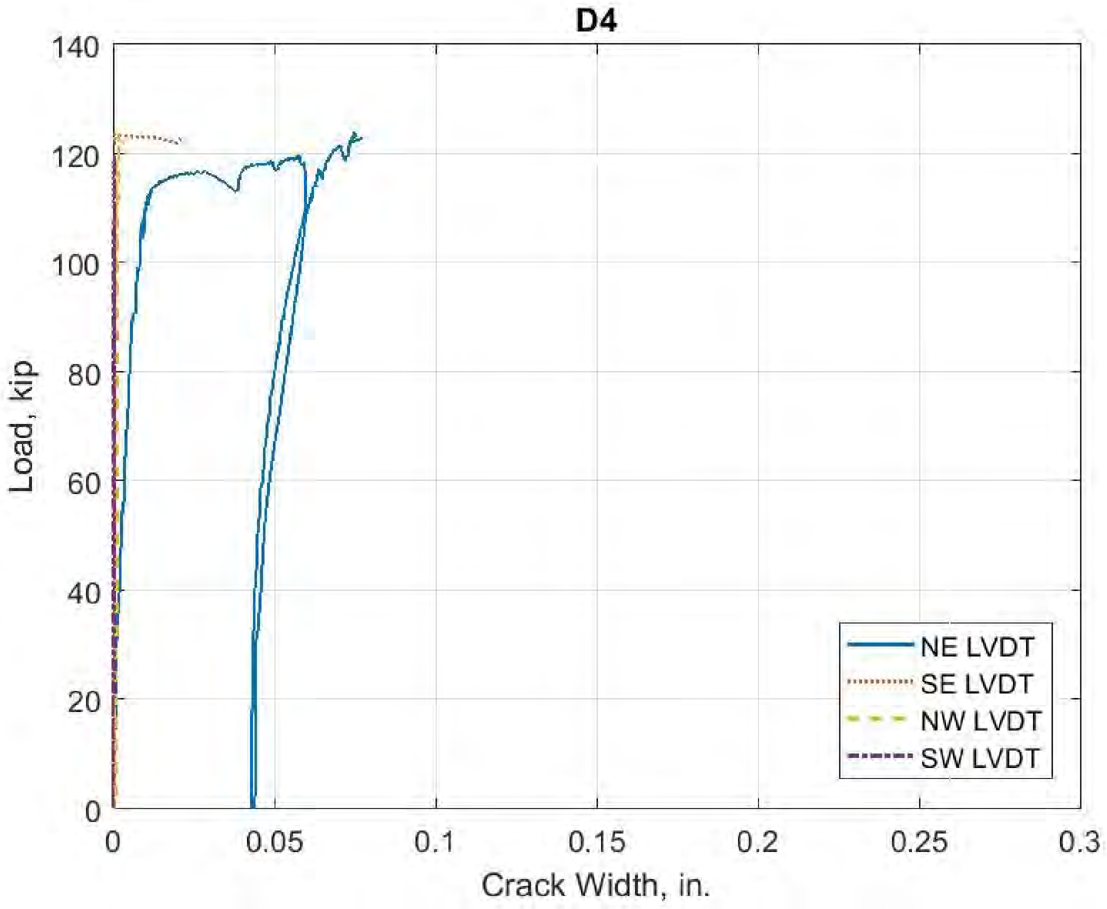


Figure 13 D4 Load vs. Crack Width

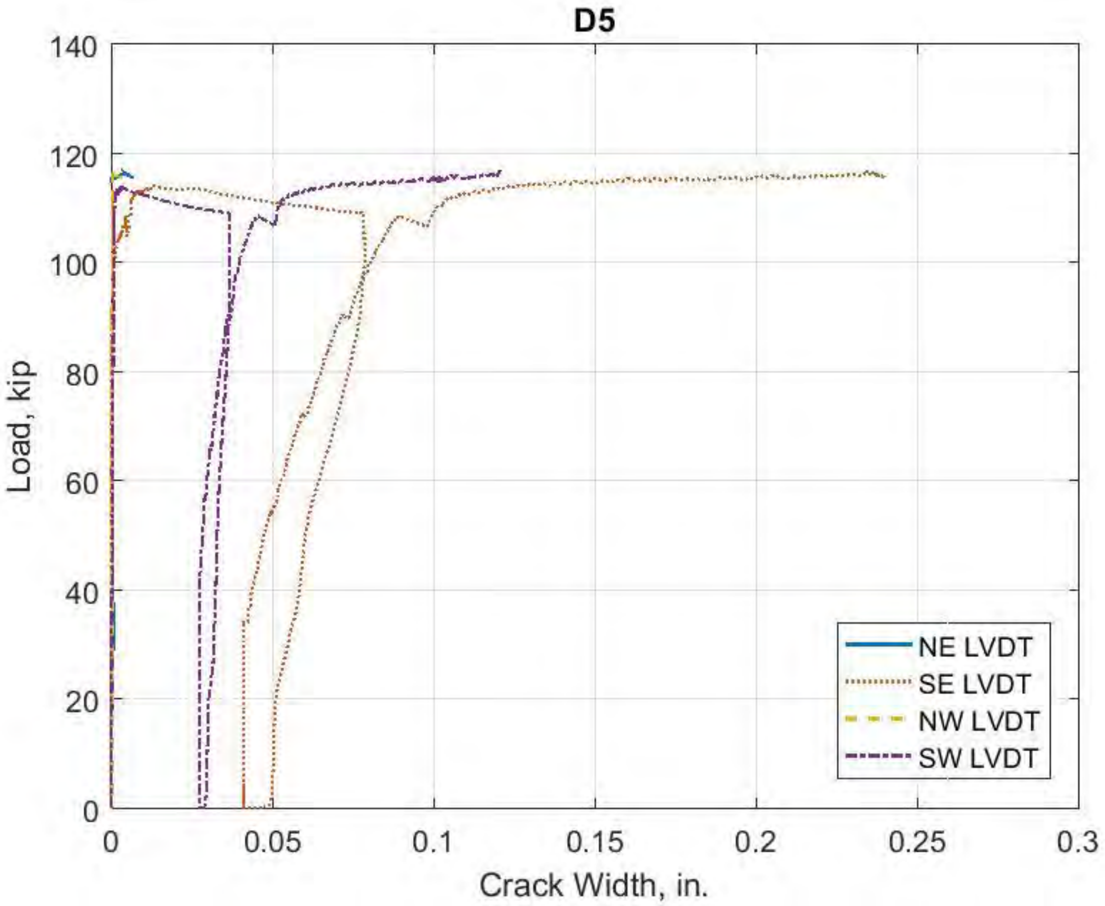


Figure 14 D5 Load vs. Crack Width

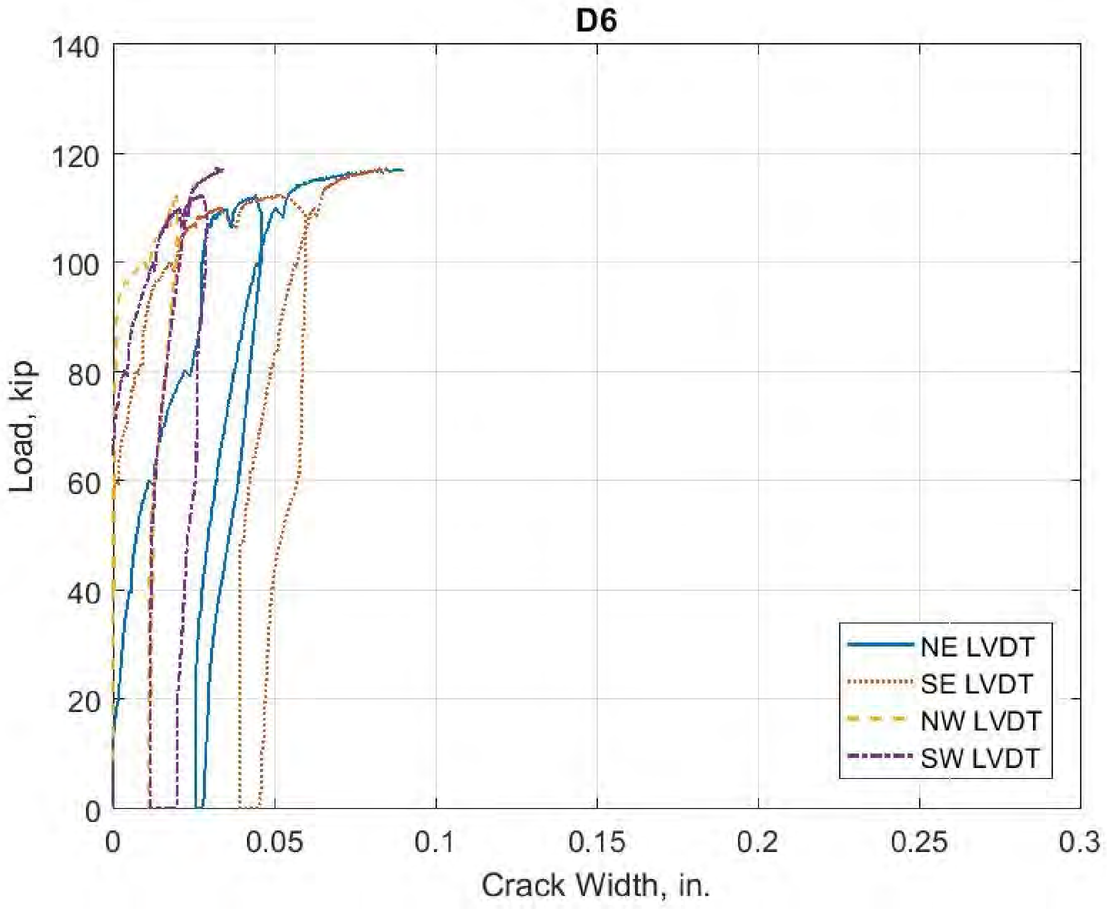


Figure 15 D6 Load vs. Crack Width

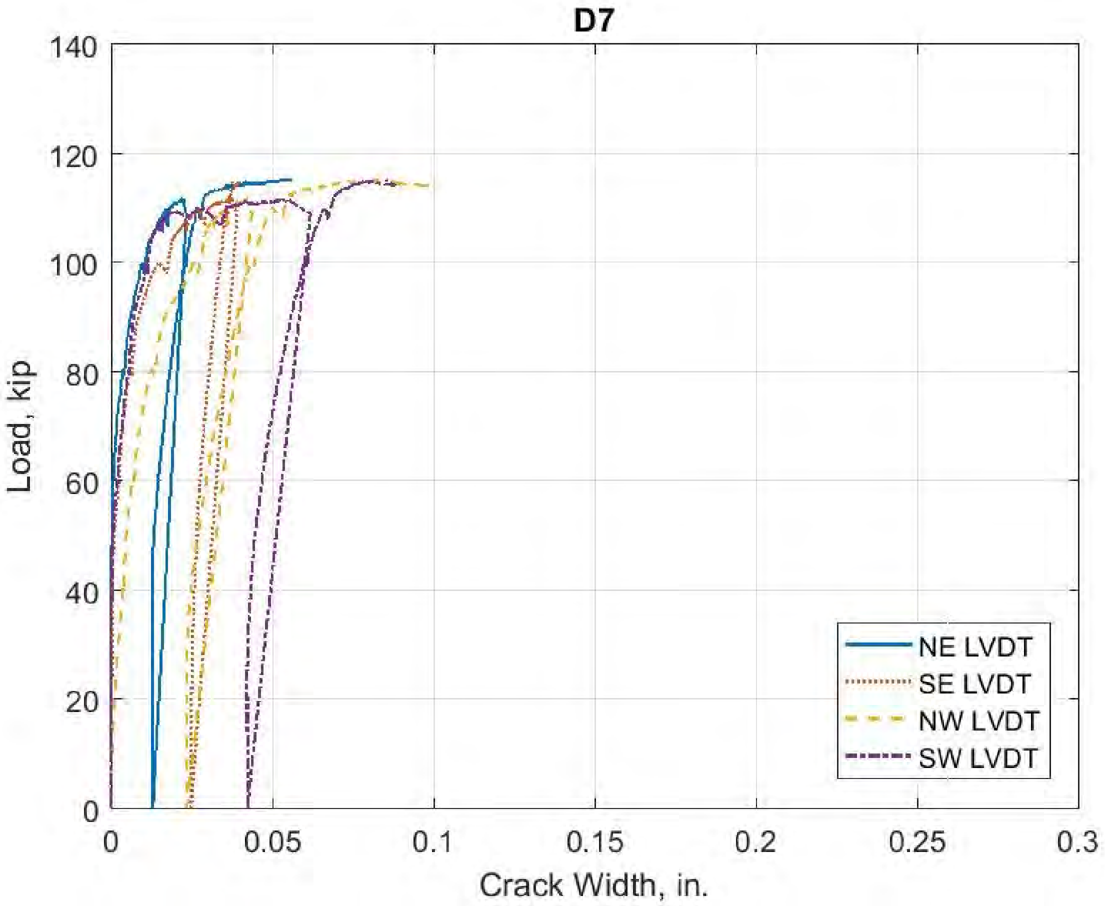


Figure 16 D7 Load vs. Crack Width

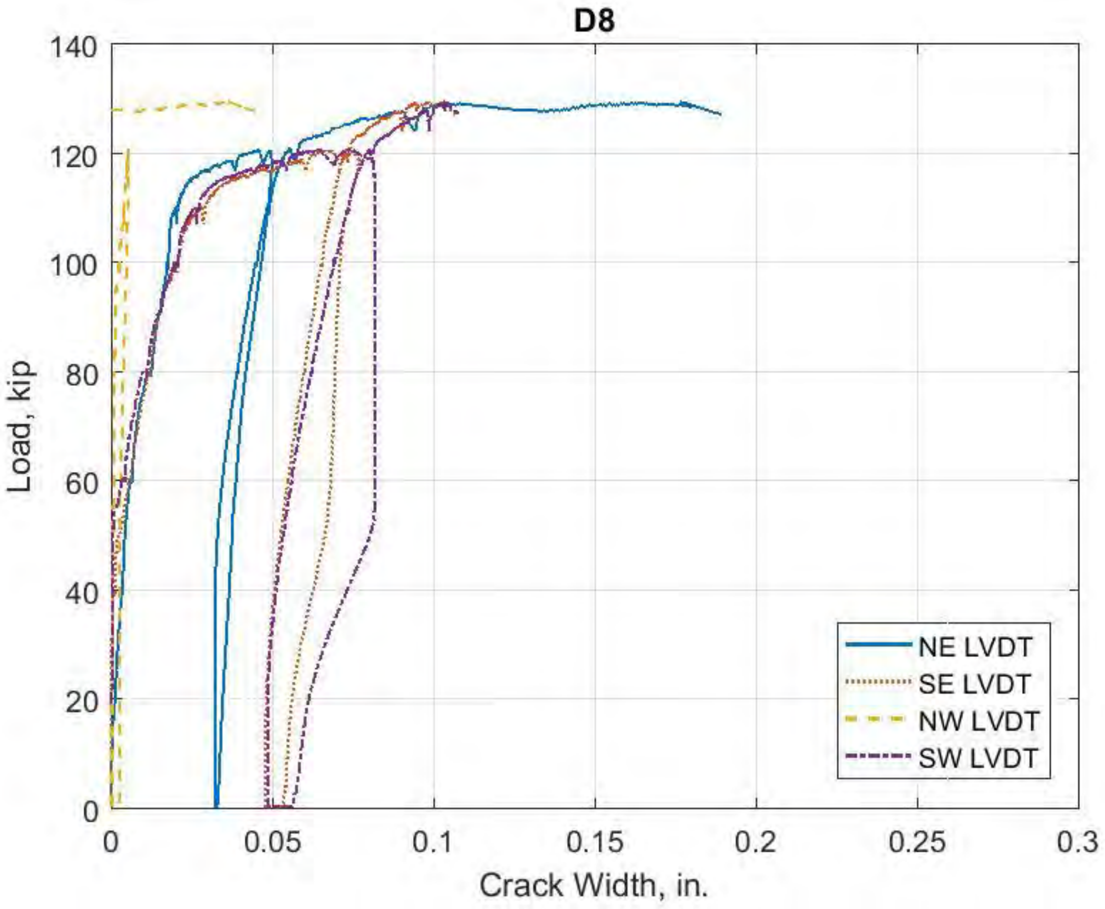


Figure 17 D8 Load vs. Crack Width

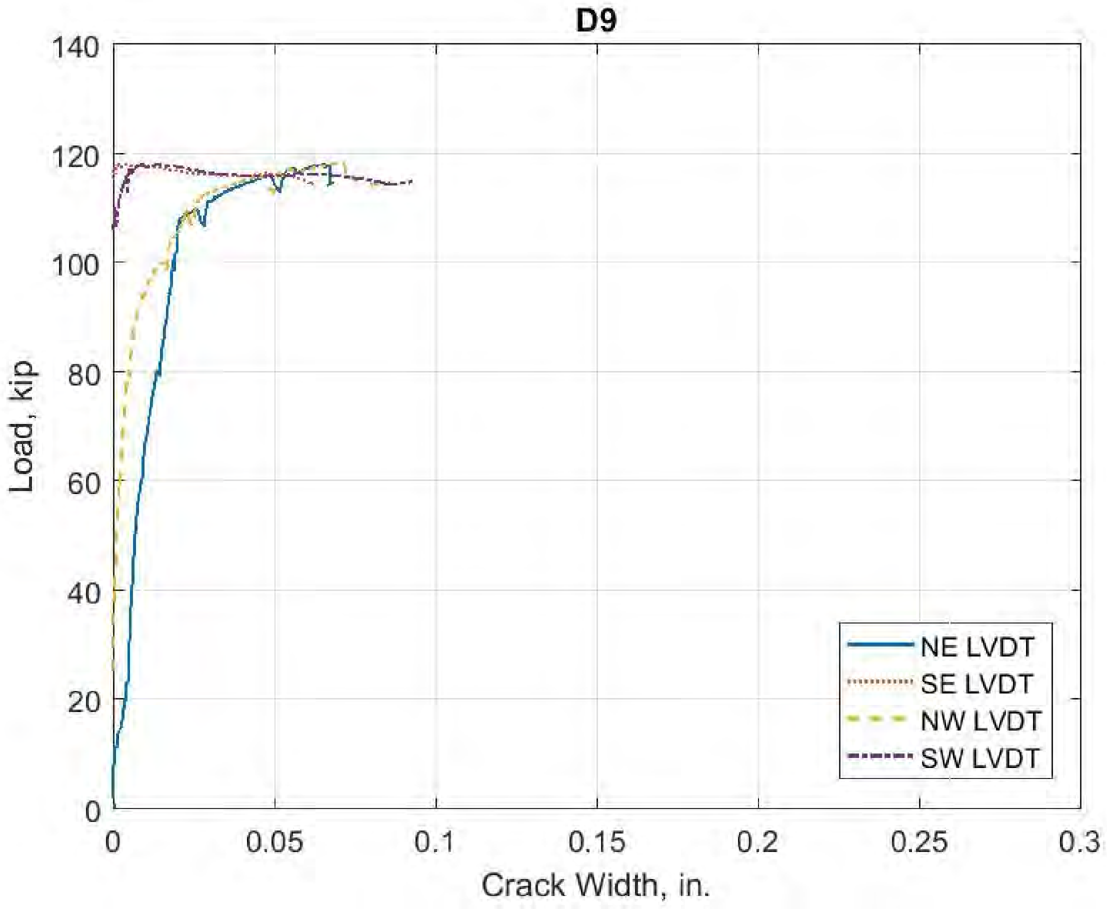


Figure 18 D9 Load vs. Crack Width

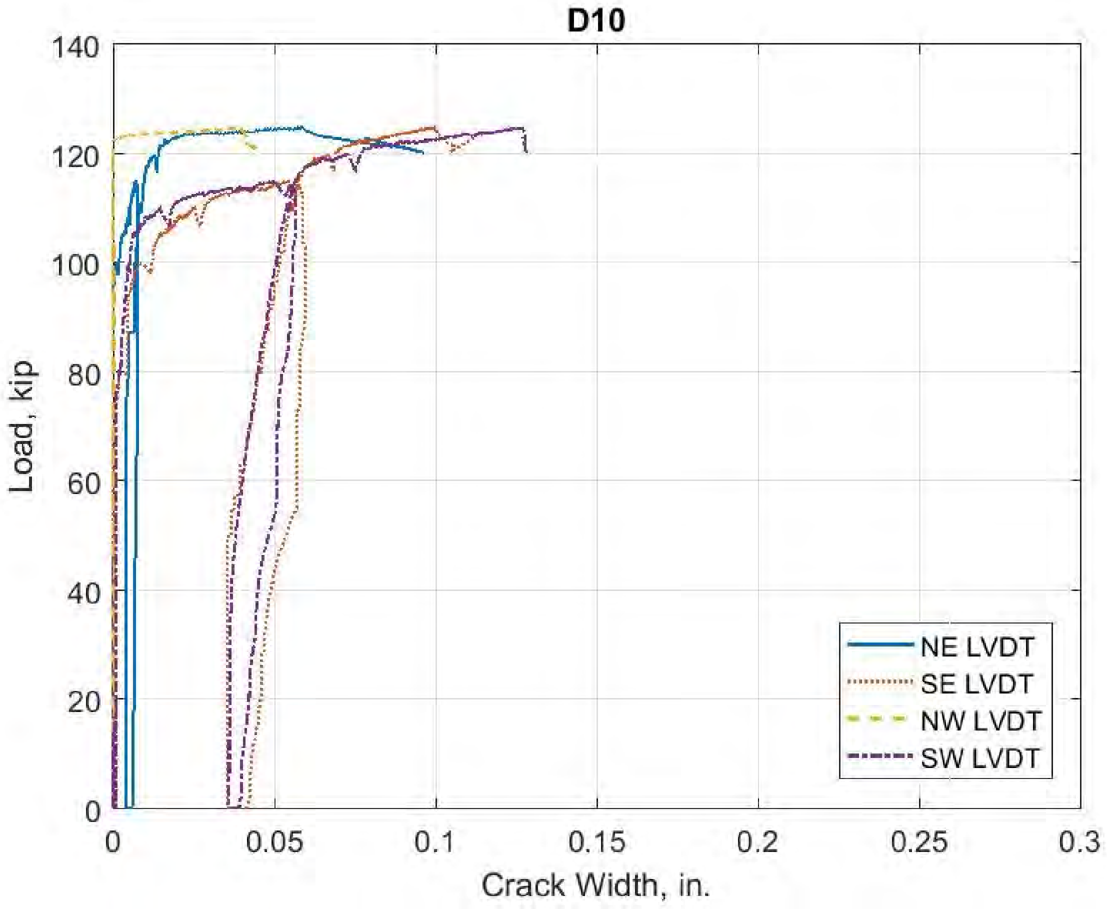


Figure 19 D10 Load vs. Crack Width

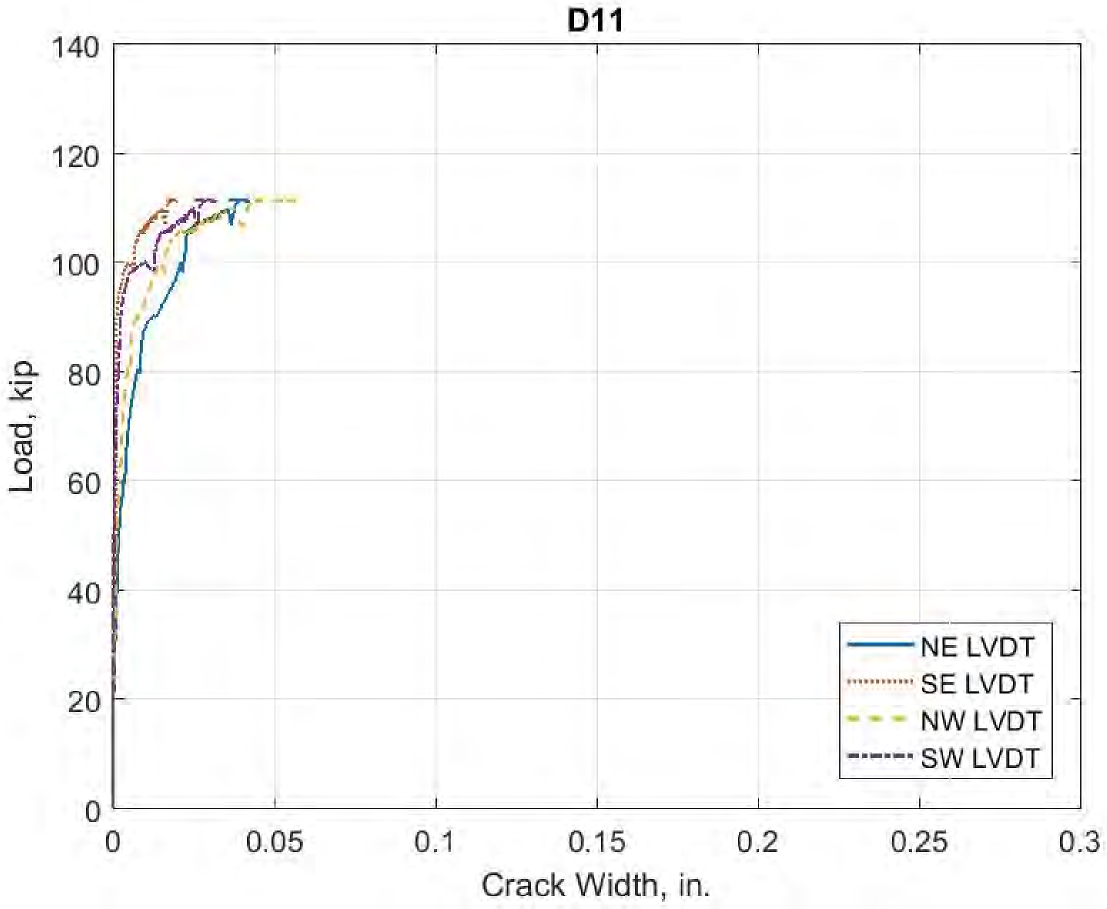


Figure 20 D11 Load vs. Crack Width

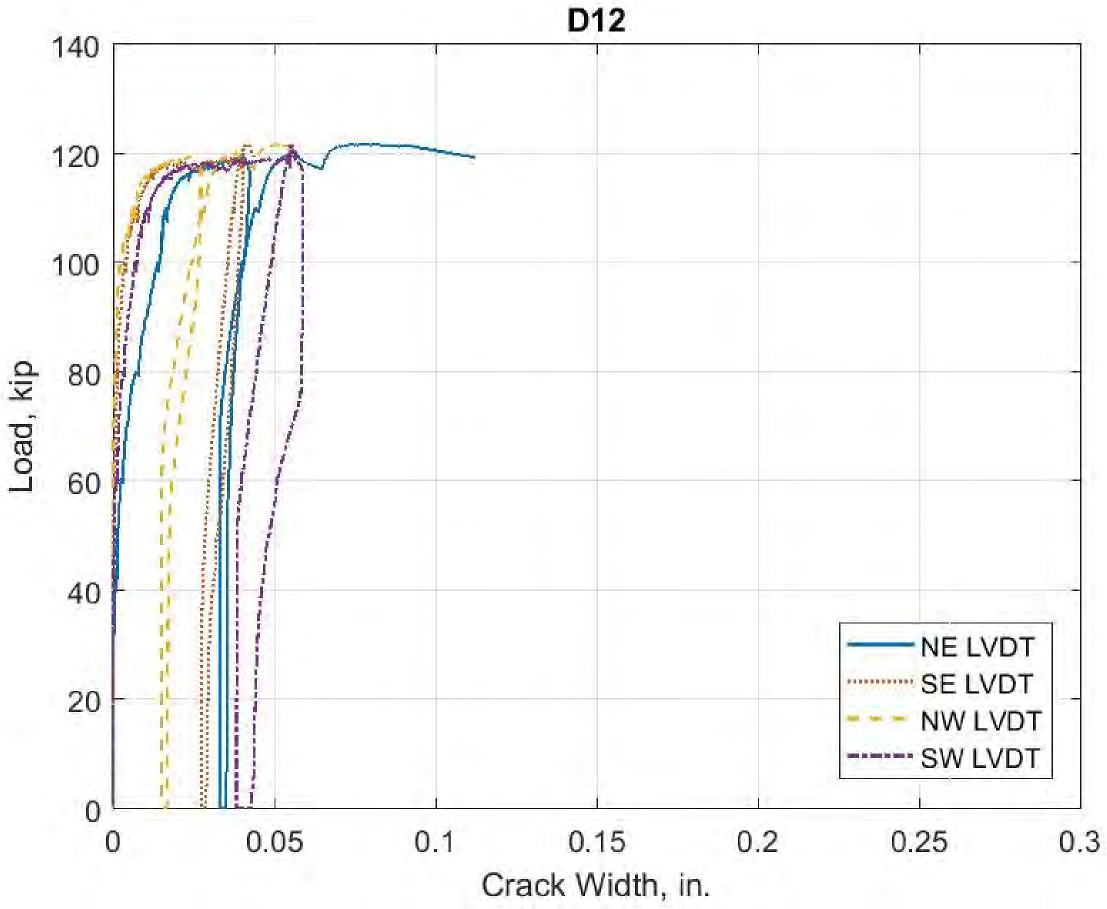


Figure 21 D12 Load vs. Crack Width

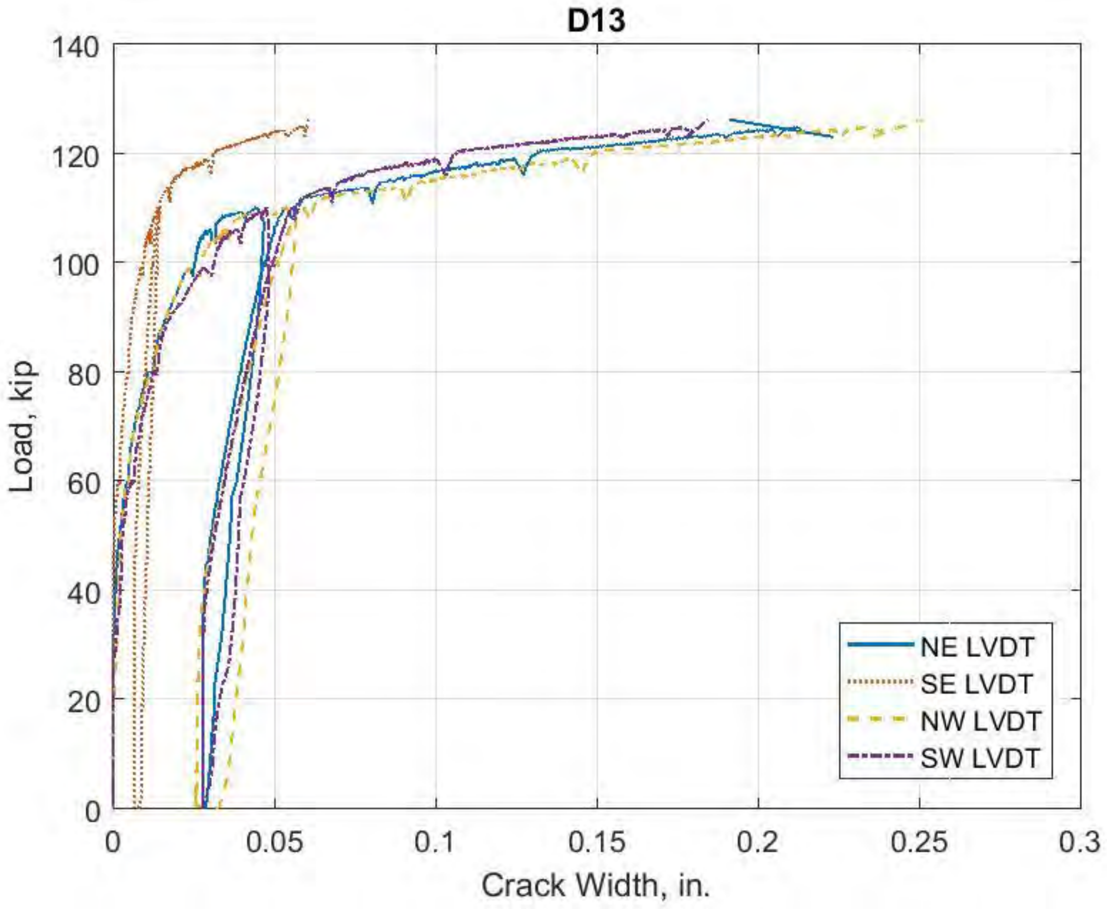


Figure 22 D13 Load vs. Crack Width

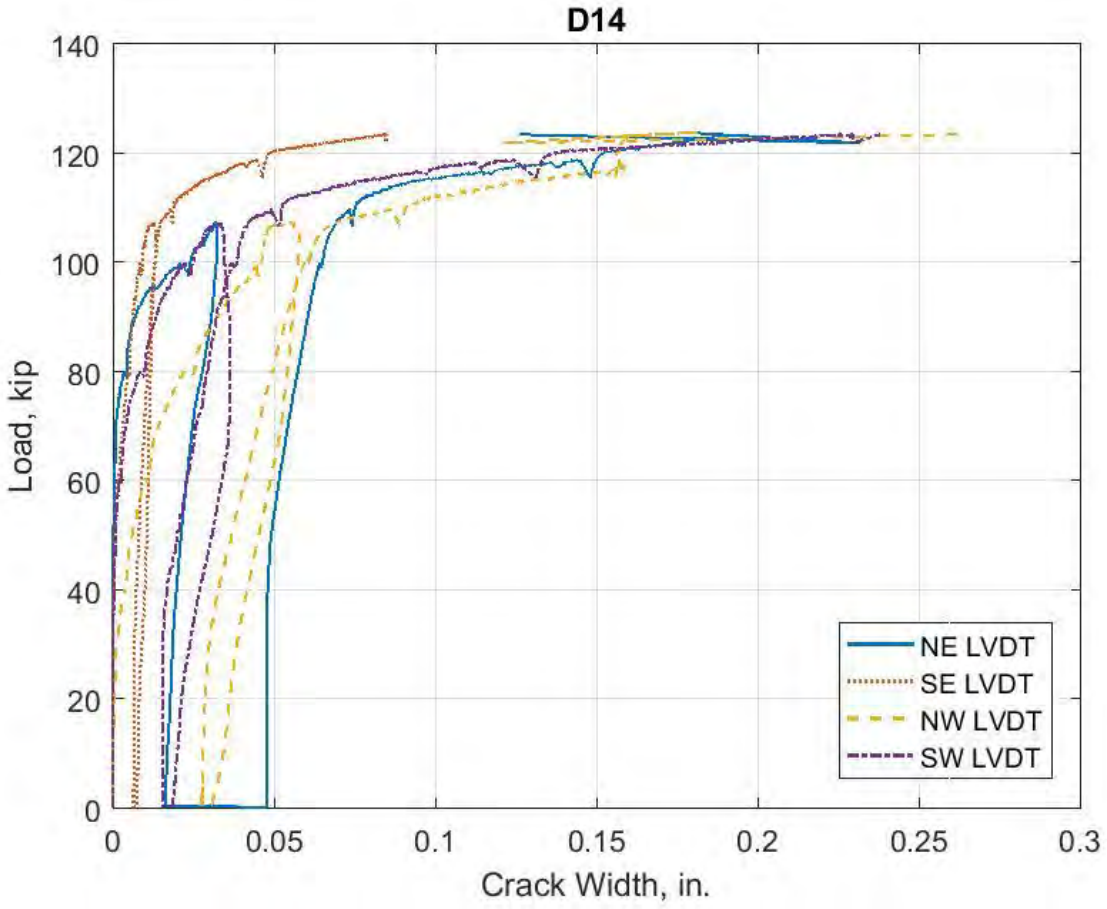


Figure 23 D14 Load vs. Crack Width

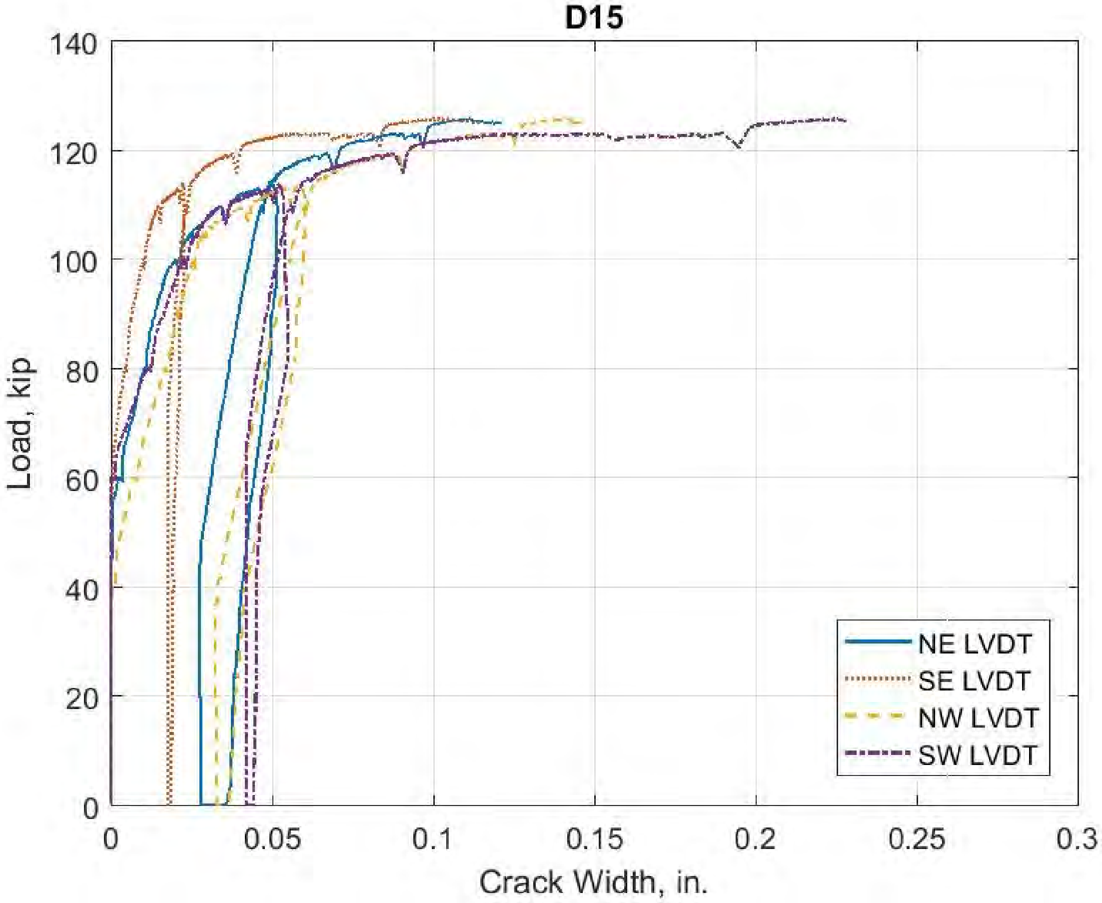


Figure 24 D15 Load vs. Crack Width

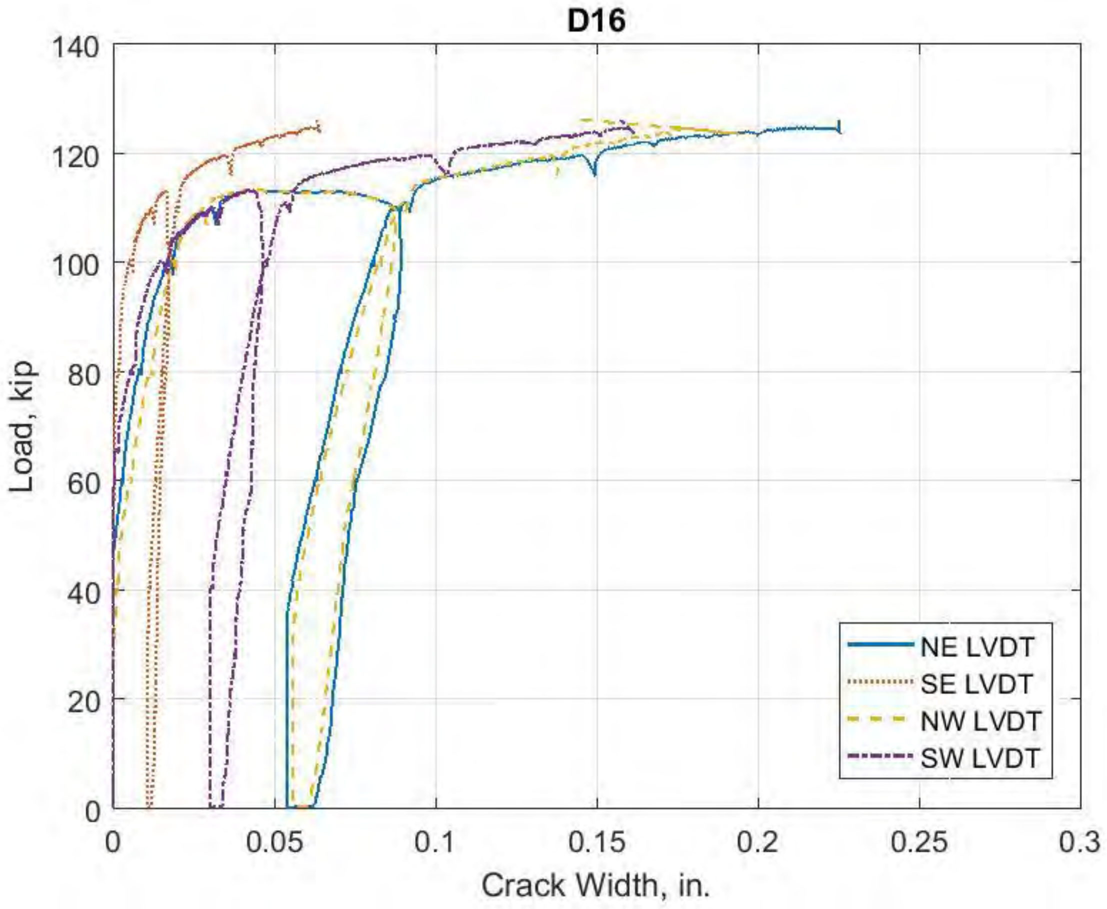


Figure 25 D16 Load vs. Crack Width

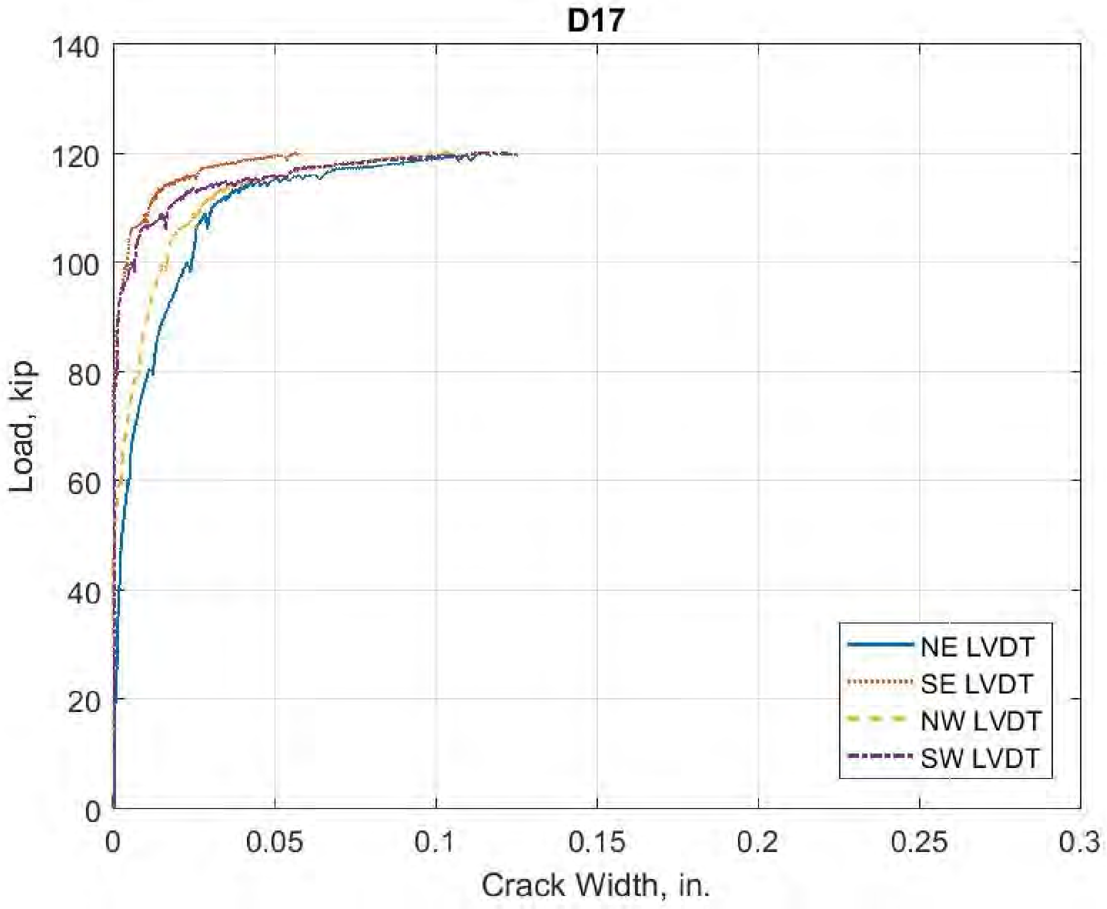


Figure 26 D17 Load vs. Crack Width

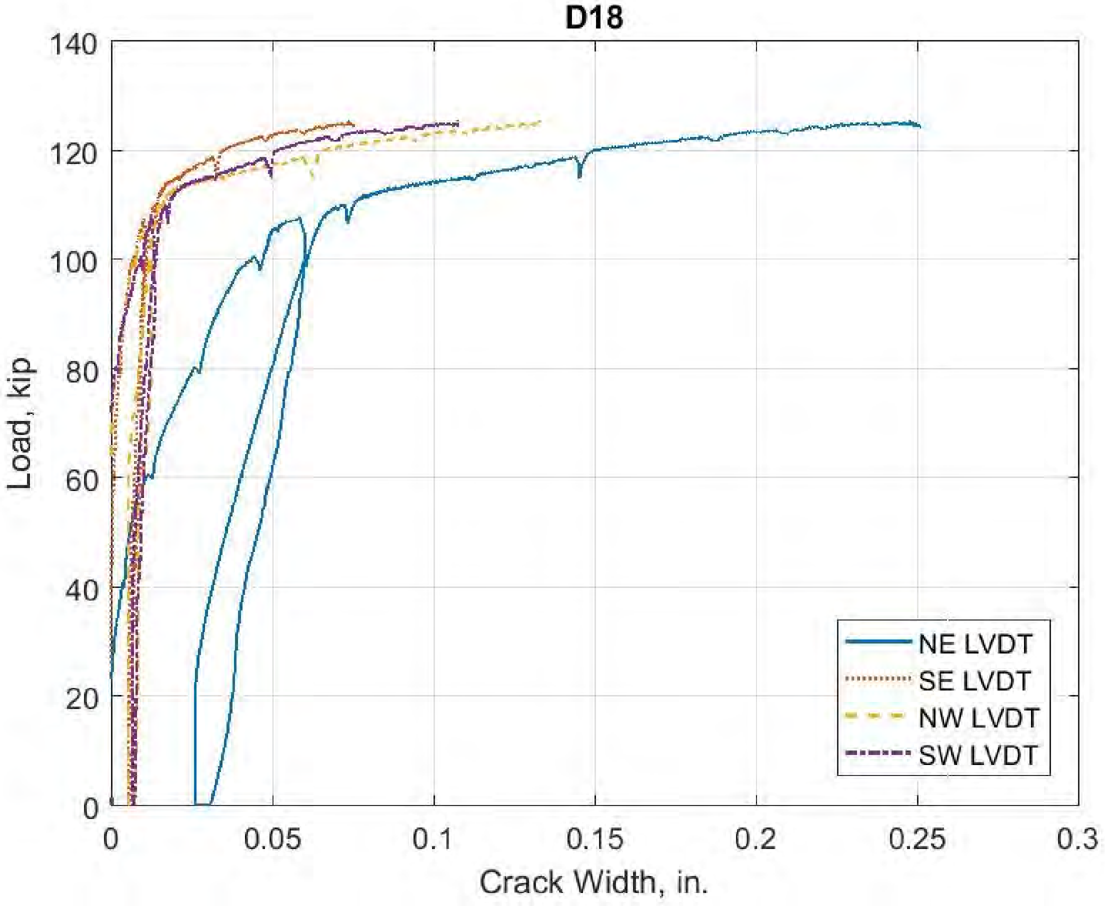
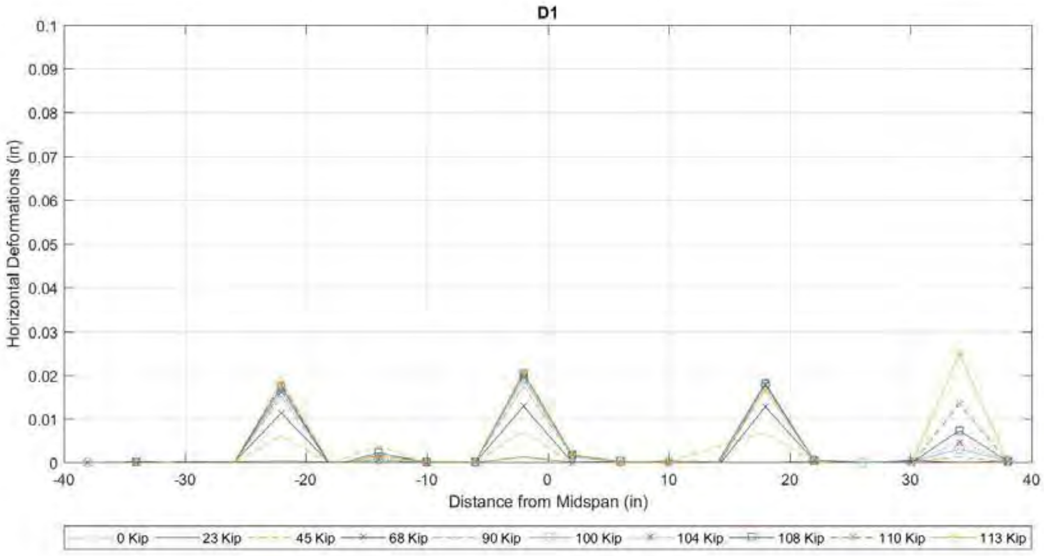


Figure 27 D18 Load vs. Crack Width



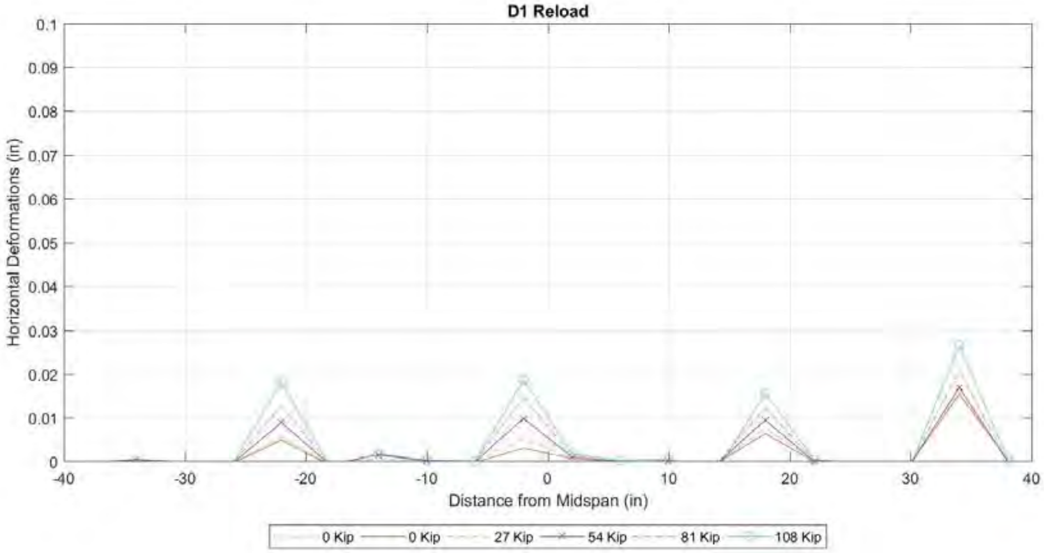
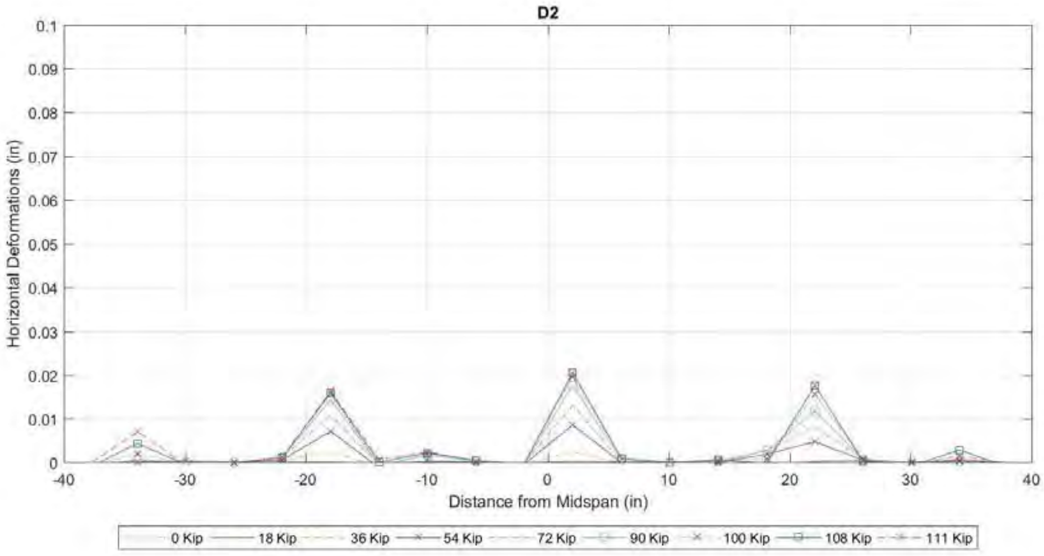


Figure 28 Horizontal Deformations, Load and Reload, D1



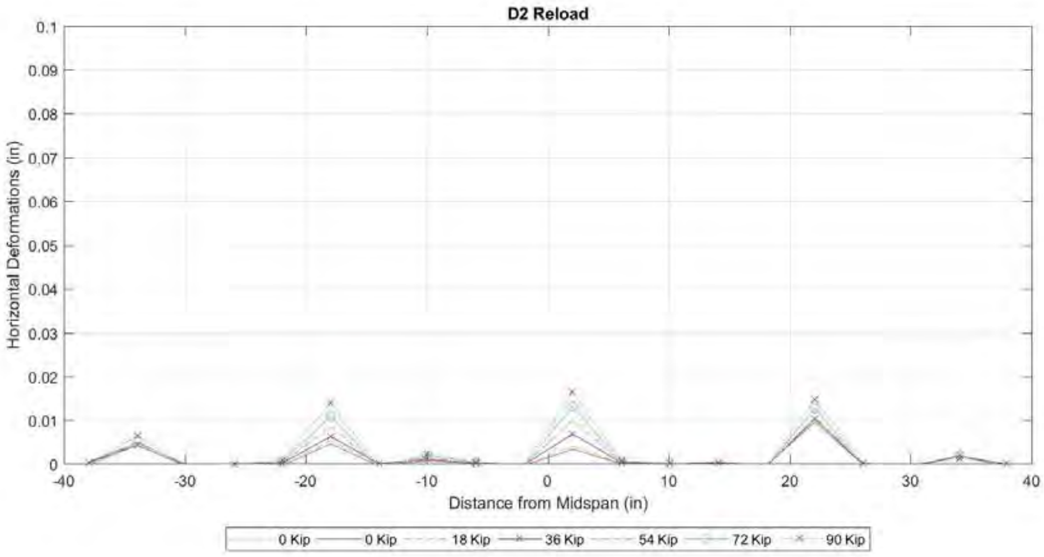


Figure 29 Horizontal Deformations, Load and Reload, D2

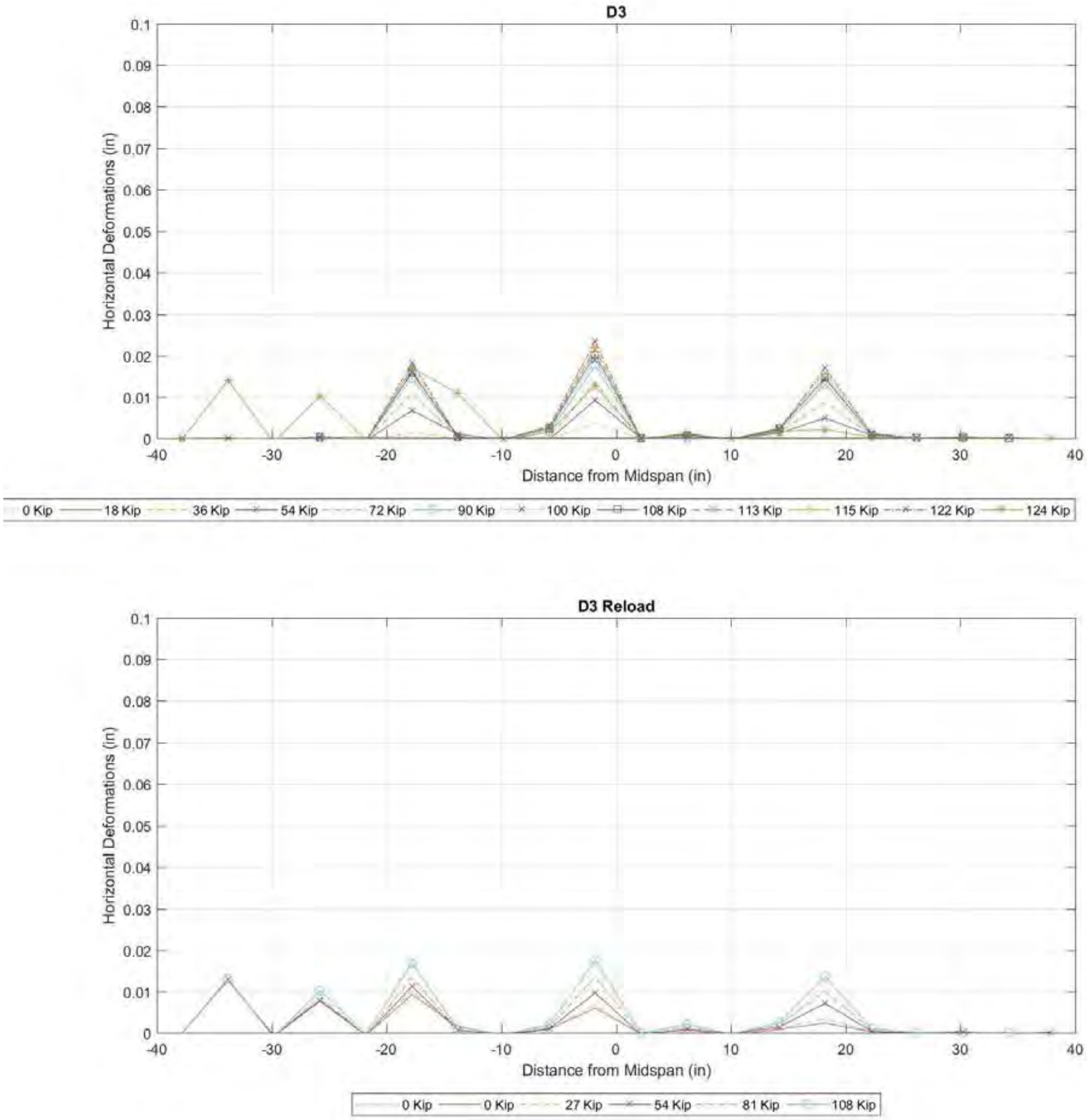


Figure 30 Horizontal Deformations, Load and Reload, D3

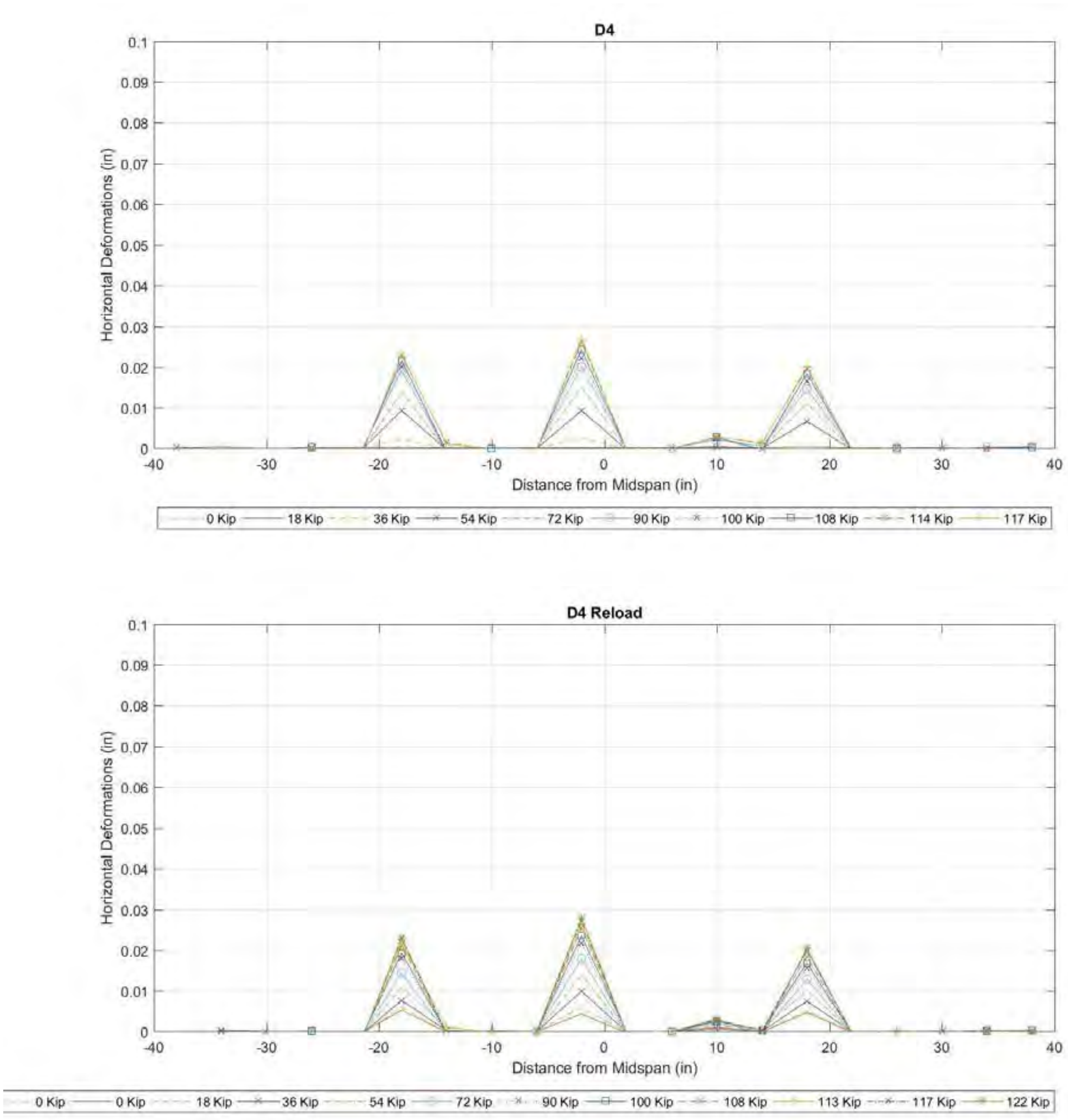


Figure 31 Horizontal Deformations, Load and Reload, D4

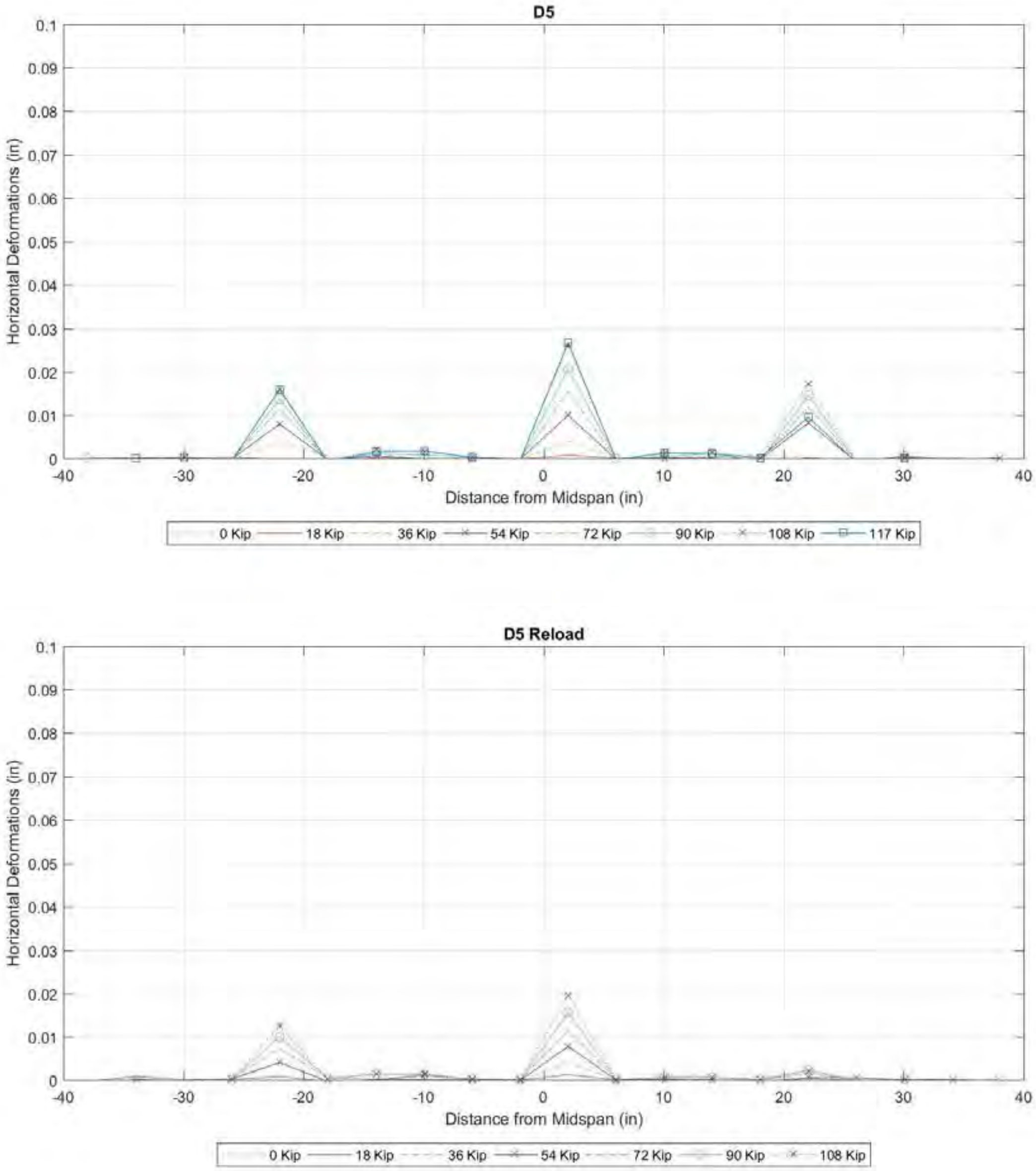


Figure 32 Horizontal Deformations, Load and Reload, D5

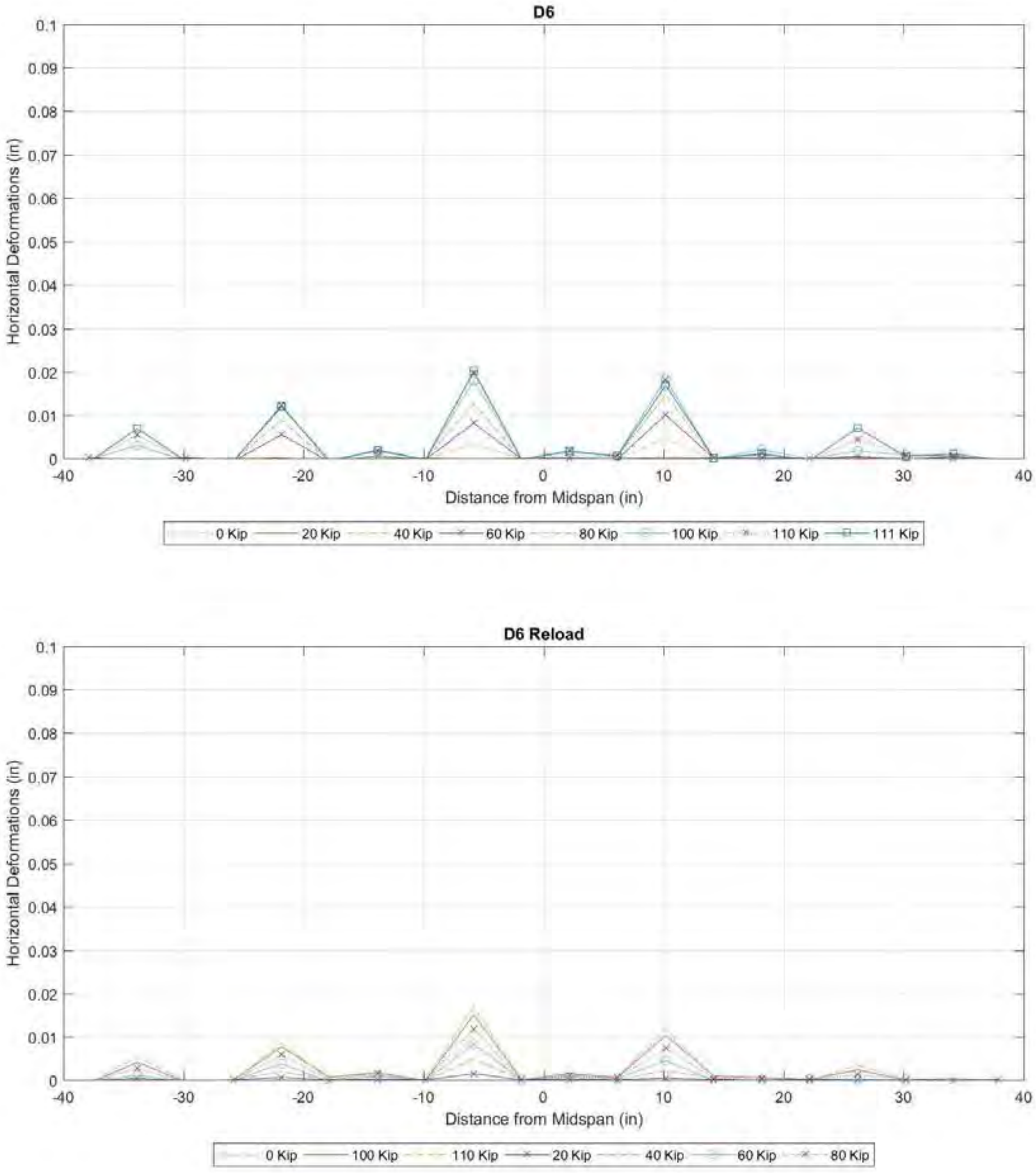
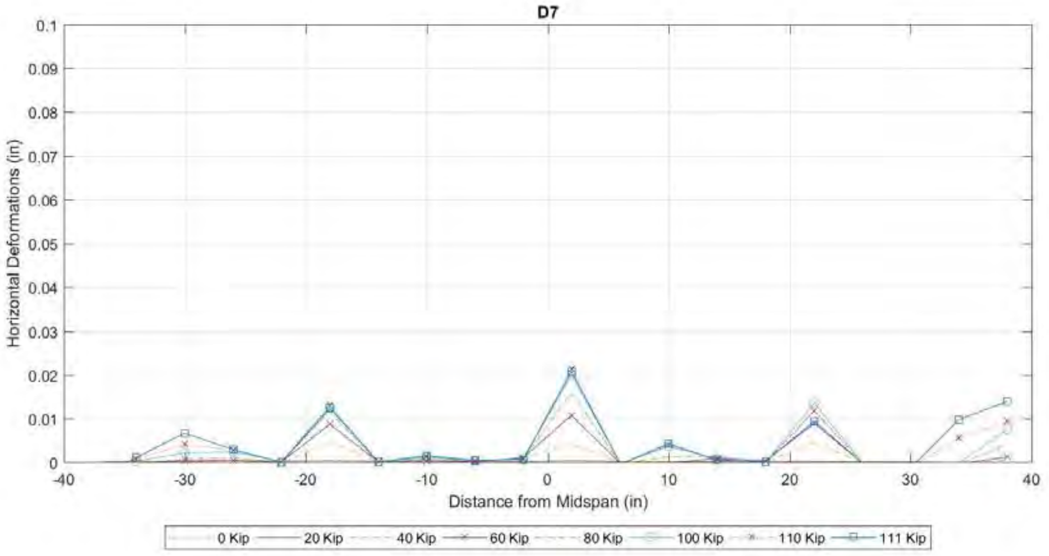


Figure 33 Horizontal Deformations, Load and Reload, D6



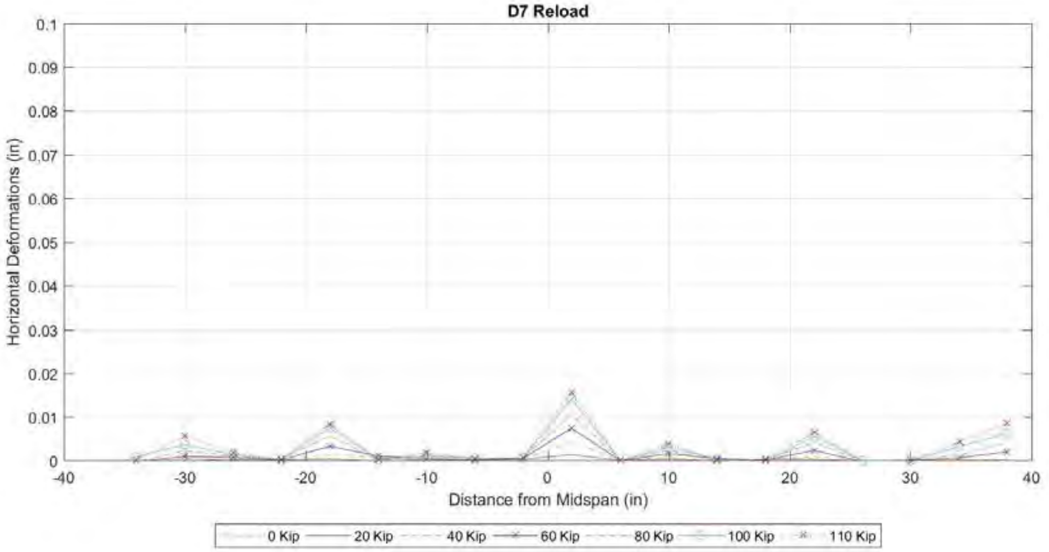
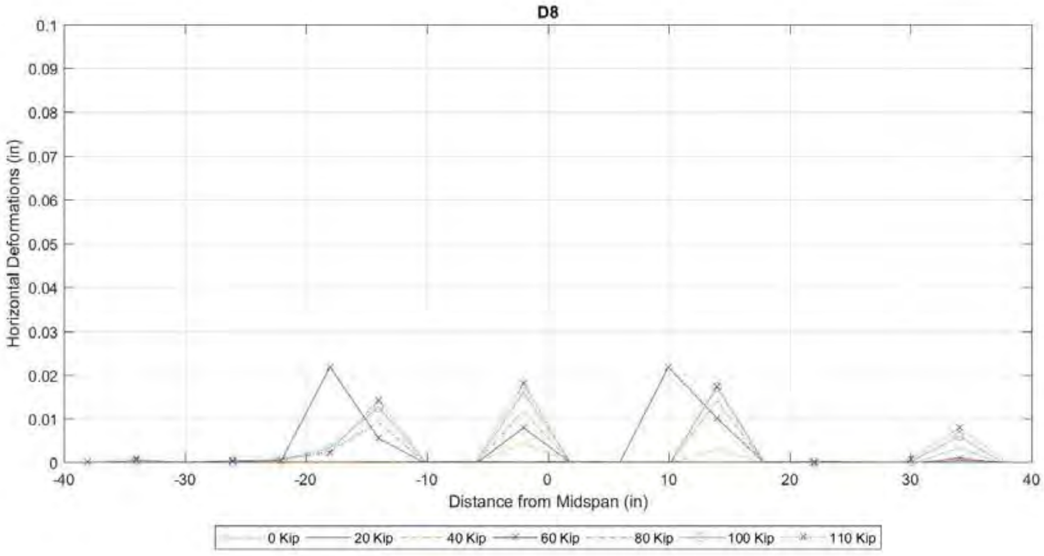


Figure 34 Horizontal Deformations, Load and Reload, D7



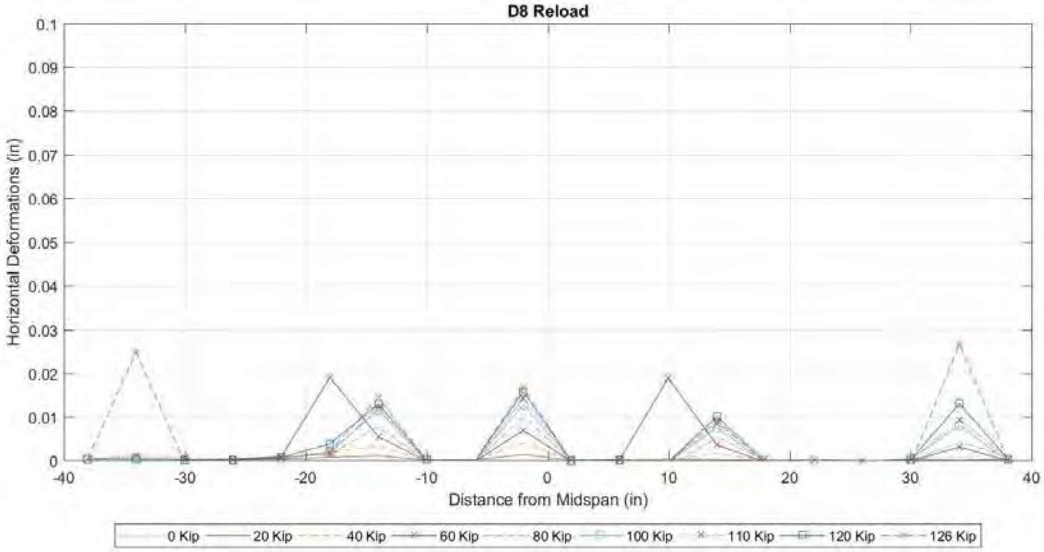


Figure 35 Horizontal Deformations, Load and Reload, D8

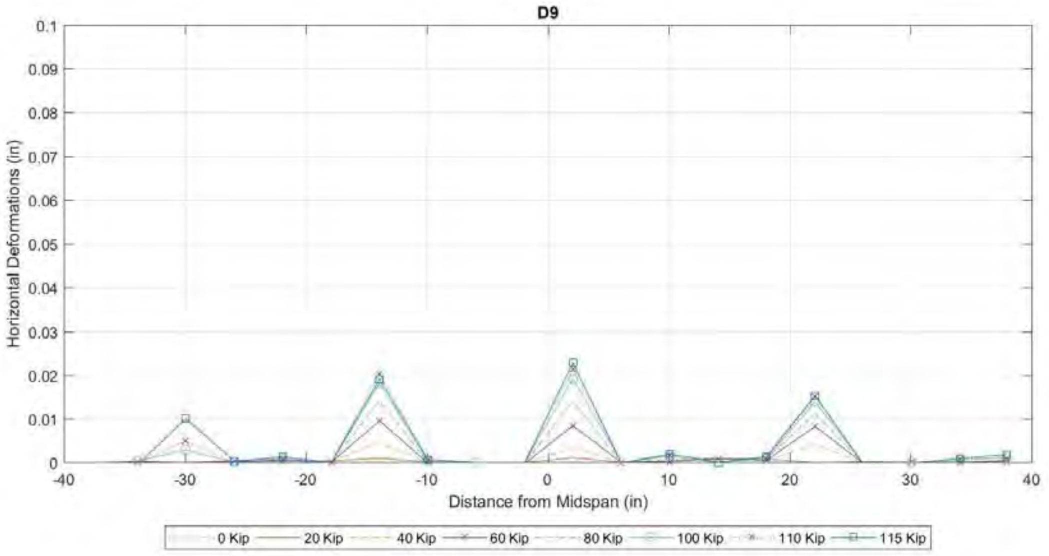
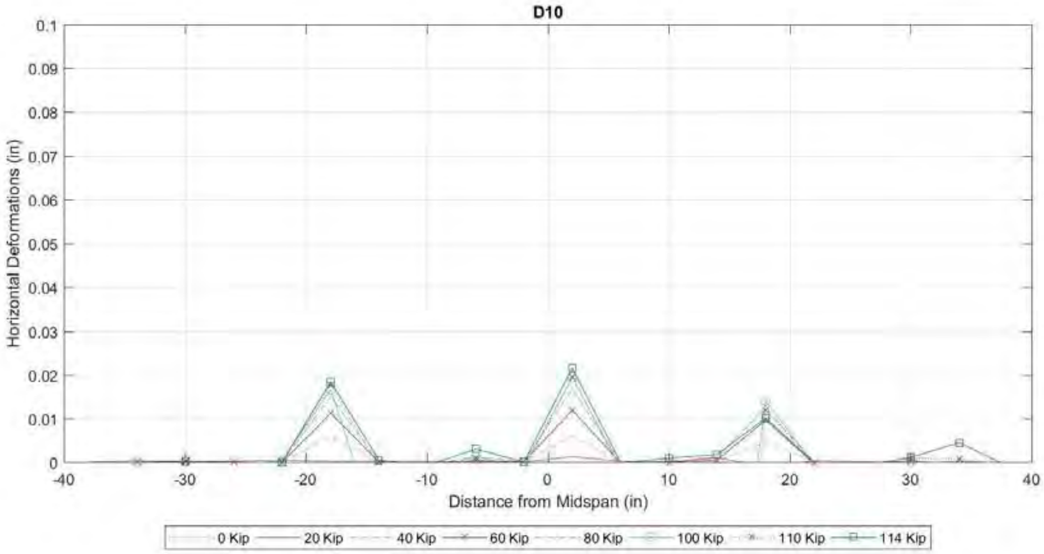


Figure 36 Horizontal Deformations, First Loading, D9



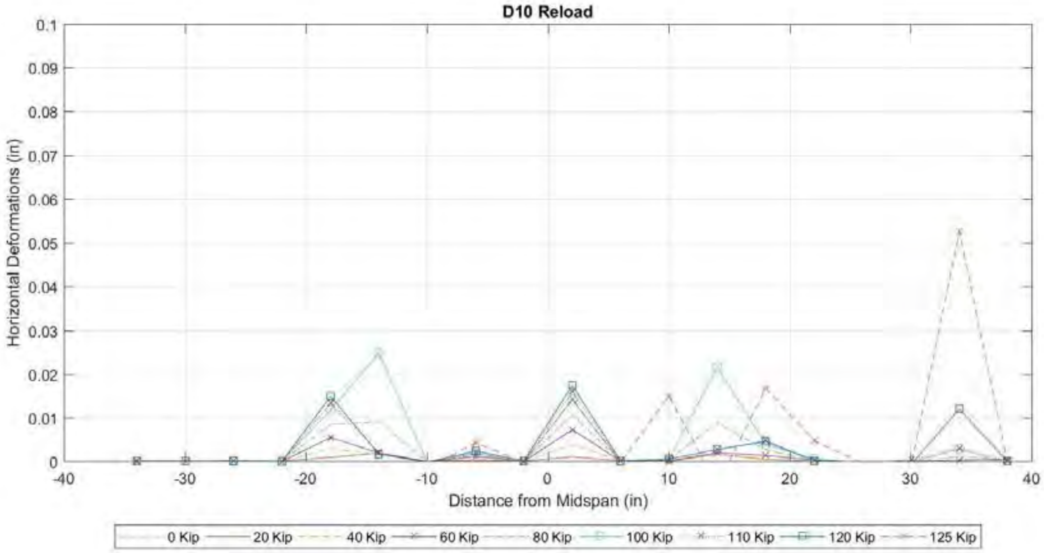


Figure 37 Horizontal Deformations, Load and Reload, D10

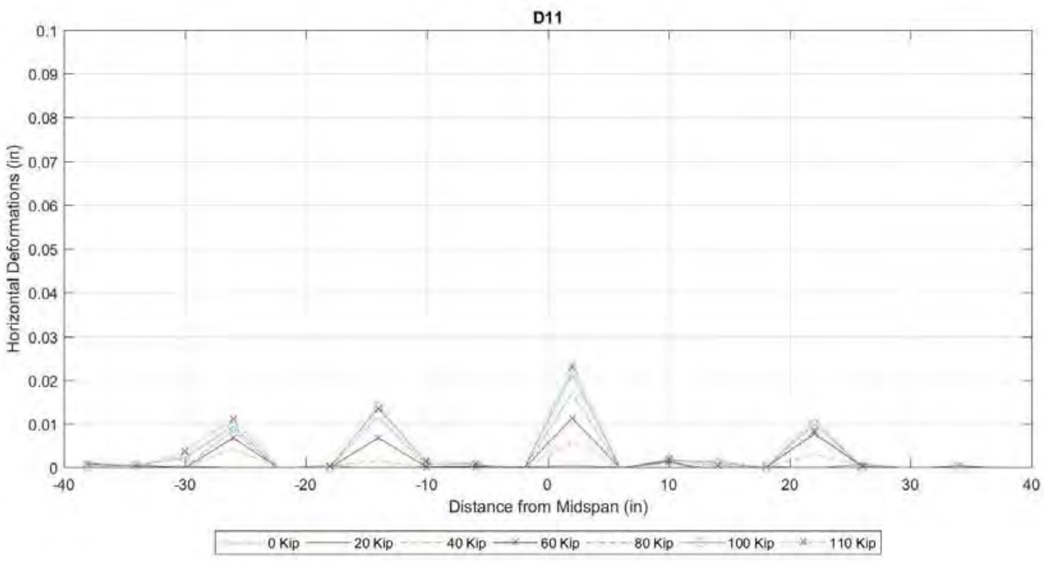
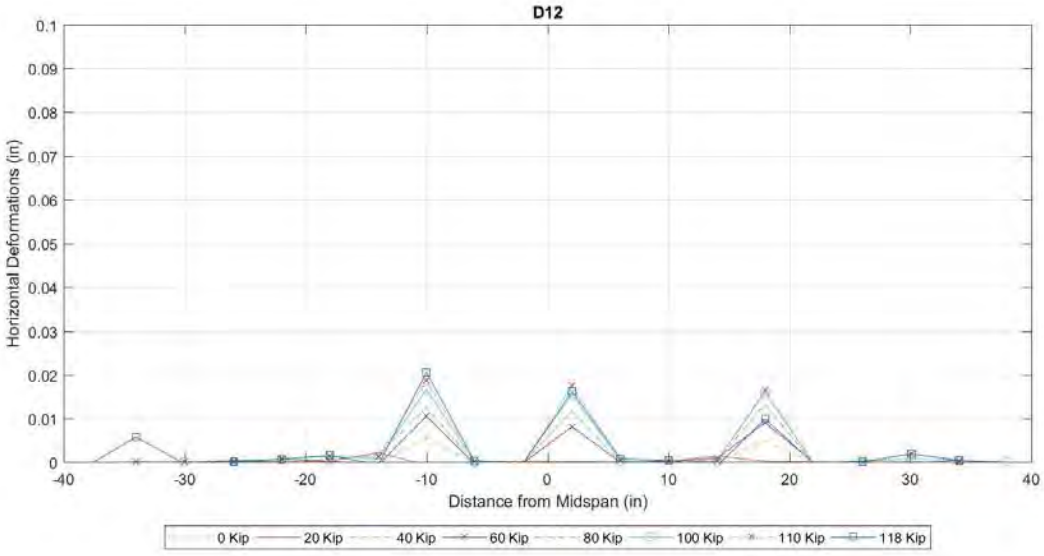


Figure 38 Horizontal Deformations, First Loading, D11



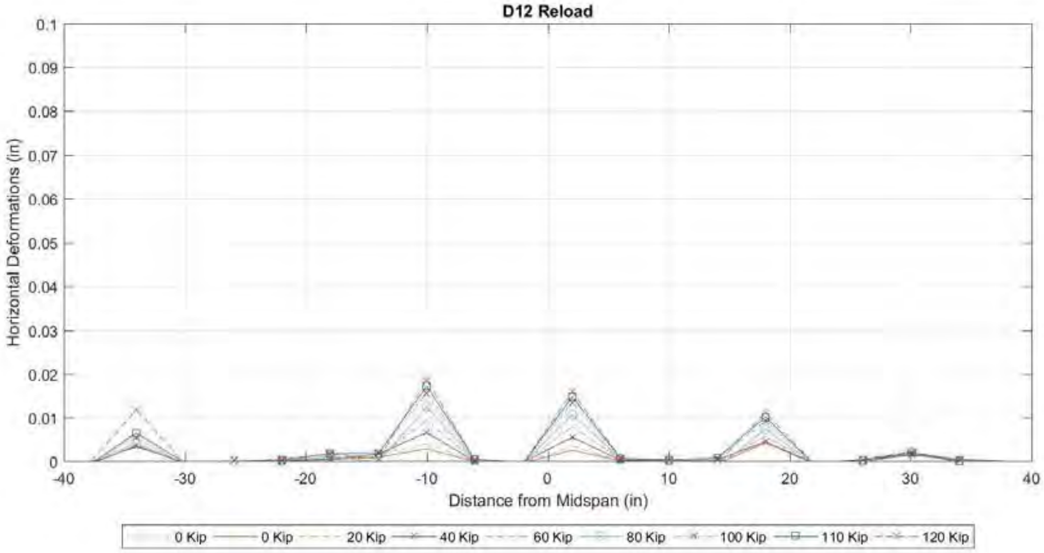


Figure 39 Horizontal Deformations, Load and Reload, D12

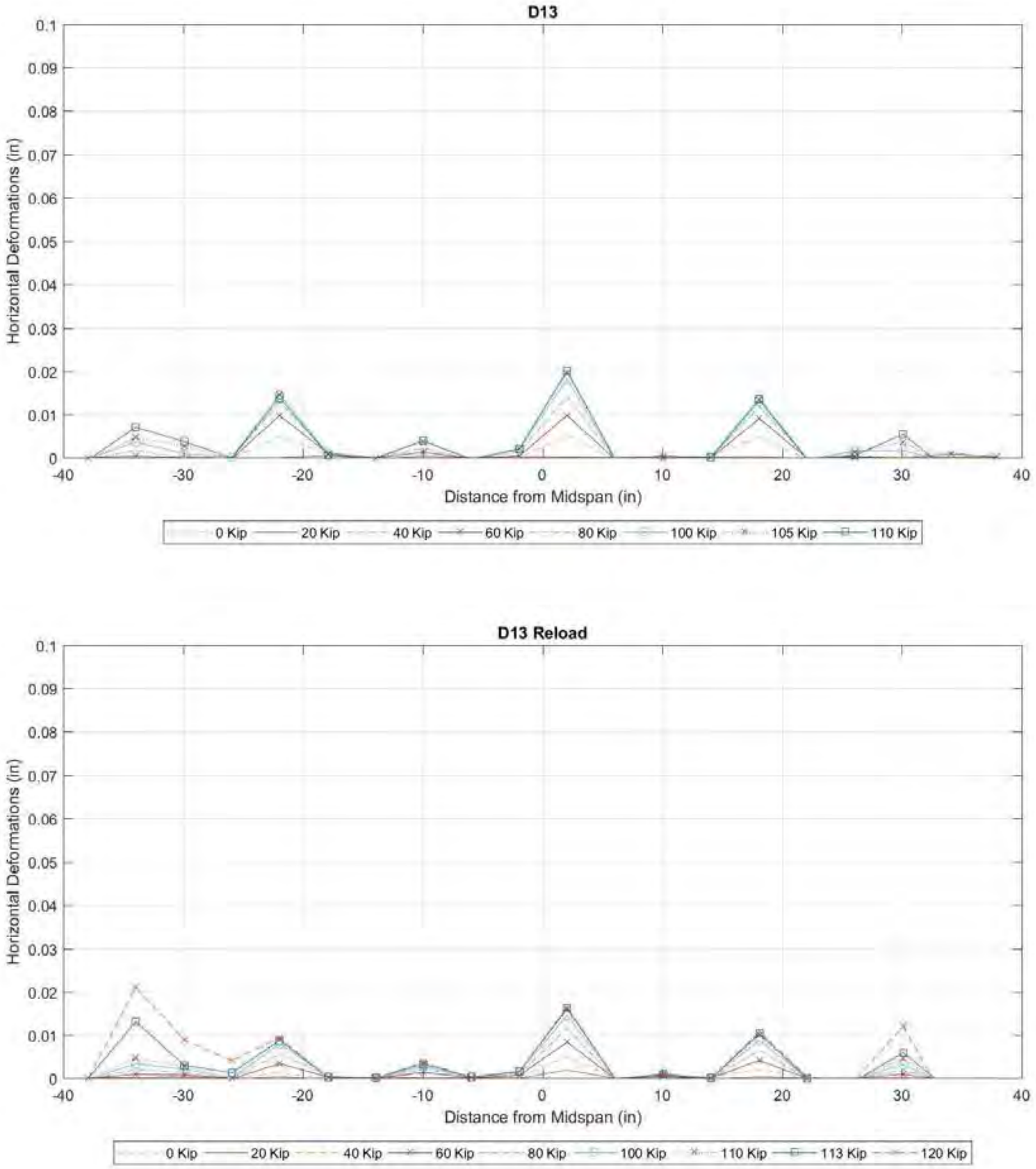
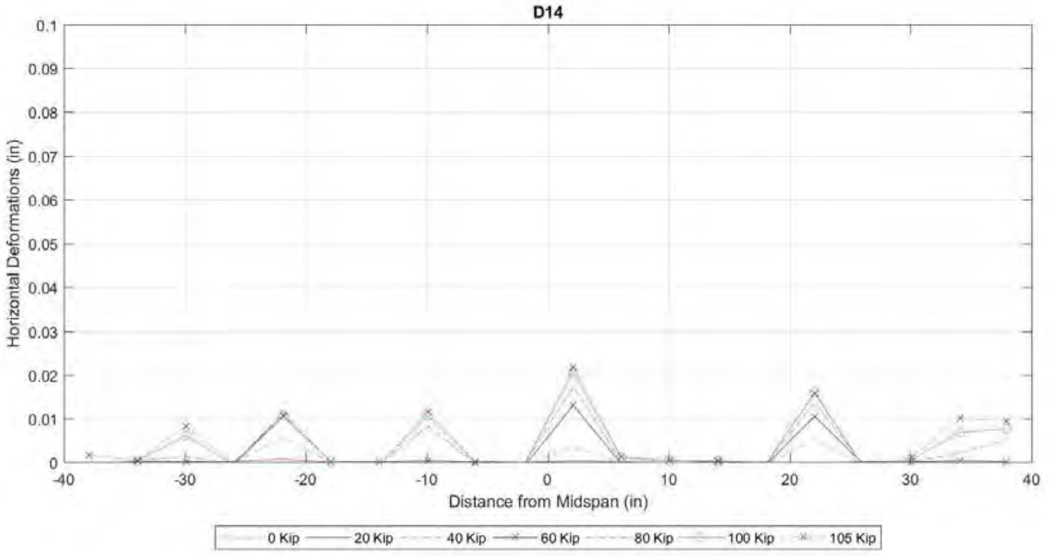


Figure 40 Horizontal Deformations, Load and Reload, D13



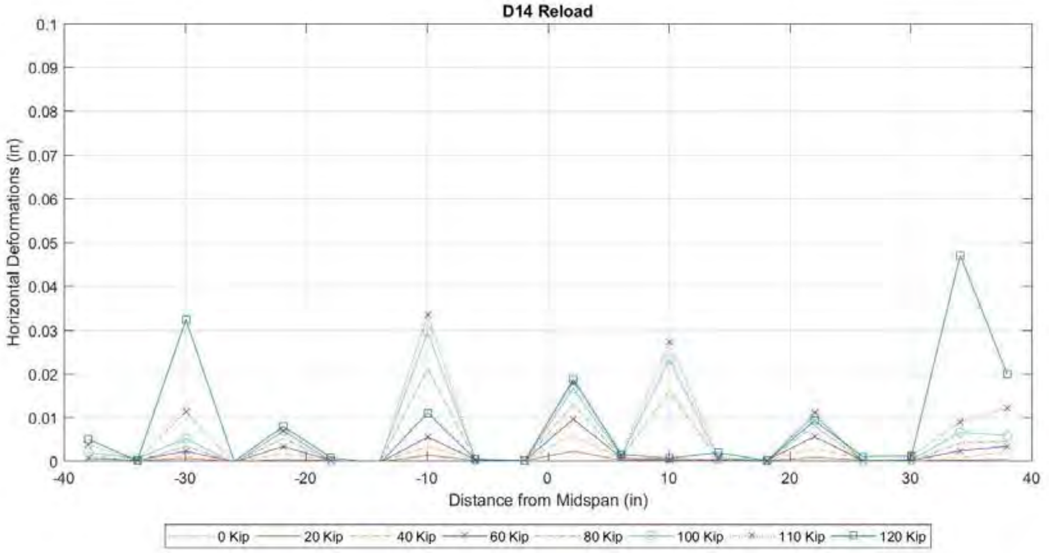


Figure 41 Horizontal Deformations, Load and Reload, D14

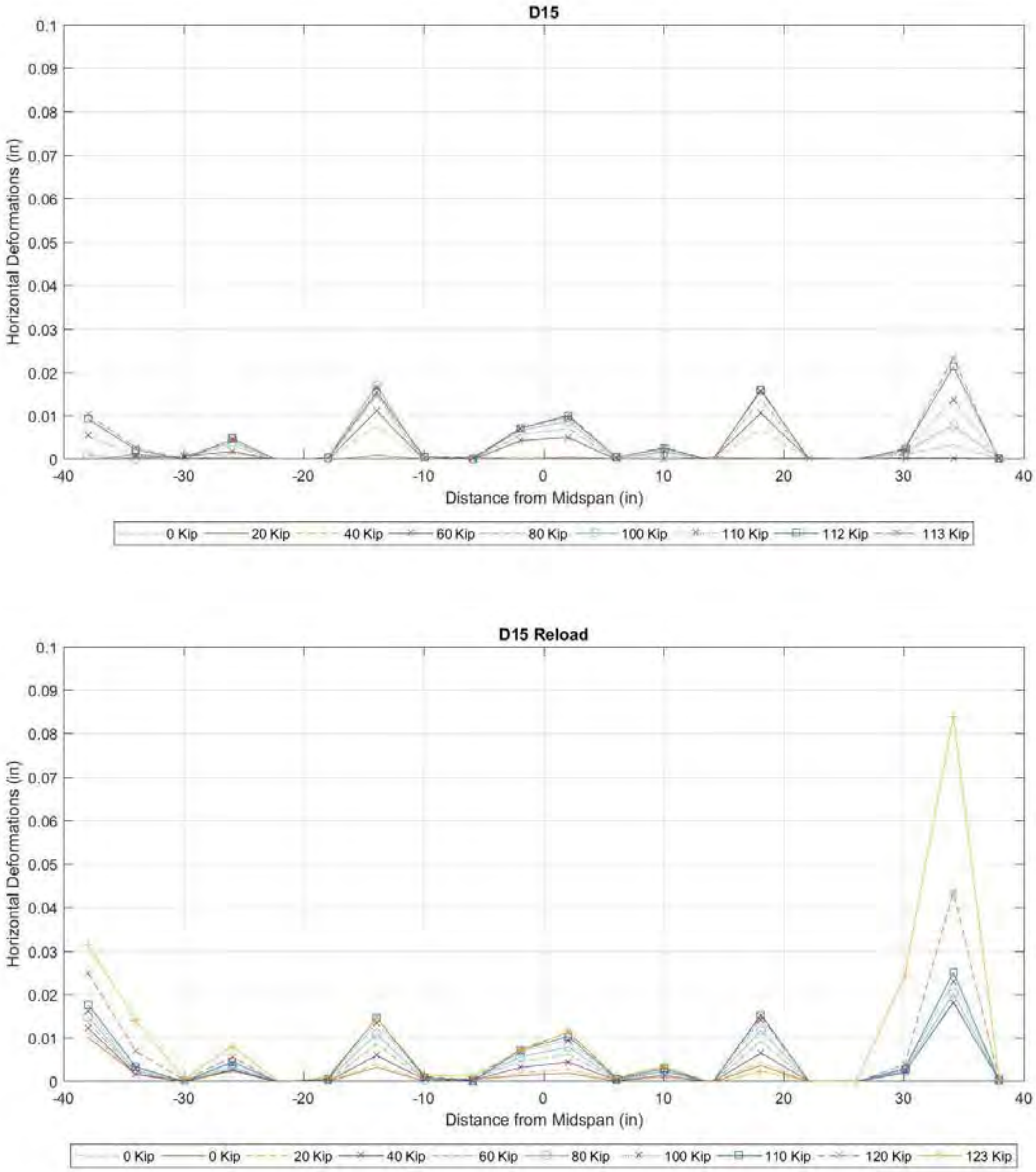
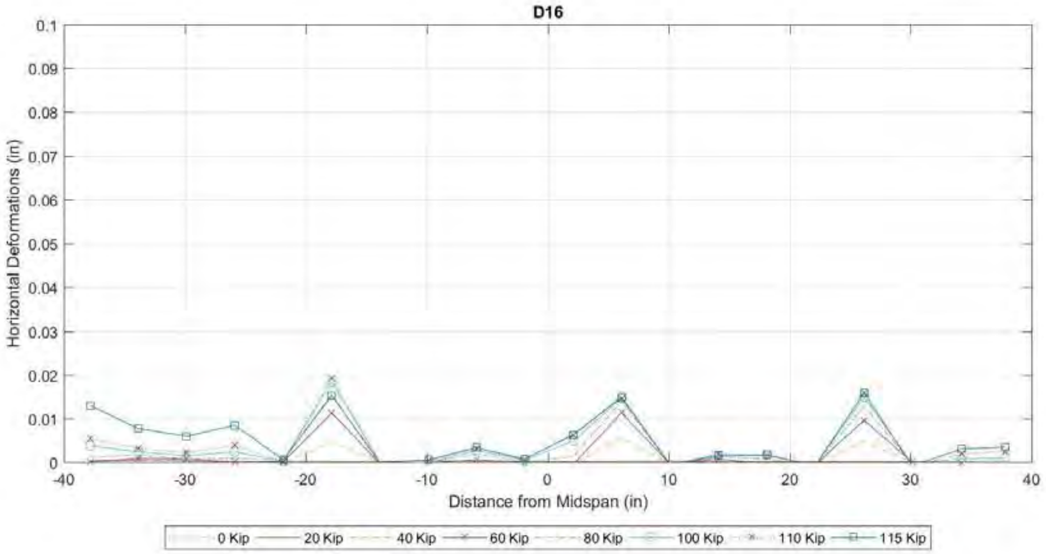


Figure 42 Horizontal Deformations, Load and Reload, D15



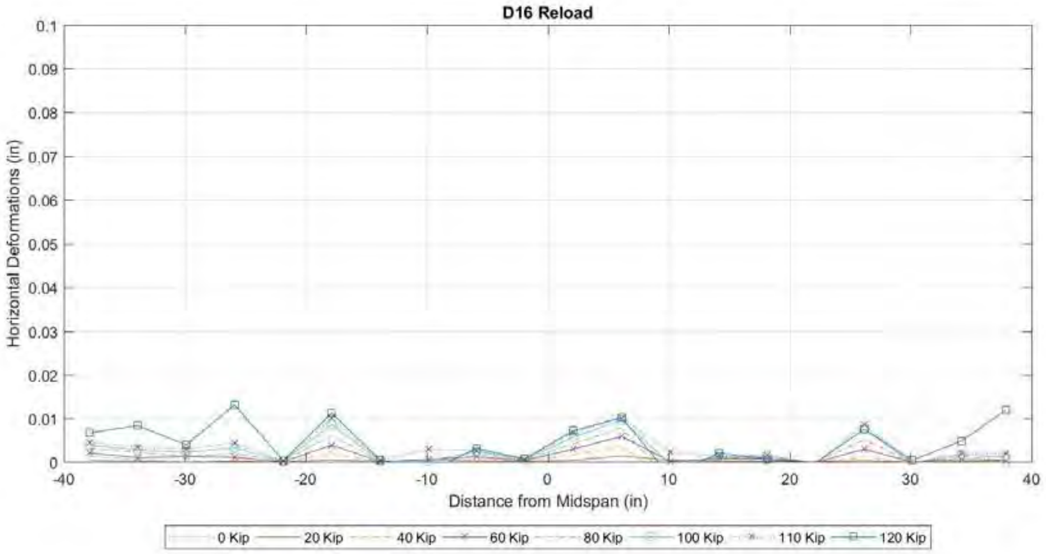


Figure 43 Horizontal Deformations, Load and Reload, D16

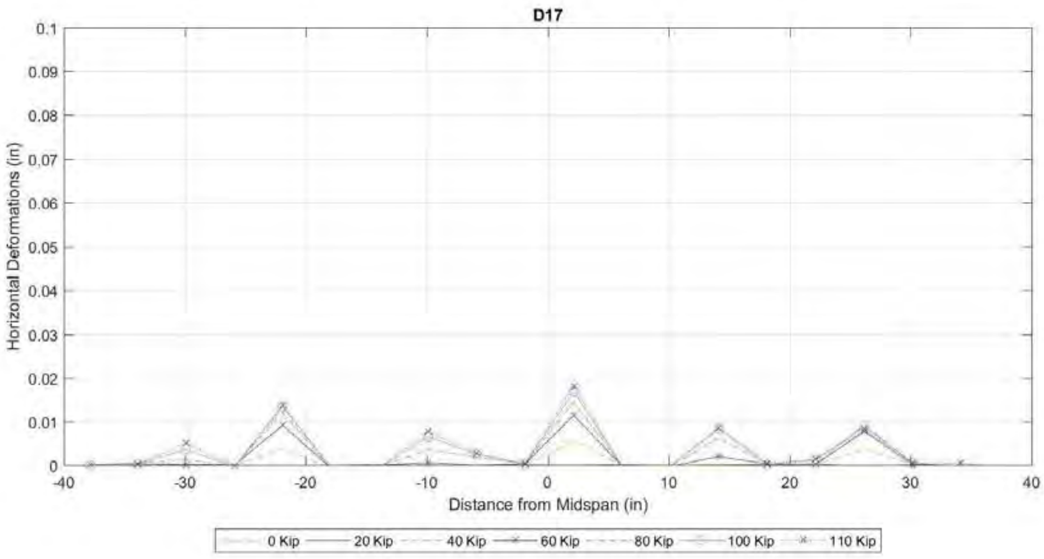
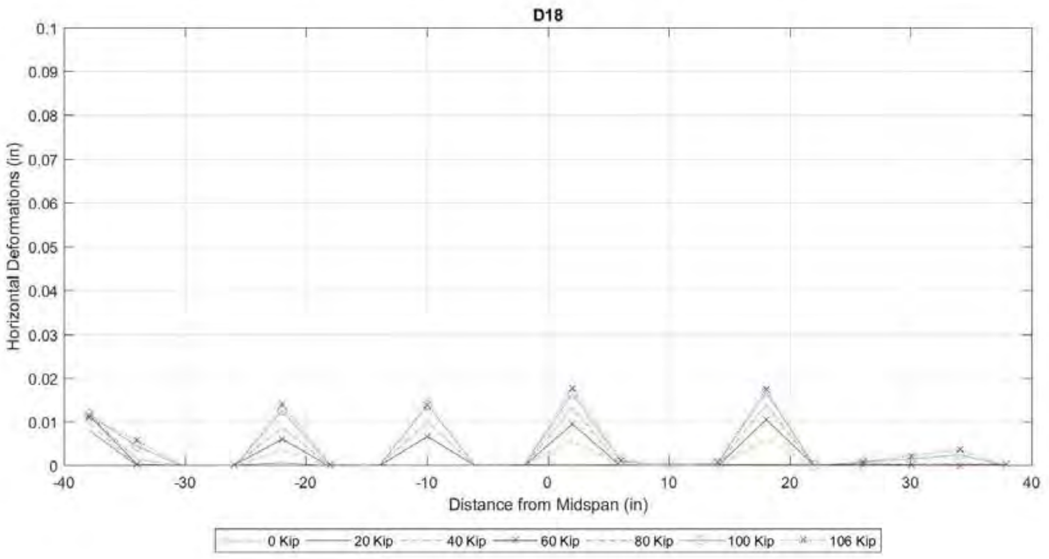


Figure 44 Horizontal Deformations, First Loading, D17



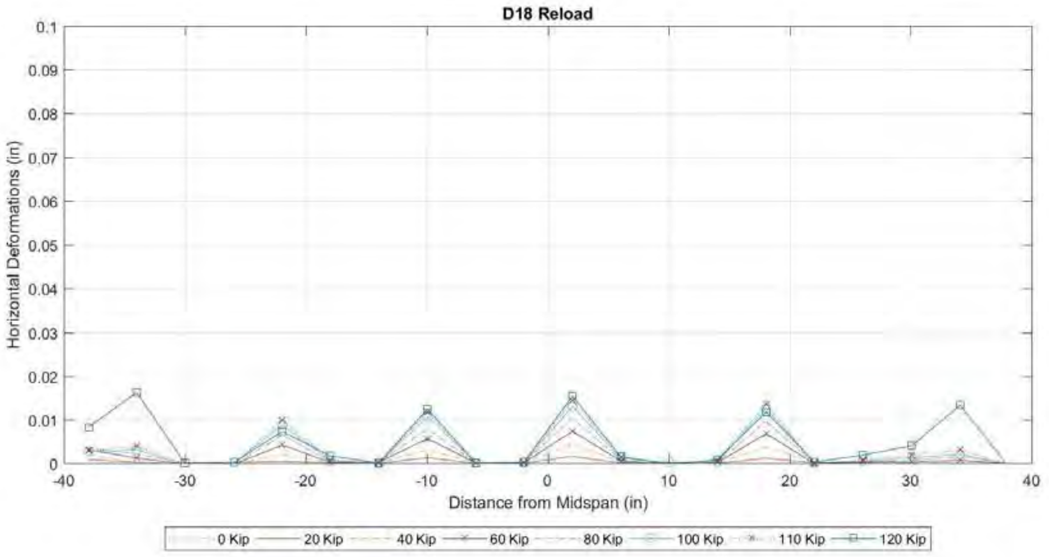


Figure 45 Horizontal Deformations, Load and Reload, D18

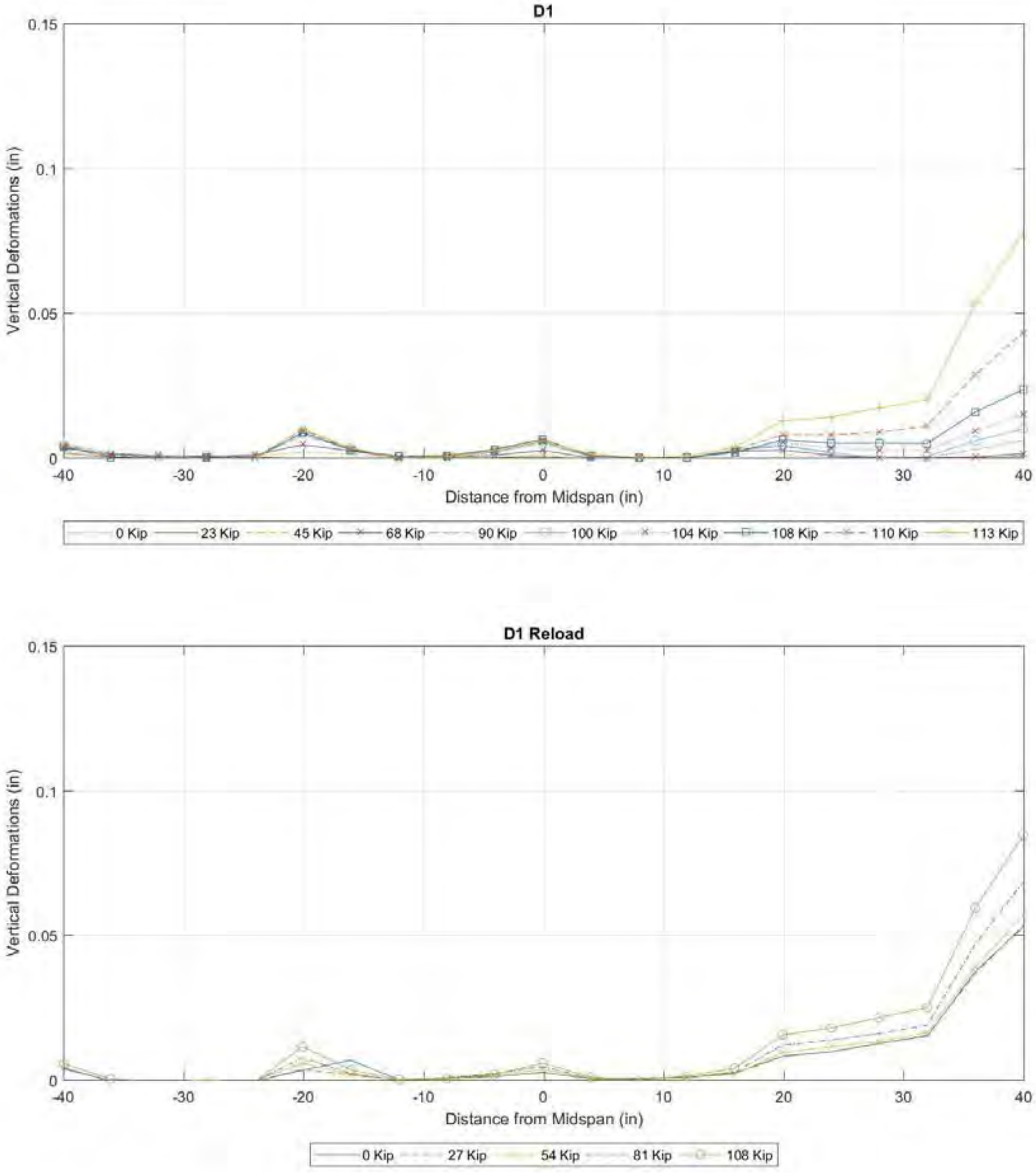


Figure 46 Vertical Deformations, Load and Reload, D1

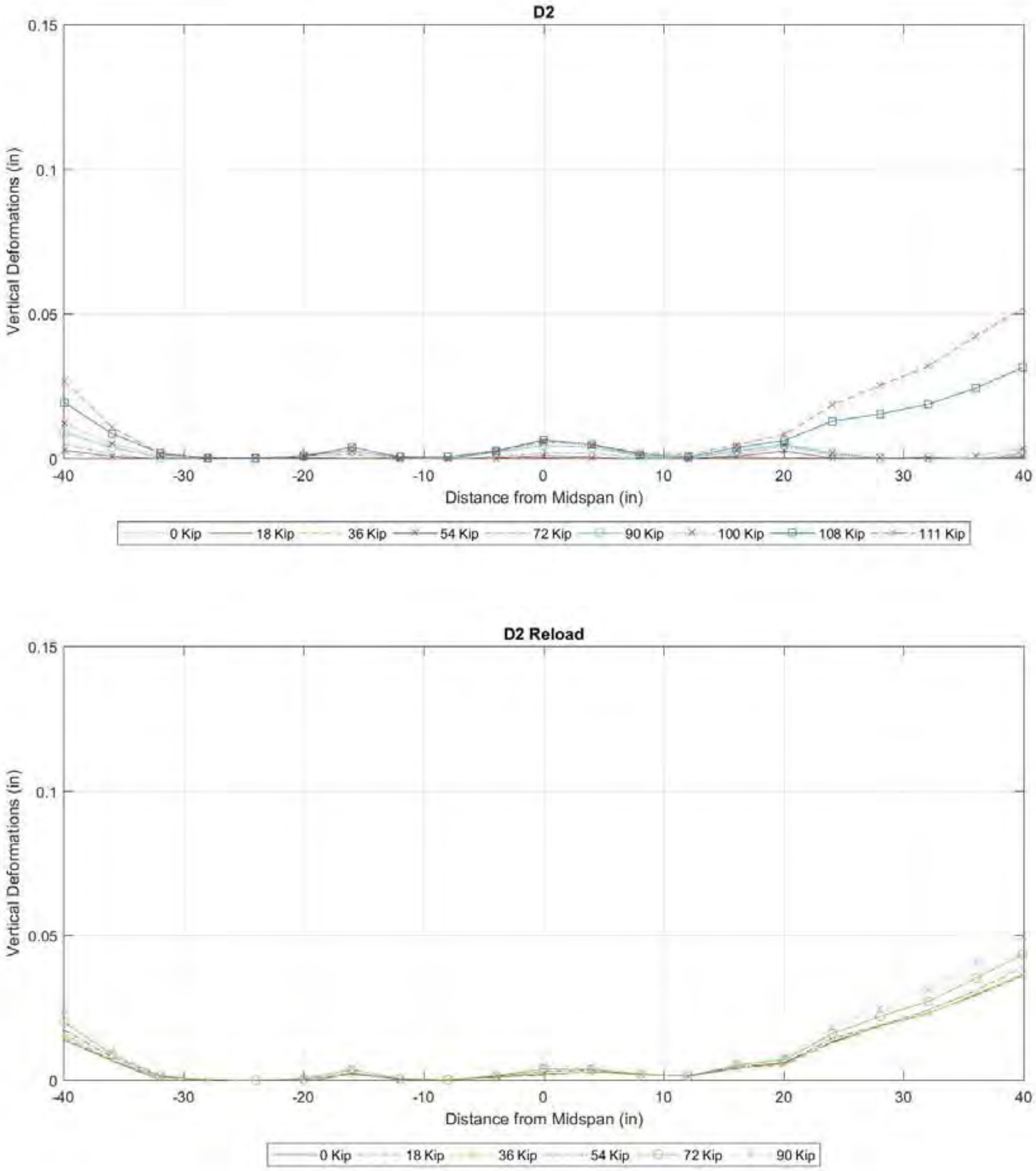


Figure 47 Vertical Deformations, Load and Reload, D2

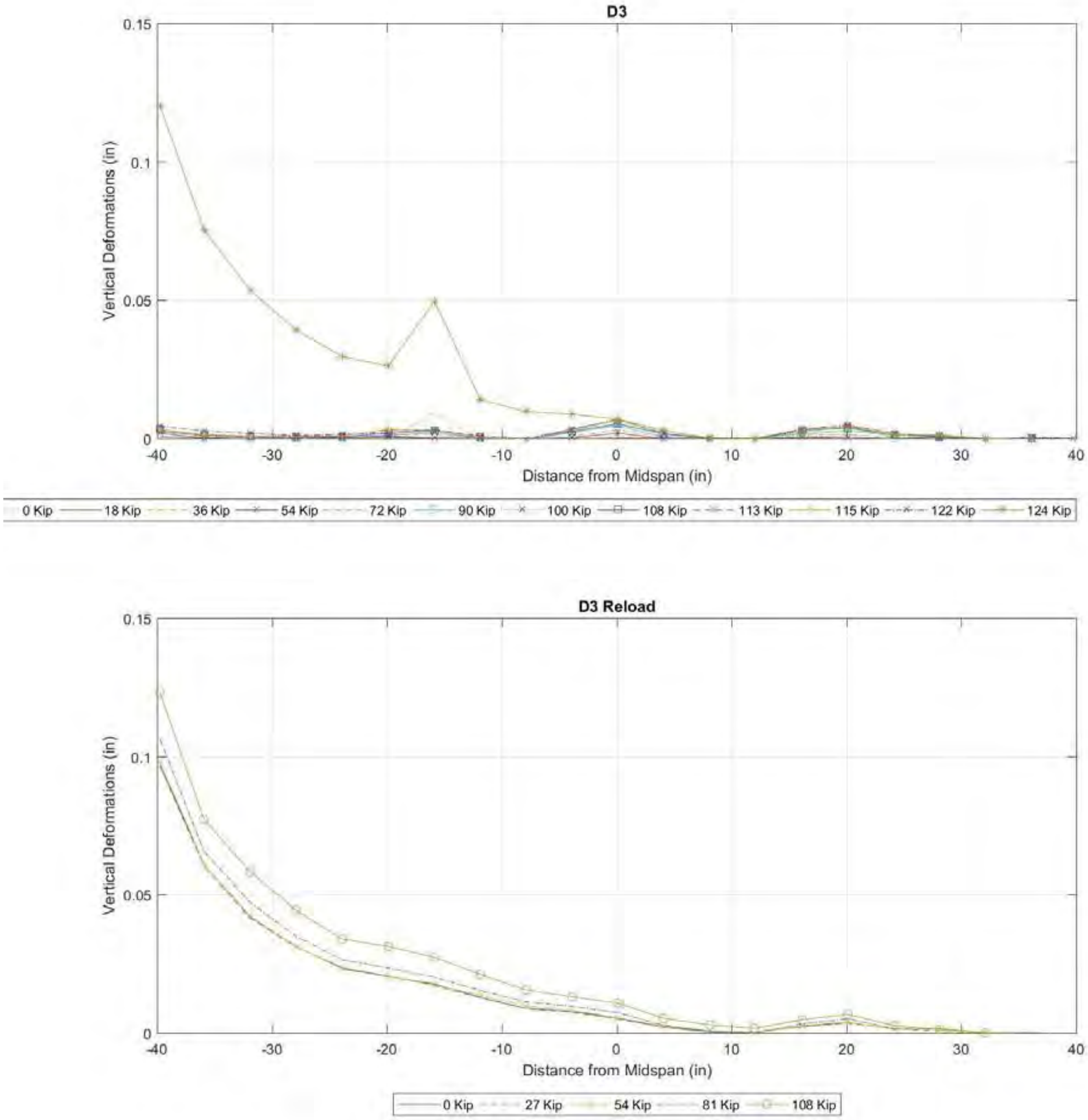


Figure 48 Vertical Deformations, Load and Reload, D3

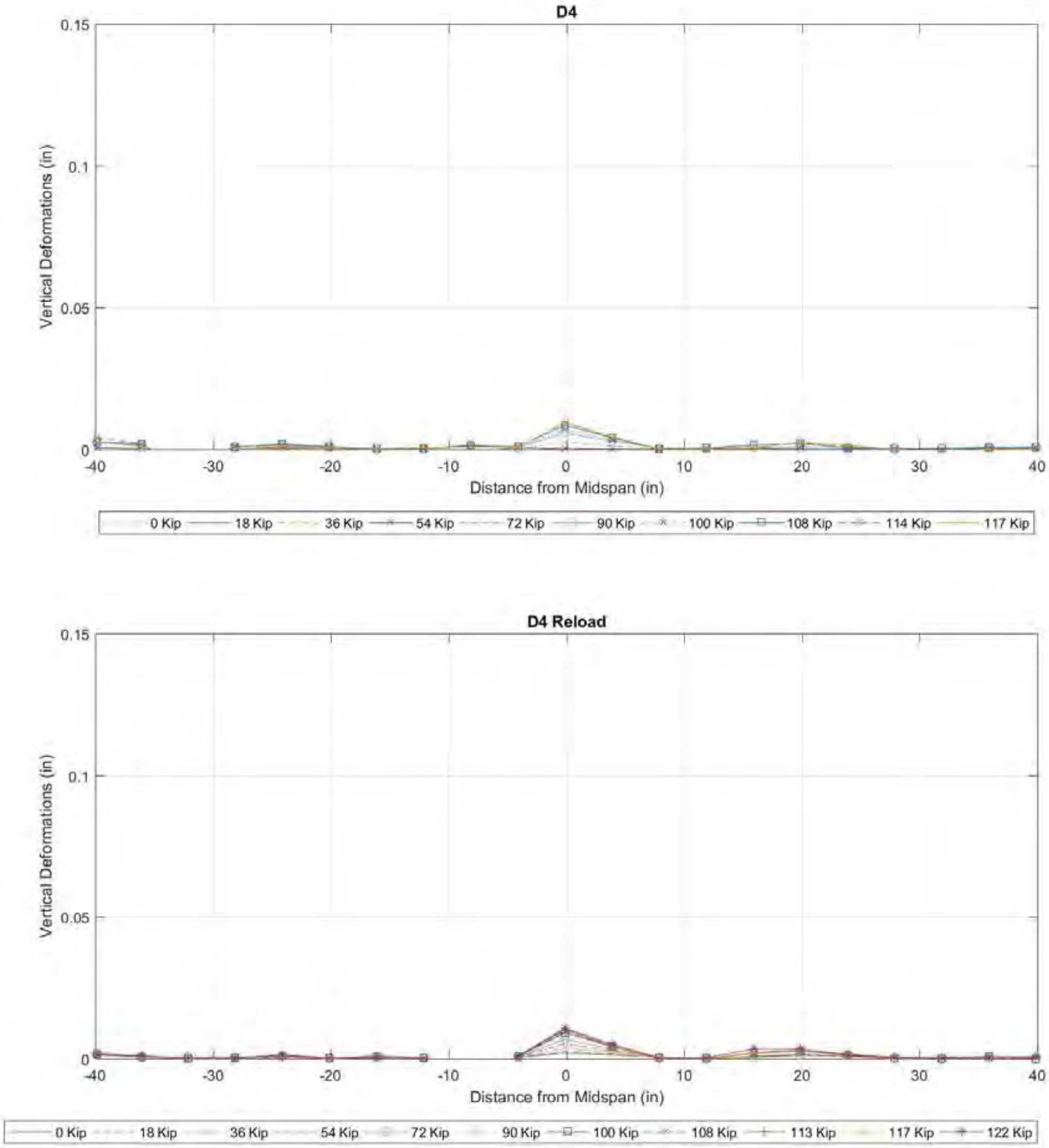
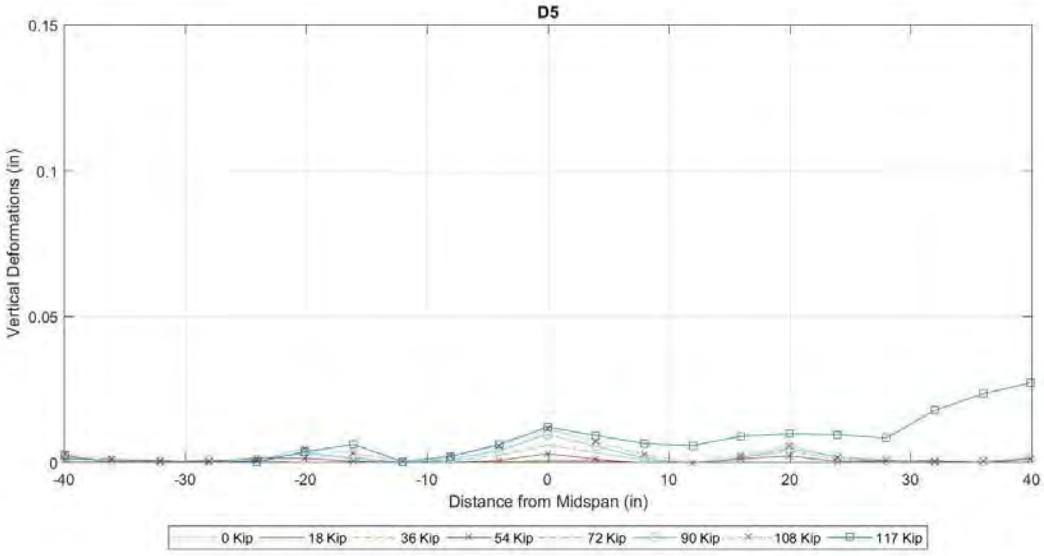


Figure 49 Vertical Deformations, Load and Reload, D4



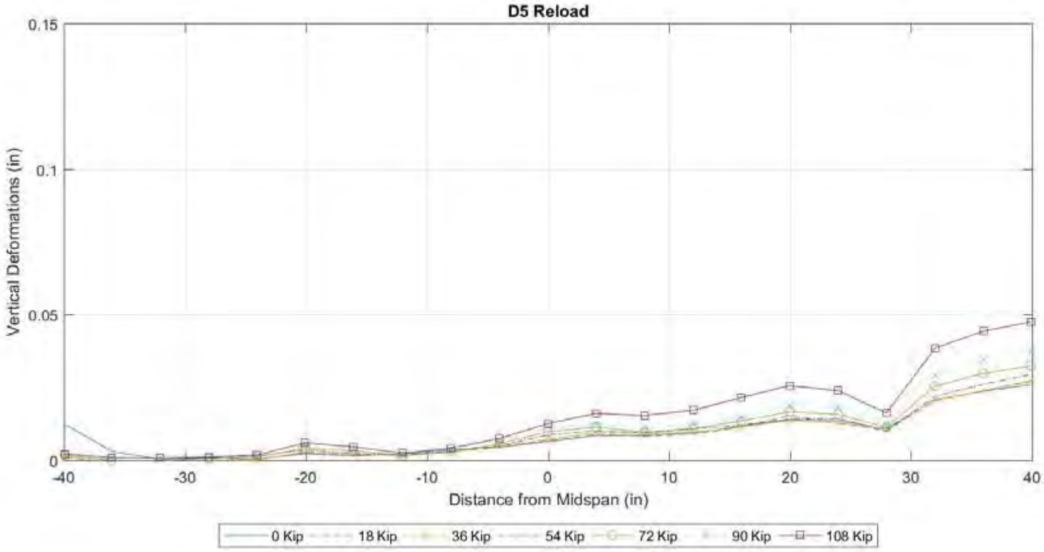
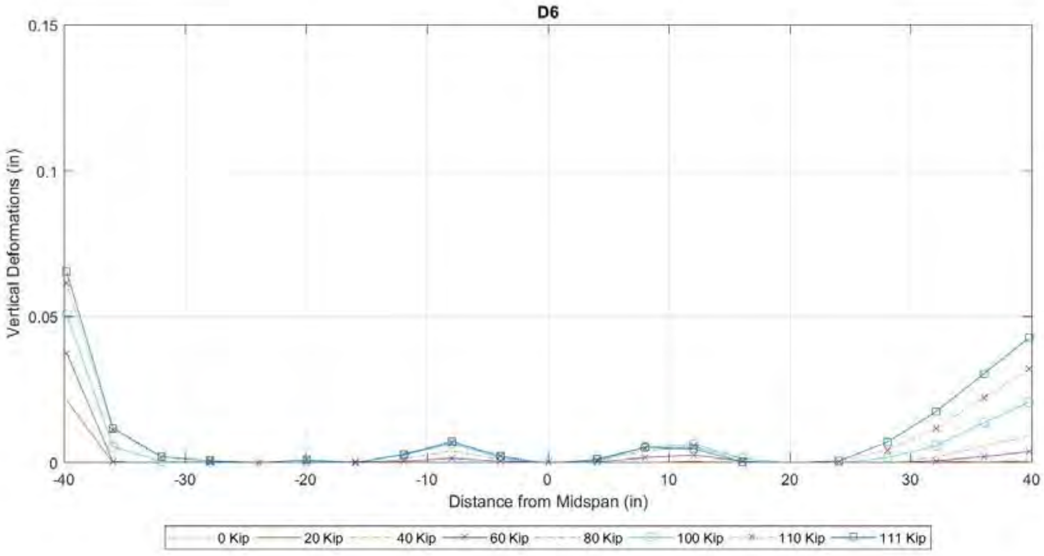


Figure 50 Vertical Deformations, Load and Reload, D5



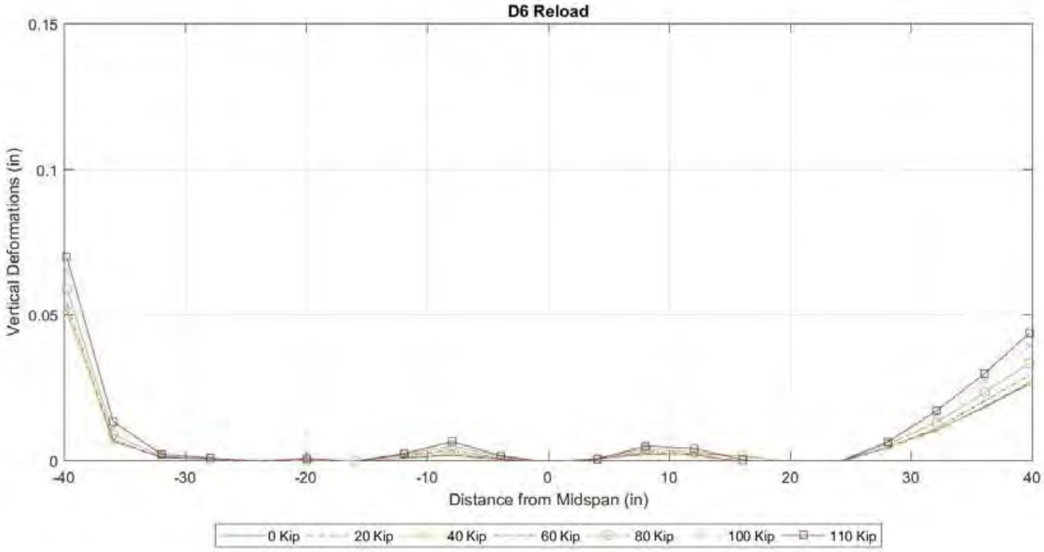


Figure 51 Vertical Deformations, Load and Reload, D6

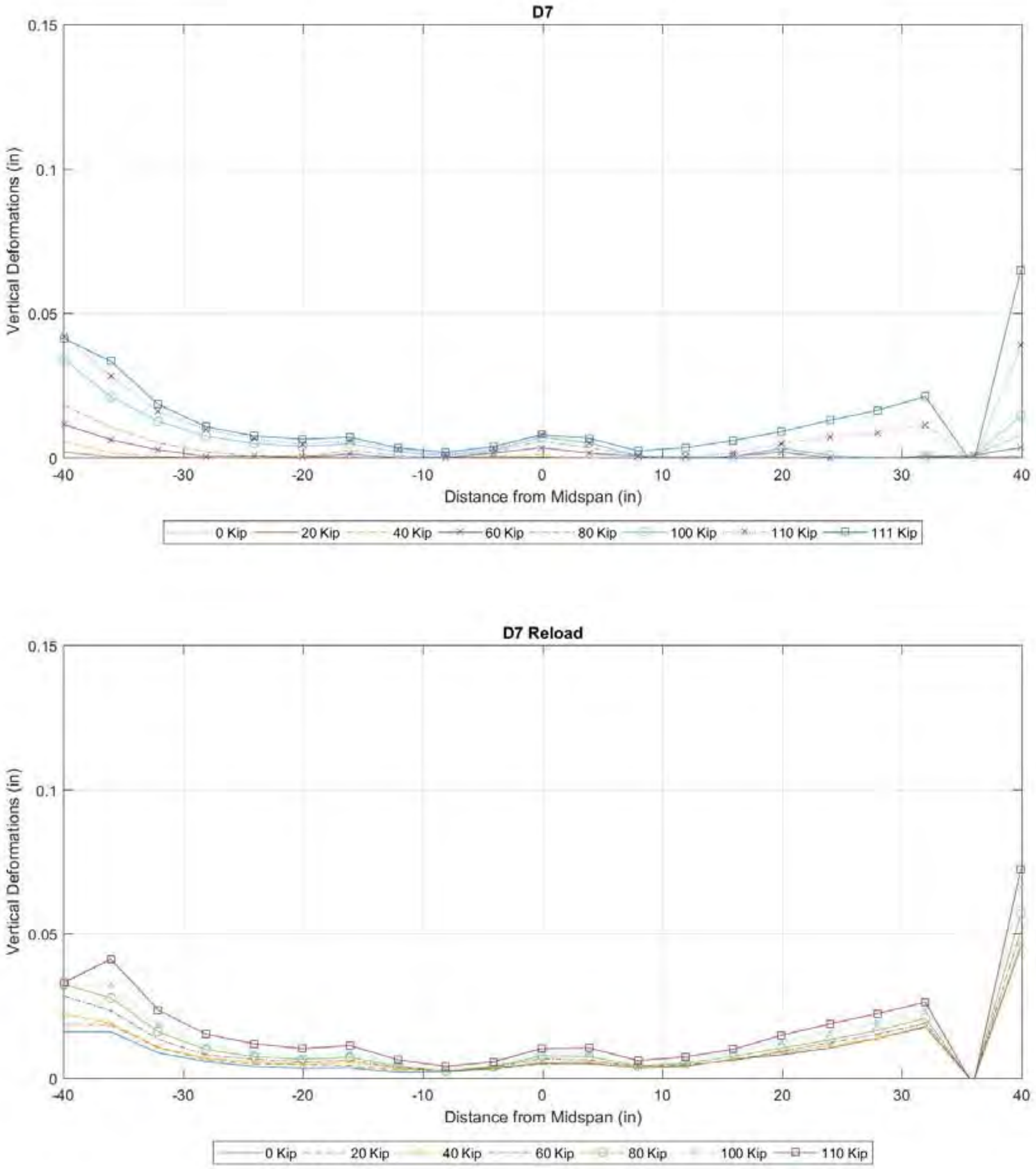


Figure 52 Vertical Deformations, Load and Reload, D7

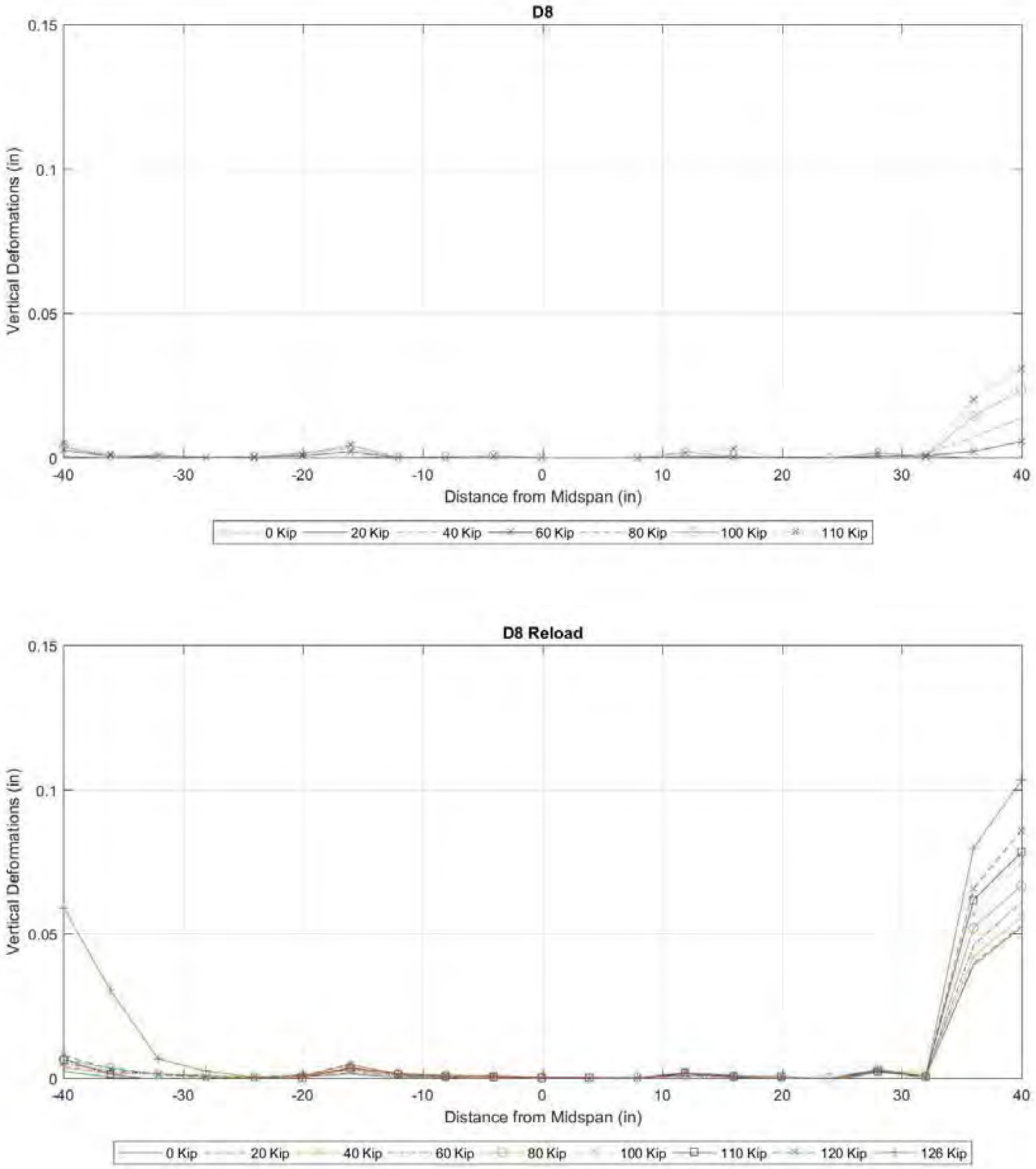


Figure 53 Vertical Deformations, Load and Reload, D8

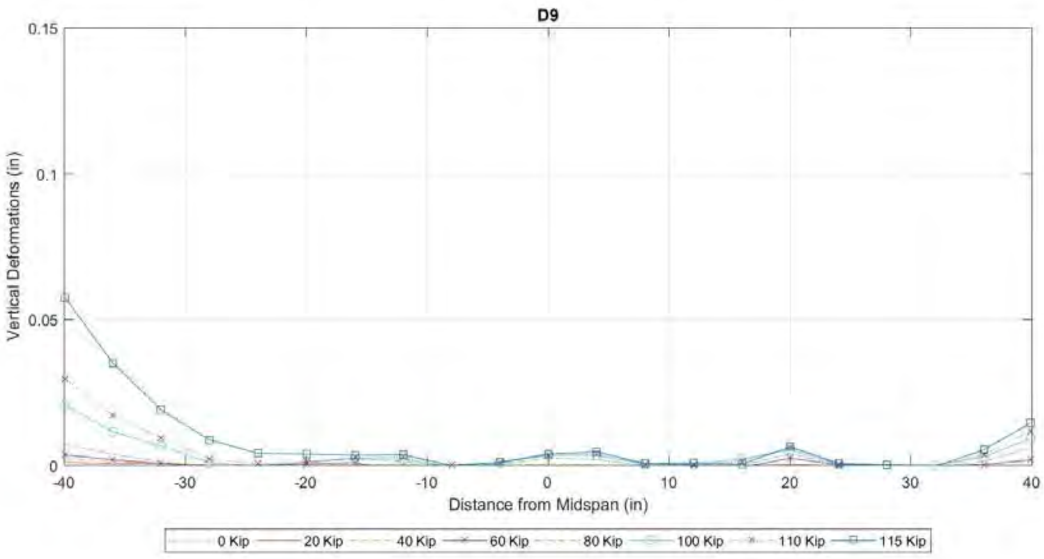
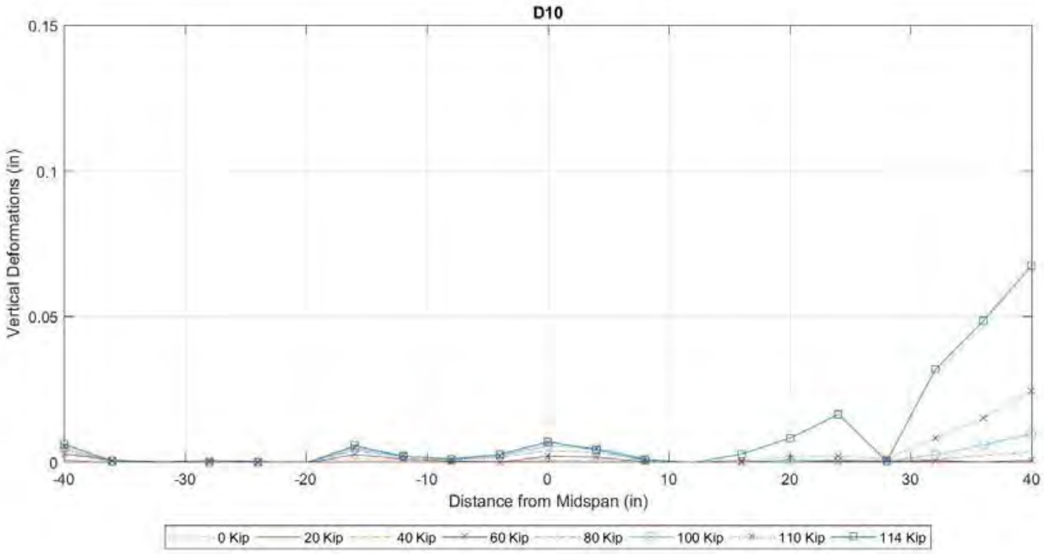


Figure 54 Vertical Deformations, First Loading, D9



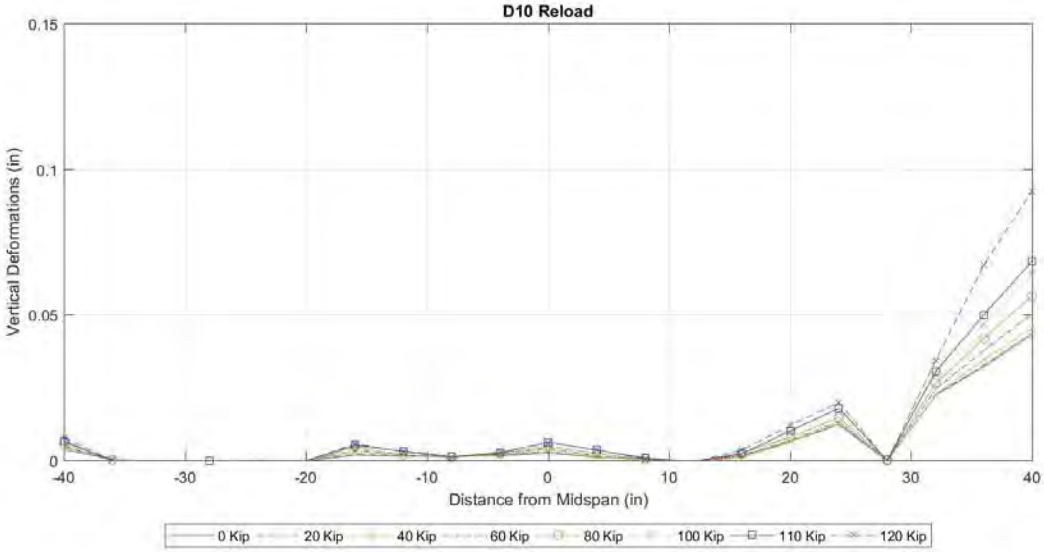


Figure 55 Vertical Deformations, Load and Reload, D10

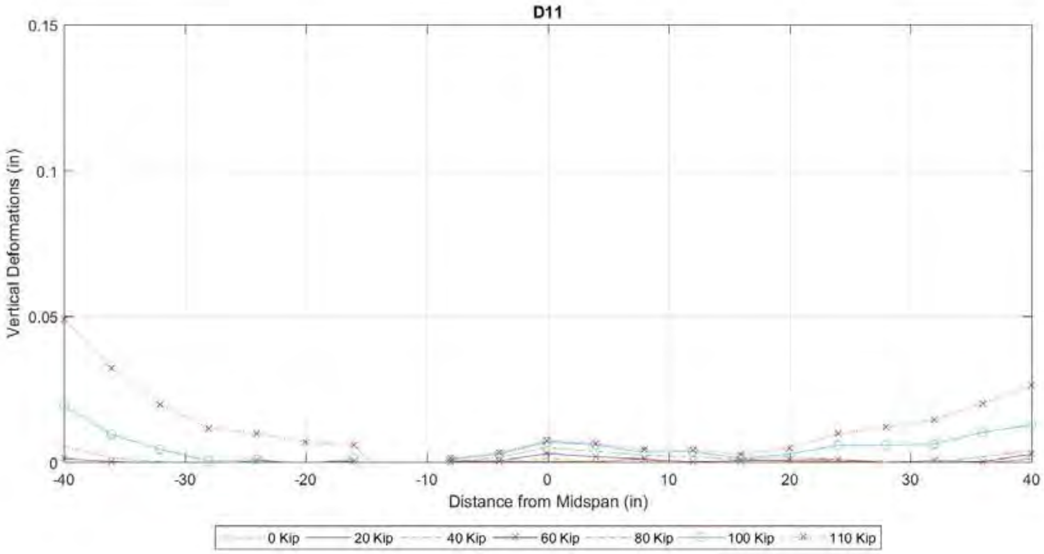


Figure 56 Vertical Deformations, First Loading, D11

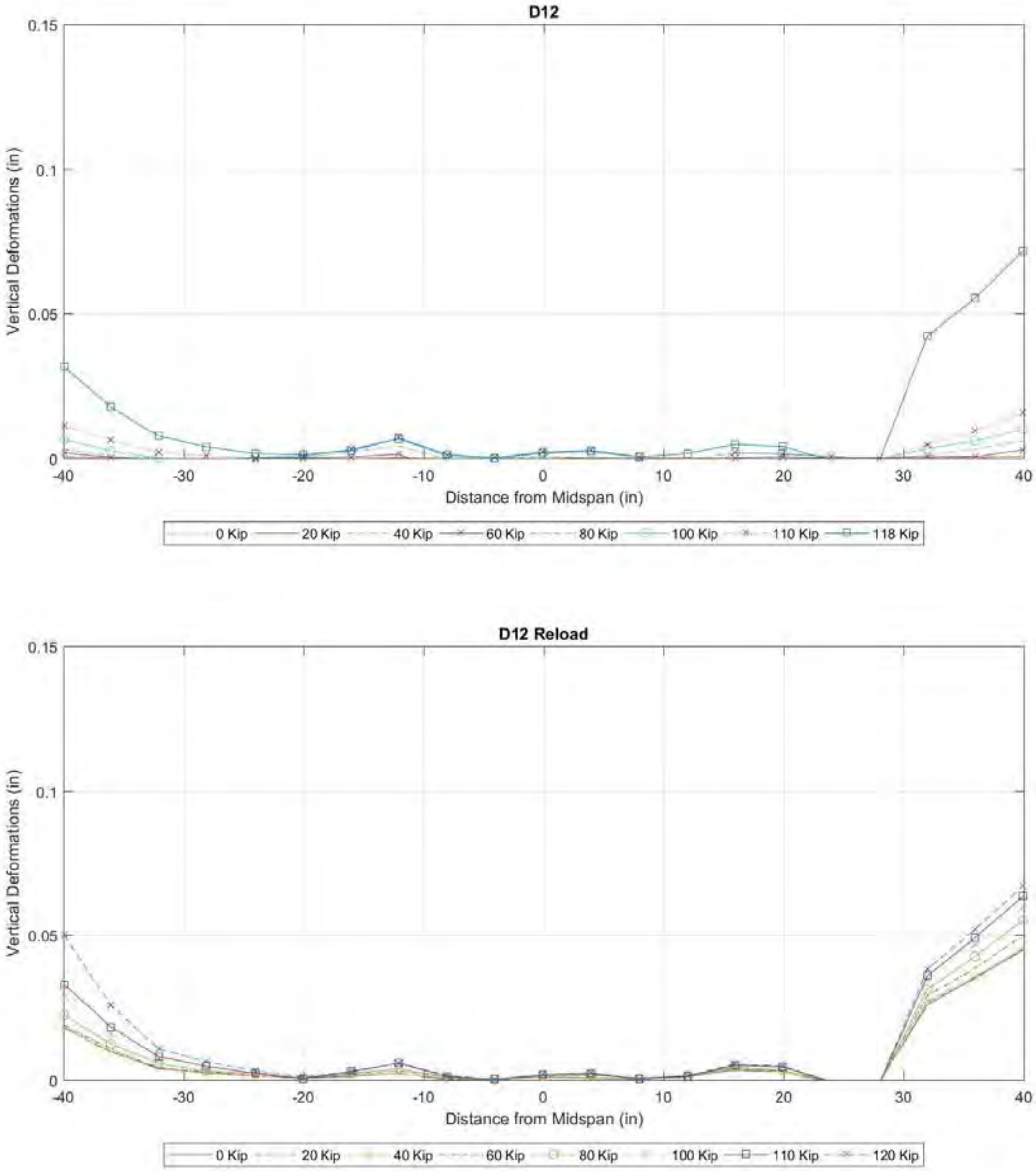


Figure 57 Vertical Deformations, Load and Reload, D12

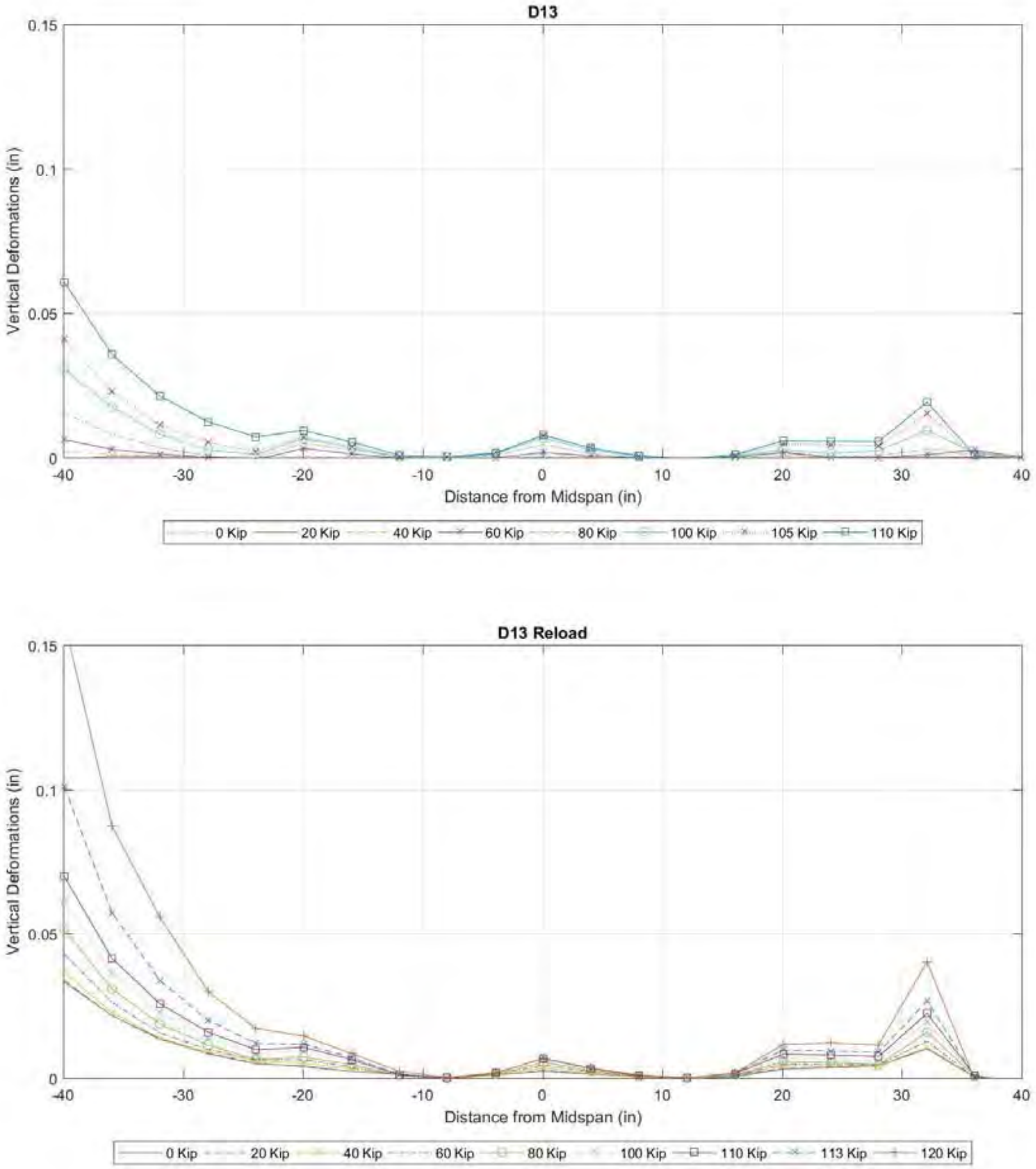
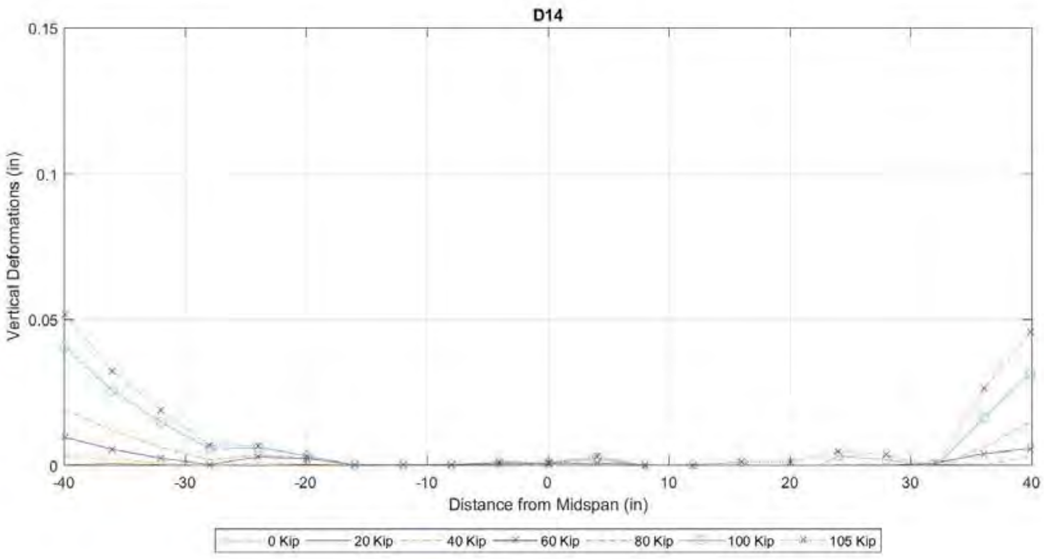


Figure 58 Vertical Deformations, Load and Reload, D13



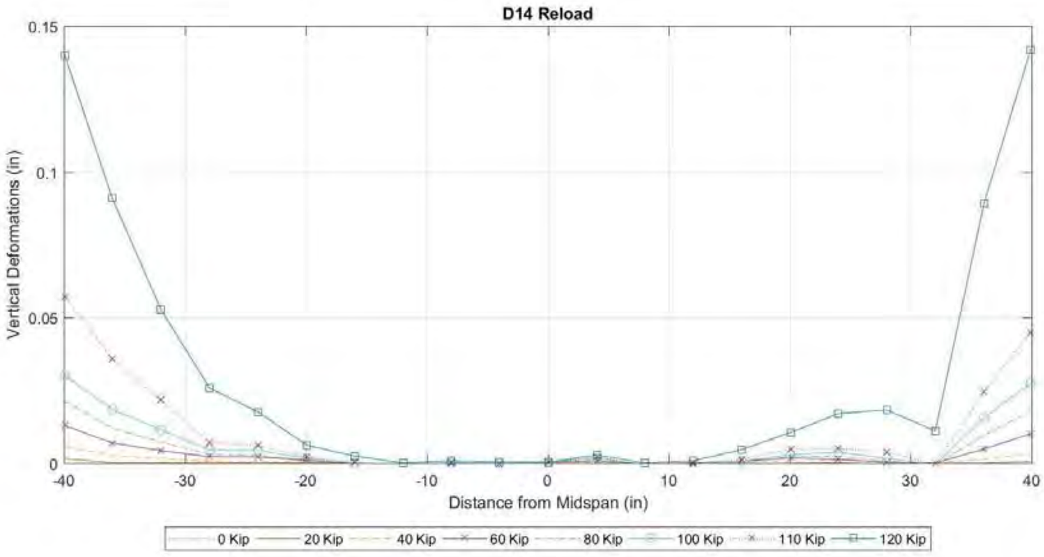


Figure 59 Vertical Deformations, Load and Reload, D14

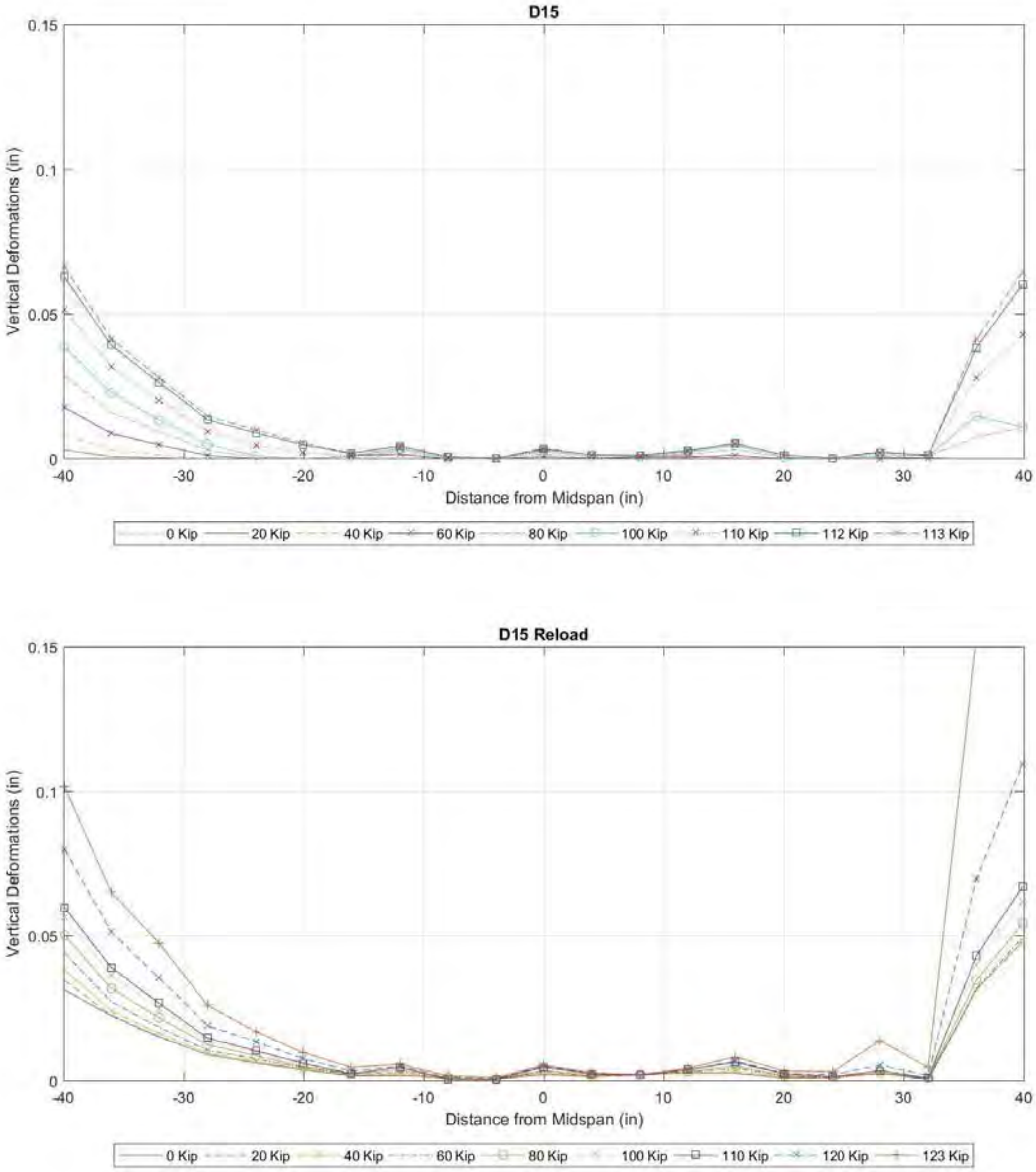


Figure 60 Vertical Deformations, Load and Reload, D15

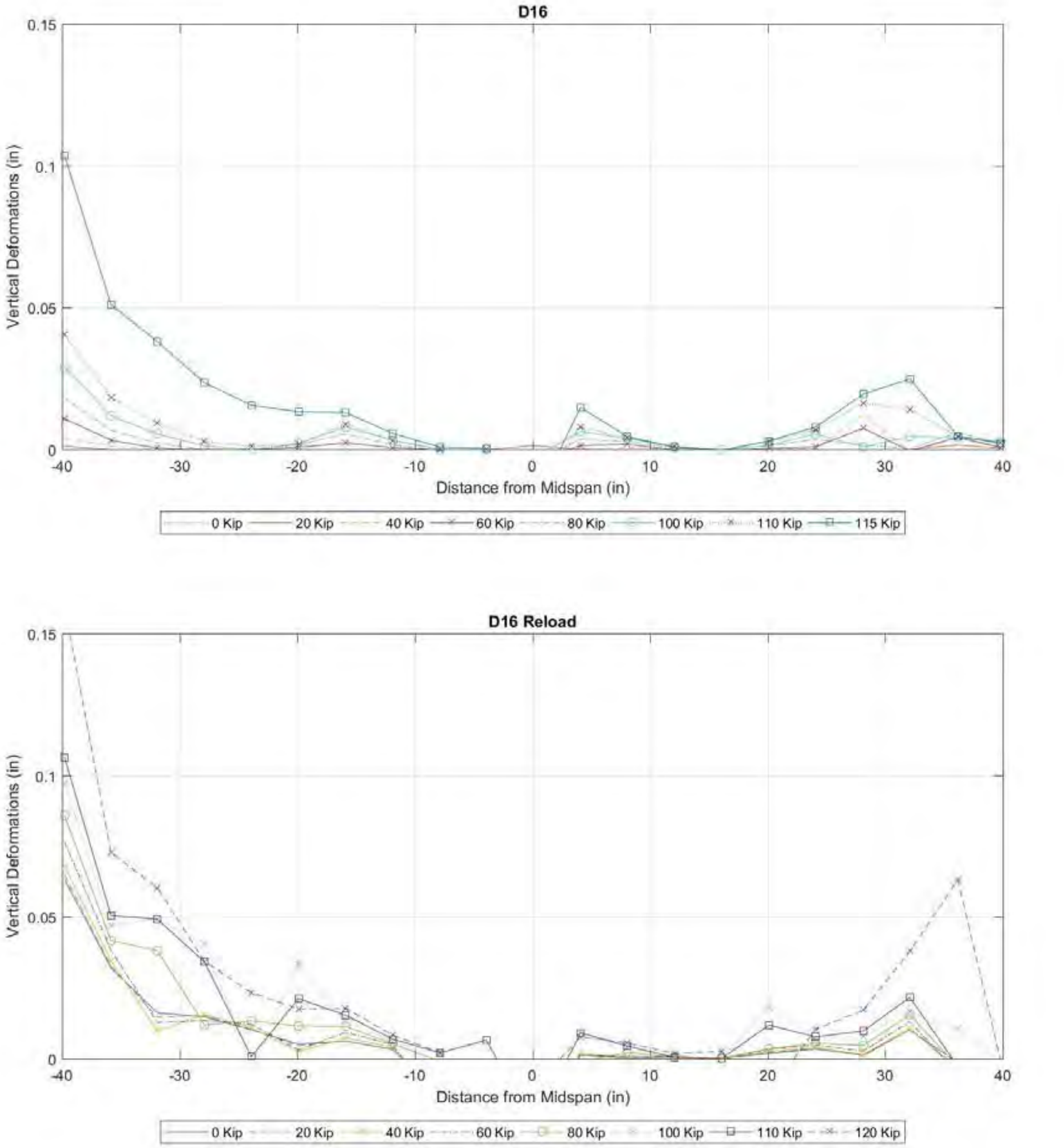


Figure 61 Vertical Deformations, Load and Reload, D16

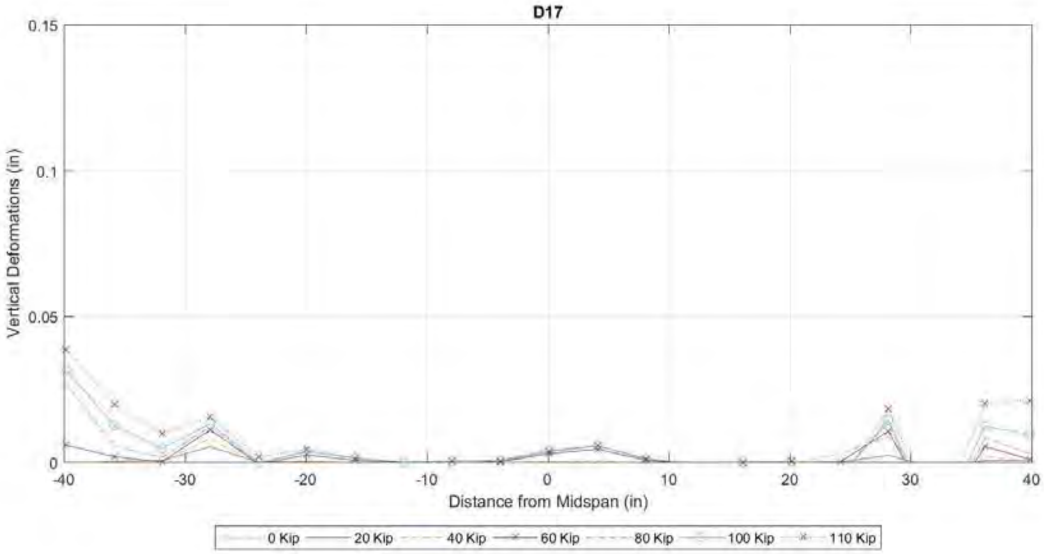
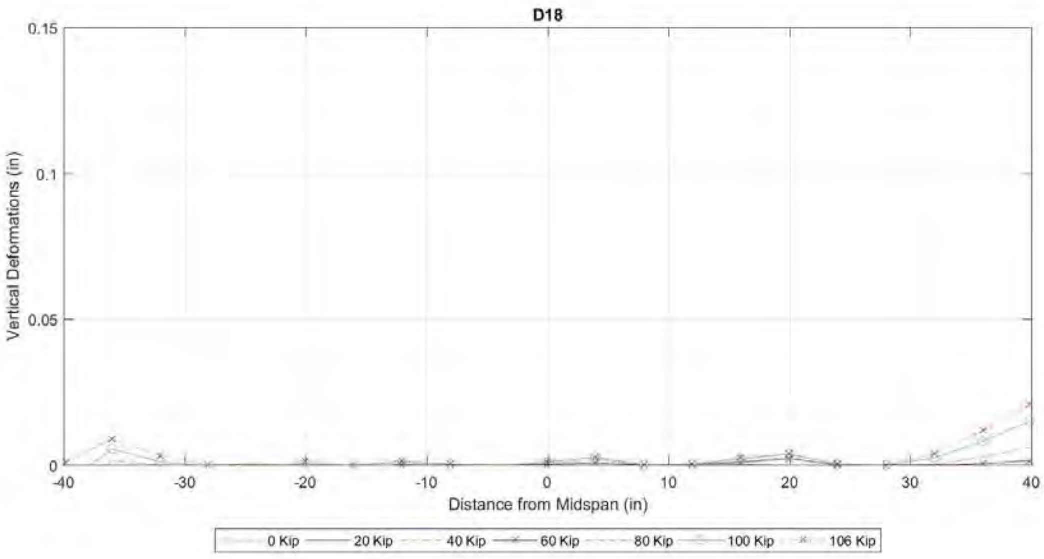


Figure 62 Vertical Deformations, Load and Reload, D17



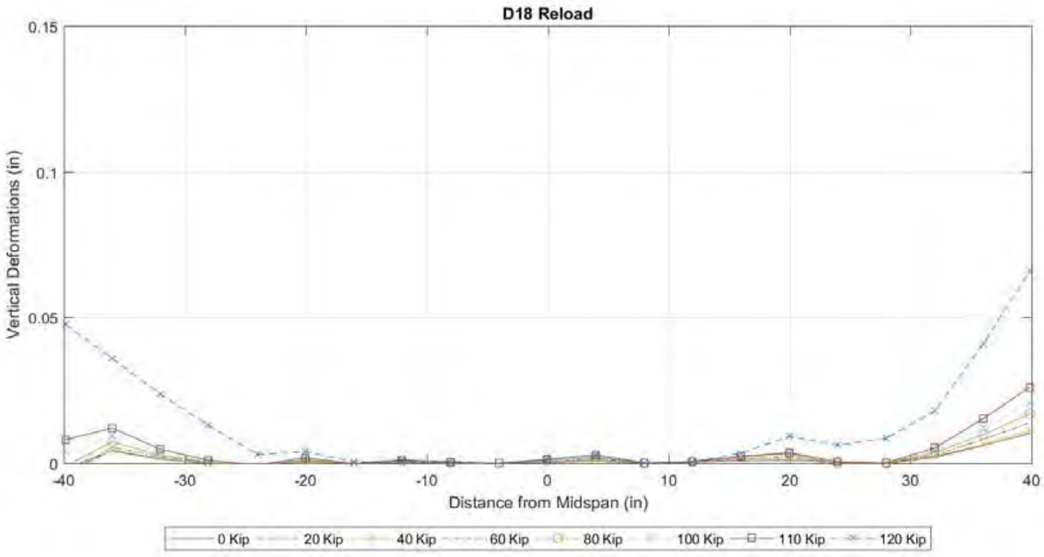


Figure 63 Vertical Deformations, Load and Reload, D18

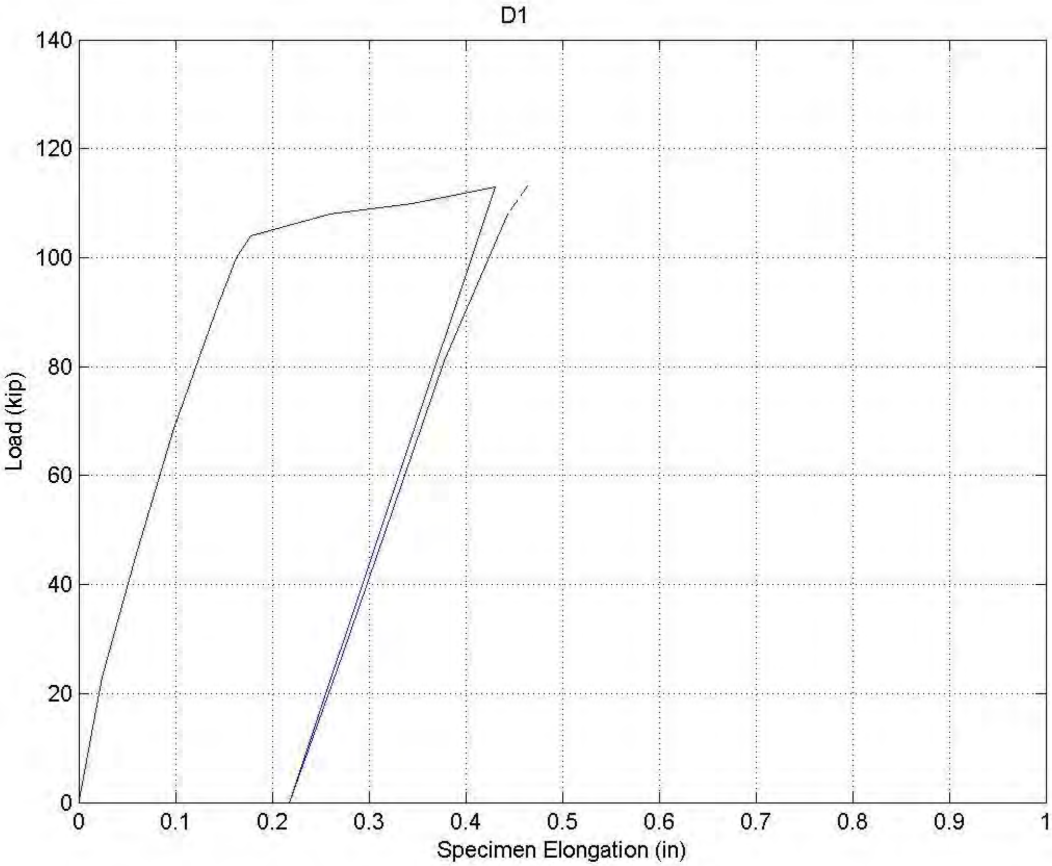


Figure 64 Specimen Elongation, Load and Reload, D1

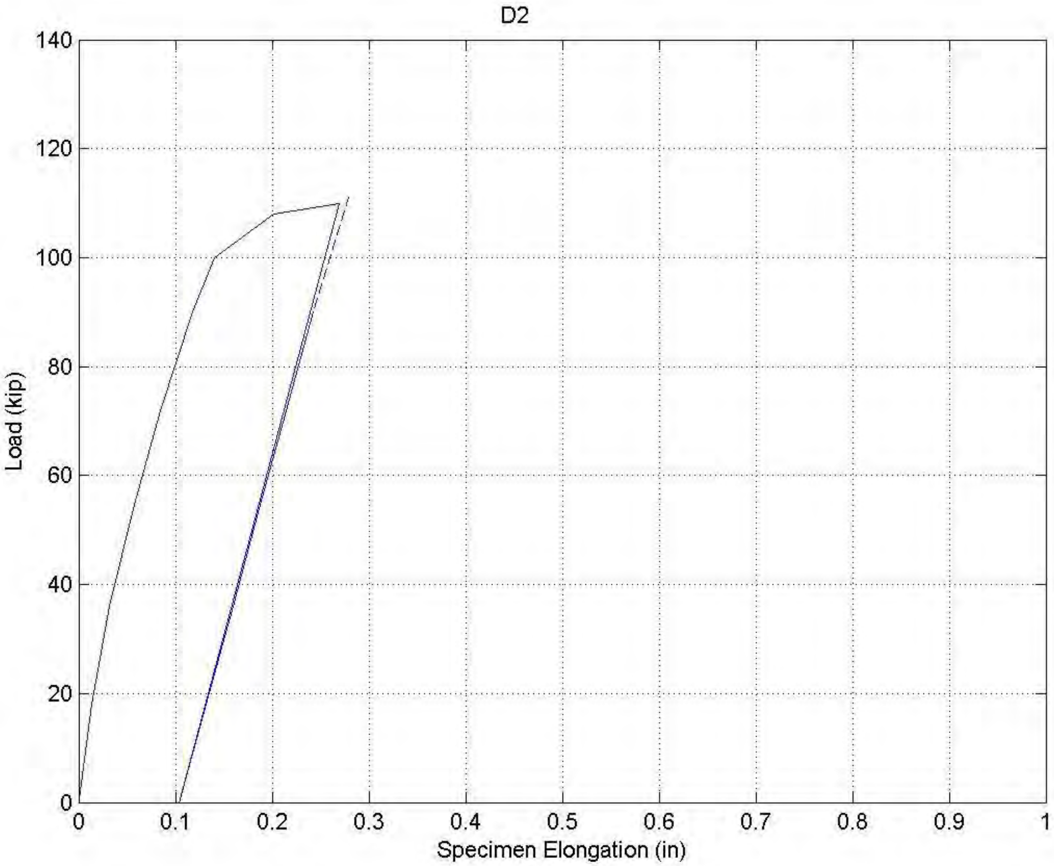


Figure 65 Specimen Elongation, Load and Reload, D2

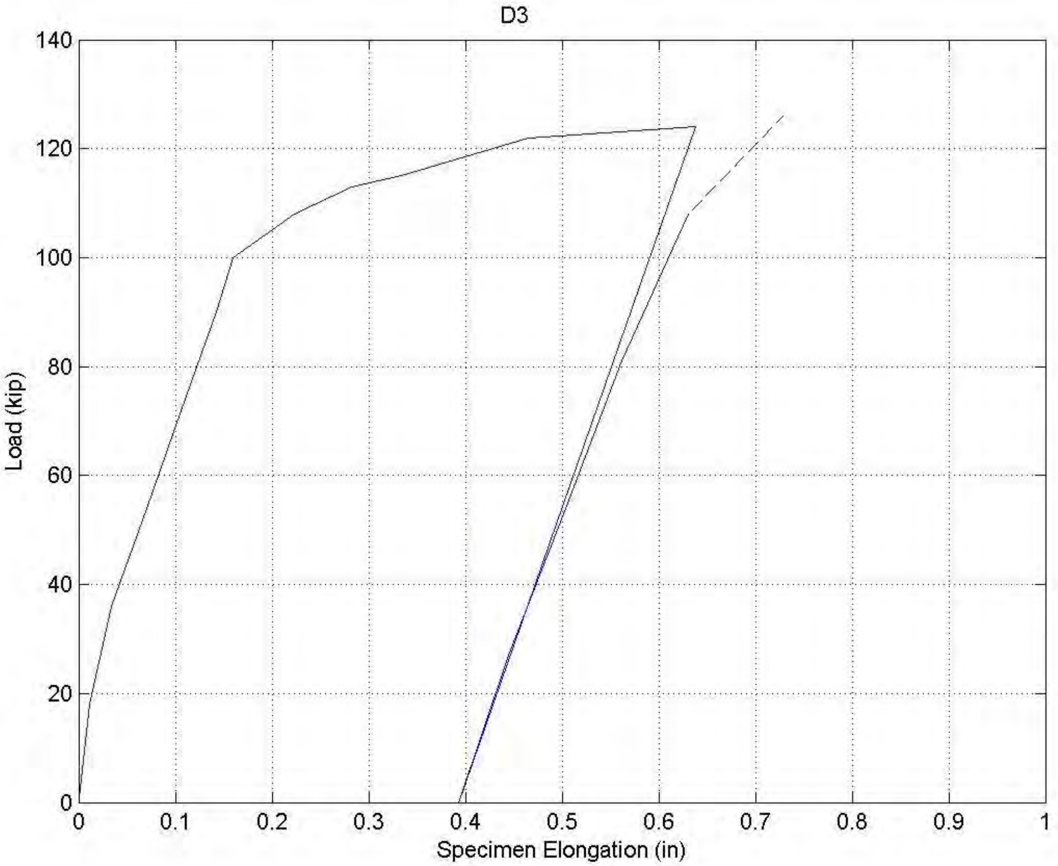


Figure 66 Specimen Elongation, Load and Reload, D3

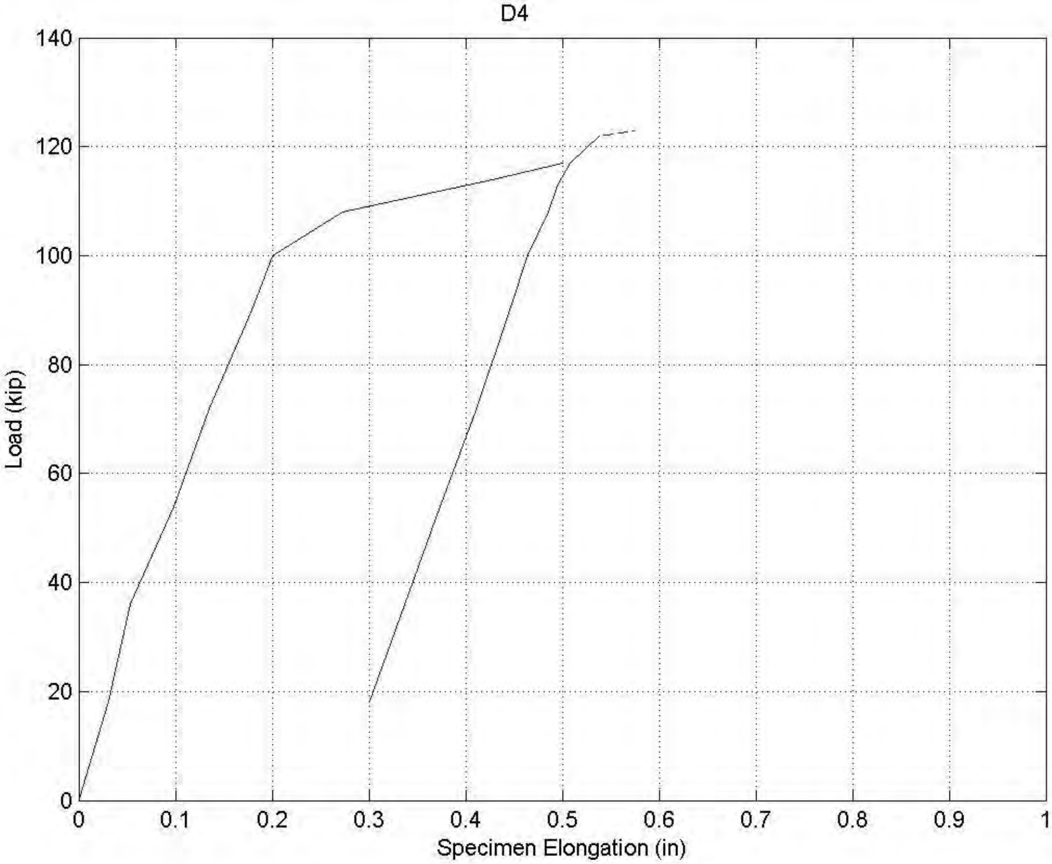


Figure 67 Specimen Elongation, Load and Reload, D4

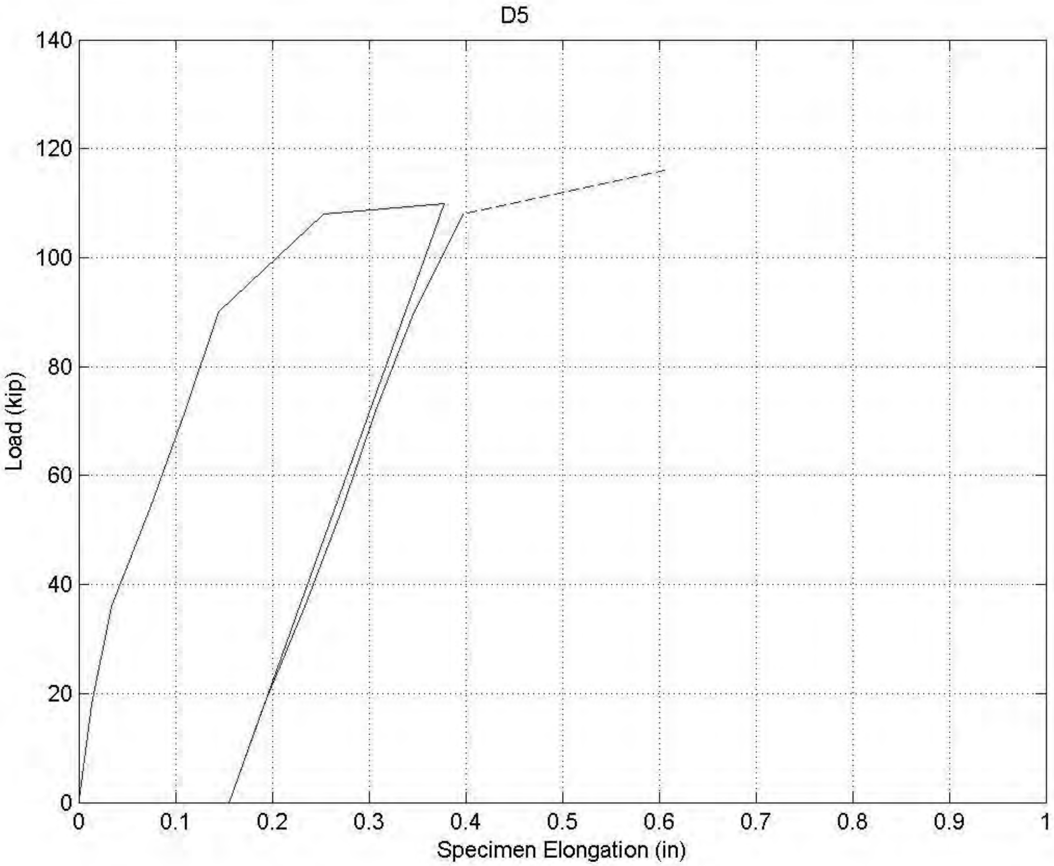


Figure 68 Specimen Elongation, Load and Reload, D5

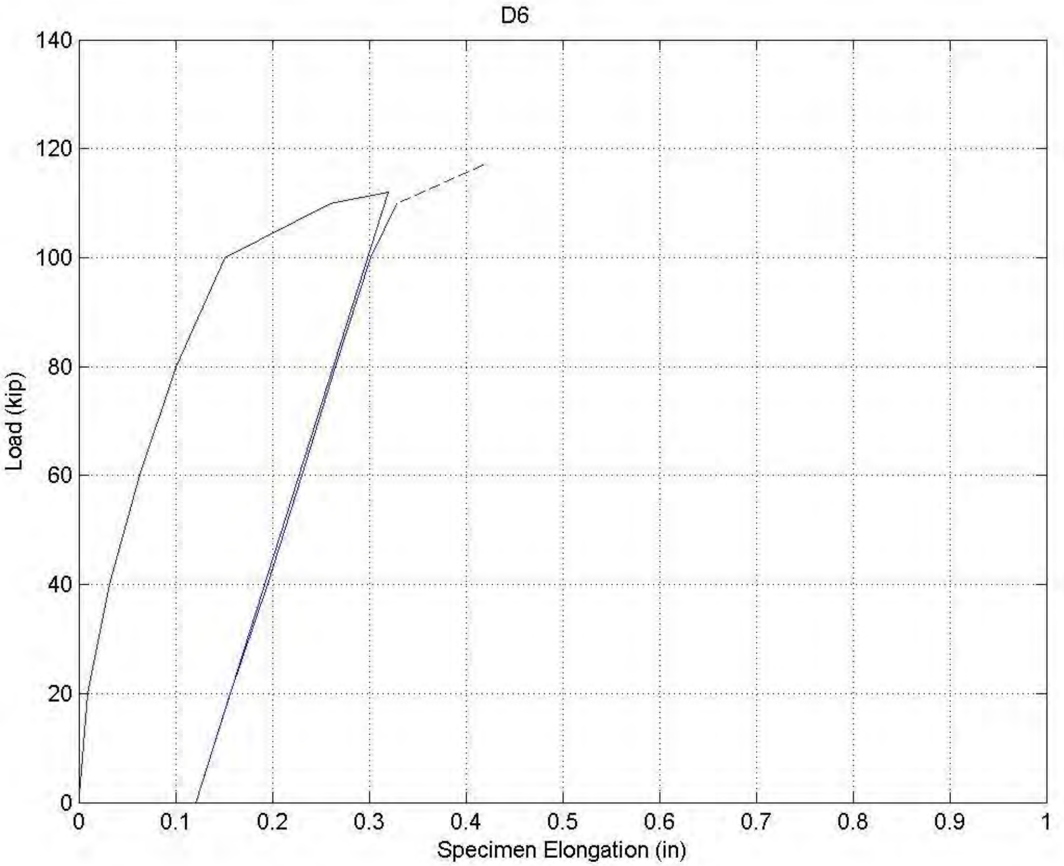


Figure 69 Specimen Elongation, Load and Reload, D6

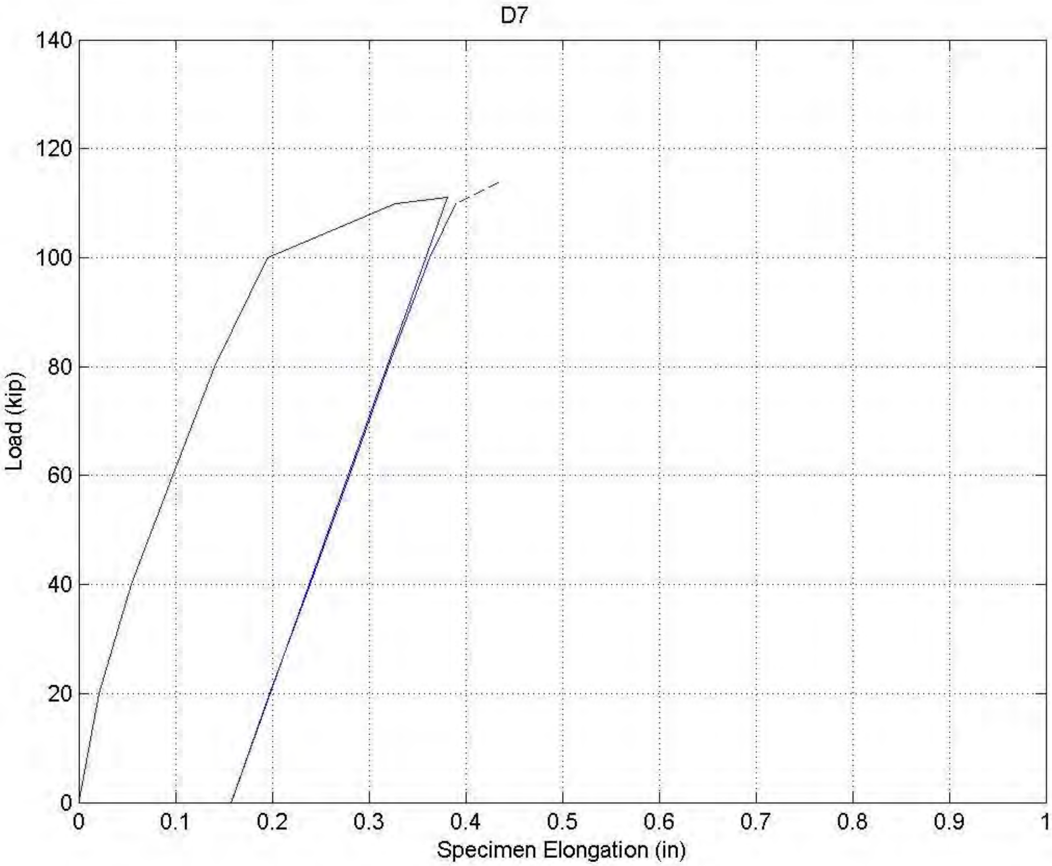


Figure 70 Specimen Elongation, Load and Reload, D7

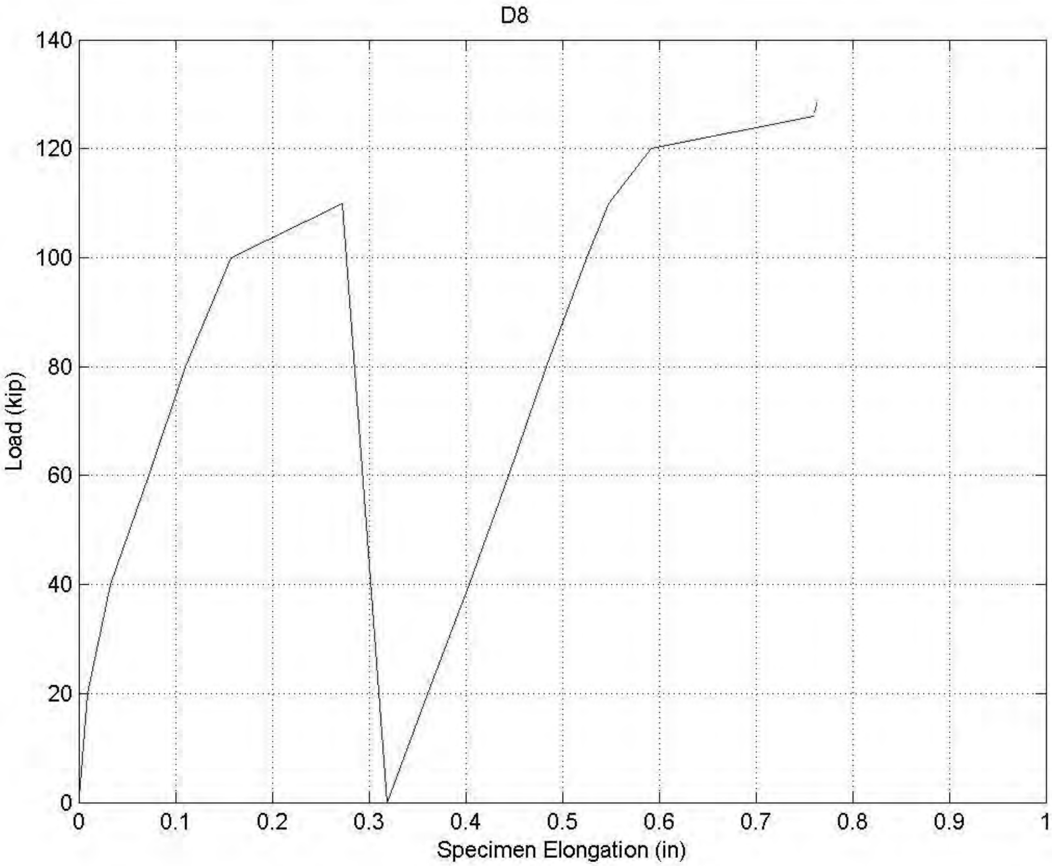


Figure 71 Specimen Elongation, Load and Reload, D8

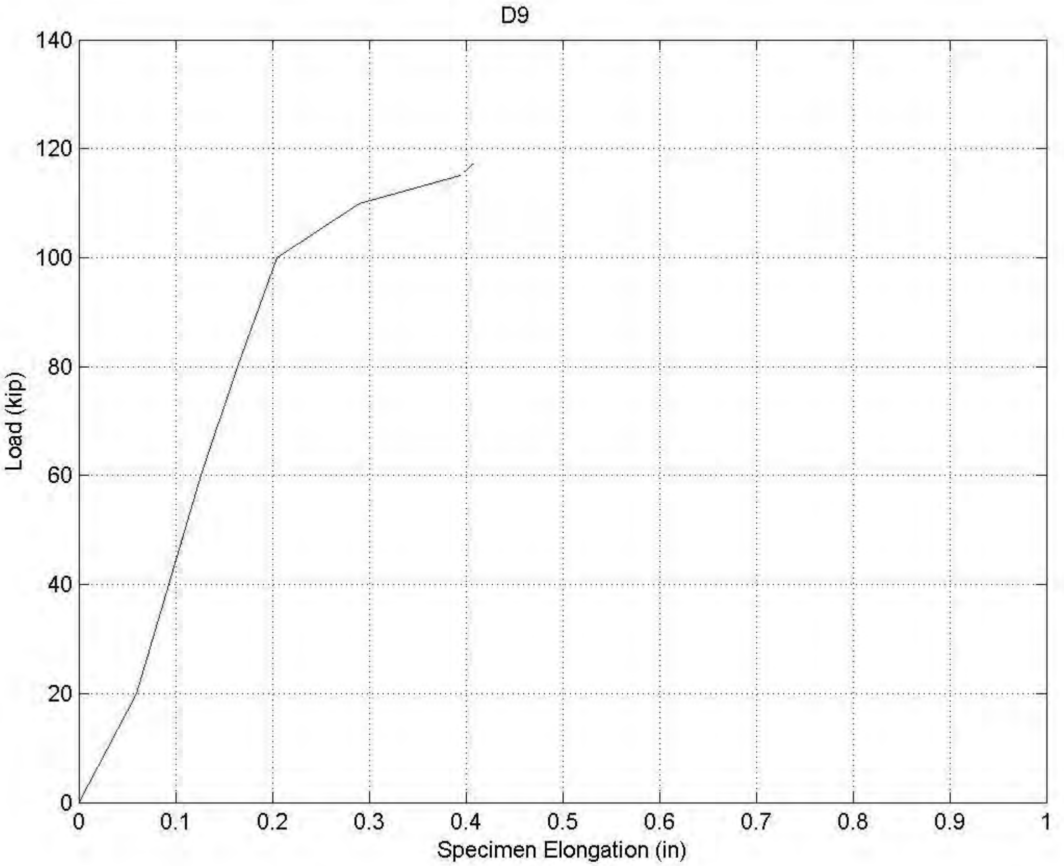


Figure 72 Specimen Elongation, Load and Reload, D9

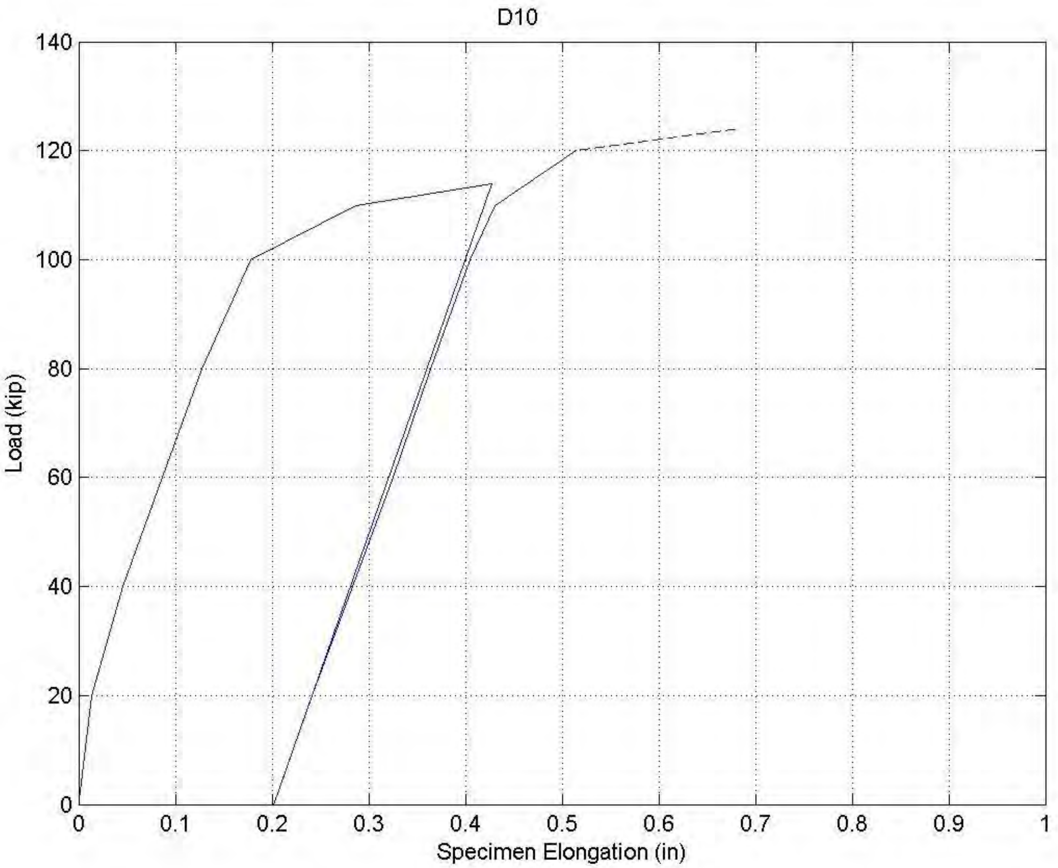


Figure 73 Specimen Elongation, Load and Reload, D10

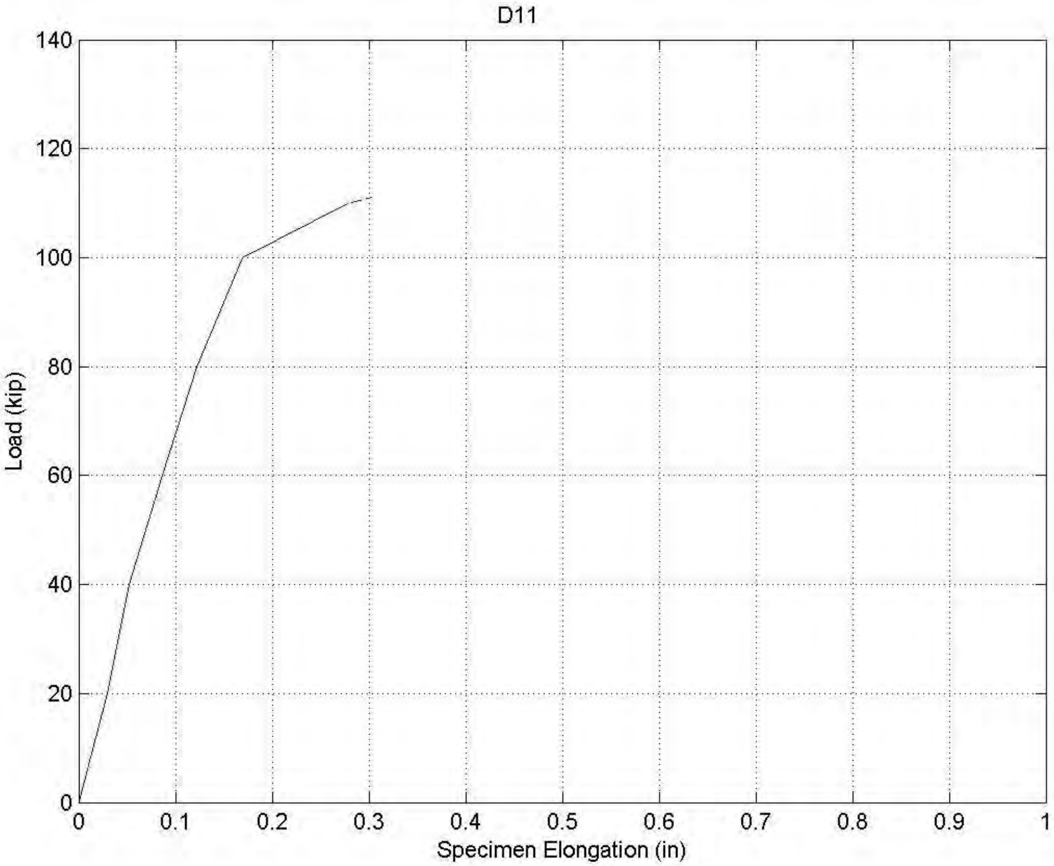


Figure 74 Specimen Elongation, Load and Reload, D11

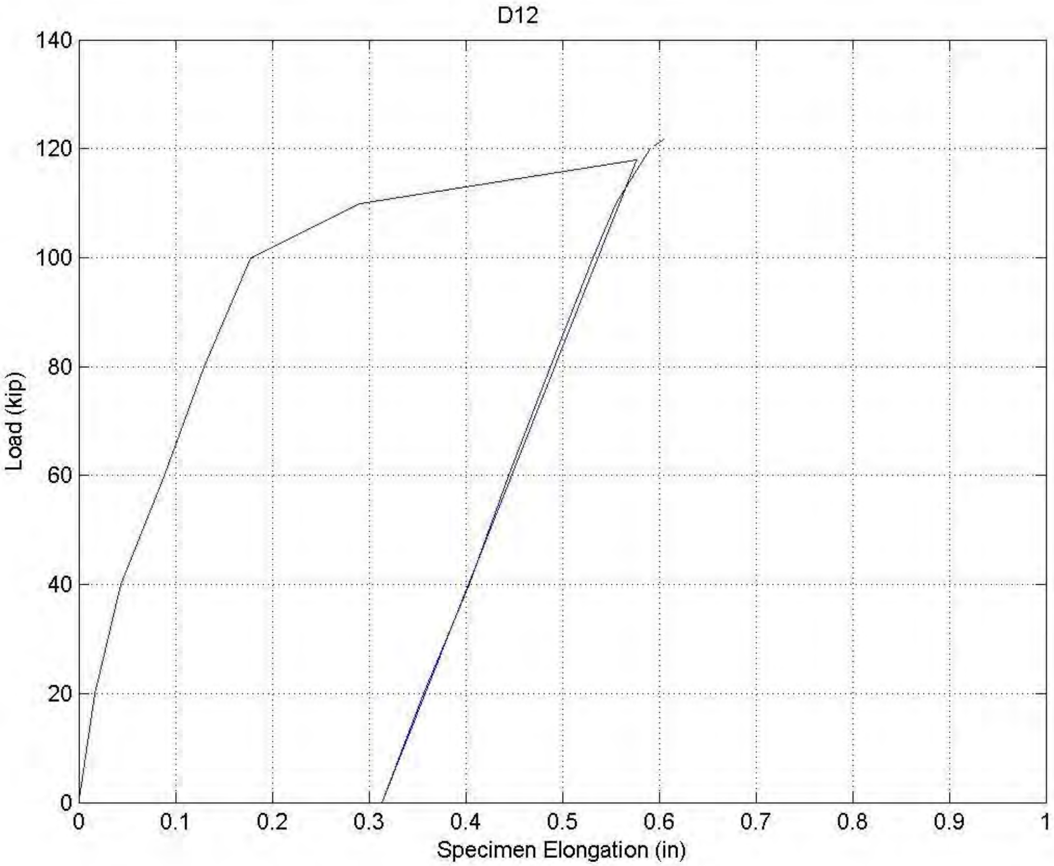


Figure 75 Specimen Elongation, Load and Reload, D12

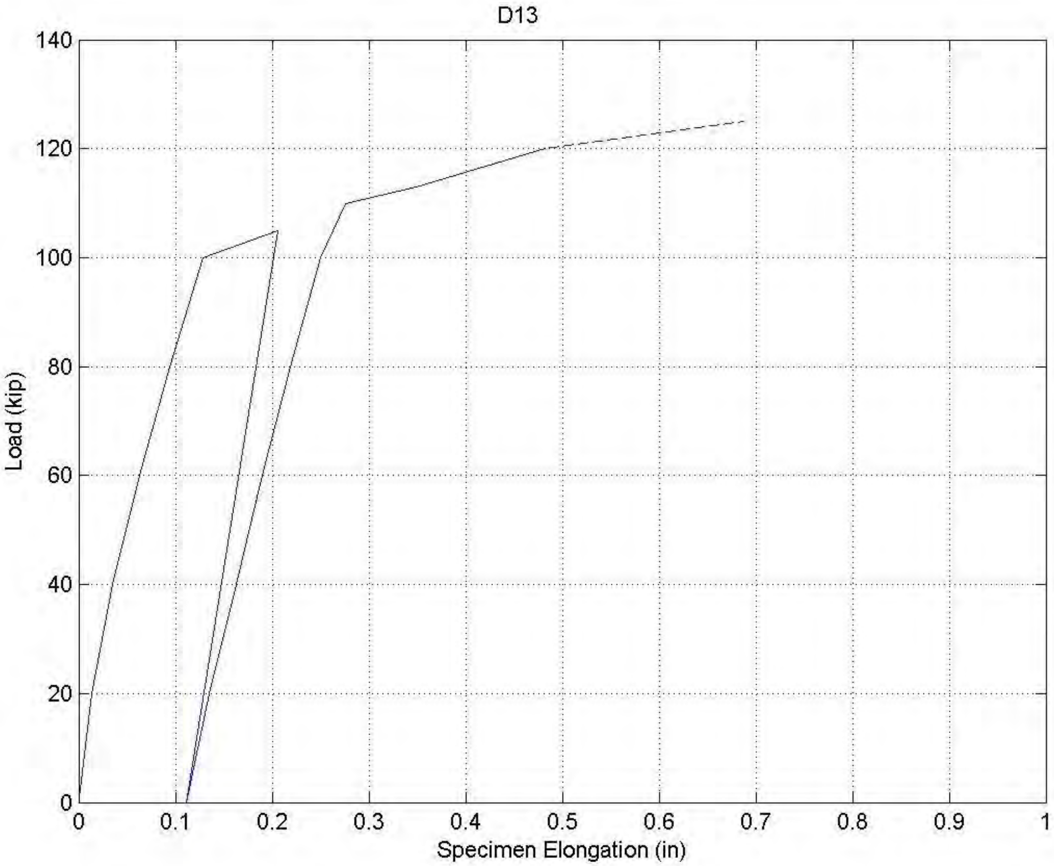


Figure 76 Specimen Elongation, Load and Reload, D13

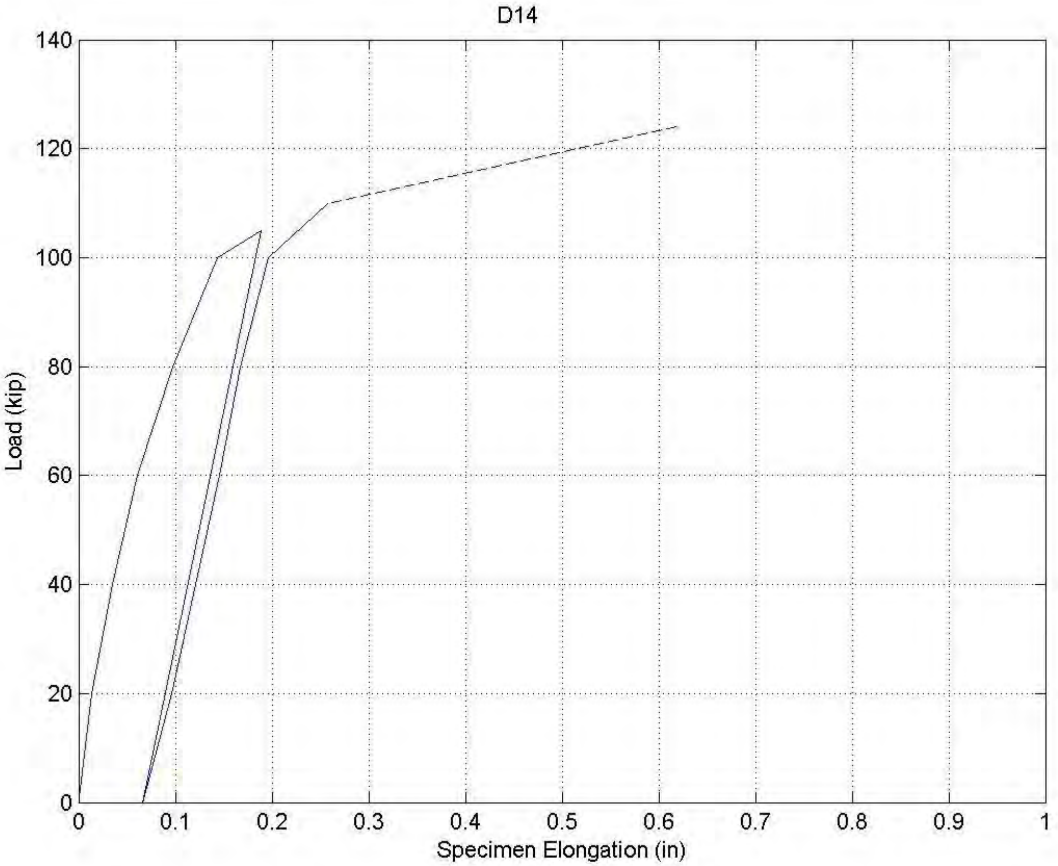


Figure 77 Specimen Elongation, Load and Reload, D14

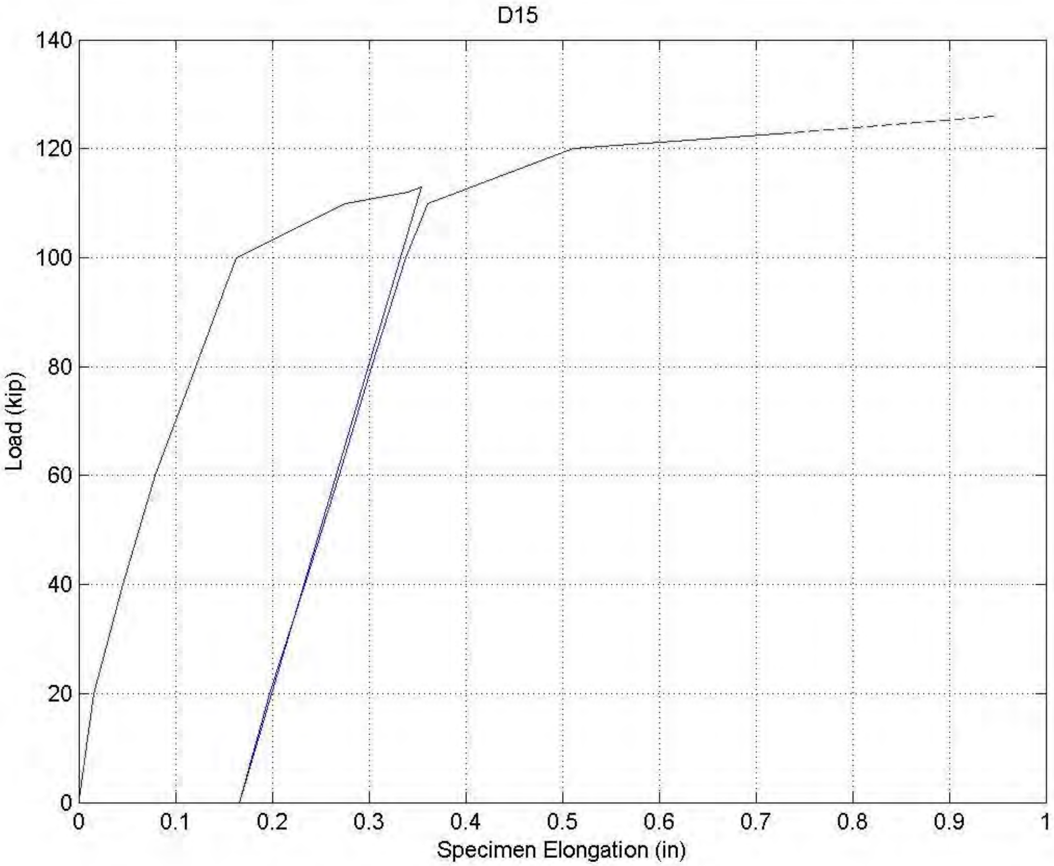


Figure 78 Specimen Elongation, Load and Reload, D15

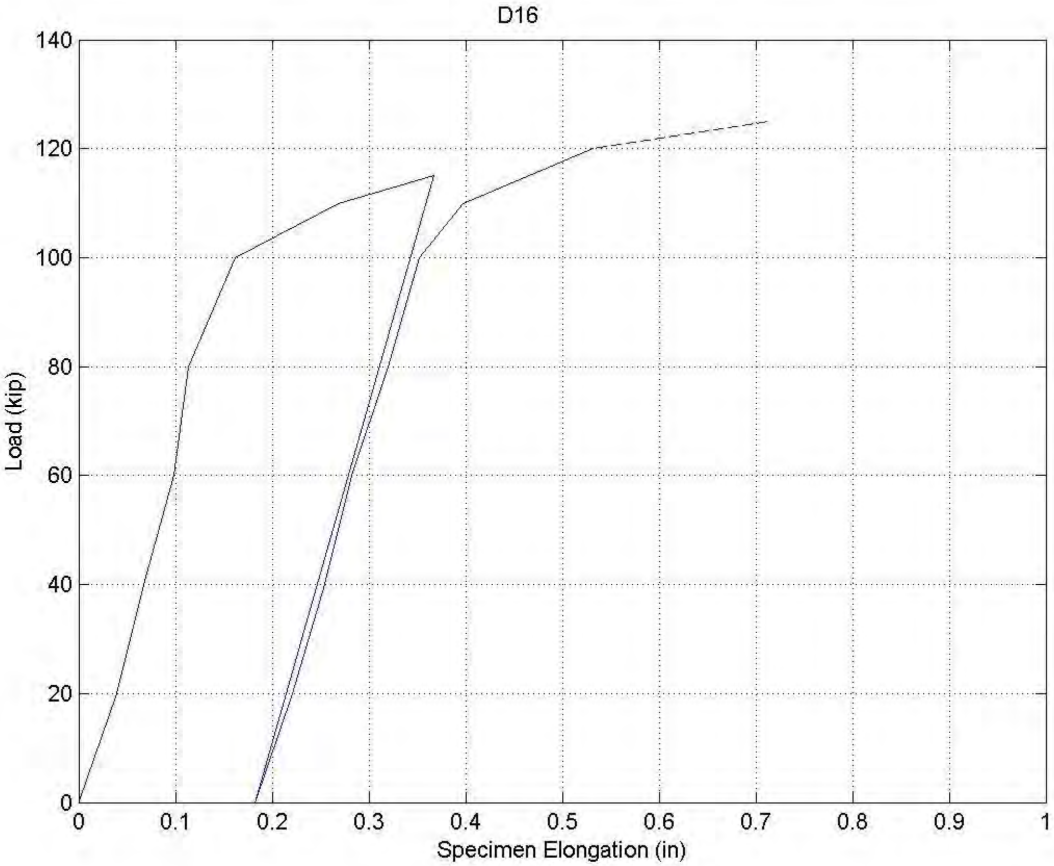


Figure 79 Specimen Elongation, Load and Reload, D16

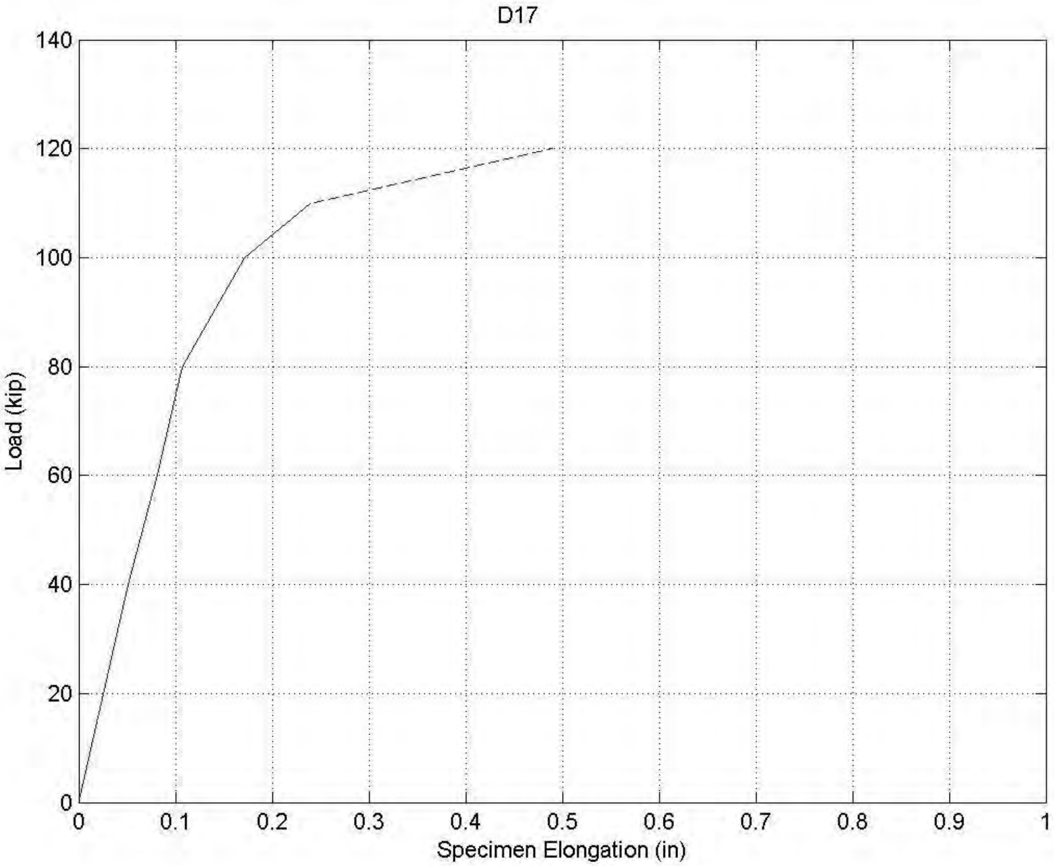


Figure 80 Specimen Elongation, Load and Reload, D17

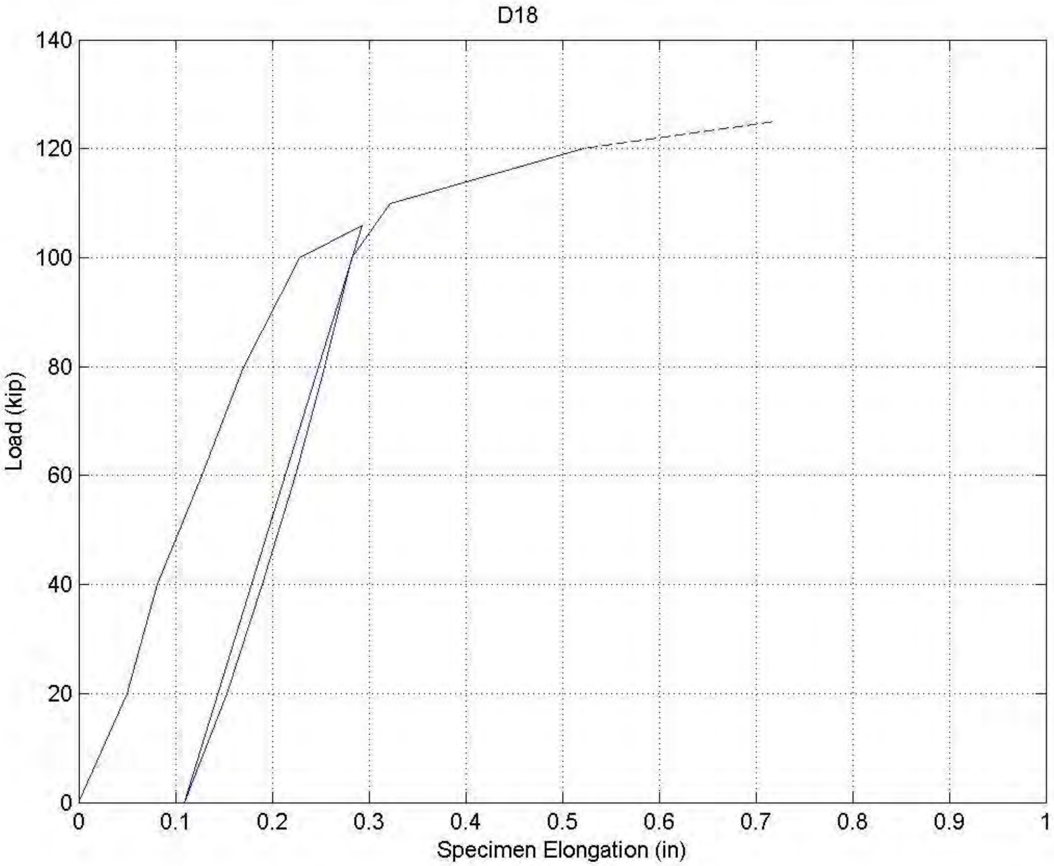


Figure 81 Specimen Elongation, Load and Reload, D18

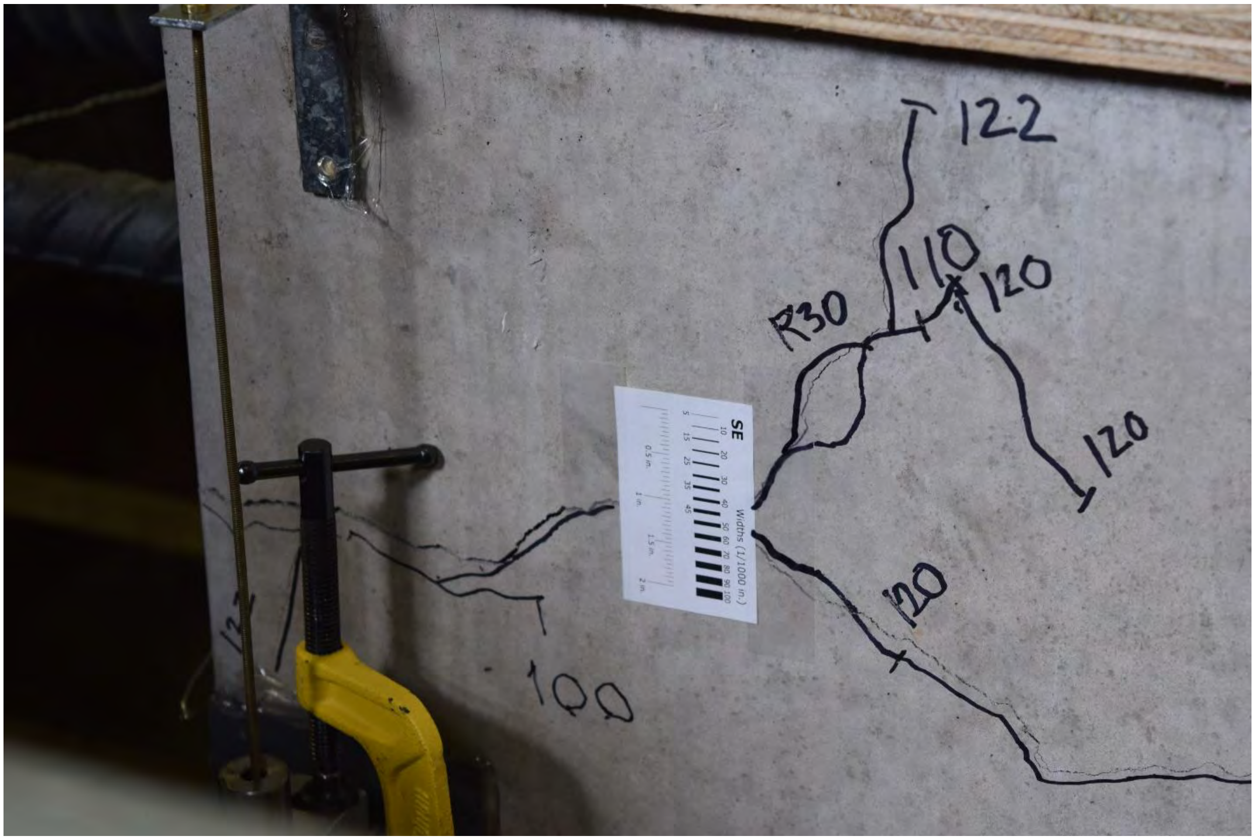


Figure 82 Test Photo Specimen D1, SE corner, 108 kips

Figure 83 Test Photo Specimen D2, NE corner, 90 kips

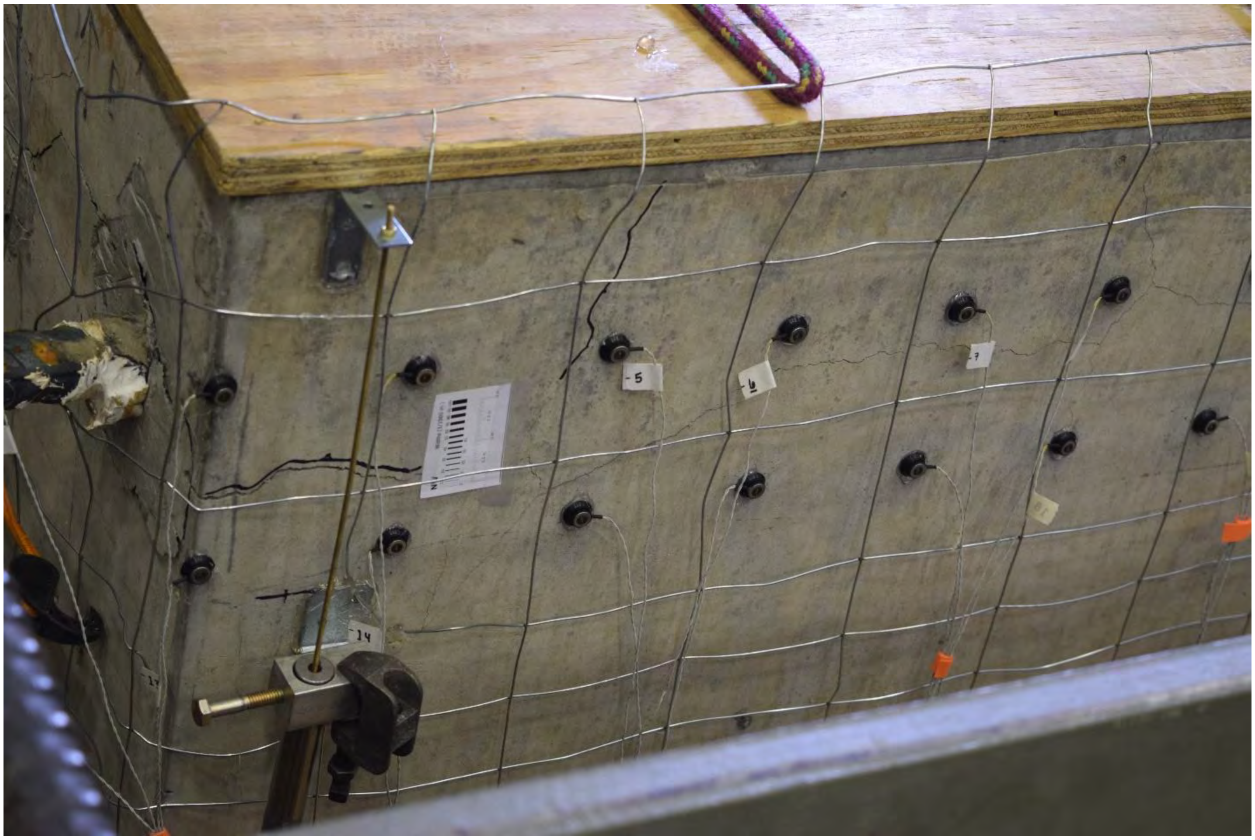


Figure 84 Test Photo Specimen D3, NW corner, 108 kips

Figure 85 Test Photo Specimen D4, NW corner, 122 kips

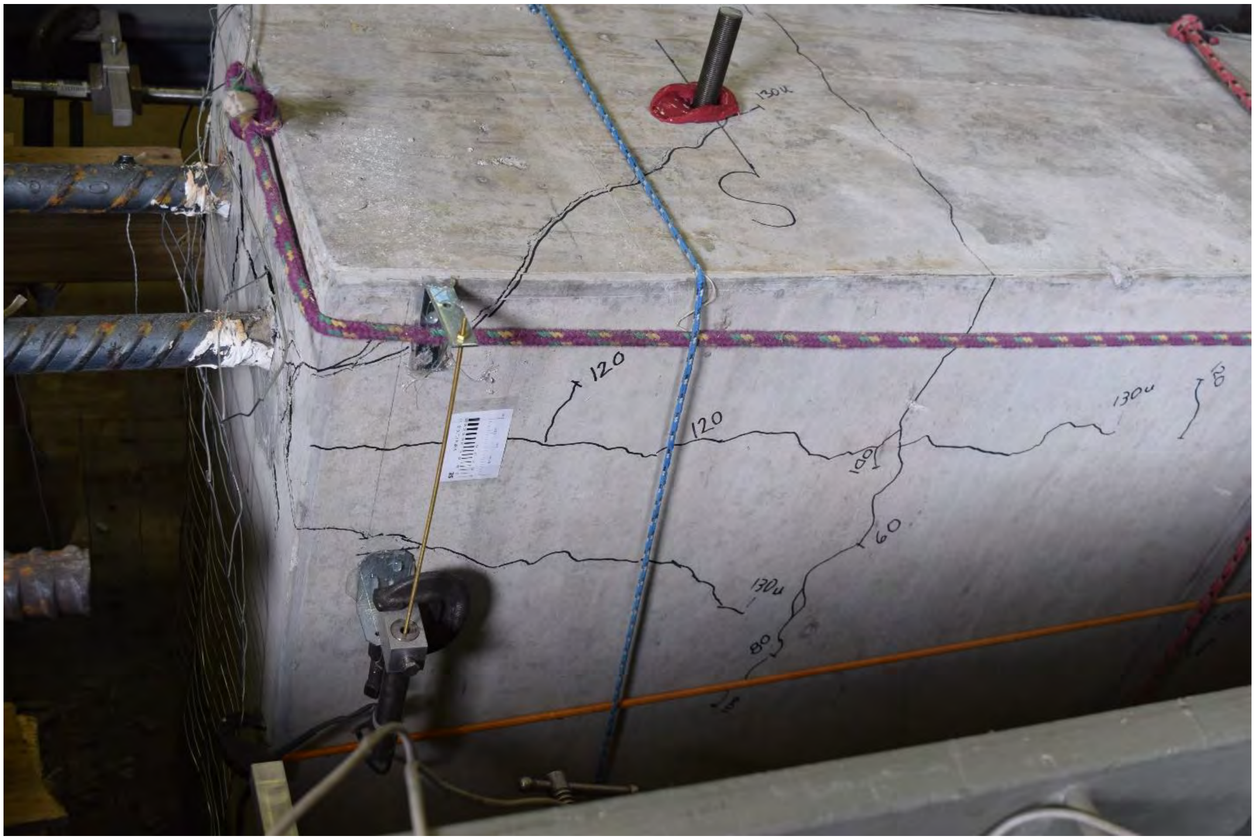


Figure 86 Test Photo Specimen D5, SE corner, 108 kips

Figure 87 Test Photo Specimen D6, SW corner, 110 kips

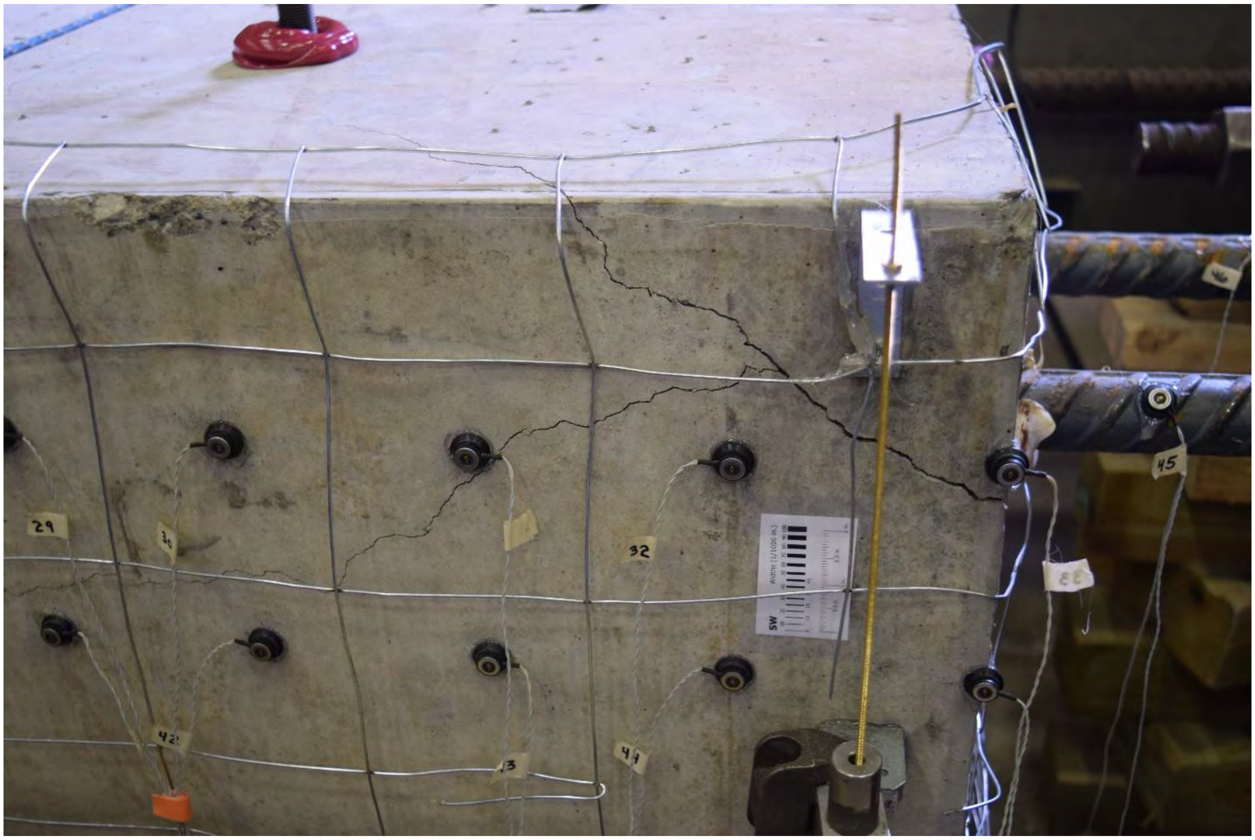


Figure 88 Test Photo Specimen D7, SW corner, 110 kips

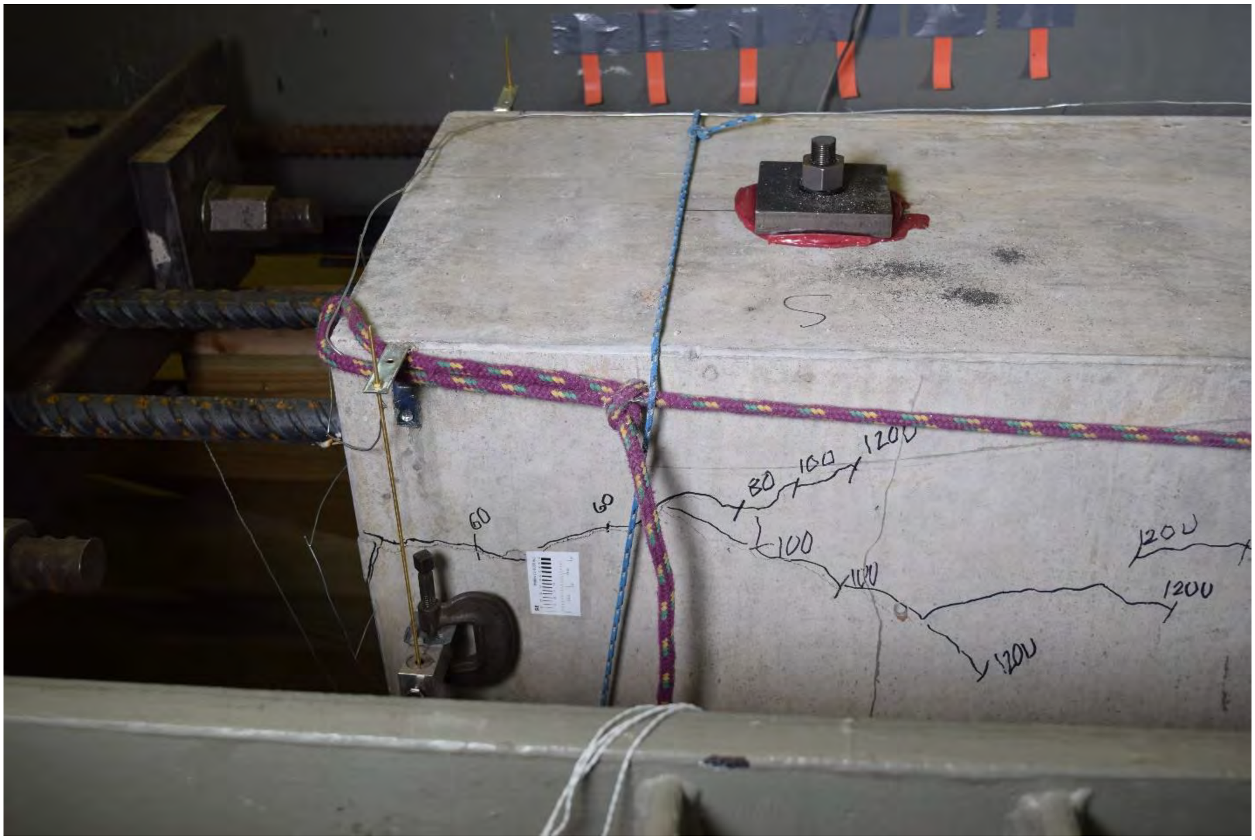


Figure 89 Test Photo Specimen D8, SE corner, 126 kips

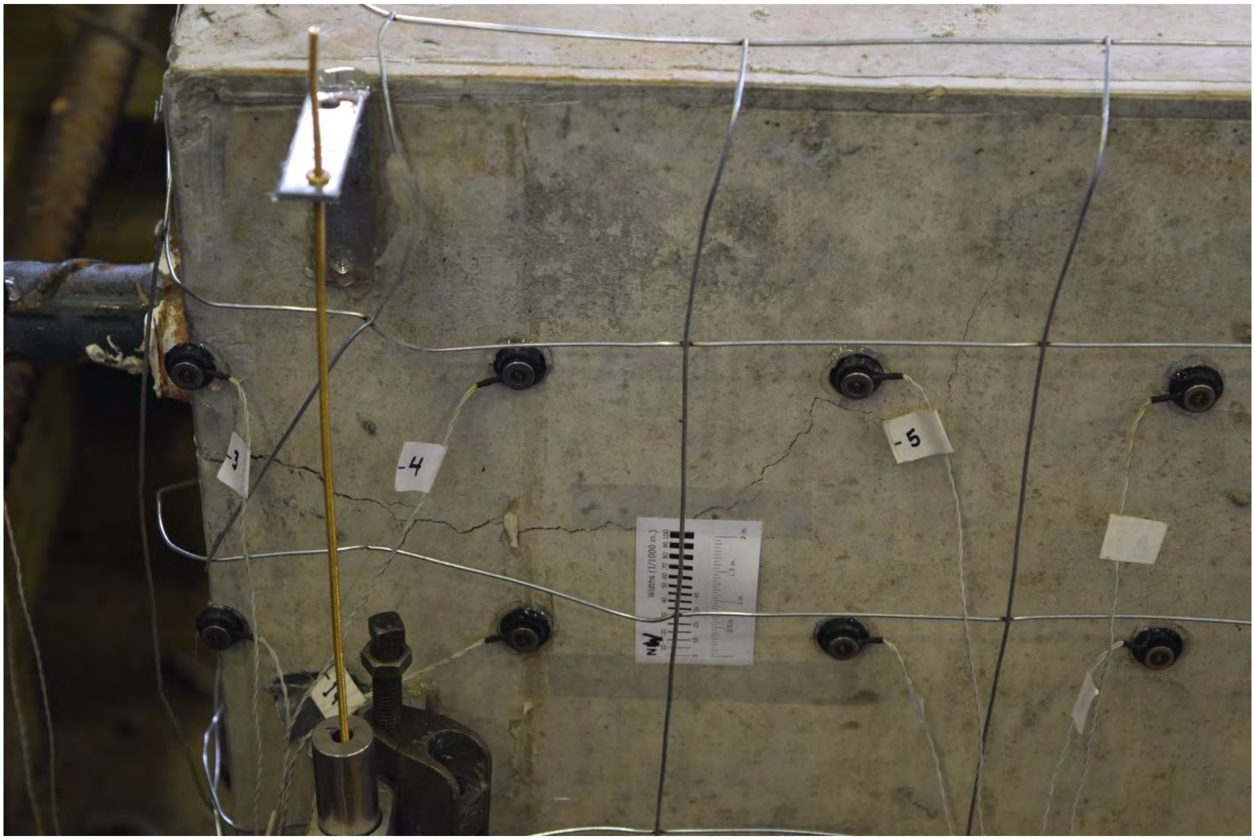


Figure 90 Test Photo Specimen D9, NW corner, 115 kips

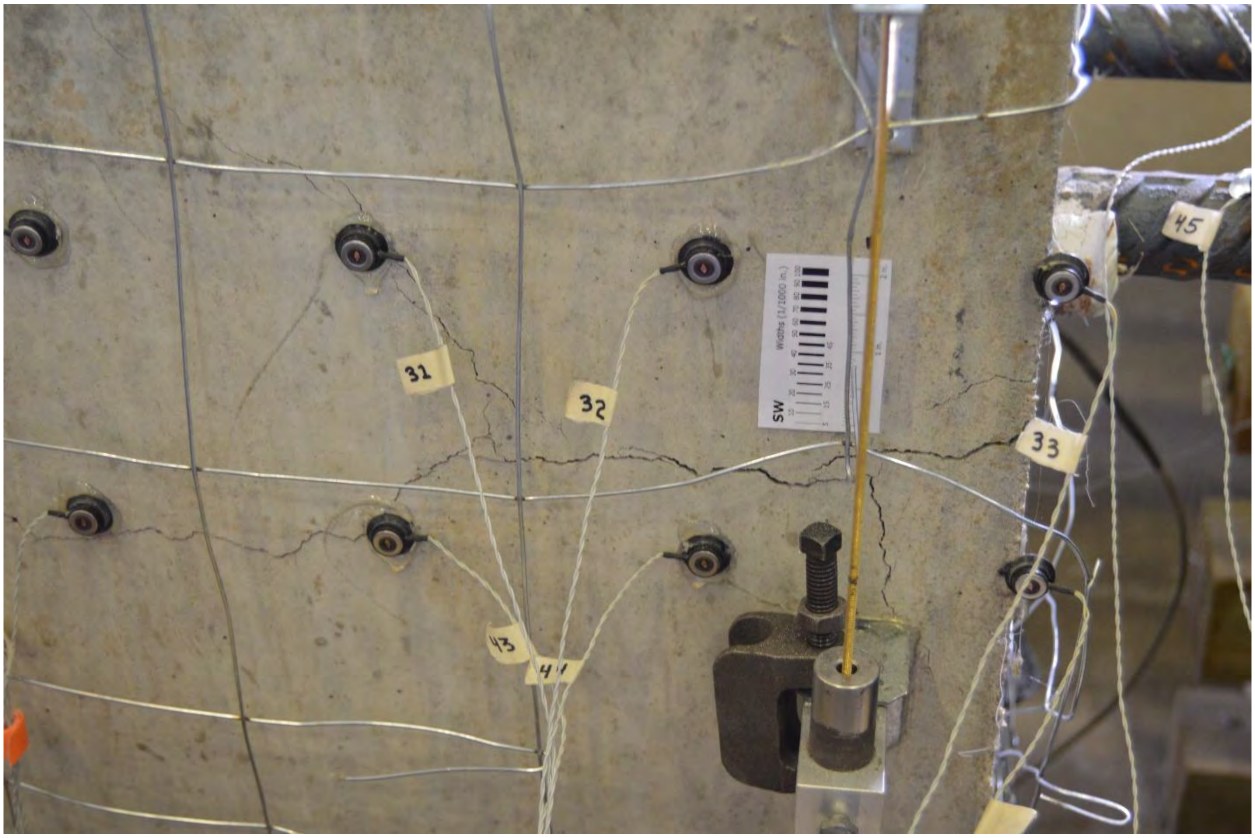


Figure 91 Test Photo Specimen D10, SW corner, 120 kips

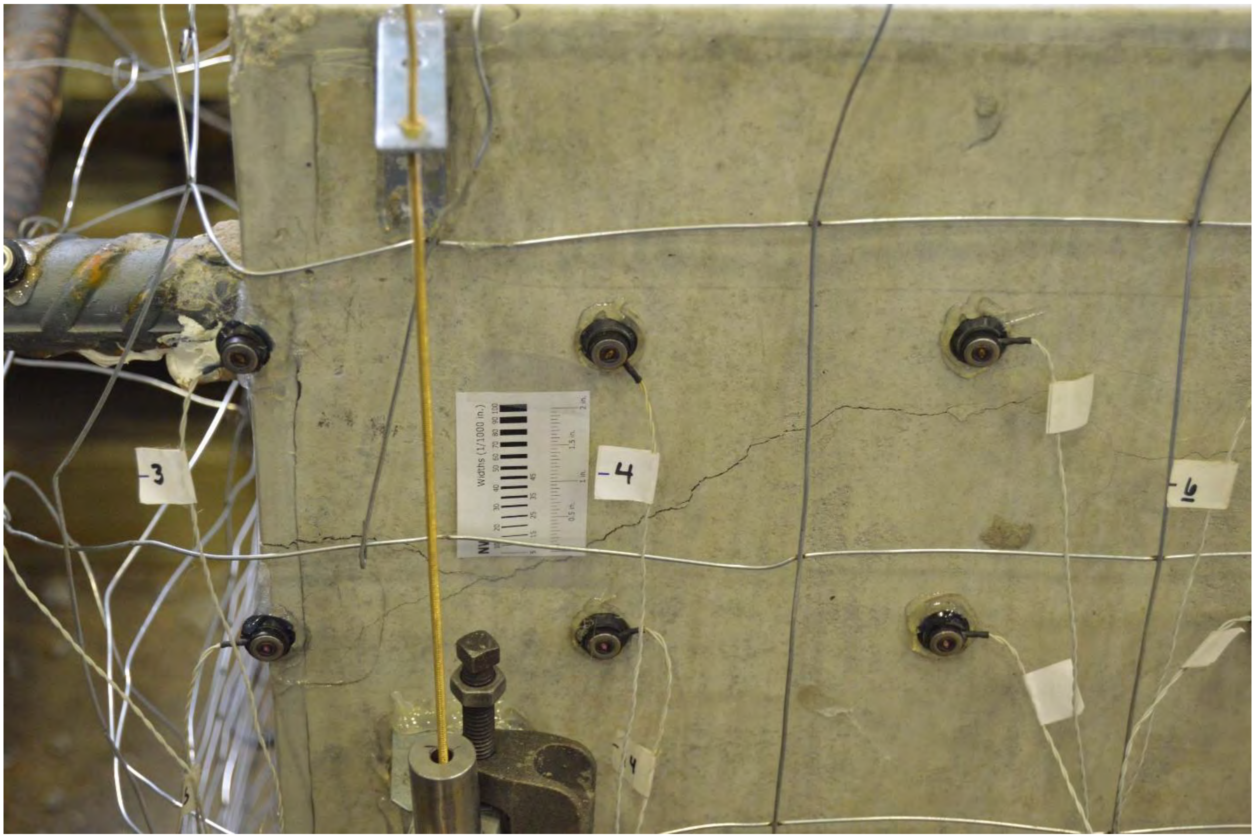


Figure 92 Test Photo Specimen D11, NW corner, 110 kips

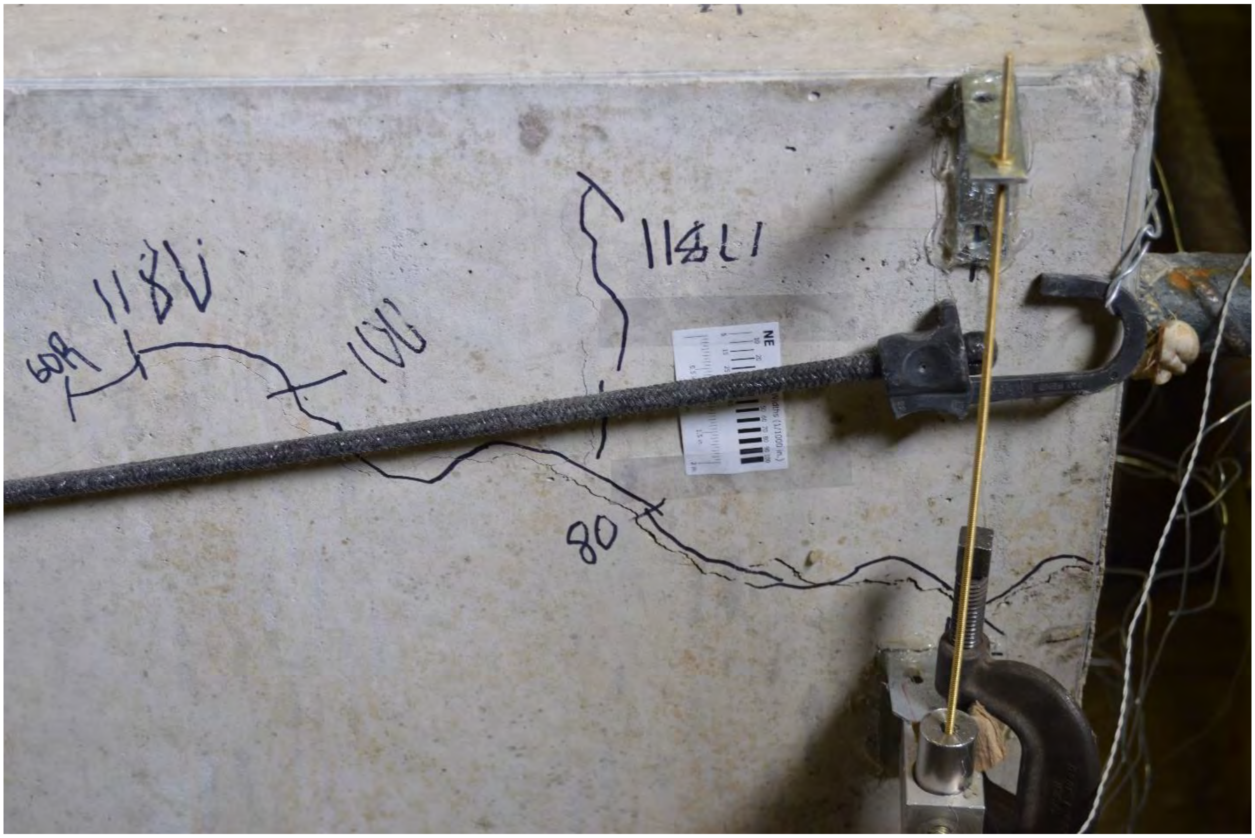


Figure 93 Test Photo Specimen D12, NE corner, 120 kips

Figure 94 Test Photo Specimen D13, SW corner, 120 kips

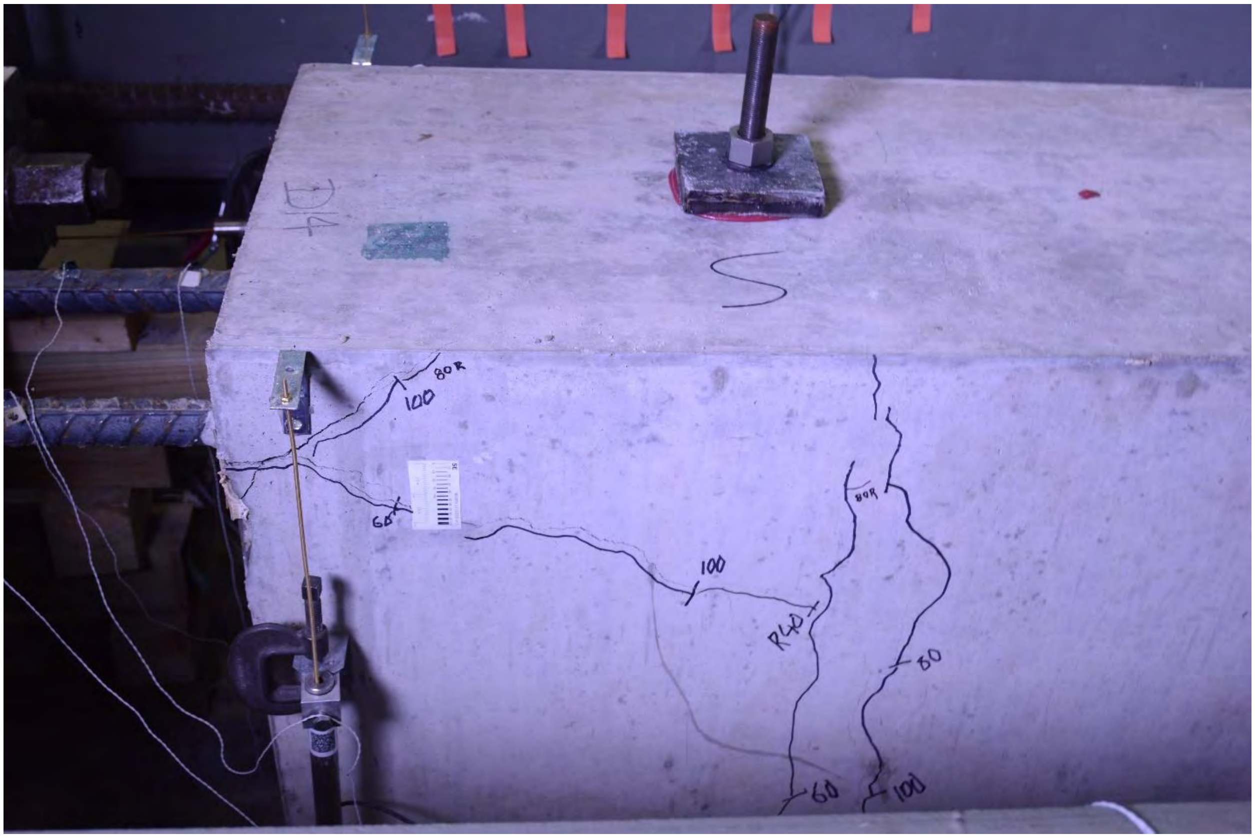


Figure 95 Test Photo Specimen D14, SE corner, 120 kips

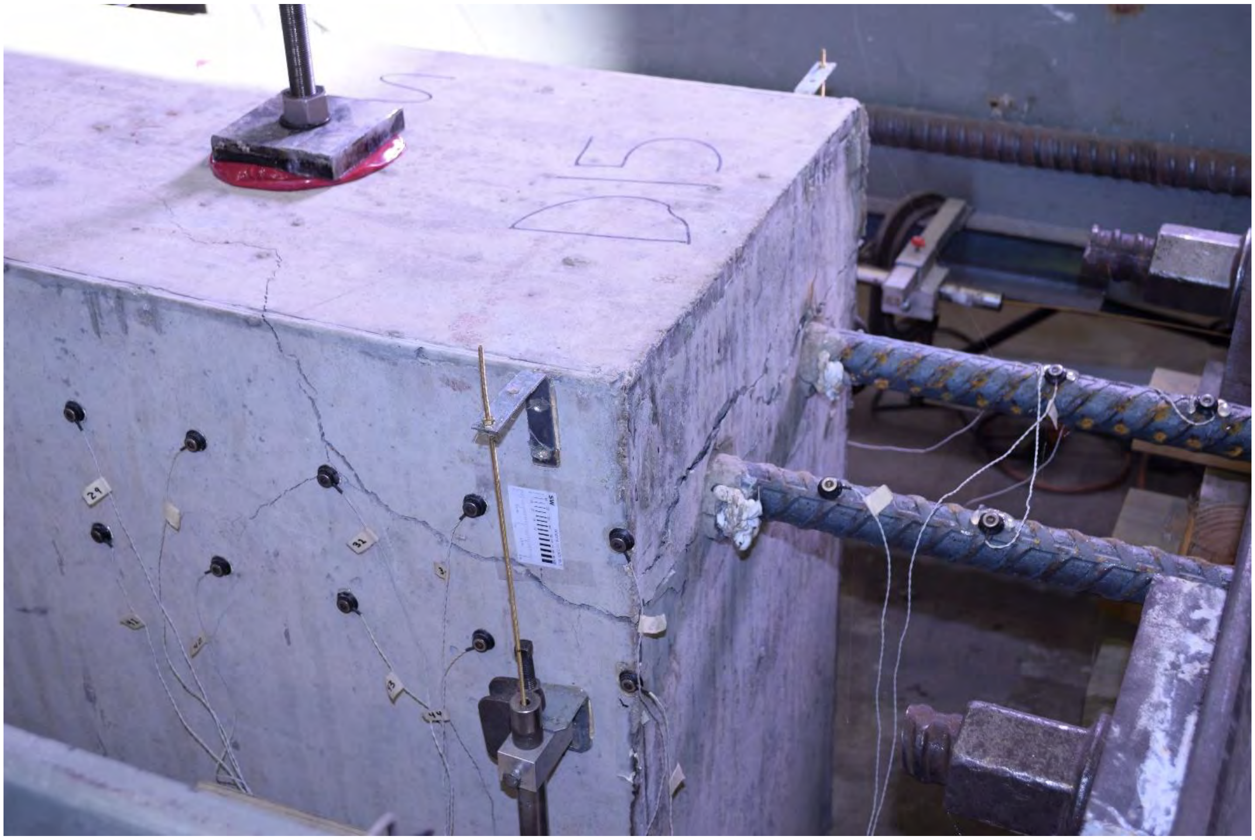


Figure 96 Test Photo Specimen D15, SW corner, 120 kips

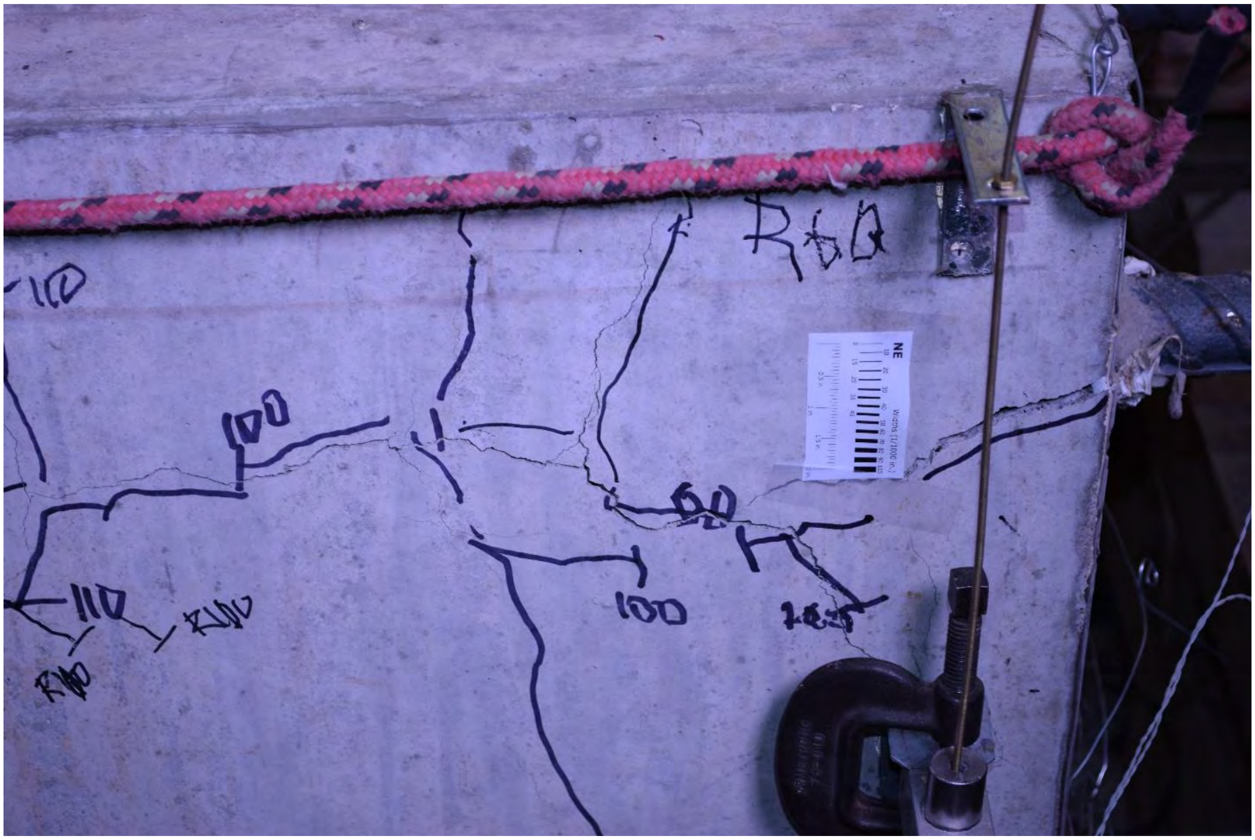


Figure 97 Test Photo Specimen D16, NE corner, 120 kips

Figure 98 Test Photo Specimen D17, NE corner, 110 kips

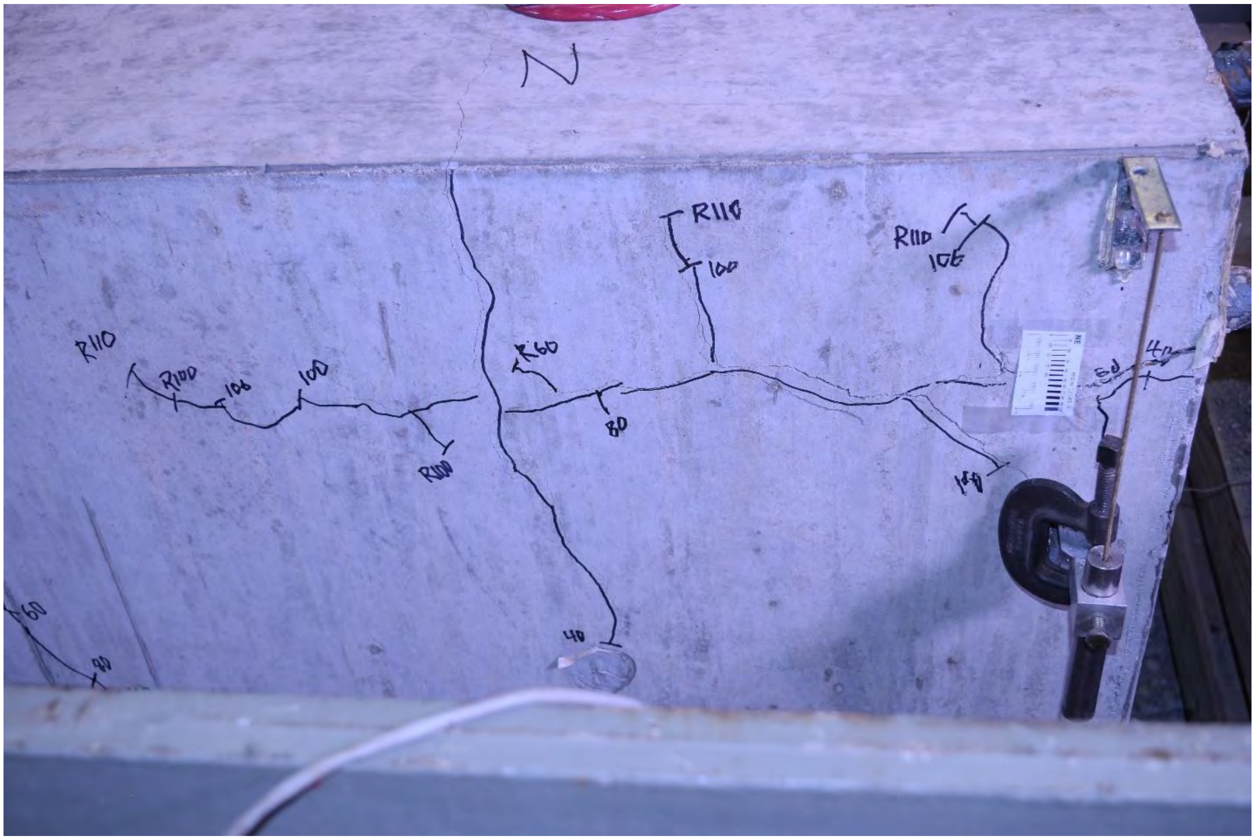


Figure 99 Test Photo Specimen D18, NE corner, 120 kips

Figure 100 Testing Setup

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Casting Documentation v.2
(Rev. 11/1/2016)

Specimen: D1-D6
Appendix 1, Pg 1 of 41
Sheet 1 of 1

General Information					
Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
01/11/17	11832573	1982	16:12	4:26 PM	
Measurements made upon arrival of concrete					
Slump (ASTM C143 - 10a)		**Air Content (ASTM C231 - 10)**			
$Time_1$	$Result_1$	$Time_1$	$Result_1$	S/N of Air Meter	
4:34 PM	$8\frac{1}{2}$"	4:49 PM	$8\frac{1}{4}$%	LAF8	
$Time_2$	$Result_2$	$Time_2$	$Result_2$	S/N of Scale	
4:51 PM	$8\frac{1}{2}$"			H3802360	
Unit Weight (ASTM C138 - 10b)					
$Time_1$	Wt. of $Cont._1$	Total Wt. $_1$	Wt. of $Conc._1$	$Result_1$ = Wt. of Conc./Vol. of Cont.	
4:40 PM	8.50	43.20	34.70	138.8	
$Time_2$	Wt. of $Cont._2$	Total Wt. $_2$	Wt. of $Conc._2$	Result2 = Wt. of Conc./Vol. of Cont.	
Times of actions during and after casting					
Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
4:38 PM	4:46 PM	4:52 PM	4:58 PM		4:56 PM
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
8:30 pm	9:30 pm	See curing	9:15 pm	See curing	See curing
Recorded by		Signature		Date	Time
JASPAL S SAINI		JSaini		01/11/17	
Checked by		Signature		Date	Time
Kinsey Skiller				1/11/17	9:30 pm
Checked by		Signature		Date	Time
Comments:					
*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09					

Truck Appendix 1, Pg 2 of 41 D1-D6

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
1982	1076	user	11832573	0	16:13	1/11/17

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
7.00 CYDS	4000CC				D	43104

Description Design Qty Adj.T Required Batched Actual Wat
Batch: 1 ----- Start: 16:13:10 End: ------- Time (hh:mm:ss): : : -----

Description	Design Qty	Adj.T	Required	Batched	Actual Wat
Buzzi	588 lb		4116 lb	4105 lb	
STONE-8	940 lb		6629 lb	6600 lb	6 gl
STONE-4	620 lb		4373 lb	4360 lb	4 gl
SAND-23	1435 lb		10547 lb	10520 lb	60 gl
WATER	322.4 lb		1742.7 lb	1732.0 lb	207.5 gl
MICROAIR	1.10 /C		45.28 oz	45.00 oz	
GLENIUM 7511	2.00 /C	#	82.32 oz	82.00 oz	

Actual Num Batches: 1
Load 27325 lb Design W/C: 0.548 Water/Cement: 0.564 A Design 270.4 gl Actual 277.4 gl To Add: 0.0 gl
Slump: 4.00 in Water in Truck: 0.0 lb Adjust Water: 0.0 lb / Load Trim Water: 10.0 lb / CYD

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

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(Rev. 11/1/2016)

Specimen: B7-B12

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General Information

Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
01/11/17	11832575	1669	16:39	4:58 PM	

Measurements made upon arrival of concrete

Slump (ASTM C143 - 10a)		Air Content (ASTM C231 - 10)		
Time₁	Result₁	Time₁	Result₁	S/N of Air Meter
5:04 PM	8 1/4"	5:12 PM	7.9%	LAF 8
Time₂	Result₂	Time₂	Result₂	S/N of Scale
5:19 PM	8 3/4"			H3802360

Unit Weight (ASTM C138 - 10b)

Time₁	Wt. of Cont.₁	Total Wt. ₁	Wt. of Conc.₁	Result₁ = Wt. of Conc./Vol. of Cont.
5:09 PM	8.50	43.70	35.20	140.8
Time₂	Wt. of Cont.₂	Total Wt. ₂	Wt. of Conc.₂	Result2 = Wt. of Conc./Vol. of Cont.

Times of actions during and after casting

Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
5:10 PM	5:12 PM	5:22PM	5:24 PM		5:25 PM
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic
8:30 pm	9:30 pm	see curing	9:15 pm	see curing	see curing

Recorded by	Signature	Date	Time
JASPAL S SAINI	JSaini	01/11/17	
Checked by	Signature	Date	Time
Kinsey Skiller		1/11/17	9:30 pm
Checked by	Signature	Date	Time

Comments:

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

Truck 2 D7-D12

```
Truck      Driver     User     Disp Ticket Num   Ticket ID   Time   Date
1669       2140       user     11832575          0           16:40  1/11/17
Load Size  Mix Code      Returned     Qty       Mix Age     Seq    Load ID
7.00  CYDS 4000CC                                           D      43106

Description        Design Qty       Adj.T    Required        Batched            Actual Wat
Batch:        1 -----     Start:   16:40:24   End:           -------  Time (hh:mm:ss):    :    :    -----
Buzzi              588  lb                     4116  lb      4110  lb
STONE-8            940  lb                     6629  lb      6580  lb             6  gl
STONE-4            620  lb                     4373  lb      4420  lb             4  gl
SAND-23           1435  lb                    10547  lb     10520  lb            60  gl
WATER            322.4  lb                   1742.7  lb    1732.0  lb         207.5  gl
MICROAIR          1.10  /C                    45.28  oz     44.50  oz
GLENIUM 7511      2.00  /C     #              82.32  oz     82.00  oz

Actual                       Num Batches:    1
Load      27370 lb    Design W/C:   0.548   Water/Cement:    0.563   A      Design    270.4 gl        Actual    277.4 gl   To Add:       0.0 gl
Slump:     4.00 in     Water in Truck:       0.0 lb     Adjust Water:      0.0   lb / Load   Trim Water:    10.0   lb /   CYD Note: Manual feed occured
```

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars. | Curing Documentation v.2 (Rev. 11/1/2016) | Purdue University - Bowen Laboratory Appendix 1, Pg 5 of 41 | Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D1 - D12 + cylinders	1/11/17	0 hrs.
	Time Beginning	Time Ending
	8:30 pm	9:30 pm
	Temperature inside Lab (deg. F)	
	55 °F	

Description of Work Performed

→ lift inserts placed into fresh concrete

→ concrete specimens + cylinders covered w/ burlap + w/ plastic tarp

Recorded by	Signature	Date	Time
Kinsey Skiller		1/11/17	9:38 pm
Checked by	**Signature**	**Date**	**Time**
Prateek Shah		1/11/17	9:38 pm
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory
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General Information

Specimen(s)	Date	Specimen Age
D1 - D12 + cylinders	1/12/17	~ 18 hrs
	Time Beginning	**Time Ending**
	7:45 am	8:20 am
	Temperature inside Lab (deg. F)	
	55 °F	

Description of Work Performed

Concrete specimens + cylinders doused w/ water. Burlap + plastic tarp covering.

Recorded by	Signature	Date	Time
Kinsey Skillen		1/12/17	8:25 am
Checked by	**Signature**	**Date**	**Time**
Prateek Shah	PShah	1/12/17	8:25 am
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

General Information

Specimen(s)	Date	Specimen Age
D1-D12 + cylinders	1/12/17	1 day
	Time Beginning	**Time Ending**
	7:30 pm	7:45 pm
	Temperature inside Lab (deg. F)	
	55° F	

Description of Work Performed

Specimens + cylinders dowsed w/ water and recovered w/ plastic tarp

Recorded by	Signature	Date	Time
Kinsey Skiller		1/12/17	8:00 pm
Checked by	**Signature**	**Date**	**Time**
Prateek Shah	PShah	1/12/17	8:00 pm
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
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Purdue University - Bowen Laboratory
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General Information

Specimen(s)	Date	Specimen Age
D1-D12 + cylinders	1/13/17	2 day
	Time Beginning	Time Ending
	7:30 am	8:00 am
	Temperature inside Lab (deg. F)	
	55° F	

Description of Work Performed

specimens + cylinders doused w/ water + recovered w/ plastic tarp.

Recorded by	Signature	Date	Time
Kinsey Skillen		1/13/17	8:10 am
Checked by	Signature	Date	Time
Prateek Shah	P Shah	1/13/17	8:10 am
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory
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Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D1-D12 + cylinders	1/13/17	2 days
	Time Beginning	**Time Ending**
	2:00 pm	5:30 pm
	Temperature inside Lab (deg. F)	
	55°F	

Description of Work Performed

- cylinder molds struck, specimens removed from formwork.

- Re-covered w/ doused burlap and plastic sheeting upon form + cylinder striking.

Recorded by	Signature	Date	Time
Kinsey Skillen		1/13/17	6:00 pm
Checked by	**Signature**	**Date**	**Time**
Prateek Shah	PShah	1/13/17	6:00 pm
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

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Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D1 - D12 + cylinders	1/14/17	3 days
	Time Beginning	Time Ending
	9:00 am	9:15 am
	Temperature inside Lab (deg. F)	
	55 °F	

Description of Work Performed

cylinders + specimens dowsed w/ water and recovered w/ plastic sheeting.

Recorded by	Signature	Date	Time
Kinsey Skiller		1/14/17	9:30 am
Checked by	Signature	Date	Time
Prateek Shah	PShah	1/14/17	9:30 am
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

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Purdue University - Bowen Laboratory
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General Information

Specimen(s)	Date	Specimen Age
D1-D12 + cylinders	1/14/17	3 day
	Time Beginning	Time Ending
	6:00 pm	6:15 pm
	Temperature inside Lab (deg. F)	
	55°F	

Description of Work Performed

cylinders + specimens doused w/ water and recovered w/ plastic tarp

Recorded by	Signature	Date	Time
Kinsey Skillen		1/14/17	6:30 pm
Checked by	Signature	Date	Time
Prateek Shah	P Shah	1/14/17	6:30 pm
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

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General Information

Specimen(s)	Date	Specimen Age
D1 - D12 + cylinders	1/15/17	4 day
	Time Beginning	Time Ending
	9:30 am	9:45 am
	Temperature inside Lab (deg. F)	
	55° F	

Description of Work Performed

Specimens doused w/ water
and recovered

Recorded by	Signature	Date	Time
Kinsey Skillen		1/15/17	9:50 am
Checked by	Signature	Date	Time
Prateek Shah	P Shah	1/15/17	9:50 am
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2 (Rev. 11/1/2016)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D1 - D12 + cylinders	1/15/17	4 day
	Time Beginning	**Time Ending**
	5:15 pm	5:25 pm
	Temperature inside Lab (deg. F)	
	55°F	

Description of Work Performed

specimens doused w/ water
+ recovered

Recorded by	Signature	Date	Time
Kinsey Skiller		1/15/17	5:30 pm
Checked by	**Signature**	**Date**	**Time**
Prateek Shah	PShah	1/15/17	5:30 pm
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

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Purdue University - Bowen Laboratory
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General Information

Specimen(s)	Date	Specimen Age
D1-D12 + cylinders	1/16/17	8 day
	Time Beginning	**Time Ending**
	7:45 am	7:55 am
	Temperature inside Lab (deg. F)	
	55°F	

Description of Work Performed

specimens doused w/ water and covered

Recorded by	Signature	Date	Time
Kinsey Skiller		1/16/17	8:00 am
Checked by	**Signature**	**Date**	**Time**
Prateek Shah	PShah	1/16/17	8:00am
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminar cracks on 79-in lap splices of #11 reinforcing bars.

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General Information

Specimen(s)	Date	Specimen Age
D1-D12 + cylinders	1/16/17	5 day
	Time Beginning	Time Ending
	6:30 pm	6:45 pm
	Temperature inside Lab (deg. F)	
	55°F	

Description of Work Performed

Specimens doused w/ water and covered

Recorded by	Signature	Date	Time
Kinsey Skiller		1/16/17	6:50 pm
Checked by	**Signature**	**Date**	**Time**
Prateek Shah	PShah	1/16/17	6:50 pm
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

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Purdue University - Bowen Laboratory
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General Information

Specimen(s)	Date	Specimen Age
D1-D12 + cylinders	1/17/17	6 day
	Time Beginning	**Time Ending**
	8:15 am	8:30 am
	Temperature inside Lab (deg. F)	
	55°F	

Description of Work Performed

specimens doused w/ water and covered

Recorded by	Signature	Date	Time
Kinsey Skillen		1/16/17	8:40 am
Checked by	**Signature**	**Date**	**Time**
Prateek Shah	PShah	1/16/17	8:40am
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

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Purdue University - Bowen Laboratory
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General Information

Specimen(s)	Date	Specimen Age
D1-D12 + cylinders	1/17/17	6 day
	Time Beginning	**Time Ending**
	7:15 pm	7:30 pm
	Temperature inside Lab (deg. F)	
	55°F	

Description of Work Performed

Specimens doused w/ water and covered

Recorded by	Signature	Date	Time
Kinsey Skillen		1/17/17	7:35 pm
Checked by	**Signature**	**Date**	**Time**
Prateek Shah	PShah	1/17/17	7:35 pm
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D1-D12 + cylinders	1/18/17	7 day
	Time Beginning	Time Ending
	8:15 am	8:25 am
	Temperature inside Lab (deg. F)	
	55° F	

Description of Work Performed

specimens + cylinders doused w/ water + covered

Recorded by	Signature	Date	Time
Kinsey Skiller		1/18/17	8:40 am
Checked by	Signature	Date	Time
Prateek Shah	PShah	1/18/17	8:40am
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
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Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D1-D12 + cylinders	1/18/17	7 day
	Time Beginning	**Time Ending**
	4:20 pm	4:30 pm
	Temperature inside Lab (deg. F)	
	55° F	

Description of Work Performed

Specimens + cylinders dowsed w/ water + covered

Recorded by	Signature	Date	Time
Kinsey Skiltz		1/18/17	5:10 pm
Checked by	**Signature**	**Date**	**Time**
Prateek Shah	PShah	1/18/17	5:10 pm
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Statement Of Traceability

This Thermometer with Serial number 330717 has been calibrated and tested against standards traceable to the **National Institute of Standards and Technology (NIST)** using the methods outlined in Monograph 150, Monograph 250-23 from NIST and ASTM E77-07 in THERMCO's ISO/IEC and ILAC accredited calibration laboratory. Each thermometer has a unique serial number for identification. The thermometer can be calibrated or certified at individual temperature points of your choice at an additional charge by contacting Thermco Products, Inc. technical support team.

R. CASARIO

R. Casario, Laboratory Director
email: Lab@ThermcoProducts.com
fax: 973-940-1112

CAL DATE FEB 09 2016

THERMCO®
PRODUCTS, INC

www.ThermcoProducts.com
10 Millpond Drive Unit #10 Lafayette, NJ 07848 - Phone: 973.300.9100

CL-033

Statement Of Traceability

This Thermometer with Serial number 330706 has been calibrated and tested against standards traceable to the **National Institute of Standards and Technology (NIST)** using the methods outlined in Monograph 150, Monograph 250-23 from NIST and ASTM E77-07 in THERMCO's ISO/IEC and ILAC accredited calibration laboratory. Each thermometer has a unique serial number for identification. The thermometer can be calibrated or certified at individual temperature points of your choice at an additional charge by contacting Thermco Products, Inc. technical support team.

R. CASARIO

R. Casario, Laboratory Director
email: Lab@ThermcoProducts.com
fax: 973-940-1112

CAL DATE FEB 09 2016

CALSER CORPORATION 302 N. Belt East, Swansea, IL 62226 (618) 277-0329

SCALE CALIBRATION DATA AND REPORT

Report #: VN# 10576-011

Page 1 of 1

Customer	Patriot Engineering & Environmental
Location	717 C Farabee Court Lafayette, IN 47905
Machine	AND 150lb Scale Model FG-60K
Serial No.	H3802360
Customer Asset No.	N/A

Date	03/23/16
Customer Order No.	Email
Order Date	02/22/16
Temp.	64° F
Date Last Done	03/25/15
Calibration Next Due	3/17

Applied Force	*	Indicated Force	Error	%	Applied Force	*	Indicated Force	Error	%
Run #1		"As Found" Condition			Run #2		"As Left" Condition		
150lb Range	*	.05lb / DIV			150lb Range	*	.05lb / DIV		
0	W	0	0	0.00	0	W	0	0	0.00
2	W	2.00	0.00	0.00	2	W	2.00	0.00	0.00
4	W	4.00	0.00	0.00	4	W	4.00	0.00	0.00
6	W	6.00	0.00	0.00	6	W	6.00	0.00	0.00
8	W	8.00	0.00	0.00	8	W	8.00	0.00	0.00
10	W	10.00	0.00	0.00	10	W	10.00	0.00	0.00
20	W	20.00	0.00	0.00	20	W	20.00	0.00	0.00
30	W	30.00	0.00	0.00	30	W	29.90	-0.10	0.33
40	W	40.05	0.05	0.13	40	W	40.05	0.05	0.13
50	W	50.00	0.00	0.00	50	W	50.00	0.00	0.00
60	W	60.05	0.05	0.08	60	W	60.05	0.05	0.08
70	W	70.05	0.05	0.07	70	W	70.05	0.05	0.07
80	W	80.05	0.05	0.06	80	W	80.05	0.05	0.06
90	W	90.05	0.05	0.06	90	W	90.05	0.05	0.06
100	W	100.05	0.05	0.05	100	W	100.05	0.05	0.05
109	W	109.05	0.05	0.05	109	W	109.05	0.05	0.05
0	W	0	0	0.00	0	W	0	0	0.00

Notes:

1. Calibration done according to NIST Handbook 44 and Calser Corporation Procedure # 4-01, Rev 1.
2. Uncertainties of all weights meet class F tolerance and certifiicates for individual weights are available.
3. Linearity was checked.
4. Weights meet specifications of ASTM E-4 (Par. 12.1)

*CALIBRATION EQUIPMENT

All verification equipment-including dead weights, proving rings, load cells, etc, is calibrated and traceable to the latest procedures stipulated by the National Institute of Standards and Technology (NIST). All instrument readings have been corrected for temperature where necessary.

ACCURACY SUMMARY

Capacity Range	Loading Range Within	Error (%)
Run 1		
150lb Range	2 - 109	0.13 %
Run 2		
150lb Range	2 - 109	0.33 %

Verification Equipment

Manufacturer and Serial #	* L/C	Range	Verification Agency and Date
Rice Lake	W	1 - 109lb	MO Dept. of Agriculture
Set # 99-452 & Various dead weights			06/03/10

Calibration Technician: Jerry Parker

This report shall not be copied except in its entirety without express written approval of Calser Corp.

FORM# 111-01-Rev2

Revised 11/10/2000

PATRIOT ENGINEERING
and ENVIRONMENTAL, INC.
717 C Farabee Court
Lafayette, IN 47905
(765) 447-4477 FAX: (765) 447-4045

Air Meter Calibration

Air Meter Calibration Record

Calibrated by: Amy Kolzow

Date: 12/9/2016

Equipment: Type B Pressure Meter

Serial No: LAF-8

Range of Calibration: 5.0 +/- 0.1%

Previous Calibration Date: 8/30/2016

Next Due Date: 3/9/2017

Calibration Equip Used: Traceable Thermometer 112003335, O'Haus 8,100g Scale Model AV8101, O'Haus 35lb Scale 2407-00

Calib.Procedure: **CME #21**

Action Recommended: Repair ____ Replace ____ None x

Other ____ Explain: ____

PROCEDURE: Screw short pipe into threaded hole on underside of lid. Fill bowl with water and attach the lid to the bowl. Open both petcocks and fill the meter with water through the petcock that has the pipe affixed to it. Attach the curved pipe to the petcock to whcih the short pipe has been affixed. Close the opposite petcock and pump the meter up to its initial pressure. Place the measuring device under the curved pipe and release the air from the meter, filling the device to capacity. Release the remaining air, remove the curved pipe, then pump the meter back to its set point.Release the air, tapping on the gauge until a constant reading is reached. This should equal 5%.

CALIBRATION:

Trial #	Theoretical	Actual
1	5%	5.1
2	5%	5.1
3	5%	5.1

IP: 3 %

Volume: 0.2513 cf
0.0071 cm

COMMENTS: ____

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Casting Documentation v.2
(Rev. 11/1/2016)

Specimen: D13 - D18

Sheet 1 of 1

General Information					
Date	Disp Ticket Num	Truck No.	Time on Ticket	Time of Arrival	Temp. in Lab
04/27/17	11633525	506	12:32	12:55	50 °F

Measurements made upon arrival of concrete				
Slump (ASTM C143 - 10a)		Air Content (ASTM C231 - 10)		
Time₁	Result₁	Time₁	Result₁	S/N of Air Meter
1:15pm	7 3/4"	1:15 pm	6.7 %	LAF-3
Time₂	Result₂	Time₂	Result₂	S/N of Scale
1:30pm	6 3/4"	1:30pm	6.8%	AE40116811

Unit Weight (ASTM C138 - 10b) V = 0.2503 cf

Time₁	Wt. of Cont.₁	Total Wt. ₁	Wt. of Conc.₁	Result₁ = Wt. of Conc./Vol. of Cont.	
1:15pm	8.15 lb	44.20 lb	36.05 lb		
Time₂	Wt. of Cont.₂	Total Wt. ₂	Wt. of Conc.₂	Result2 = Wt. of Conc./Vol. of Cont.	
1:30pm	8.15 lb	43.70 lb			

Times of actions during and after casting					
Layer 1 placed	Layer 1 vibration complete	Layer 2 placed	Layer 2 vibration complete	Top surface struck off	Truck Departing Lab
1:00pm +	1:15pm	1:15 pm +	1:35pm	2:00pm	1:36pm
Lifting Inserts Placed	Covered with plastic	Plastic removed	Covered with burlap	Burlap doused with water	Covered with plastic

Recorded by	Signature	Date	Time
Checked by	Signature	Date	Time
Kinsey Skillen		4/27/17	1:45 pm
Checked by	Signature	Date	Time

Comments:

*The following ASTM standards and specifications will be followed during casting: C172-10, C192-07, C470-09

D13-D18

Truck	Driver	User	Disp Ticket Num	Ticket ID	Time	Date
506	3634	user	11633525	0	12:32	4/27/17

Load Size	Mix Code	Returned	Qty	Mix Age	Seq	Load ID
7.00 CYDS	4000CC				W	45861

Description	Design Qty		Required	Batched	% Var	% Moisture	Actual Wat
buzzi	588 lb	#	4116 lb	4100 lb	-0.39%		
STONE-8	940 lb	#	6613 lb	6560 lb	-0.80%	0.50% M	4 gl
STONE-4	620 lb	#	4340 lb	4300 lb	-0.92%		
SAND-23	1435 lb	#	10547 lb	10580 lb	0.31%	5.00% M	60 gl
WATER	322.4 lb	#	1721.7 lb	1746.0 lb	1.41%		209.2 gl
GLEN 3030	.00 /C	#	.00 oz	.00 oz			
microair	1.10 /C	#	45.28 oz	45.00 oz	-0.61%		
GLEN 7511	2.00 /C	#	82.32 oz	83.00 oz	0.83%		

Actual Num Batches: 1

Design 270.4 gl Actual 273.5 gl To Add: 0.0 gl

Slu 4.00 in

D13-D18

General Information

Specimen(s)	Date	Specimen Age
D13 - D18 + cylinders	4/27/17	0 hrs.
	Time Beginning	**Time Ending**
	5:00 pm	5:30 pm
	Temperature inside Lab (deg. F)	
	65° F	

Description of Work Performed

→ lift inserts placed

→ Specimens covered w/ burlap, doused and covered w/ plastic

Recorded by	Signature	Date	Time
Kinsey Skiller		4/27/17	5:45 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D13 - D18 + cylinders	4/28/17	~16 hrs
	Time Beginning	Time Ending
	10:00 am	10:15 am
	Temperature inside Lab (deg. F)	
	65° F	

Description of Work Performed

specimens + cylinders doused w/ water and covered w/ plastic

Recorded by	Signature	Date	Time
Kinsey Skiller	K.C.	4/27/17	10:20 am
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D13 - D18 + cylinders	4/28/17	1 day
	Time Beginning	Time Ending
	6:00 pm	6:15 pm
	Temperature inside Lab (deg. F)	
	65° F	

Description of Work Performed

specimens + cylinders doused w/ water and recovered w/ plastic

Recorded by	Signature	Date	Time
Kinsey Skiller	K. C. Skiller	4/29/17	6:20 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory
Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D13 - D18 + cylinders	4/29/17	2 day
	Time Beginning	Time Ending
	8:00 am	8:15 am
	Temperature inside Lab (deg. F)	
	65° F	

Description of Work Performed

specimens watered, cylinders watered, recovered w/ plastic

Recorded by	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	4/30/17	8:20 am
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory
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Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D13 - D18 + cylinders	4/29/17	2 day
	Time Beginning	**Time Ending**
	5:00 pm	5:15 pm
	Temperature inside Lab (deg. F)	
	65° F	

Description of Work Performed

specimens, cylinders watered and covered

Recorded by	Signature	Date	Time

Checked by	Signature	Date	Time

Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory
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General Information

Specimen(s)	Date	Specimen Age
D13-D18 + cylinders	4/30/17	3 days
	Time Beginning	**Time Ending**
	7:45 am	8:00 am
	Temperature inside Lab (deg. F)	
	65° F	

Description of Work Performed

specimens, cylinders watered and covered

Recorded by	Signature	Date	Time
Kinsey Skiller	K. C. Skiller	4/30/17	8:05 am

Checked by	Signature	Date	Time

Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2 (Rev. 11/1/2016)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D13 - D18 + cylinders	4/30/17	3 days
	Time Beginning	**Time Ending**
	4:00 pm	7:30 pm
	Temperature inside Lab (deg. F)	
	65° F	

Description of Work Performed

→ forms struck

→ specimens, cylinders watered and covered

Recorded by	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	4/30/17	7:40 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory
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Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D13- D18 + cylinders	5/1/17	4 day
	Time Beginning	**Time Ending**
	9:00 am	9:15 am
	Temperature inside Lab (deg. F)	
	65° F	

Description of Work Performed

Specimens, cylinders watered and covered

Recorded by	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	5/1/17	9:20 am
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D13- D18 + cylinders	5/1/17	4 day
	Time Beginning	Time Ending
	5:00 pm	6:00 pm
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

specimens and cylinders watered and recovered

Recorded by	Signature	Date	Time
Kinsey Skiles	K.C. Skiles	5/1/17	6:00 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2 (Rev. 11/1/2016)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D13 - D18 + cylinders	5/2/17	5 day
	Time Beginning	Time Ending
	9:30 am	9:45 am
	Temperature inside Lab (deg. F)	
	70° F	

Description of Work Performed

specimen, cylinders watered and covered

Recorded by	Signature	Date	Time
Kinsey Skillen	K. C. Skillen	5/2/17	10:00 am
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D13- D18 + cylinders	5/2/17	5 days
	Time Beginning	**Time Ending**
	6:00 pm	6:15 pm
	Temperature inside Lab (deg. F)	
	70° F	

Description of Work Performed

cylinders, specimens watered and covered

Recorded by	Signature	Date	Time
Kinsey Skiller	K. C. Skiller	5/2/17	6:20 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

General Information

Specimen(s)	Date	Specimen Age
D13 - D18 + cylinders	5/3/17	6 day
	Time Beginning	Time Ending
	10:00 am	10:15 am
	Temperature inside Lab (deg. F)	
	65° F	

Description of Work Performed

specimens, cylinders watered and covered

Recorded by	Signature	Date	Time
Kinsey Skiller	K. C. Skiller	5/3/17	10:30 am
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory
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Sheet 1 of 1

General Information		
Specimen(s)	Date	Specimen Age
D13 - D18 + cylinders	5/3/17	6 day
	Time Beginning	Time Ending
	7:00 pm	7:15 pm
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

specimens and cylinders watered and covered

Recorded by	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	5/3/17	7:30 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D13 - D18 + cylinders	5/4/17	7 day
	Time Beginning	**Time Ending**
	9:00 am	9:15 am
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

Specimens, cylinders watered and covered

Recorded by	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	5/4/17	9:30 am
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Curing Documentation v.2
(Rev. 11/1/2016)

Purdue University - Bowen Laboratory

Sheet 1 of 1

General Information

Specimen(s)	Date	Specimen Age
D13-D18 + cylinders	5/4/17	7 day
	Time Beginning	**Time Ending**
	4:30 pm	5:00 pm
	Temperature inside Lab (deg. F)	
	65°F	

Description of Work Performed

Specimens, cylinders watered + covered

Recorded by	Signature	Date	Time
Kinsey Skillen	K.C Skillen	5/4/17	5:15 pm

Checked by	Signature	Date	Time

Checked by	Signature	Date	Time

Comments:

*Test specimens and associated cylinders are to be cured under wet burlap for seven days

CALSER CORPORATION 302 N. Belt East, Swansea, IL 62226 (618) 277-0329

SCALE CALIBRATION DATA AND REPORT

Report #: VN# 11467-007

Page 1 of 1

Customer	Patriot Engineering & Environmental		
Location	717 C Farabee Court	**Date**	03/07/17
	Lafayette, IN 47905	**Customer Order #**	Email
Machine	Adam 165lb Scale Model CPW Plus 75	**Order Date**	02/14/17
Serial No.	AE40116811	**Temp.**	71
Customer Asset No.	N/A	**Date Last Done**	03/23/16
		Condition of Machine	Good

Verification Reading	*	Machine Reading	Error	%	*	Machine Reading	Error	%	*	Machine Reading	Error	%
Run #1			"As Found" Condition			Run #2	"As Left" Condition			Run #3	"As Left" Condition	
165lb Range	*	.05lb / DIV			*				*			
0	S	0	0	0.00	S	0	0	0.00	S	0	0	0.00
10	S	10.10	0.10	1.00	S	10.00	0.00	0.00	S	10.00	0.00	0.00
20	S	20.20	0.20	1.00	S	20.00	0.00	0.00	S	20.00	0.00	0.00
30	S	30.30	0.30	1.00	S	30.00	0.00	0.00	S	30.00	0.00	0.00
50	S	50.50	0.50	1.00	S	50.00	0.00	0.00	S	50.00	0.00	0.00
60	S	60.60	0.60	1.00	S	60.00	0.00	0.00	S	60.00	0.00	0.00
80	S	80.85	0.85	1.06	S	80.00	0.00	0.00	S	80.00	0.00	0.00
100	S	101.00	1.00	1.00	S	100.00	0.00	0.00	S	100.00	0.00	0.00
120	S	121.25	1.25	1.04	S	119.95	-0.05	0.04	S	120.00	0.00	0.00
130	S	131.35	1.35	1.04	S	130.00	0.00	0.00	S	130.00	0.00	0.00
0	S	0	0	0.00	S	0	0	0.00	S	0	0	0.00

Notes:

1. Calibration done according to NIST Handbook 44 and Calser Corporation Procedure # 4-01, Rev 1.
2. Uncertainties of all weights meet class F tolerance and certifiicates for individual weights are available.
3. Linearity was checked.
4. Weights meet specifications of ASTM E-4 (Par. 12.1)

*CALIBRATION EQUIPMENT

All verification equipment-including dead weights, proving rings, load cells, etc, is calibrated and traceable to the latest procedures stipulated by the National Institute of Standards and Technology (NIST). All instrument readings have been corrected for temperature where necessary.

ACCURACY SUMMARY

Capacity Range	Loading Range Within	Error (%)
Run 1		
165lb Range	10 - 130	1.06 %
Run 2		
165lb Range	10 - 130	0.04 %
Run 3		
165lb Range	10 - 130	0.00 %

VERIFICATION EQUIPMENT

Manufacturer & Serial #	* L/C	Class A Range	Agency & Date
Rice Lake	S	1 - 151 lb	Itin Scale Company
	Various		05/06/14
Taylor	TH4	30°F - 120°F	Quality Calibration
TH4			08/26/16

Calibration Technician Ronnie Agne

This report shall not be copied except in its entirety without express written approval of Calser Corp.

FORM# 116-02-Rev3

D13-D18

Revised 11/10/2000

PATRIOT ENGINEERING
and ENVIRONMENTAL, INC.
717 C Farabee Court
Lafayette, IN 47905
(765) 447-4477 FAX: (765) 447-4045

Air Meter Calibration

Calibrated by: Ken Bosar
Date: 3/6/2017
Equipment: Type B Pressure Meter
Serial No: LAF-3
Range of Calibration: 5.0 +/- 0.1%
Previous Calibration Date: 1/16/2017
Next Due Date: 11/15/2016
Calibration Equip Used: Traceable Thermometer 112003335, O'Haus 8,100g Scale Model AV8101, O'Haus 35lb Scale 2407-00
Calib.Procedure: **CME #21**
Action Recommended: Repair ____ Replace ____ None X
Other ____ Explain: ____

PROCEDURE: Screw short pipe into threaded hole on underside of lid. Fill bowl with water and attach the lid to the bowl. Open both petcocks and fill the meter with water through the petcock that has the pipe affixed to it. Attach the curved pipe to the petcock to whcih the short pipe has been affixed. Close the opposite petcock and pump the meter up to its initial pressure. Place the measuring device under the curved pipe and release the air from the meter, filling the device to capacity. Release the remaining air, remove the curved pipe, then pump the meter back to its set point.Release the air, tapping on the gauge until a constant reading is reached. This should equal 5%.

CALIBRATION:

Trial #	Theoretical	Actual
1	5%	5
2	5%	5
3	5%	5

IP: 3 %
Volume: 0.2503 cf
0.0071 cm

COMMENTS: ____

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D1-D3 wk 1

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D1-D3	2/16/17	6:00 pm	Dry	6	5.98	12.00	12.00	12.00	104,000	5
D1-D3	2/16/17	6:00 pm	"	6.01	5.98	12.00	12.00	12.00	116,000	5
D1-D3	2/16/17	6:00 pm	"	6.01	5.98	11.95	12.00	12.00	111,000	5

S/N of Testing Machine:	Forney 9T058		
Recorded by:	Signature	Date	Time
Aishwarya Puranam	Aishwarya	2/16/17	6:00 pm
Checked by:	Signature	Date	Time
Lucas Laughery	Lucas Laughery	2/16/17	6:00 pm
Checked by:	Signature	Date	Time

Comments:

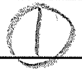
*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'$_c$) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D1-03 week 1

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D 1	2/16/17	5:30 pm	Dry	5.95	5.95	6.00	12.00	12.00	49,000	
D 2	2/16/17	↓	Dry	6.00	5.95	6.00	12.00	12.00	54,000	
D 3	2/16/17		Dry	6.00	5.95	6.00	12.00	12.00	52,000	
~~4~~										
~~5~~										
~~6~~										

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Aishwarya Puranam	Aishwarya	2/16/17	5:30 pm
Checked by:	Signature	Date	Time
Lucas Laughery	Lucas Laughery	2/16/17	5:30 pm
Checked by:	Signature	Date	Time

Comments:

$$f_t = \frac{2P_{max}}{\pi D L_{avg}}$$

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D3 - D6 Week 2
Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D3-D6	2/24/17	4:35 pm	Dry	5.99	6.05	11.95	12.00	12.00	121,000	6
D3-D6	2/24/17	4:42 pm	Dry	5.95	6.04	12.00	12.00	11.95	118,000	6
D3-D6	2/24/17	4:50 pm	Dry	5.99	6.00	12.00	12.00	11.95	104,000	6

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		2/24/17	5:14 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'$_c$) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D4 - D6 week 2

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
1										
2										
3										
D 4	2/24/17	4:55 pm	Dry	6.03	6.01	5.99	12.00	12.00	38,000	
D 5	2/24/17	5:00 pm	Dry	5.98	6.02	6.00	12.00	12.00	28,000	
S 6	2/24/17	5:08 pm	Dry	5.99	6.02	6.04	12.00	12.00	47,000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		2/24/17	5:30 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

$$f_t = \frac{2P_{max}}{\pi D_{avg} L_{avg}}$$

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb$_f$/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D7

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D7	2/26/17	8:00 pm	Dry	6.00	5.98	12.00	12.00	12.00	118000	5
"	"	8:15 pm	Dry	6.00	5.97	12.00	12.00	12.00	121000	5
"	"	8:23 pm	Dry	6.00	5.99	12.00	12.00	12.00	115000	6

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		2/26/17	8:30 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

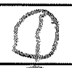
*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'$_c$) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D7

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D7	2/26/17	8:45 pm	Dry	6.01	6.00	5.99	12.00	12.00	44000	
D7	"	8:50 pm	"	6.00	6.00	6.01	12.00	11.98	48000	
D7	"	8:55 pm	"	5.99	6.02	6.02	12.00	12.03	39000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		2/26/17	9:00 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D8

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D8	3/6/17	6:00 pm	Dry	5.98	6.01	12.00	11.95	12.00	112000	5
D8	3/6/17	6:12 pm	"	5.98	6.00	12.00	12.00	11.95	114000	5
D8	3/6/17	6:20 pm	"	5.95	6.00	12.00	11.95	11.95	119000	5

S/N of Testing Machine:			
Recorded by:	Signature	Date	Time
Kinsey Skiller		3/6/17	6:25 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D8

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D8	3/6/17	6:33 pm	Dry	5.97	6.01	6.02	12.00	12.00	46000	
"	"	6:40 pm	"	5.95	6.00	6.00	12.00	12.00	51000	
"	"	6:45 pm	"	6.02	5.99	5.97	12.00	12.00	53000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		3/6/17	7:00 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D9

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D9	3/10/17	4:30 pm	Dry	6.03	5.99	12.00	11.95	12.00	115000	5
D9	3/10/17	4:40 pm	Dry	6.02	5.96	12.00	12.00	12.00	117000	6
D9	3/10/17	4:50 pm	Dry	5.98	6.01	12.00	12.00	12.00	114000	6

S/N of Testing Machine:			
Recorded by:	Signature	Date	Time
Kinsey Skiller		3/10/17	5:00 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'$_c$) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D9

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D9	3/10/17	5:20 pm	Dry	5.96	5.99	6.00	12.00	12.00	43000	
"	"	5:25 pm	"	5.99	6.00	6.00	12.00	12.00	51000	
"	"	5:30 pm	"	6.01	6.02	5.99	12.00	12.00	46000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		3/10/17	5:45 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D10

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D10	3/14/17	5:30 pm	Dry	6.03	6.01	11.95	12.00	12.00	118000	6
"	"	5:40 pm	Dry	5.98	5.99	12.00	12.00	12.00	120000	5
"	"	5:48 pm	Dry	6.01	6.00	11.95	12.00	12.00	117000	6

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		3/14/17	6:00 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

Appendix 2, Pg 11 of 28

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'$_c$) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D10
Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D10	3/14/17	6:20 pm	Dry	5.95	6.01	6.02	12.00	12.00	55000	
"	"	6:26 pm	"	5.99	6.00	6.00	12.00	12.00	52000	
"	"	6:32 pm	"	6.00	5.98	6.01	12.00	12.00	46000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinzey Skiller		3/14/17	6:45 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D11

Sheet 1 of

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D11	3/17/17	4:00 pm	Dry	5.99	6.04	12.00	12.05	11.95	123000	6
D11	3/17/17	4:12 pm	Dry	6.02	5.96	12.00	12.00	11.95	119000	5
D11	3/17/17	4:19 pm	Dry	6.00	5.99	12.00	12.00	12.00	121000	5

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsy Skiller		3/17/17	4:48 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D11

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D11	3/17/17	5:02 pm	Dry	6.01	5.98	6.01	12.00	12.00	48000	
"	"	5:08 pm	"	6.00	6.00	5.97	12.00	12.00	52000	
"	"	5:15 pm	"	6.03	5.95	6.02	12.00	12.00	41000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen		3/17/17	5:20 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D12

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D12	3/22/17	2:00 pm	Dry	5.97	6.00	12.00	12.00	12.00	112000	6
D12	3/22/17	2:15 pm	Dry	5.98	6.02	11.95	11.95	12.00	117000	6
D12	3/22/17	2:24 pm	Dry	5.99	6.00	12.00	11.95	12.00	119000	6

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller		3/22/17	2:30 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D12

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D12	3/22/17	3:30 pm	Dry	5.95	6.02	6.04	12.00	12.00	55000	
"	"	3:37 pm	"	5.99	6.00	6.01	12.00	12.00	42000	
"	"	3:45 pm	"	5.99	6.00	6.02	12.00	12.00	51000	

S/N of Testing Machine:	Forney 99055		
Recorded by:	Signature	Date	Time
Kinsey Skiller		3/22/17	4:00 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D13

Sheet 1 of

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D13	6/14/17	9:30 am	Dry	6	6	12	12	12	125000	5
D13	6/14/17	9:36 am	Dry	6	6	12	12	12	127000	5
D13	6/14/17	9:42 am	Dry	6	6	12	12	12	119000	5

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen	K.C. Skillen	6/14/17	10:15 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D13

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D13	6/14/17	9:50 am	Dry	6	6	6	12	12	50000	
D13	6/14/17	9:55 am	Dry	6	6	6	12	12	43000	
D13	6/14/17	10:00 am	Dry	6	6	6	12	12	53000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller	K.C Skiller	6/14/17	10:15 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D14
Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D14	6/19/17	10:15 am	Dry	6	6	12	12	12	123000	5
D14	6/19/17	10:20 am	Dry	6	6	12	12	12	118000	6
D14	6/19/12	10:25 am	Dry	6	6	12	12	12	120000	5

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen		6/19/17	10:30 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D14

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D14	6/19/17	10:35 am	Dry	6	6	6	12	12	47000	
D14	6/19/17	10:39 am	Dry	6	6	6	12	12	51000	
D14	6/19/17	10:45 am	Dry	6	6	6	12	12	48000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen	K.C. Skillen	6/19/17	10:50 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D15
Sheet 1 of

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D15	6/22/17	10:00 am	Dry	6	6	12	12	12	127000	5
D15	6/22/17	10:07 am	Dry	6	6	12	12	12	125000	5
D15	6/22/17	10:11 am	Dry	6	6	12	12	12	128000	6

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen	K.C.Skillen	6/22/17	10:20 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'_c) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D15

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D15	6/22/17	10:23 am	Dry	6	6	6	12	12	38000	
D15	6/22/17	10:27 am	Dry	6	6	6	12	12	49000	
D15	6/22/17	10:32 am	Dry	6	6	6	12	12	48000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen	K.C. Skillen	6/22/17	10:40 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D16
Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D16	6/29/17	11:30 am	Dry	6	6	12	12	12	123000	5
D16	6/29/17	11:33 am	Dry	6	6	12	12	12	119000	6
D16	6/29/17	11:38 am	Dry	6	6	12	12	12	125000	6

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen	K.C. Skillen	6/29/17	11:45 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'$_c$) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D16

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D16	6/29/17	11:50 am	Dry	6	6	6	12	12	43000	
D16	6/29/17	11:54 am	Dry	6	6	6	12	12	50000	
D16	6/29/17	12:00 pm	Dry	6	6	6	12	12	52000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	6/29/17	12:05 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb_f/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D17
Sheet 1 of

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D17	7/5/17	9:05 am	Dry	6	6	12	12	12	128000	6
D17	7/5/17	9:10 am	Dry	6	6	12	12	12	120000	5
D17	7/5/17	9:14 am	Dry	6	6	12	12	12	127000	5

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen	KCSkillen	7/5/17	9:20 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb_f/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'$_c$) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D17

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb$_f$]	Fracture Sketch
				end	middle	end	1	2		
D17	7/5/17	9:25 am	Dry	6	6	6	12	12	52000	
D17	7/5/17	9:30 am	Dry	6	6	6	12	12	46000	
D17	7/5/17	9:34 am	Dry	6	6	6	12	12	49000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	7/5/17	9:40 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb$_f$/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Compression Tests Documentation v.3
(Rev. 11/1/2016)

Specimen: D18

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]		Length [nearest 0.05 in.]			P_{max} [lb_f]	Fracture Type (1-6)
				1	2	1	2	3		
D18	7/6/17	9:00 am	Dry	6	6	12	12	12	121000	5
D18	7/6/17	9:05 am	Dry	6	6	12	12	12	120000	6
D18	7/6/17	9:10 am	Dry	6	6	12	12	12	126000	5

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skillen	KL Skillen	7/6/17	9:15 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-39-12 and C-1231-10a with a loading rate of 60,000lb$_f$/min at concrete ages of 3, 7, 14, 28 days, and on same day that test of corresponding specimen is conducted. Specimens and caps free of defects unless otherwise noted in comments. Average cylinder diameter and area and unit compressive stress (f'$_c$) calculated on sheet 2 of 2.

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Cylinder Split Tensile Tests Documentation v.2
(Rev. 11/1/2016)

Specimen: D18

Sheet 1 of 2

Specimen	Date	Time of Test	Wet/Dry	Diameter [nearest 0.01 in.]			Length [nearest 0.1 in.]		P_{max} [lb_f]	Fracture Sketch
				end	middle	end	1	2		
D18	7/6/17	9:20 am	Dry	6	6	6	12	12	41000	
D18	7/6/17	9:25 am	Dry	6	6	6	12	12	53000	
D18	7/6/17	9:29 am	Dry	6	6	6	12	12	58000	

S/N of Testing Machine:	Forney 99058		
Recorded by:	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	7/6/17	9:40 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

*Cylinders to be test per ASTM C-496-11 with a loading rate of 15,000lb$_f$/min at a concrete age of 28 days and on same day that the test of the corresponding specimen is conducted. Specimens free of defects unless otherwise noted in comments. Average cylinder diameter and area and splitting tensile strength (f_t) calculated on sheet 2 of 2.

411

Page: 1

SOLD TO:
WHITACRE ENGINEERING CO INC
PO BOX 8444
CANTON, OH 44711-8444

NUCOR
NUCOR STEEL MARION, INC.

CERTIFIED MILL TEST REPORT

SHIP TO:
WHITACRE ENGINEERING CO INC
3171 MAGNOLIA RD NW
MAGNOLIA, OH 44643-9527

Ship from:

MTR #: 0000061674
Nucor Steel Marion, Inc.
912 Cheney Avenue
Marion, OH 43302
7403834011

Date: 6-Jun-2016
B.L. Number: 409367
Load Number: 141652

Material Safety Data Sheets are available at www.nucorbar.com or by contacting your inside sales representative.

NBMG-08 January 1, 2012

LOT # HEAT #	DESCRIPTION	PHYSICAL TESTS					CHEMICAL TESTS						
		YIELD P.S.I.	TENSILE P.S.I.	ELONG % IN 8"	BEND	WT% DEF	C / Ni	Mn / Cr	P / Mo	S / V	Si / Cb	Cu / Sn	C.E.
PO# =>	W20165												
MR1610248001	Nucor Steel - Marion, Inc.	68,800	111,800	13.2%	OK	-5.3%	.42	1.28	.014	.033	.27	.34	.66
MR16102480	36/#11 Rebar	474MPa	771MPa			.078	.11	.18	.042	.005	.002		
	64' A615M GR420 (Gr60)												
	ASTM A615/A615M-14 GR 60[420]												
	AASHTO M31-07												
PO# =>	W20165												
MR1610248102	Nucor Steel - Marion, Inc.	66,500	111,400	8.9%	OK	-5.3%	.42	1.25	.019	.033	.26	.32	.66
MR16102481	36/#11 Rebar	459MPa	768MPa			.078	.13	.21	.054	.005	.002		
	64' A615M GR420 (Gr60)												
	ASTM A615/A615M-14 GR 60[420]												
	AASHTO M31-07												

I hereby certify that the material described herein has been manufactured in accordance with the specifications and standards listed above and that it satisfies those requirements.
1.) Weld repair was not performed on this material.
2.) Melted and Manufactured in the United States.
3.) Mercury, Radium, or Alpha source materials in any form have not been used in the production of this material.

QUALITY ASSURANCE: Ignatius Okafor

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D1

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 2/13/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skillen		2/13/17
Prateek Shah		2/13/17
Pete Corrado		2/13/17
Santiago Pujol	Pujol	2/13/2017
Lucas Laughery	Lucas Laughery	13/Feb/2017
AISHWARYA PURANAM	Aishwarya	02/13/17

Recorded by: Kinsey Skillen

Checked by:

Checked by:

Test: D1

Date: 2/13/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
25^K	7:05	25.3	24.9	-.0009	.001	.0002	0	0
50^K	7:10	50.6	50	-.0001	.0014	.0006	.0000	0.0014
75^K	7:17	75.1	75	.0014	.0014	.0011	.0006	.0014
100^K	7:23	100.2	99.5	.0028	.0014	.0049	.0042	.0049
110^K	7:30	109.5	108.9	.0039	.0014	.0085	.0077	.0085
115^K	7:35	113.6	113.3	.0061	.0014	.0106	.0122	.0122
120^K	7:41	117.7	118.5	.011	.0014	.0165	.0192	.0192
122^K	7:48	121.0	122.2	.0128	.0014	.0345	.0356	.0356
125^K	7:54	124	125.3	.0148	.0014	.0596	.0643	.0643
0^K	8:00	0	0	.0109	.0014	.0423	.0459	.0459
30^K R	8:07	30.2	29.7	.0107	.0014	.0423	.0455	.0455
60^K R	8:14	60.3	60.3	.0107	.0014	.0449	.0474	.0474
90^K R	8:20	90.5	90.5	.0118	.0014	.0534	.0571	.0571
120^K R	8:26	119.3	119	.0255	.0002	.0676	.0719	.0719
Failure	8:33	126^K	126^K					.075

Notes:

LVDT E 1.227 in @ 120^K reload, then reset to -.0479 in

LVDT W 1.173 in @ 120^K reload, then reset to -.0329 in

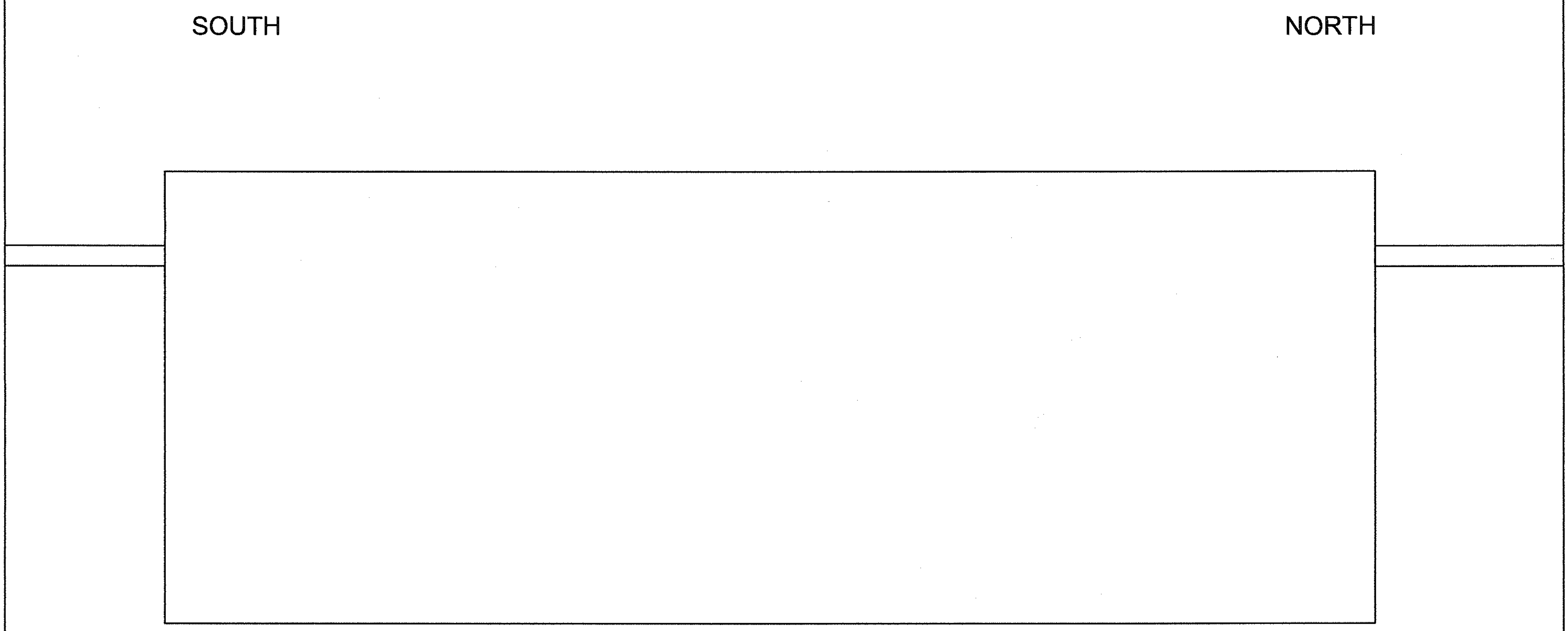
Recorded by:

Kinsey Skiller

Signature:

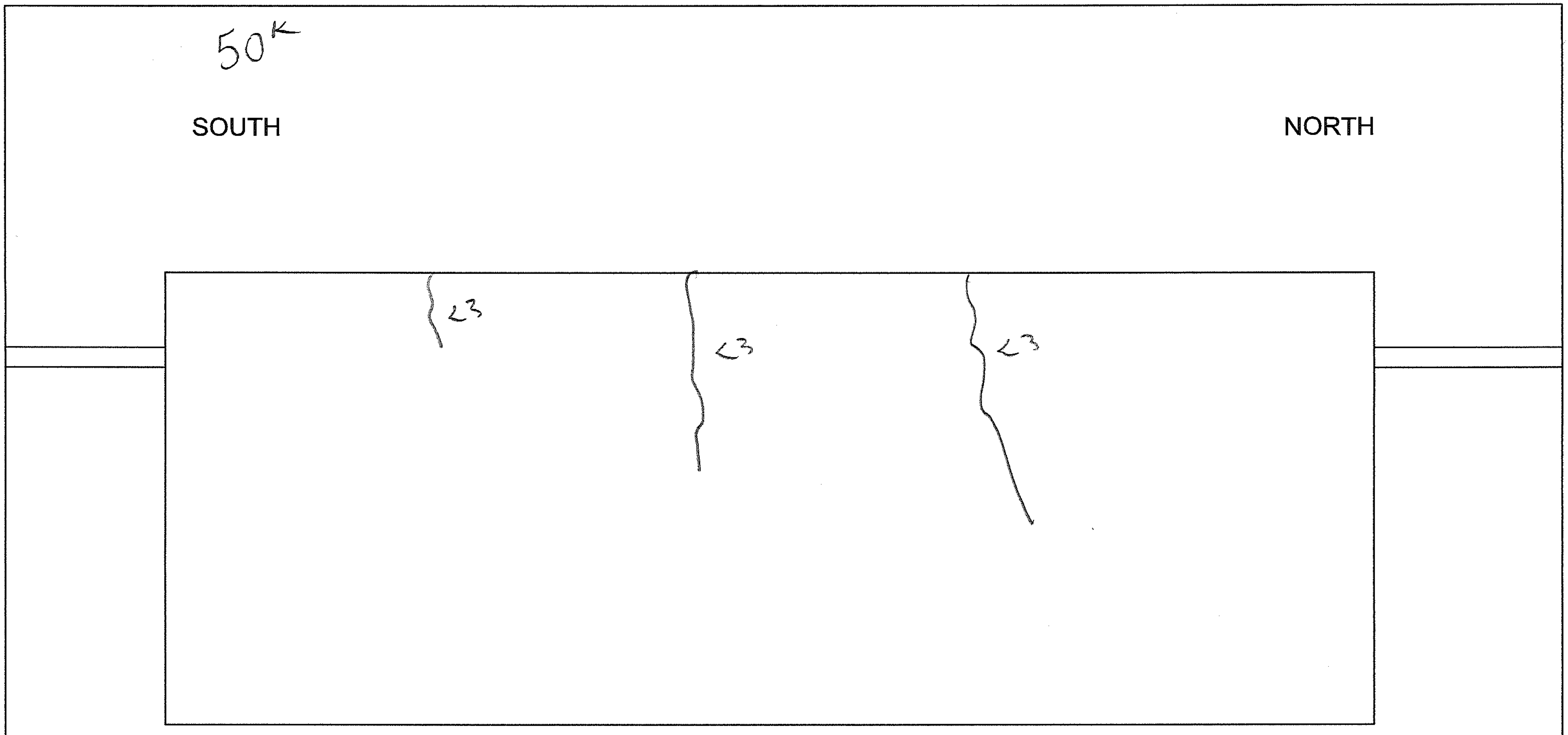
.060" crack width achieved before unload crack widths $\times 10^{-3}$ in

25^k no cracks



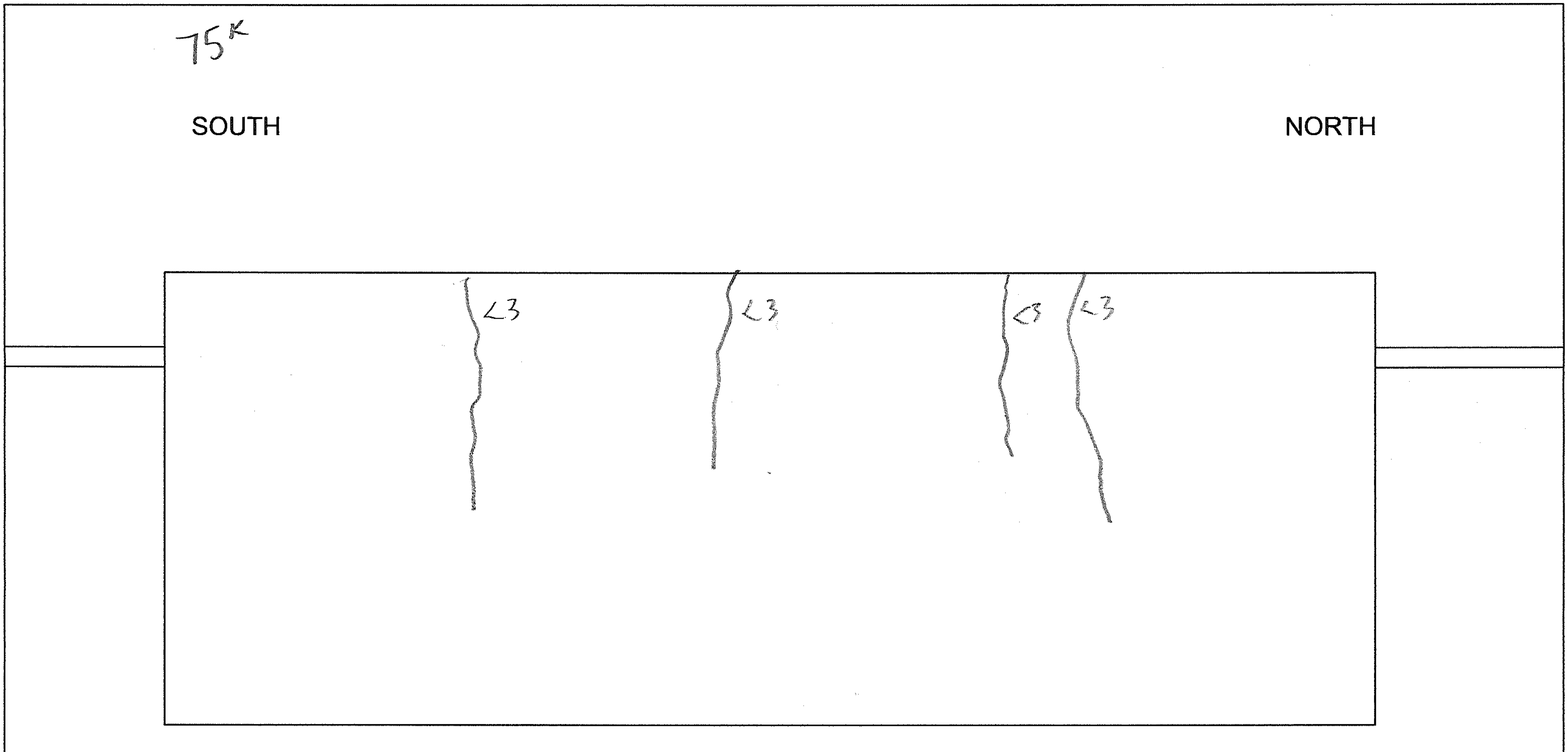
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1 of 1	
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	



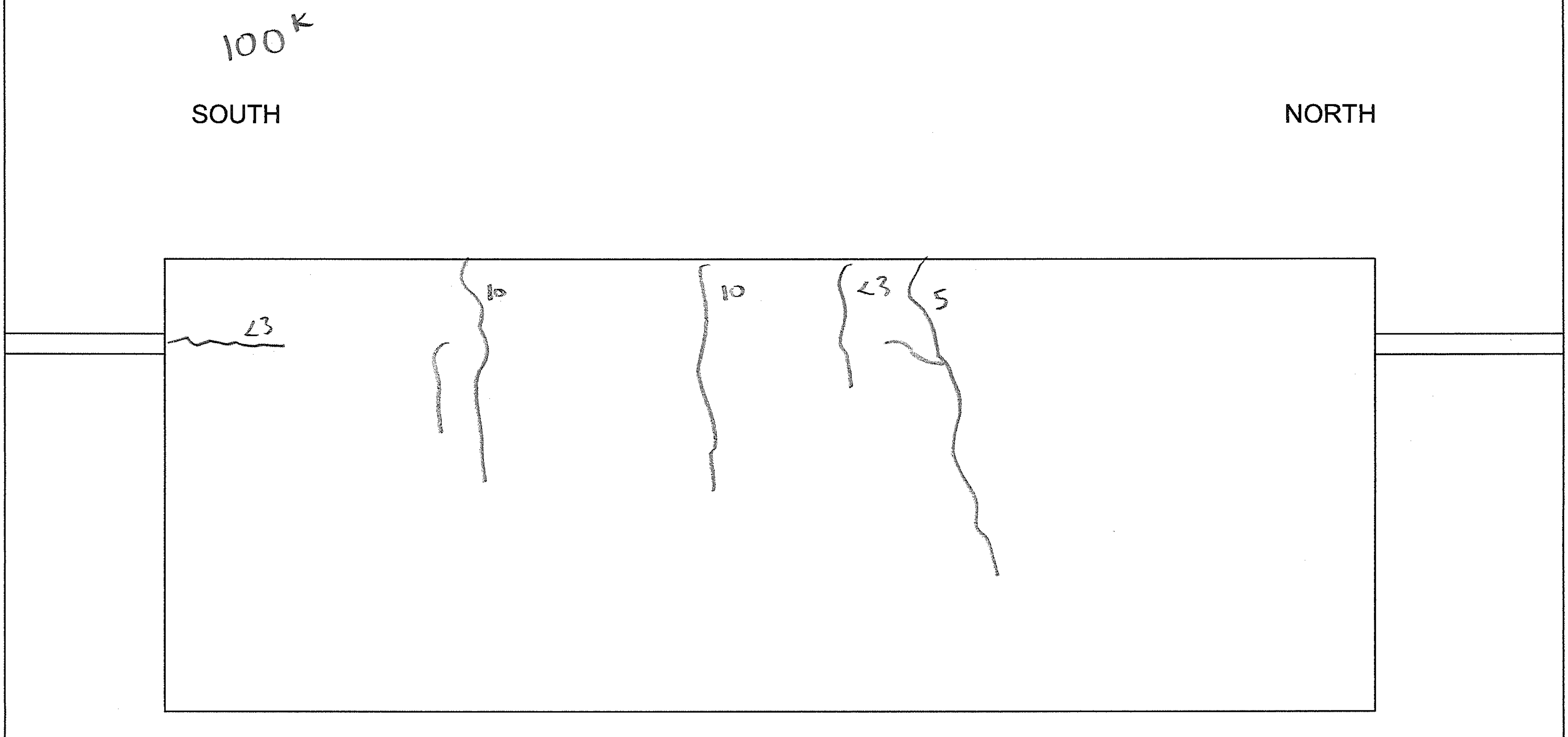
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		



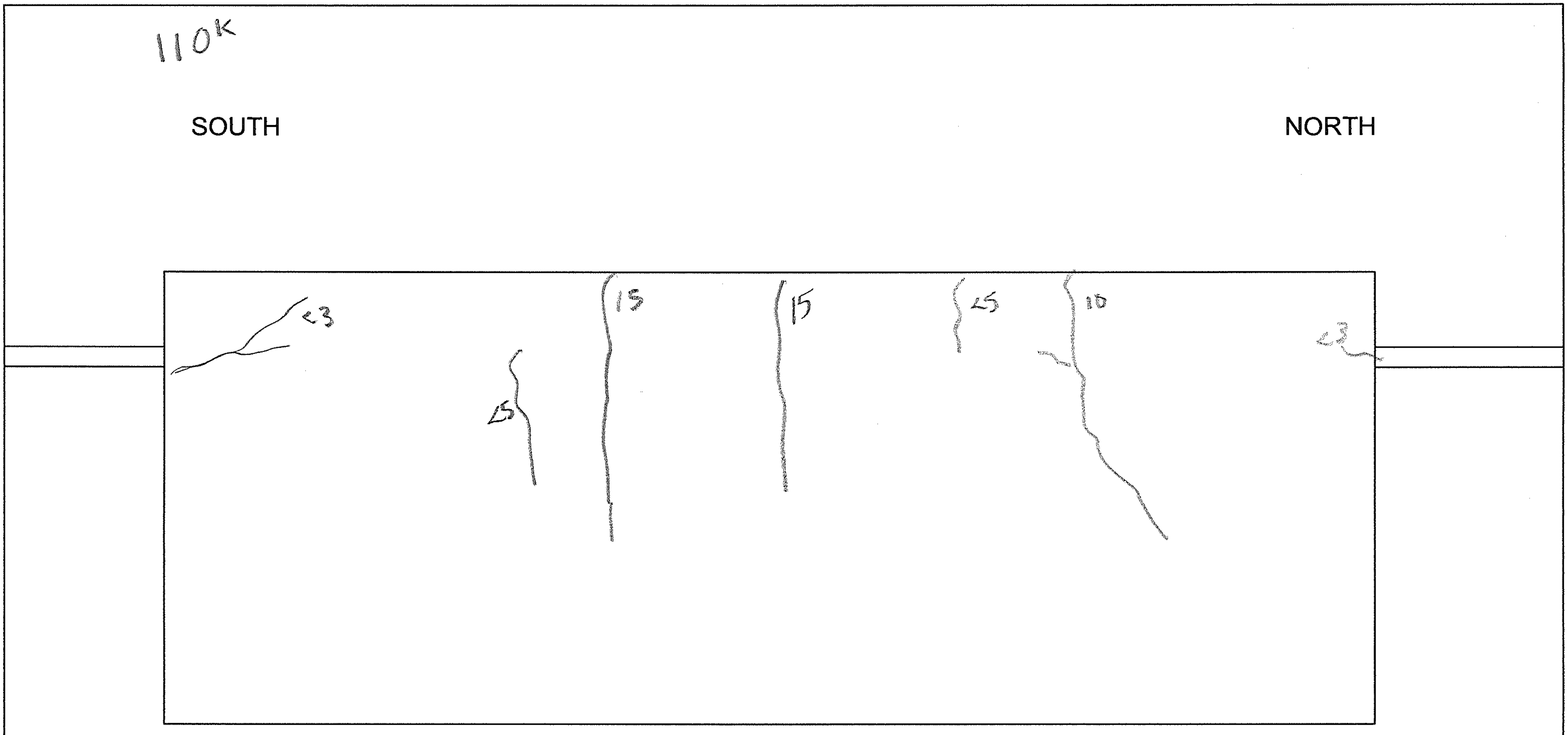
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		



Series D

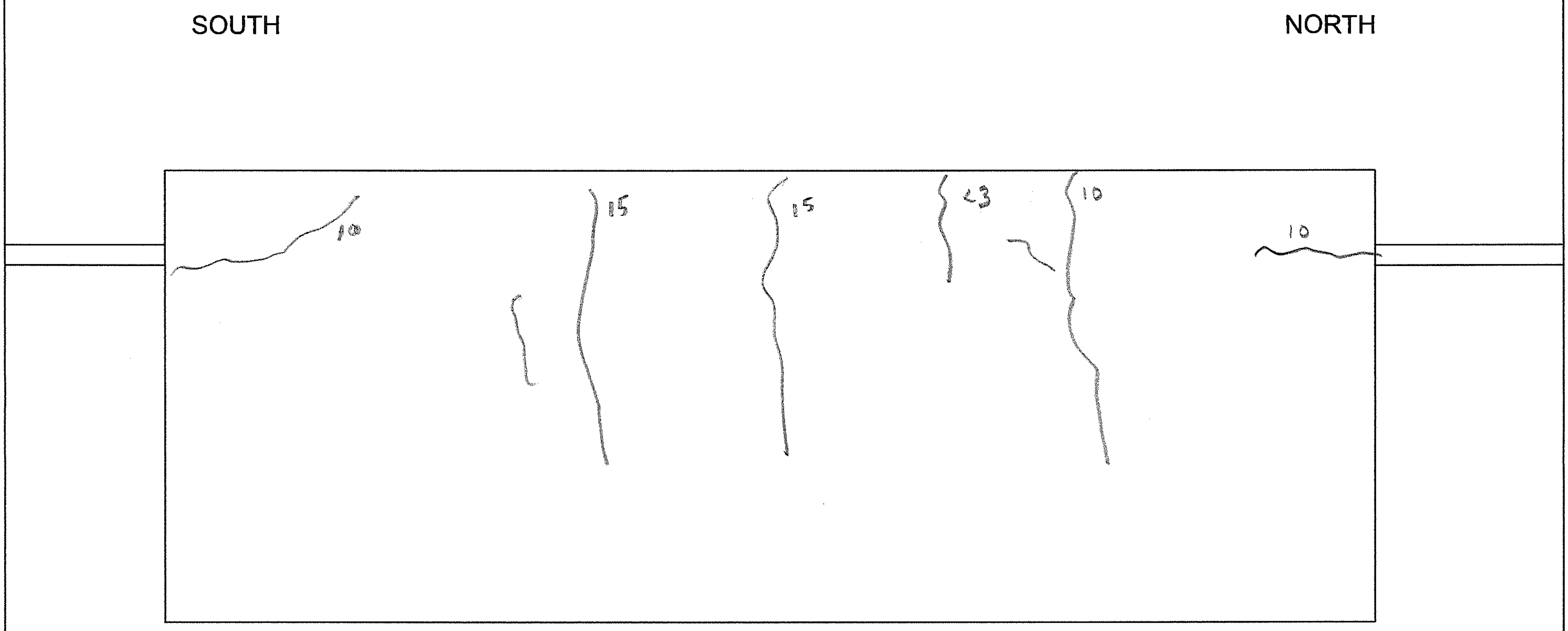
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		



Series D

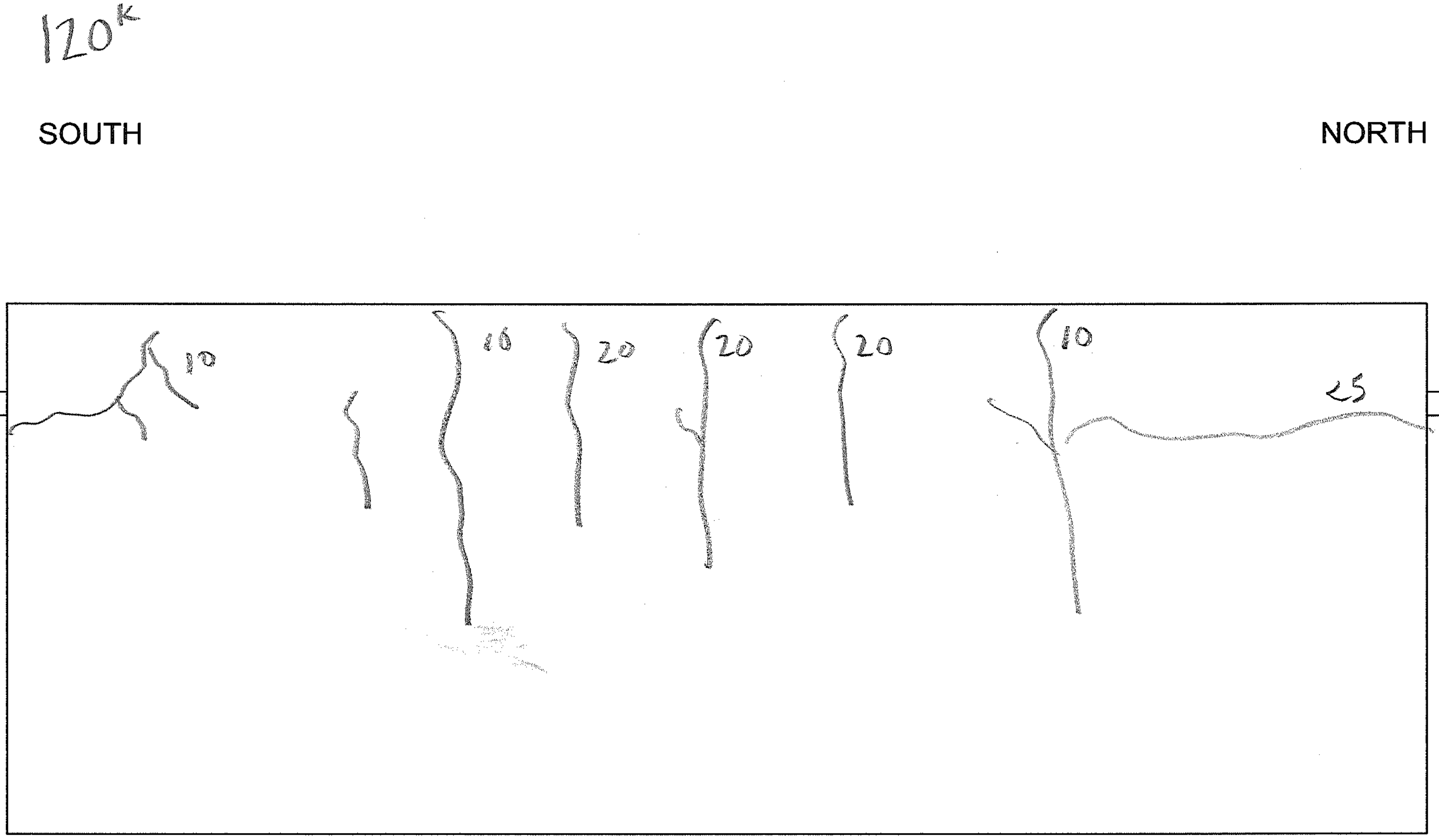
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

115^k



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

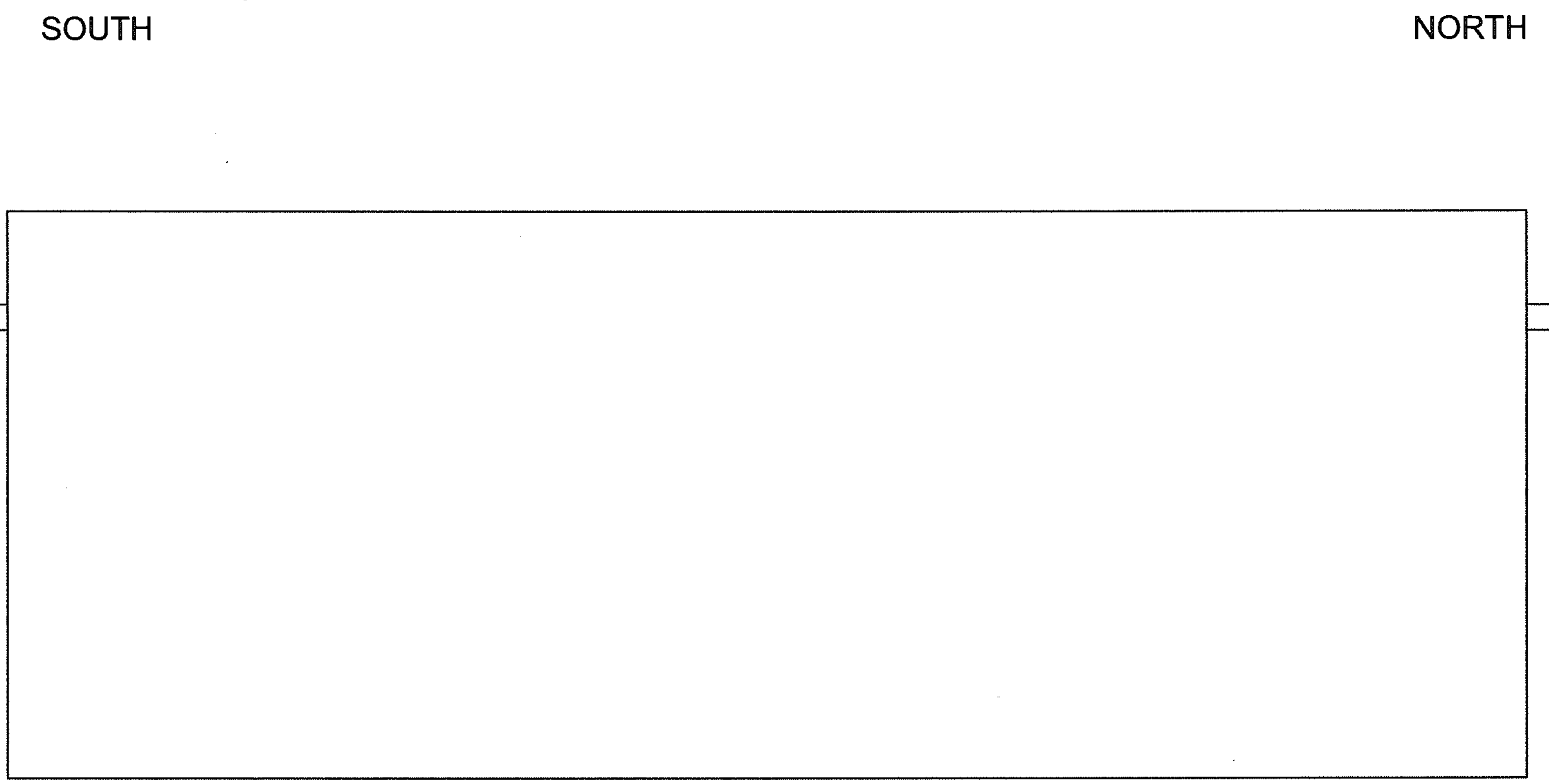


Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

123^{K} no cracks marked, see photos



Series D

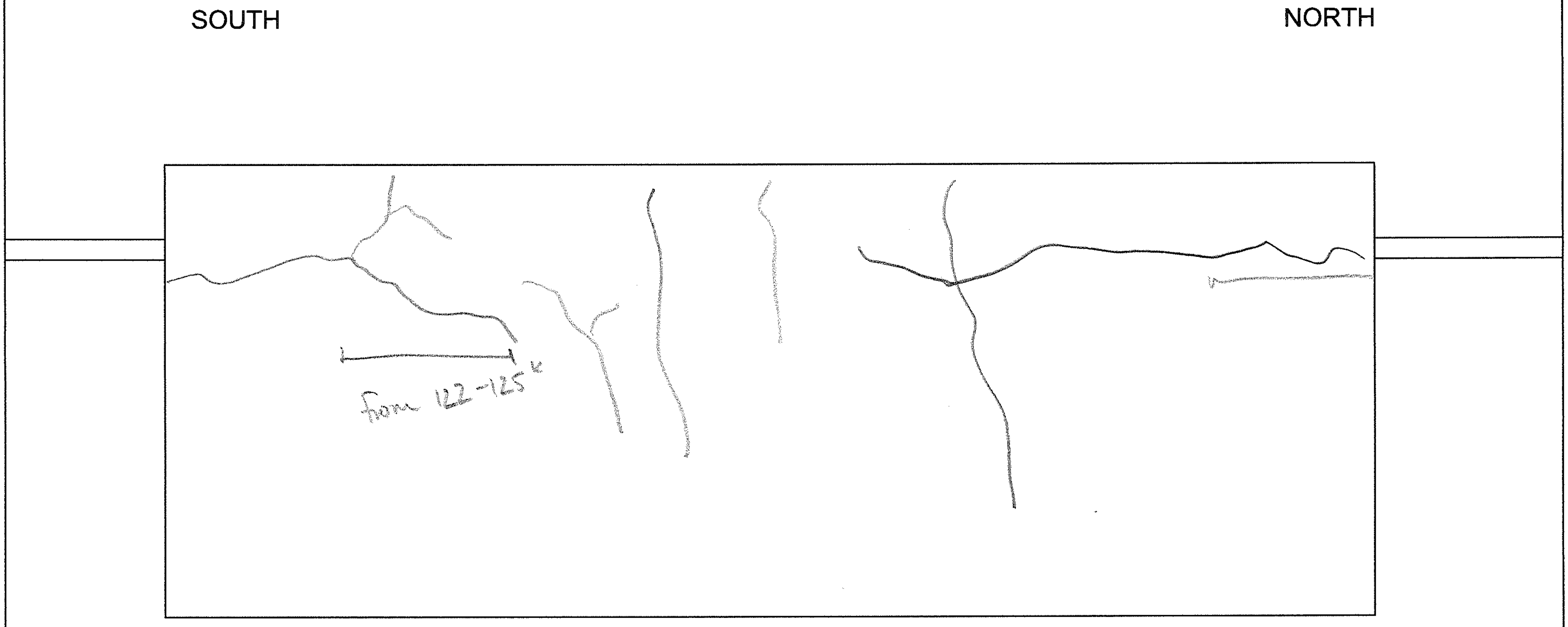
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1 of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

125^{k} no cracks marked

Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

0k Unload

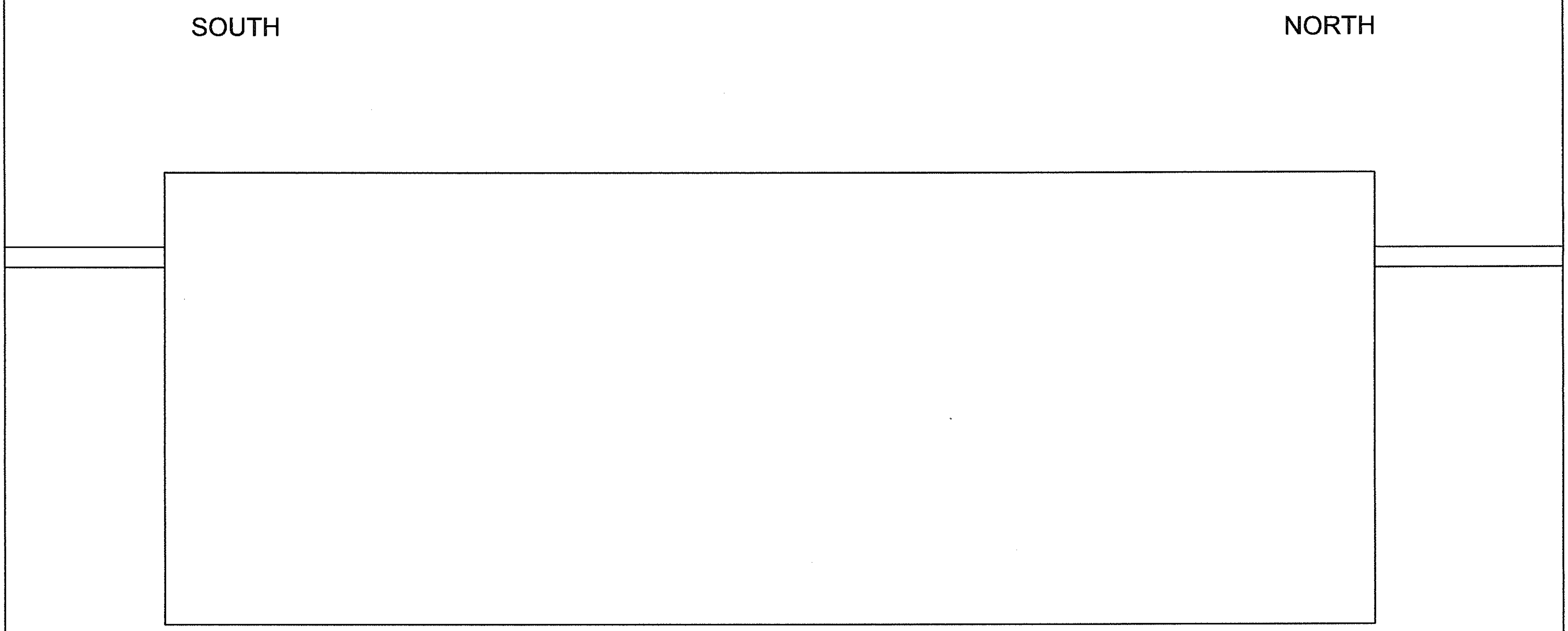


Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

30^k R no new cracks

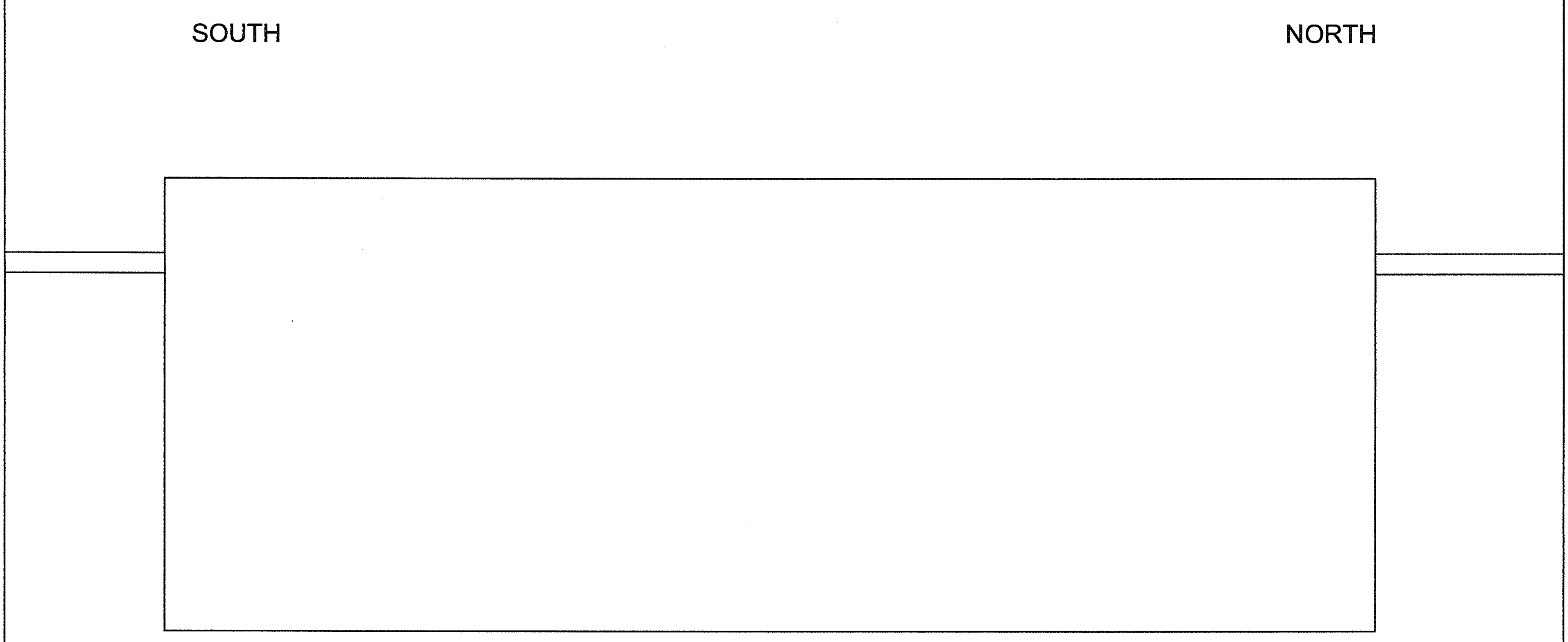


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

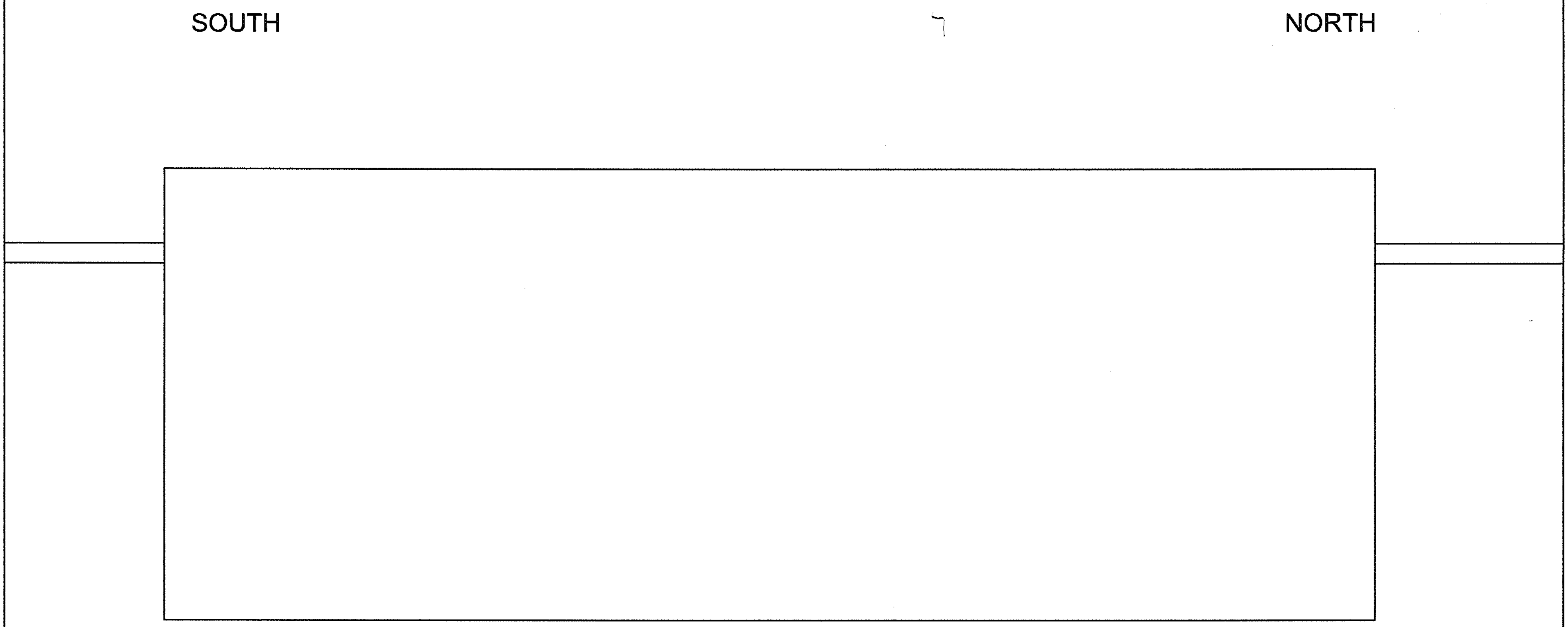
60 k R no new cracks



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

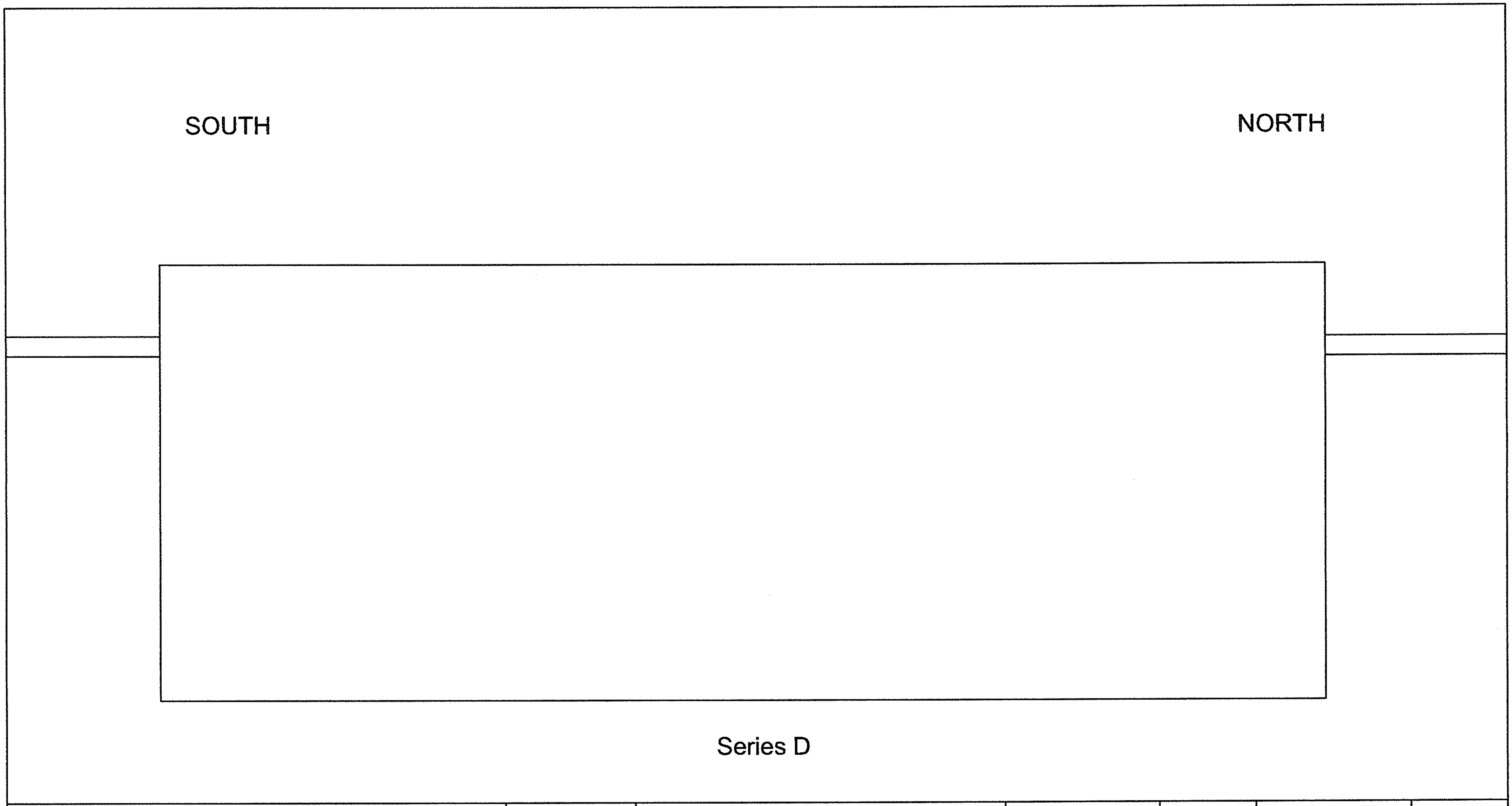
90^K R no new cracks



Series D

BOWEN LABORATORY **PURDUE UNIVERSITY**	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

120^{k} R cracks not measured see photos.



BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D2

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 2/15/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skillen		2/15/17
Ash	Aishwarya	02/15/17
Pete Carrato	P J Carrato	2/15/17
Prateek Shah	P Shah	2/15/17
WILL POLLALIS		2/15/17
LUCAS LAUGHERY	Lucas Laughery	2/15/2017

Recorded by:

Checked by:

Checked by:

Test: D2

Date: 2/15/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
20K	7:51	20.2	20.2	0	0	0	0	0
40K	7:56	40.5	39.9	.001	.001	.001	0	.001
60K	8:00	60.7	59.3	.003	.001	.001	0	.003
80K	8:05	80	79.8	.009	.002	.001	0	.009
100K	8:10	99.8	99.5	.019	.005	.003	0	.019
110K	8:17	109.9	109.9	.029	.007	.003	0	.029
120K	8:26	118	117	.041	.010	.014	.022	.041
123K	8:37	122	121.6	.057	.014	.039	.041	.057
0K unload	8:38	0	0					
20K R	8:48	20.	20.3	.040	.007	.027	.033	.040
40K R	8:54	40.2	40.5	.040	.007	.028	.033	.040
60K R	8:59	61	60.3	.041	.007	.031	.033	.041
80K R	9:07	80	80.1	.046	.009	.036	.034	.046
100K R	9:08	100	100	.054	.011	.041	.039	.054
120K R								-

Notes:

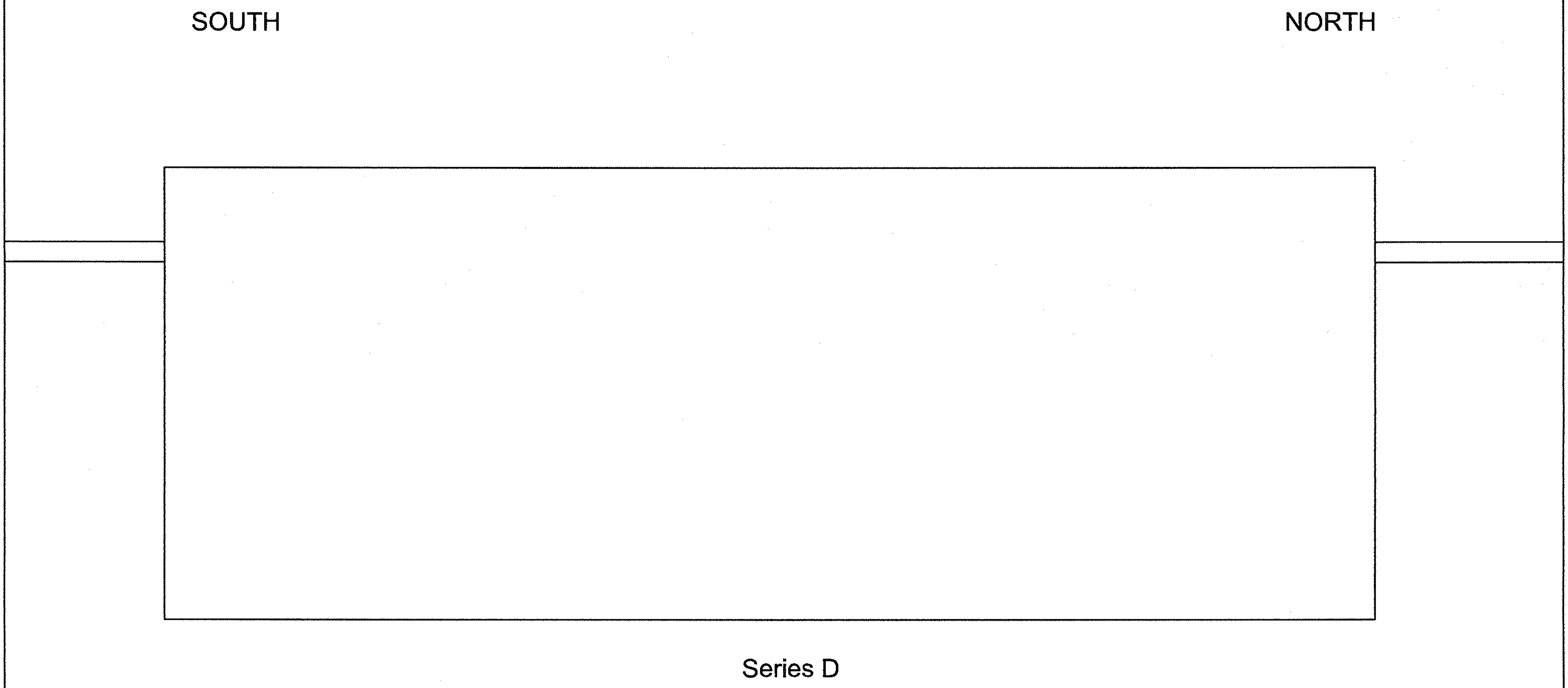
0.60" crack width achieved before Reload

Recorded by: Kinsey Skillen

Signature:

D2 2/15/17

20^k no cracks

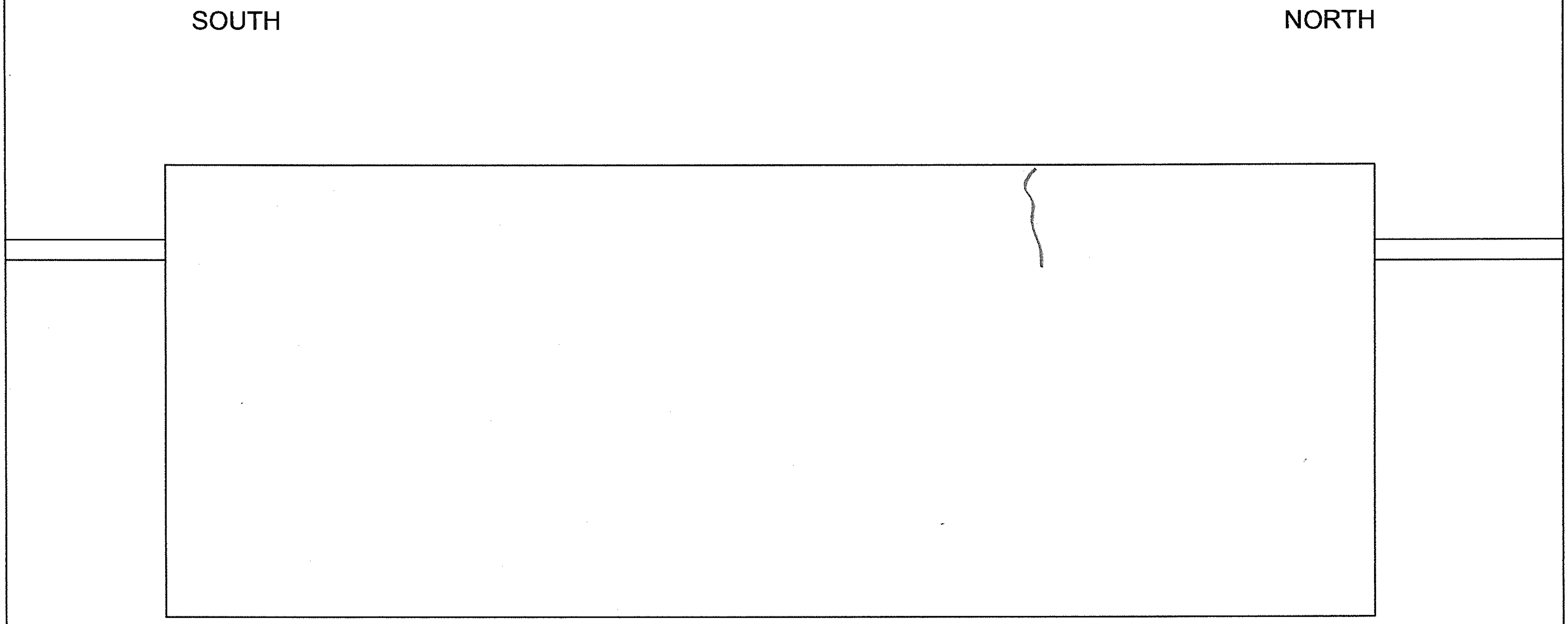


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D2 2/15/17

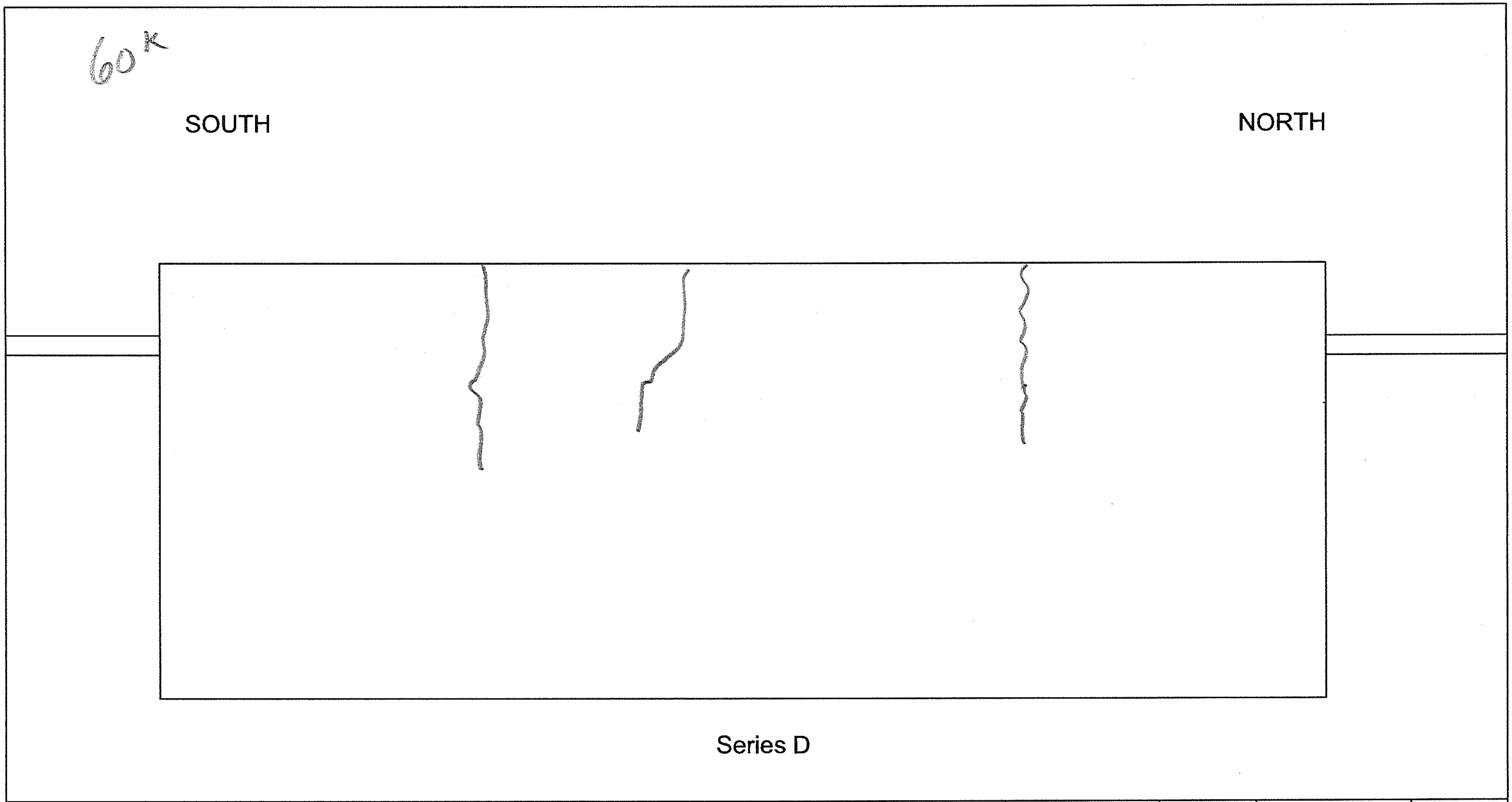
40k



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D2 2/15/17

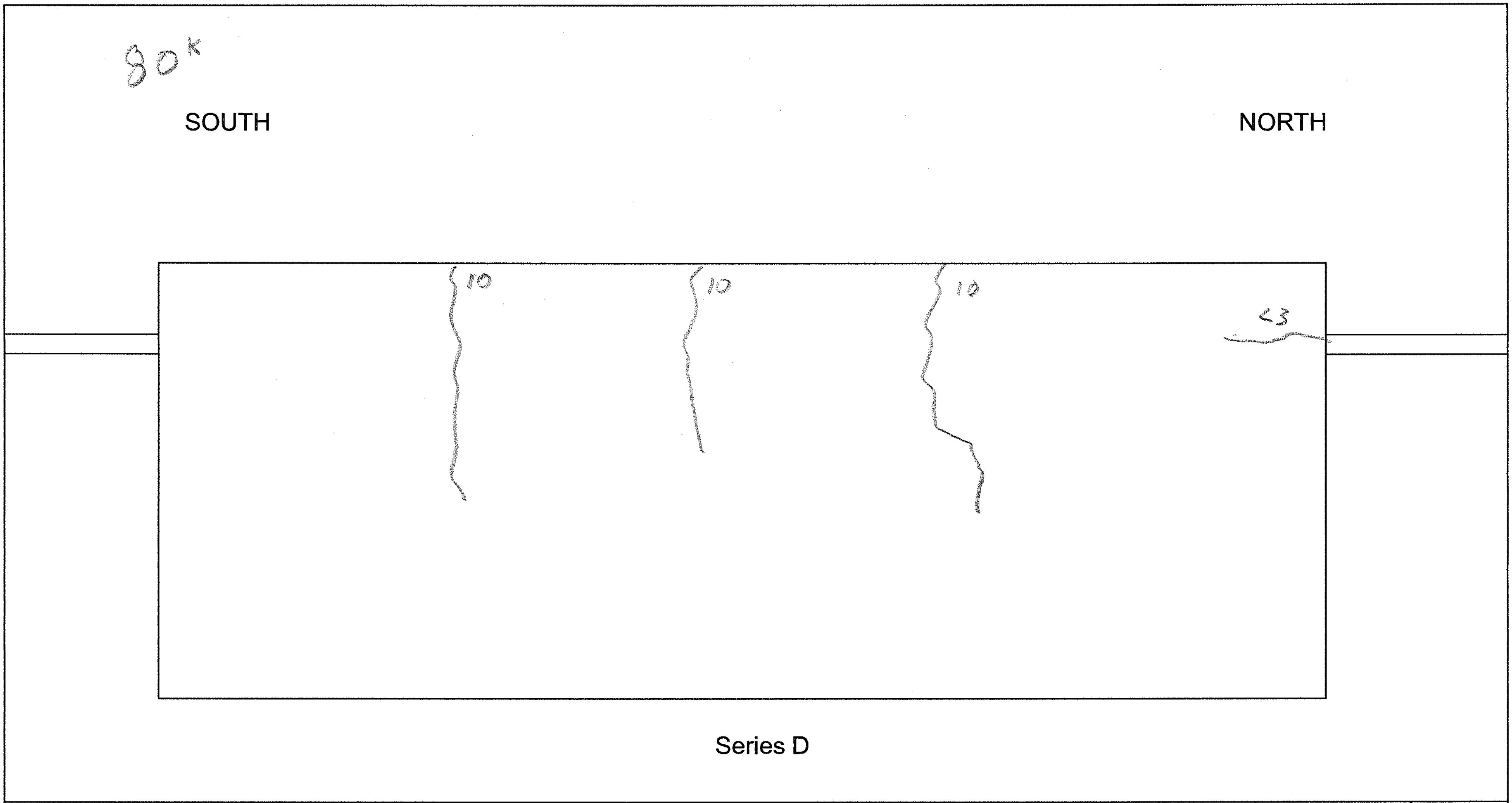


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D2 2/15/17

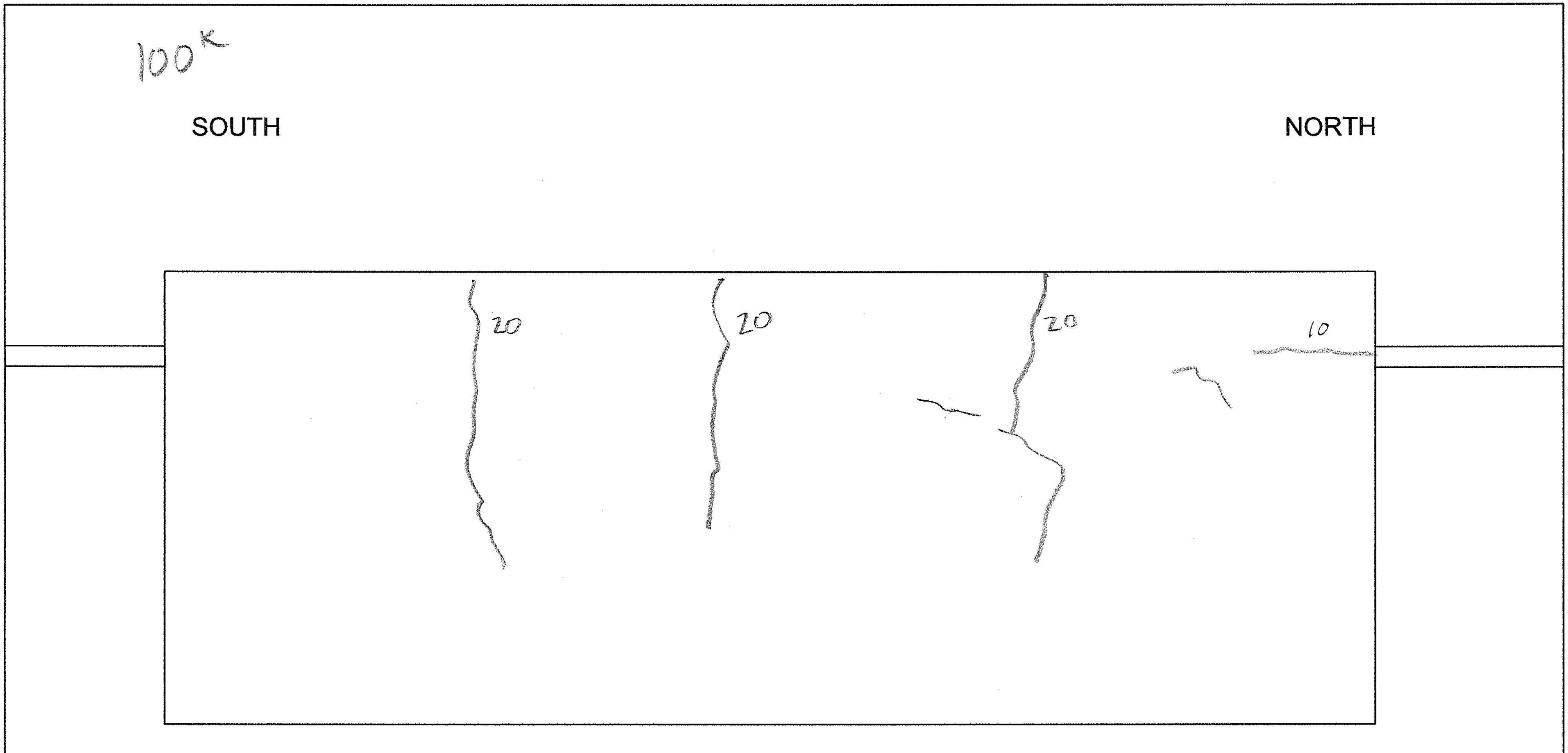
80k



Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D2 2/15/17



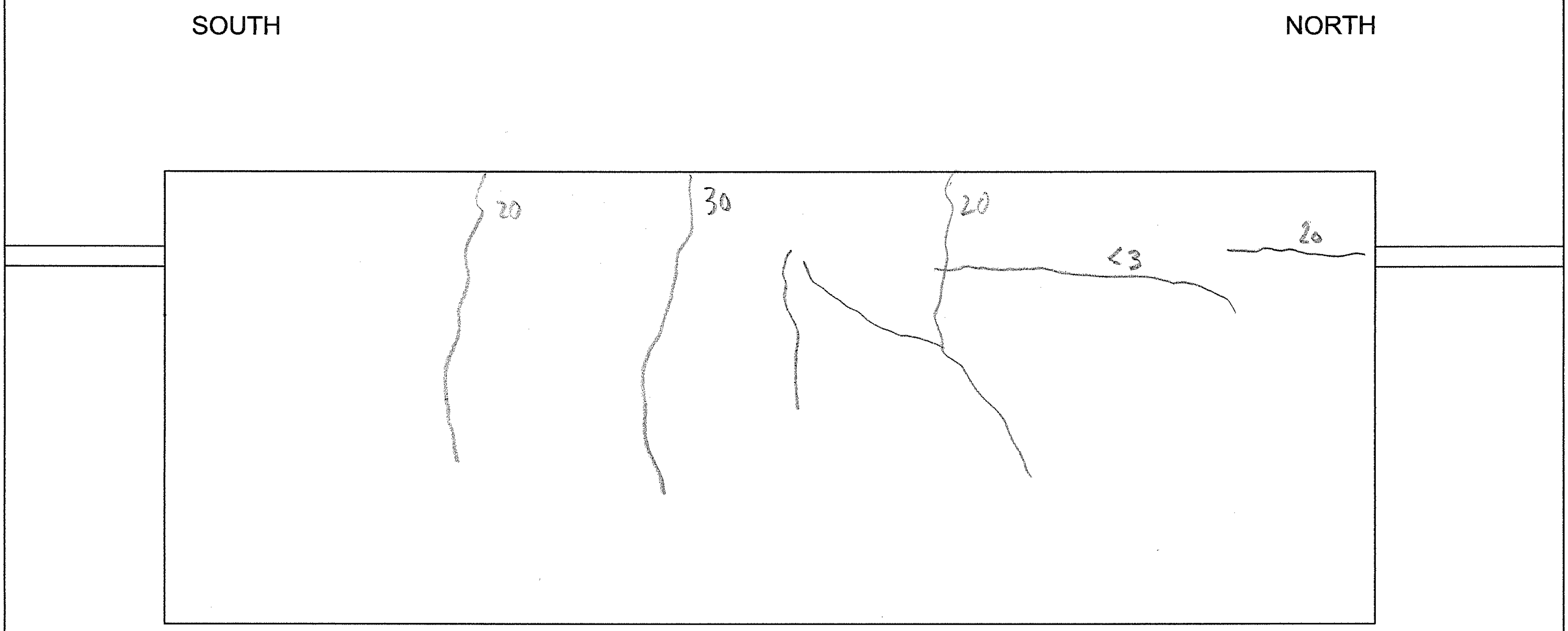
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D2 2/15/17

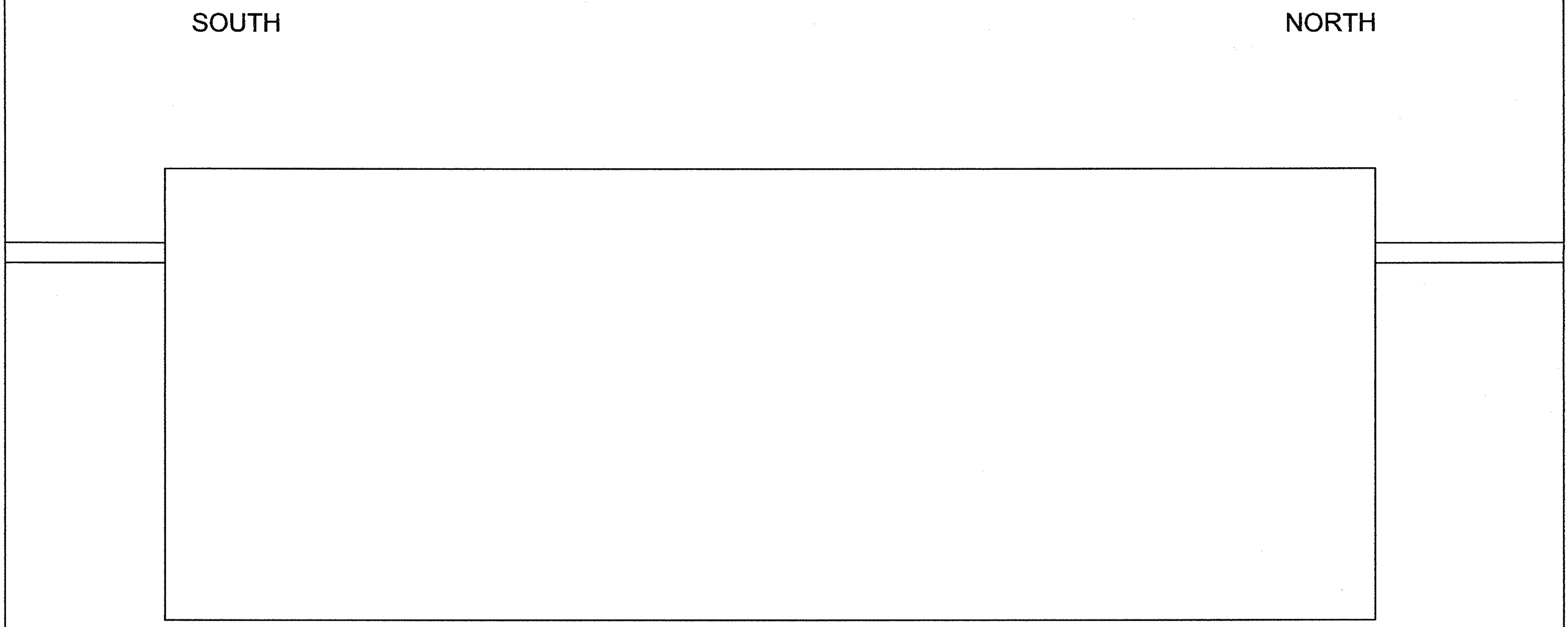
110^k



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

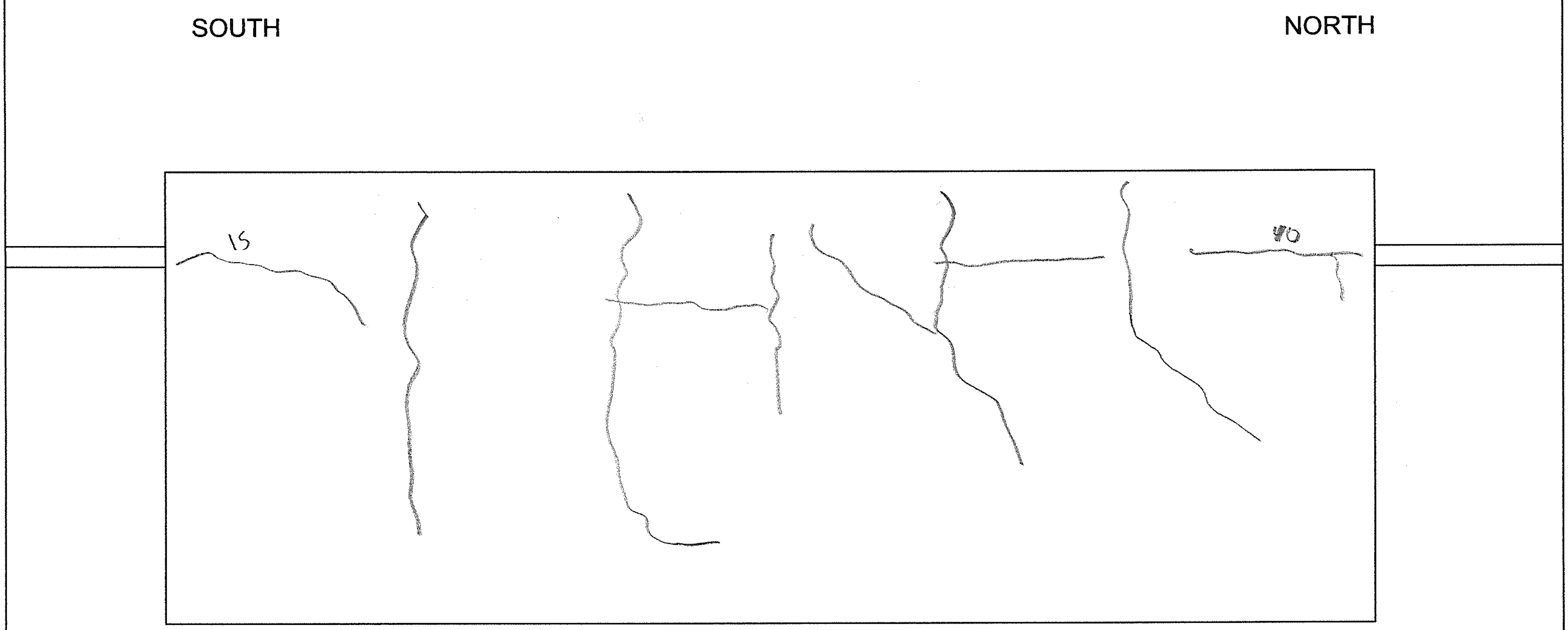
120^{k}, 123^{k} no cracks



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

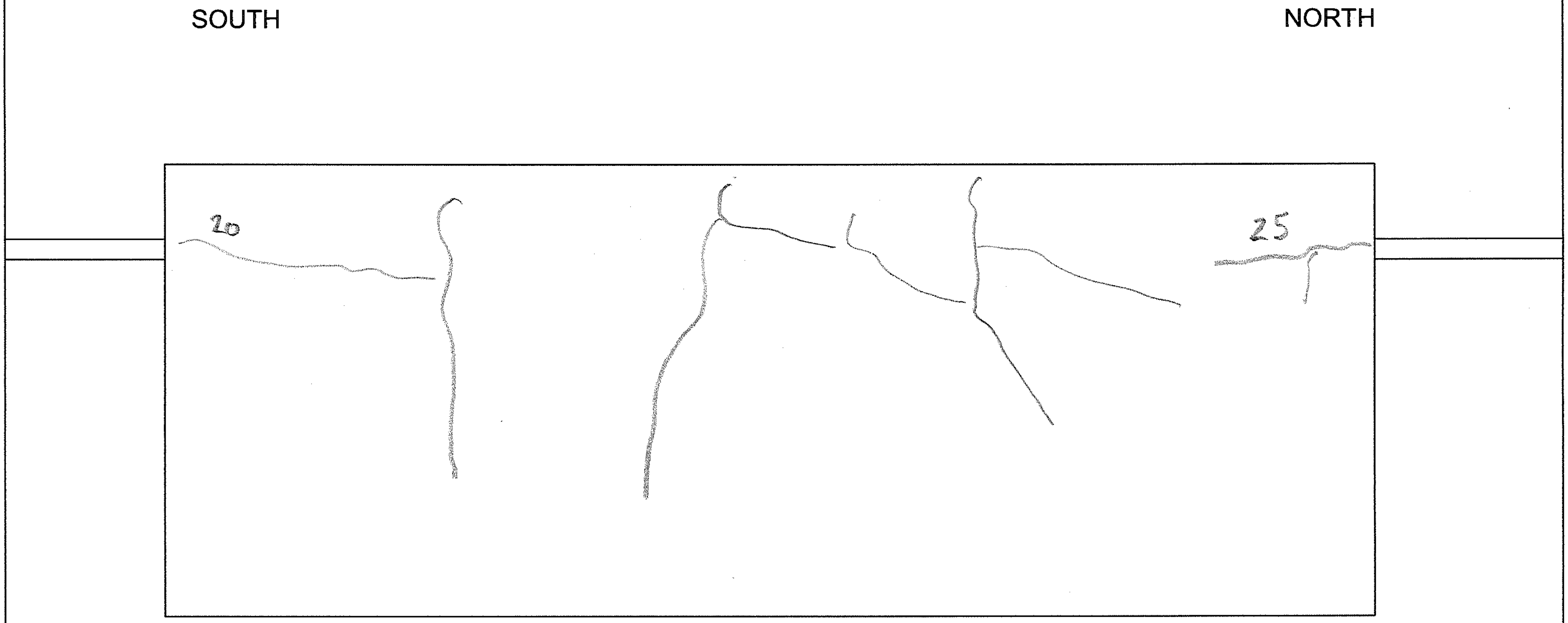
20^{k} R



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

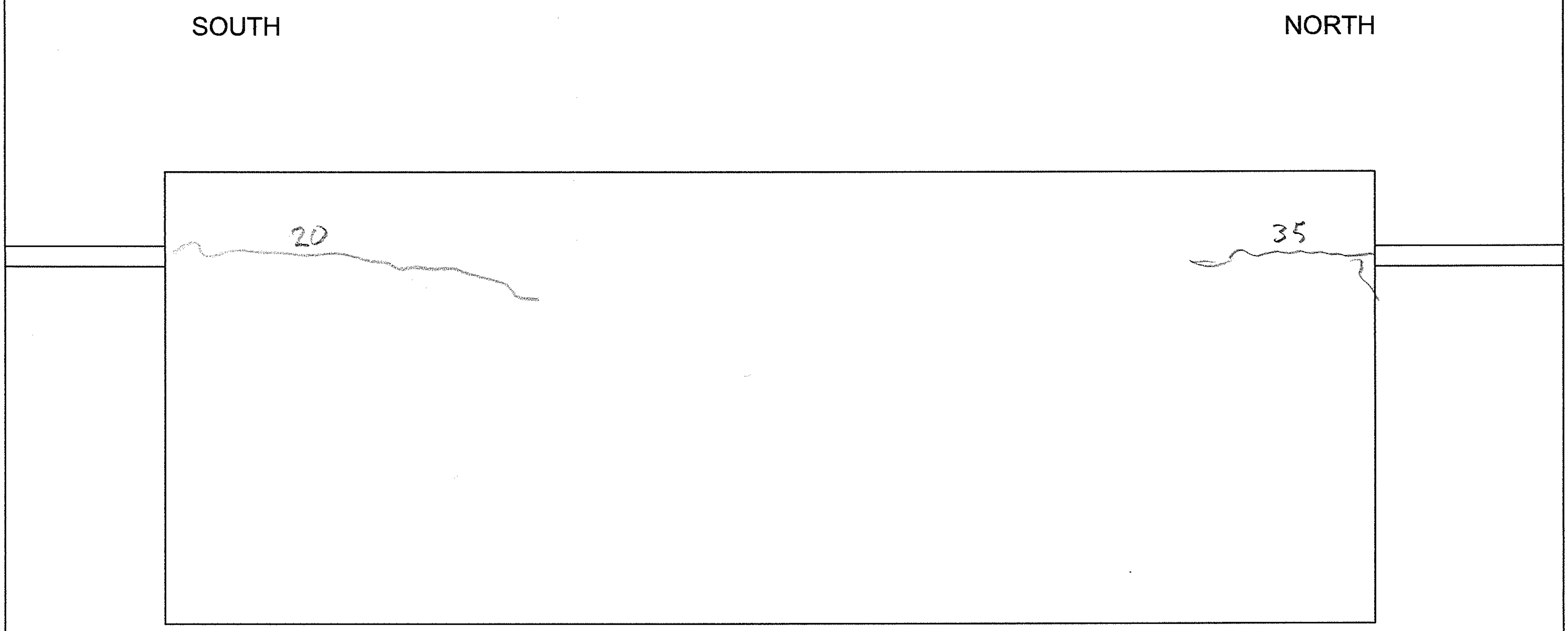
40k R



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

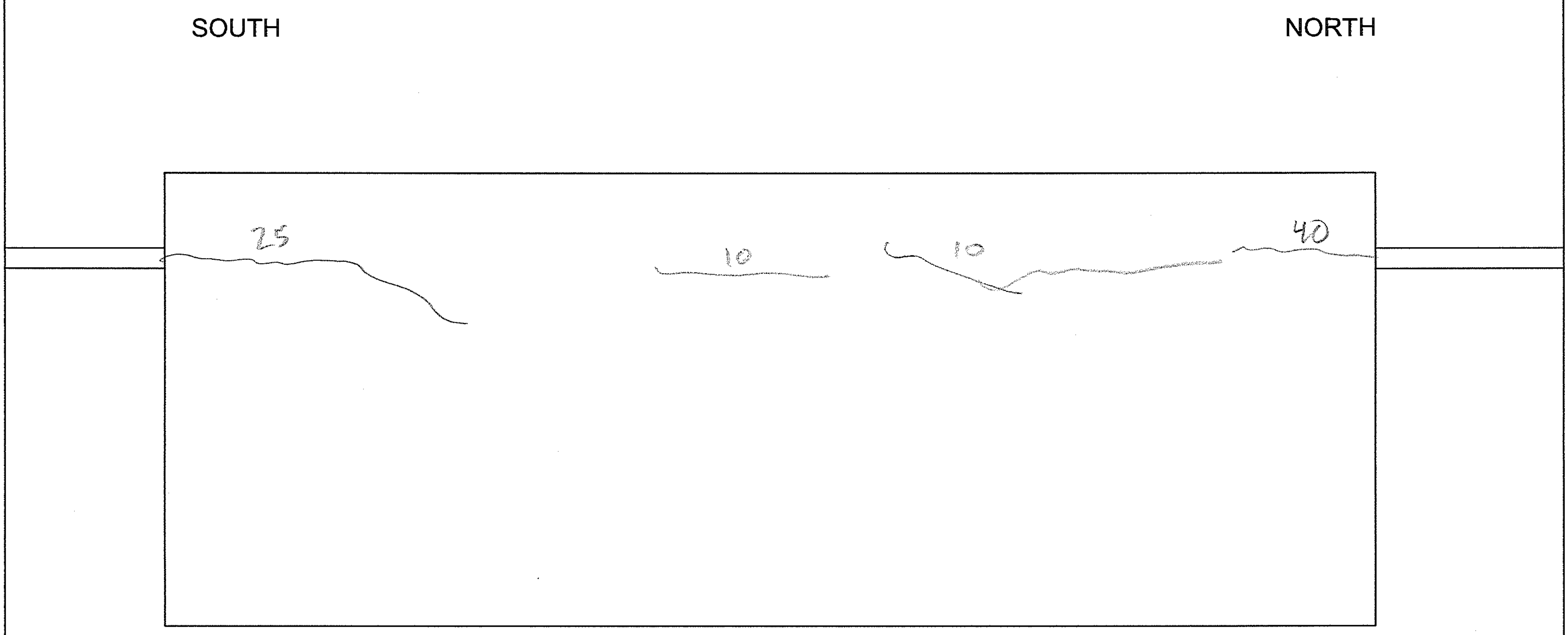
60^kR   only lam cracks measured



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

80^K R

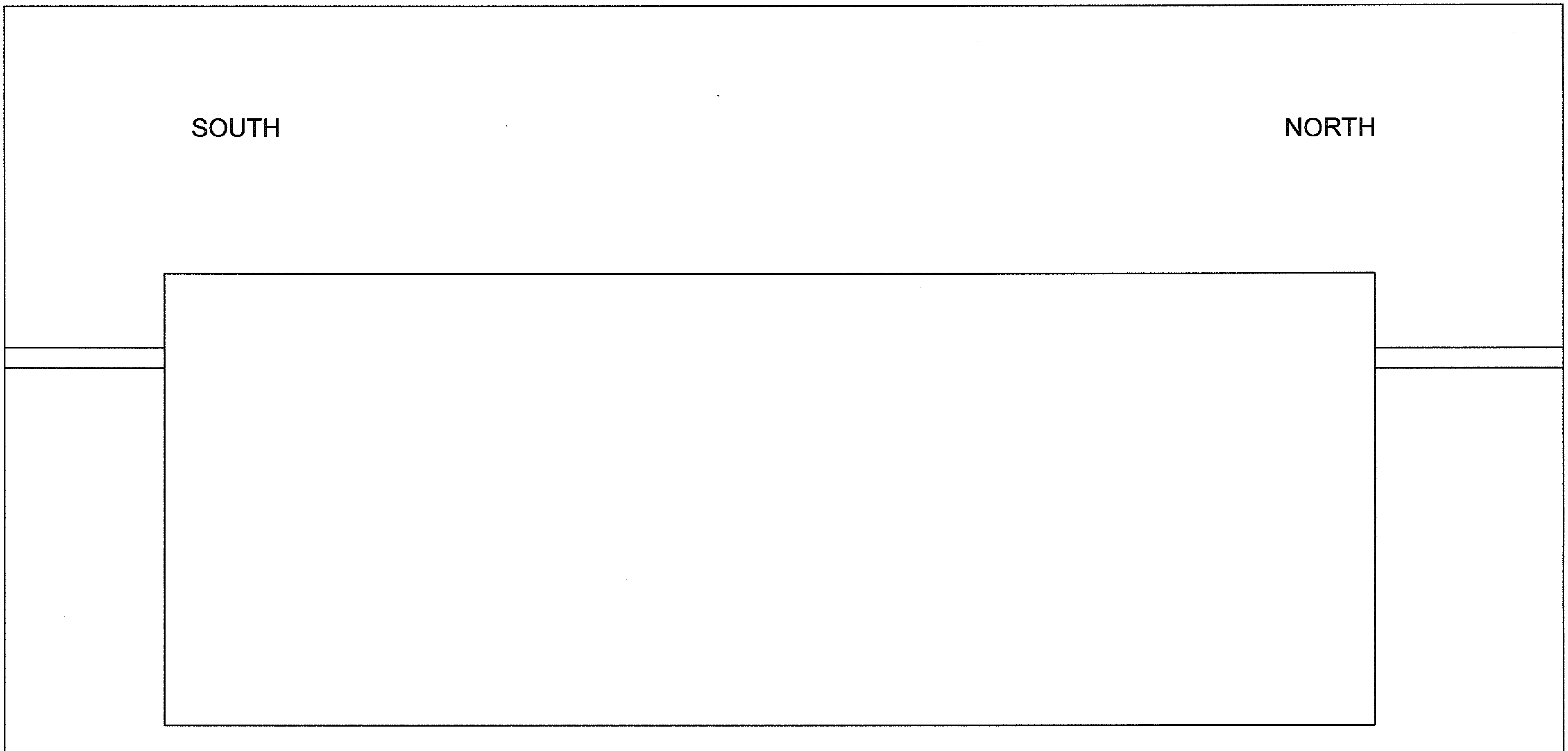


Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

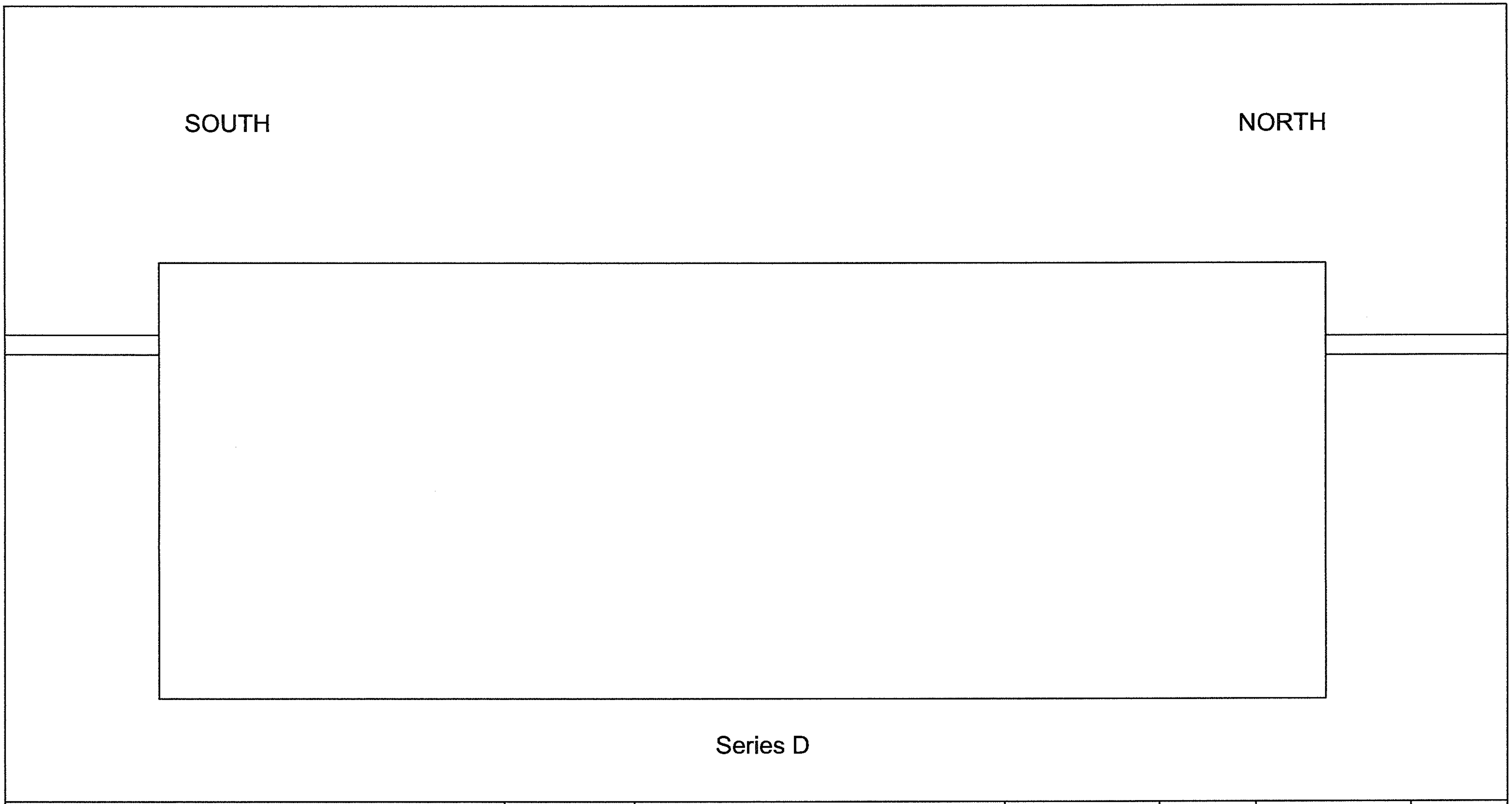
100 k R see photos



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

120^{k} R See photos



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1 of 1	
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D3

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 2/15/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skillen		2/15/17
Prateek Shah	PShah	2/15/17
Mete A Sozen	Mete A Sozen	2/15/17
Pete Carrato	PJ Carrato	2/15/17
WILL POLLALIS		2/15/17
Ash		02/15/17
S. Pujol	Pujol	02/15/17
Merve Usta		02/15/17
Lucas Laughery	Lucas Laughery	15/Feb/17

Recorded by: Checked by: Checked by:

Test: D3						Date: 2/15/17		
load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
Start	6:39							
20^{K}	6:40	20.2	20	0	0	0	0	0
40^{K}	6:44	40.5	39.7	0	.001	0	0	.001
60^{K}	6:48	60.3	59	0	.001	0	0	.001
80^{K}	6:54	80.2	80.1	0	.001	0	0	.001
100^{K}	7:00	100	99.6	0	.001	0	0	.001
110^{K}	7:04	109	109	0	.001	0	0	.001
120^{K}	7:09	118.5	117.4	.001	.001	0	.001	.001
125^{K}	7:14	123.6	122.5	.001	.001	0	.001	.001
128^{K}	7:19	127.5	126.3	.002	.001	0	.001	.002
135^{K}	7:25	134.4	133.2	.016	-.003	0	.001	.016
138^{K}	7:30	137	138	.110	.105			.110
Unload	7:34	0	0	.088	.085	0	0	.088
30^{K} R	7:39	30.5	30.3	.088	.084	0	0	.088
60^{K} R	7:44	60.5	60.2	.090	.085	0	0	.090

Notes:

@ 128^{K} NW LVDT moved to -.003

.1" crack width achieved before reload

Recorded by:

Kinsey Skiller

Signature:

Test: D3

Date:

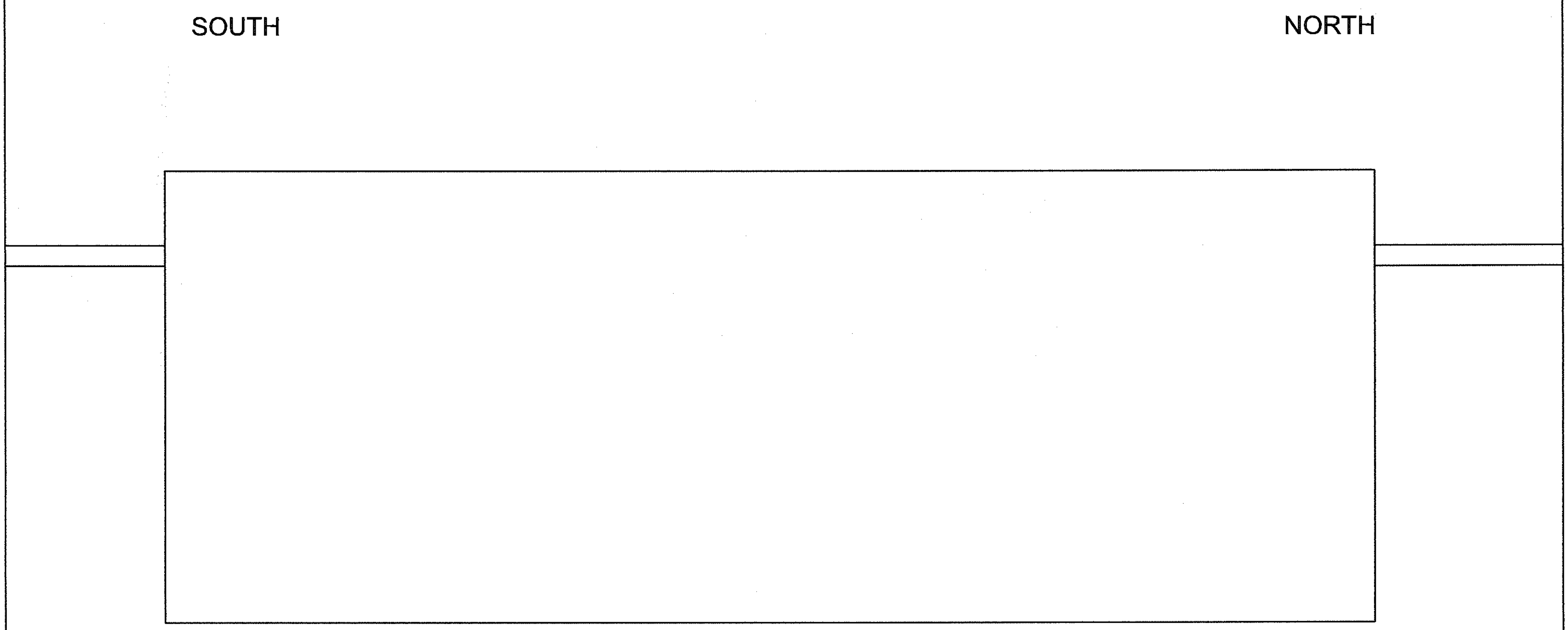
load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
90^{k} R	7:48	90.9	90.8	.099	.092	0	0	.092
120^{k} R	7:50	122	120	.117	.107	0	0	.117

Notes:

Recorded by:

Signature:

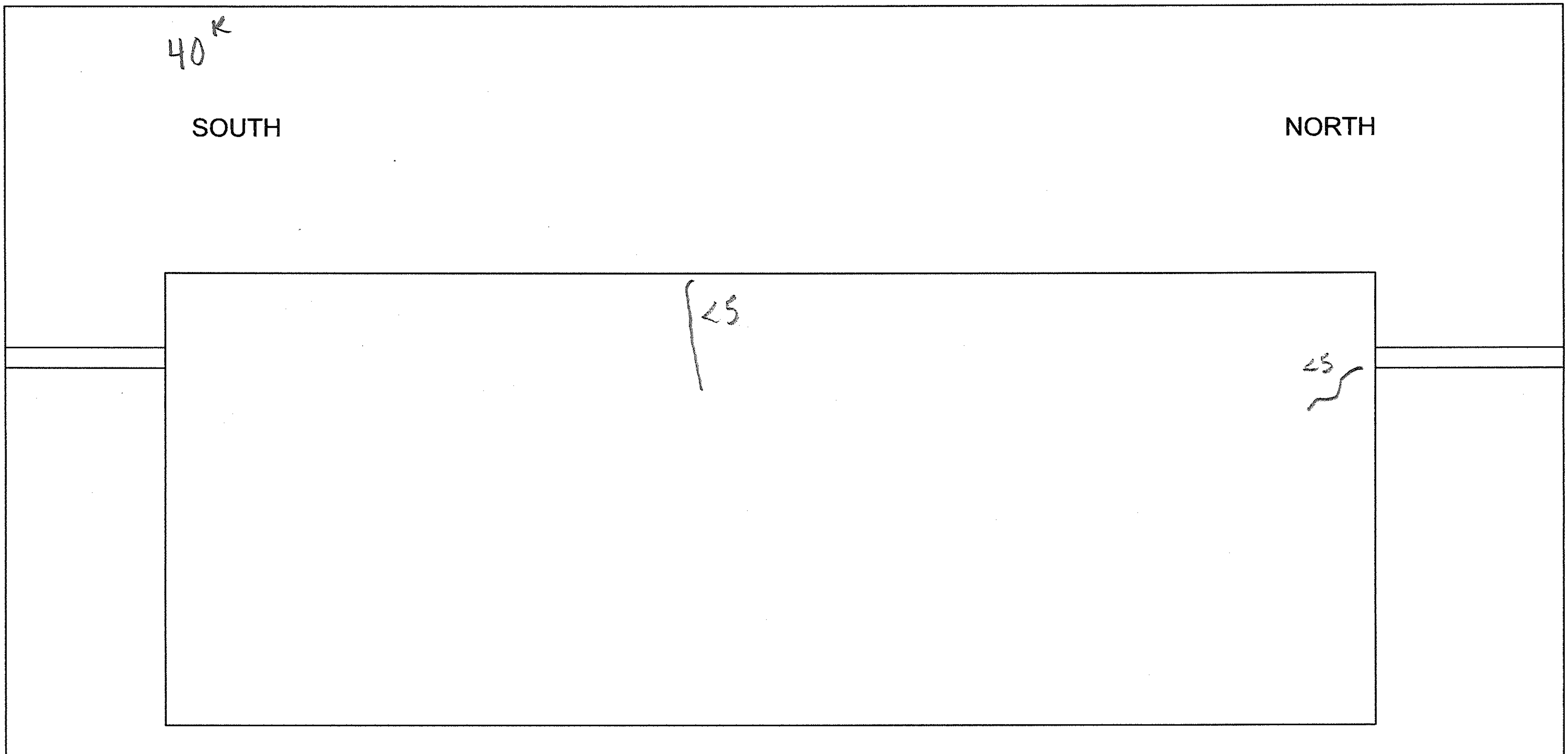
20^{K} no cracks



Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

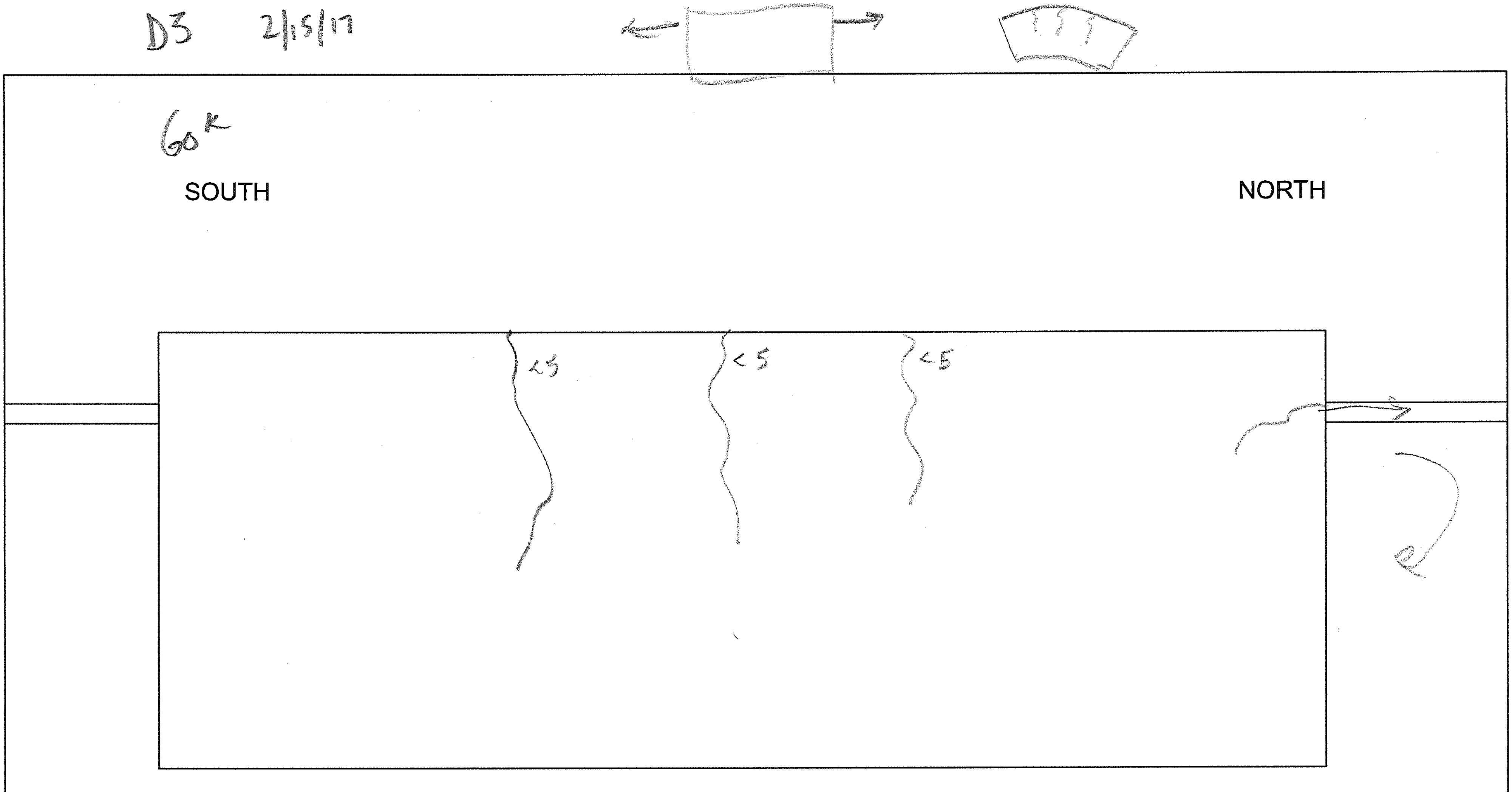
Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		



Series D

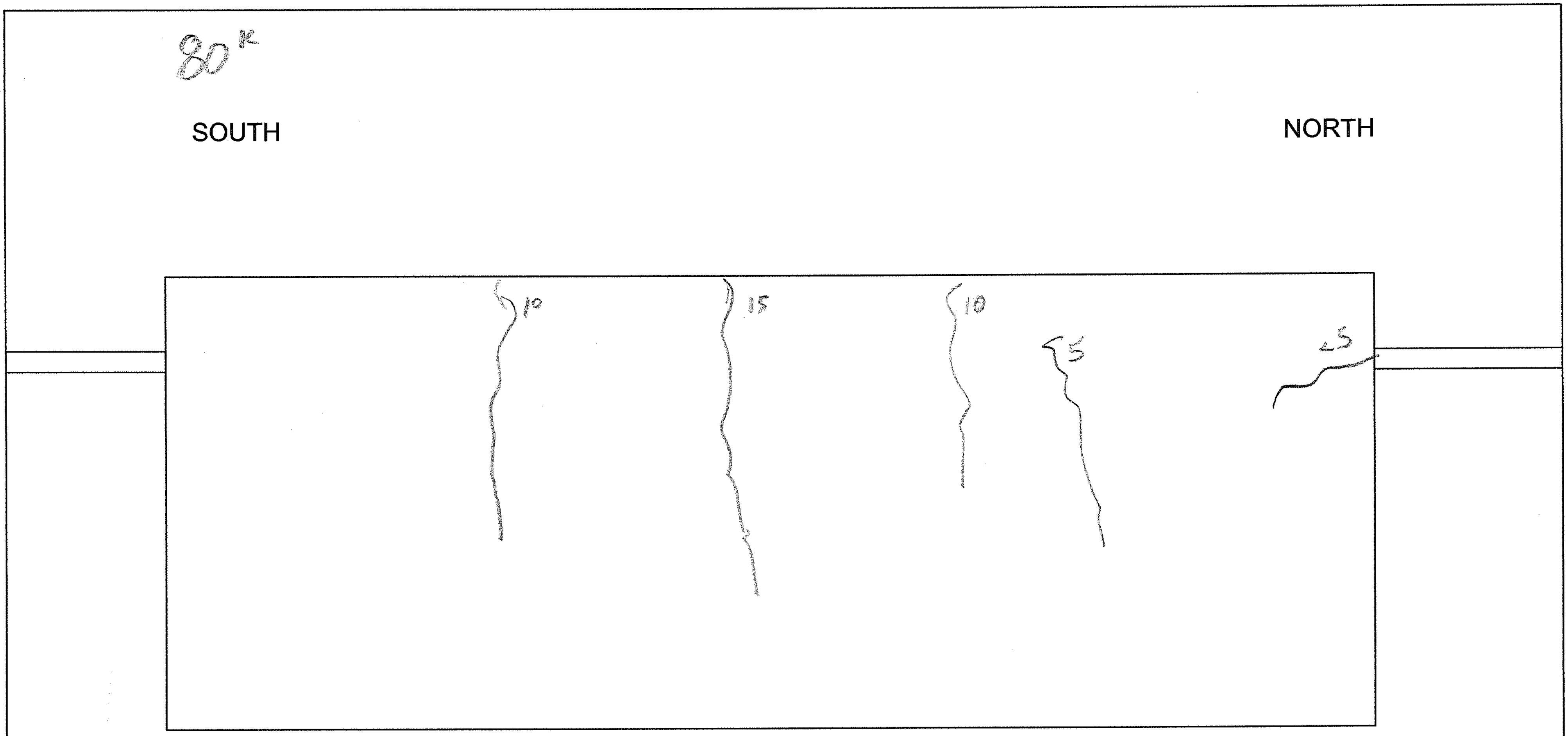
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D3 2/15/17



Series D

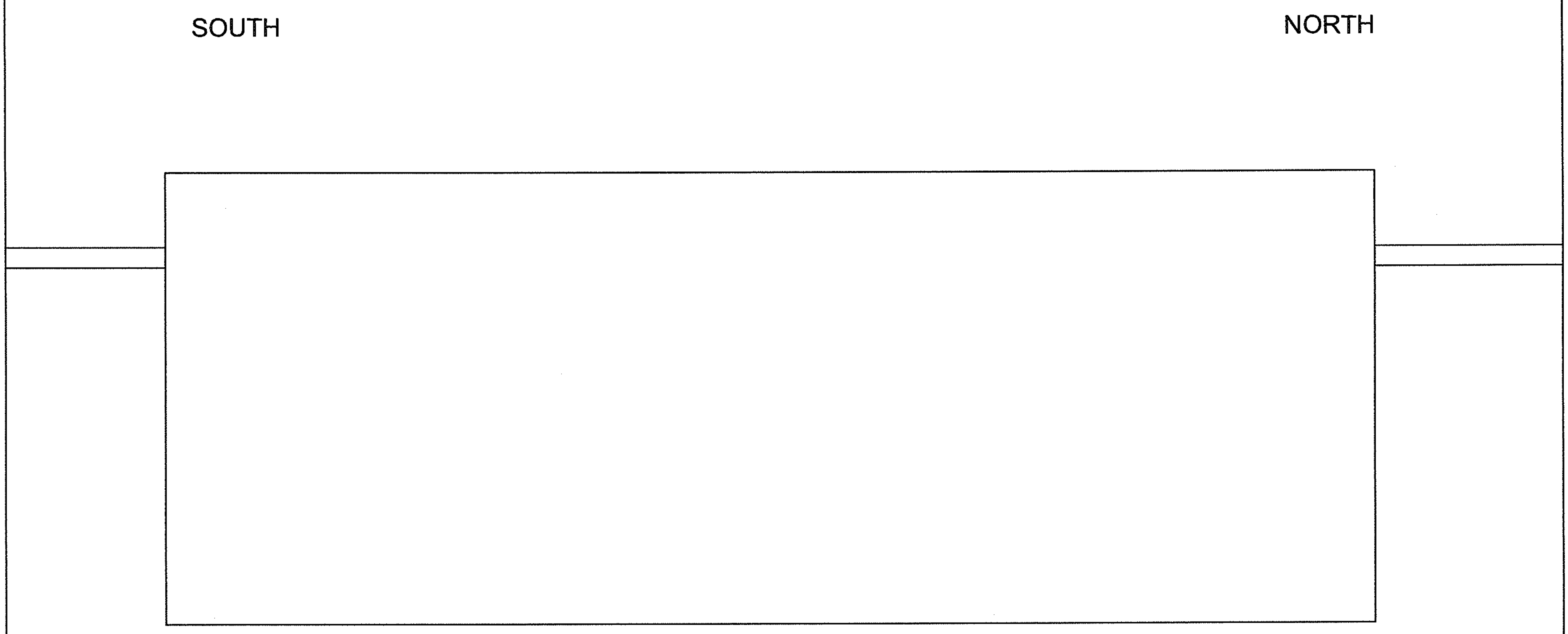
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		



Series D

BOWEN LABORATORY **PURDUE UNIVERSITY**	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

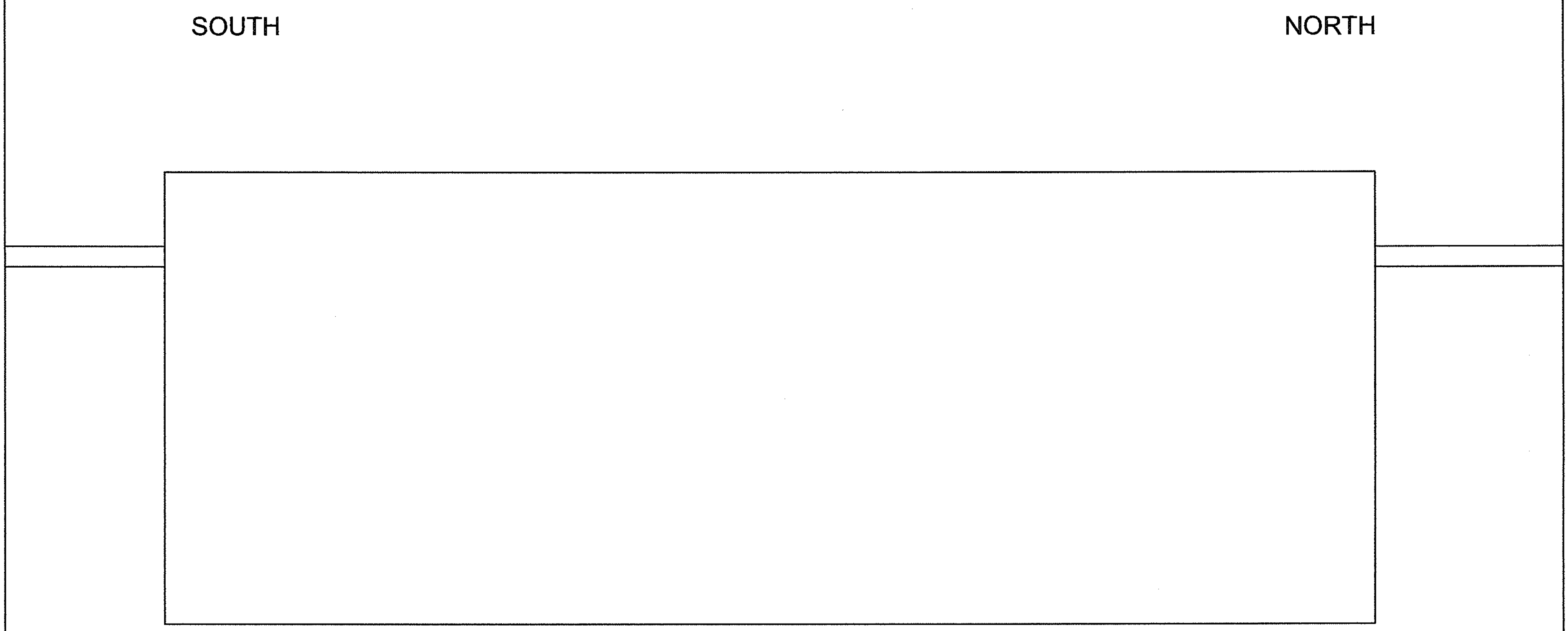
100^k no lam marks



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

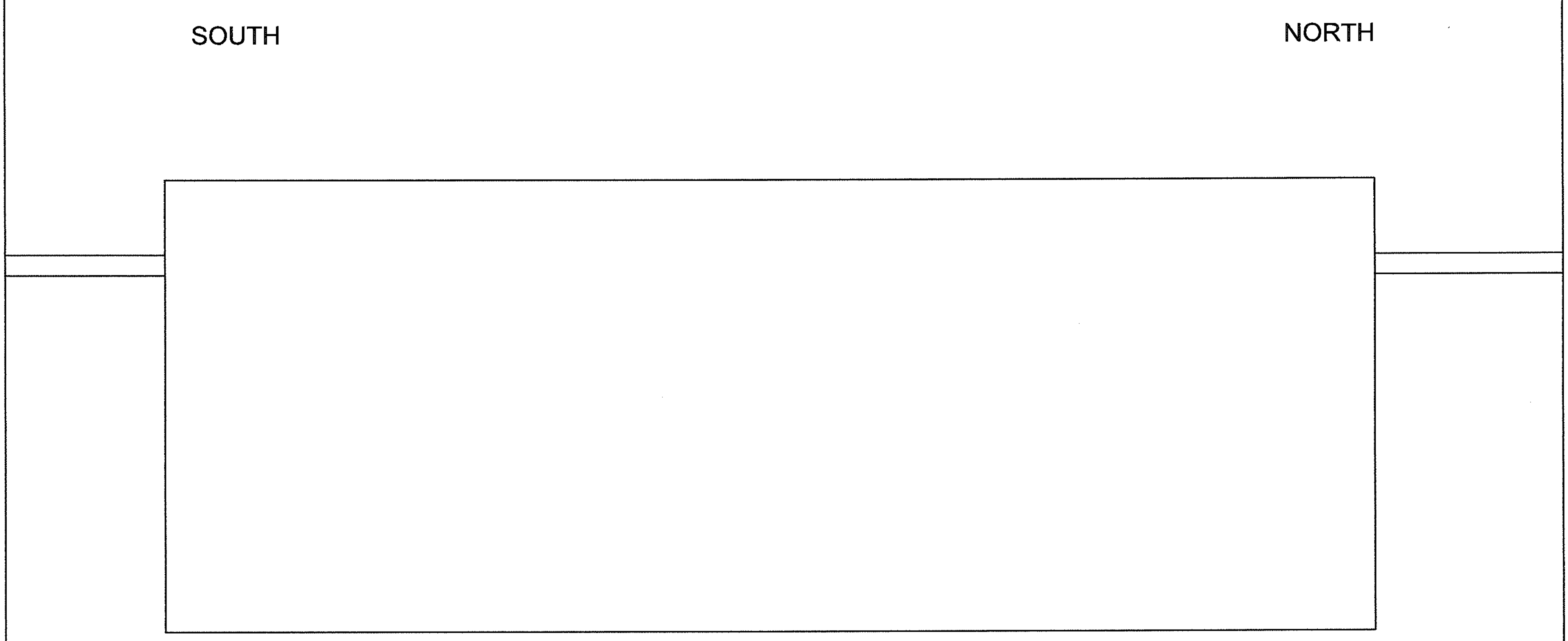
120^{k} No cracks marked



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

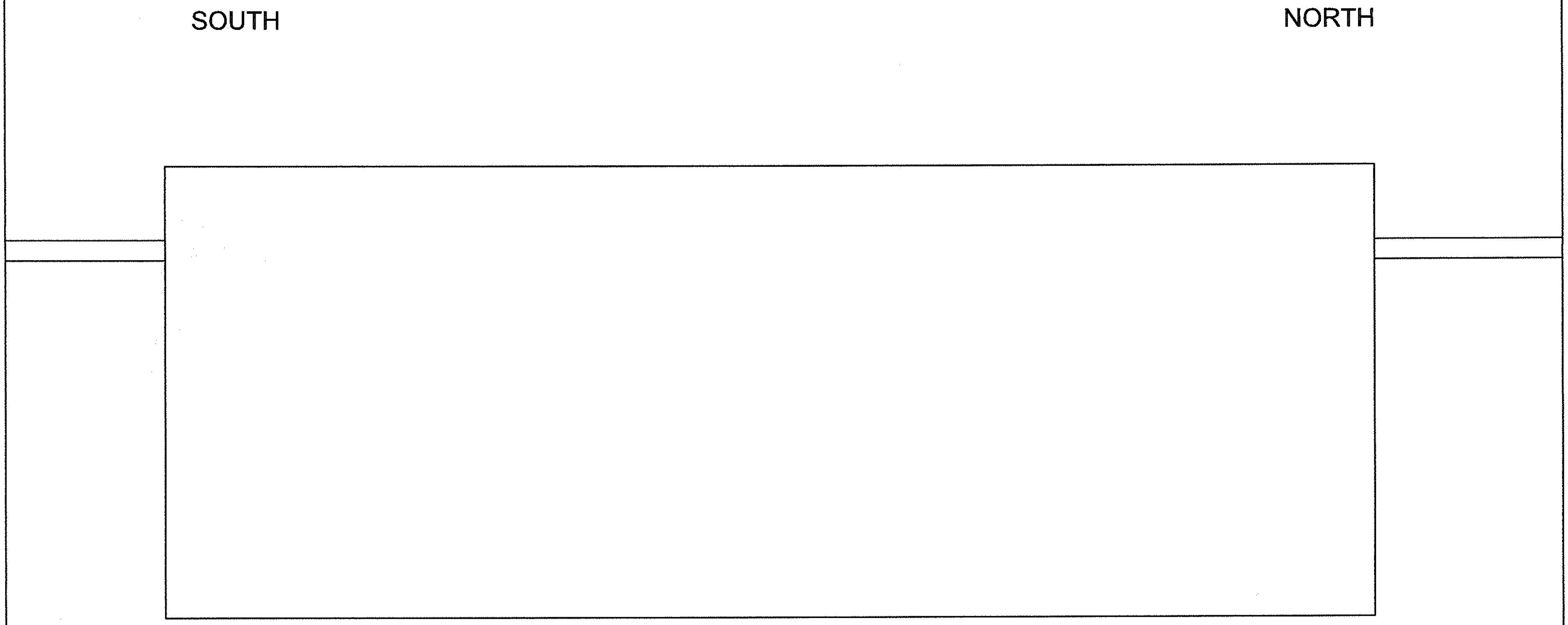
125^k no cracks



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

138^{K} → unload

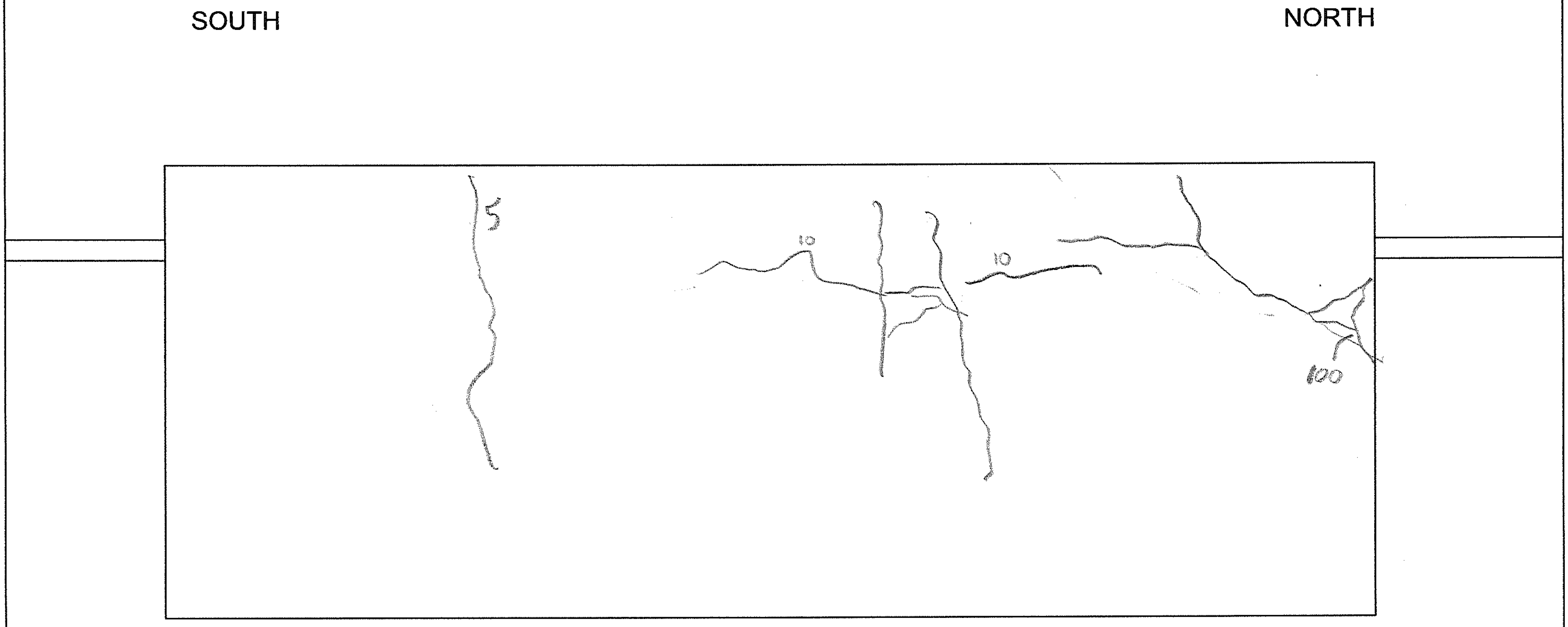


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

30^k Reload



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D4

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 2/20/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skiller		2/20/17
Prateek Shah		2/20/17
AISHWARYA PURANAM	Aishwarya	2/20/17
WILL POLLALIS		2/20/17
LUCAS LAUGHERY	Lucas Laughery	20/Feb/17
JASPAL SAINI	JSaini	02/20/17
Mete A. Sozen		2/20/17

Recorded by: Checked by: Checked by:

Test: D4

Date: 2/20/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0K	3:43	0	0	0	0	0	0	—
20K	3:55	20.7	20.3	.001	0	0	0	—
40K	3:58	40.1	40.2	.001	0	0	0	—
60K	4:03	60.6	60.3	.003	0	0	0	—
80K	4:09	79.7	79.7	.004	0	0	0	—
100K	4:15	100	100	.006	0	0	.001	—
110K	4:23	109	109	.008	0	.001	.001	.008
120K	4:29	118	118	.009	0	.001	0	.009
127K	4:36	127	127	.036	0	.001	0	.036
130K	4:40	130	130	.060	0	.001	0	.060
0K	4:43	0	0	.043 -	0	0	0	.043
Epoxy	6:00 pm							

Notes:

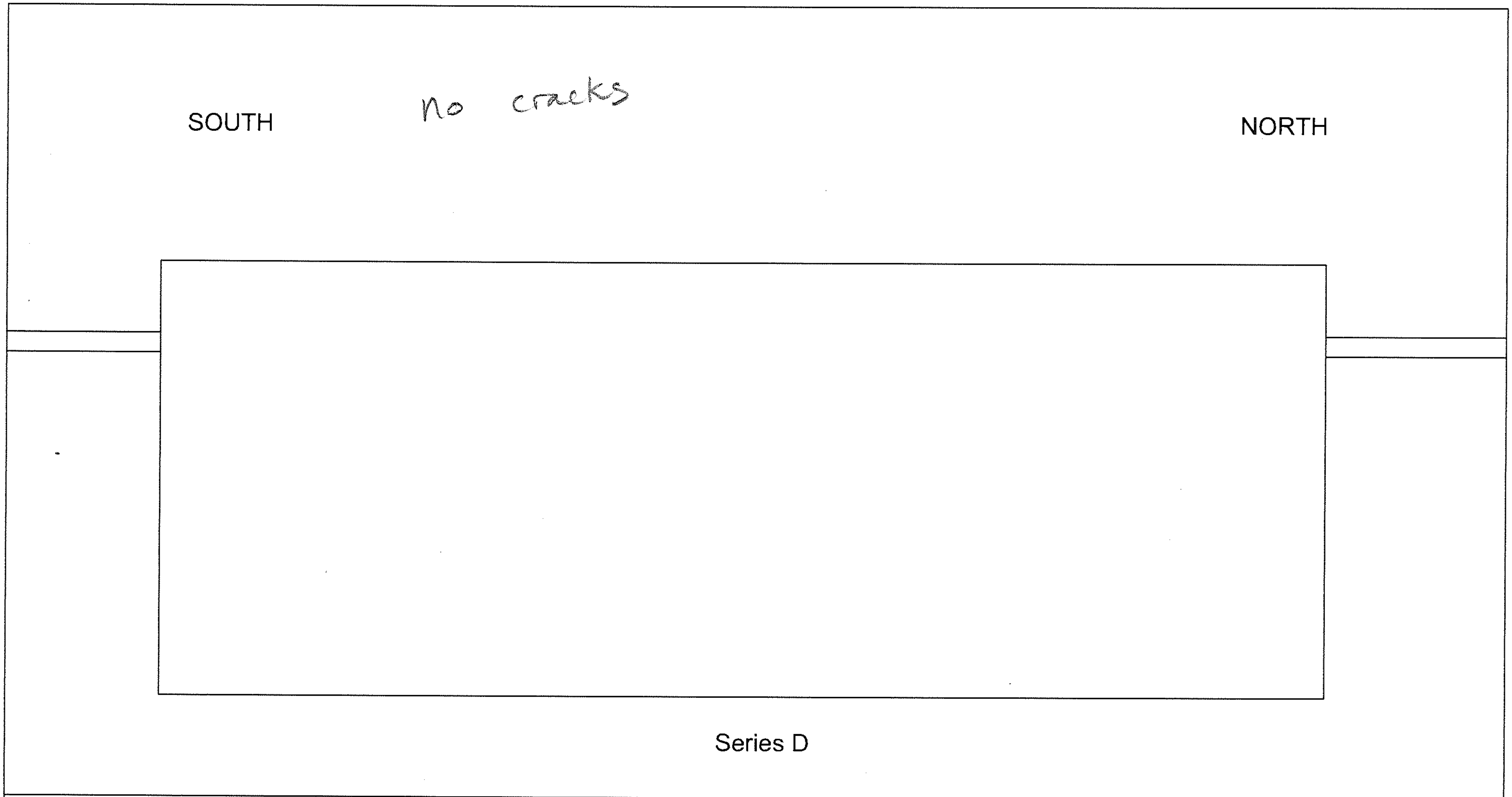
Anchors embedded 10", possible dust in hole

0.60" crack width added before anchor installed, 24 hr cure time

Recorded by: Kinsey Skiller

Signature:

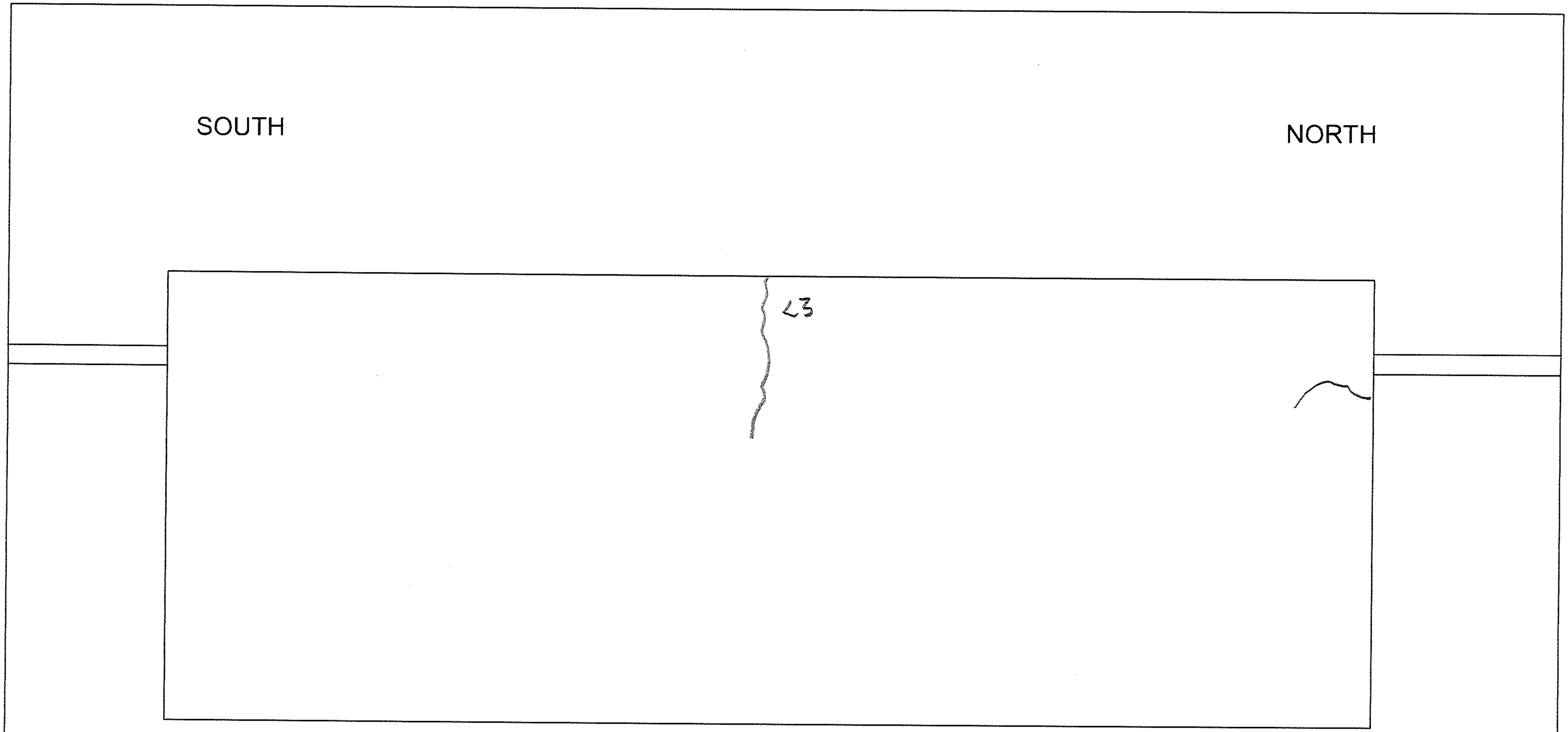
D4 20^{k}



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D4 40^{k}

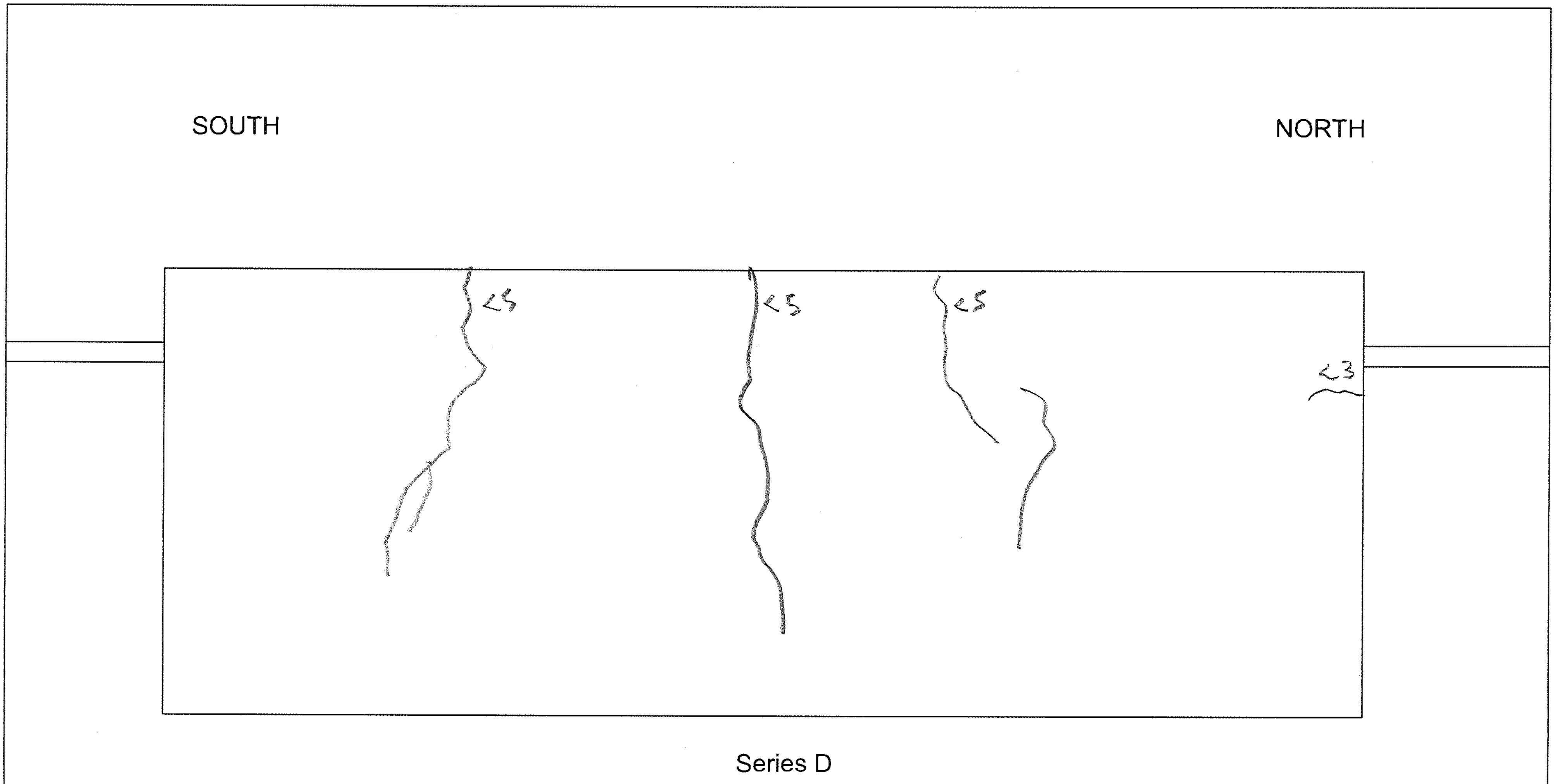


Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

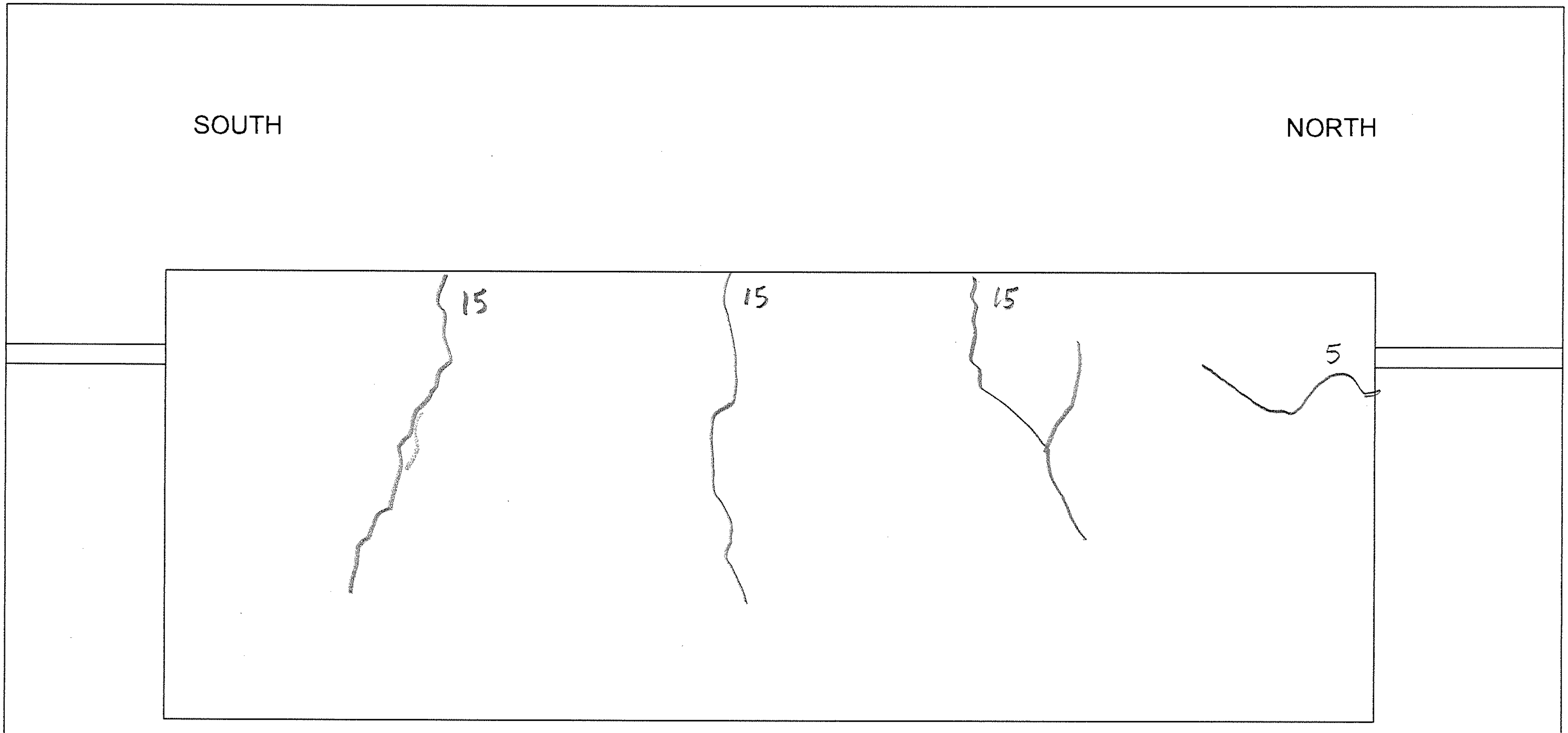
D4 60^{k}



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

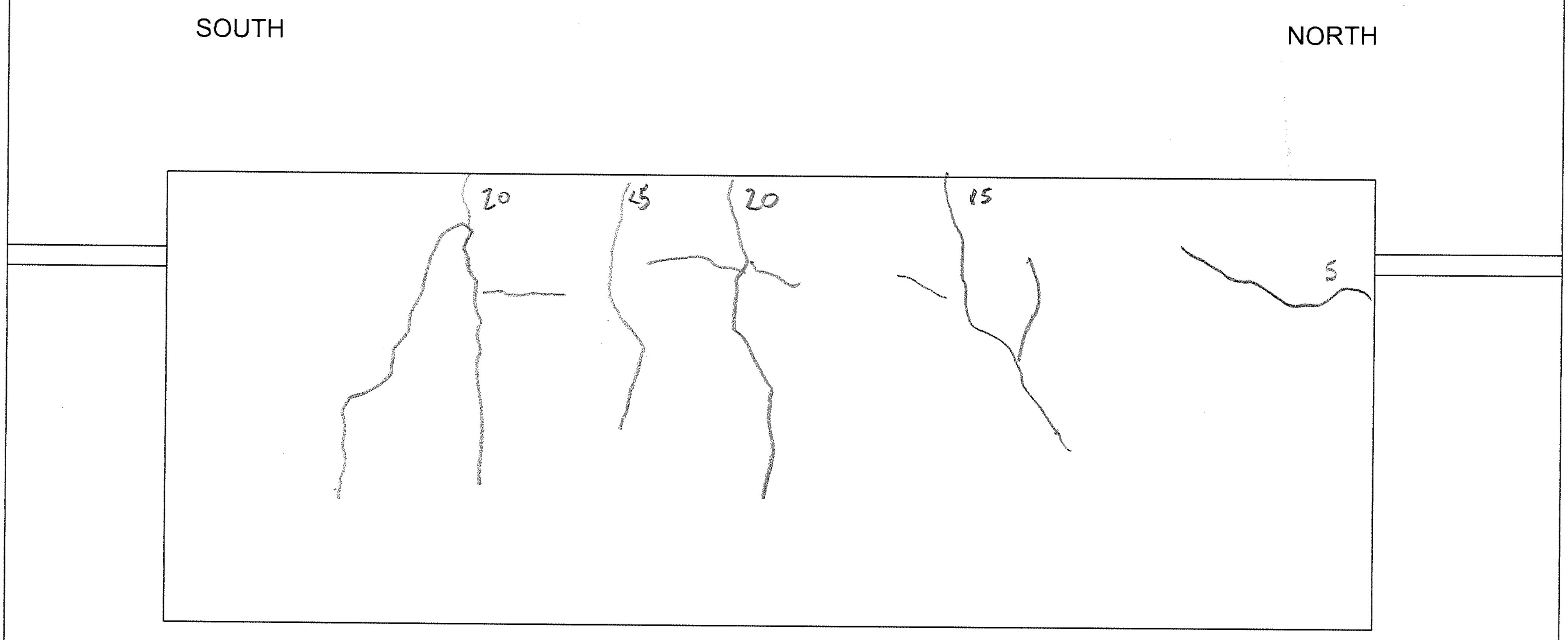
D4 80k



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D4 100^{k}

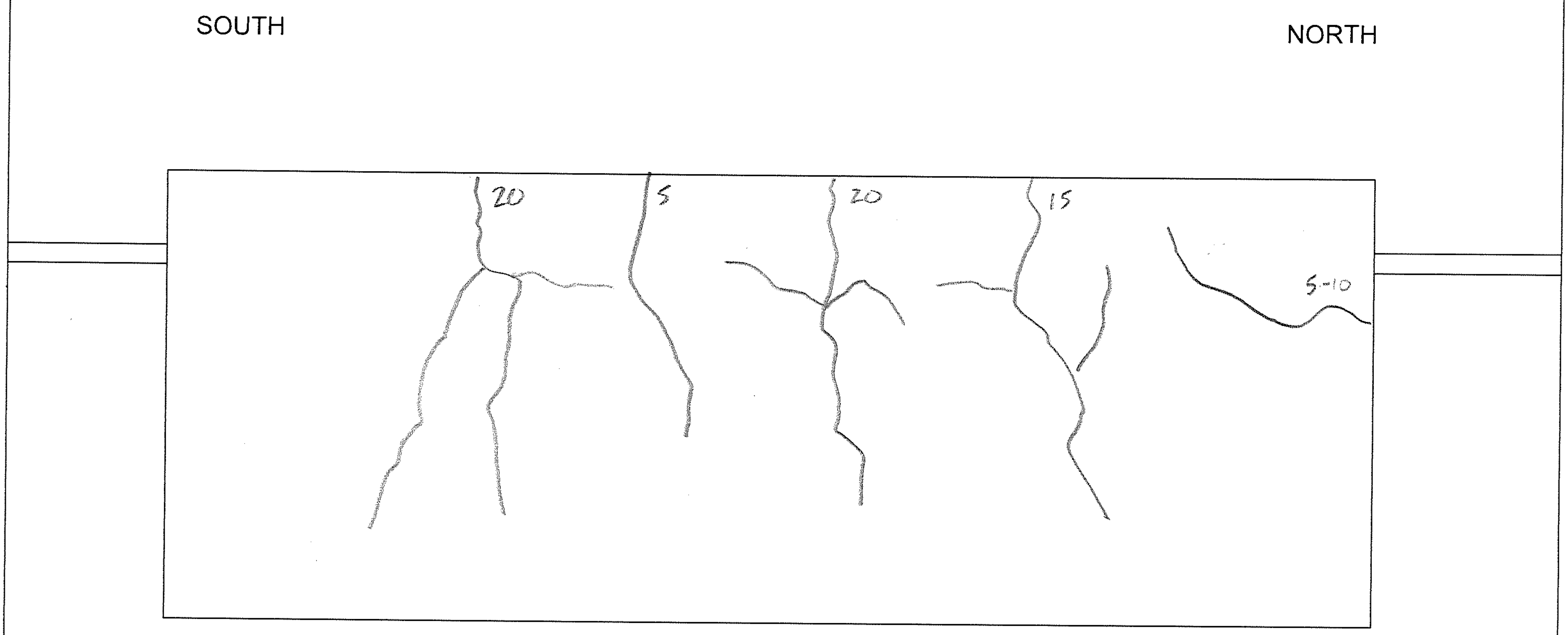


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D4 110^K



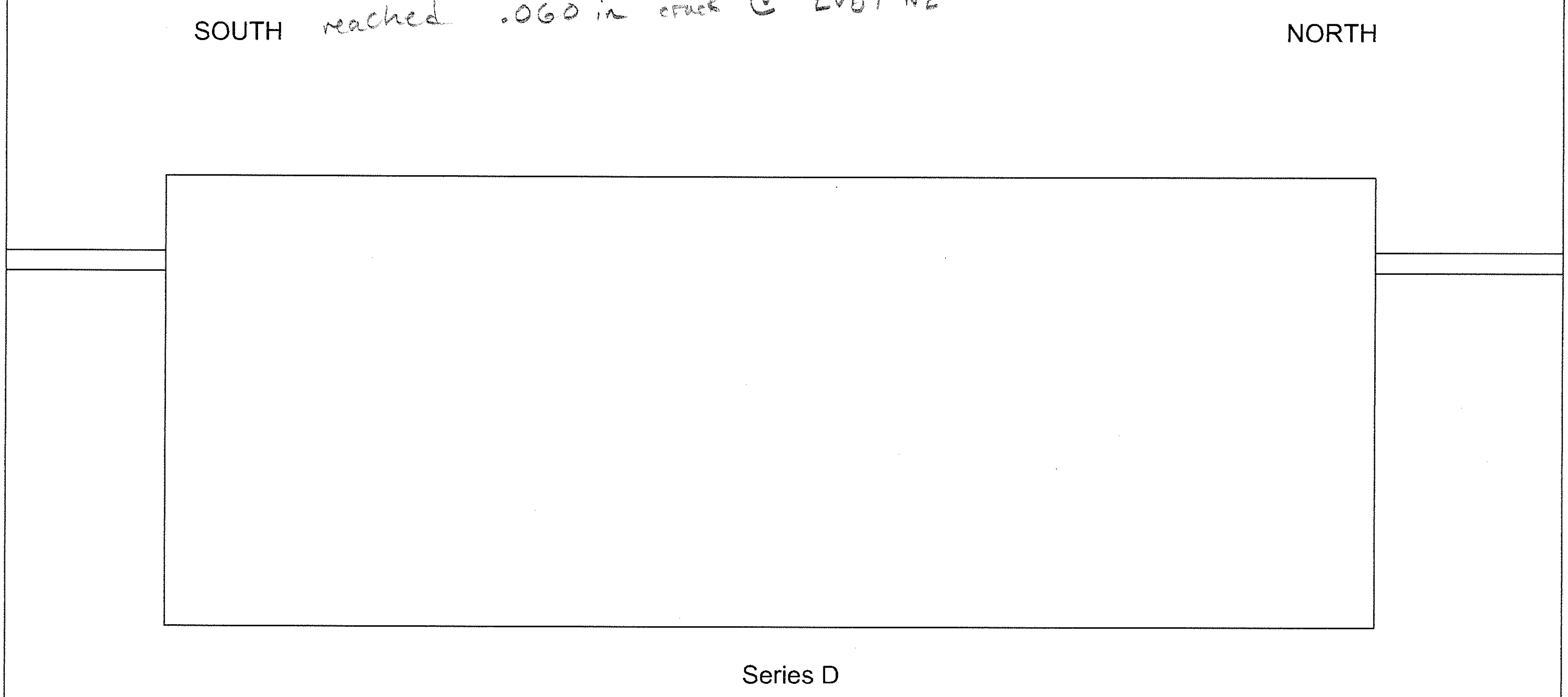
Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D4 130^{K}

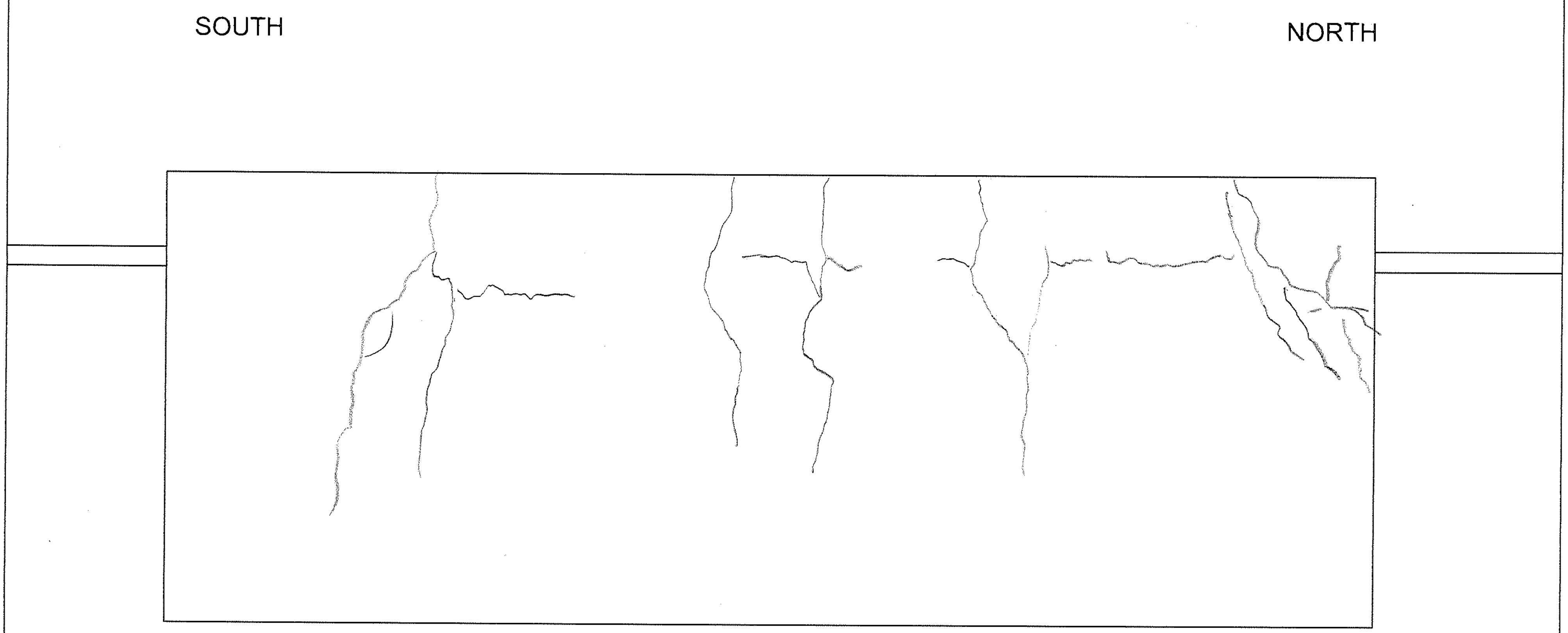
no cracks marked

reached .060 in crack @ LVDT NE



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1 of 1	
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D4 unload OK



Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Test: DH Reload w/ Anchors

Date: 2/21/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0k	6:48 pm	0	0	.043	0	0	-.003	.043
20k	6:54	19.9	20	.043	0	0	-.003	.043
40k	6:59	39.9	39.8	.044	0	0	-.003	.044
60k	7:01	60.1	59.9	.045	0	0.001	-.003	.045
80k	7:07	80	80.7	.049	0	.001	-.003	.049
100k	7:13	100	99.9	.053	0	.001	-.003	.053
110k	7:19	110	110	.056	0	.001	-.003	.056
120k	7:24	120	120	.059	0	.001	-.003	.059
125k	7:29	124.5	124.5	.061	0	.001	-.003	.061
130k	7:34	130.2	130.4	.065	-.001	.002	-.003	.065
135k	7:40	134.4	134.6	.071	-.001	.002	-.003	.071
137k								
Failure								

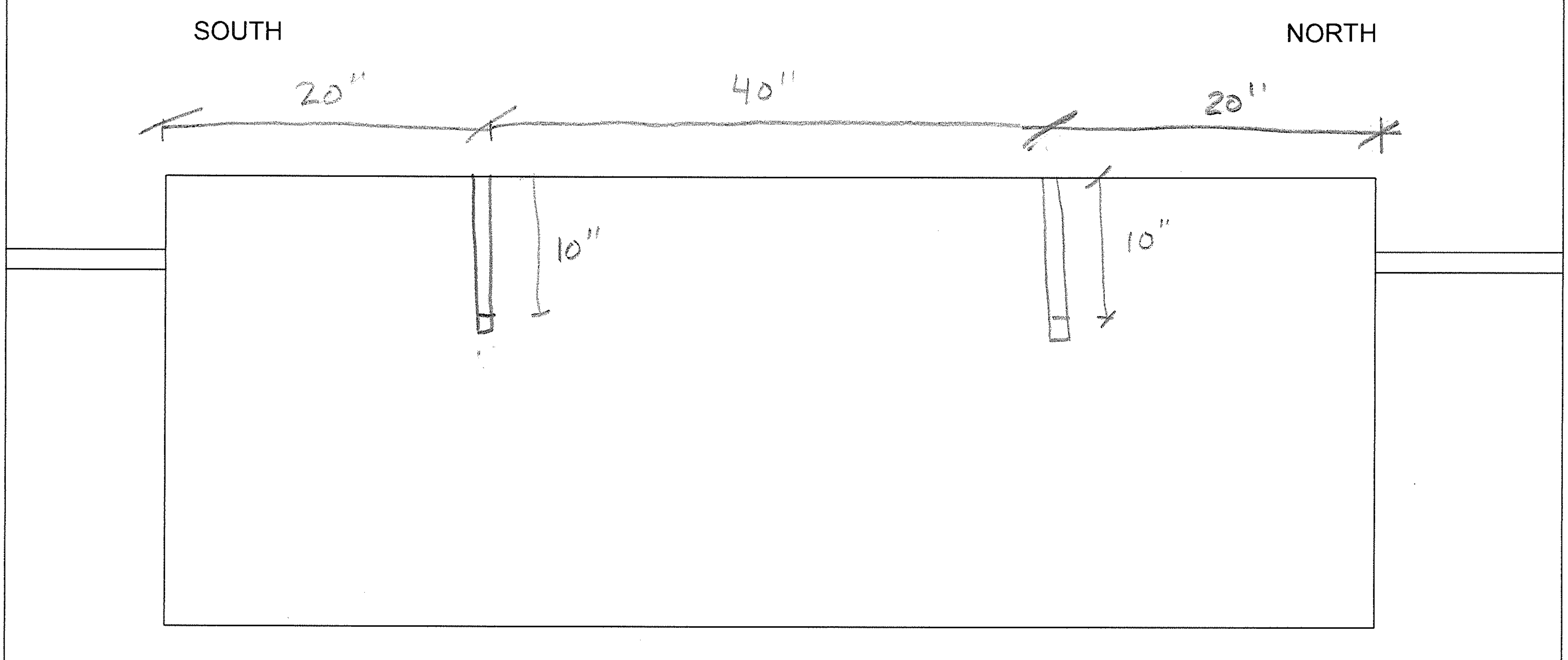
Notes:

24 hr cure time from anchor install

Recorded by: Kinsey Skiller

Signature:

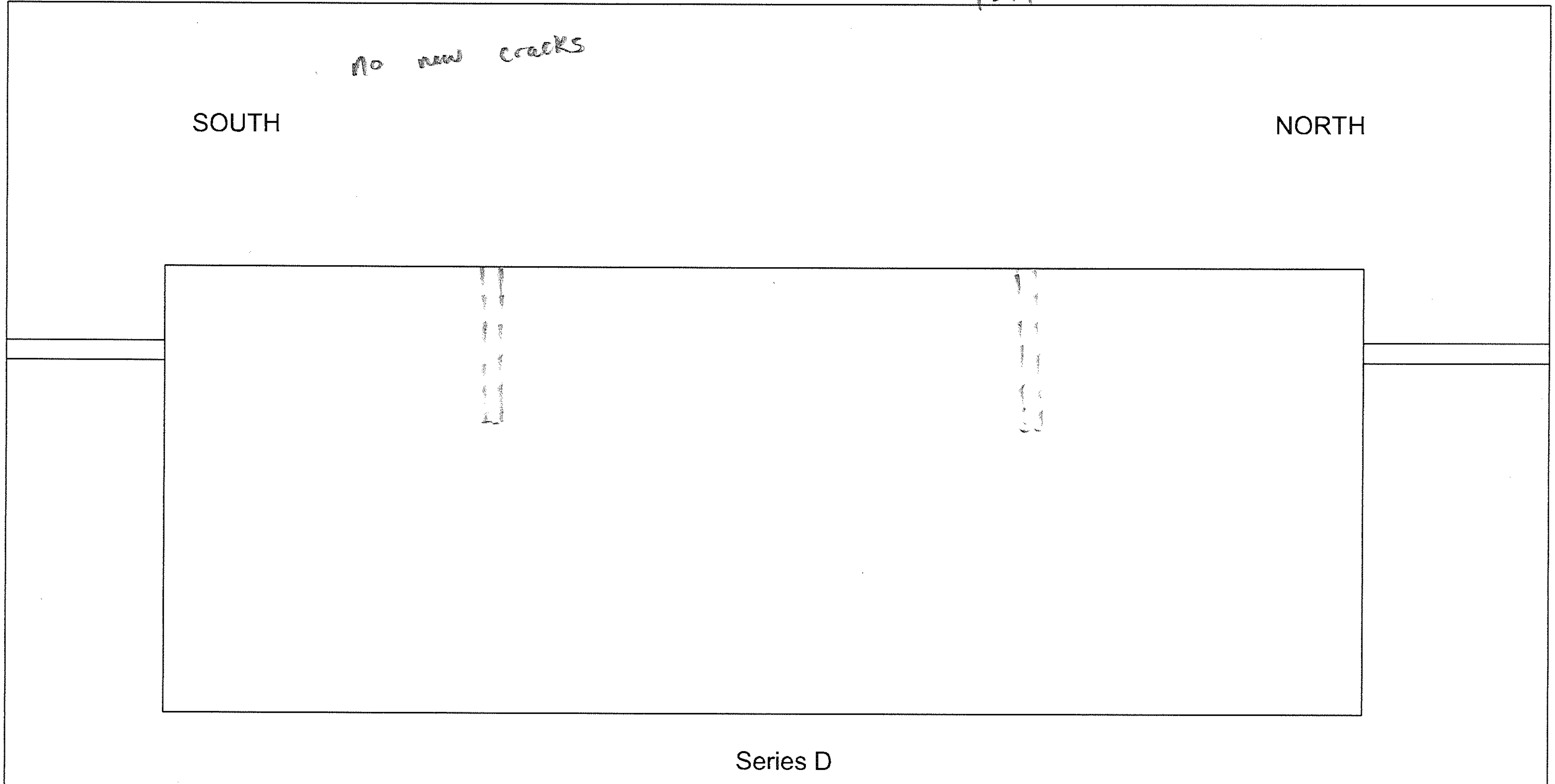
D4 20^{K} no new cracks
Reload w/ Anchor



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D4 40k Reload w/ Anchor 2/21/17

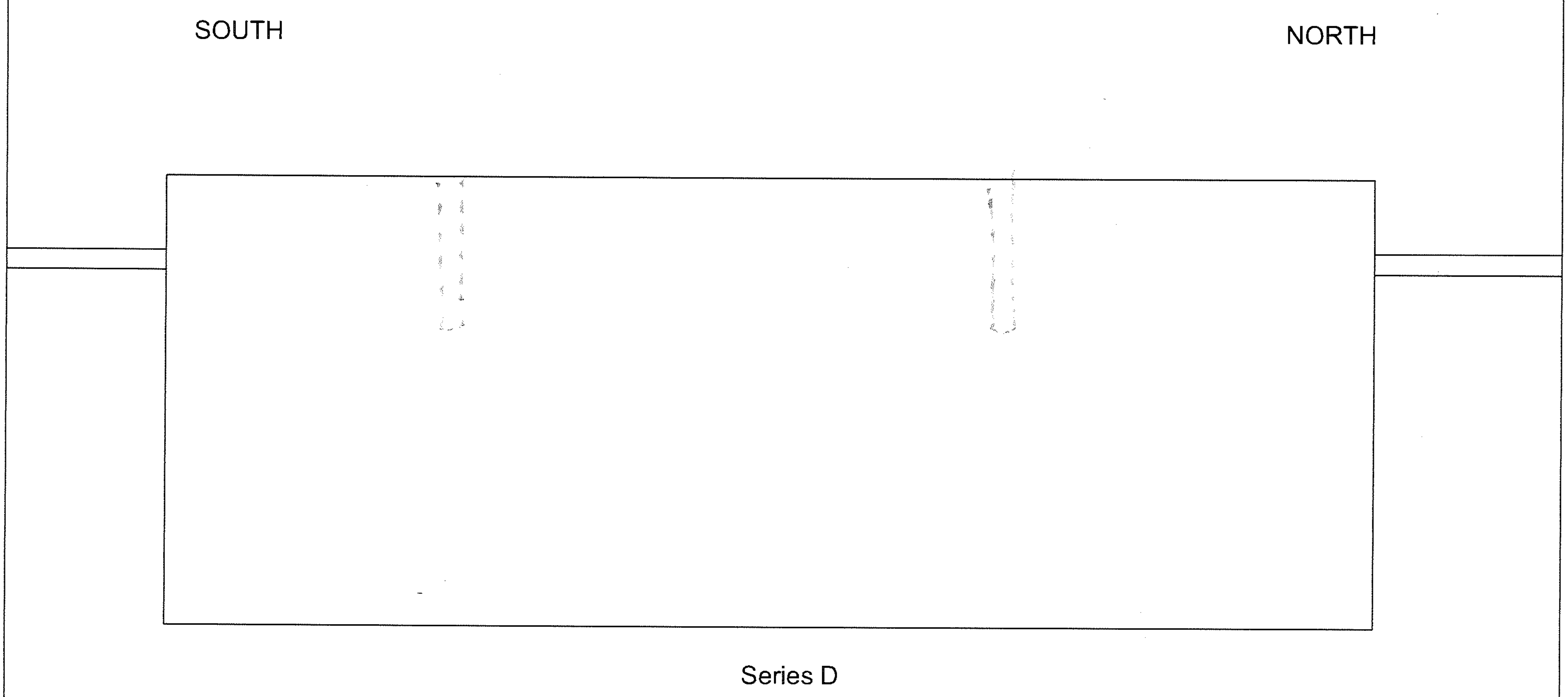


no new cracks

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D4 60^k Reload w/ Anchors

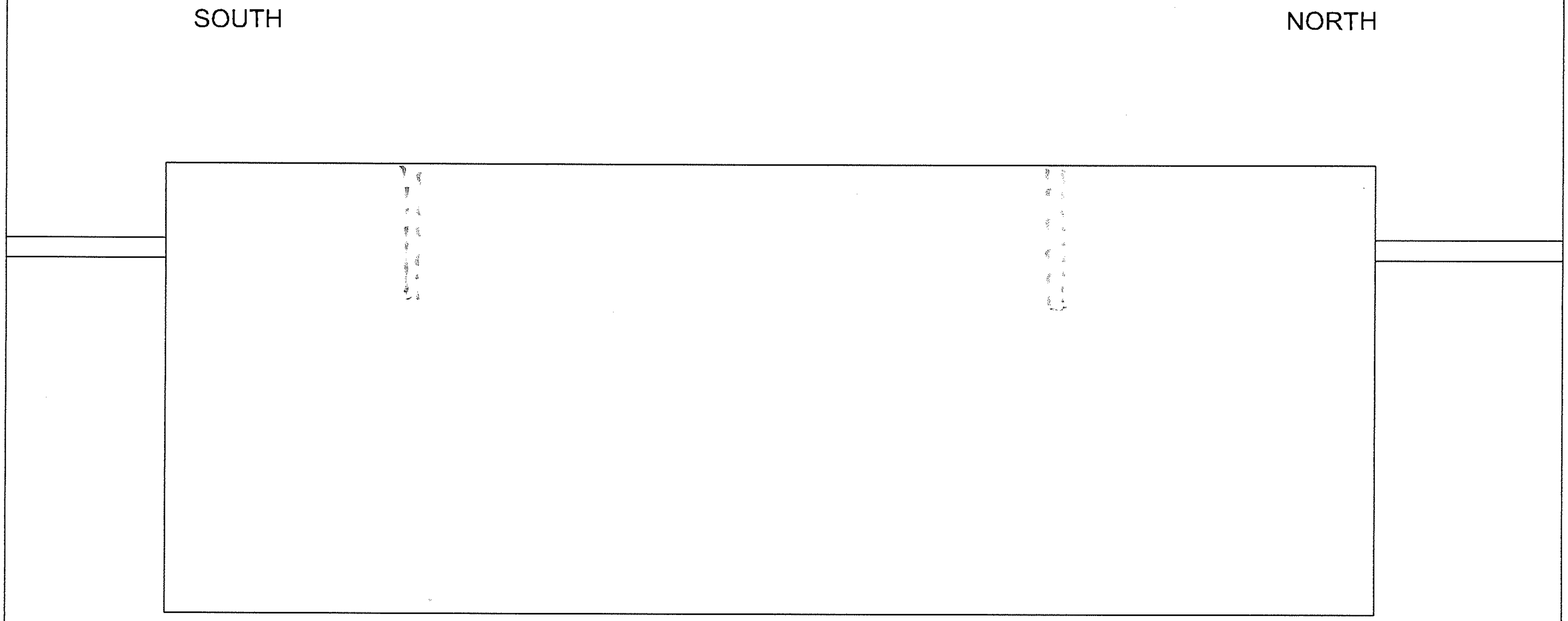
no new cracks



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D4 80^{k} Rload w/ Anchor

no new cracks

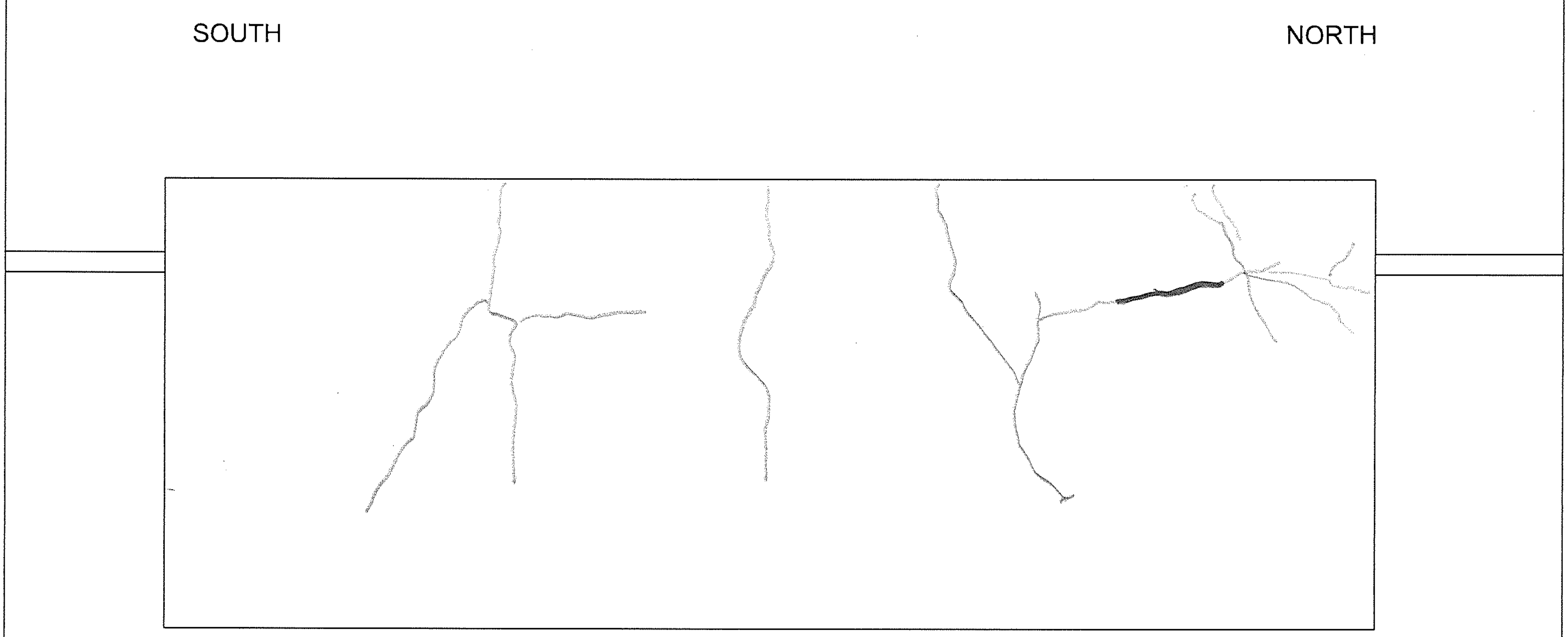


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D4 Reload w/ Anchors

100^k

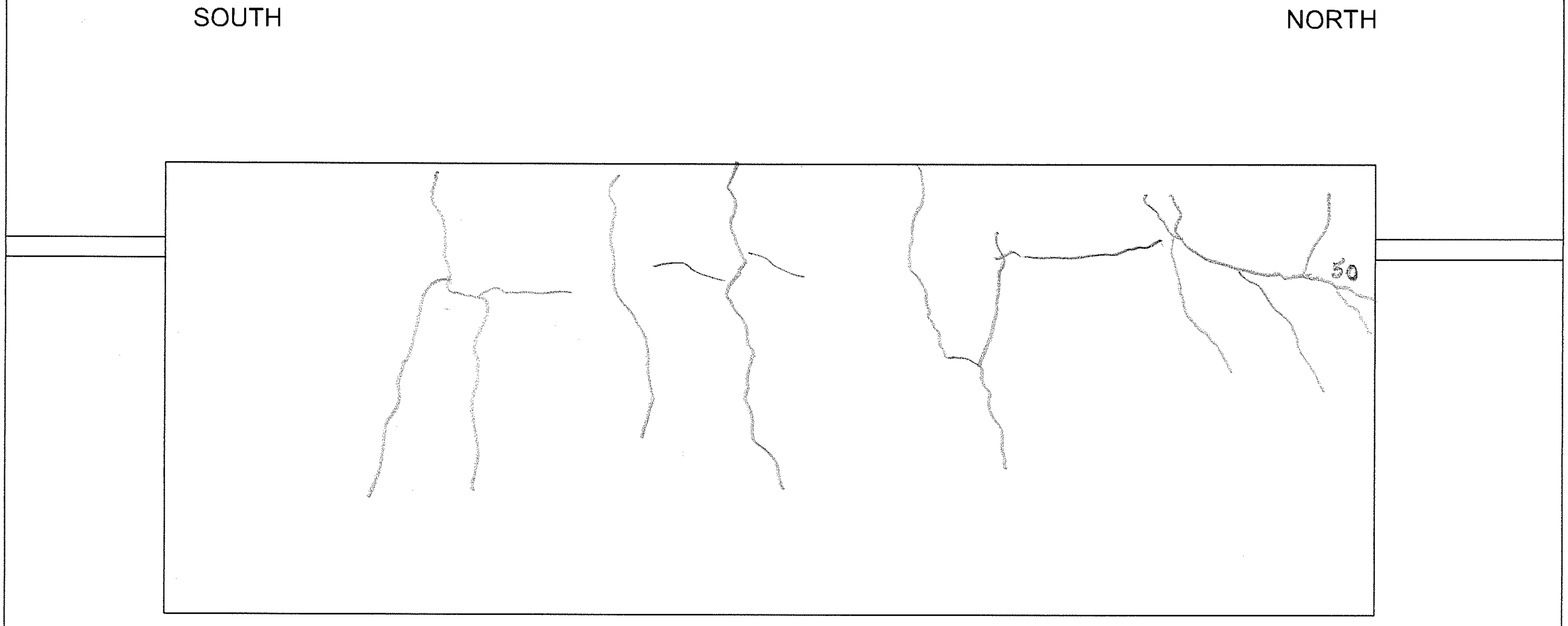


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D4 110ᵏ Reload w/ Anchors

No new cracks

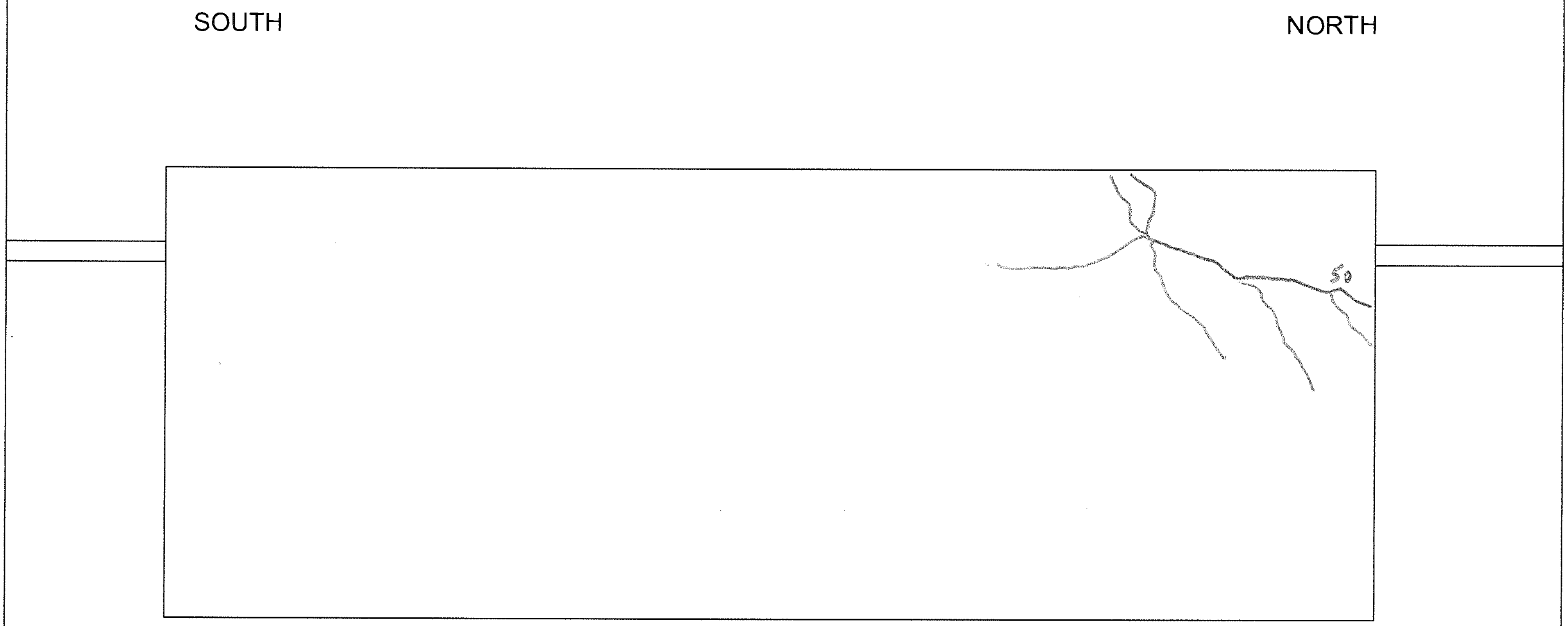


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D4 120^k Reload w/ Anchors

no new cracks, none drawn



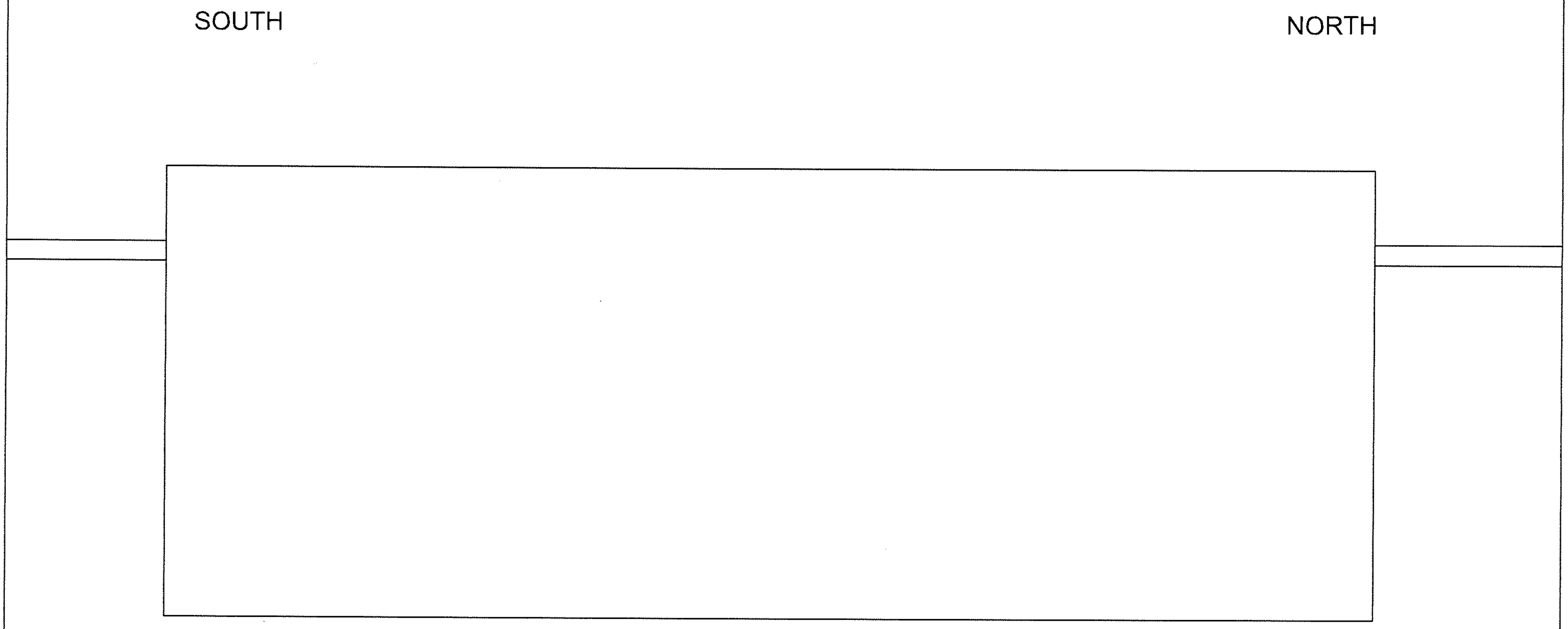
Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

D4 125^k Reload w/ Anchor

no cracks drawn or manually measured

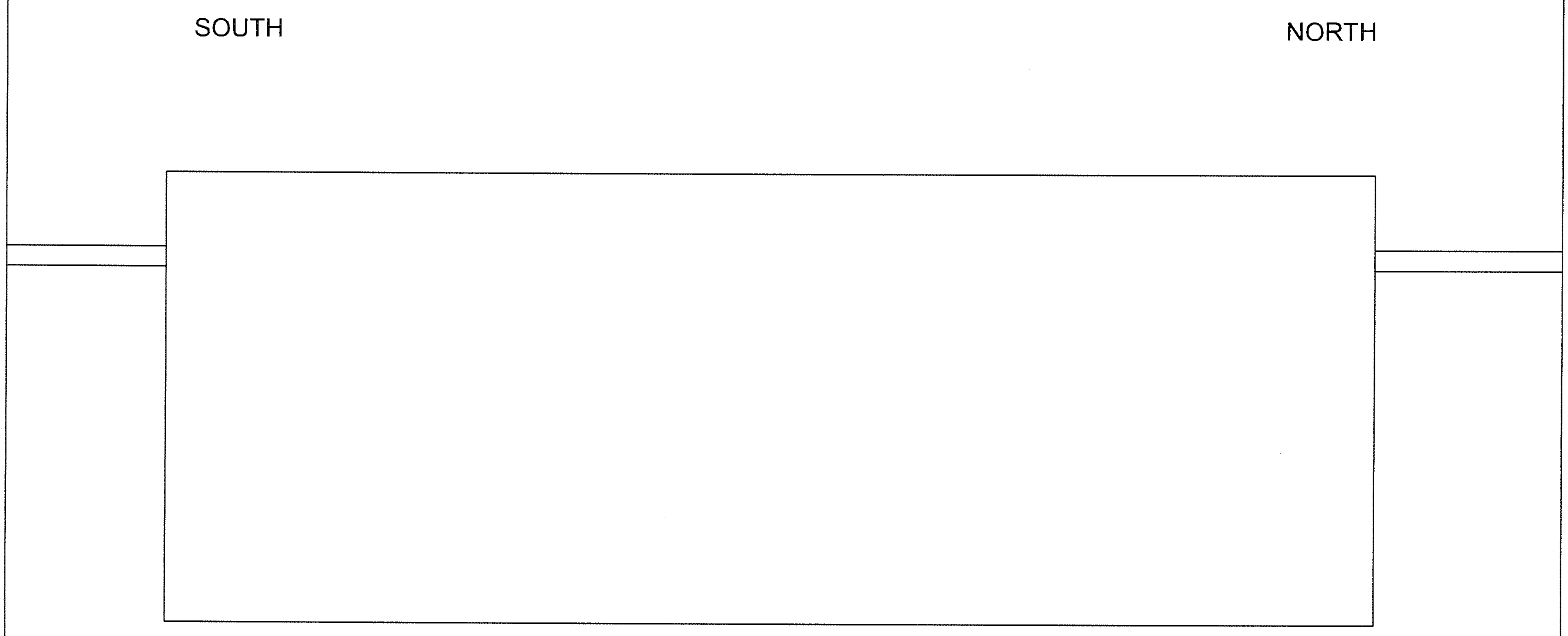


Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D4 130^k Reload w/ Anchor

no new cracks drawn



Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D5

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 2/22/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skiller		2/22/17
JASPAL SAINI	JSaini	02/22/17
WILL POLLALIS		2/22/17
LUCAS LAUGHERY	Lucas Laughery	22·Feb·17
AISHWARYA PURANAM	Aishwarya	02/22/17

Recorded by:

Checked by:

Checked by:

Test: D5

Date: 2/22/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
20K	7:49	20.3	19.8	0	0	0	0	0
40K	7:51	40.1	39.8	.001	0	0	0	0
60K	7:56	59.8	59.6	0	0	0	0	0
80K	8:05	80	80	0	0	0	.001	0
100K	8:10	99	99.1	-.001	0	0	.001	0
120K	8:27	119.8	119.7	-.001	0	.005	.001	
Epoxy Anchor	10:00 am							

Notes:

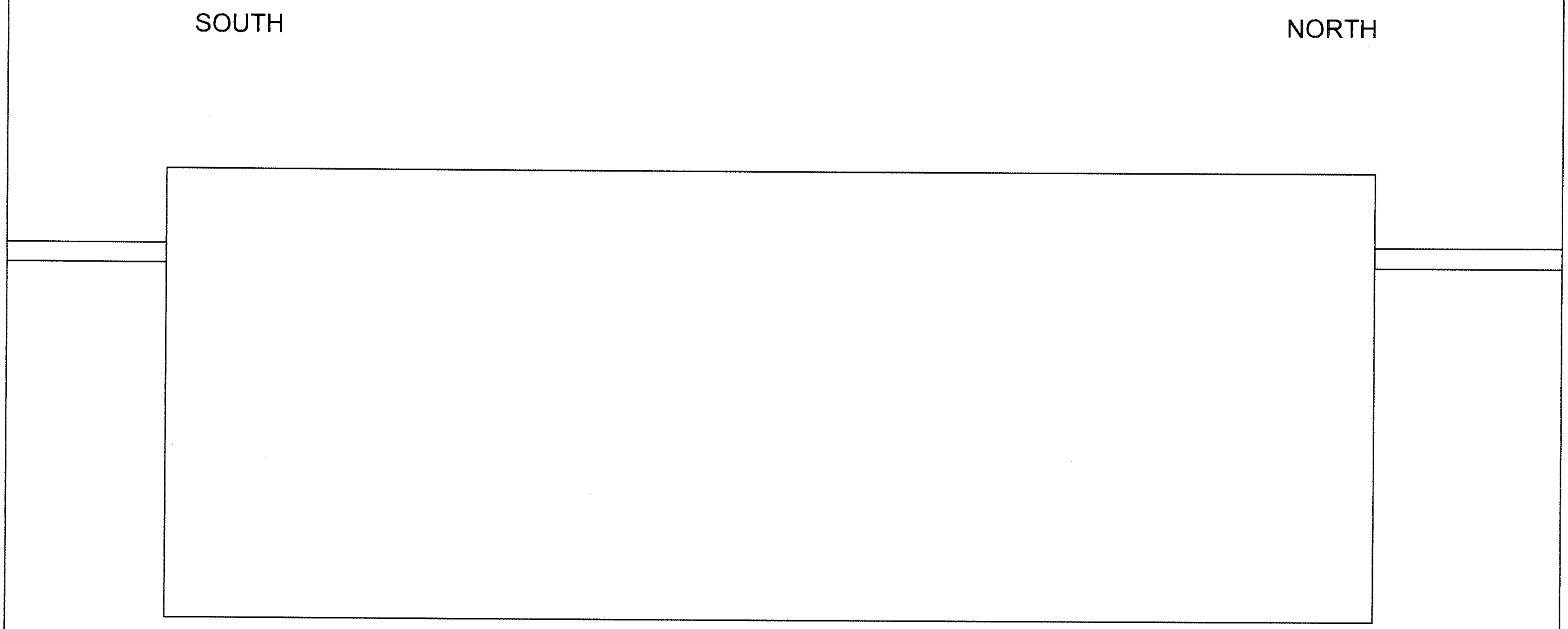
.070" crack width on SE LVDT achieved before anchor installed

Recorded by: Kinsey Skillen

Signature:

D5

20^{k} no cracks

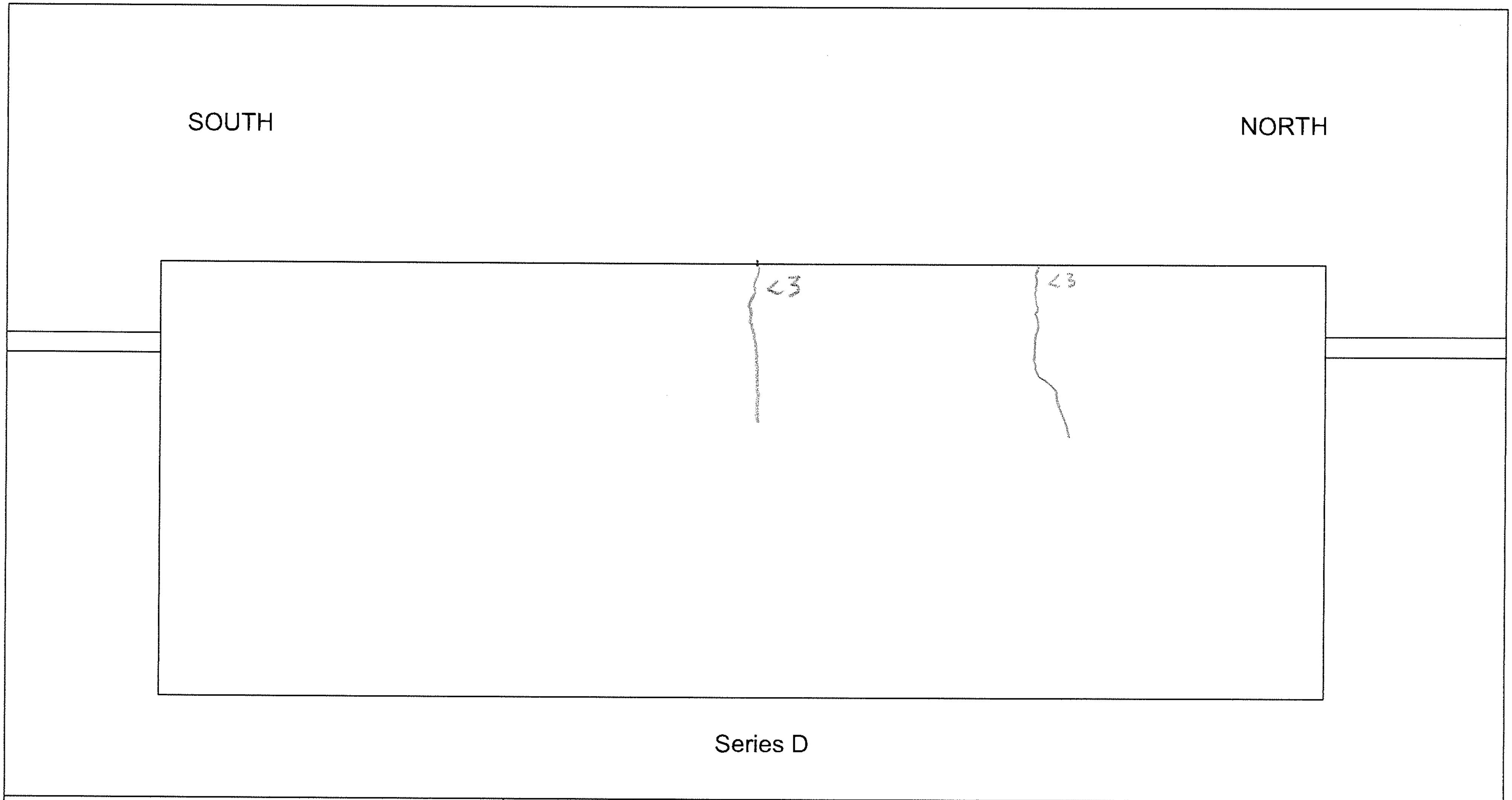


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

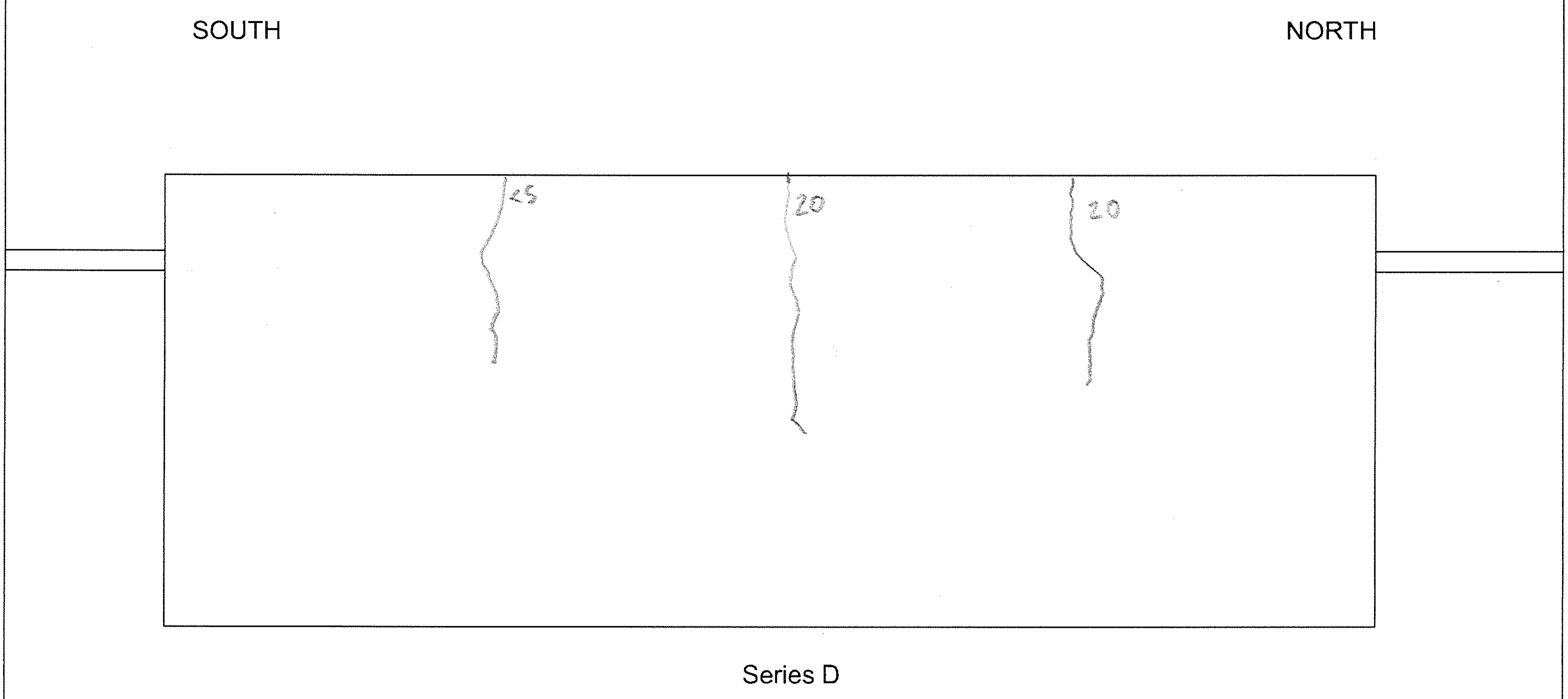
Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D5 40^{k}



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

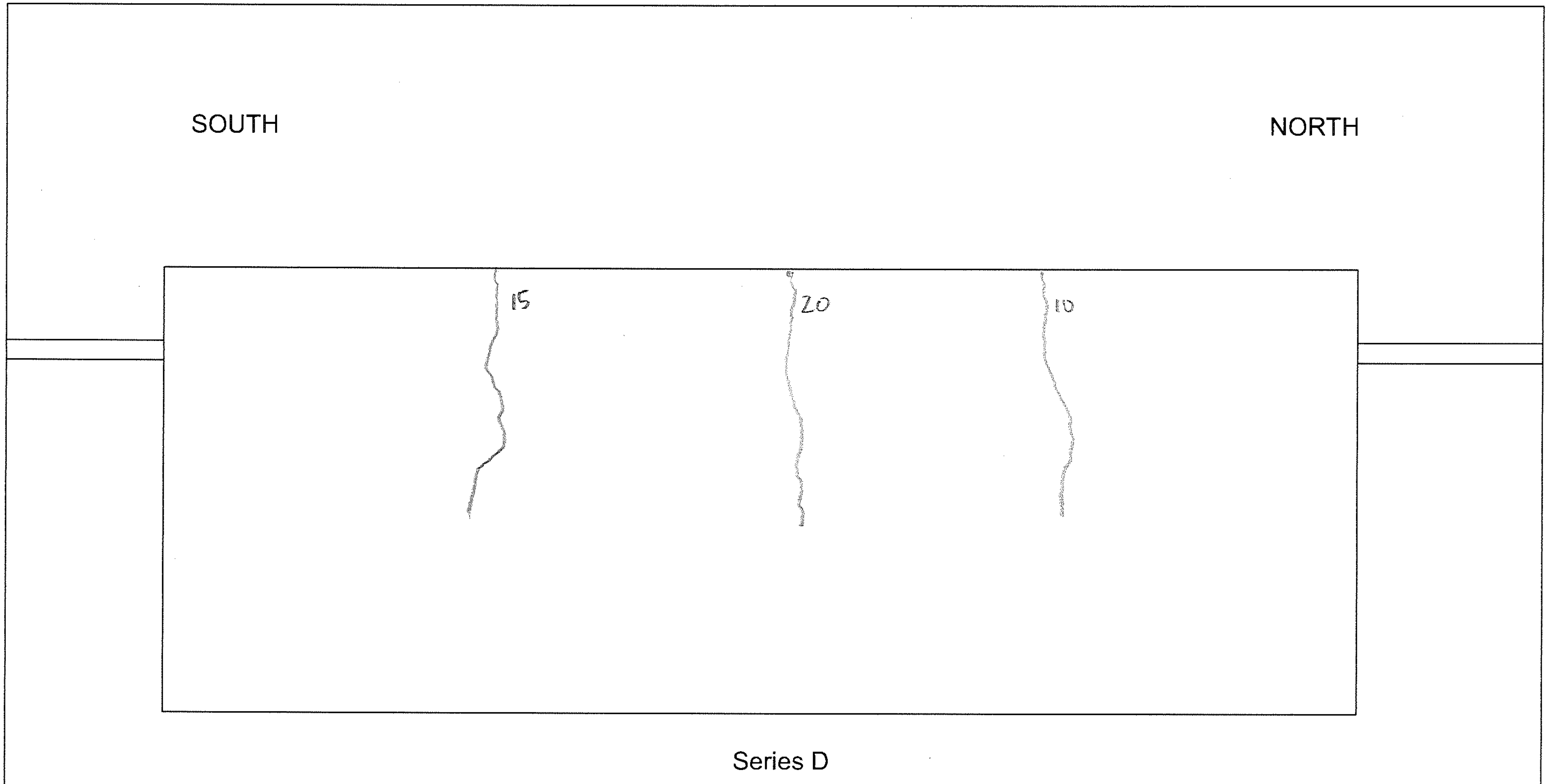
D5 60k



BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

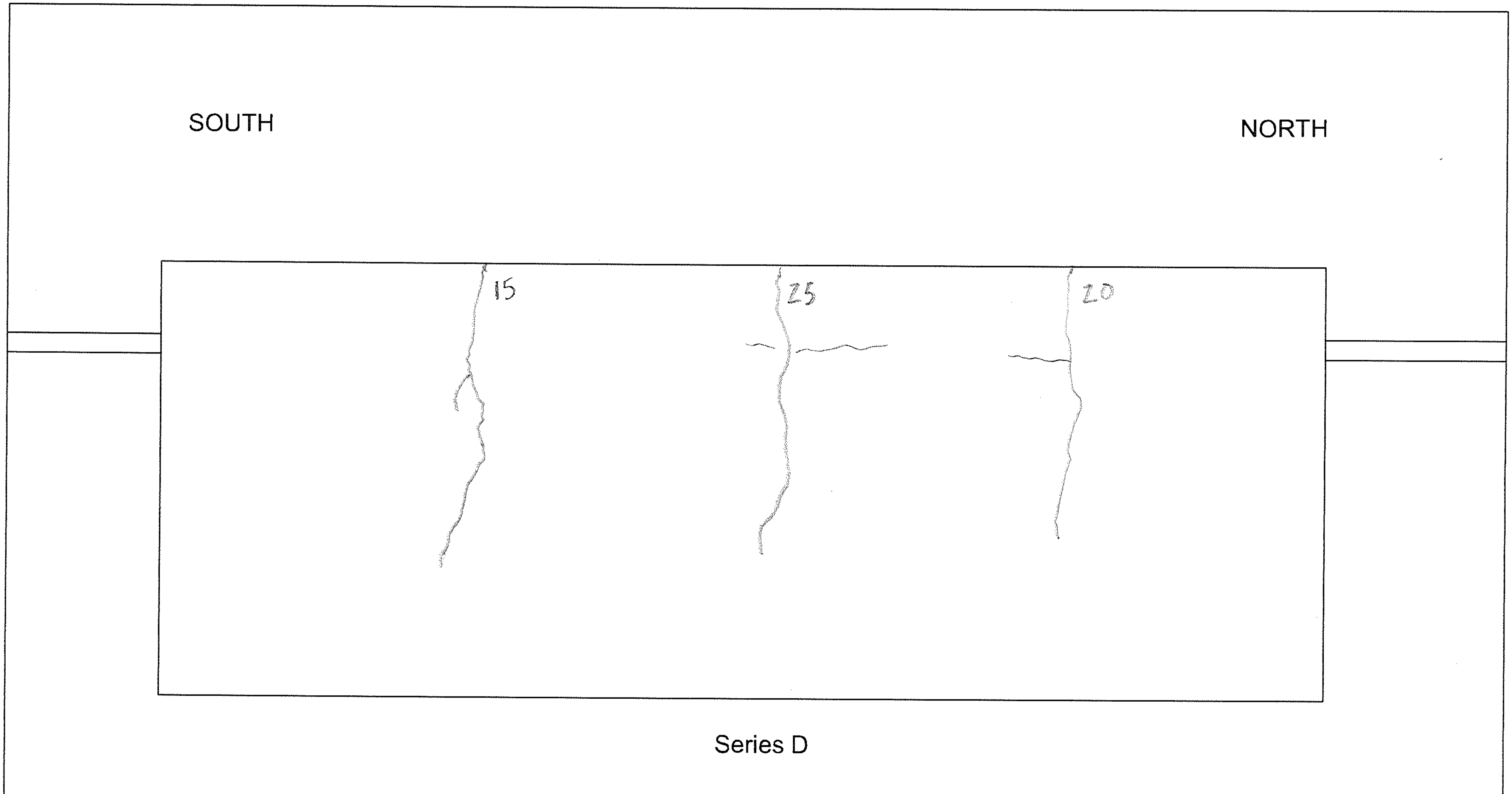
D5 80^{K}



BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

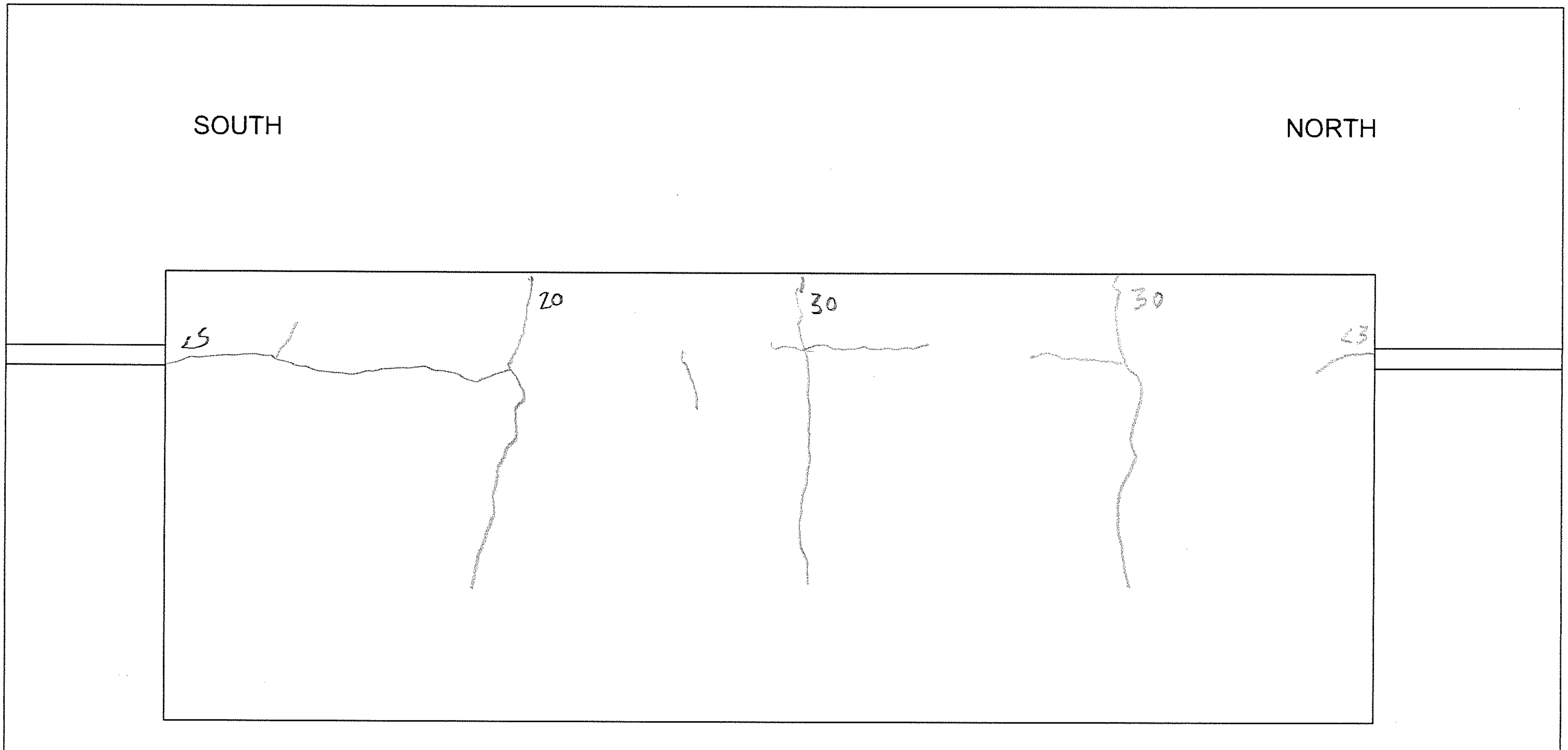
D5 100 k



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D5 120^K

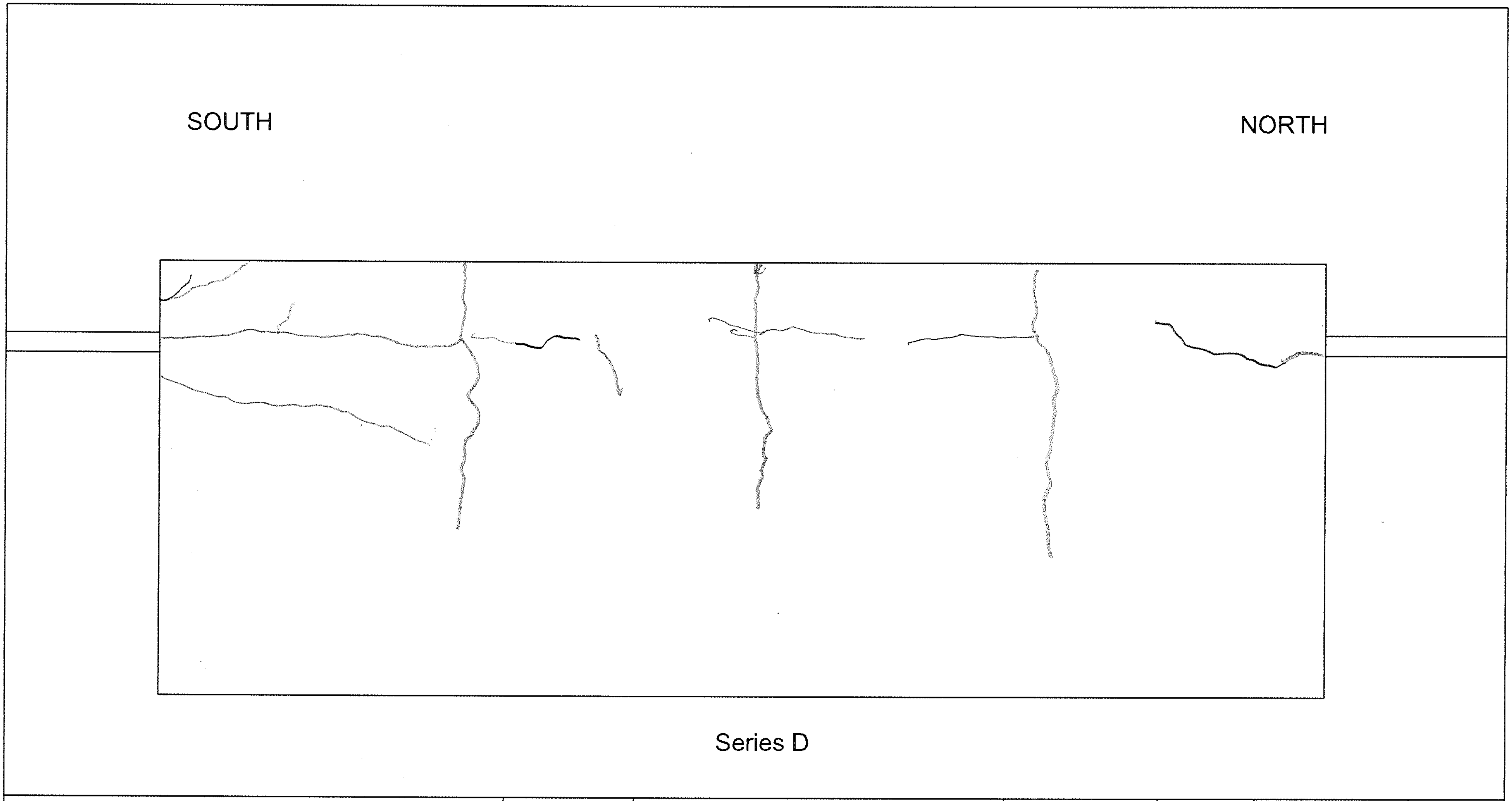


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

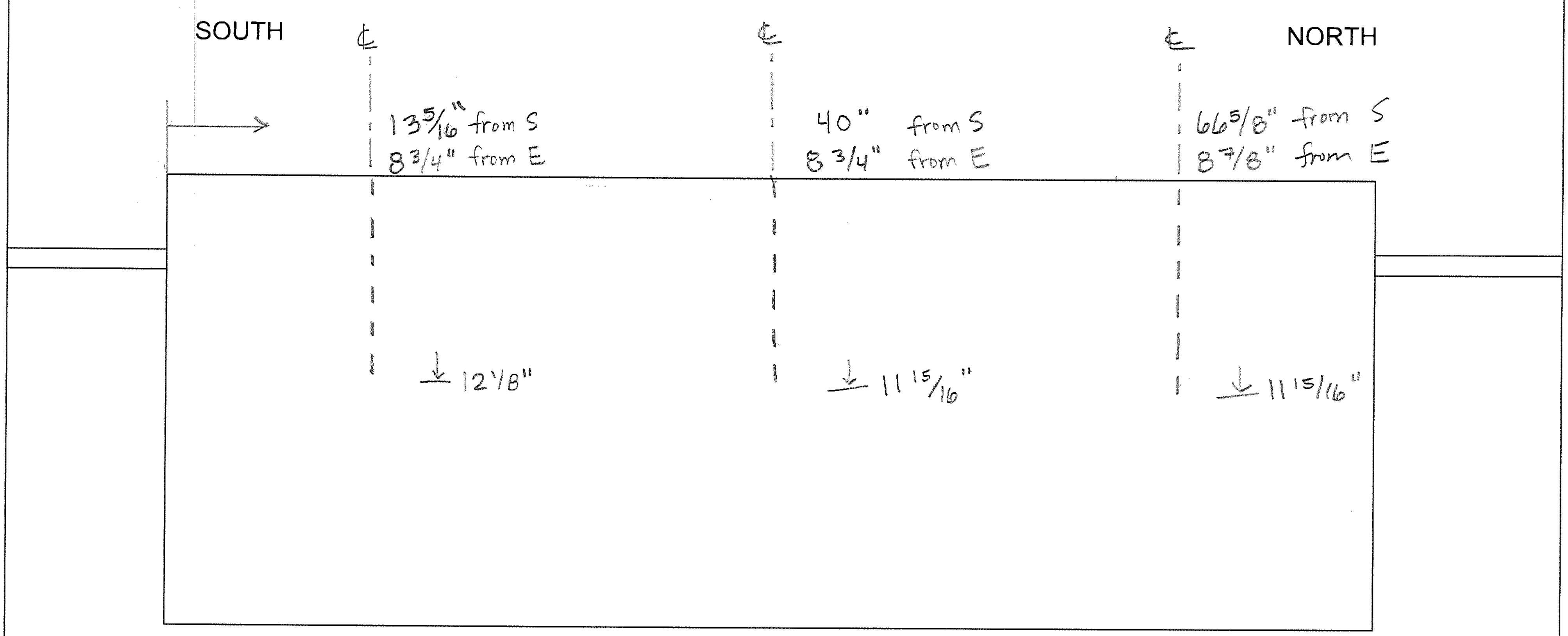
D5 130^{k} Unload



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

ANCHOR INSTALLATION AS-BUILTS NTS



Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

LVDT W -10500 mV → Reset → 3376
LVDT E 712 mV

Test: D5 Reload w/ Anchors	Date: 2/23/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0	10:23 am	0	.551	-.003	0	.041	.027	.041
20K	10:40	21	20.2	-.003	0	.041	.027	.041
40K	10:48	40.5	40	-.003	0	.043	.027	.043
60K	10:53	60.2	60.2	-.003	0	.050	.029	.050
80K	11:00	80.2	80.2	-.002	0	.060	.032	.060
100K	11:10	100.2	100.3	-.002	0	.073	.037	.073
120K	11:19	119.5	119.6	-.001	0	.096	.050	.096
130K								
→ failed						7.2		

Notes:

Anchors cured for 24 hrs.

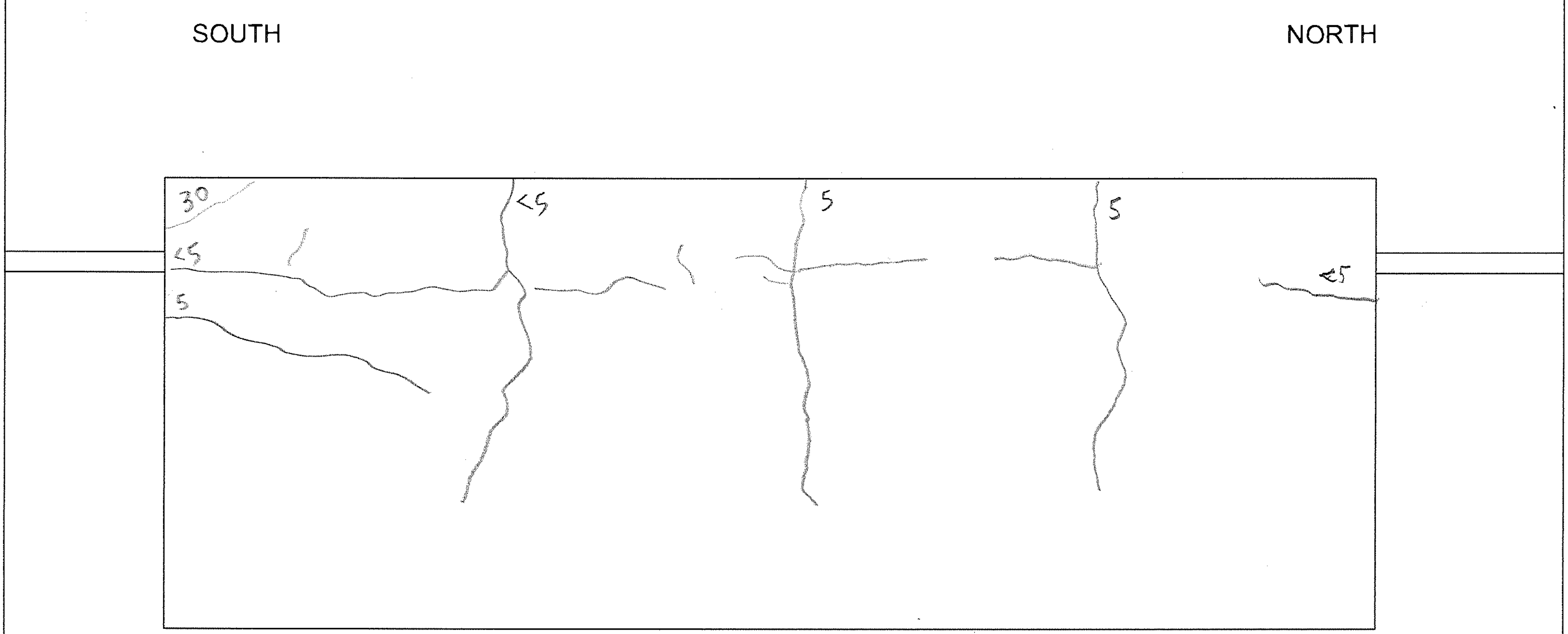
LVDT W -10500 mV → Reset → 3376 mV
LVDT E 712 mV → OK

Recorded by: Kinsey Skiller

Signature:

D5 Reload w/ Anchors

20K



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

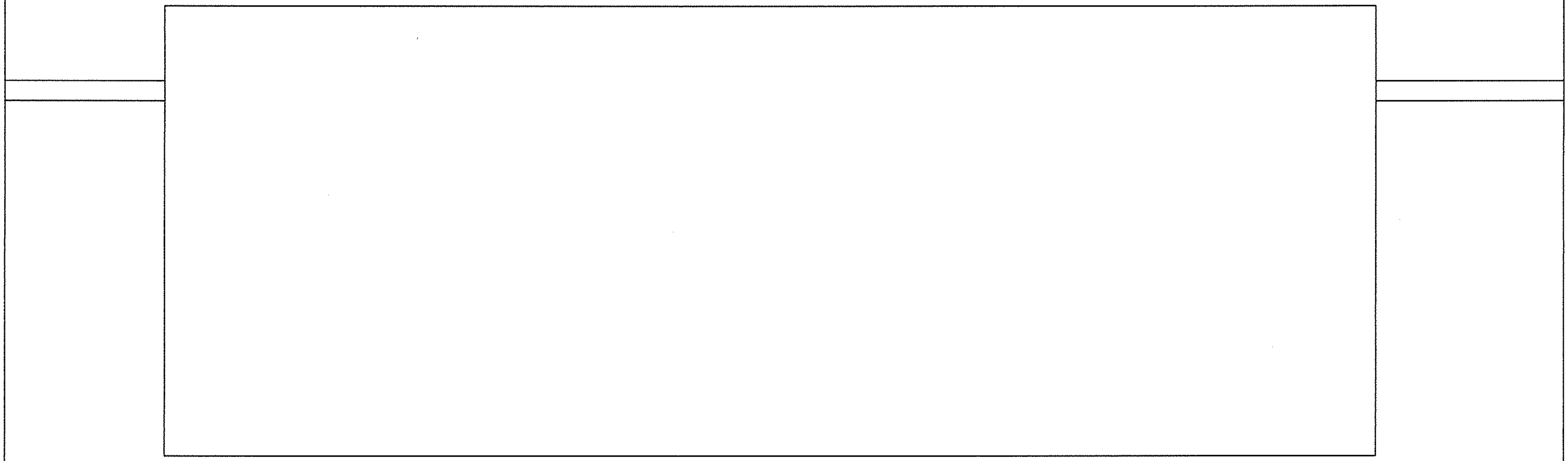
D5 Reload w/ Anchors

40^{K}

SOUTH

NORTH

no new cracks or growth from 20^{k}

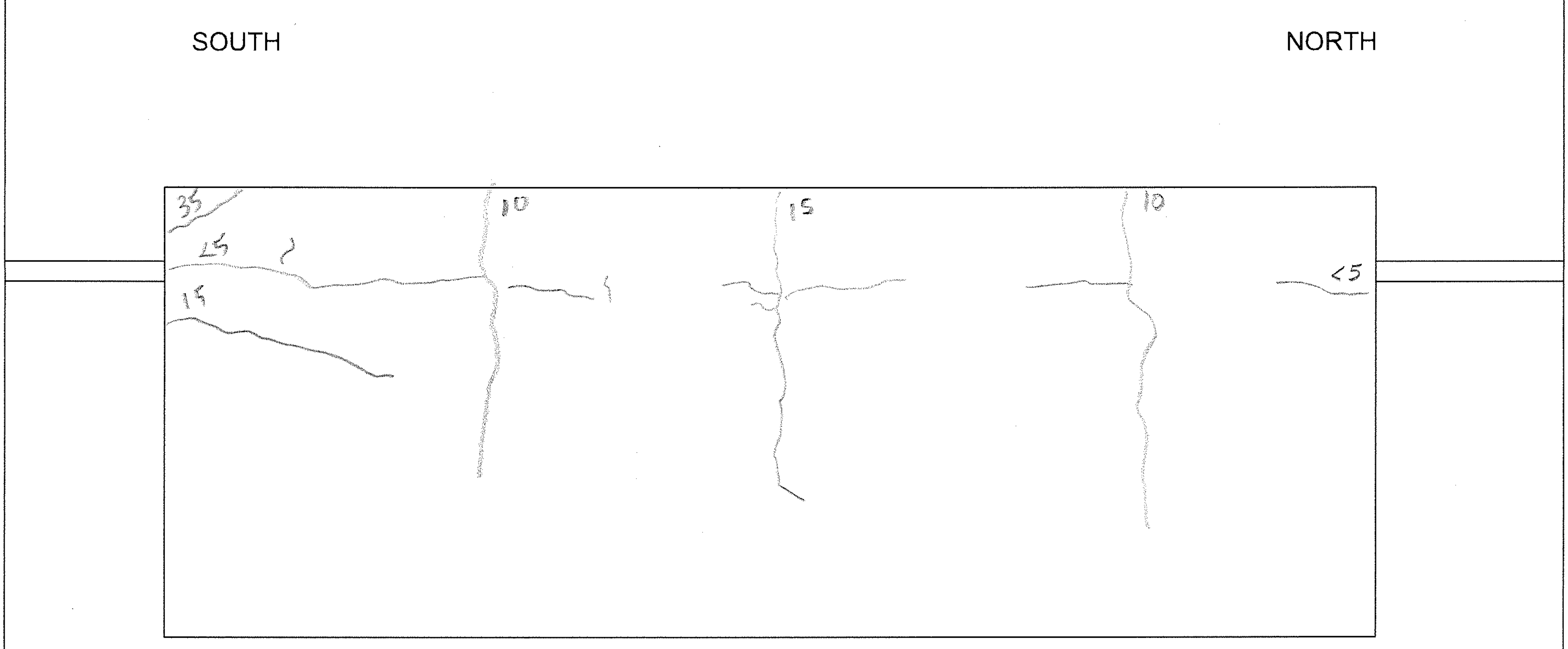


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D5 Reload w/ Anchor

60K



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

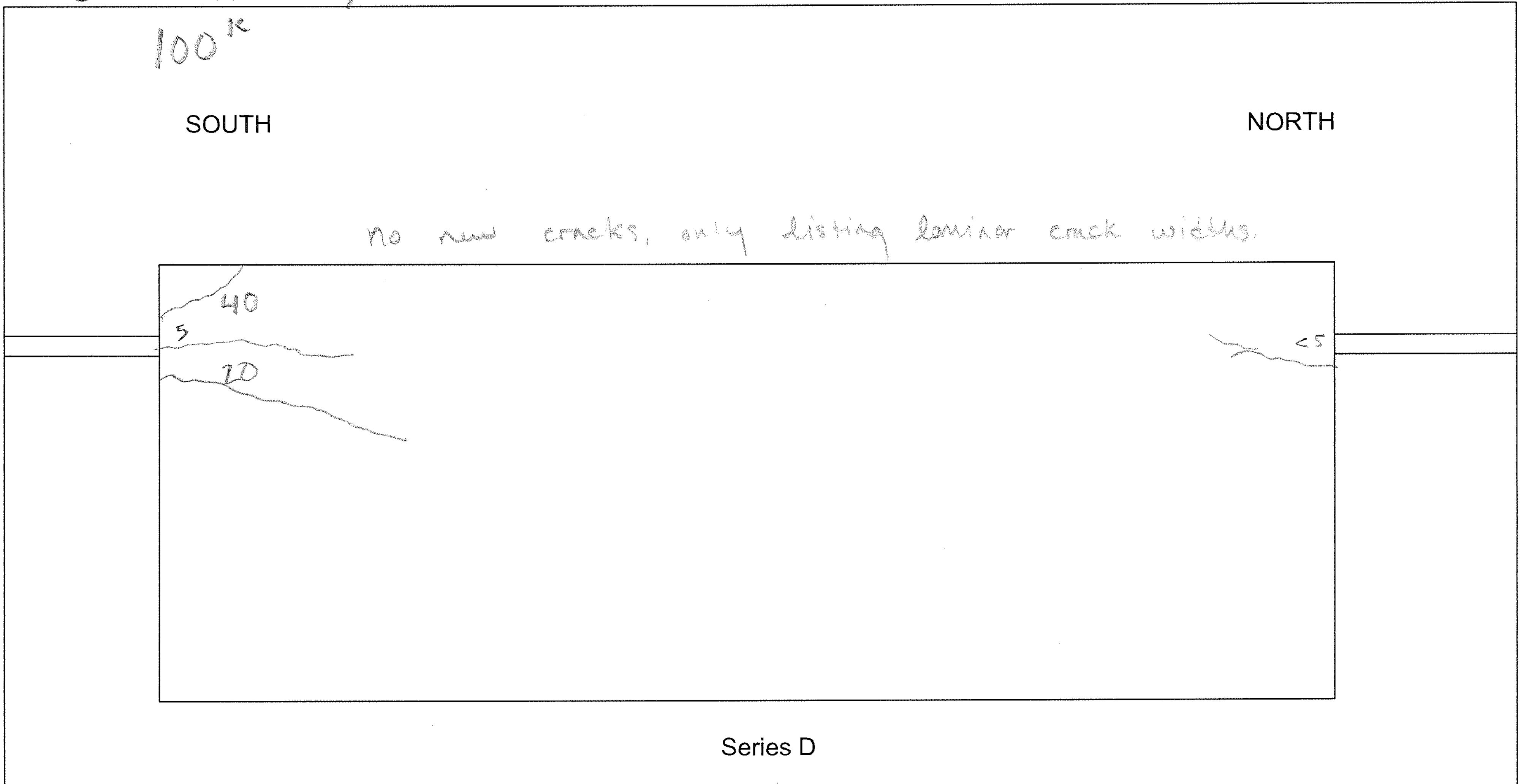
D5 Reload w/ Anchor

Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D5 Reload w/ Anchors

100^{K}



no new cracks, only listing laminar crack widths.

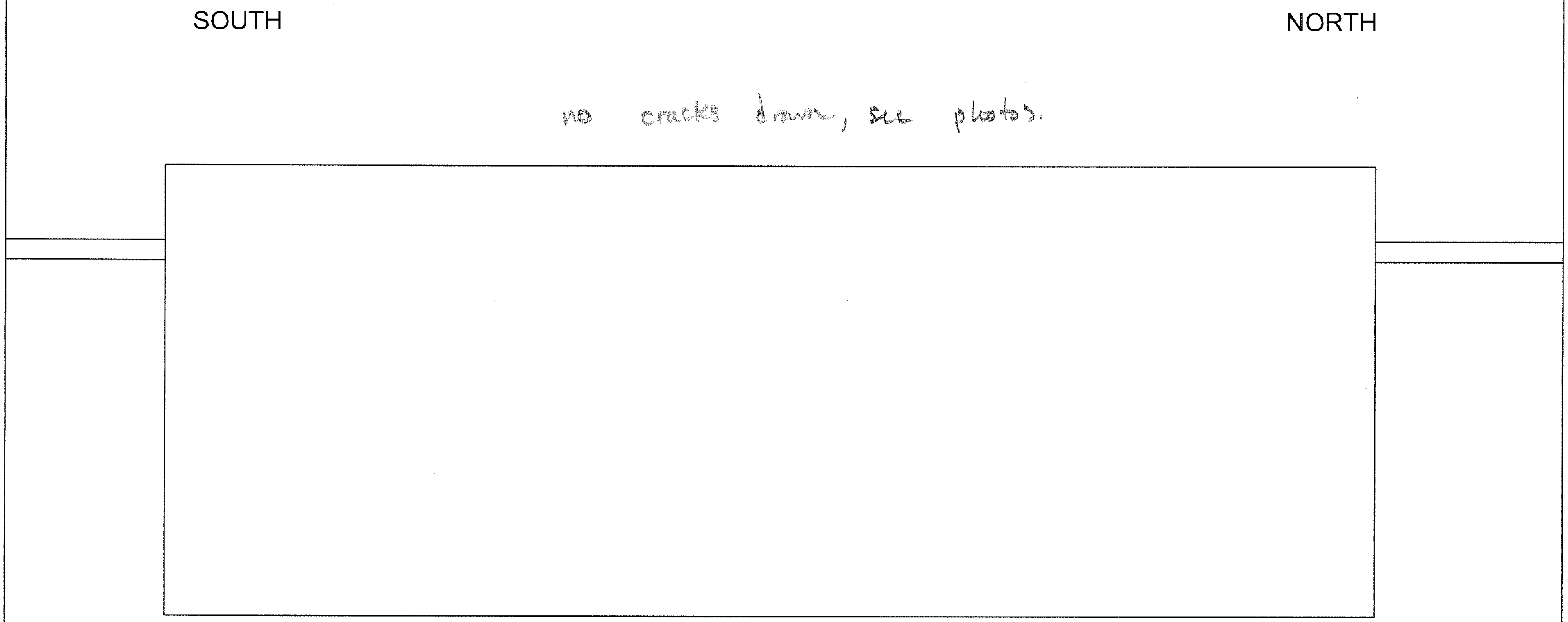
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D5 Reload w/ Anchor

120 K



no cracks drawn, see photos.

Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D6

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 2/23/17 - 2/24/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skillen		2/23/17
Jared Munsh		2/23/17
Mete A Sozen	Mete A Sozen	23 Feb 2017
S. PUJOL	S. Pujol	2/23/17
ASH	Aishwarya	02/23/17
Prateek Shah	PShah	02/23/17
WILL POLLALIS		2/24/17
LUCAS LAUGHERY	Lucas Laughery	24/Feb/17

Recorded by: Checked by: Checked by:

Test: D6

Date: 2/23/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
20K	6:06	20.5	20	.002	0	0	-.001	—
40K	6:11	39.6	39.6	.006	0	0	-.001	—
60K	6:17	59.7	59.7	.012	0	.002	0	.012
80K	6:22	80.2	79.4	.023	.001	.007	.004	.023
100K	6:30	98.6	98.6	.027	.011	.019	.013	.027
110K	6:38	107.8	107.6	.036	.018	.037	.021	.037
110K	6:45	109.4	109.5	.046	.020	.059	.029	.059
⊥.060 w/c								
0K	6:47	0	0	.027	.011	.045	.019	.045
Anchors	7:34 pm							

Notes:

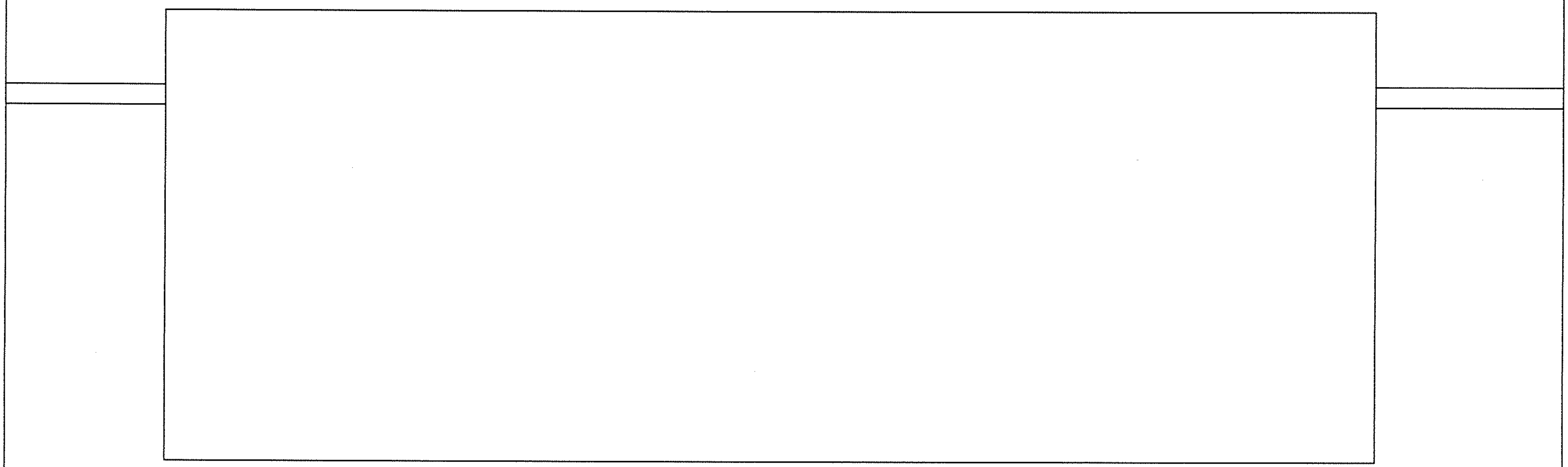
.060" crack width achieved before anchor install

Recorded by: Kinsey Skillen

Signature:

D6 2/23/17 6:00 pm

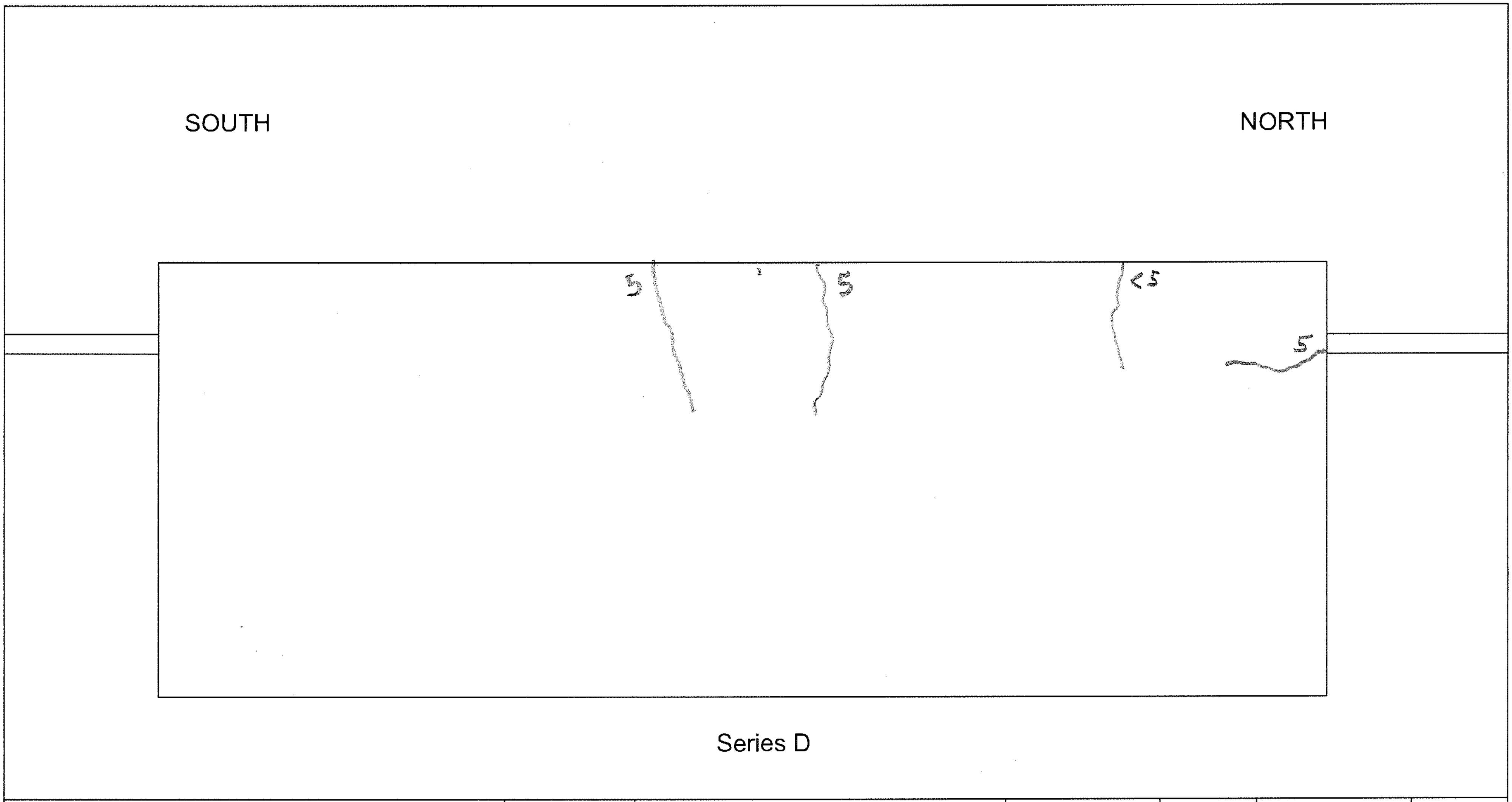
20^k no cracks



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

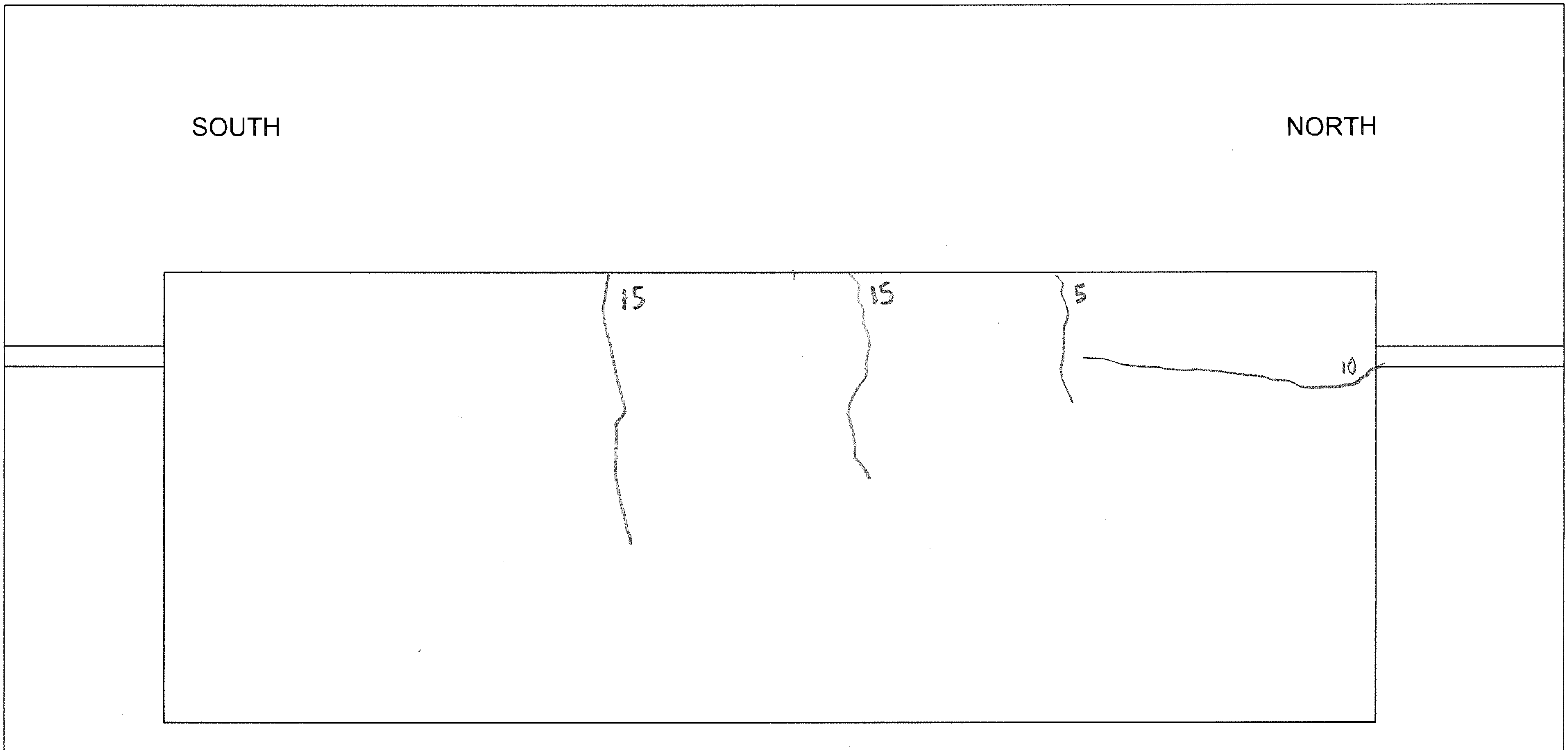
D6 40^k



BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

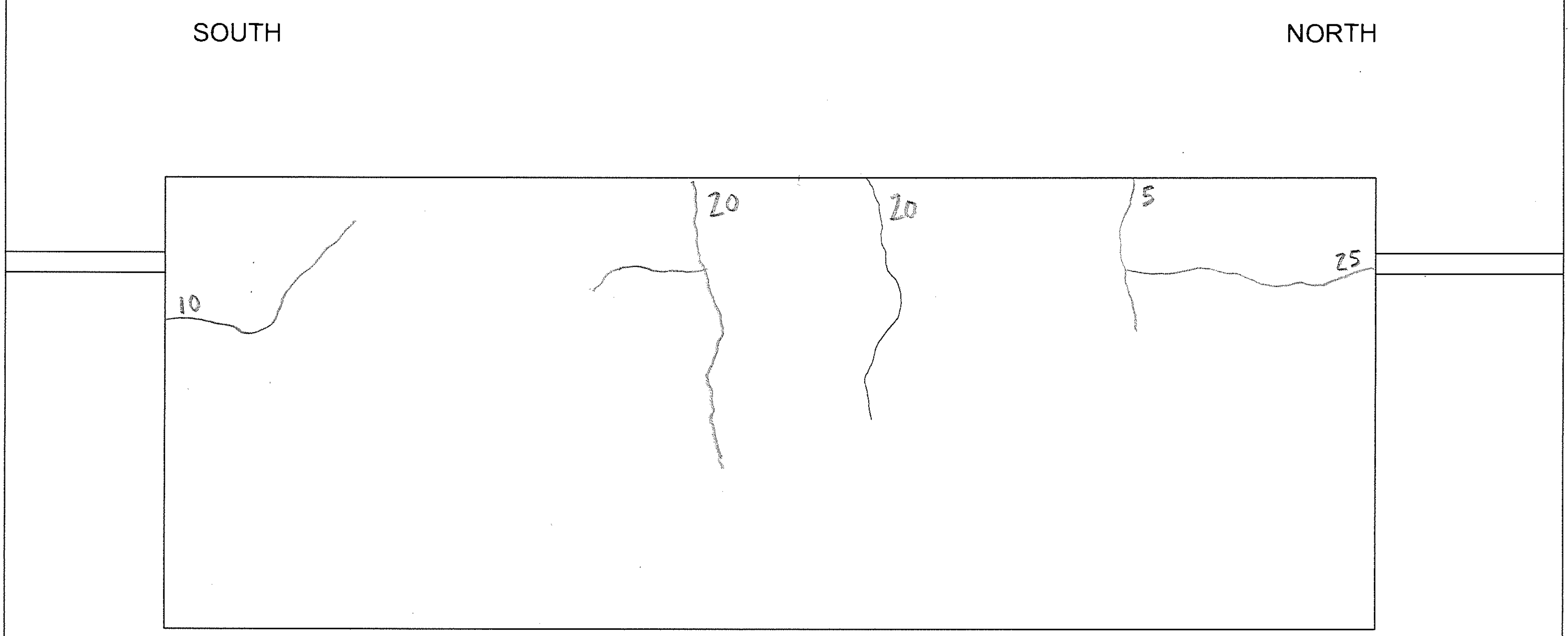
D6 60^{k}



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D6 80k

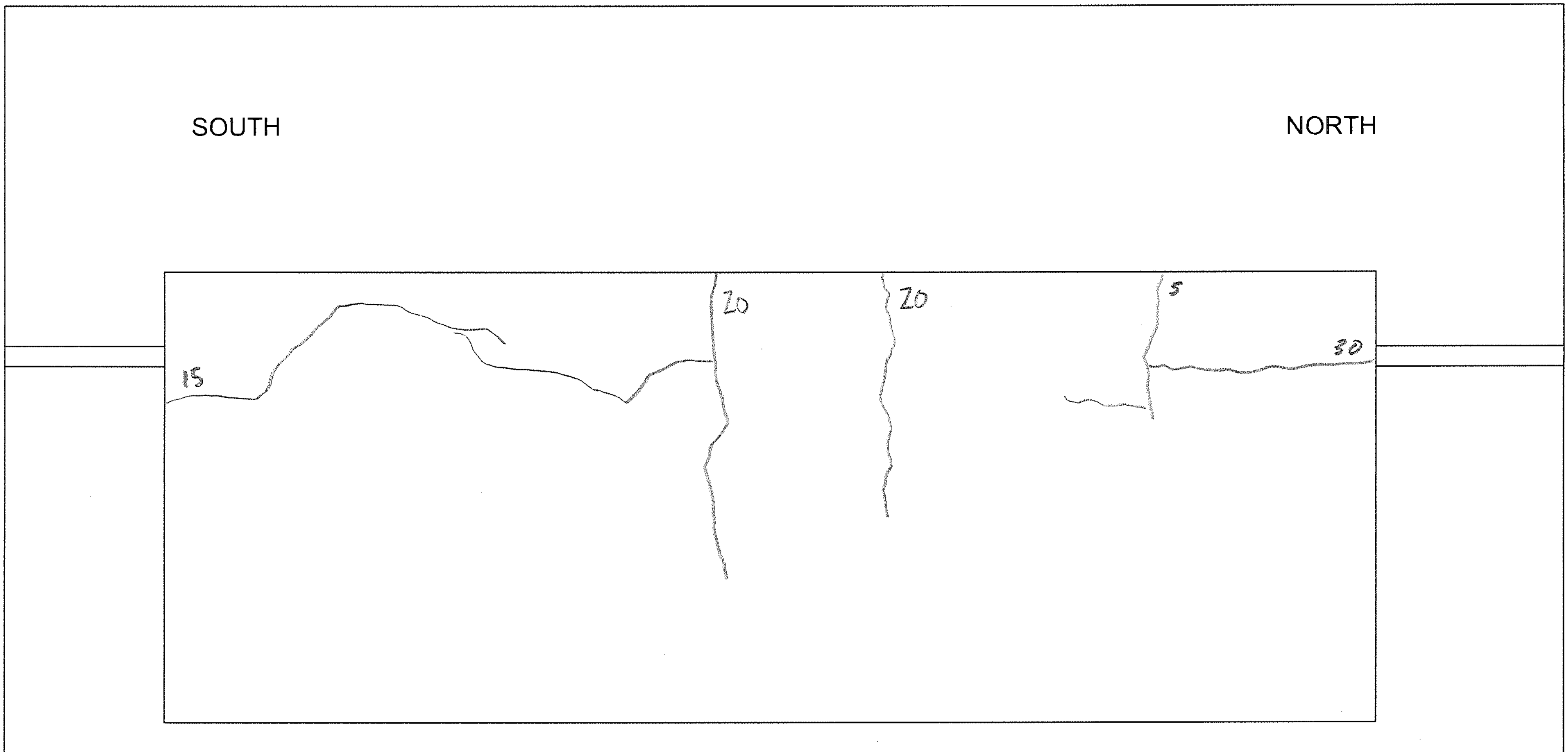


Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

D6 100^{k}

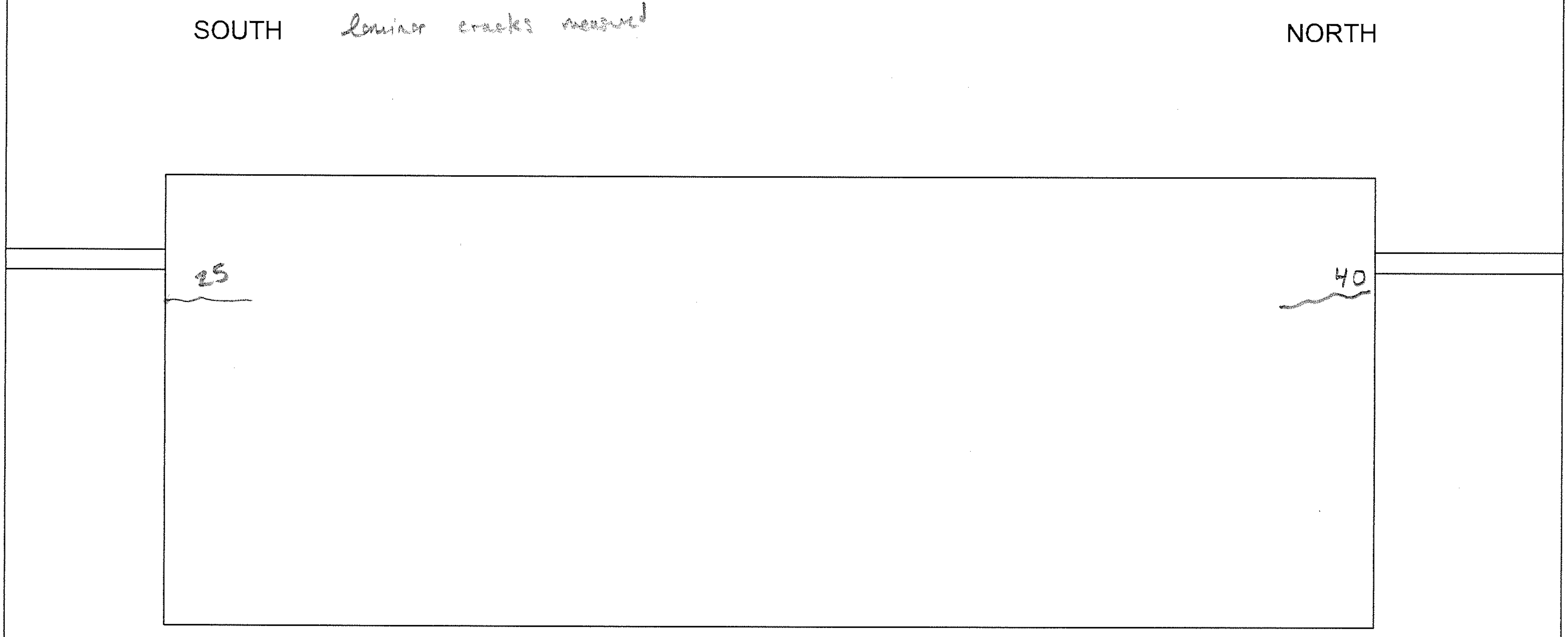


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D6 110k

no new cracks drawn,
laminar cracks measured



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

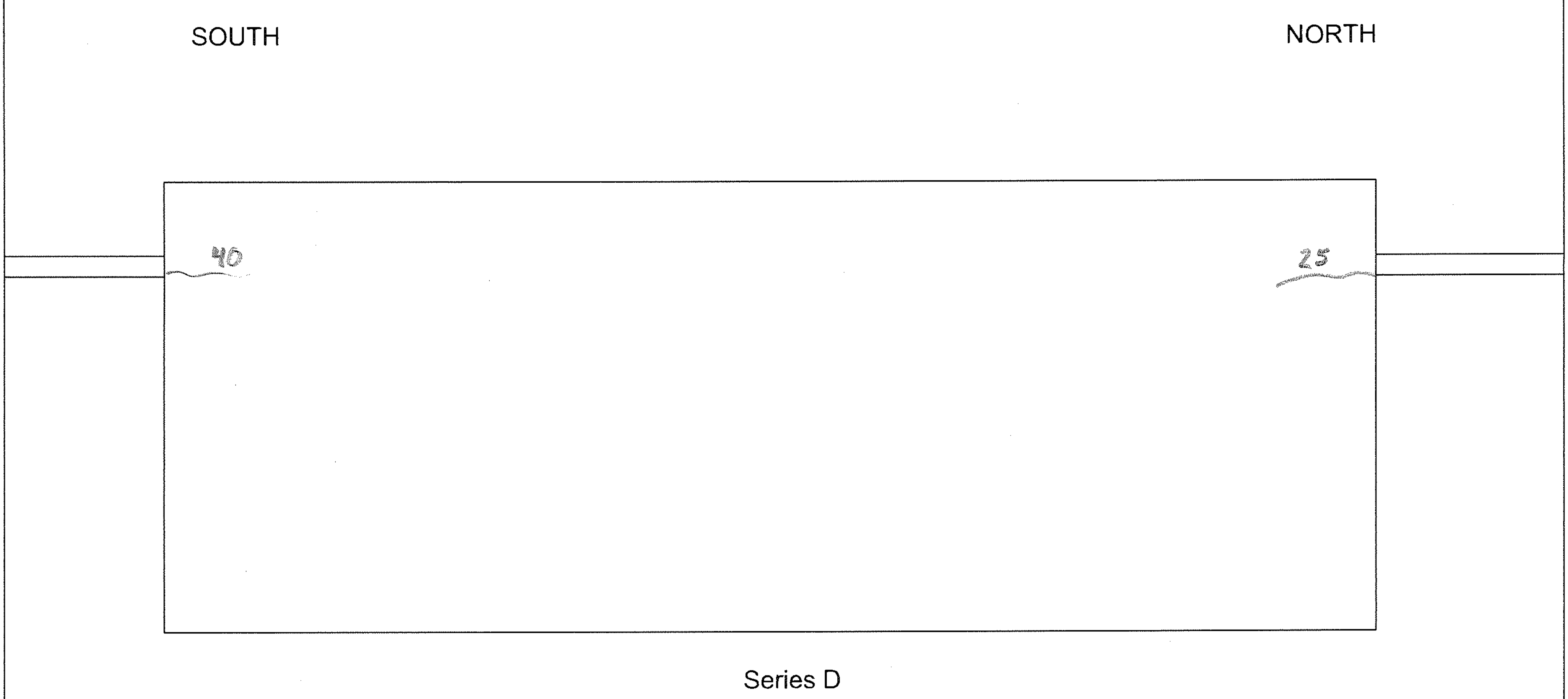
D6 110^K → unload 6:47 pm

Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D6 unload



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

Test: D6 Reload w/ Anchors

Date: 2/24/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0K	7:17 pm	0	0	.026	.011	.039	.011	.039
20K	7:32	20.5	20.3	.026	.011	.039	.012	.039
40K	7:35	40.5	40.4	.028	.011	.039	.012	.039
60K	7:40	60.3	60.1	.032	.013	.043	.013	.043
80K	7:46	79.9	80.1	.038	.016	.049	.016	.049
100K	7:53	99.7	99.4	.045	.020	.057	.021	.057
110K	7:58	109.6	108.4	.051	.023	.063	.023	.063
120K								

Notes:

N Anchor 22K : pull-out test after specimen failure

Recorded by:

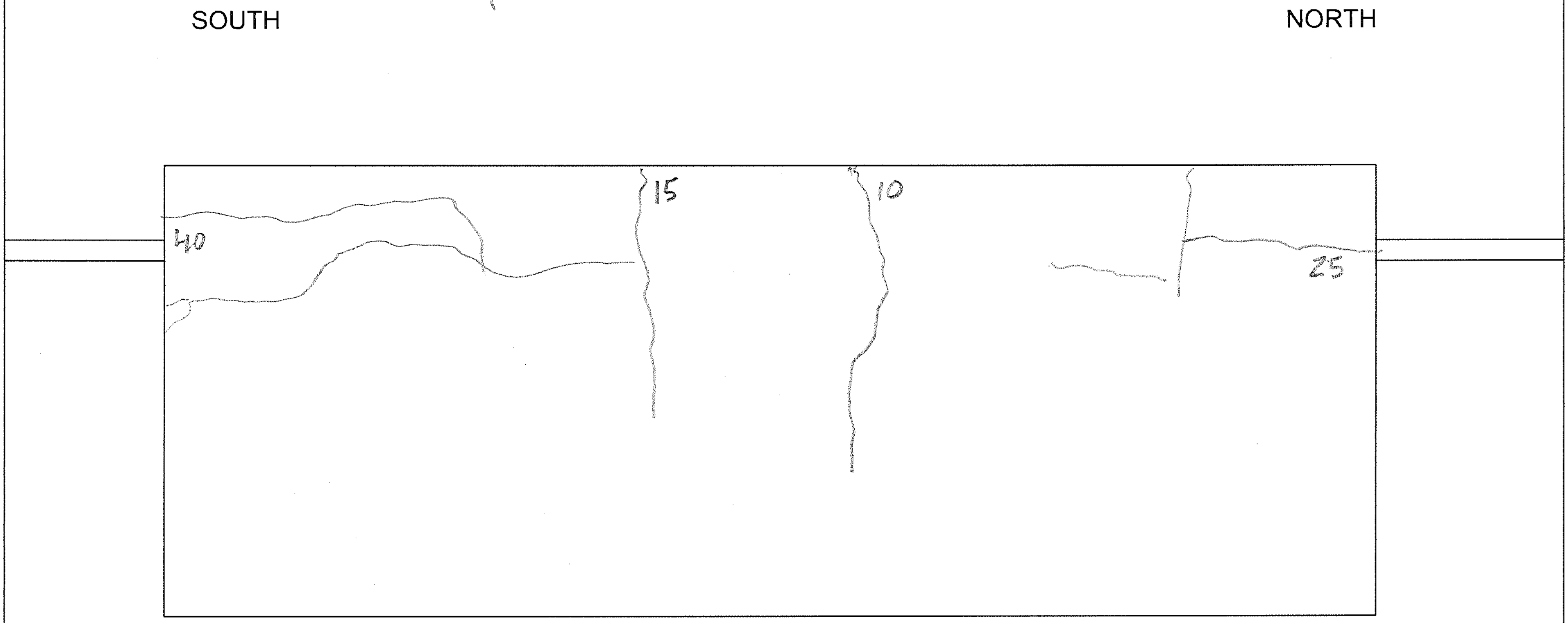
Kinsey Skiller

Signature:

0 K

D6 Reload w/ Anchors

starting crack configuration



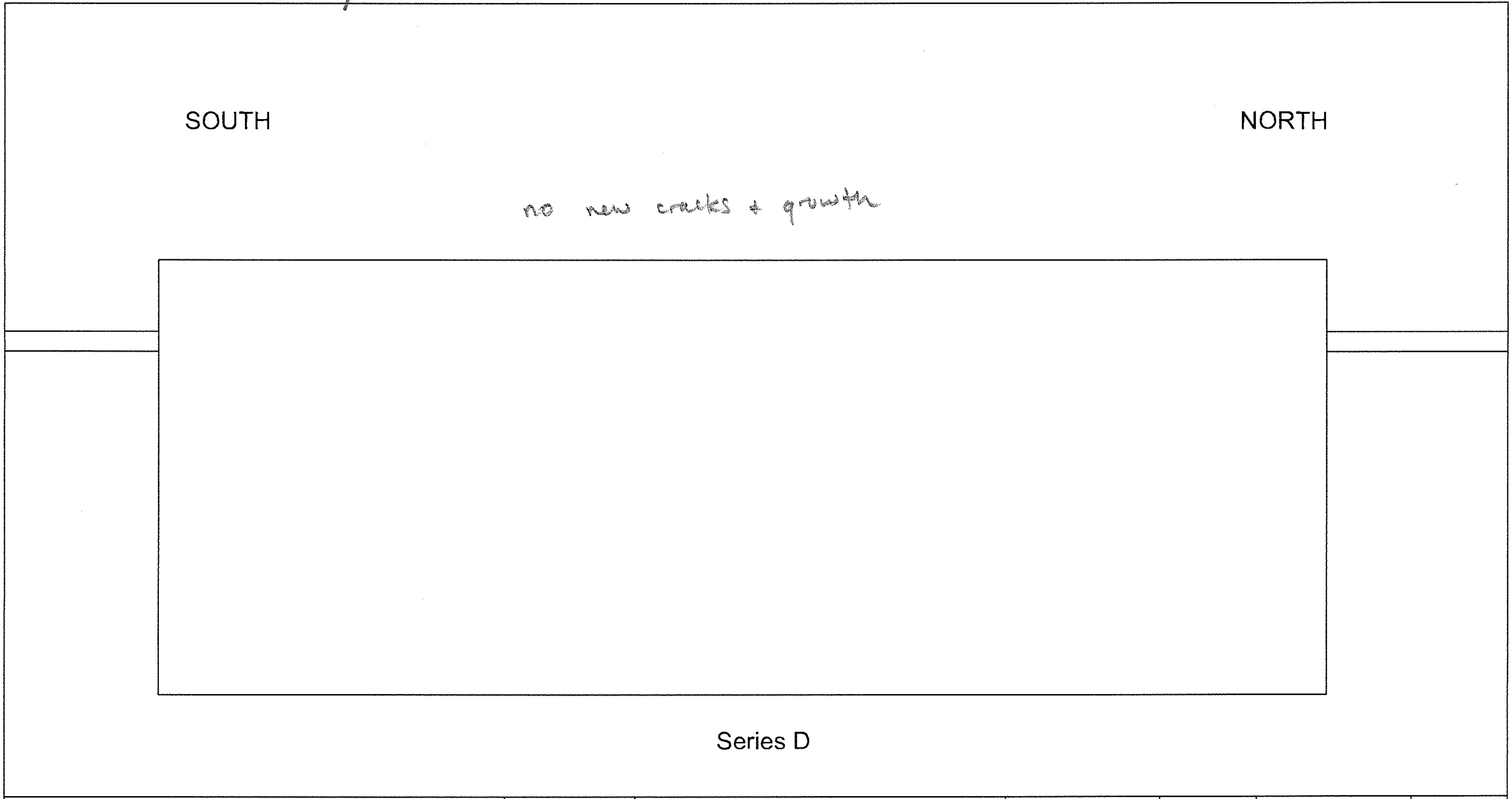
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

20^k

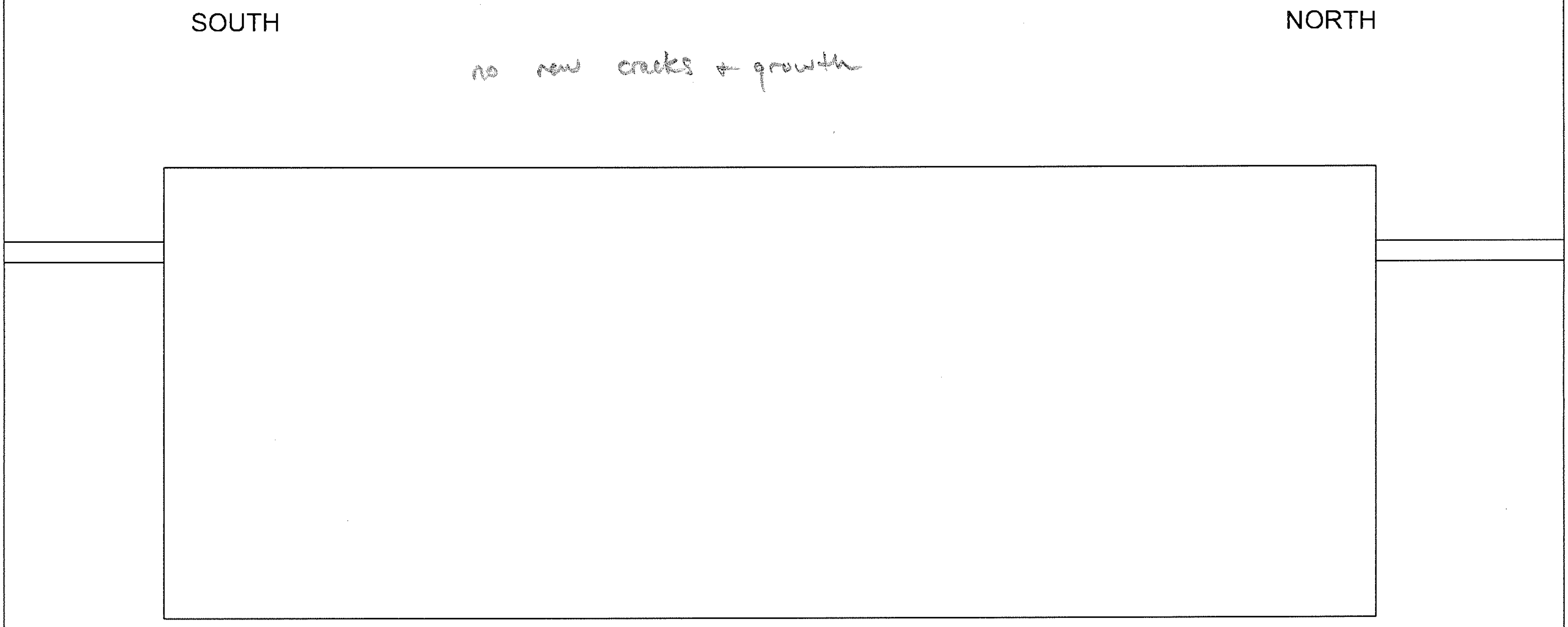
D6 Reload w/ Anchors



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

40^K
D6 Reload w/ Anchor

no new cracks + growth



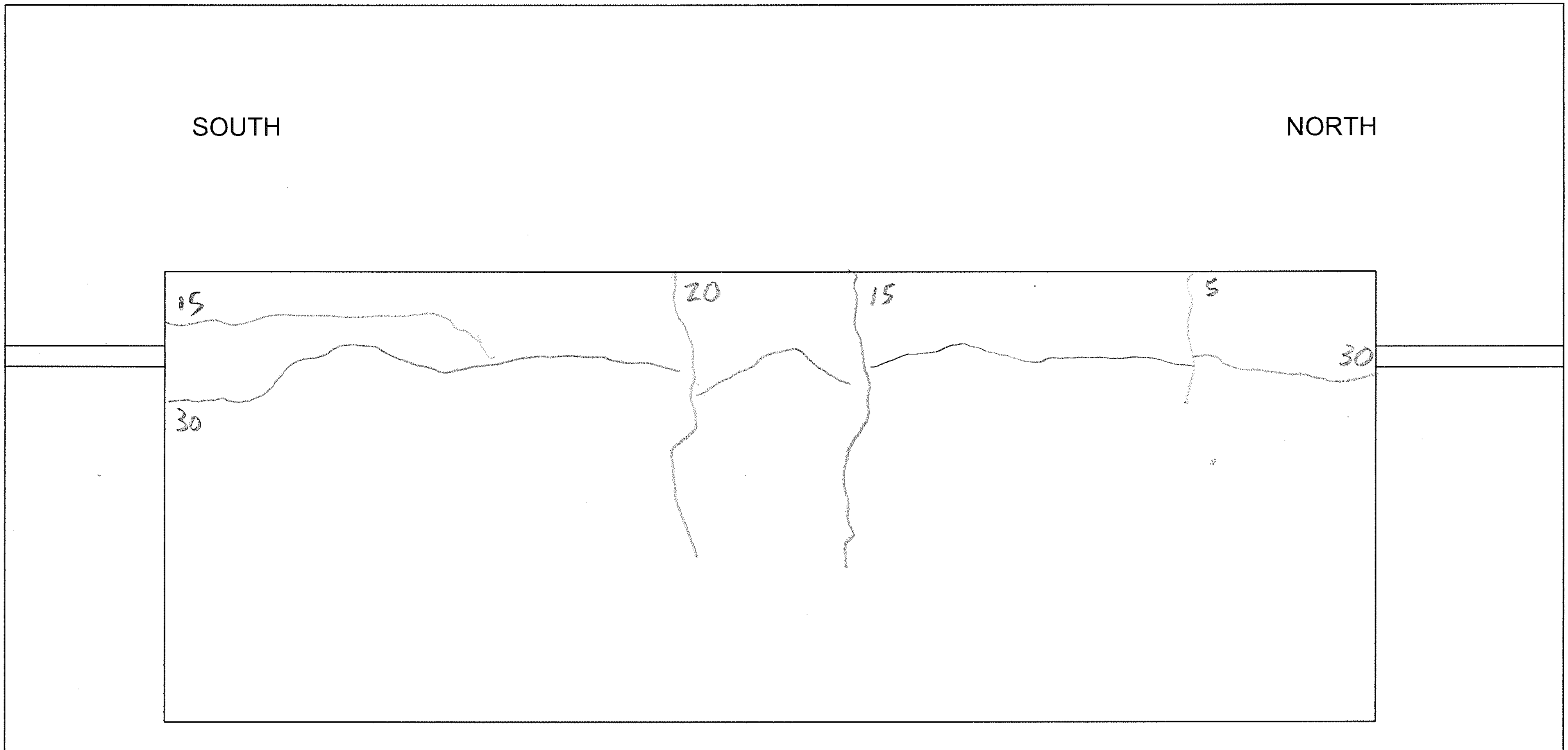
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

60k

D6 Reload w/ Anchors

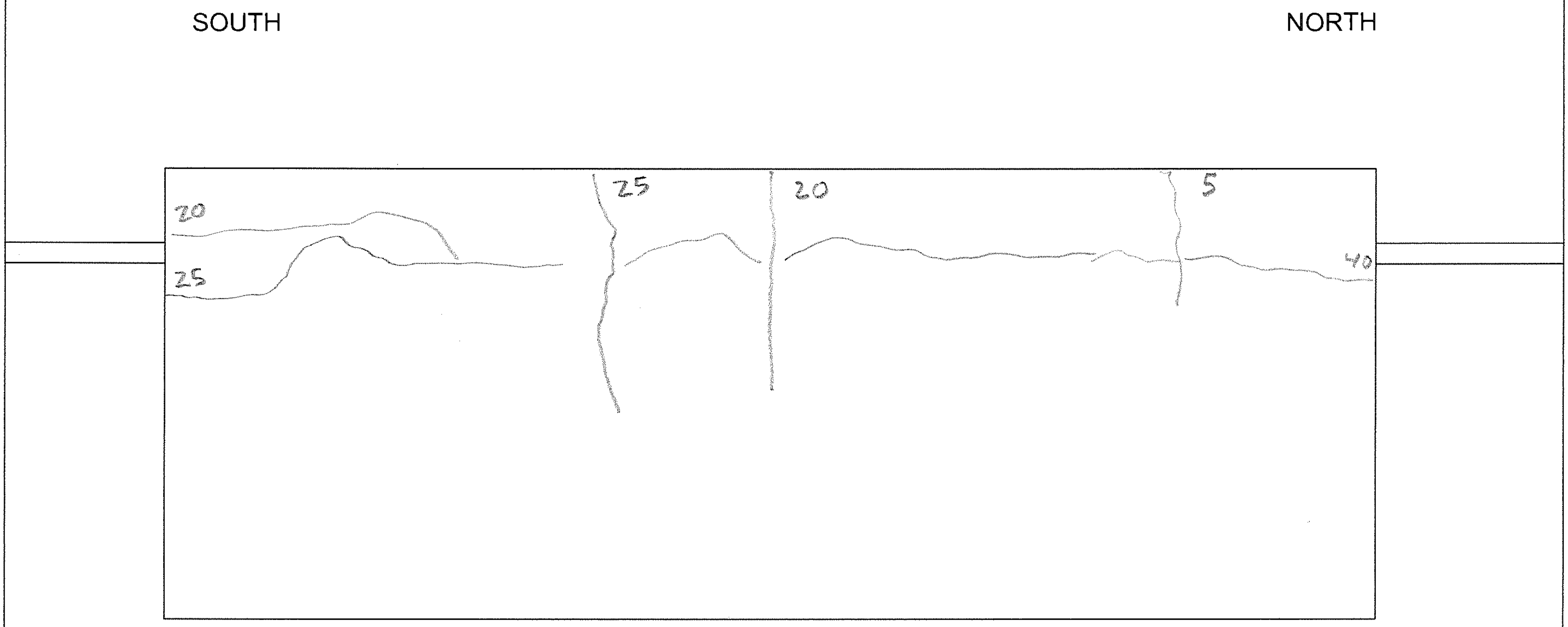


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

80^{K}

D6 Reload w/ Anchor

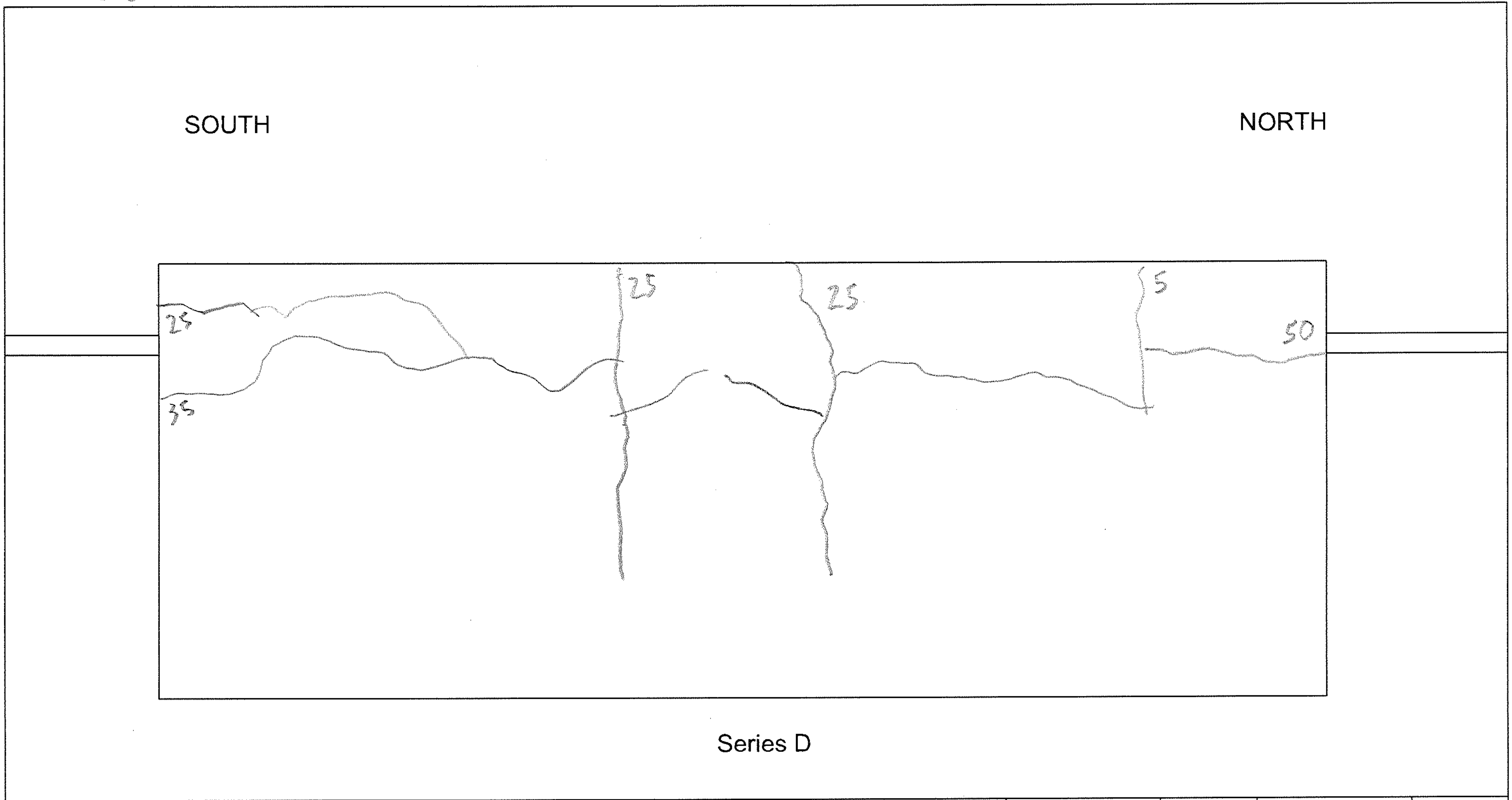


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

100k

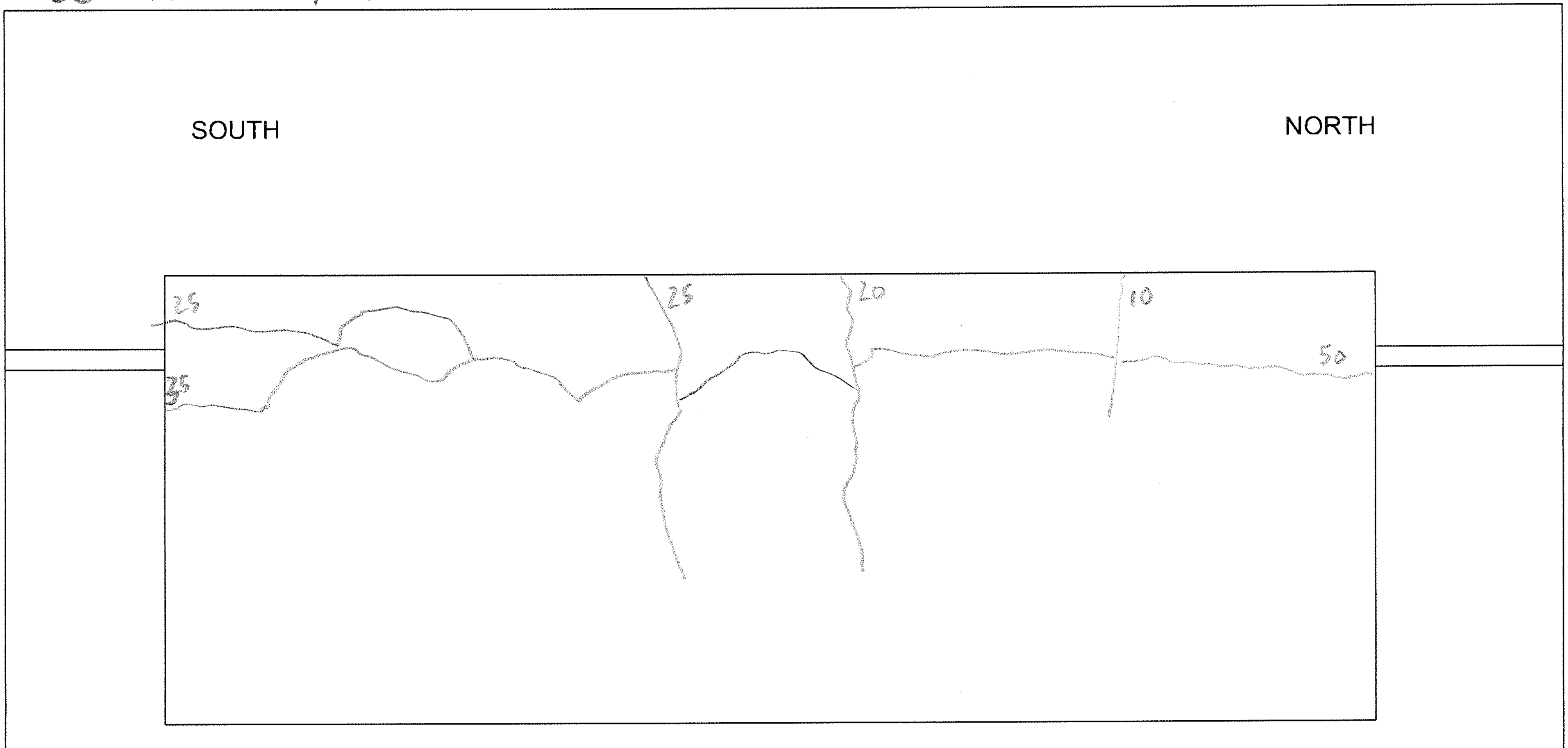
D6 Reload w/ Anchors



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

110^{k}

D6 Reload w/ Anchor



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D7

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 2/26/17 prior to participation in the test:

Print Name	Sign Name	Date
S. PUJOL LLANO		FEB 26, 2017
AISHWARYA Y. PURANAM		02/26/17
LUCAS LAUGHERY	Lucas Laughery	26/FEB/17
Mete A. Sozen	MeteASozen	26Feb2017

Recorded by:

Checked by:

Checked by:

Test: D7

Date: 26-FEB-17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0	16:36	0	0	0	0	0	0	0
20k	16:41	21.9	19.6	0.00	0.001	0.00	0.00	
40k	16:50	40.1	39.9	0	0.004	0.00	0	0.004
60k	17:00	60.2	60.2	0.001	0.007	0.002	0.002	0.007
80k	17:09	80	80	0.004	0.013	0.006	0.005	0.013
100k	17:18	99	99.3	0.01	0.026	0.016	0.011	0.026
110k	17:30	108.7	108	0.017	0.036	0.028	0.032	0.036
UNLOAD	17:40	200	260	0.014	0.025	0.029	0.046	0.046
→ went up to CW ~ 0.060 SW LVDT (check photograph)								

Notes:

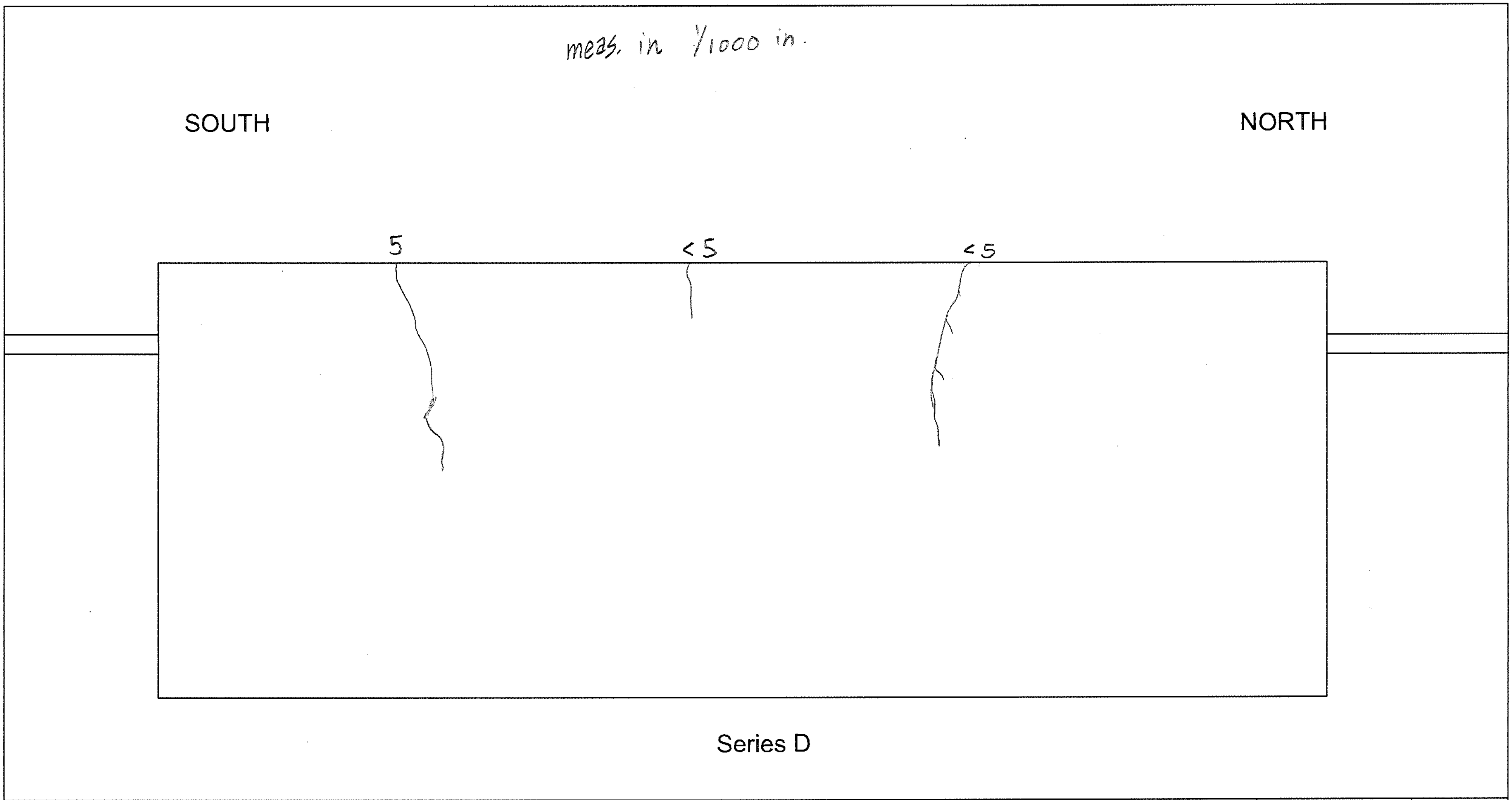
Recorded by:

AISHWARYA PURANAM

Signature:

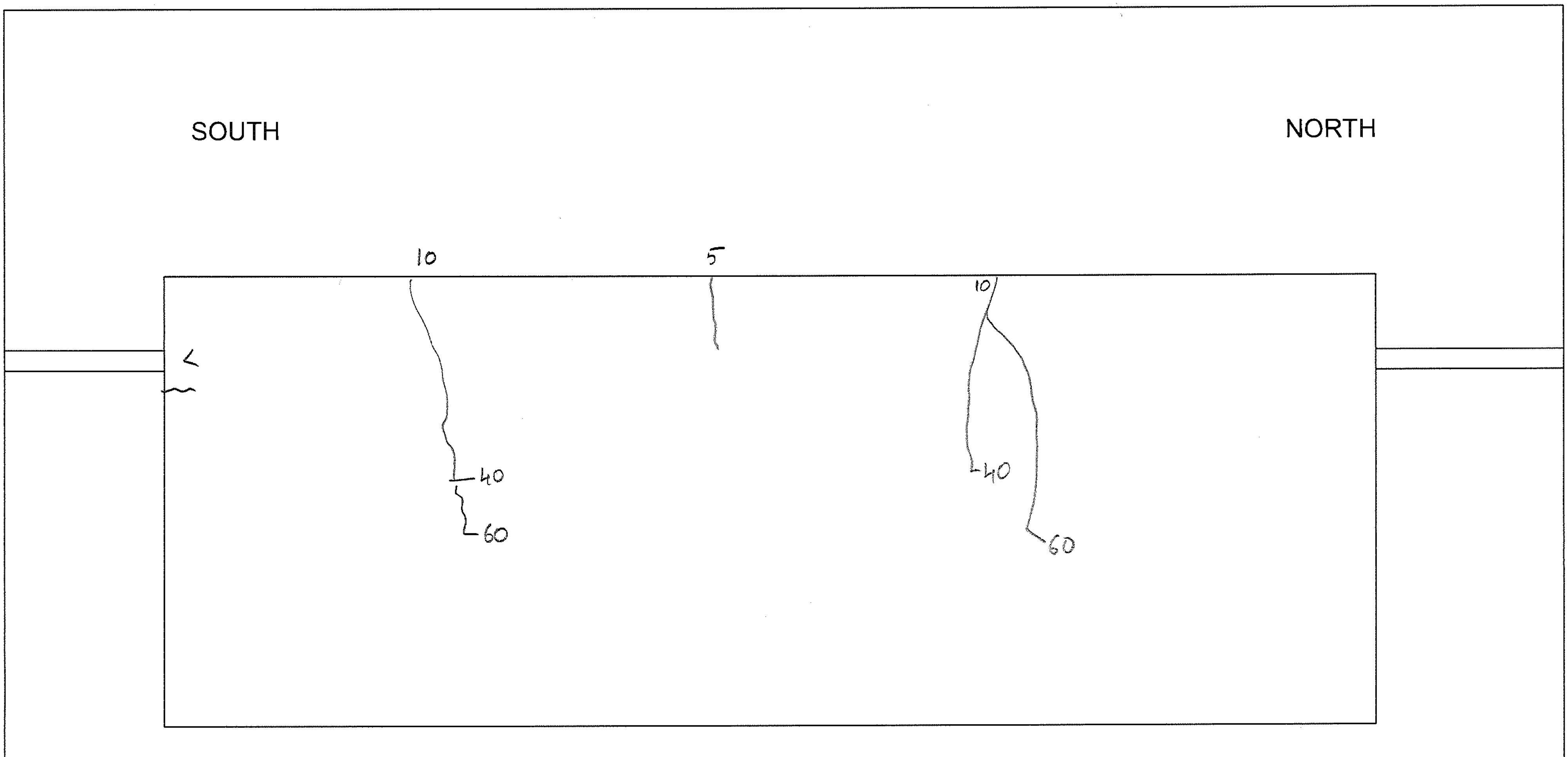
Aishwarya.

40k



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

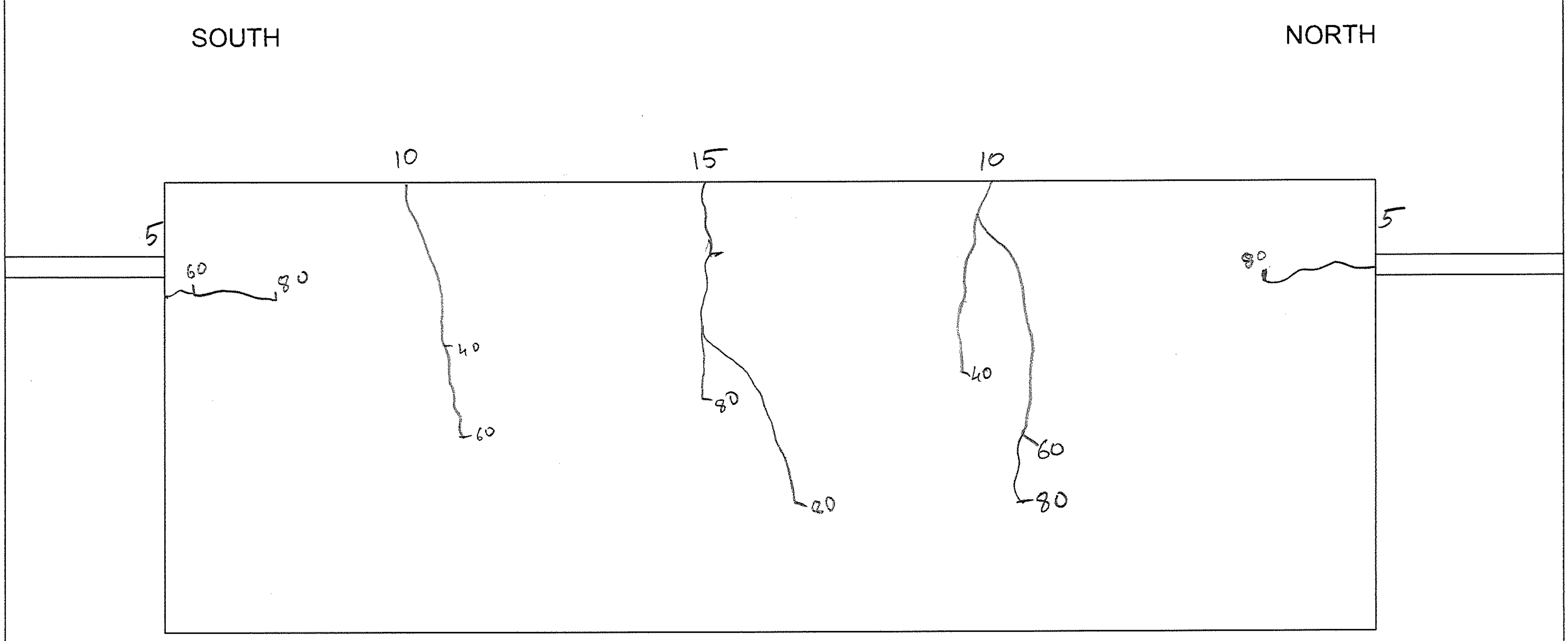
60k



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

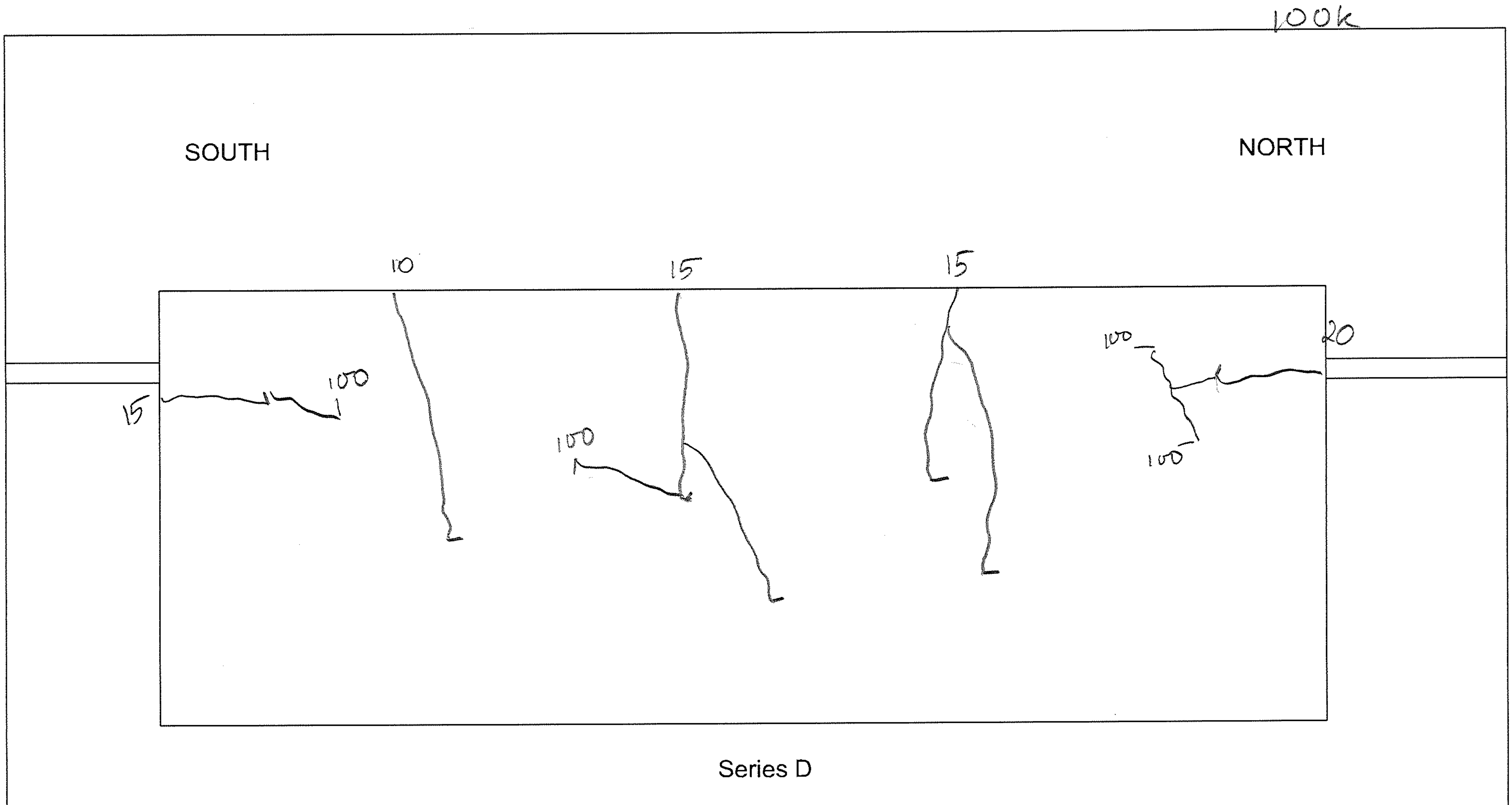
80k



Series D

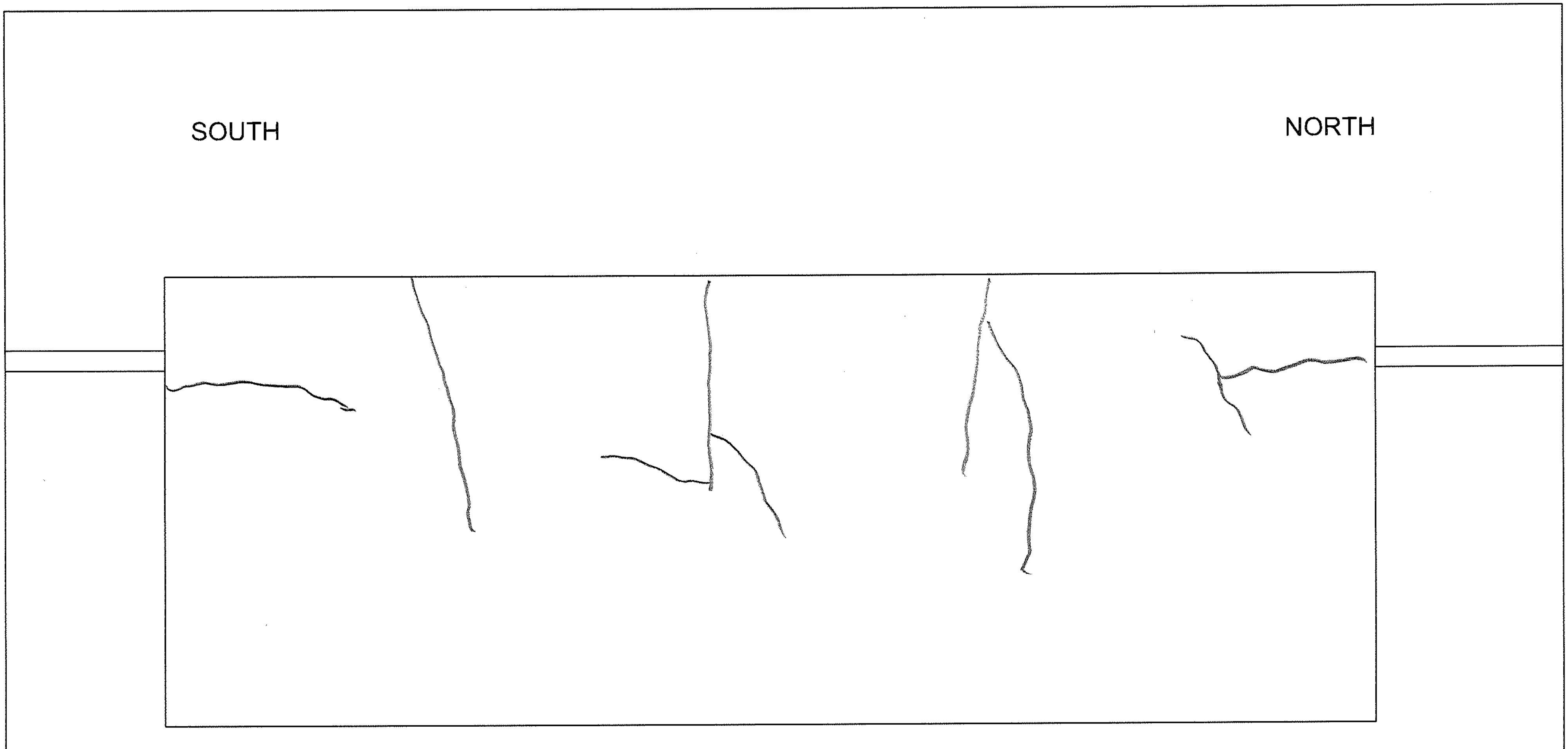
BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

Test: D7-2 Reload w/ Anchor

Date: 2/28/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0K	6:35	.18	.26	.013	.024	.025	.043	.043
20K	6:41	20.7	20.2	.013	.023	.025	.042	.042
40K	6:45	40.8	40.3	.013	.025	.026	.043	.043
60K	6:50	60.4	60.1	.015	.030	.028	.047	.047
80K	6:56	79.8	80	.018	.036	.030	.053	.053
100K	7:04	99.6	99.7	.023	.044	.034	.061	.061
110K	7:10	109.1	108.7	.027	.052	.036	.067	.067

Notes:

28K to pullout S Anchor
after test

Recorded by:

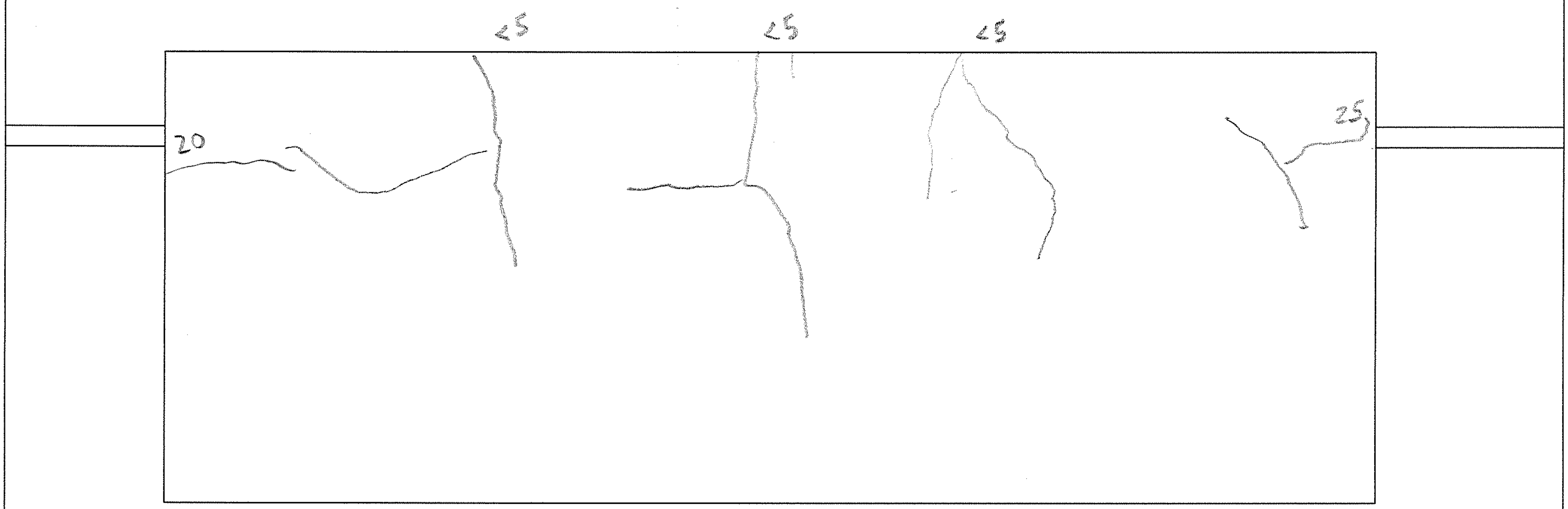
Kinsey Skiller

Signature:

D7

20^{k} Reload w/ Anchor 2/28/17

SOUTH NORTH



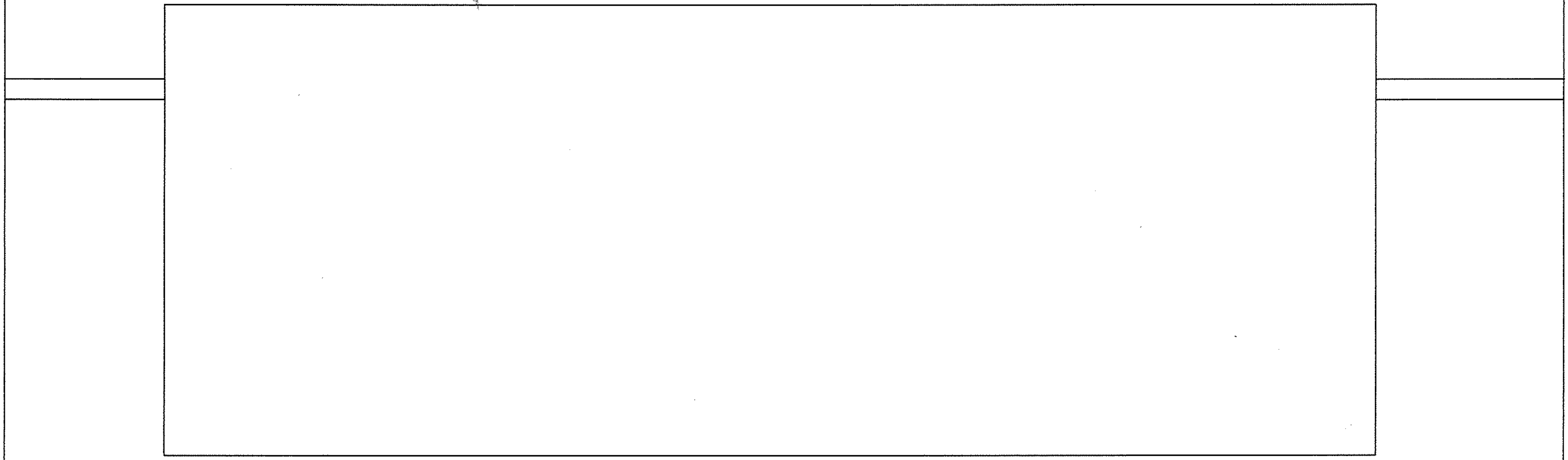
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D7 40^k Reload w/ Anchors

SOUTH NORTH

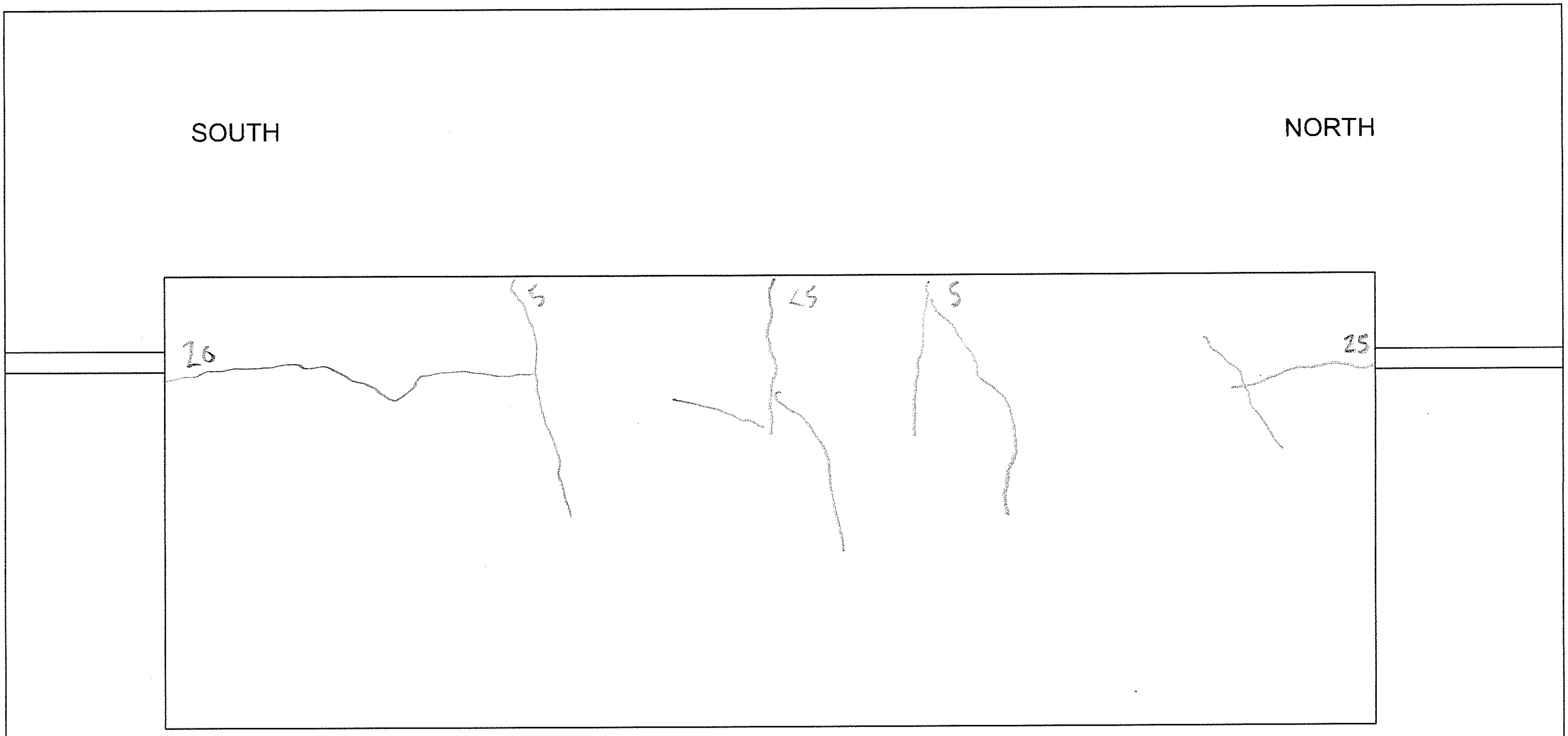
Same crack map + widths as 20^k reload



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

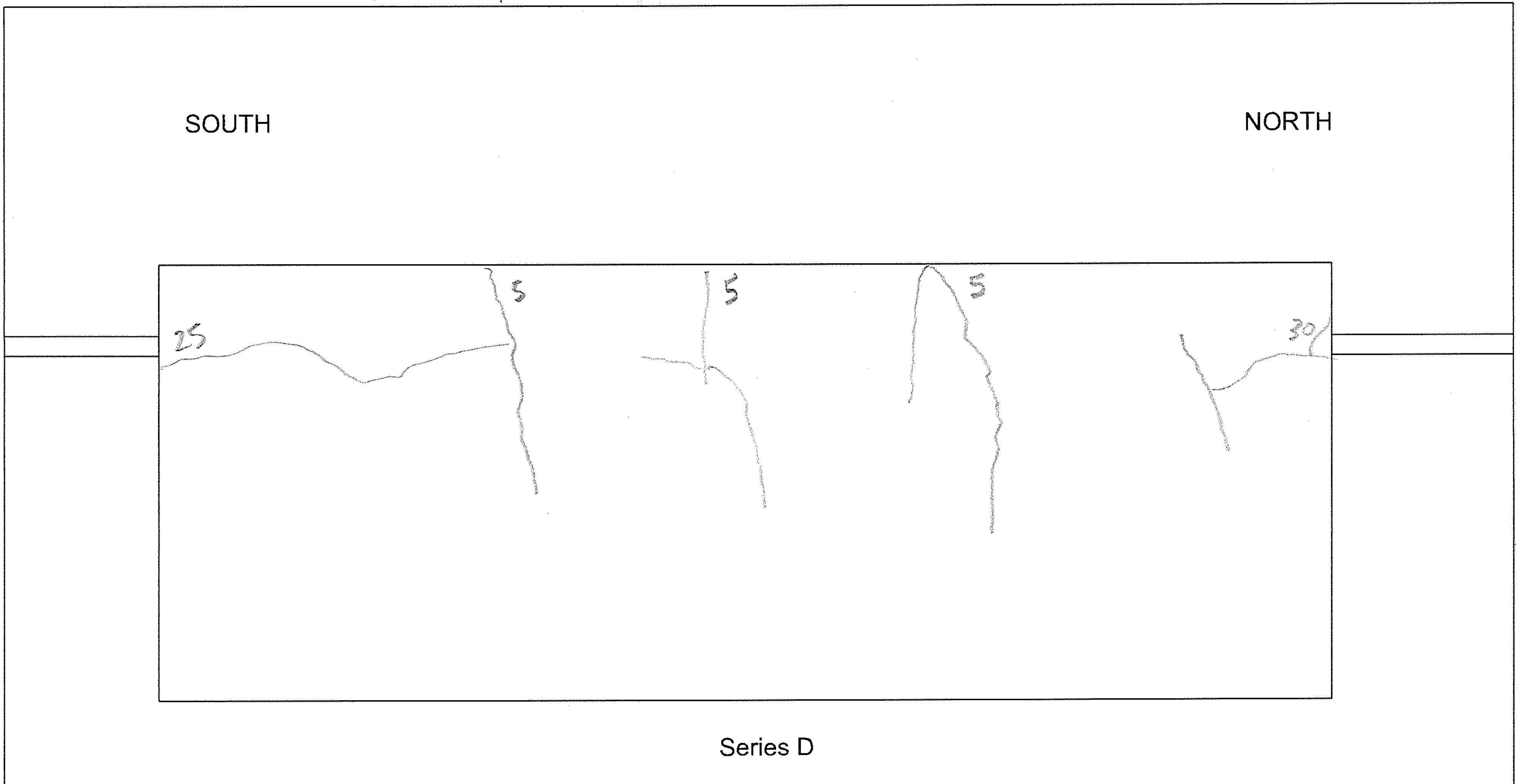
D7 60K Reload w/ Anchor



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D7 80^k Reload w/ Anchors

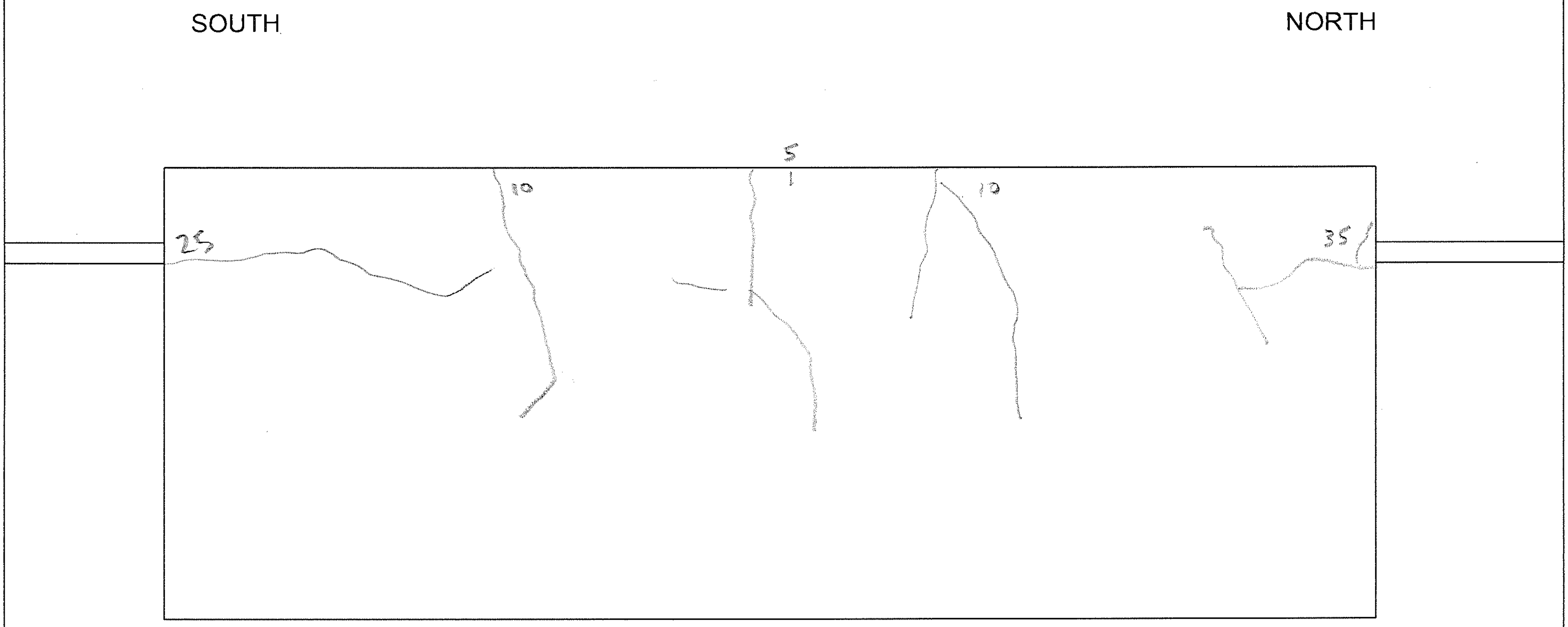


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D7 100^k Reload w/ Anchors



Series D

BOWEN LABORATORY PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D8

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 3/6/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skillen		3/6/17
Pete Conrado		3/6/17
Prateek Shah	PPS	3/6/17
Lucas Laughery	Lucas Laughery	6-Mar-17
Mete A. Sozen	Mete Sozen	3/6/7/2017

Recorded by: Checked by: Checked by:

Test: D8

Date: 3/6/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0K	1:26	0	0	0	0	0	0	0
20K	1:34	20.2	20.2	.001	0	0	0	0
40K	1:38	39.6	39.8	.003	.001	.001	0	.003
60K	1:45	60.2	60.3	.006	.001	.006	.004	.006
80K	1:52	79.6	79.8	.012	.001	.012	.011	.012
100K	2:00	99.4	99.4	.017	.003	.020	.020	.020
110K	2:09	108.9	108.3	.020	.004	.028	.027	.028
120K	See photos	→						.080

Notes:

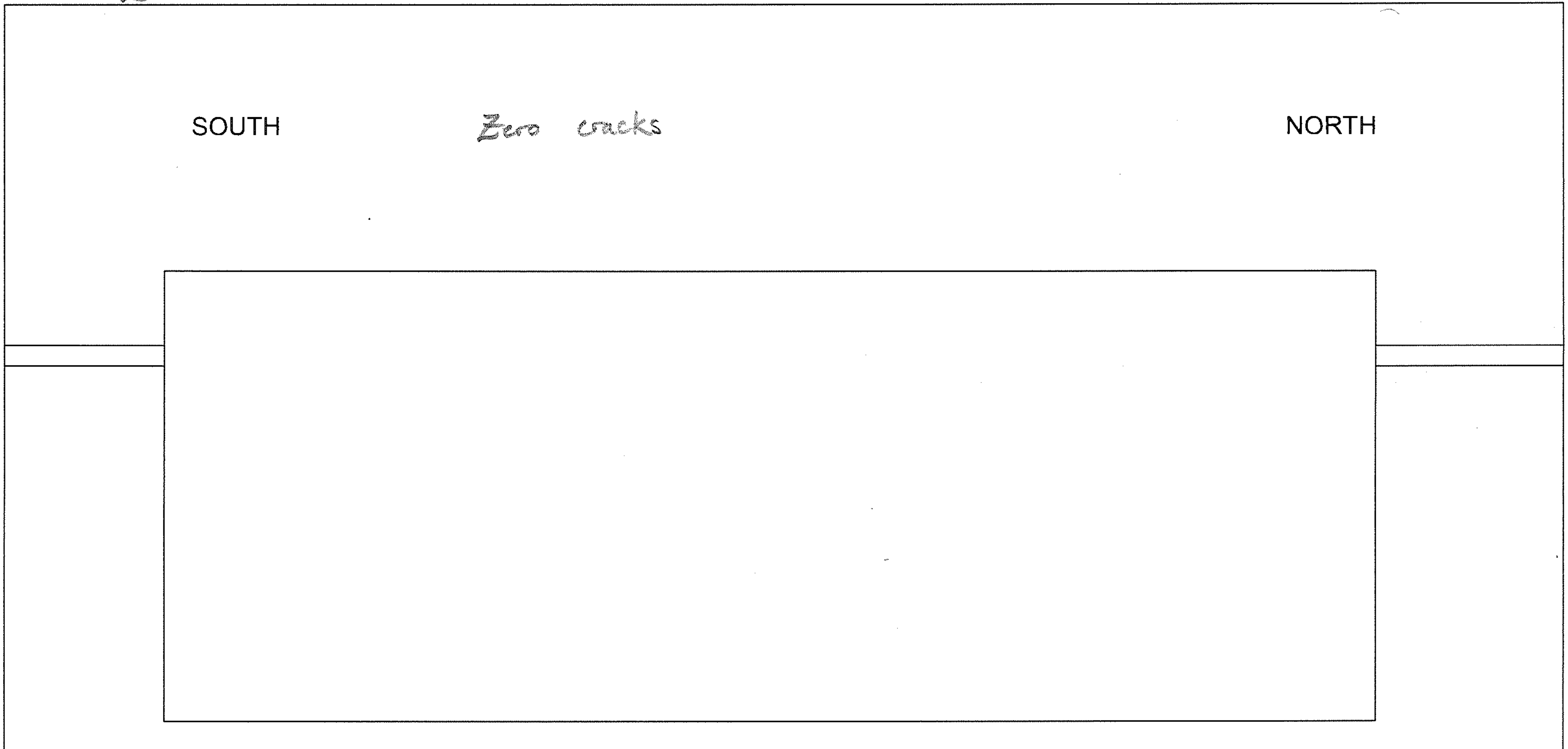
Took 1 Optotrak reading @ 0.08 in then unloaded. @ SE

- Bumped SE LVDT during anchor install

Recorded by: Kinsey Skillen

Signature:

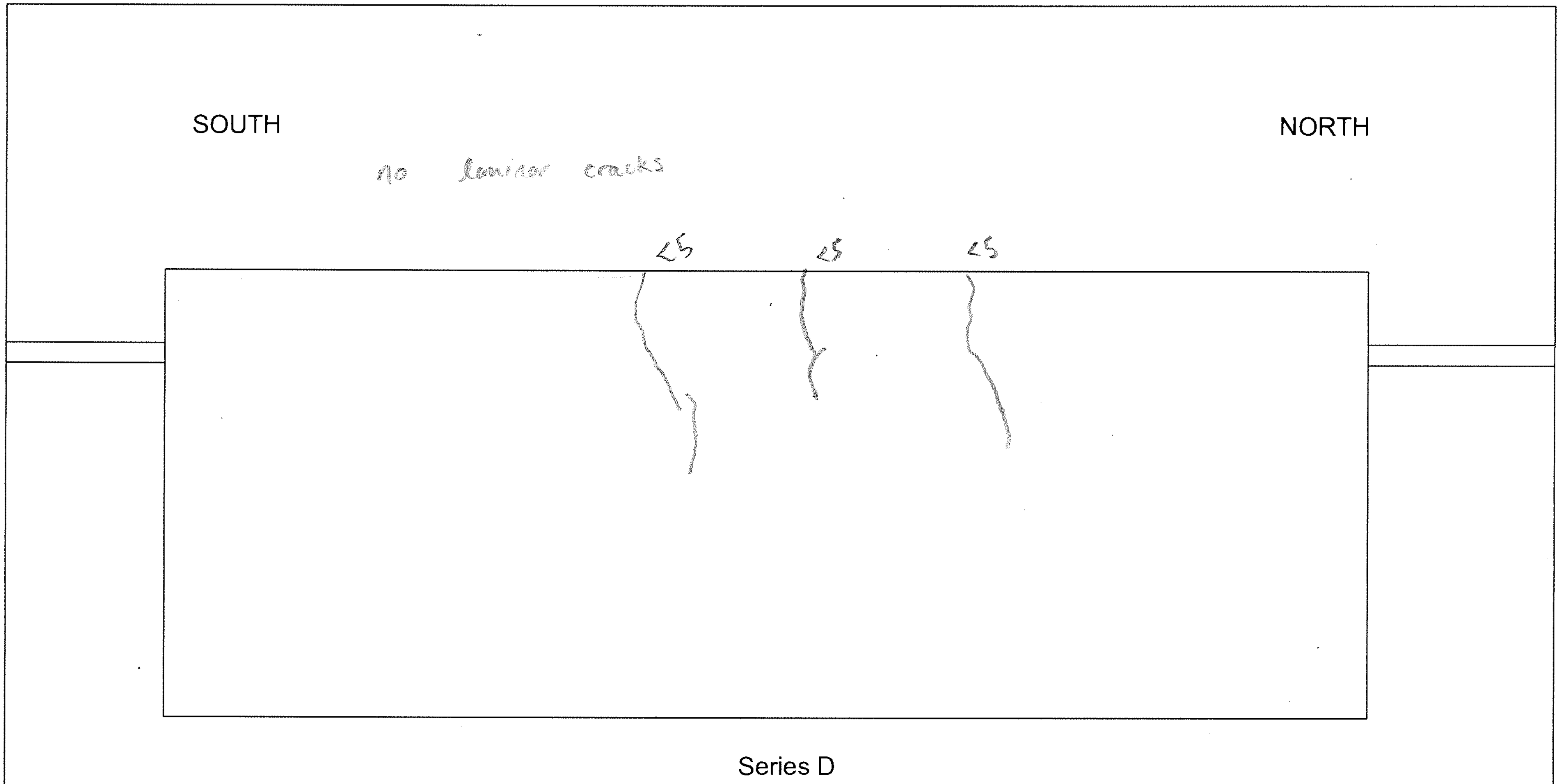
20k



Series D

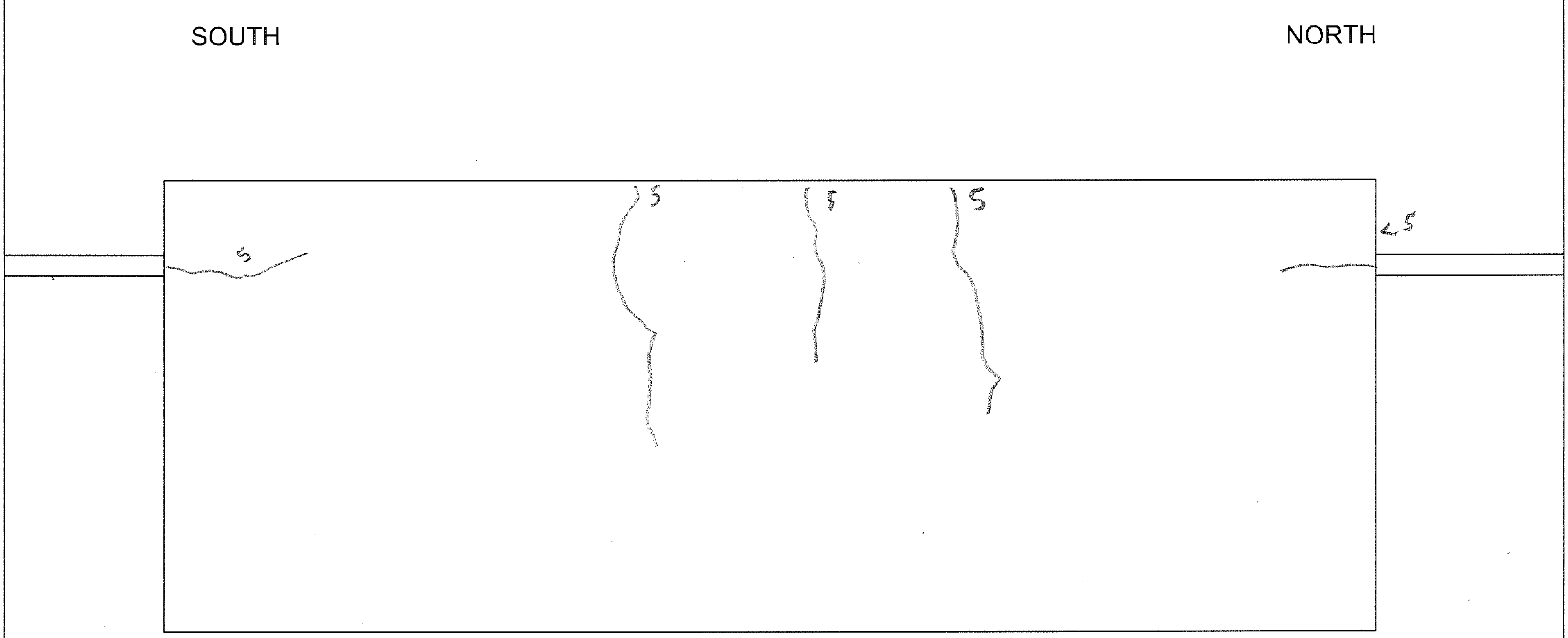
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

40 k



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

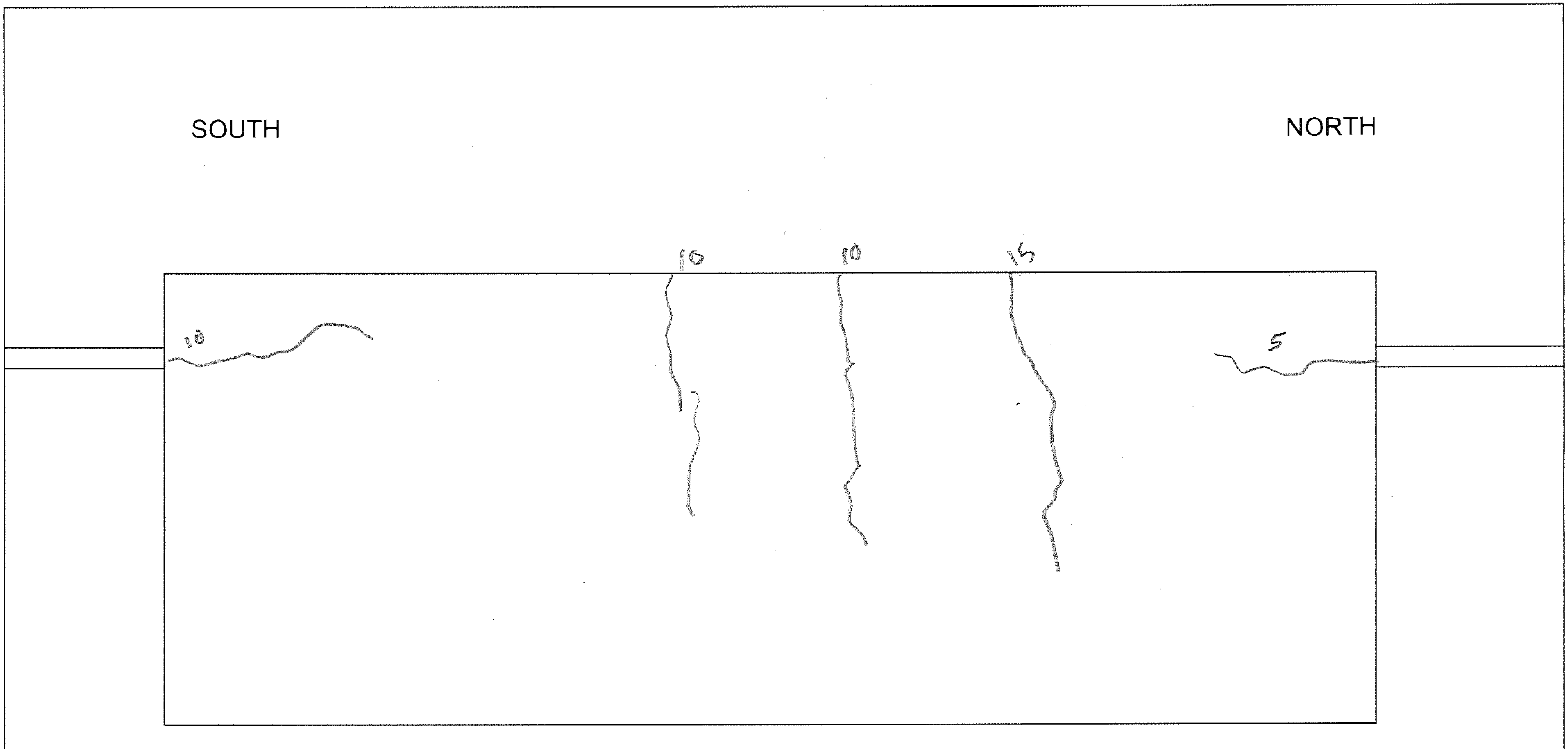
60k



Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

80 K

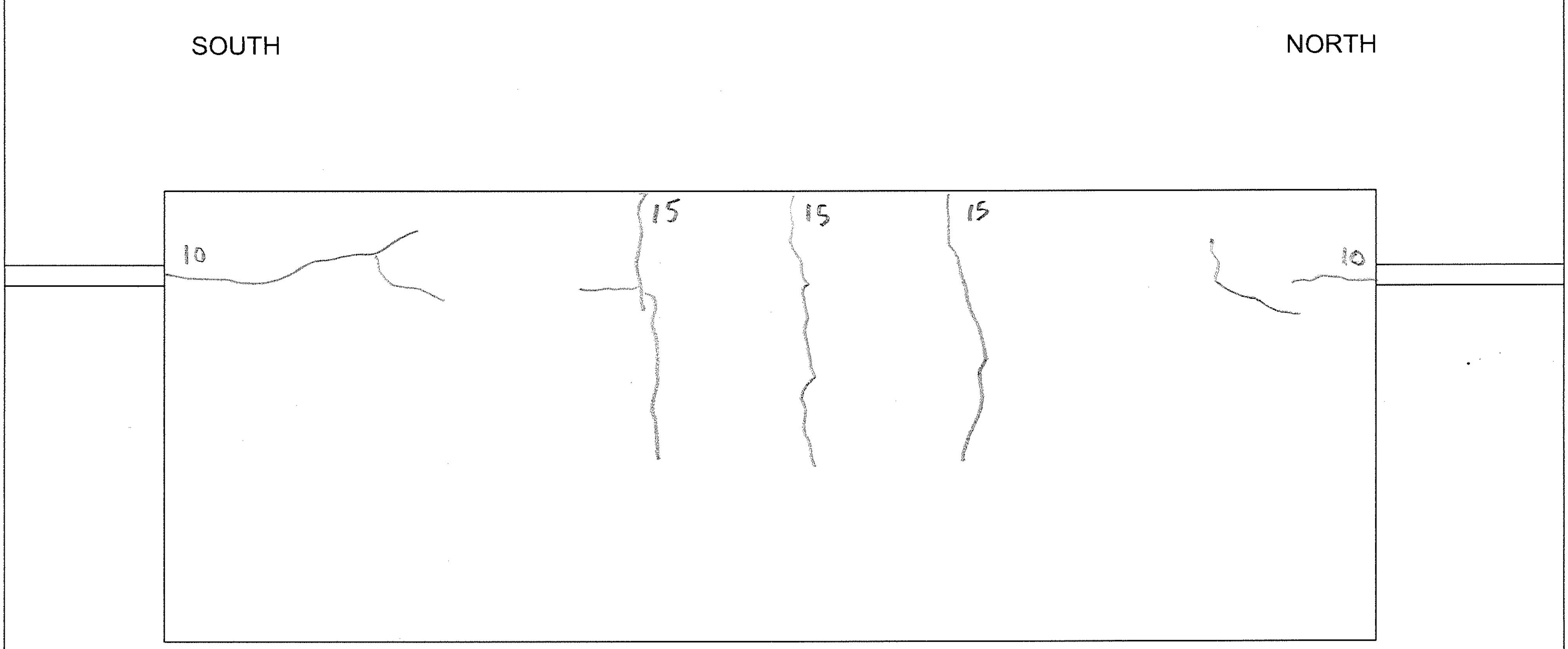


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

100^K

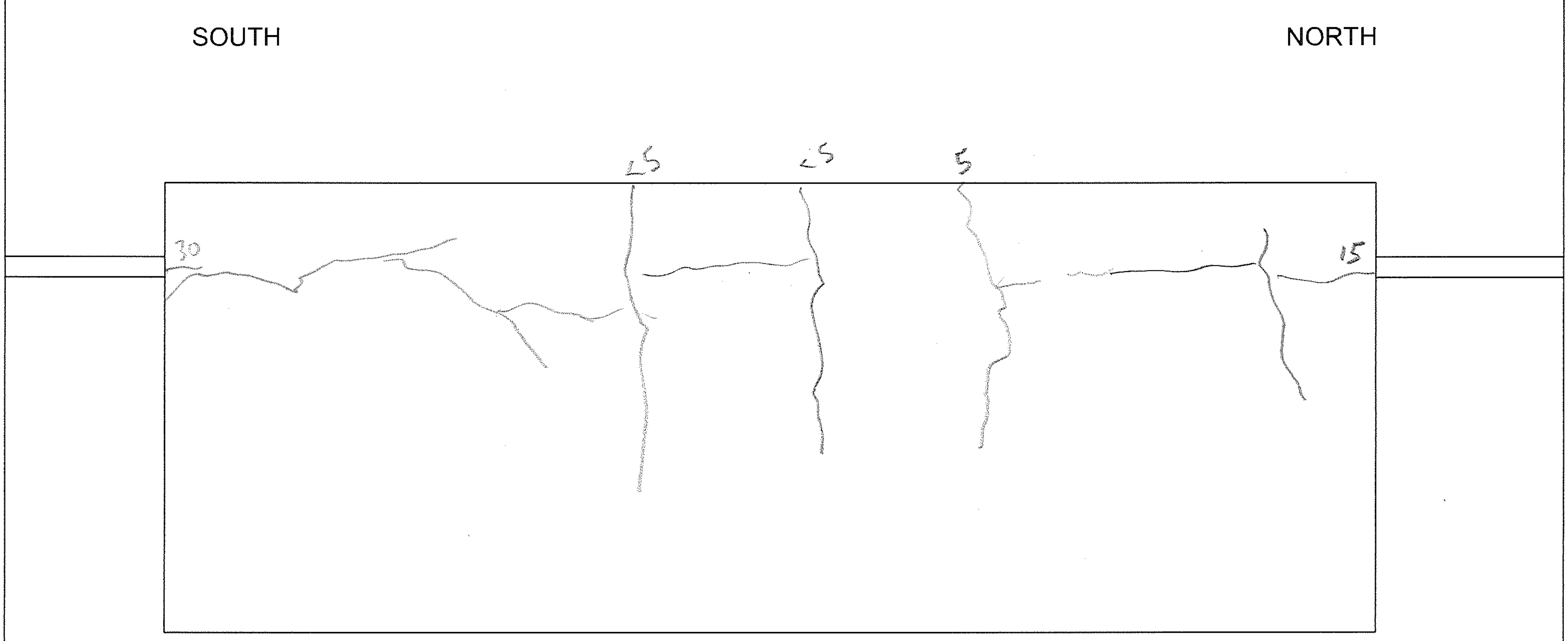


Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

120^{k} unload



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

Test: D8 Reload

Date: 3/7/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0^{K}	4:22	0	0	.032	-.065	.048	.049	.049
20^{K}	4:28	20.1	19.9	.032	-.065	.048	.049	.049
40^{K}	4:31	40.2	40.2	.032	-.065	.051	.051	.051
60^{K}	4:37	60	60.7	.035	-.065	.055	.056	.056
80^{K}	4:41	80.1	80.2	.039	-.065	.060	.062	.062
100^{K}	4:48	99.4	99.6	.045	-.062	.065	.069	.069
110^{K}	4:55	109.4	109.4	.049	-.062	.068	.074	.074
120^{K}	5:01	119.8	119.8	.057	-.060	.073	.081	.081
126^{K}	5:05	126^{K}	126^{K}	.093	-.023	.090	.098	.098
130^{K}	5:08							.105
↳ Failed								

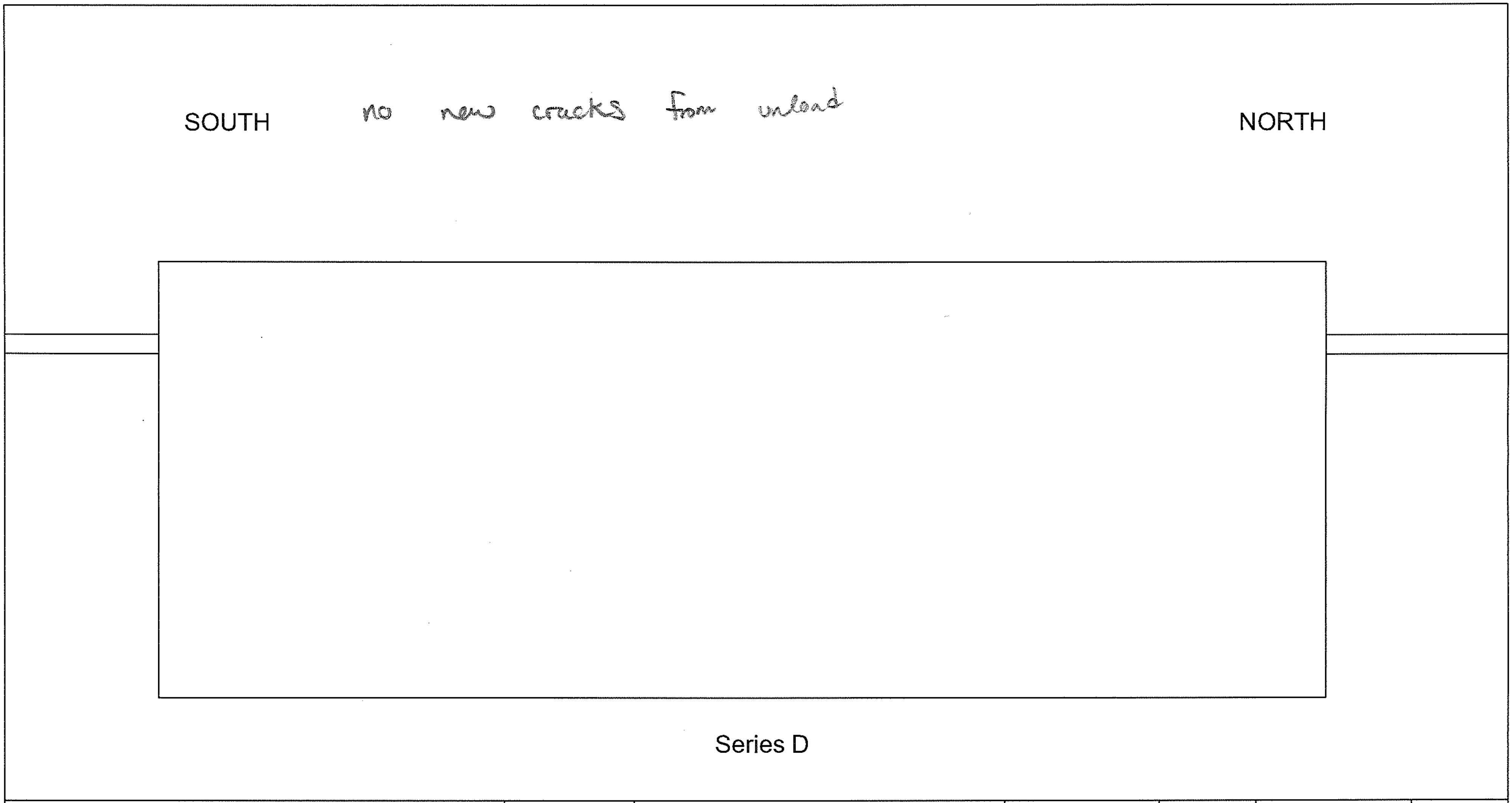
Notes:

NW LVDT bumped during anchor install, correct value from unload value in photos.

Recorded by: Kinsey Skiller

Signature:

D8 Reload 20k

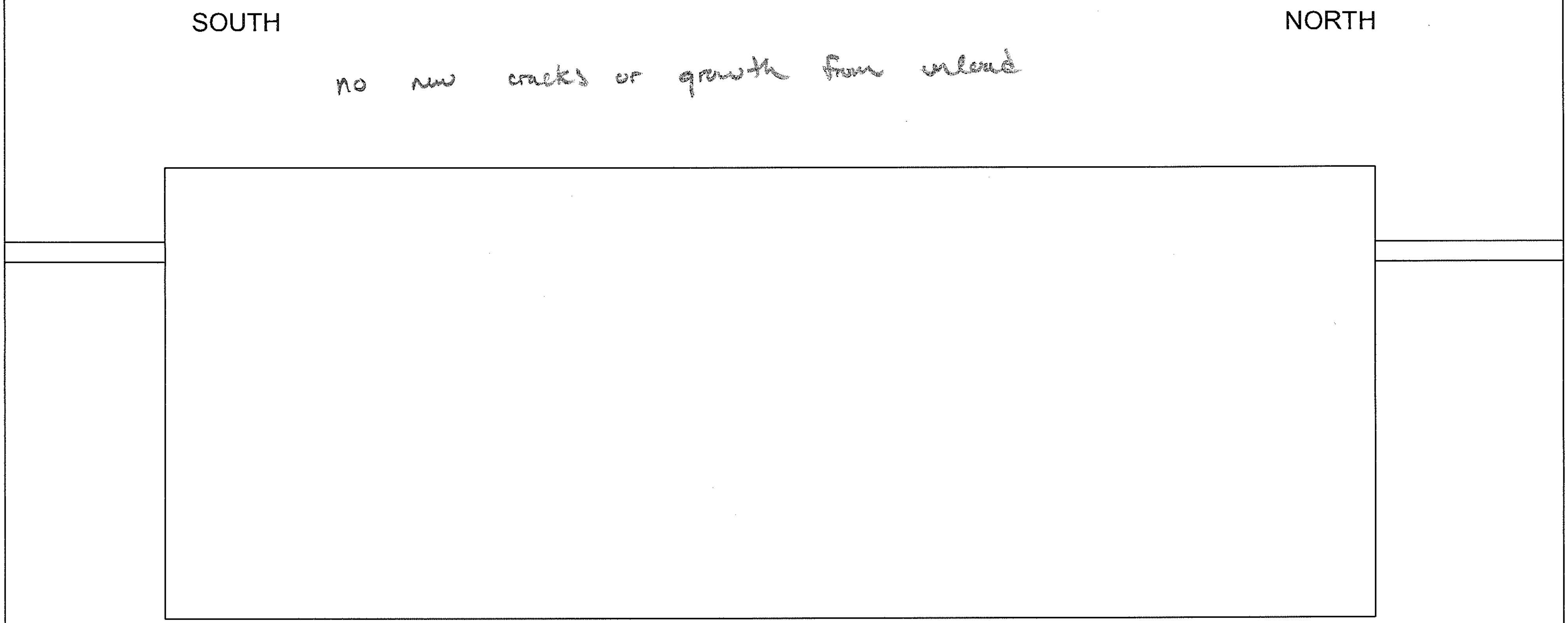


no new cracks from unload

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D8 Reload 40^k

no new cracks or growth from unload



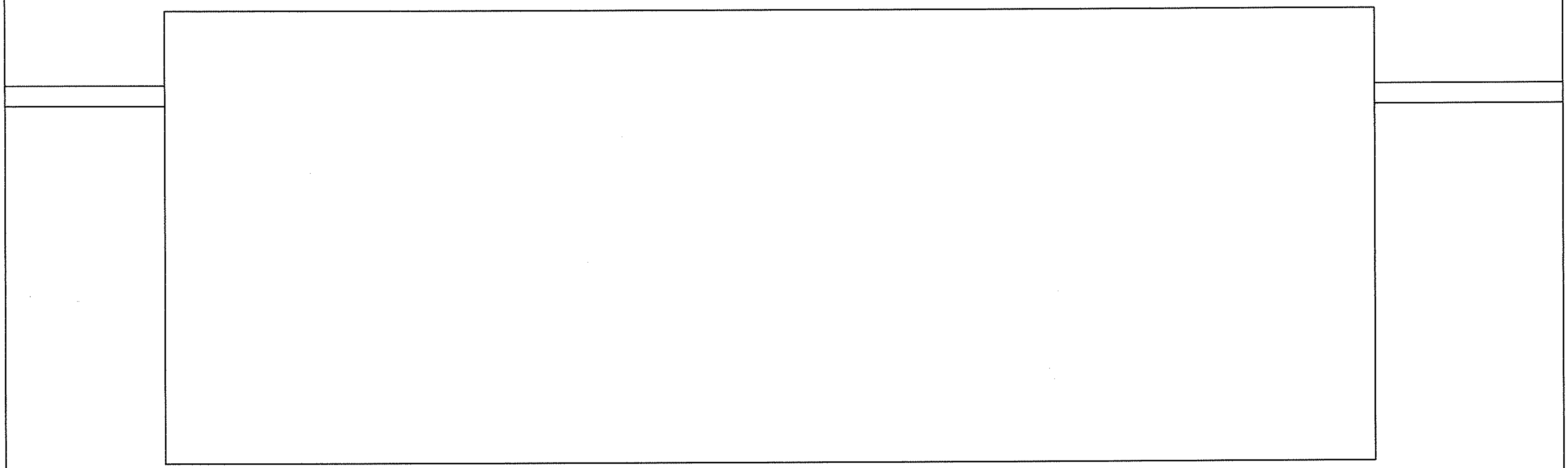
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D8 Reload 60K

SOUTH NORTH

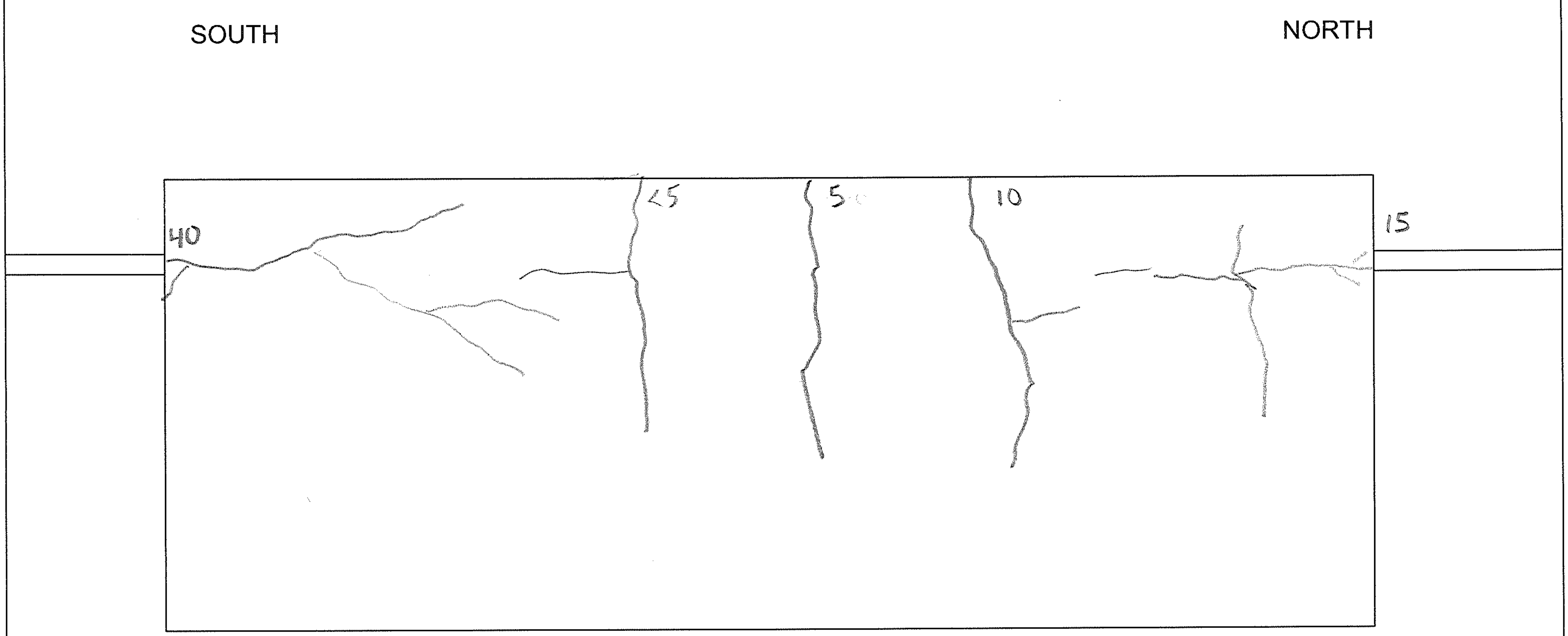
no new cracks or growth from unload



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D8 Reload 80 K



Series D

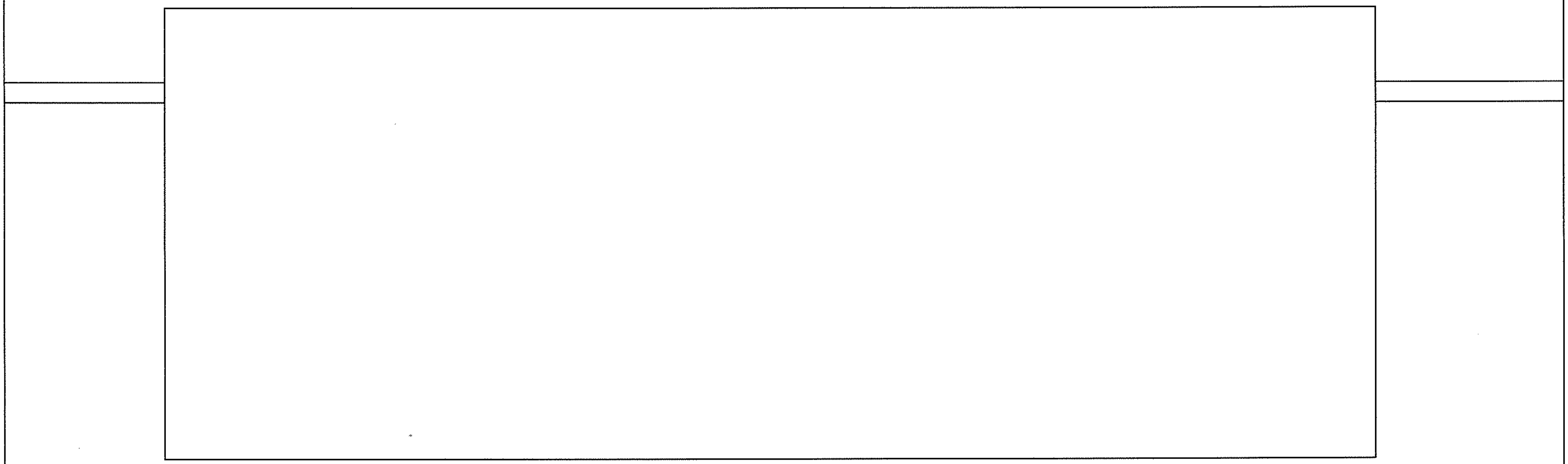
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D8 Reload 100^{k}

SOUTH

NORTH

no cracks drawn, see photos



Series D

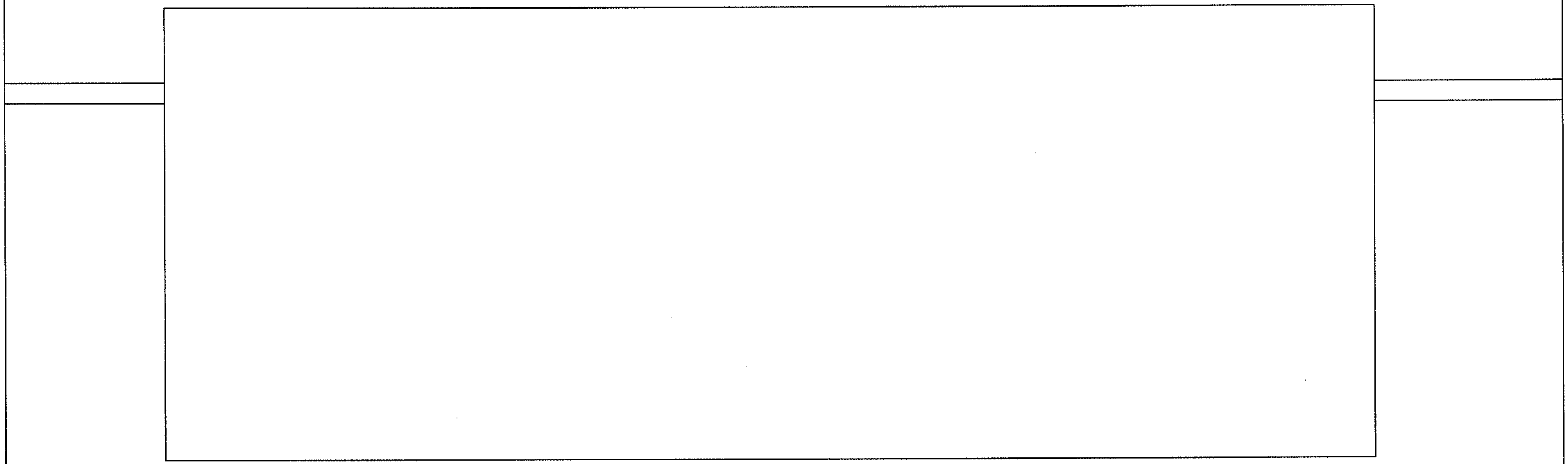
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D8 Reload 110^{K}

SOUTH

NORTH

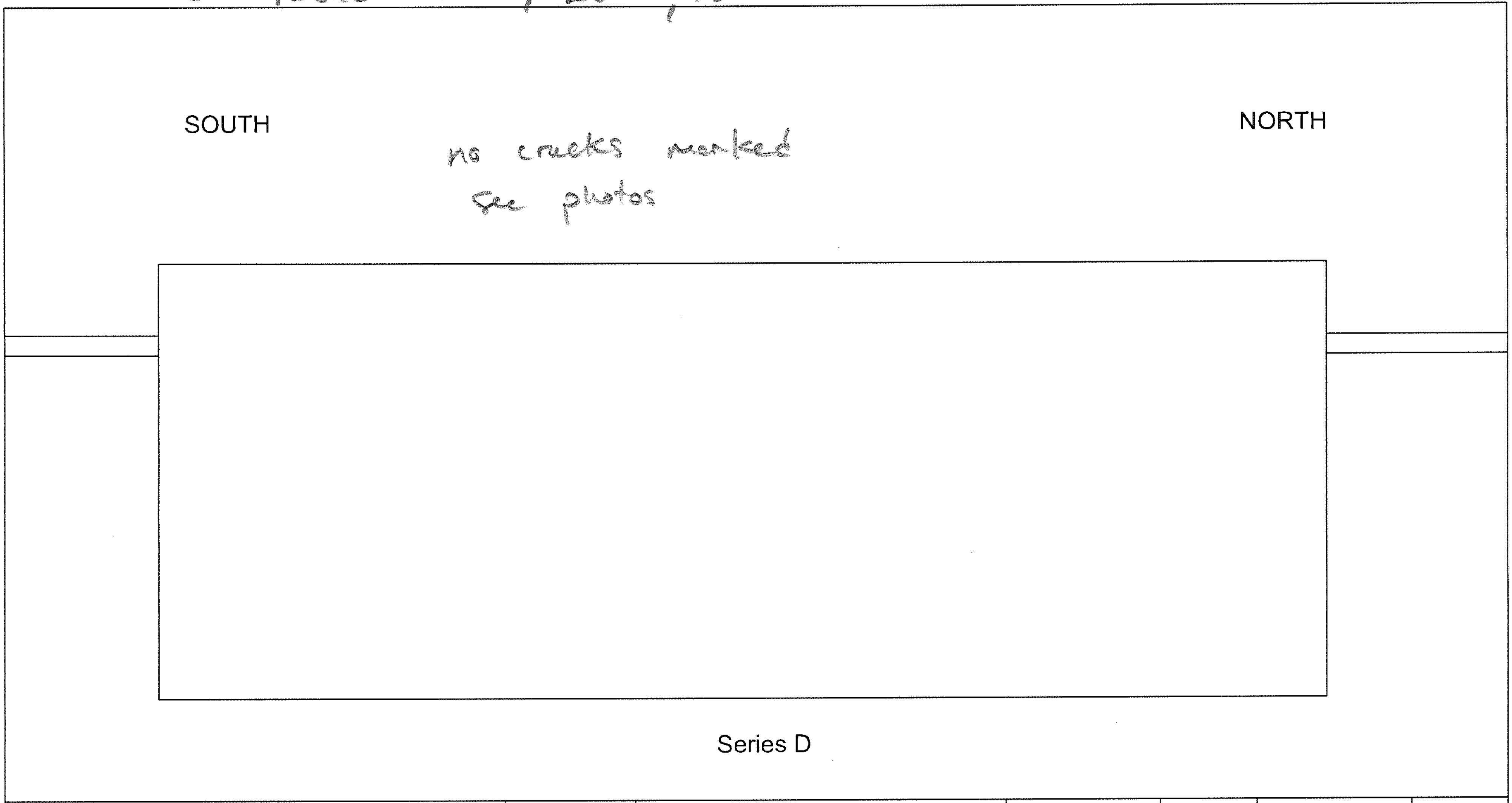
no cracks drawn, see photos



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D8 Reload 120k, 126k, 130k



no cracks marked
see photos

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D9

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 3/10/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skillen		3/10/17
Mete A. Sozen	MeteASozen	10 March 2017
Prateek Shah	PPS	3/10/17
Lucas Laughery	Lucas Laughery	10 | Mar | 17
S. PUJOL	S Pujol	10/ MAR /2017

Recorded by:

Checked by:

Checked by:

Test: D9

Date: 3/10/17

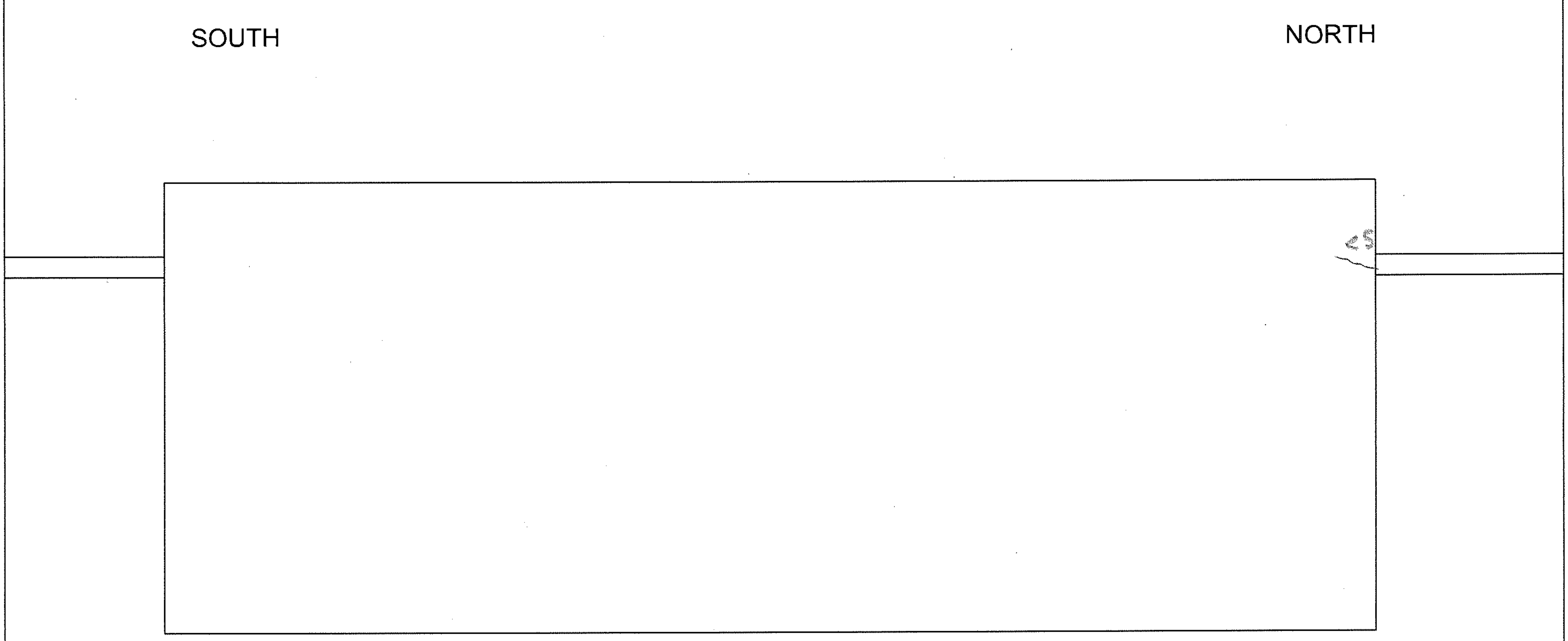
load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0^{K}	1:51	0	0	0	0	0	0	0
20^{K}	1:54	19.8	20.3	.004	.000	.000	-.009	.004
40^{K}	1:58	39.6	40.2	.006	0	0	-.009	.006
60^{K}	2:04	59.9	59.9	.009	.002	0	-.009	.009
80^{K}	2:09	79.7	79.7	.014	.005	0	-.007	.014
100^{K}	2:16	99.6	99.8	.019	.016	0	-.004	.019
110^{K}	2:24	108.1	108.3	.027	.024	0	0	.027
115^{K}	2:30	114.1	114.3	.050	.048	0	.004	.050

Notes:

Recorded by:

Signature:

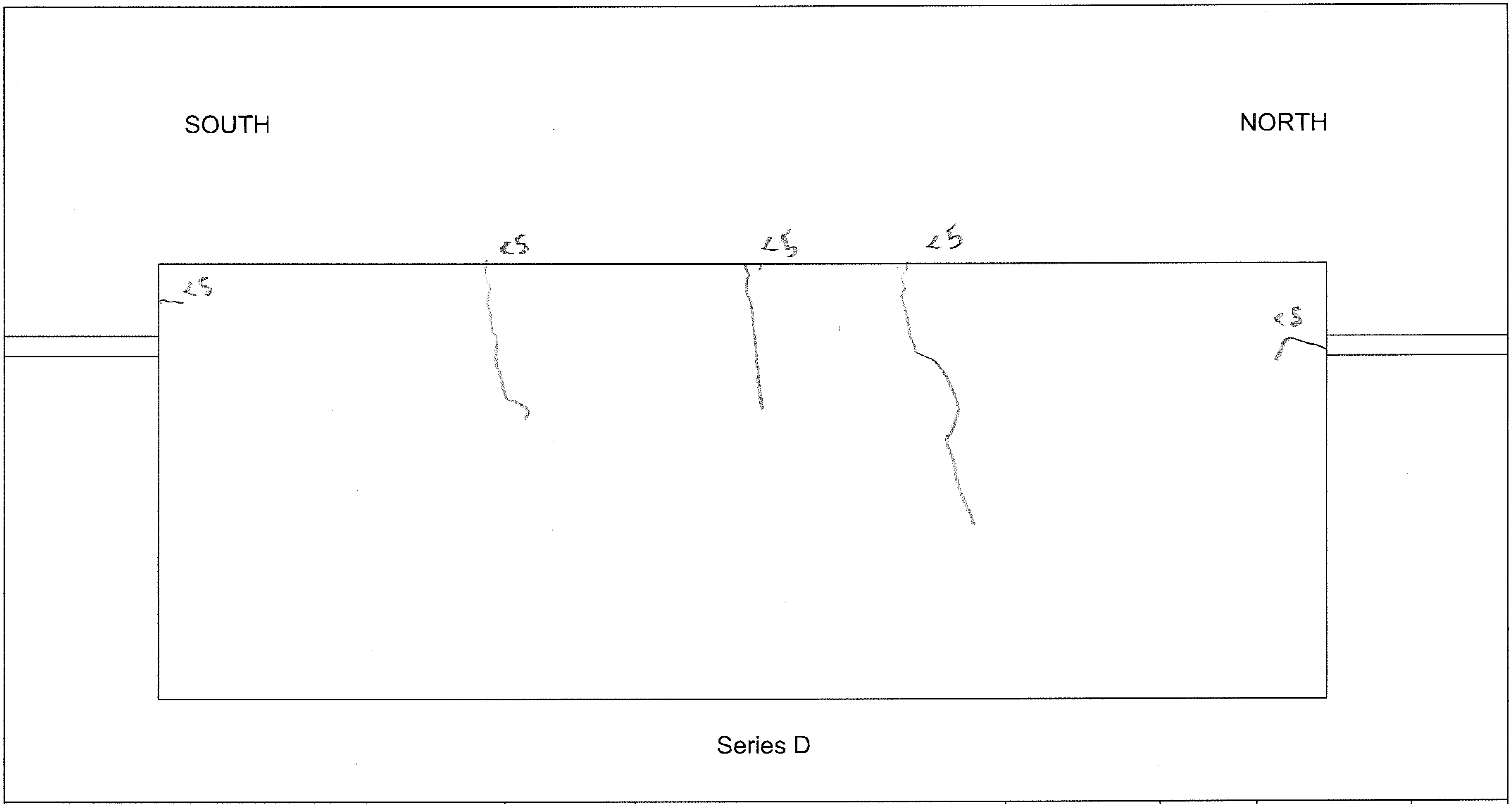
20K 3/10/17



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

40^{k} 3/10/17

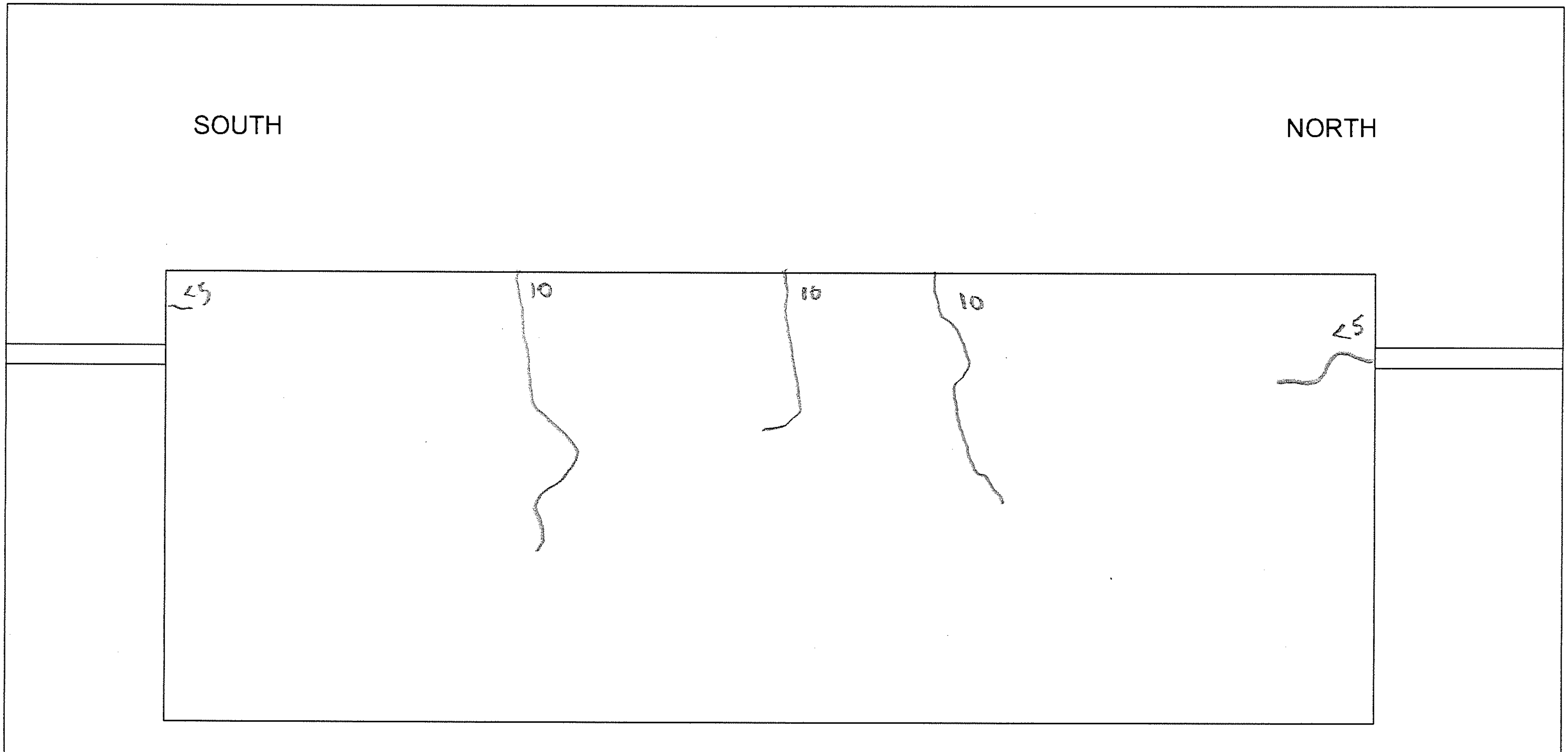


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

60k

3/10/17

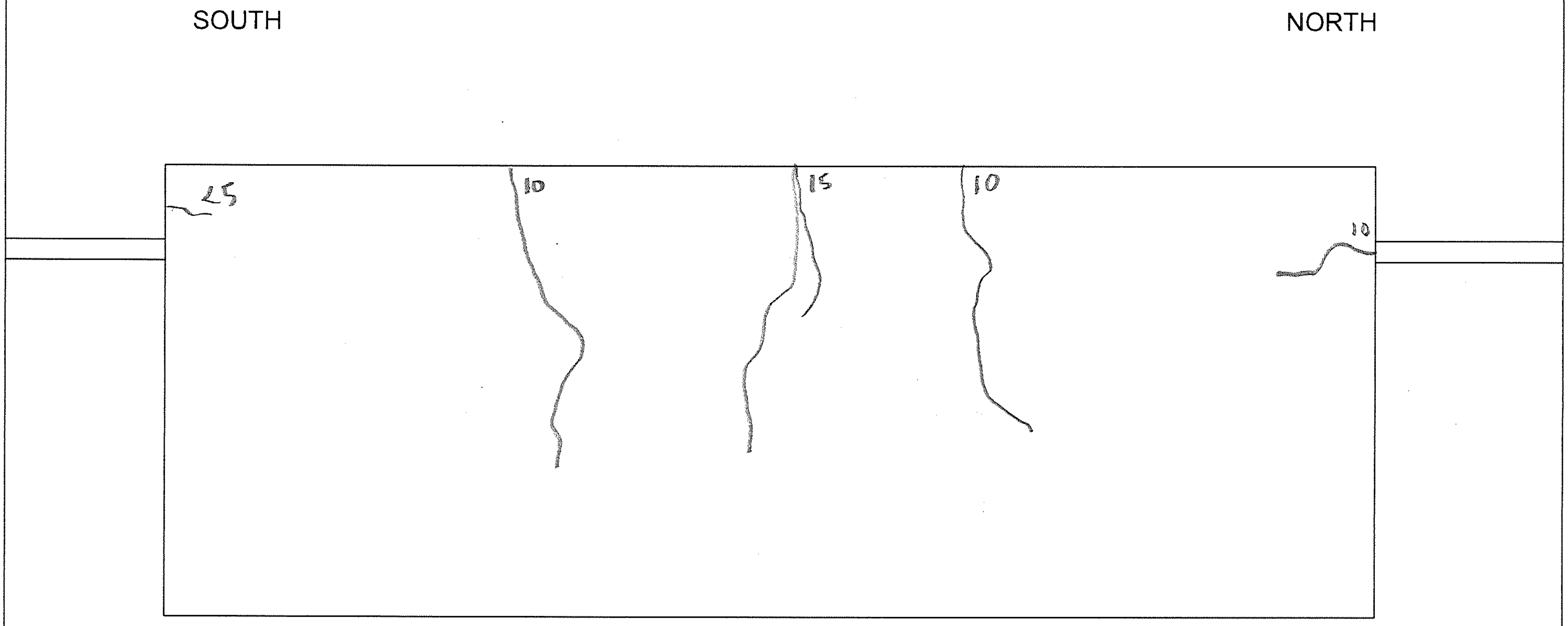


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

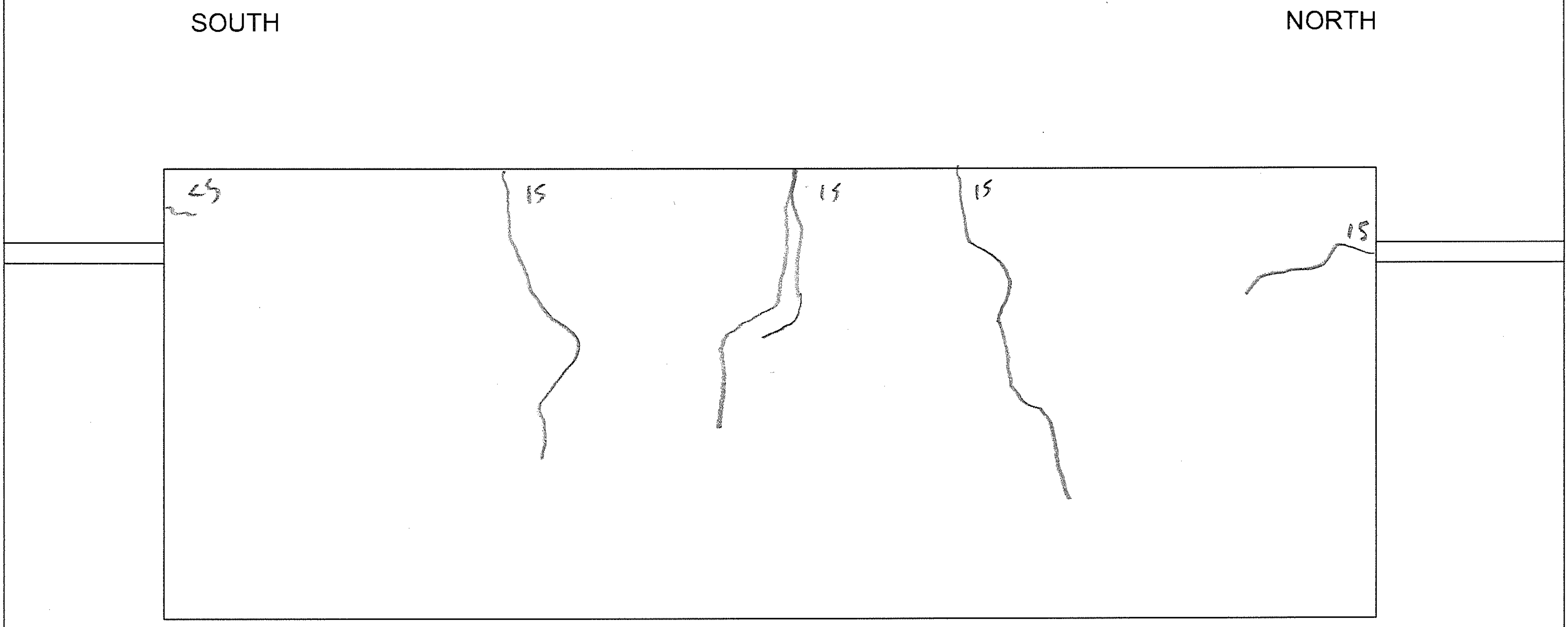
80k 3/10/17



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by: KCS	Checked by:	SP
			Date:	11/16/2016	

100^k 3/10/17

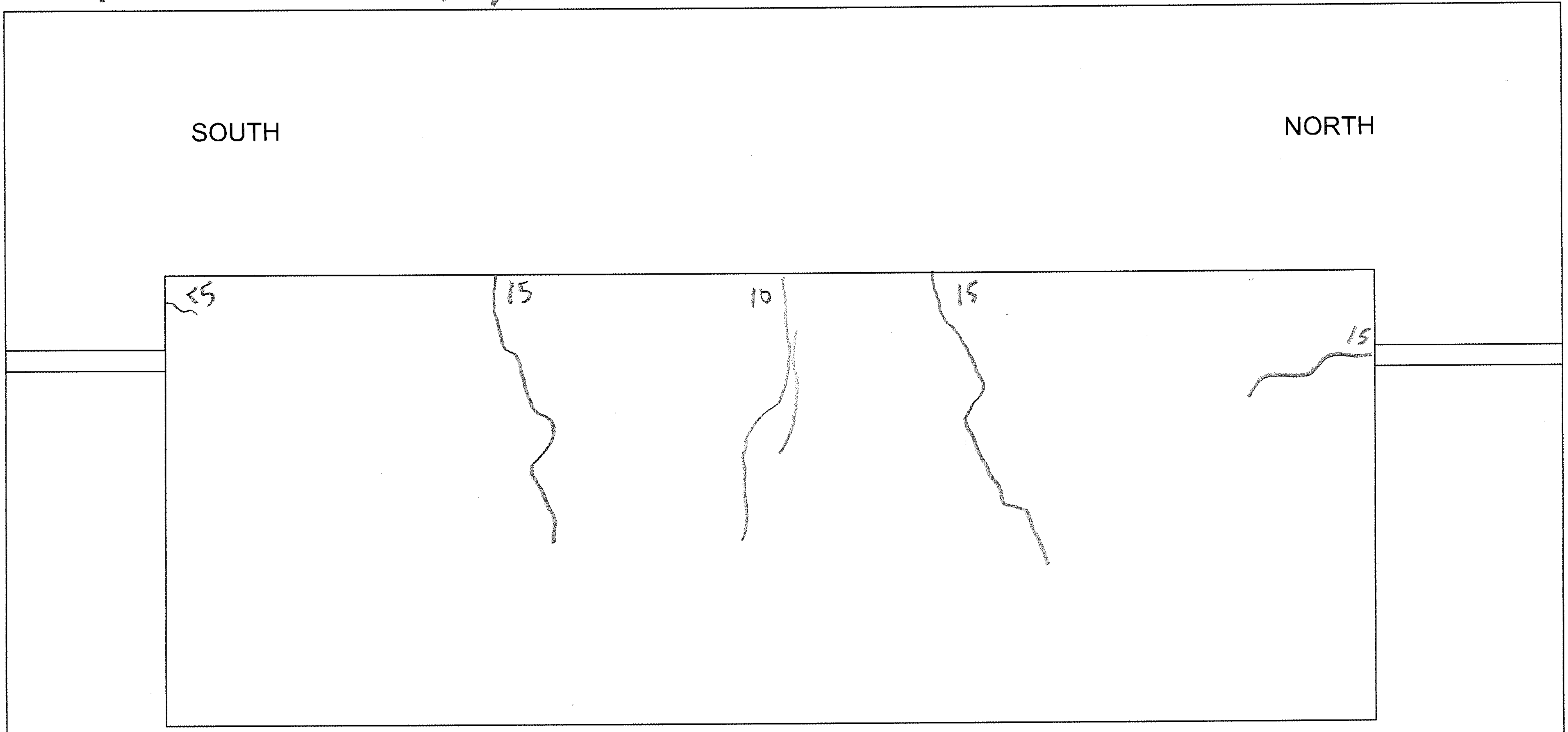


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

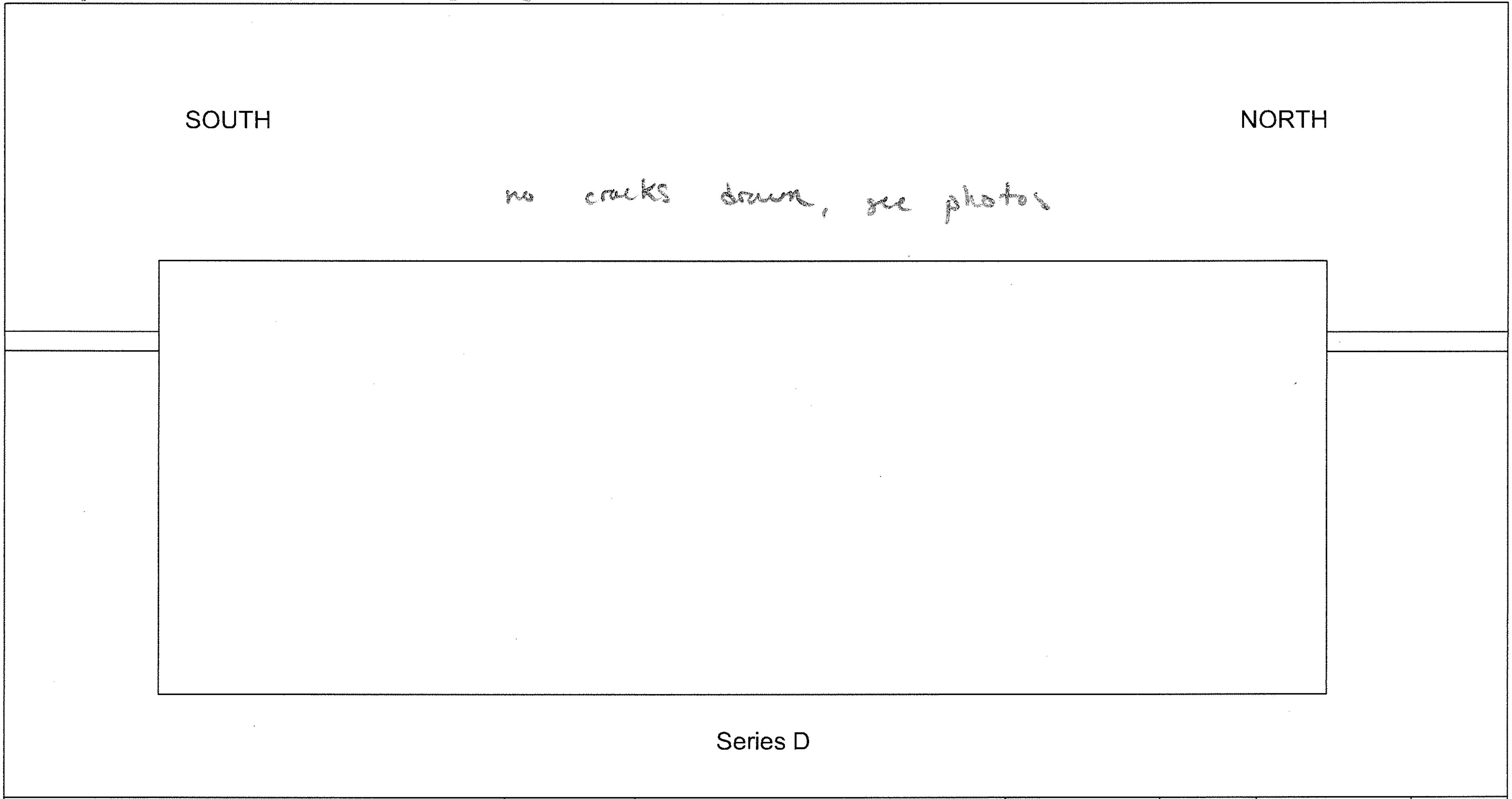
D9 110k 3/10/17



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

115k .050 in crack



no cracks drawn, see photos

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D10

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 3/14/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skillen		3/14/17
Mete A. Sozen	MeteASozen	3/14/2017
Aishwarya Y. Puranam	Aishwarya	03/14/2017
S. Pujol		3/14/17

Recorded by:

Checked by:

Checked by:

+1 hr

Test: D10

Date: 3/14/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0k	10:02	0	0	0	0	0	0	0
20k	10:15	19.9	20.5	0	0	0	0	0
20k	10:25	20.5	20.8	0	0	0	0	0
40k	10:28	40	40	0	0	0	.001	.001
60k	10:35	60.6	60.1	0	0	0	.001	.001
80k	10:42	80.1	79.9	0	0	0	.002	.002
100k	10:48	98.9	99.2	.001	0	.011	.005	.011
110k	10:57	107.8	108.3	.005	0	.026	.016	.026
114k	11:04	113.9	113.5	.007	0	.055	.052	.055
114k	11:10	114.1	113.4	.008	0	.058	.056	.058
unload	11:14							

Notes:

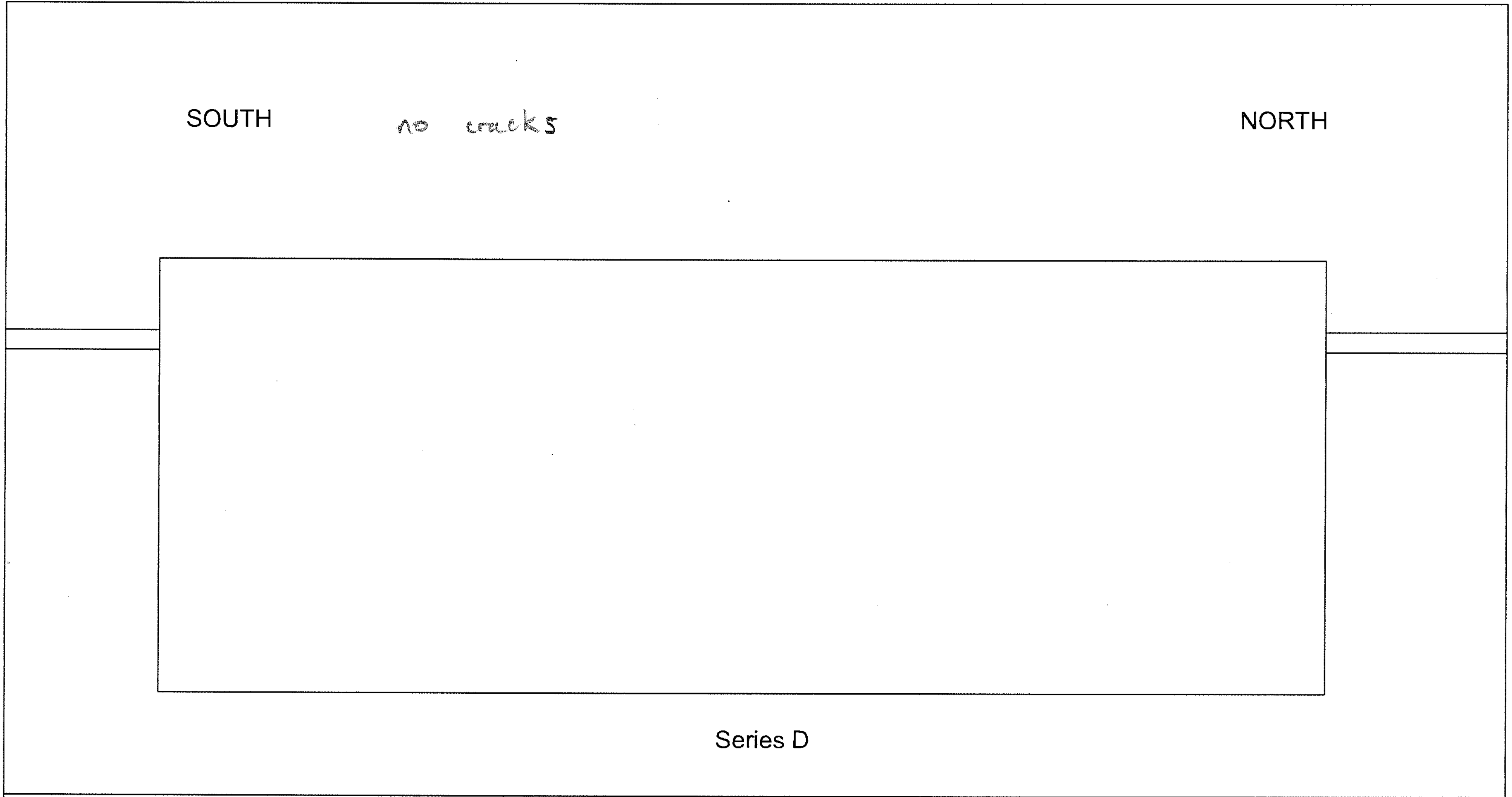
4 new Optotrak targets added

Anchors installed @ 2:30 pm

Recorded by:

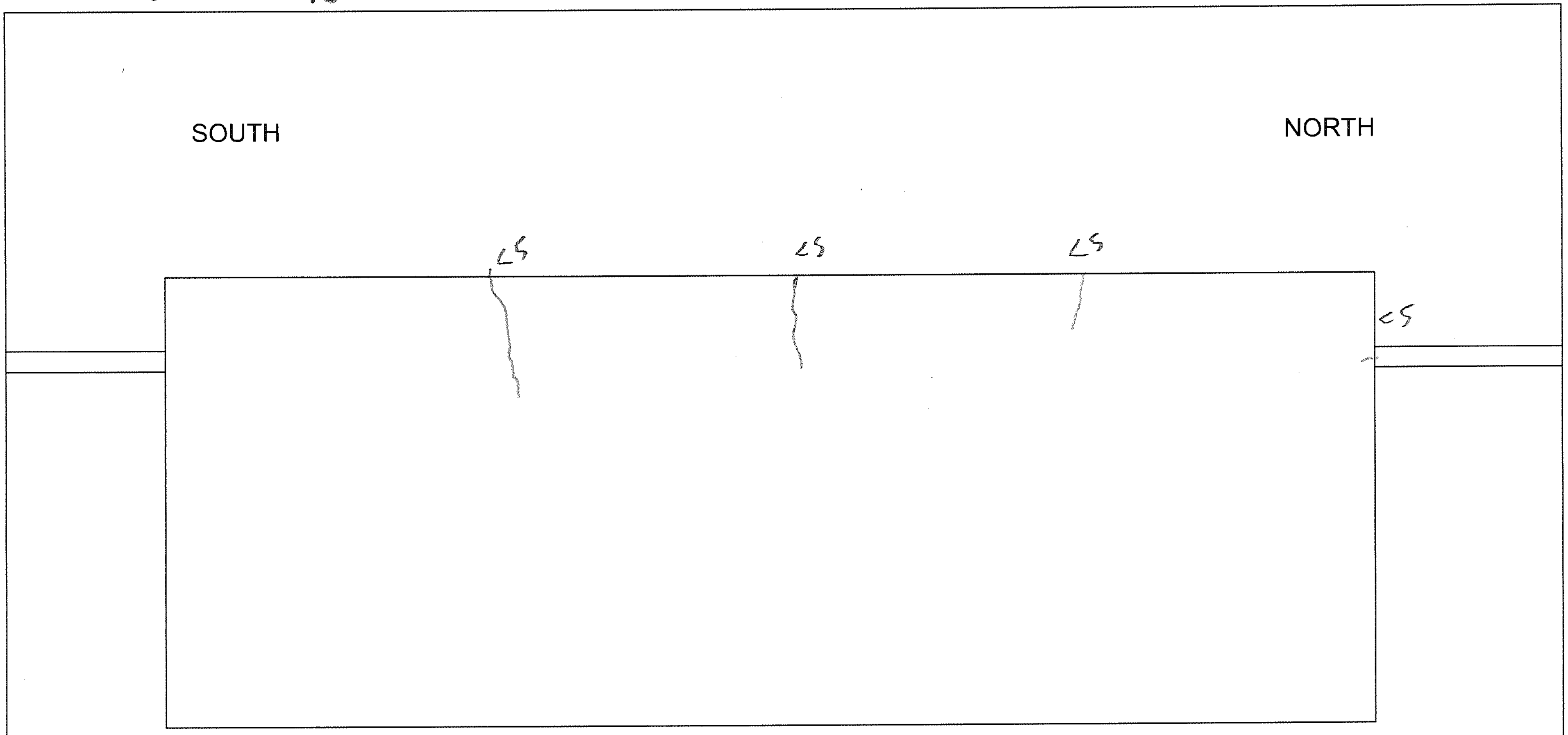
Signature:

D10 20k



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

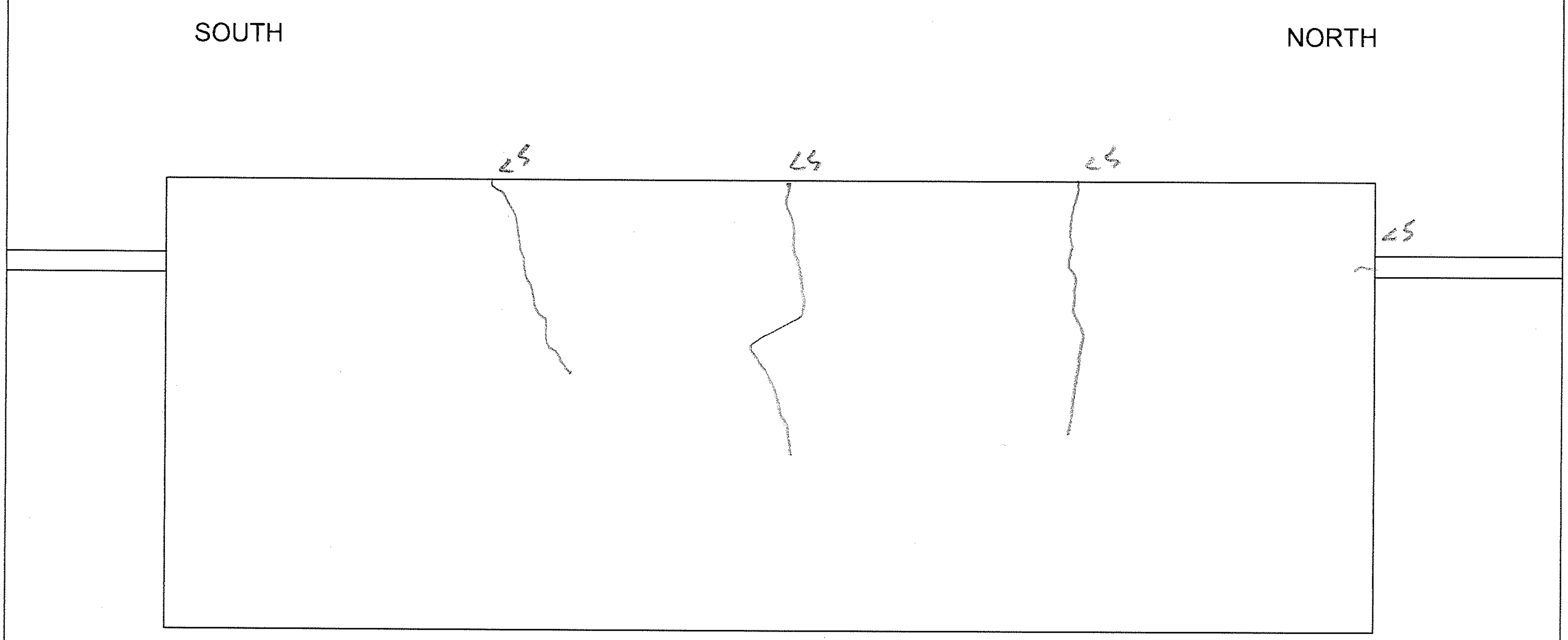
D10 40^{k}



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

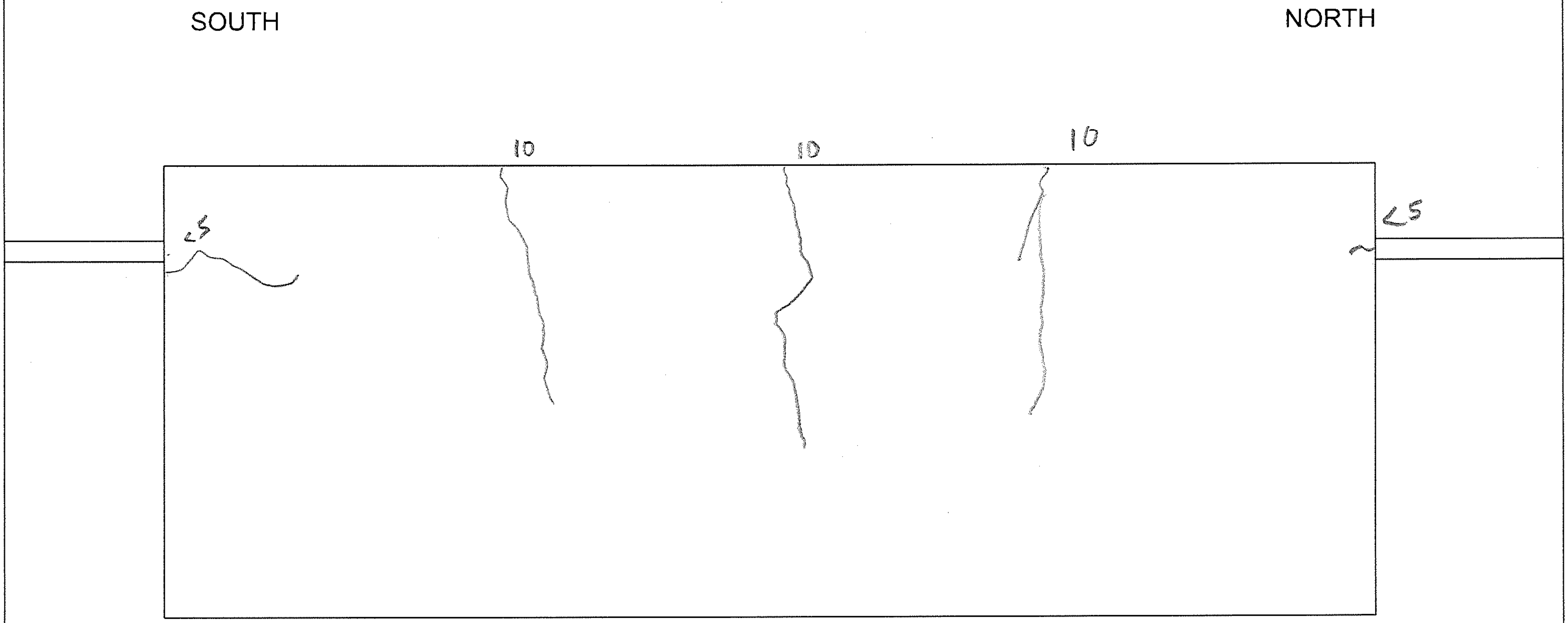
D10 60k



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

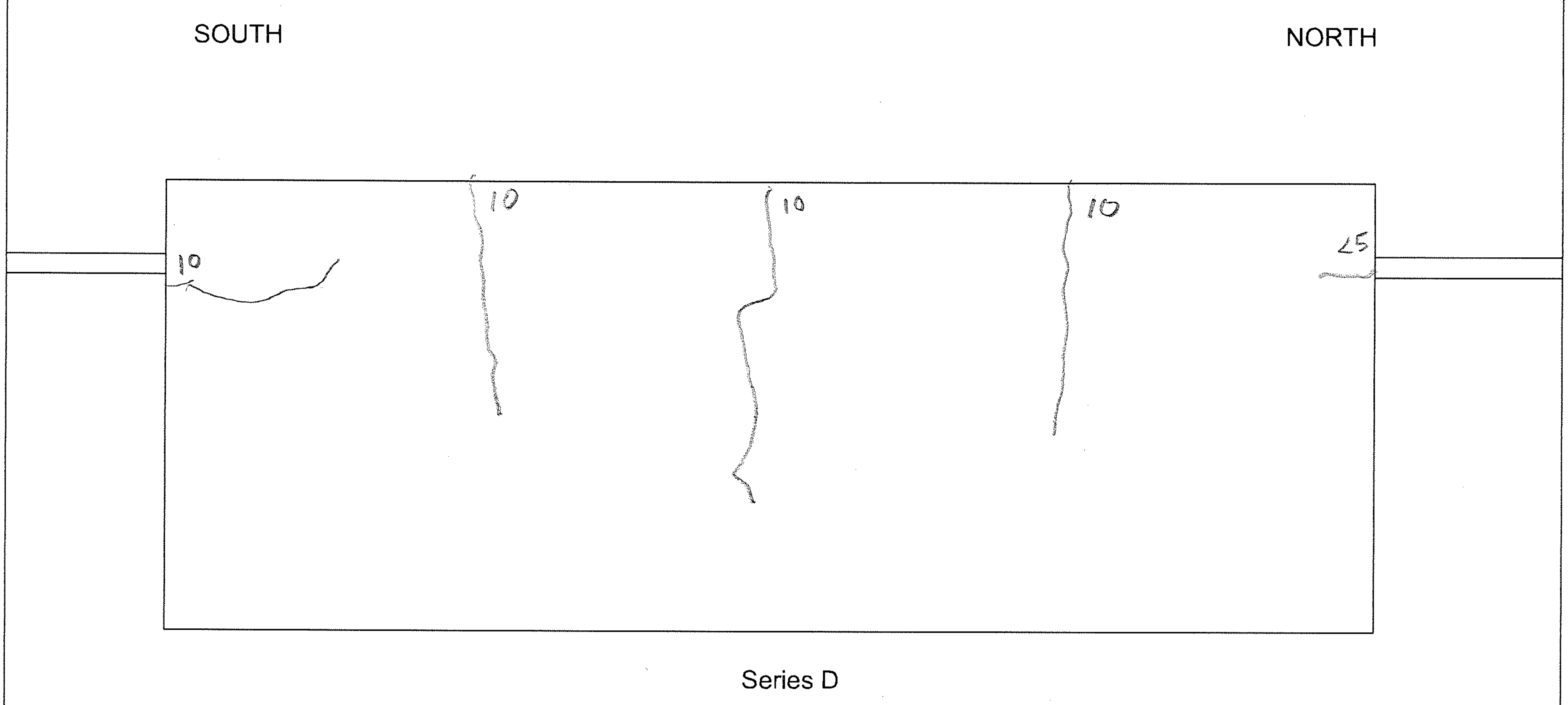
D10 80k



Series D

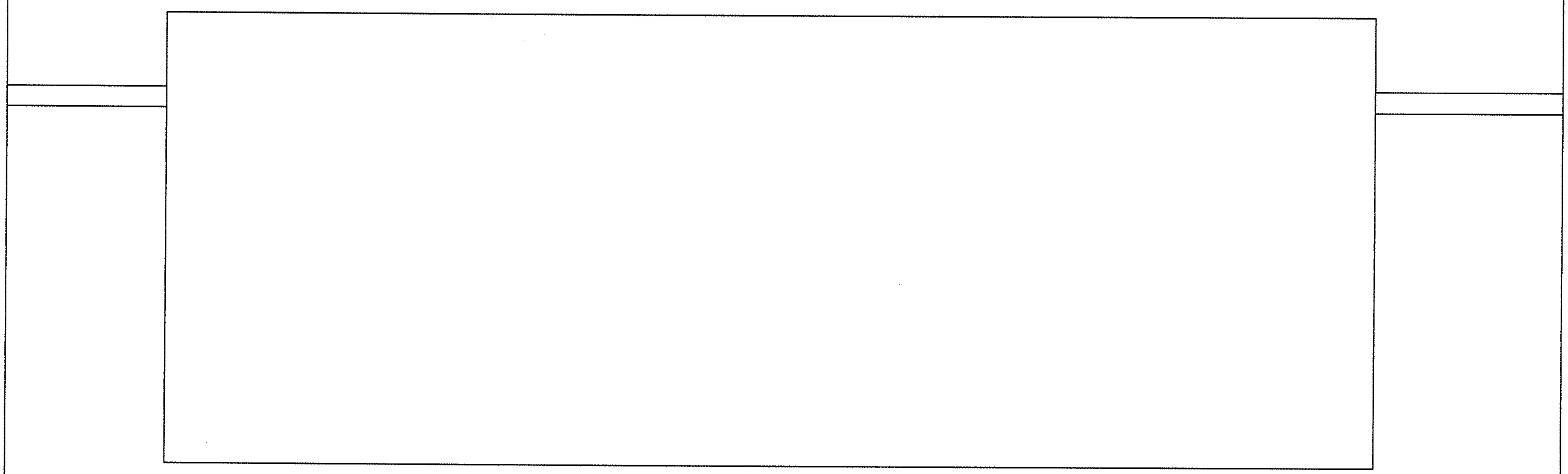
	Drawing:	Series D crack map	Sheet:	1	of 1
BOWEN LABORATORY PURDUE UNIVERSITY	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D10 100k



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D10 110k



no cracks measured, see photos

Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Test: D10-2 / Reload

Date: 3/15/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0^K	3:00	0	0	.004	0	.035	.036	.036
20^K	3:06	20.5	20.4	.004	0	.035	.036	.036
40^K	3:16	40.1	40	.004	0	.035	.037	.037
60^K	3:27	60.4	60.2	.004	0	.039	.040	.040
80^K	3:37	80.2	80	.005	0	.045	.045	.045
100^K	3:44	100.2	100.1	.007	0	.052	.051	.052
110^K	3:50	110.3	109.8	.009	0	.056	.054	.056
120^K	3:56	118	117.8	.013	0	.068	.075	.075

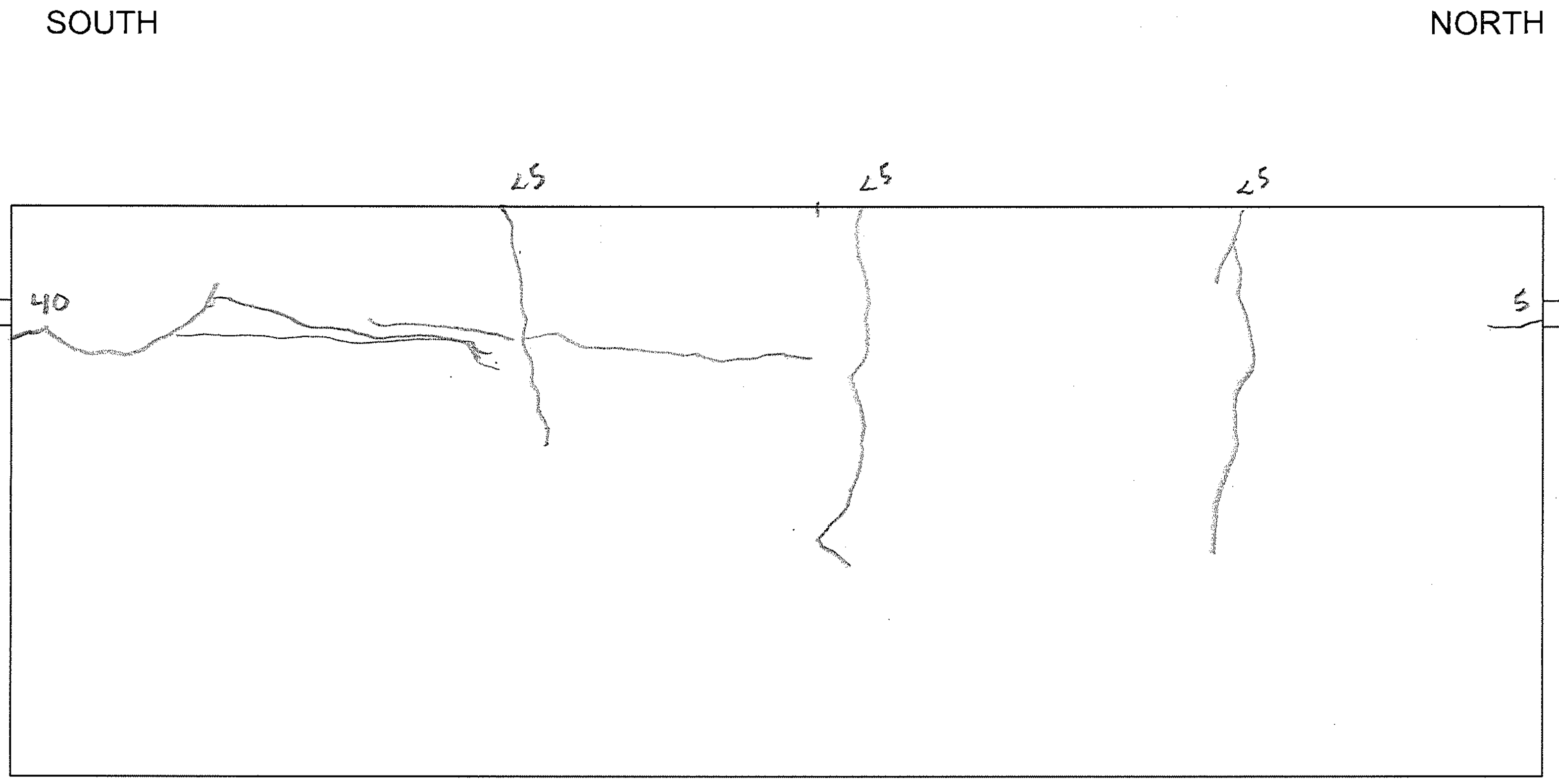
Notes:

Recorded by:

Signature:

D10 Reload w/ Anchors 3/15/17

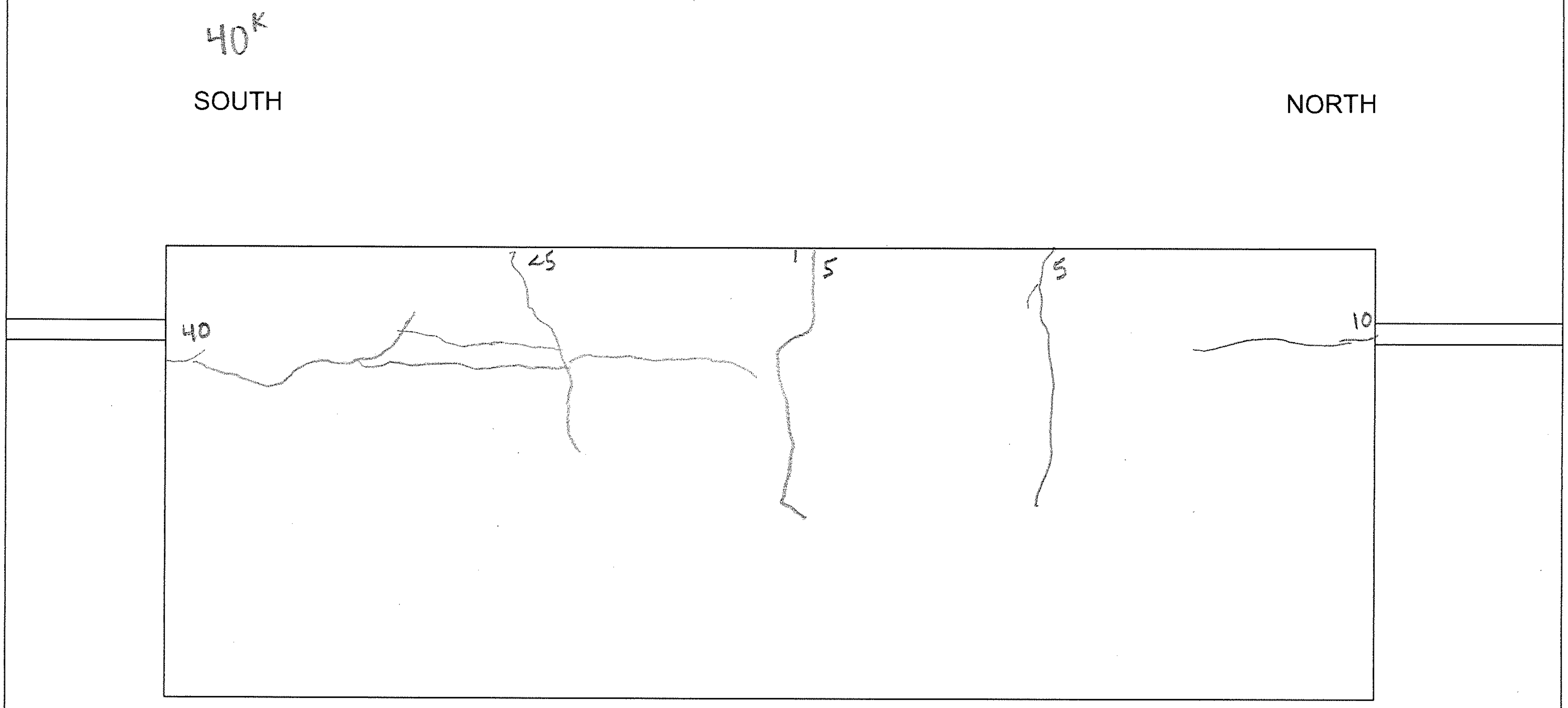
20K



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1 of 1	
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D10 Reload 3/15/17



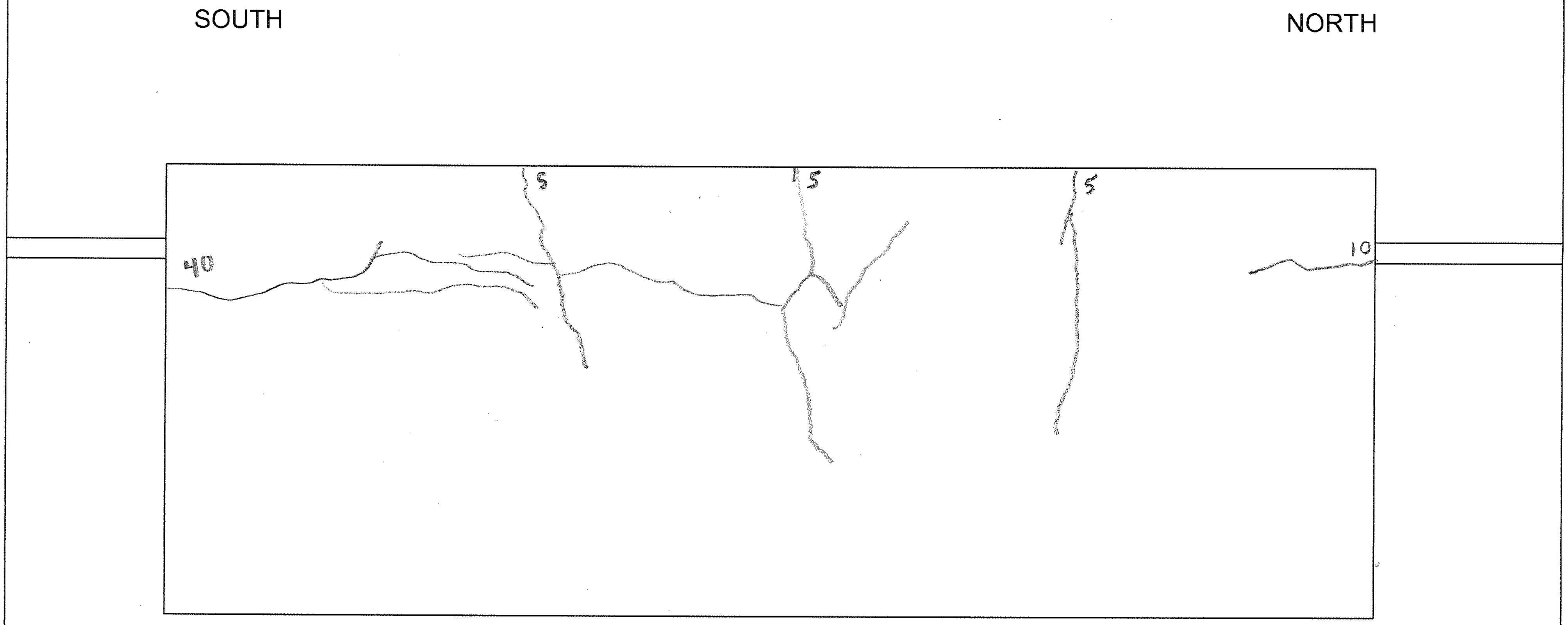
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D10 Reload w/ anchor

3/15/17

60K



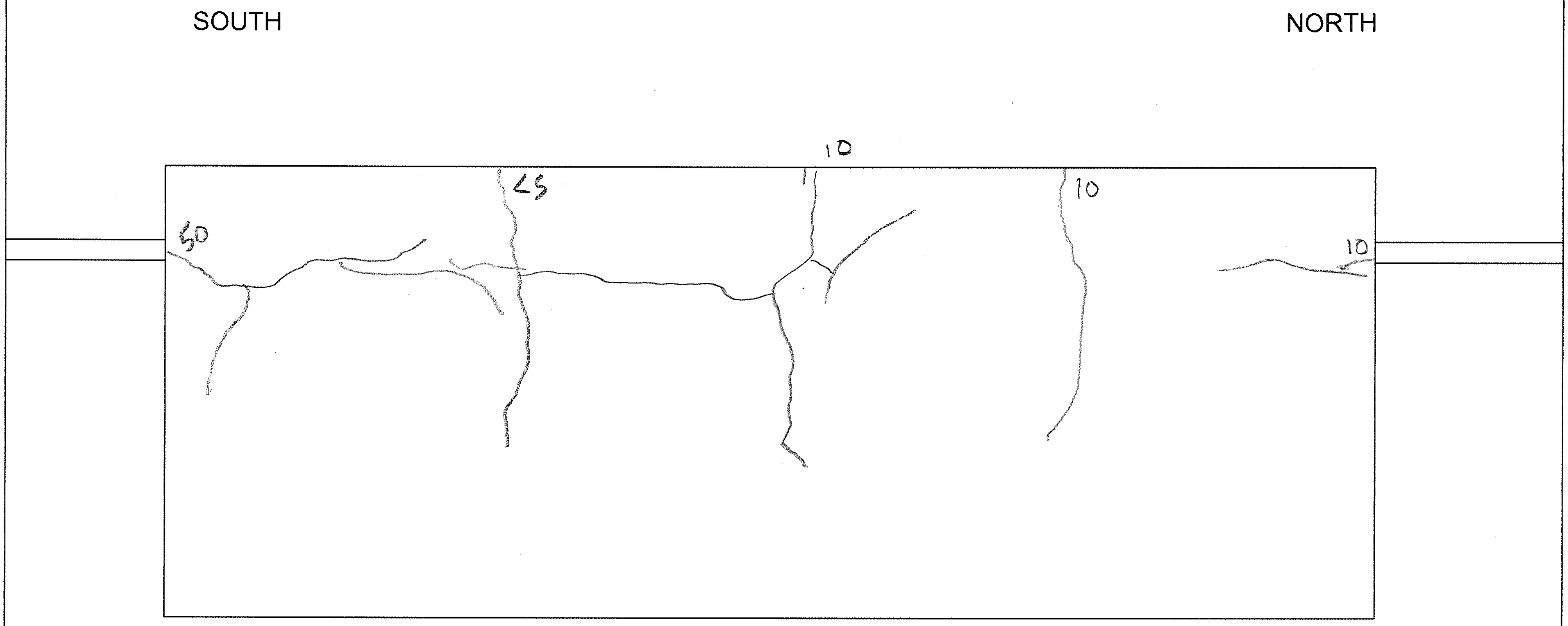
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D10 Reload w/ Anchor 80k

3/15/17

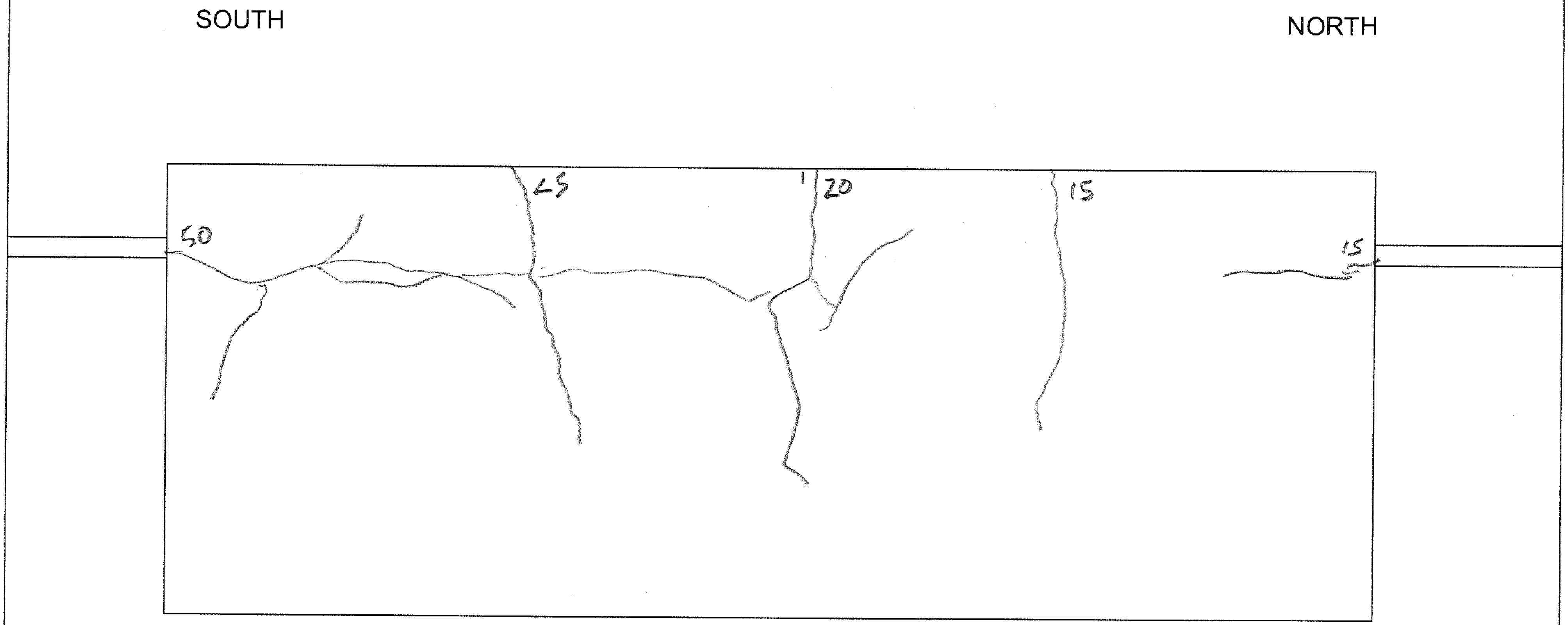


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D10 Reload w/ Anchors

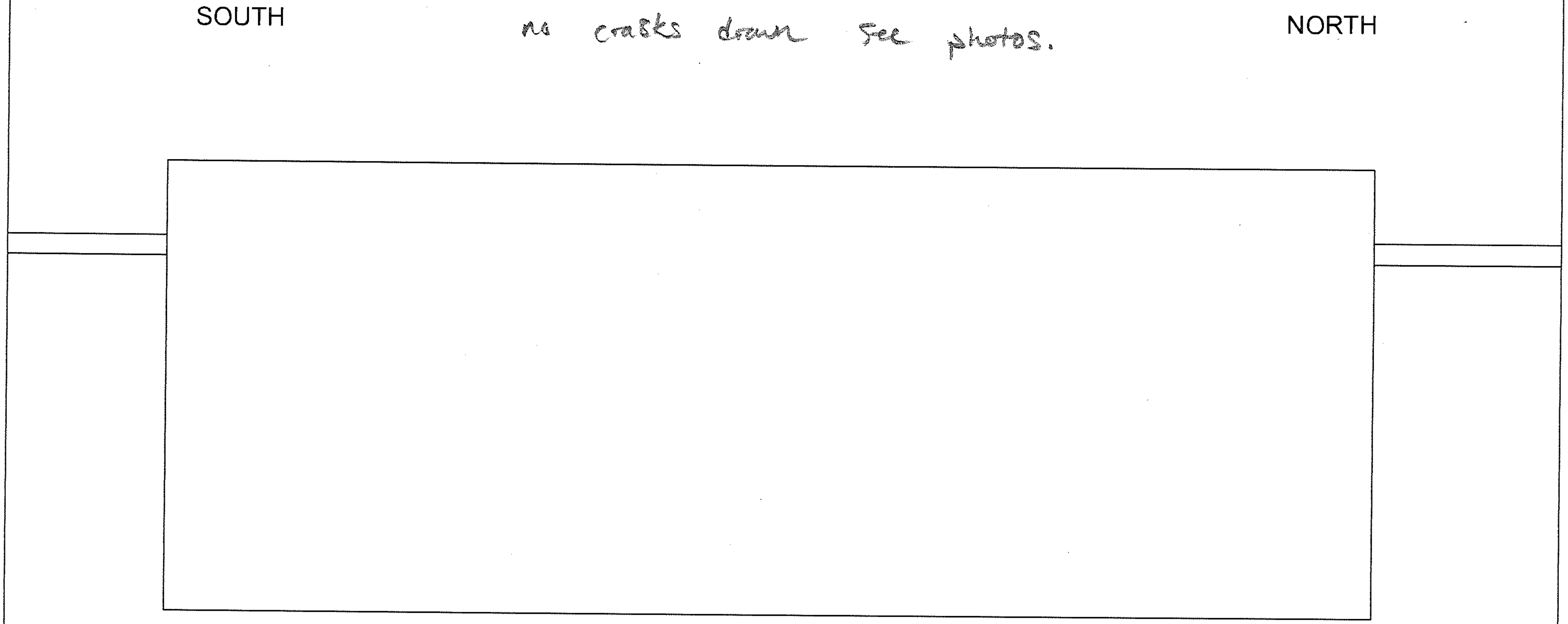
100^{k} 3/15/17



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D10 110k Reload w/ Anchors



no cracks drawn see photos.

Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D11

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 3/17/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skiller		3/17/17
Santiago Pujol	S Pujol	3/17/17
AISHWARYA Y. PURANAM	Aishwarya	03/17/17

Recorded by:

Checked by:

Checked by:

Test: D11

Date: 3/17/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0k	1:28	0	0	0	0	0	0	—
20k	1:30	20.3	20.2	0	0	0	0	—
40k	1:39	40.4	40.2	.001	.001	0	0	.001
60k	1:50	60.4	59.7	.004	.002	.001	.001	.004
80k	1:58	80.1	80.6	.005	.005	.001	.001	.008
100k	2:09	99.8	99.4	.021	.015	.005	.011	.021
110k	2:12	108.2	108.3	.036	.039	.016	.025	.039

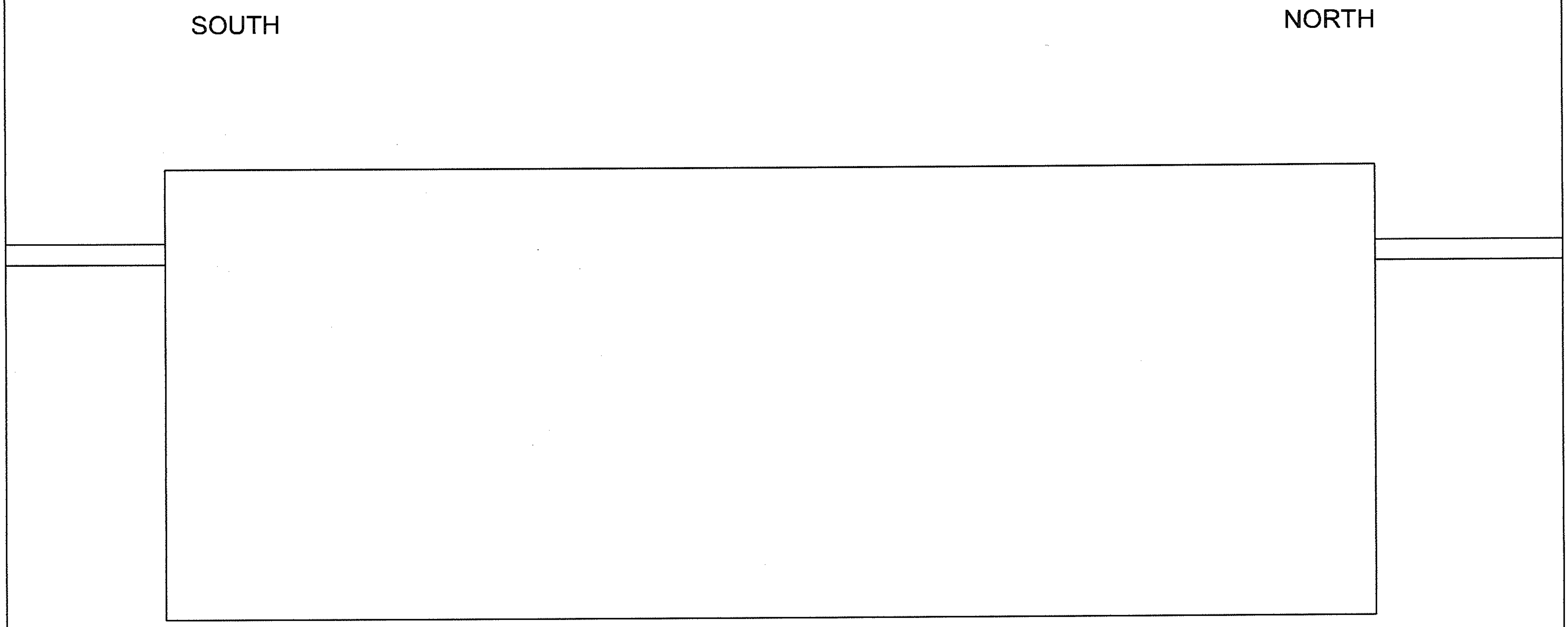
Notes:

Recorded by:

Signature:

D11 3/17/17

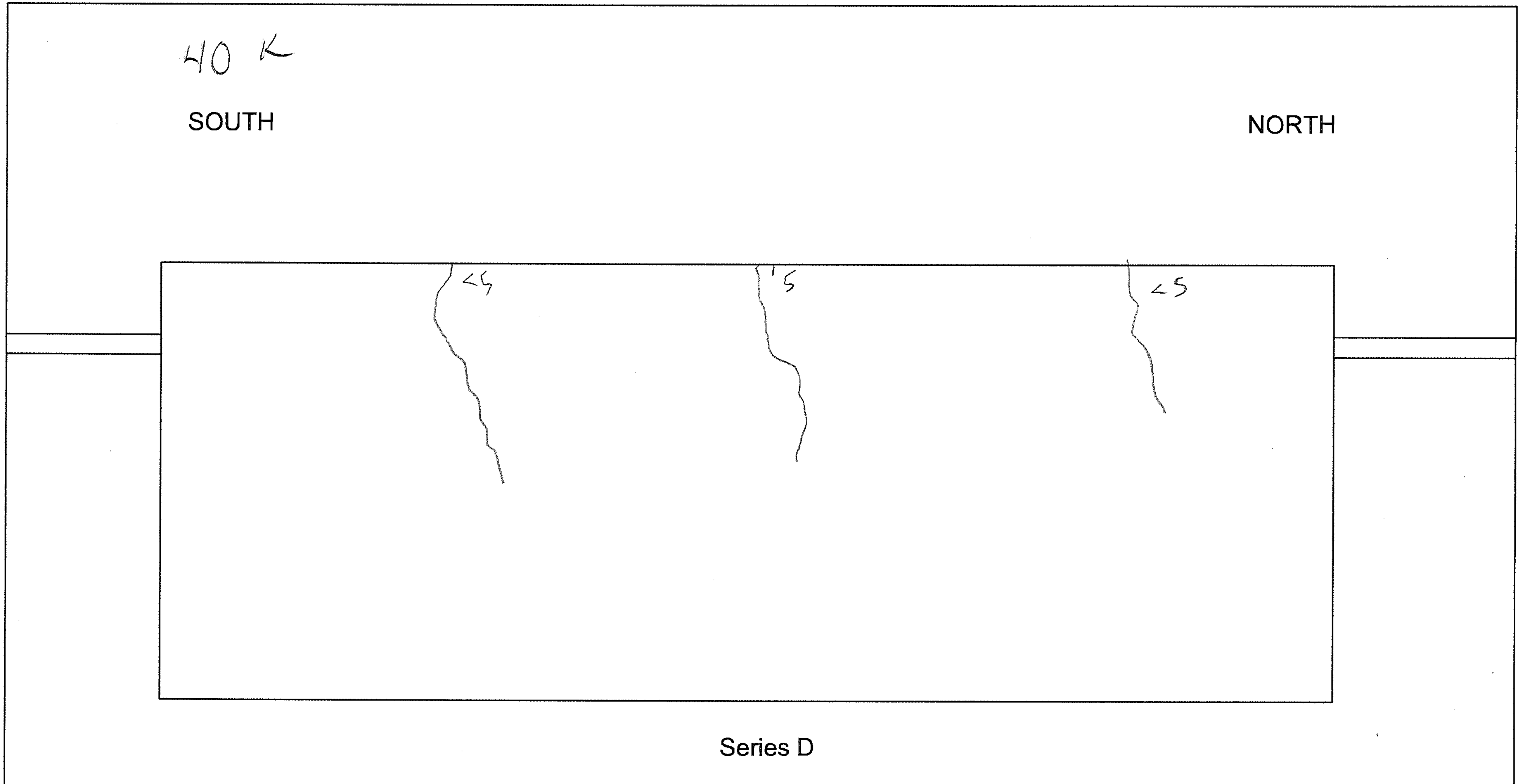
20^k no cracks



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

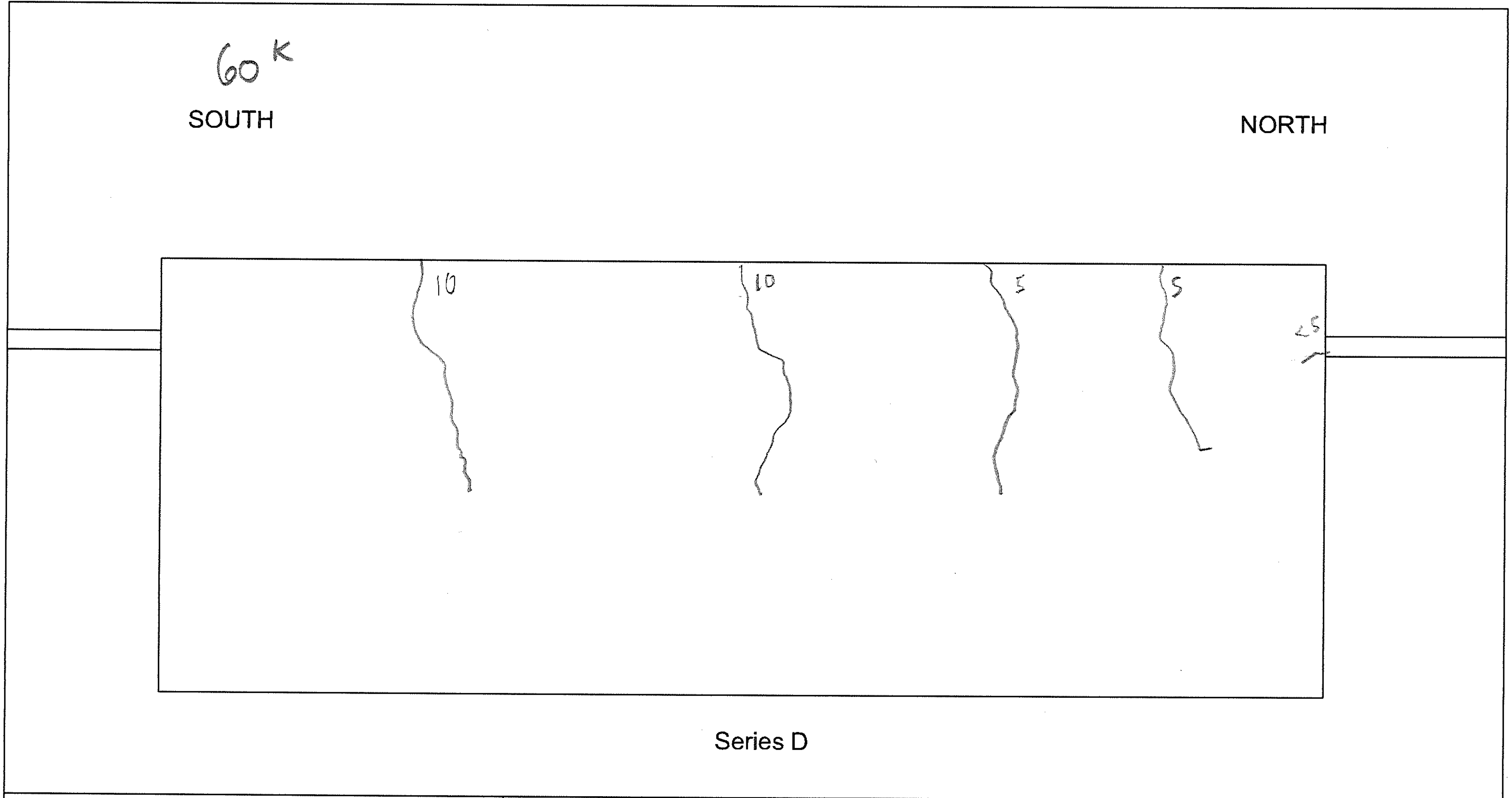
D11 3/17/17



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

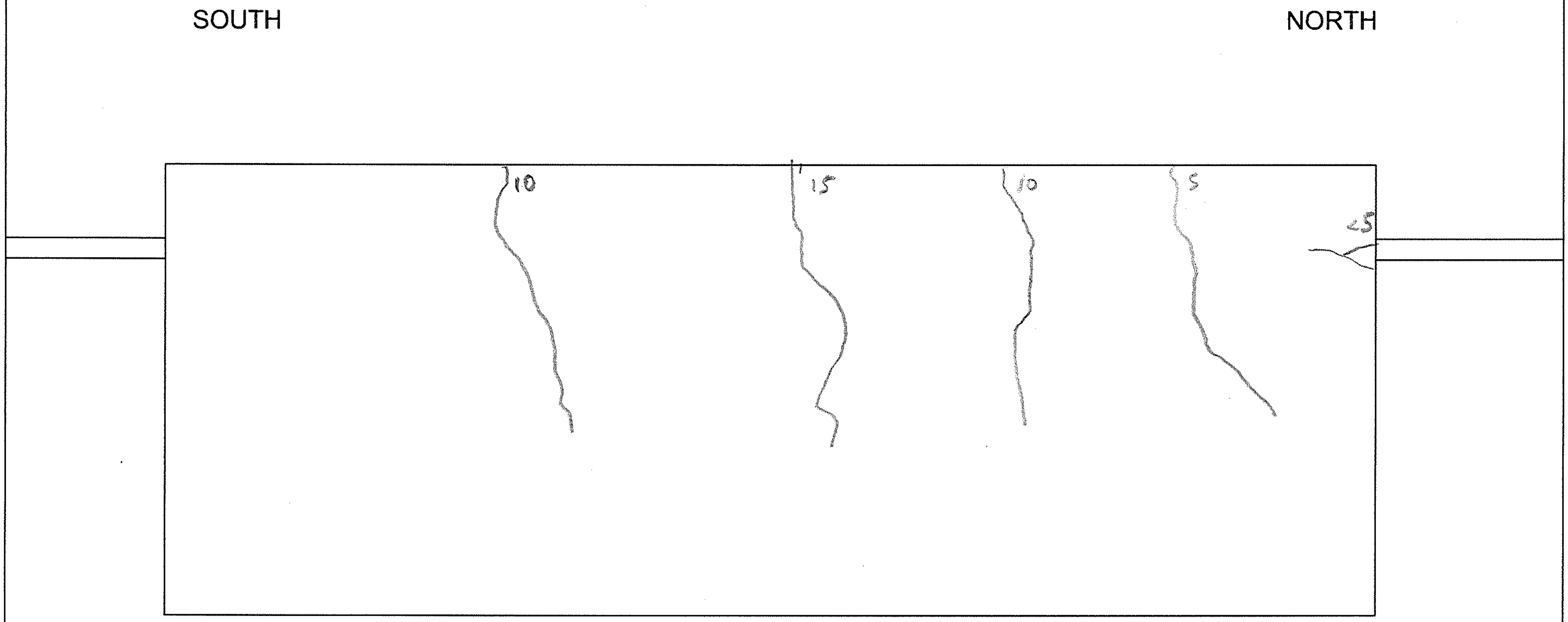
D11 3/17/17



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D11 3/17/17

80K



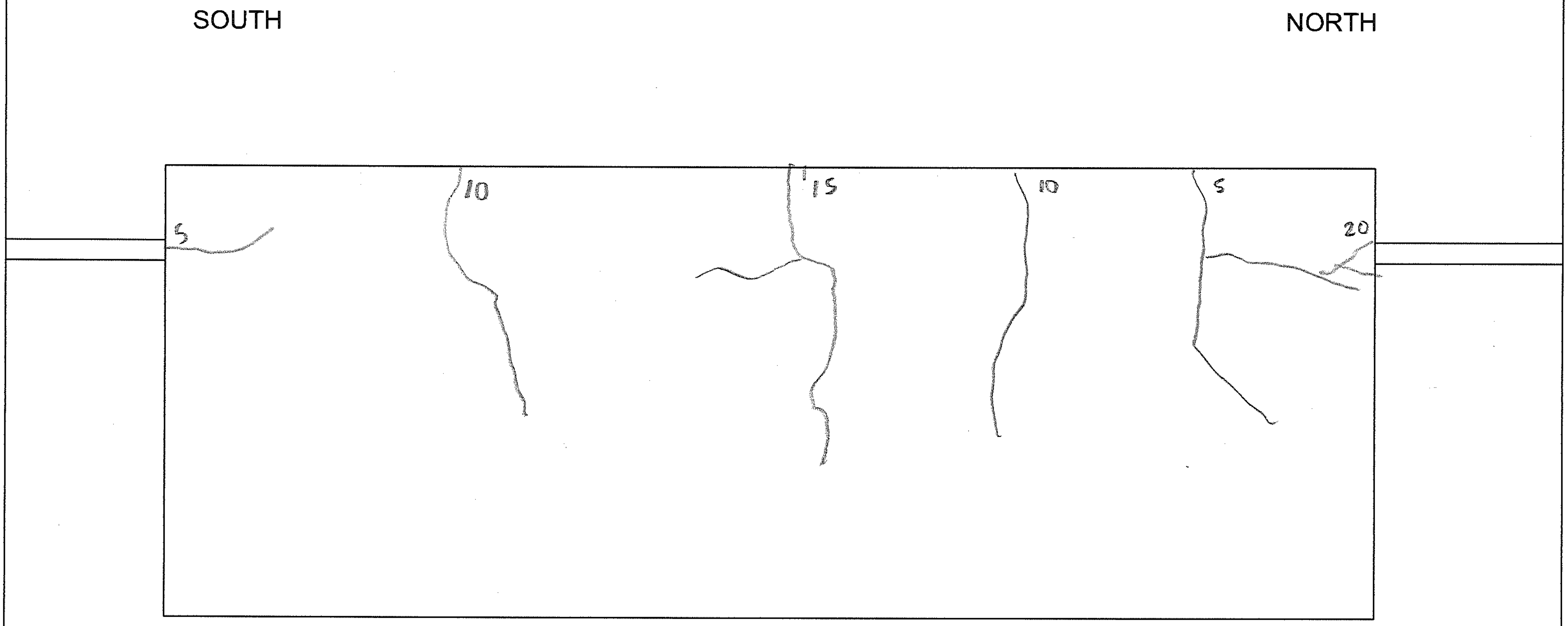
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D11 3/17/17

100^{k}



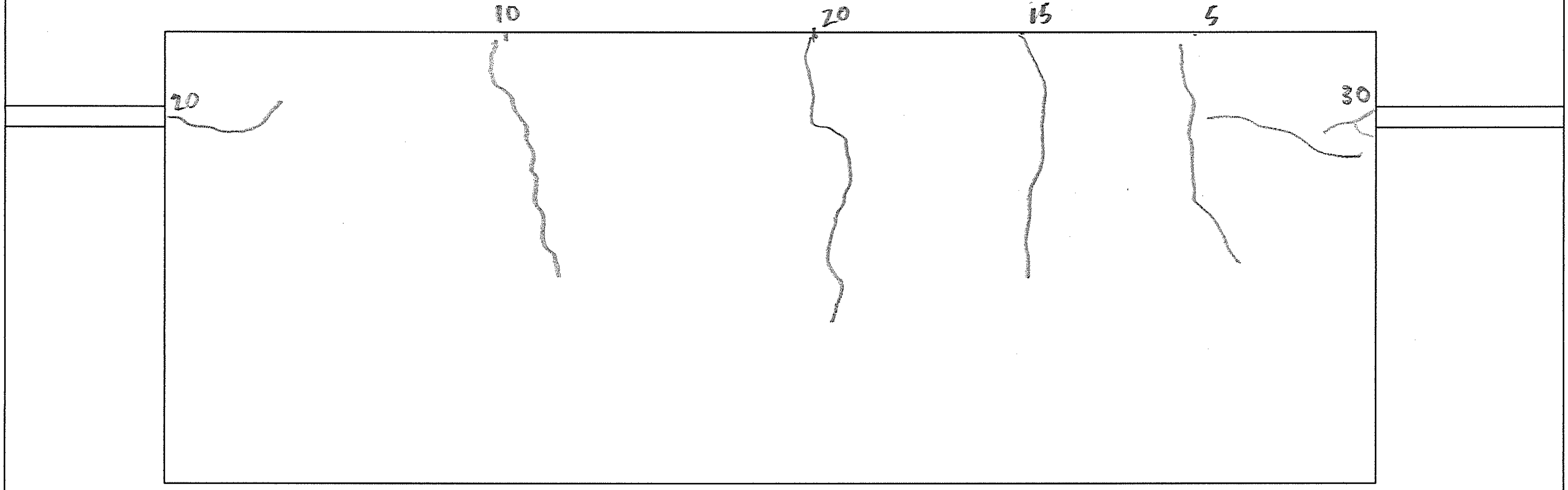
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D11 3/17/17

110^{K}

SOUTH no cracks drawn, see photos NORTH



Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

Project: Tests to Determine the Behavior of Spliced #11 Bars

Specimen: D12

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 3/22/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skiller		3/22/17
Prateek Shah	PShah	3/22/17

Recorded by:

Checked by:

Checked by:

Test: D12

Date: 3/22/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0^K	6:40	0	0	0	0	0	0	0
20^K	6:50	20.4	20.1	0	0	0	0	0
40^K	6:55	40.5	40.1	.001	0	0	0	.001
60^K	6:59	60.2	60.1	.003	0	0	.001	.003
80^K	7:04	79.9	79.6	.007	.001	.001	.003	.007
100^K	7:09	99.4	99.6	.014	.002	.004	.007	.014
110^K	7:19	108.4	109.1	.017	.006	.008	.011	.017
unload 0^K	7:32	0^K	0^K	.035	.017	.028	.042	.042

Notes:

Recorded by:

Signature:

Test: D12 Reload w/ Anchor

Date: 3/23/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0^{K}	9:20	0	0	.033	.015	.027	.038	.038
20^{K}	9:23	20.3	19.9	.033	.015	.027	.038	.038
40^{K}	9:28	40.2	40.1	.033	.015	.028	.038	.038
60^{K}	9:32	59.8	60.1	.033	.015	.030	.040	.040
80^{K}	9:43	79.6	80.2	.035	.019	.033	.045	.045
100^{K}	9:49	99.5	100.1	.040	.024	.036	.049	.049
110^{K}	9:54	109.6	109.9	.045	.028	.037	.052	.052
120^{K}								
130^{K}								

Notes:

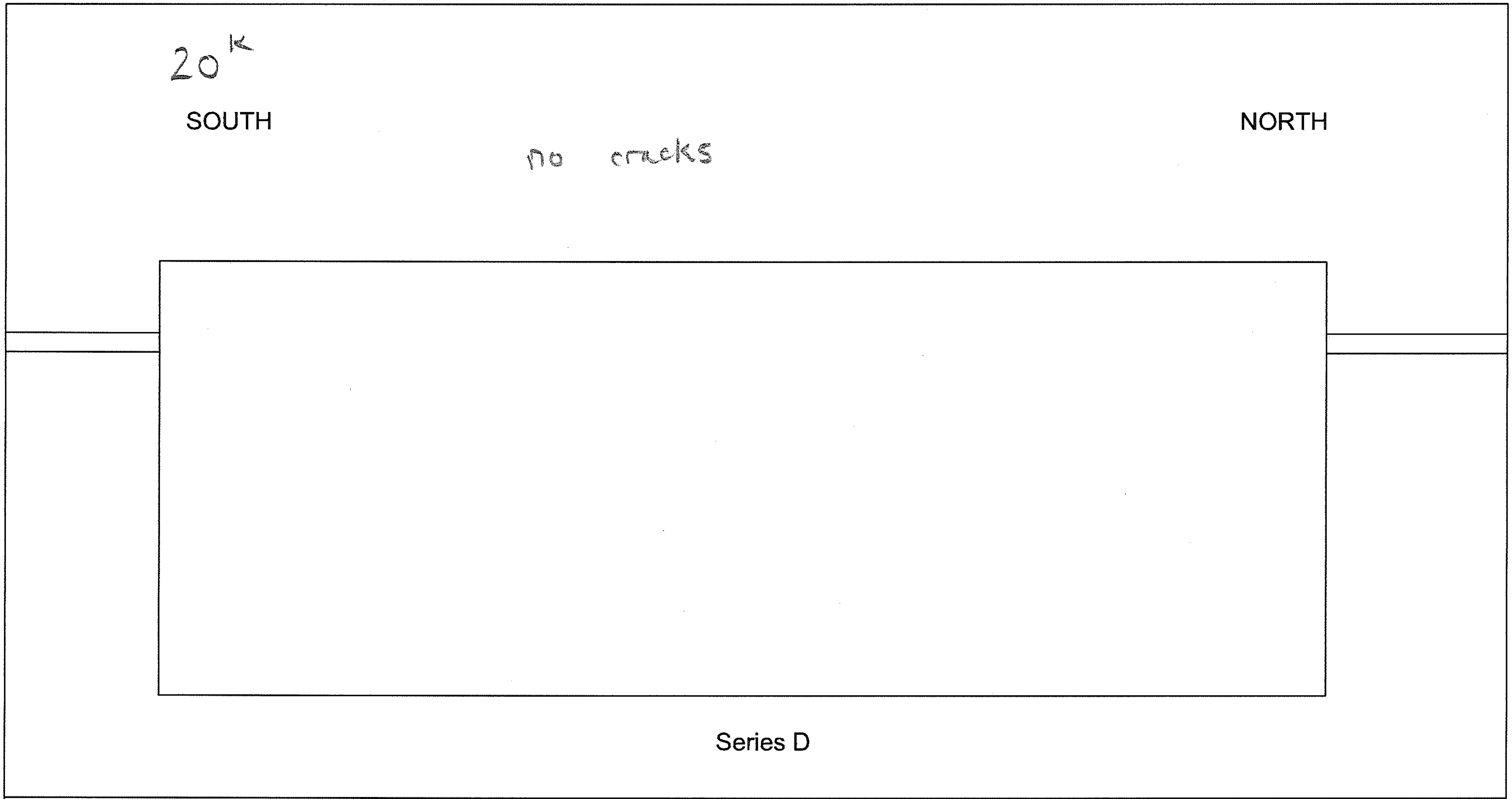
Test Started 25 hrs from anchor install

Recorded by:

Kinsey Skiller

Signature:

D12 3/22/17



20^k

no cracks

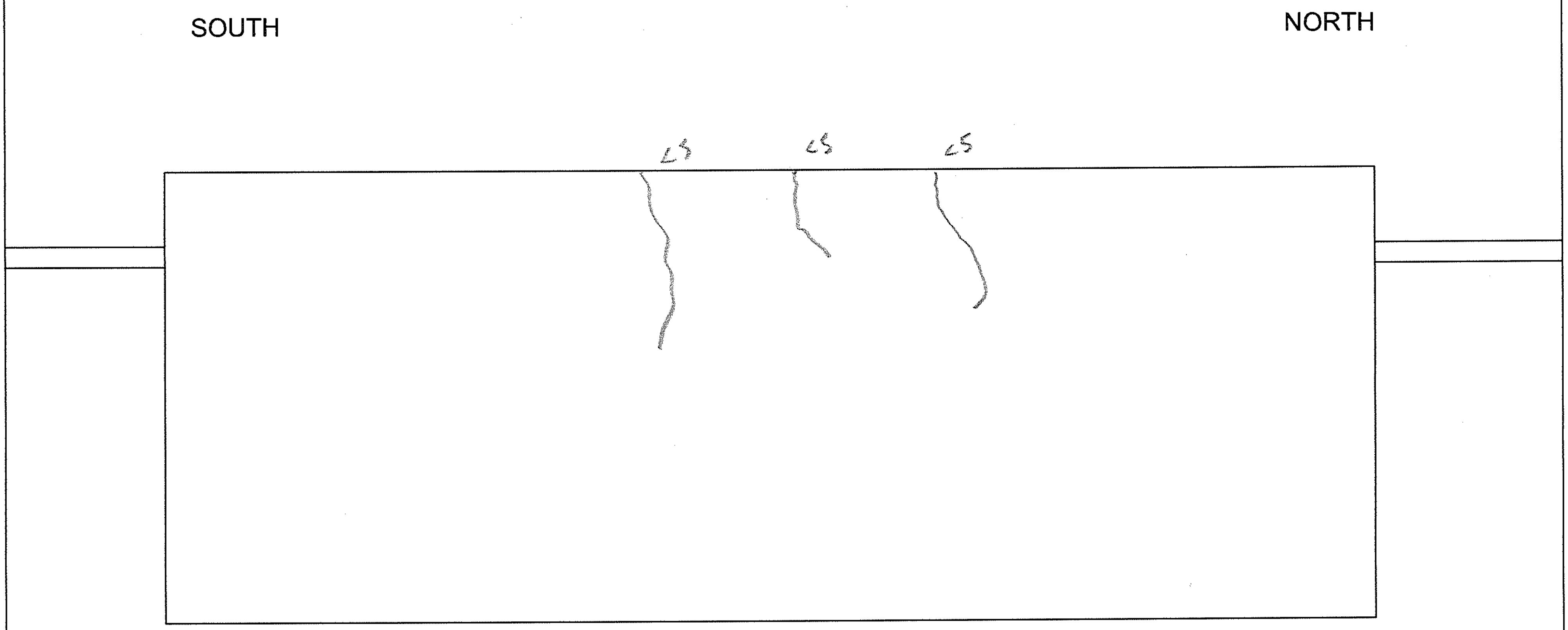
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D12 3/22/17

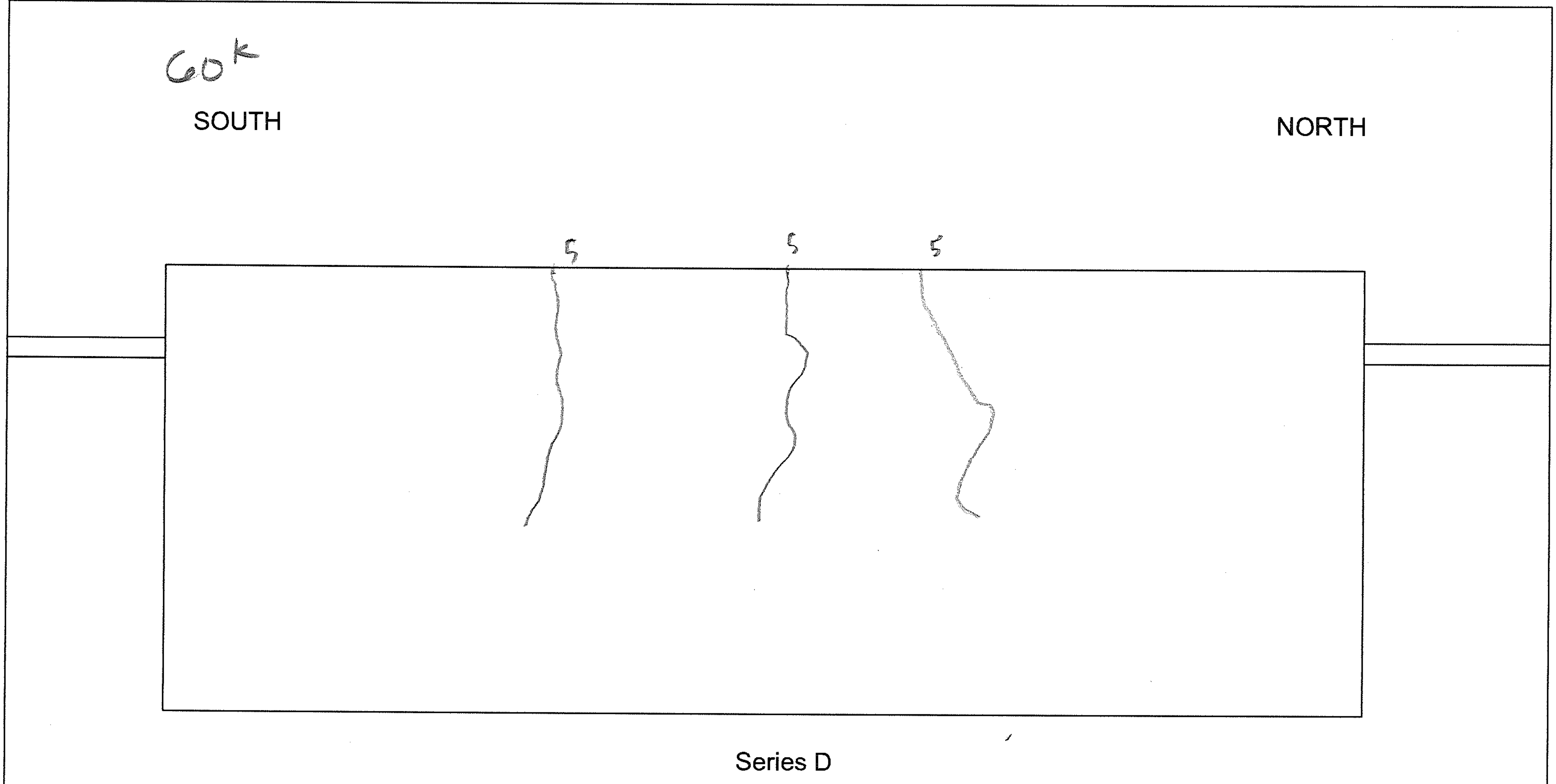
40k



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D12 3/22/17

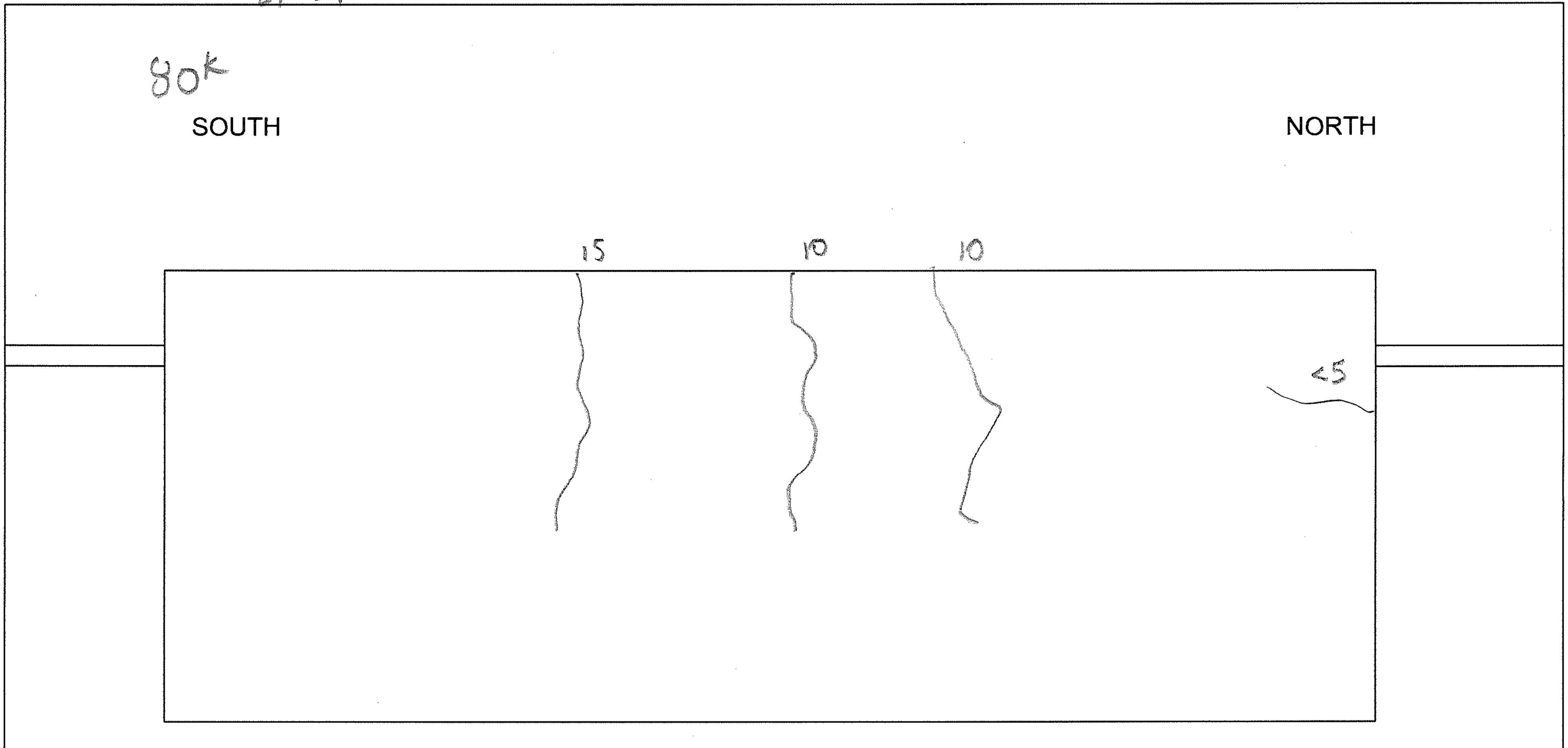


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

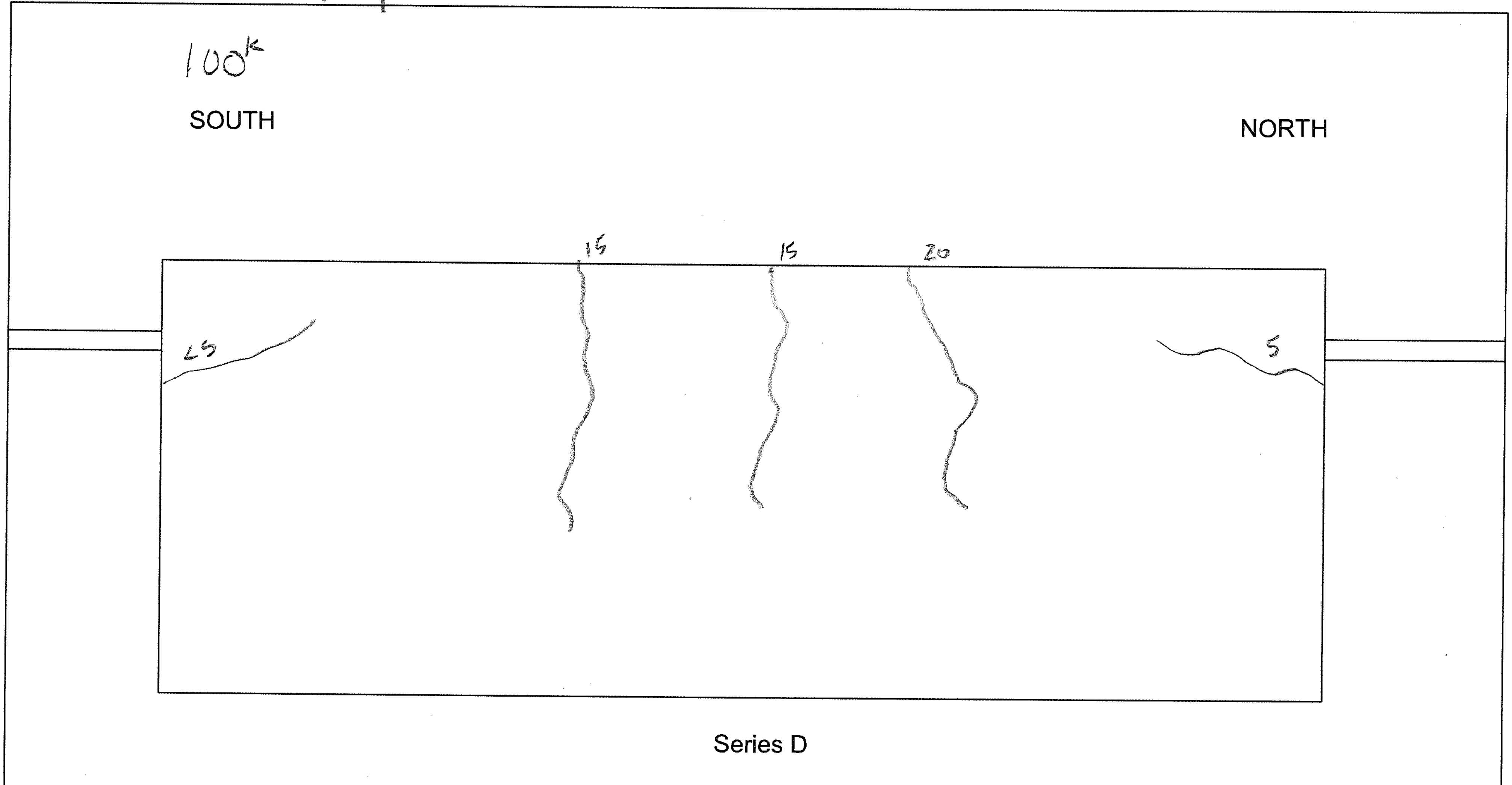
D12 3/22/17



Series D

BOWEN LABORATORY **PURDUE UNIVERSITY**	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D12 3/22/17



BOWEN LABORATORY
PURDUE UNIVERSITY

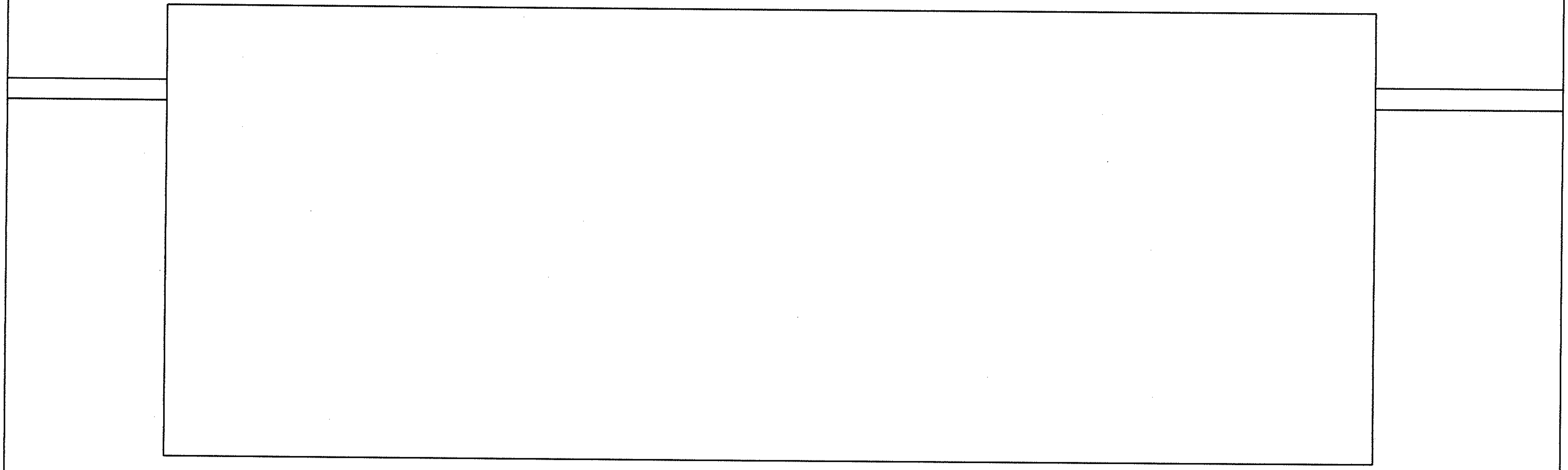
Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D12 3/22/17

110^{K}

no cracks drawn,

see photos

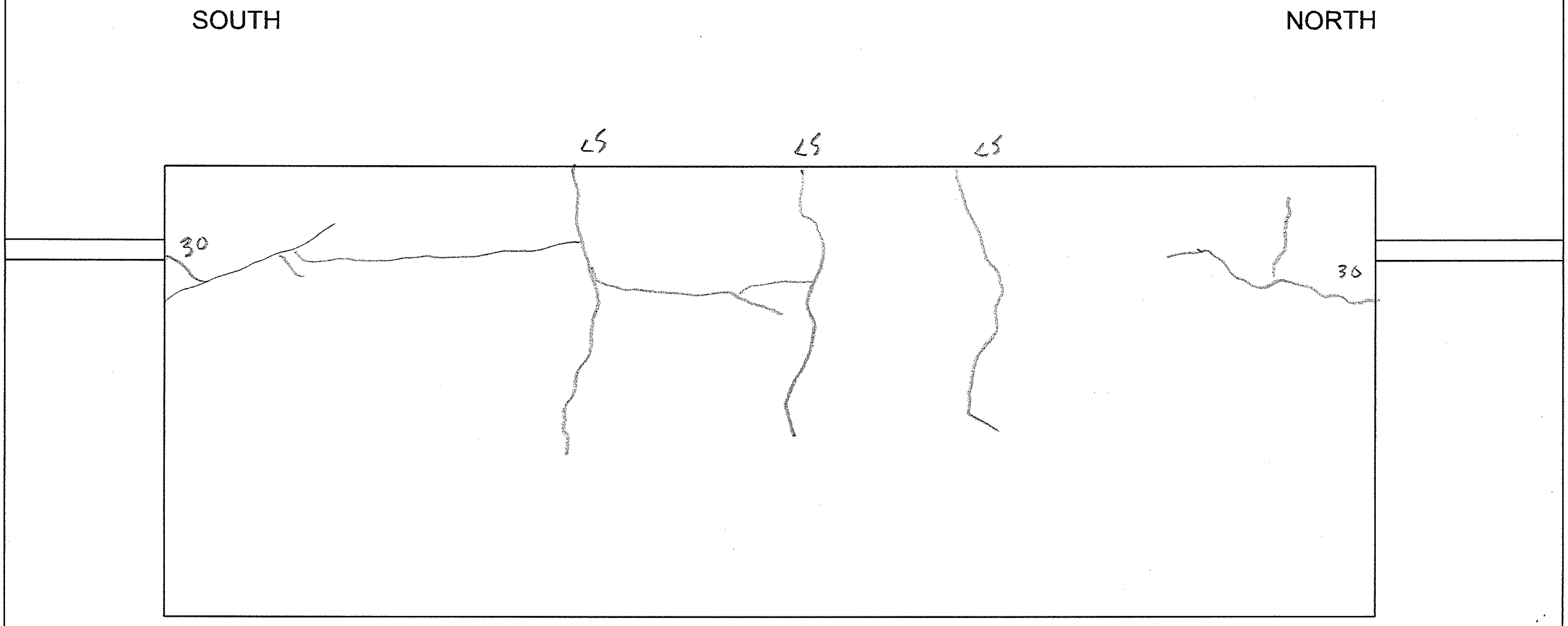


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D12 3/22/17

Unloaded crack map 0^{K}



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

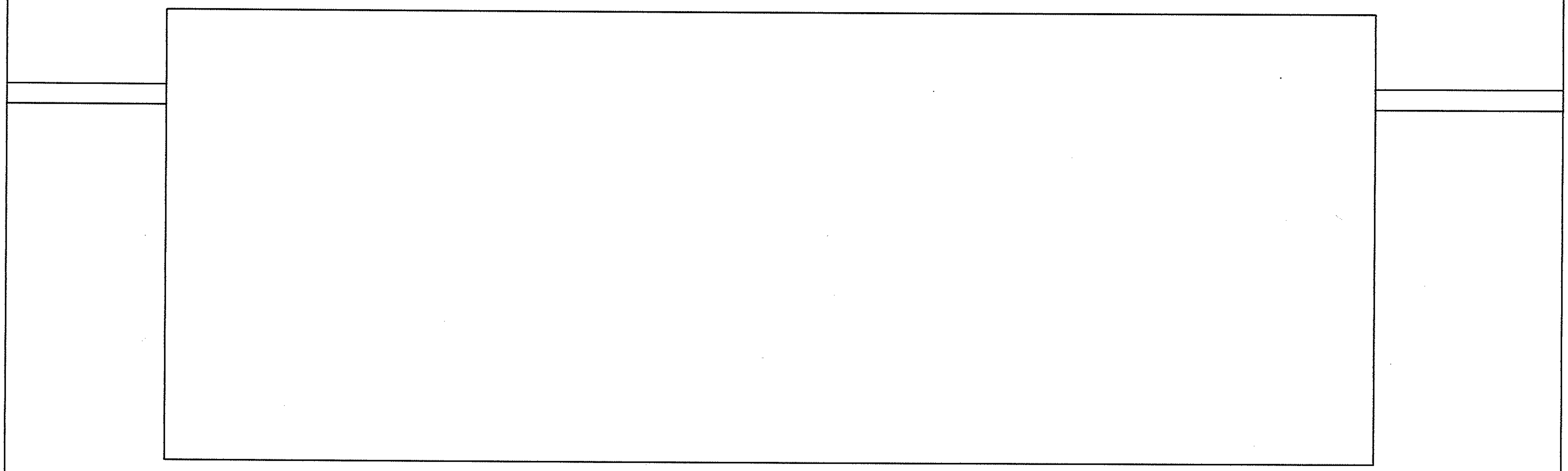
D12 Reload w/ Anchor 3/23/17

20k

SOUTH

no new cracks
from unload

NORTH

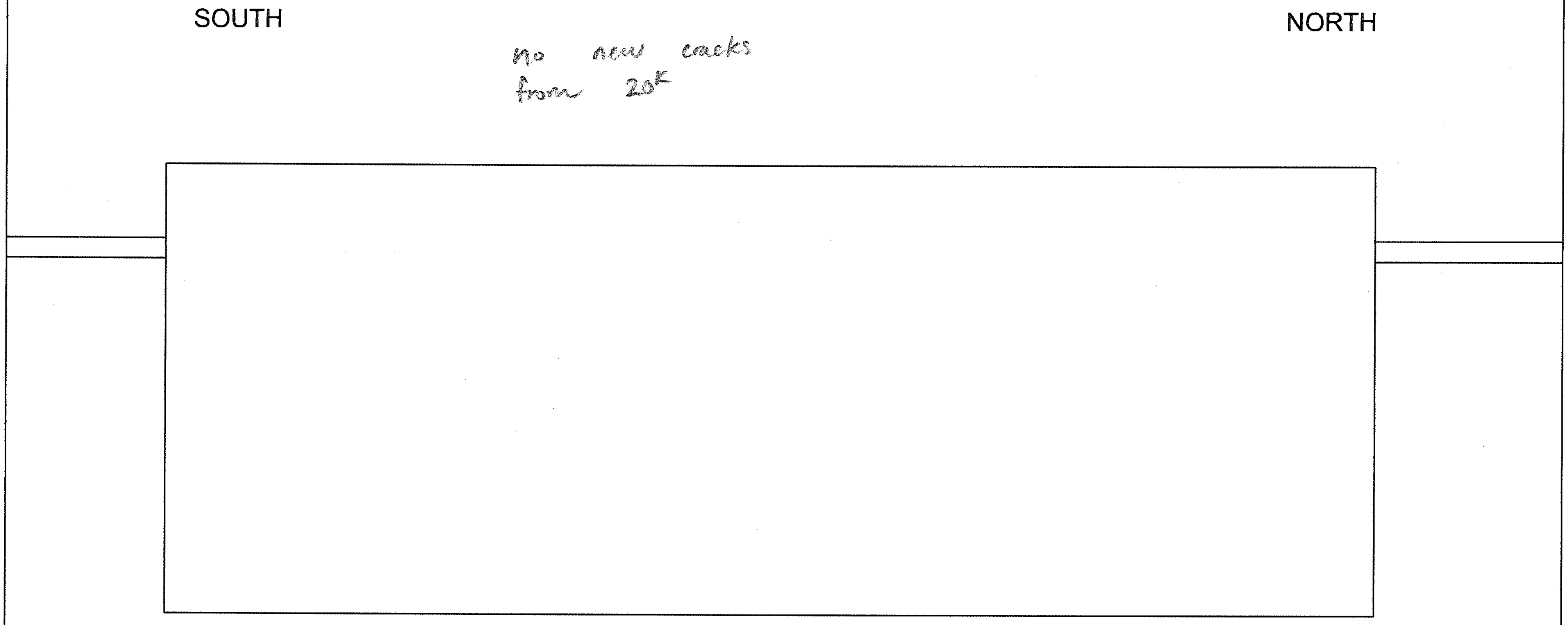


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D12 Reload 3/23/17

40k



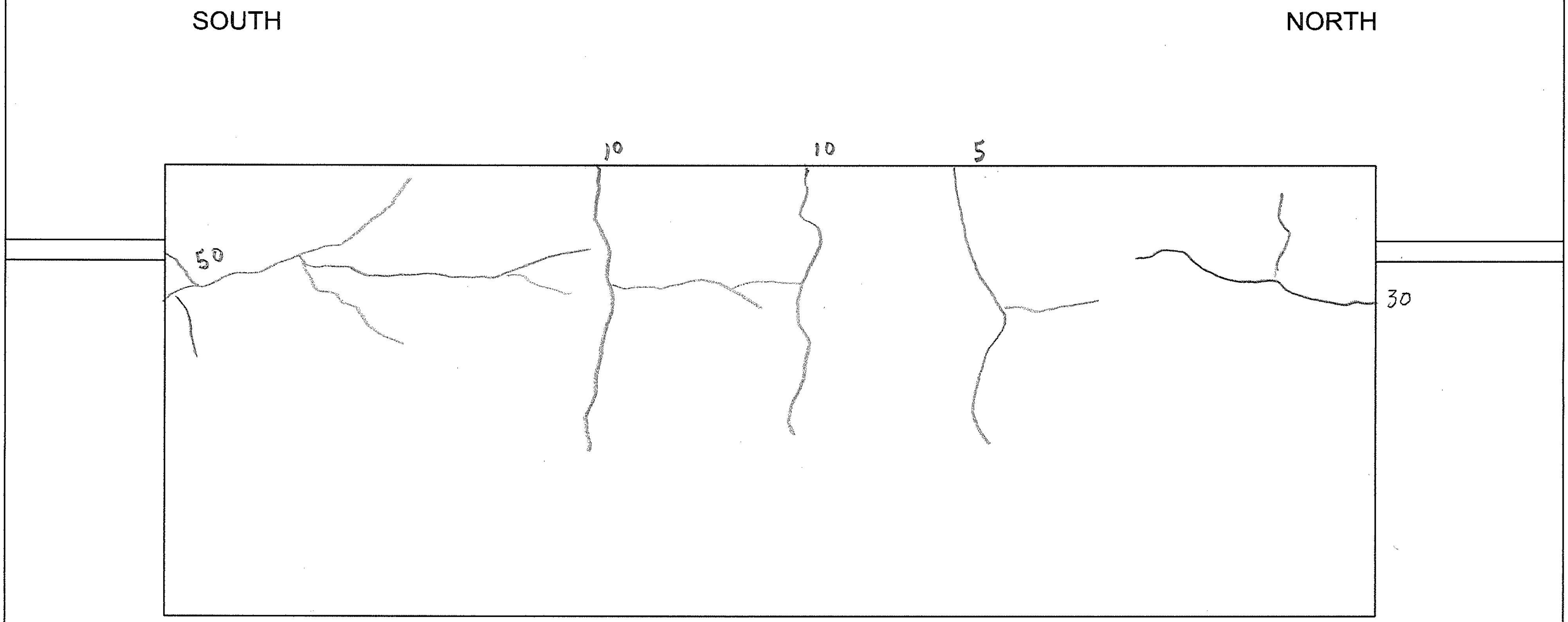
no new cracks
from 20k

Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D12 Reload 3/23/17

60k

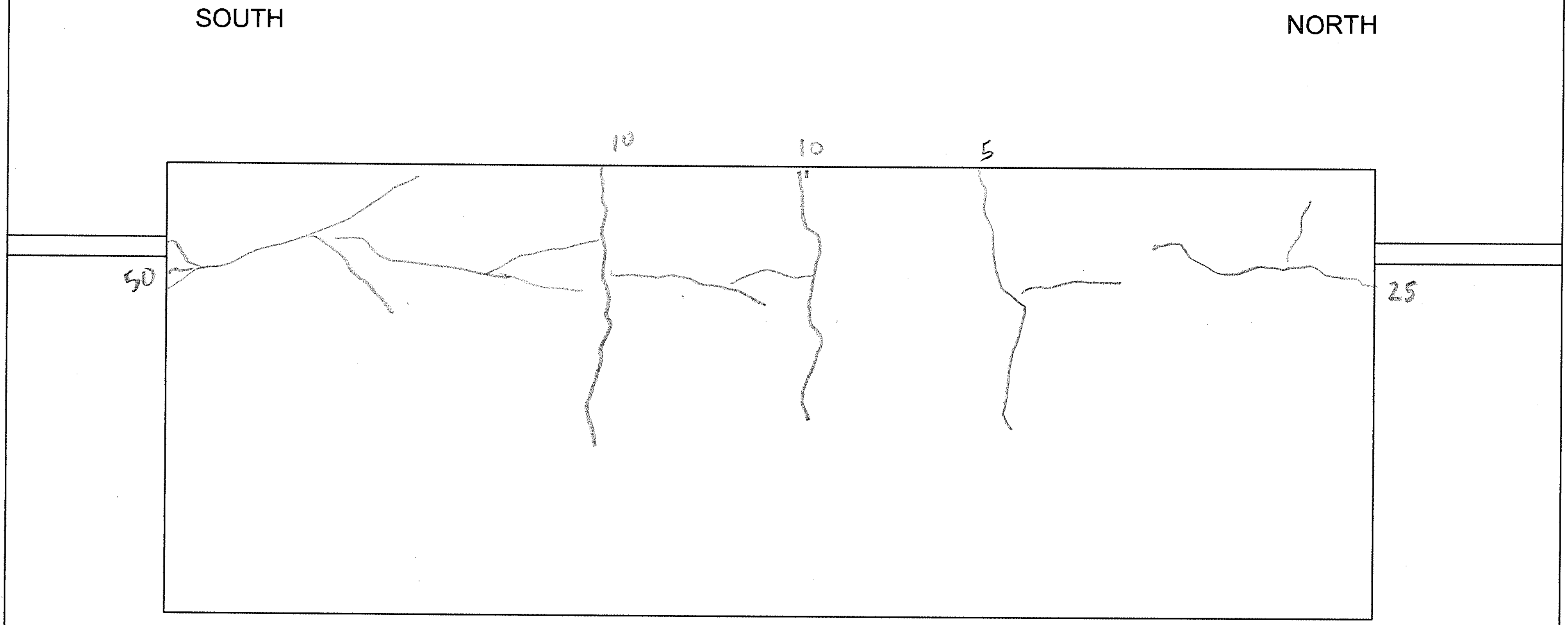


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D12 Reload

80k



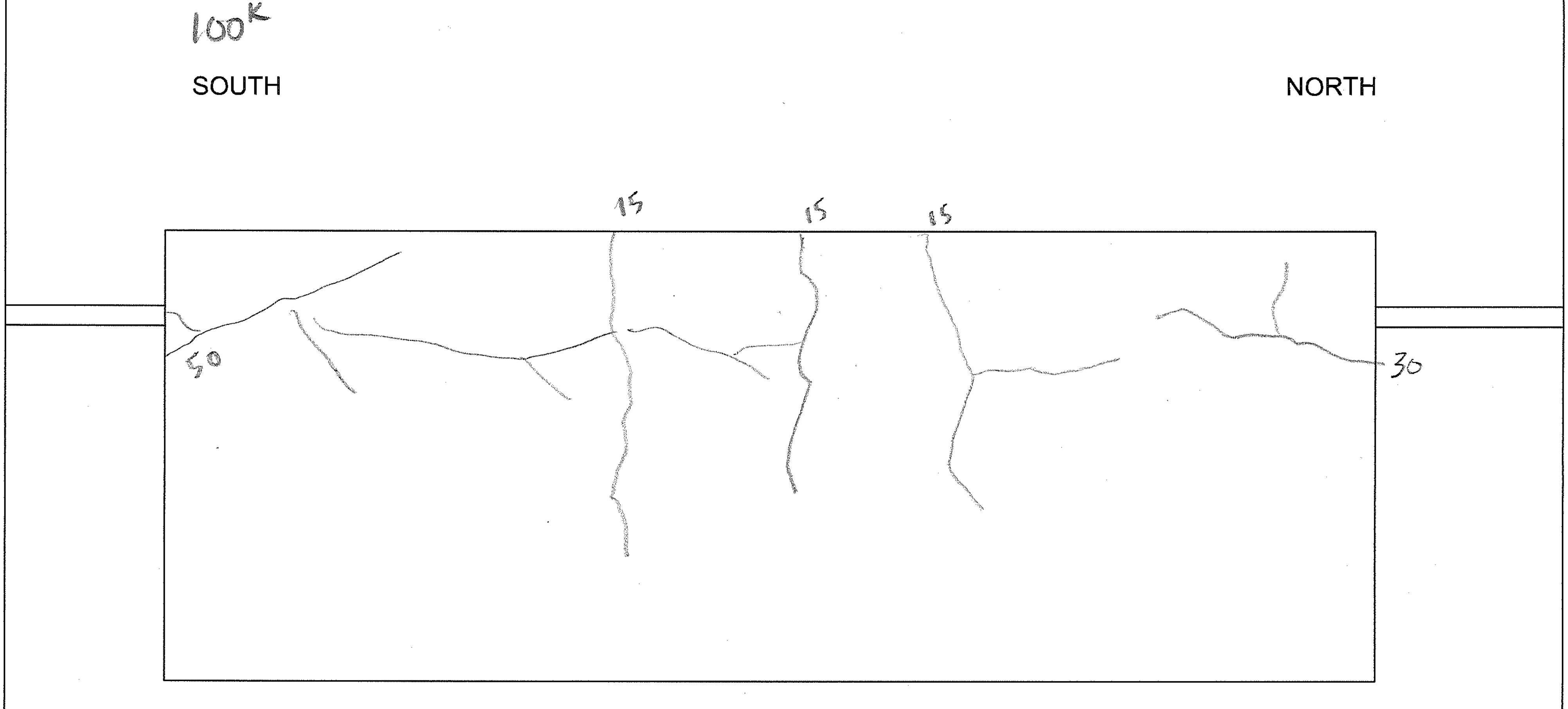
Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

D12 Reload 3/23/17

100k



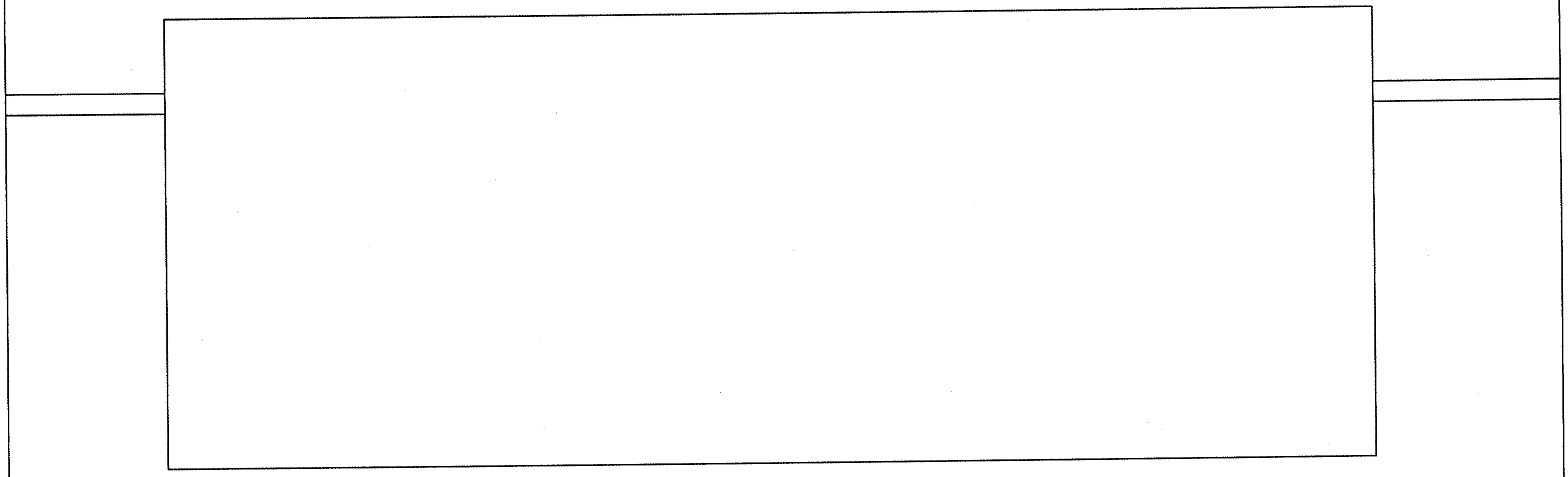
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D12 Reload 3/23/17

110k

no cracks marked / measured
see photos



Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D13

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 6/14/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skiller	KCSkiller	6/14/17
WILL POLLALIS		6/14/17
Prateek Shah	P Shah	6/14/17
JONATHAN MONICAL		07/03/17

Recorded by: KCS

Checked by:

Checked by:

Test: D13

Date: 6/14/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
20k	2:58	19.9	20	0	0	0	0	0
40k	3:02	39.5	39.5	0.001	0.002	0	0.002	0.002
60k	3:06	59.9	60	0.005	0.004	0.002	0.006	0.006
80k	3:12	80	80	0.012	0.012	0.005	0.013	0.013
100k	3:18	98.1	98.1	0.024	0.026	0.009	0.030	0.030
105k	3:26	105.2	104.6	0.030	0.035	0.012	0.039	0.039

NW crack reached 0.06, then anchor installed

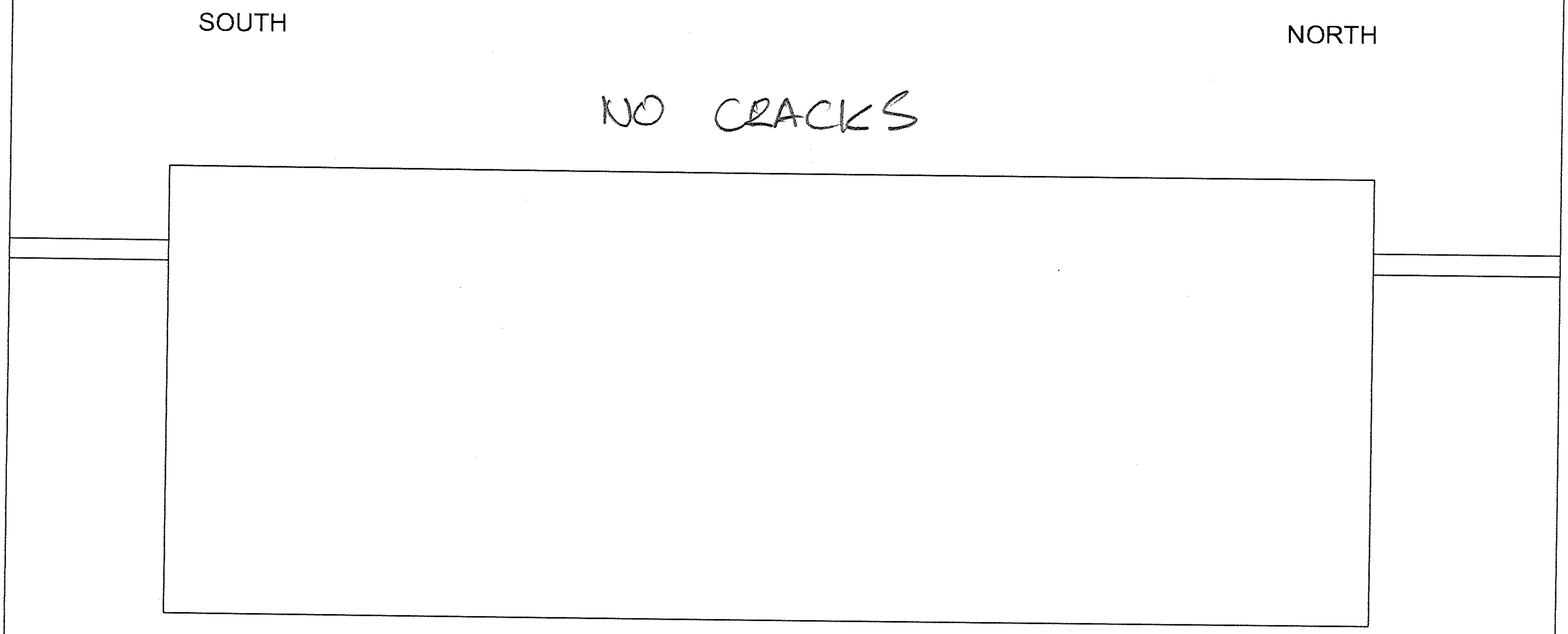
Notes:

Recorded by: Kinsey Skillen

Signature: KC Skillen

D13 06/14/17

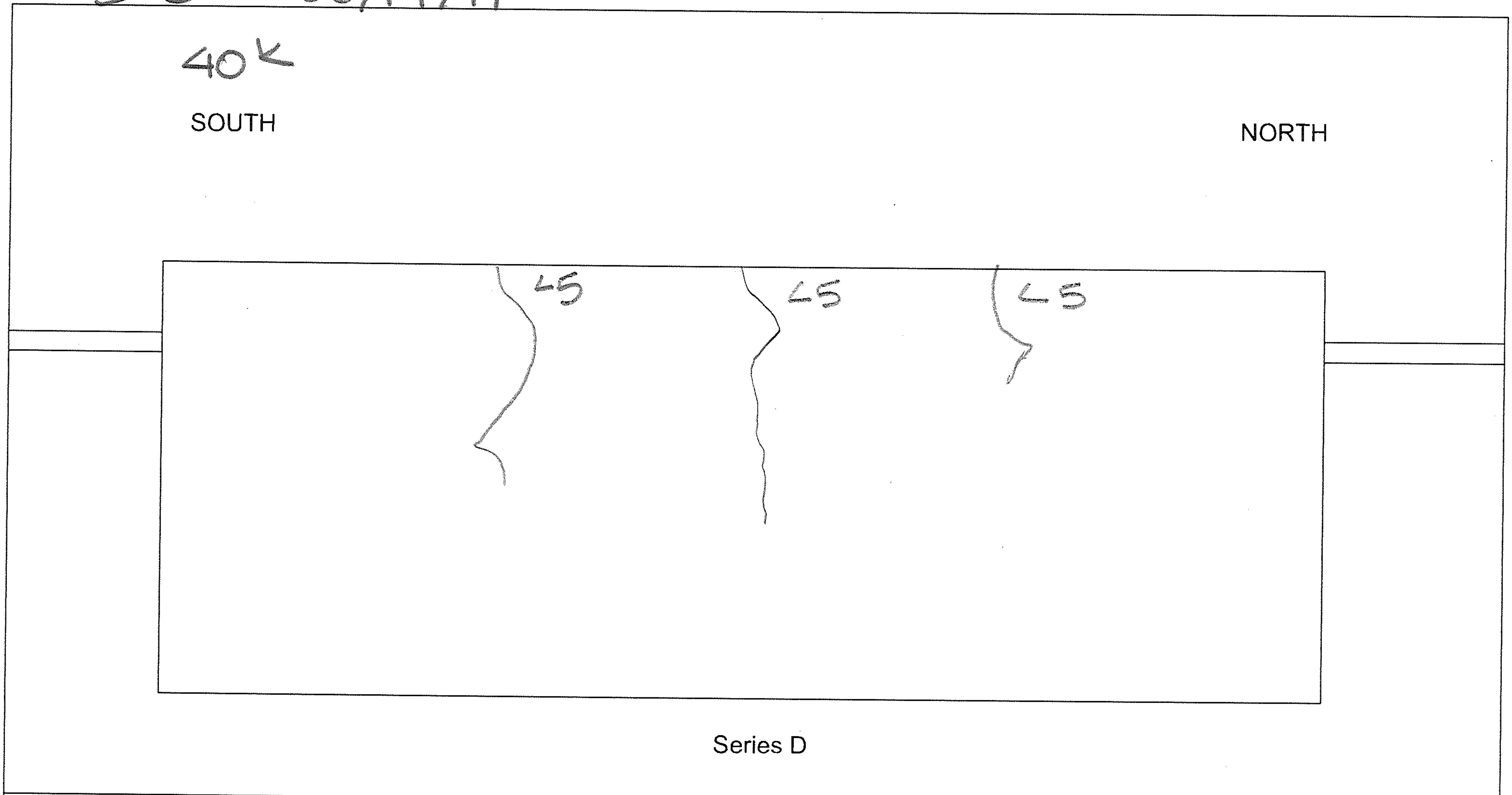
20 K



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D13 06/14/17

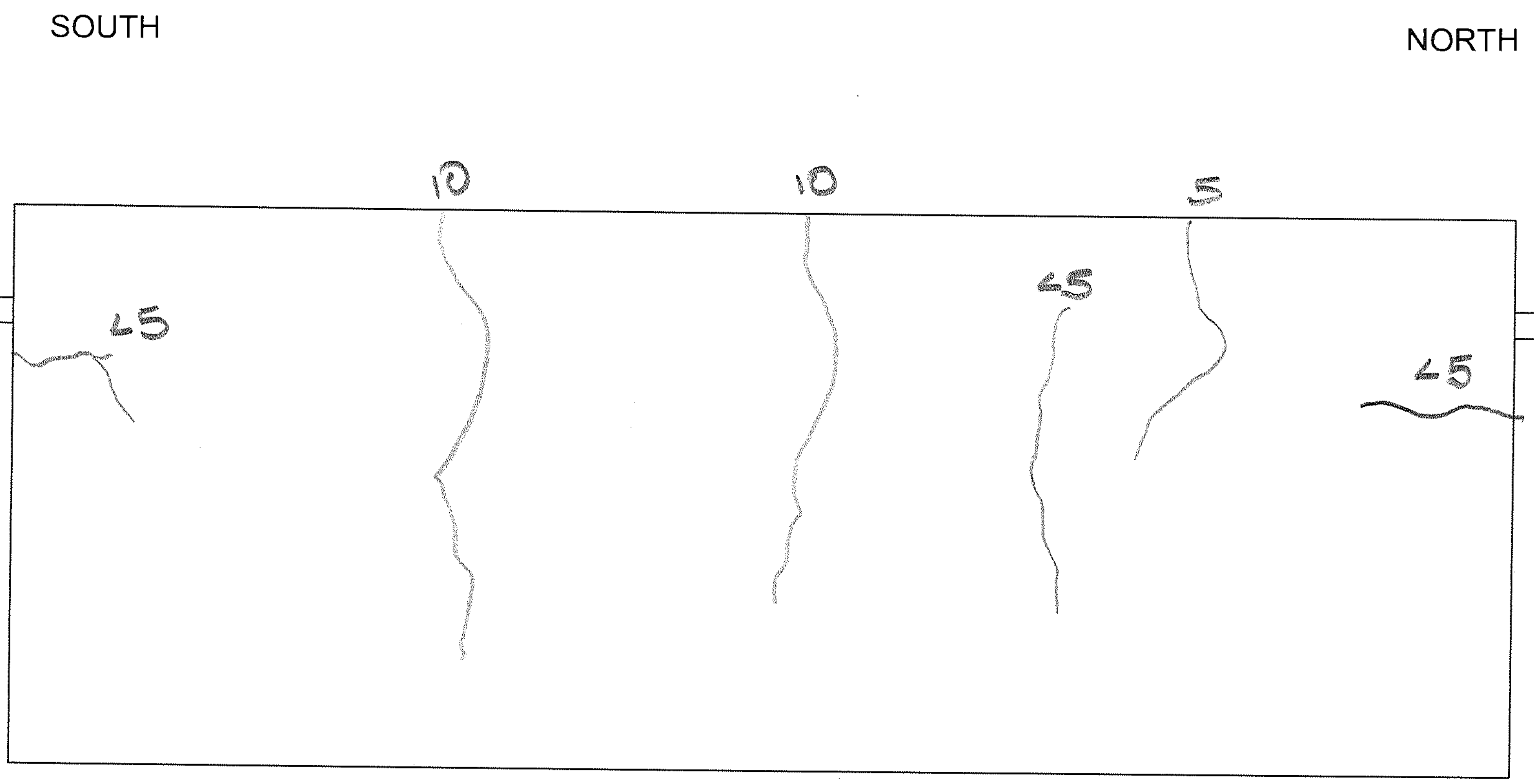


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D13 06/14/17

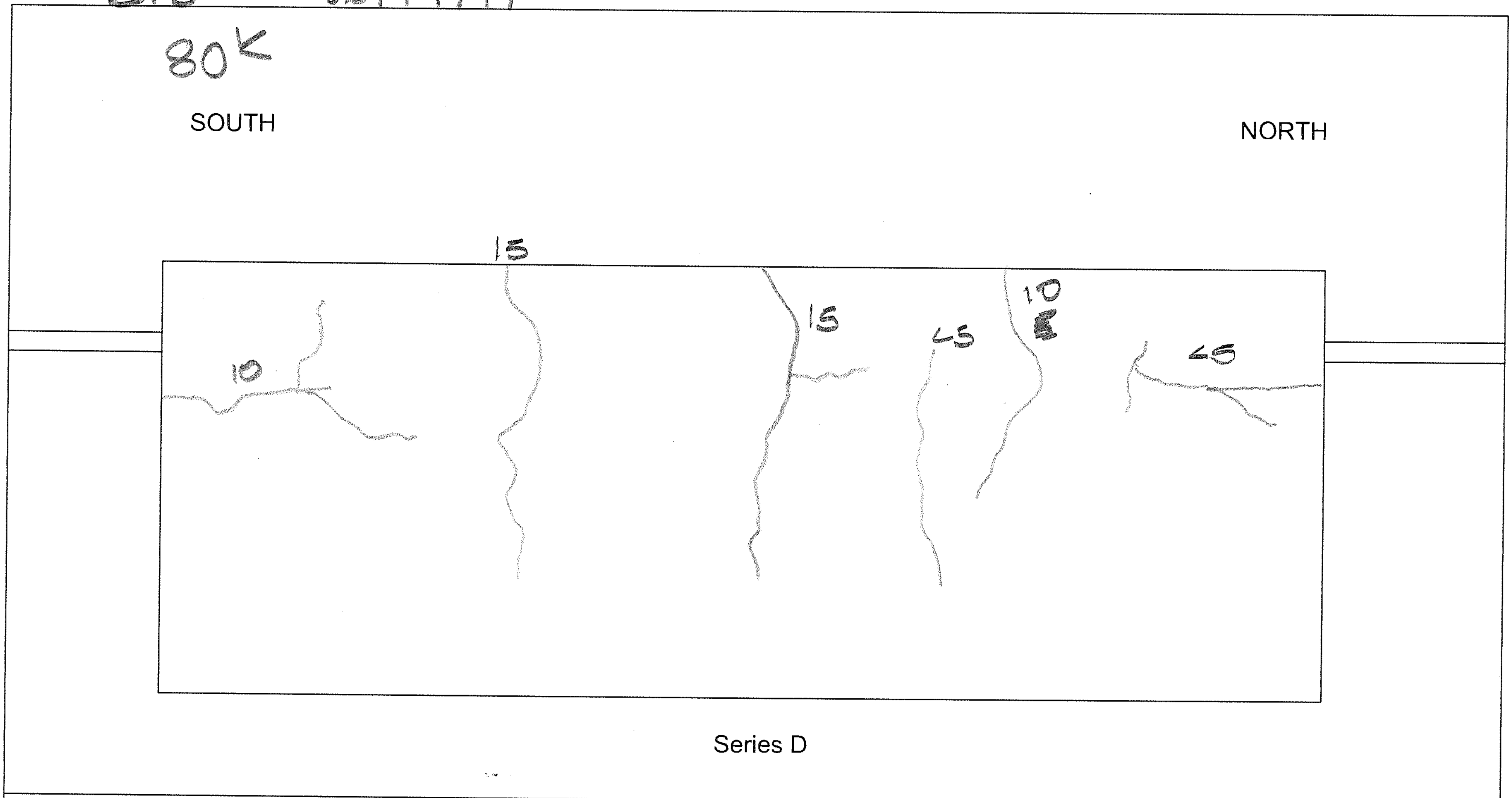
60k



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

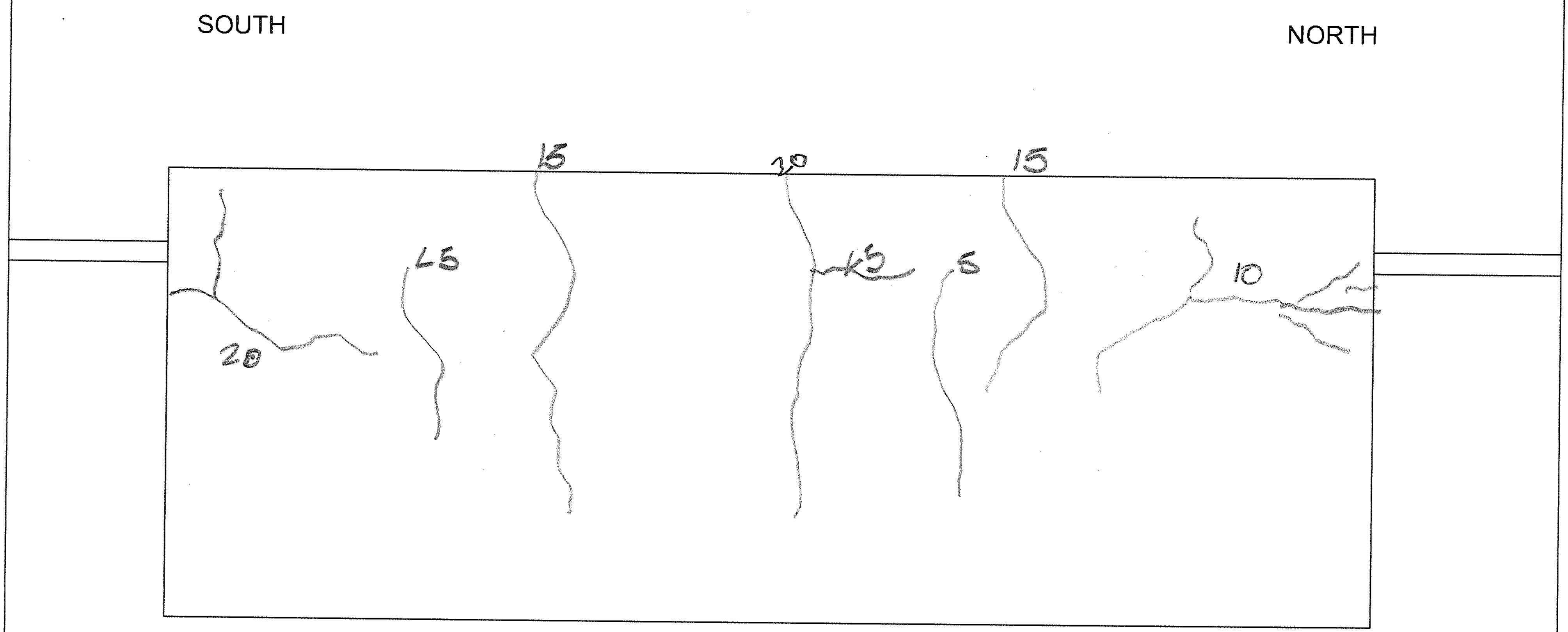
D13 06/14/17



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D13 06/14/17

100k

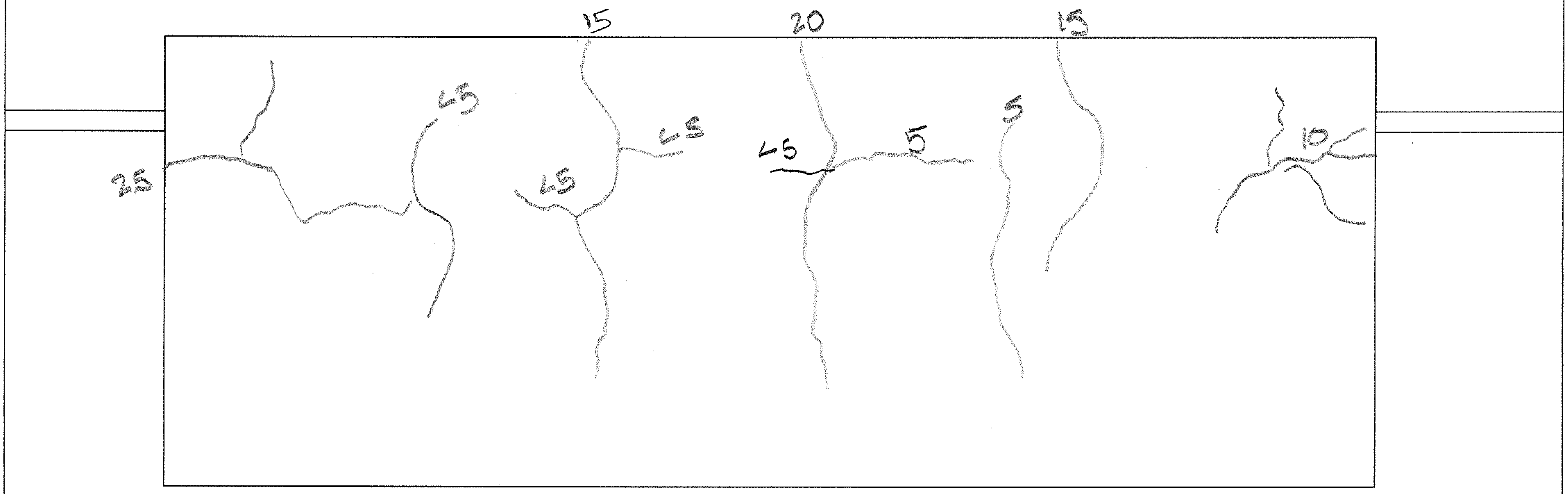


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D13 06/14/17

105k



Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Test: D13 Reload w/ Anchors

Date: 6/15/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0K	4:52	0	0	.028	.026	.007	.028	.028
20K	4:58	20.2	20	.028	.026	.007	.028	.028
40K	5:00	39.9	39.9	.028	.028	.007	.029	.029
60K	5:05	60.1	60.1	.033	.035	.008	.035	.035
80K	5:10	80.1	80	.040	.042	.010	.041	.042
100K	5:17	99.6	99.9	.047	.051	.012	.050	.051
110K	5:20							
113K	5:27	112	112	.080	.091	.017	.068	.091
120K	5:33	118	118	.126	.145	.03	.102	.145

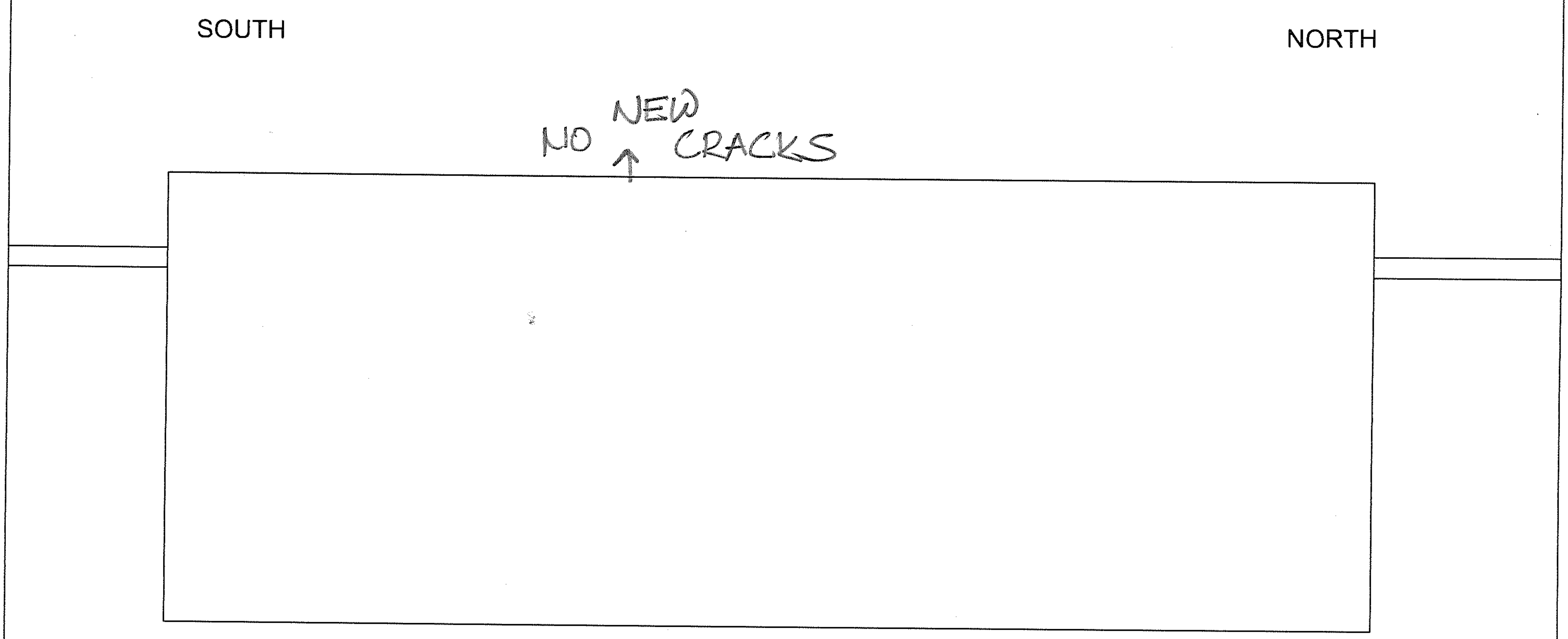
Notes:

Recorded by: Kinsey Skiller

Signature: KC Skiller

D13 06/15/17

R20

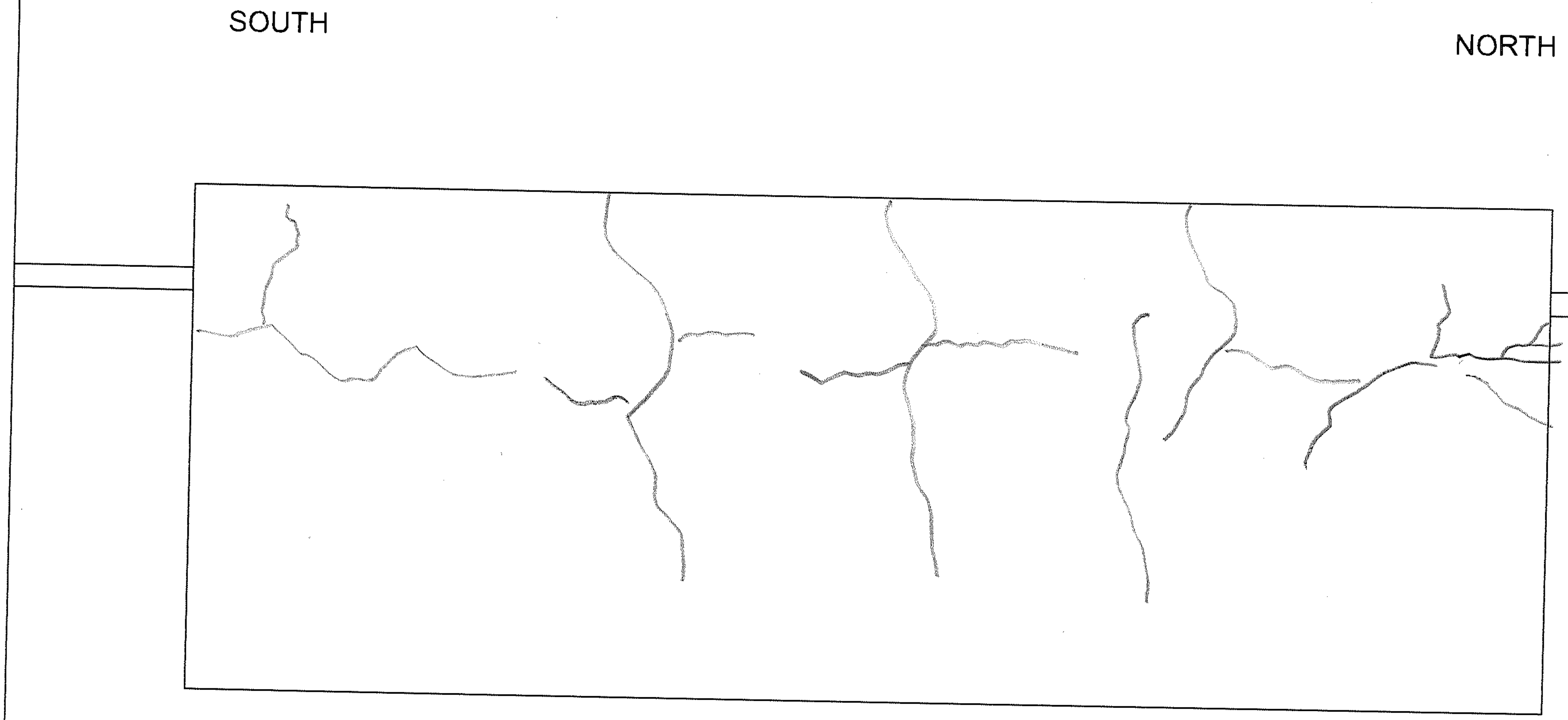


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D13 06/15/17

R40

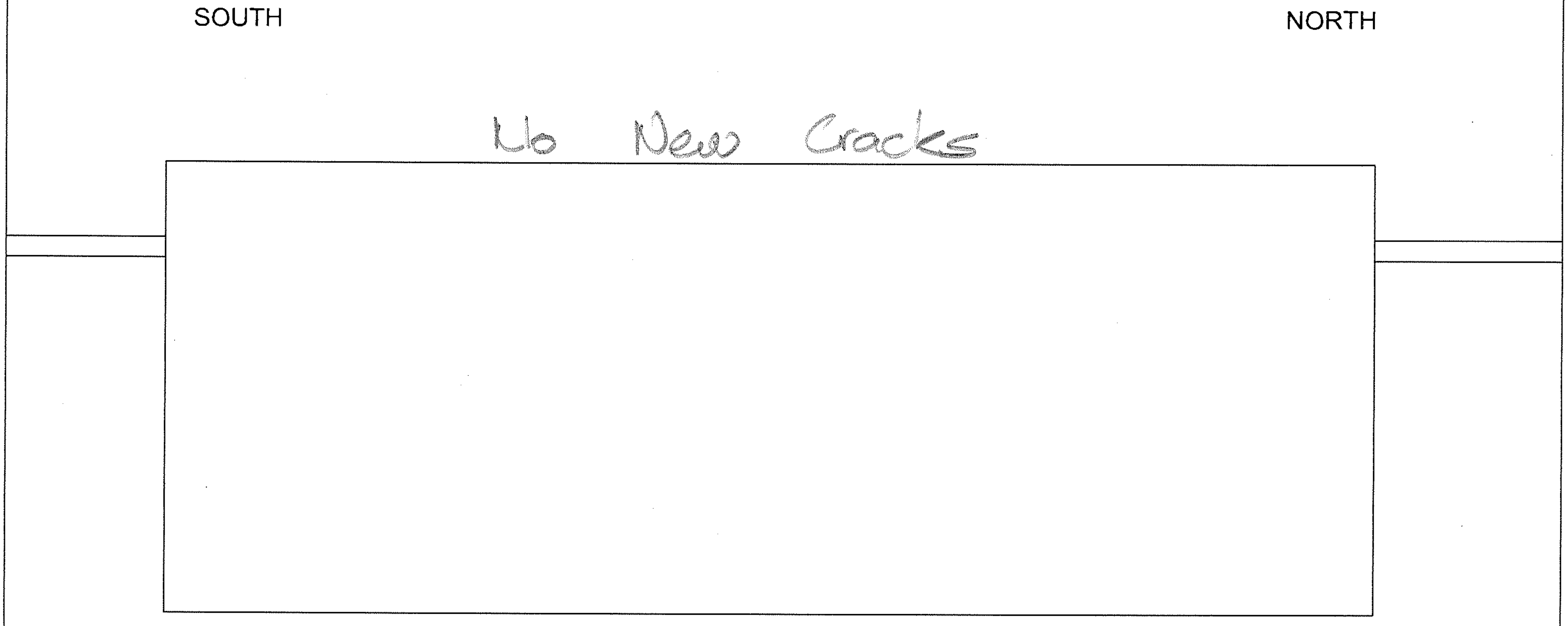


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D13 06/15/17

R60k



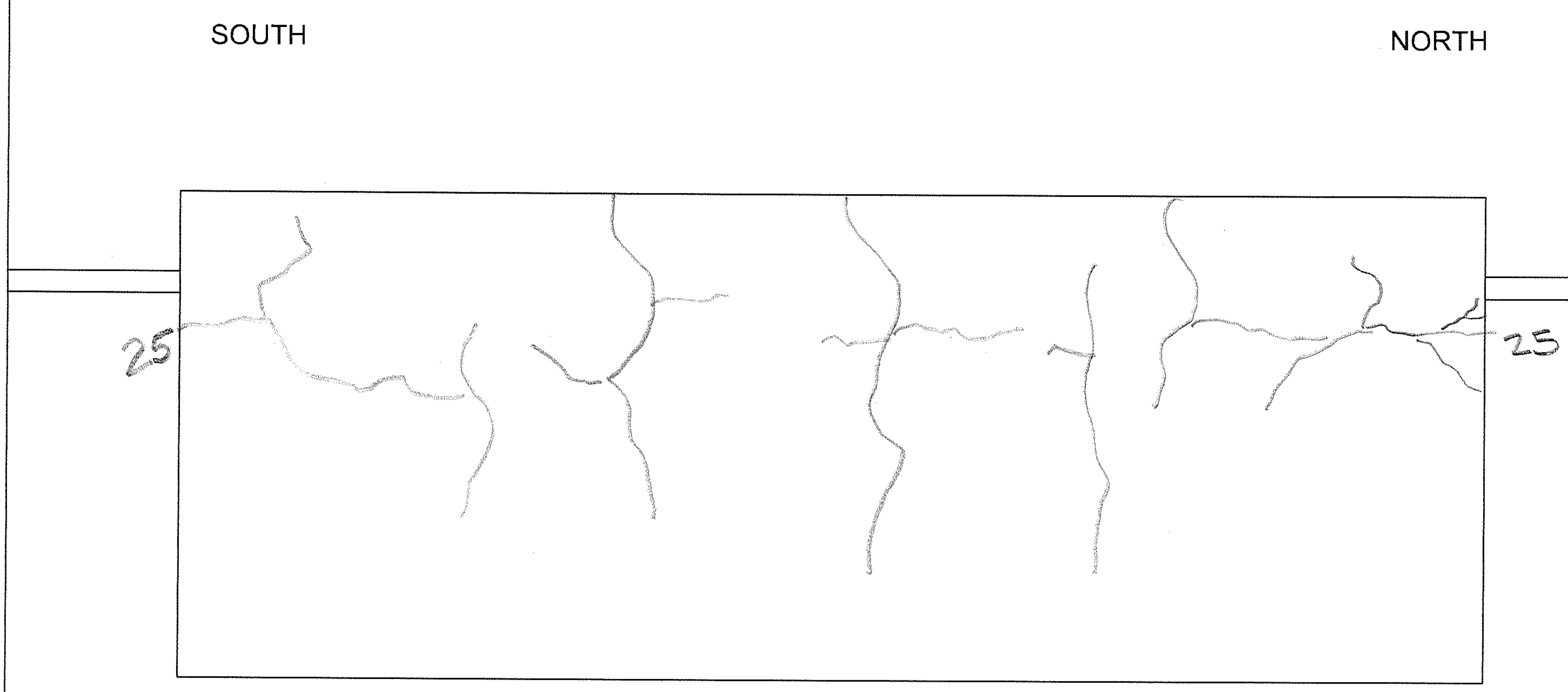
No New Cracks

Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D13 06/15/17

R80

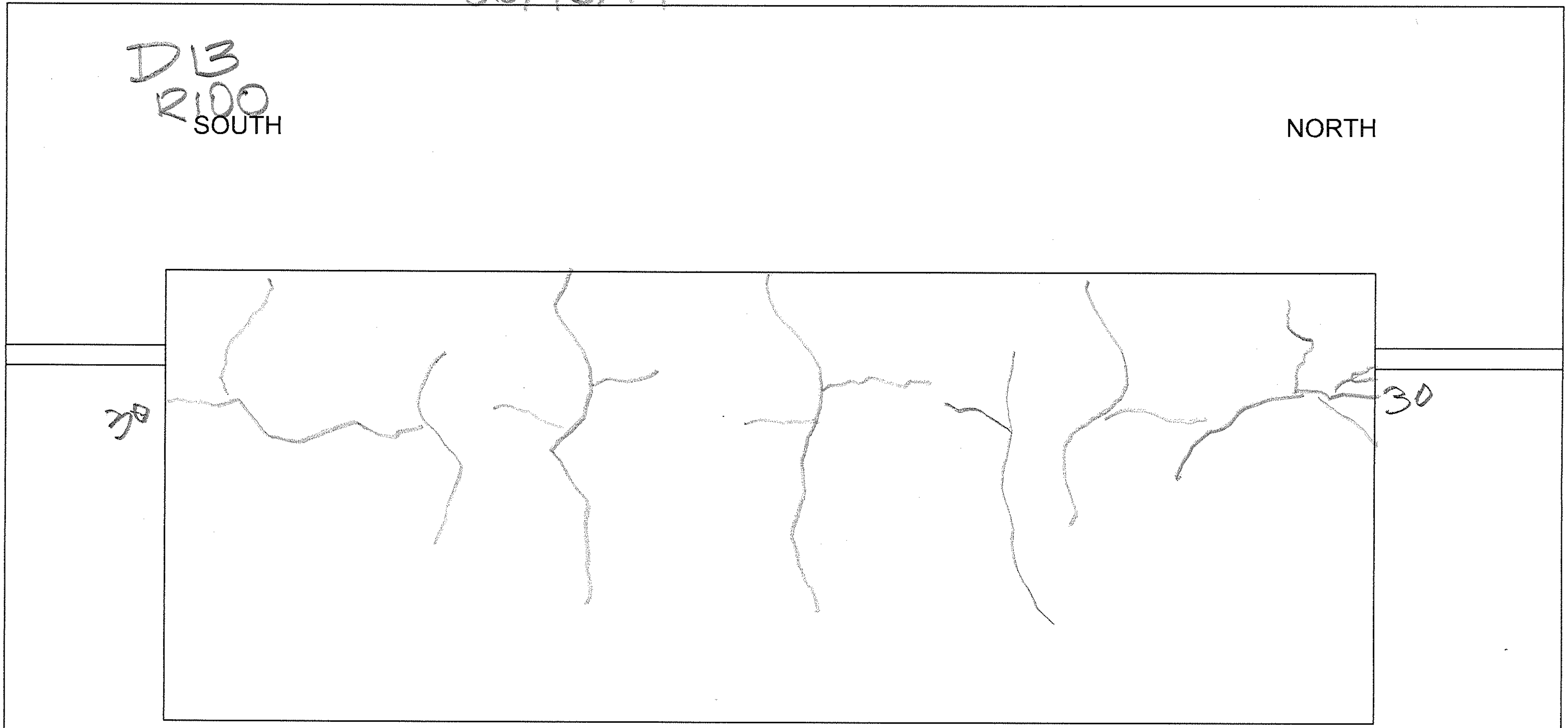


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

06/15/17

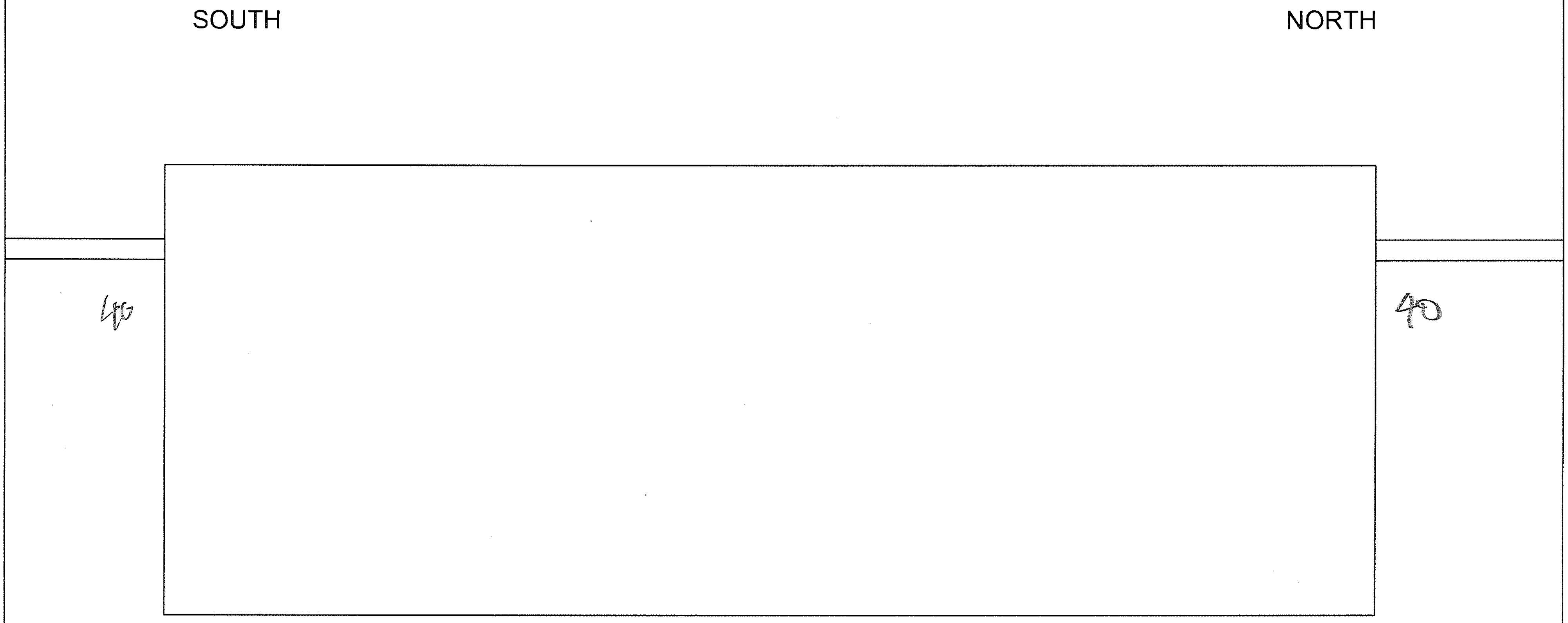

D13
R100

Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D13
R110

06/15/17



Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D14

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 6/19/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skillen	KeSkillen	6/19/17
WILL POLLALIS		6/19/17
Prateek Shah	PShah	6/19/17
JONATHAN MONICAL		07/03/17

Recorded by: KCS

Checked by:

Checked by:

Test: D14

Date: 6/19/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0K	3:00	0						
20K	3:13	20.4	19.9	0.0	0.001	0.0	0.0	0.0
40K	3:19	39.7	39.9	0.0	0.004	0.0	.001	0.004
60K	3:23	59.7	60.1	0.0	.011	0.002	0.002	0.011
80K	3:28	79.9	79.5	0.004	0.023	0.005	0.009	0.023
100K	3:34	97.8	98.3	0.023	0.045	0.009	0.024	0.045
105K	3:47				0.058			

Notes:

Recorded by: Kinsey Skillen

Signature: K C Skillen

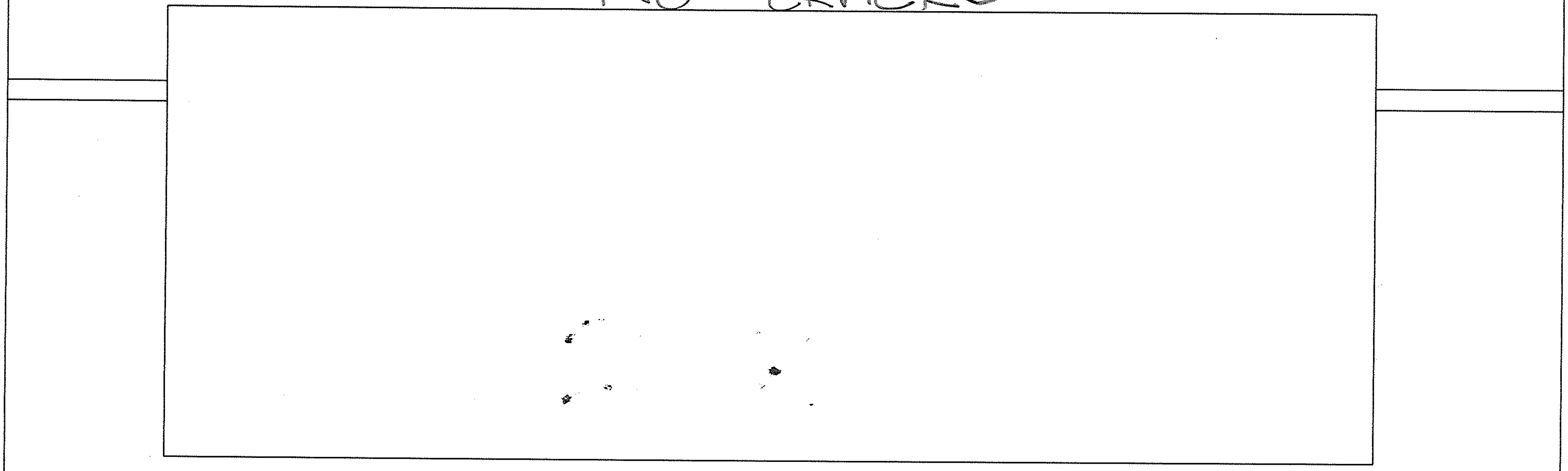
D14 06/19/17

20K

SOUTH

NORTH

NO CRACKS



Series D

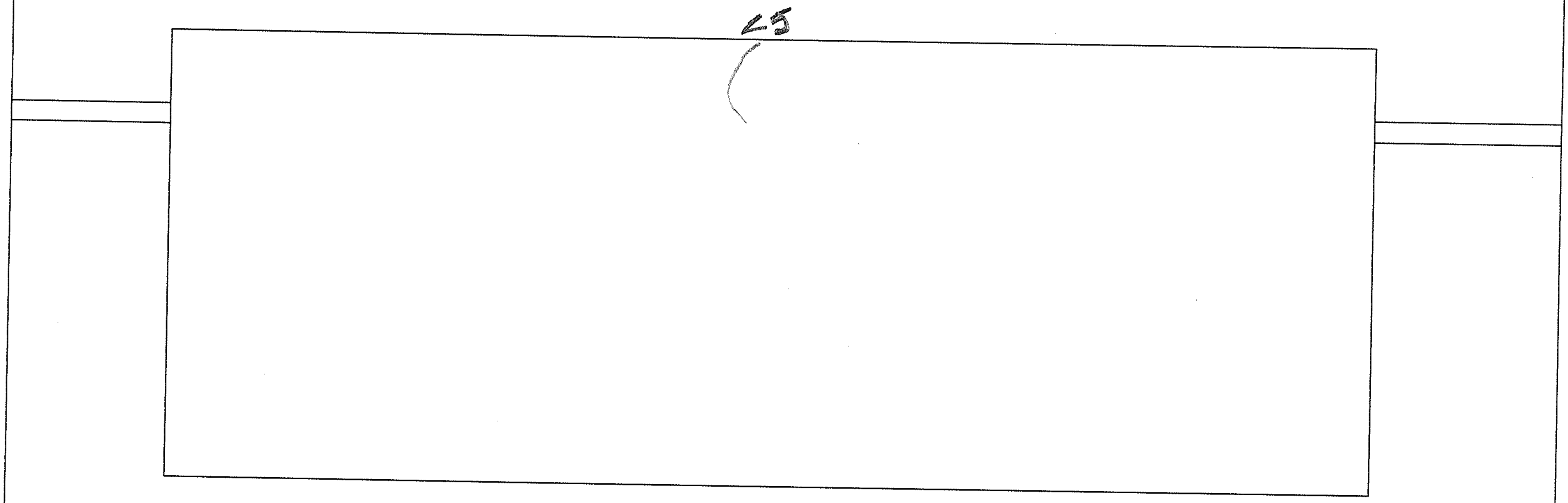
Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D14 06/19/17

40K

SOUTH

NORTH

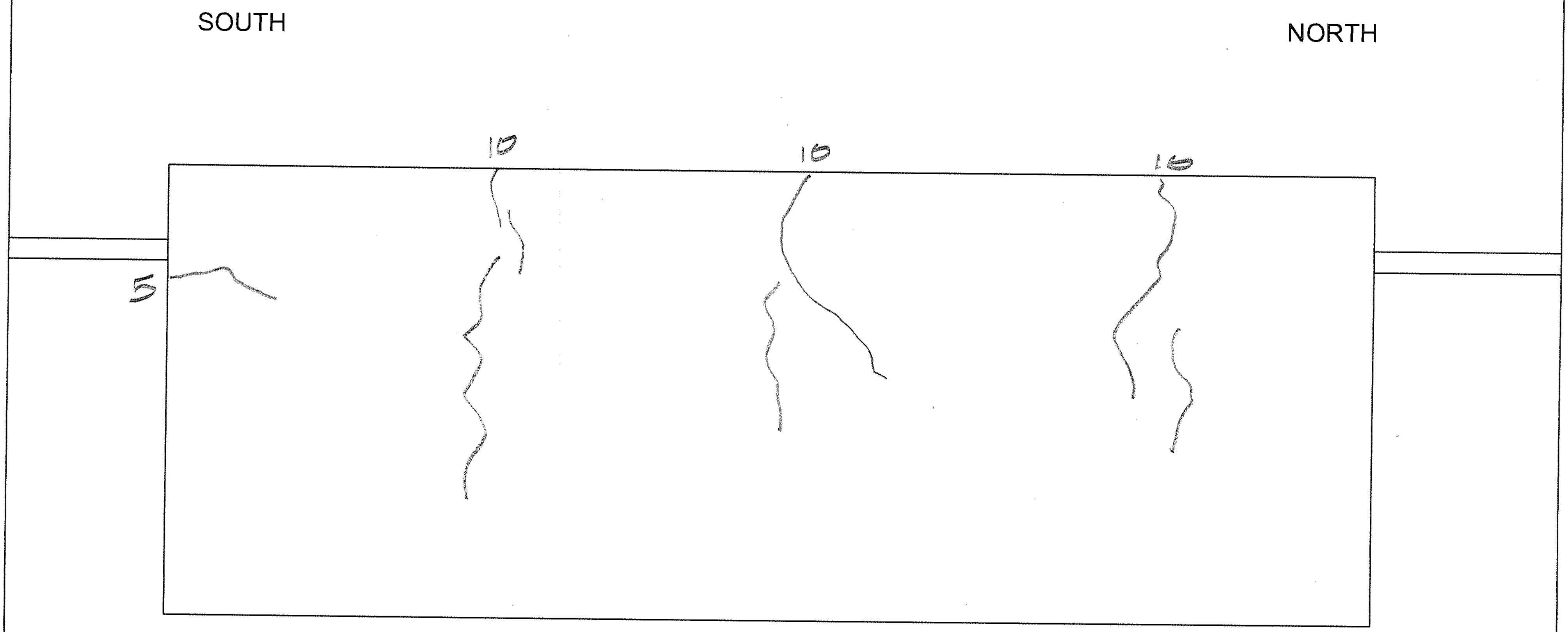


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D14 06/19/17

60 K



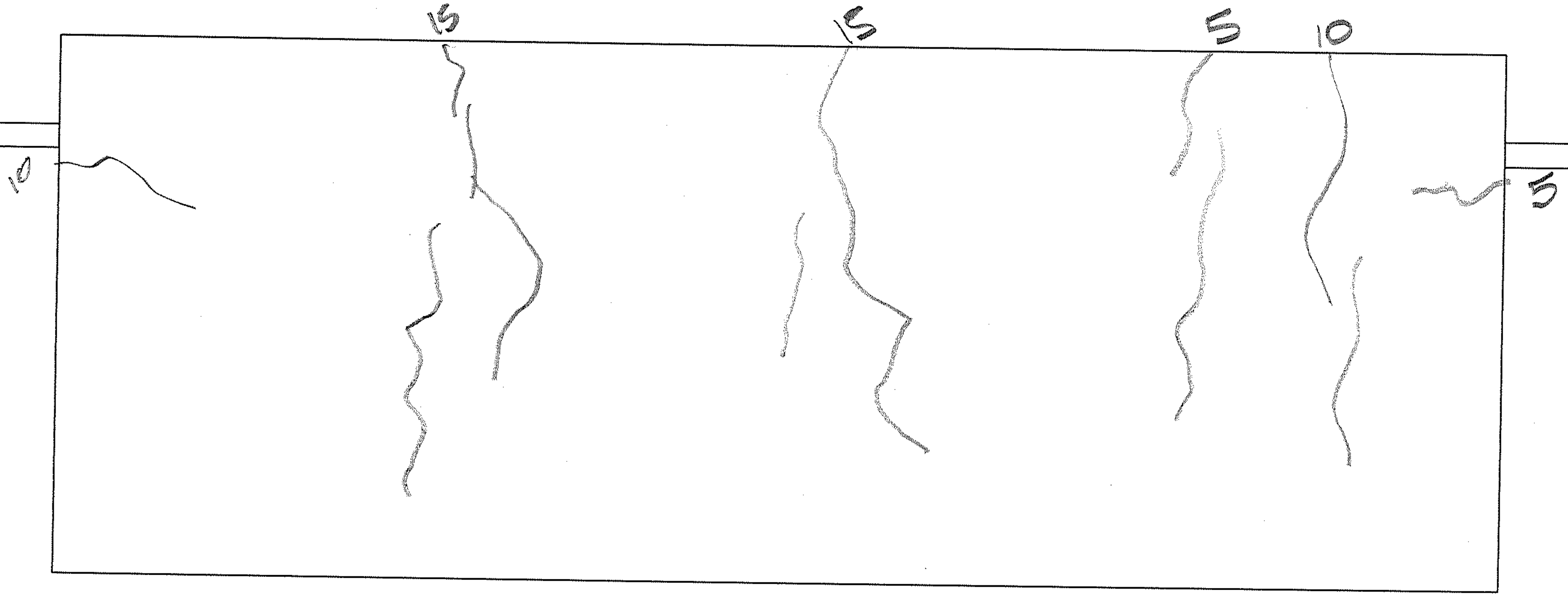
Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

D14 06/19/17

80 K

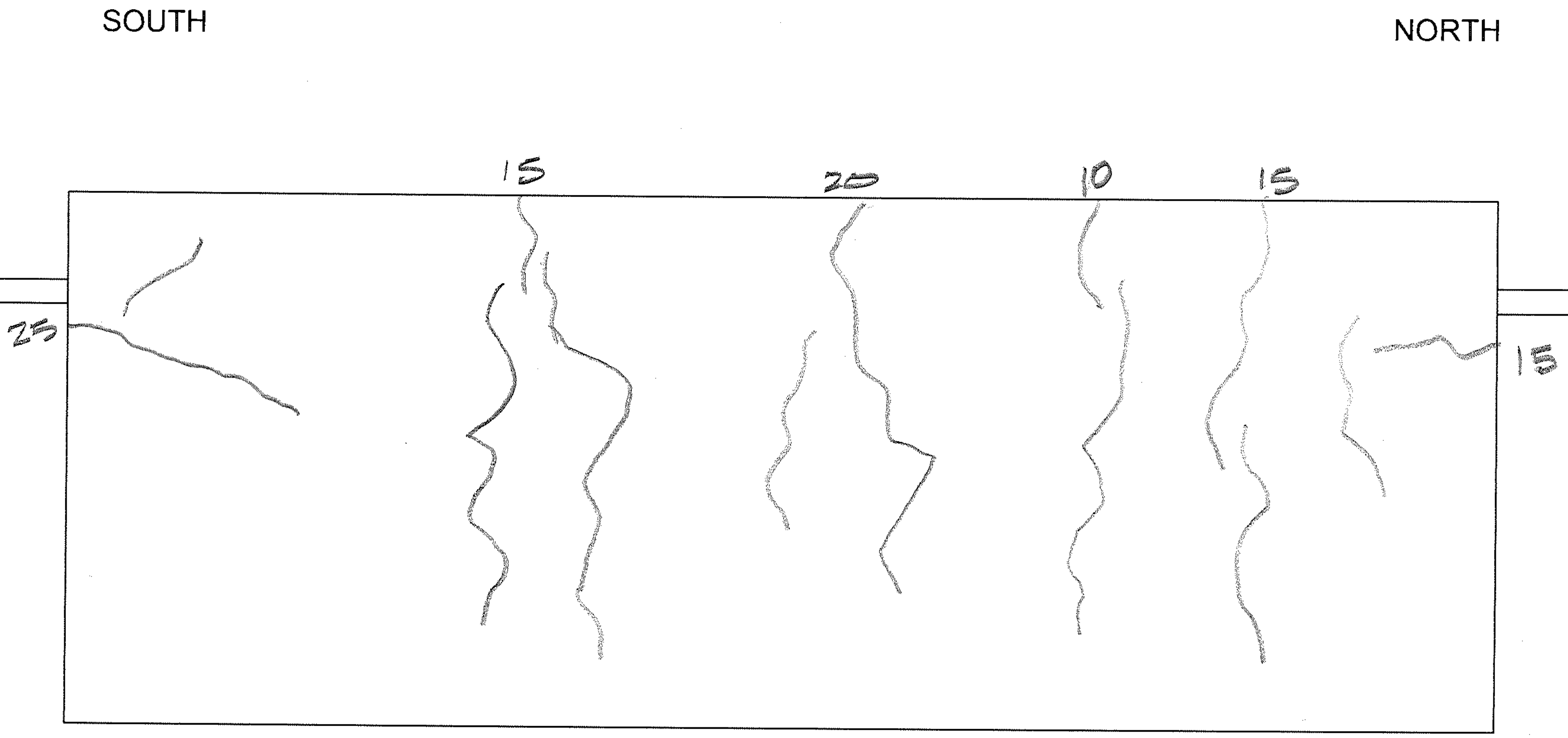


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D14 06/19/17

100k



Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Test: D14 Reload w/ Anchors

Date: 6/20/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0K	4:35 pm	0	0	0.048	0.028	0.006	0.015	0.048
20K	4:40 pm	19.7	19.9	0.048	0.029	0.006	0.015	0.048
40K	4:44 pm	40.2	40.3	0.048	0.033	0.007	0.017	0.048
60K	4:49 pm	59.9	60.1	0.052	0.041	0.009	0.023	0.052
80K	4:55 pm	79.9	79.9	0.057	0.049	0.011	0.029	0.057
100K	5:00 pm	99.3	99.4	0.064	0.060	0.013	0.037	0.064
110K	5:06 pm	109.1	109.2	0.074	0.088	0.018	0.051	0.088
120K	5:14 pm	116	116	0.147	0.157	0.096	0.130	0.157

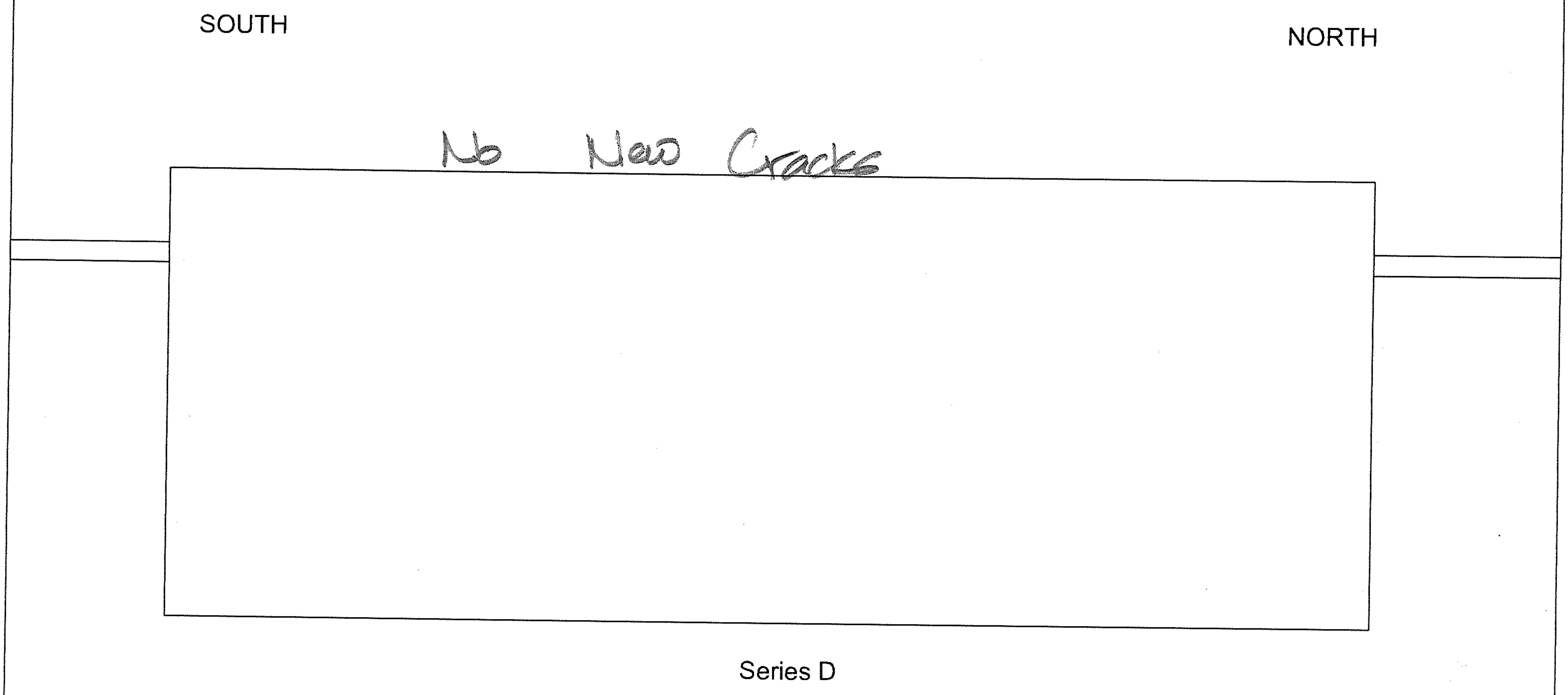
Notes:

Recorded by: Kinsey Skillen

Signature: KeSkil

D14 06/20/17

R20K



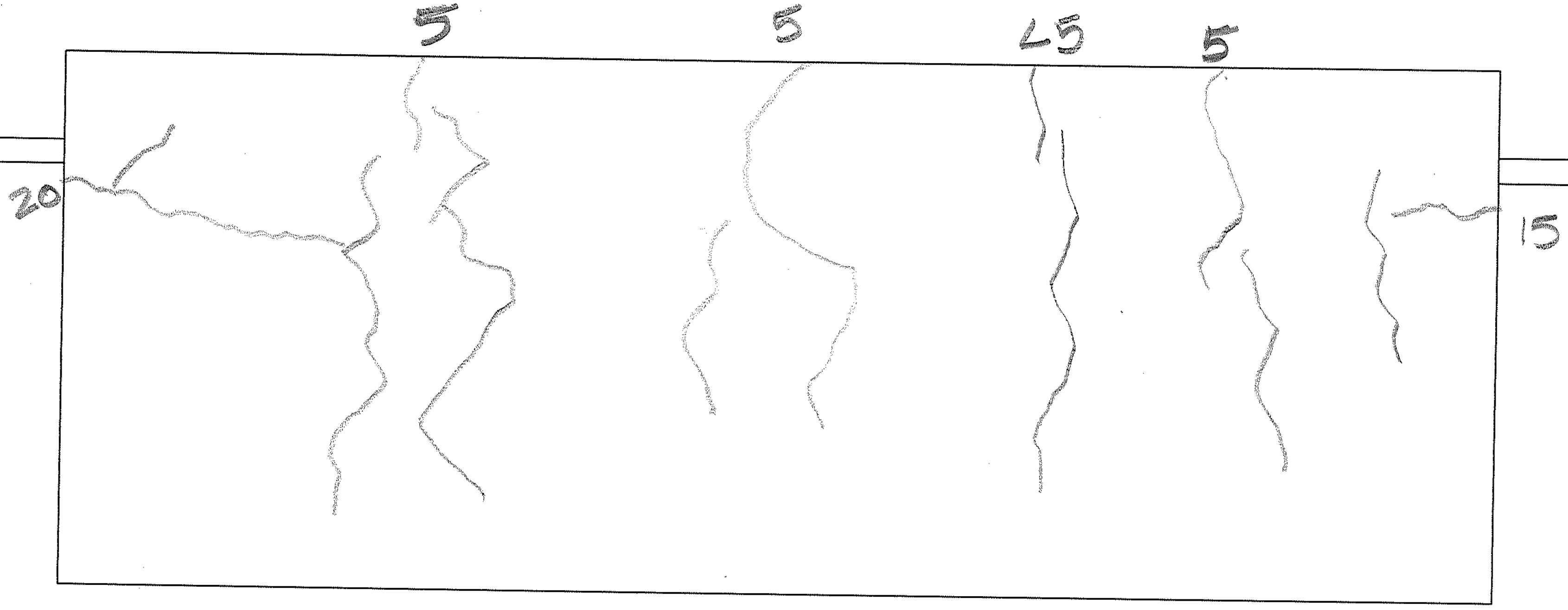
No New Cracks

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D14 06/20/17

R40K

SOUTH NORTH



Series D

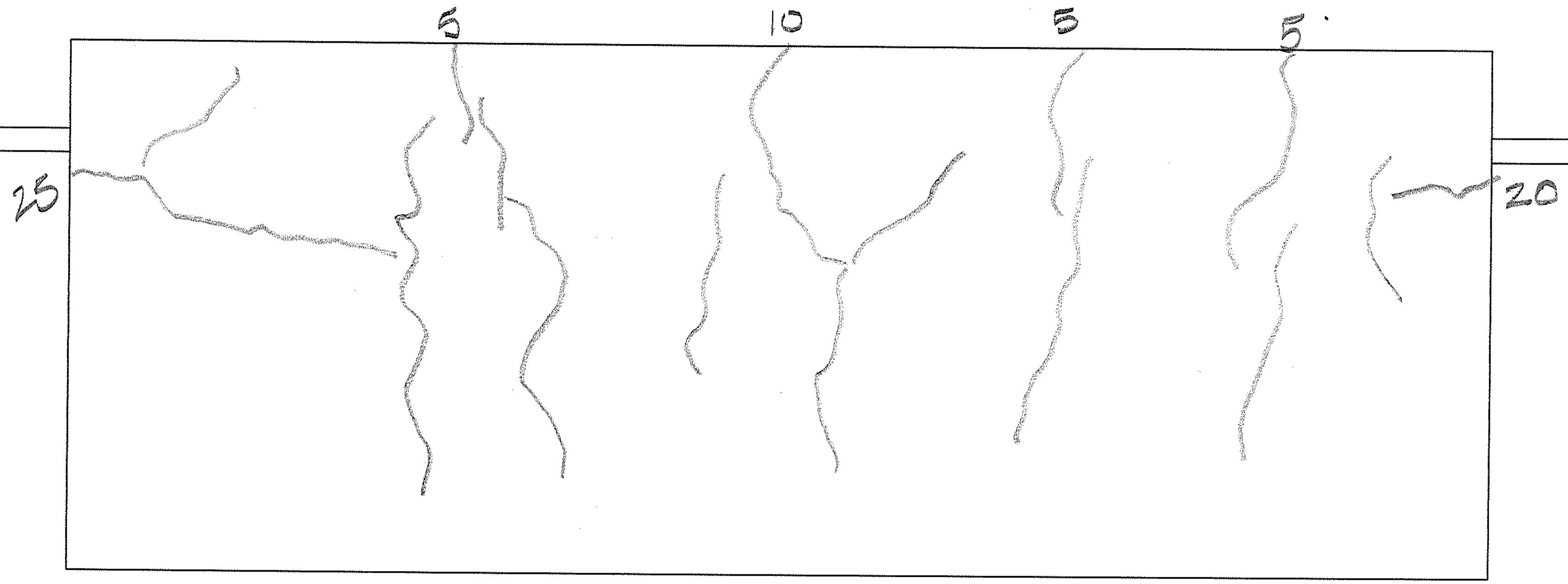
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1 of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by: KCS	Checked by:	SP
			Date:	11/16/2016	

D14 06/20/17

R60K

SOUTH

NORTH

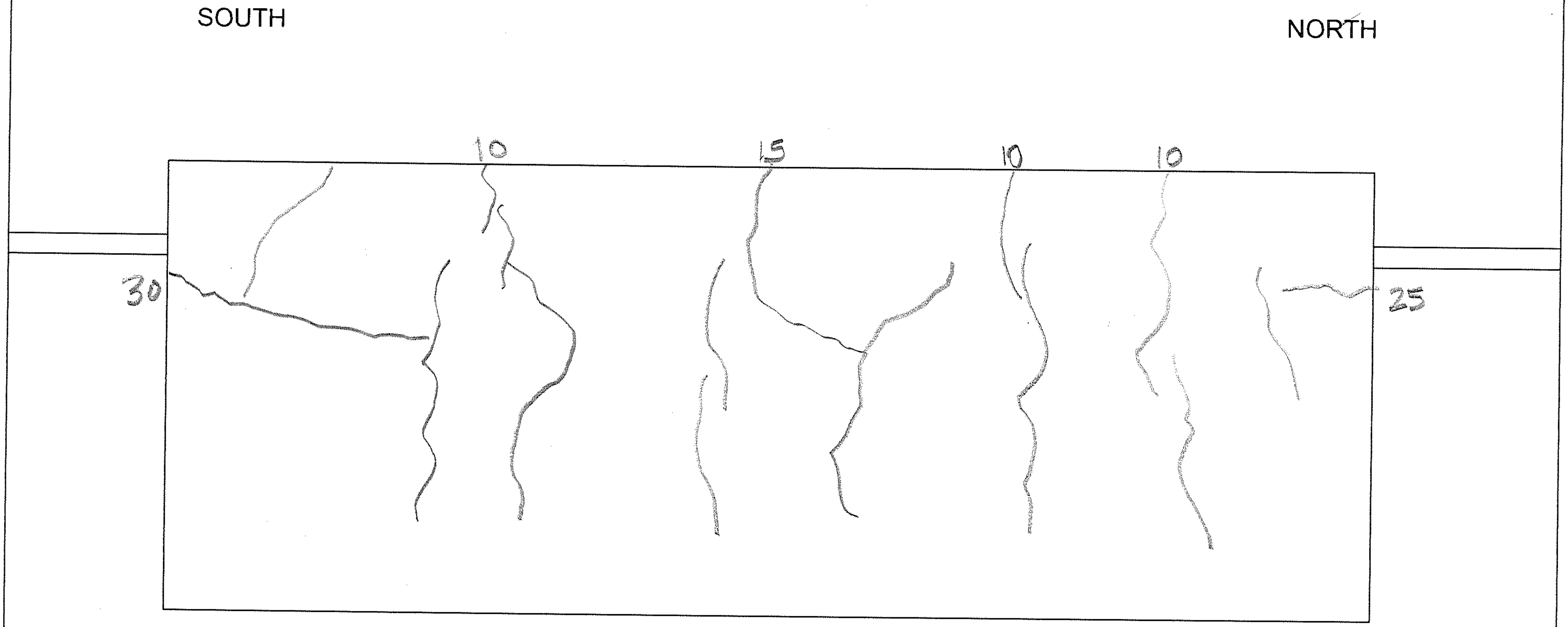


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D14 06/20/17

R80 K

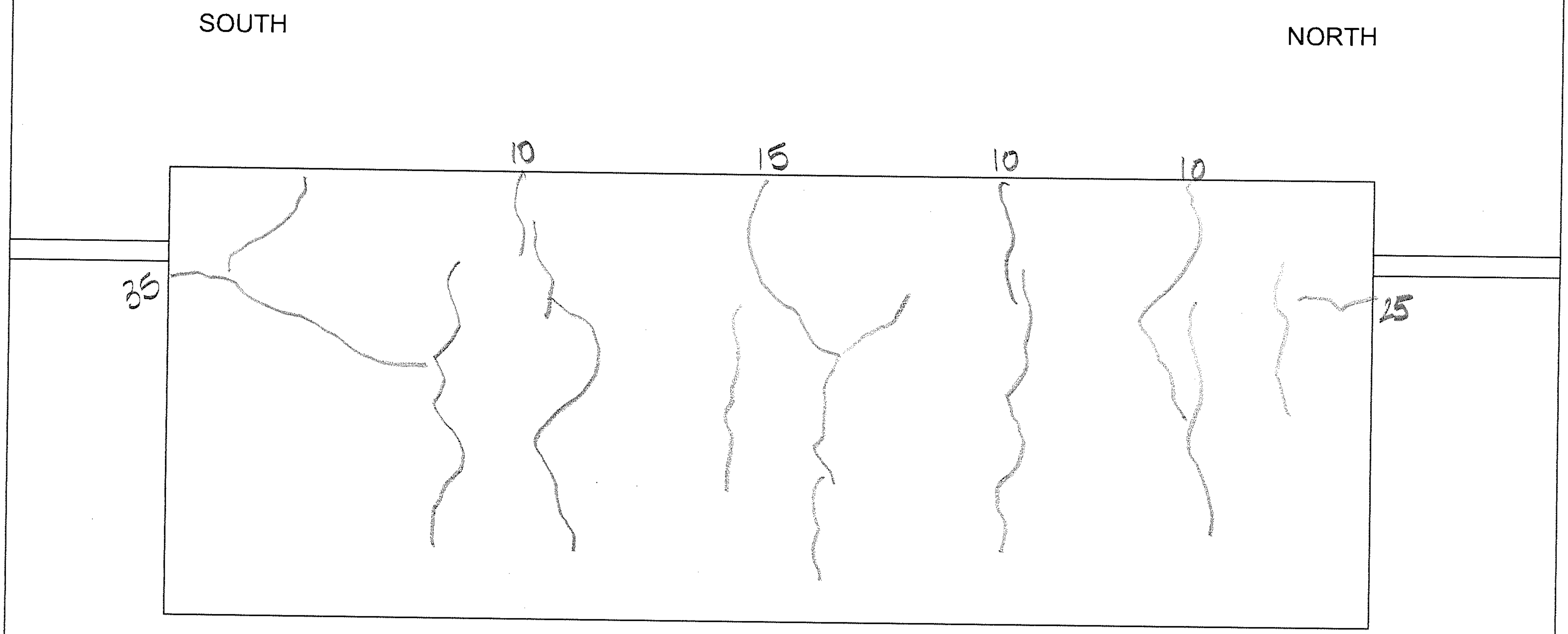


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D14 06/20/17

R100 K

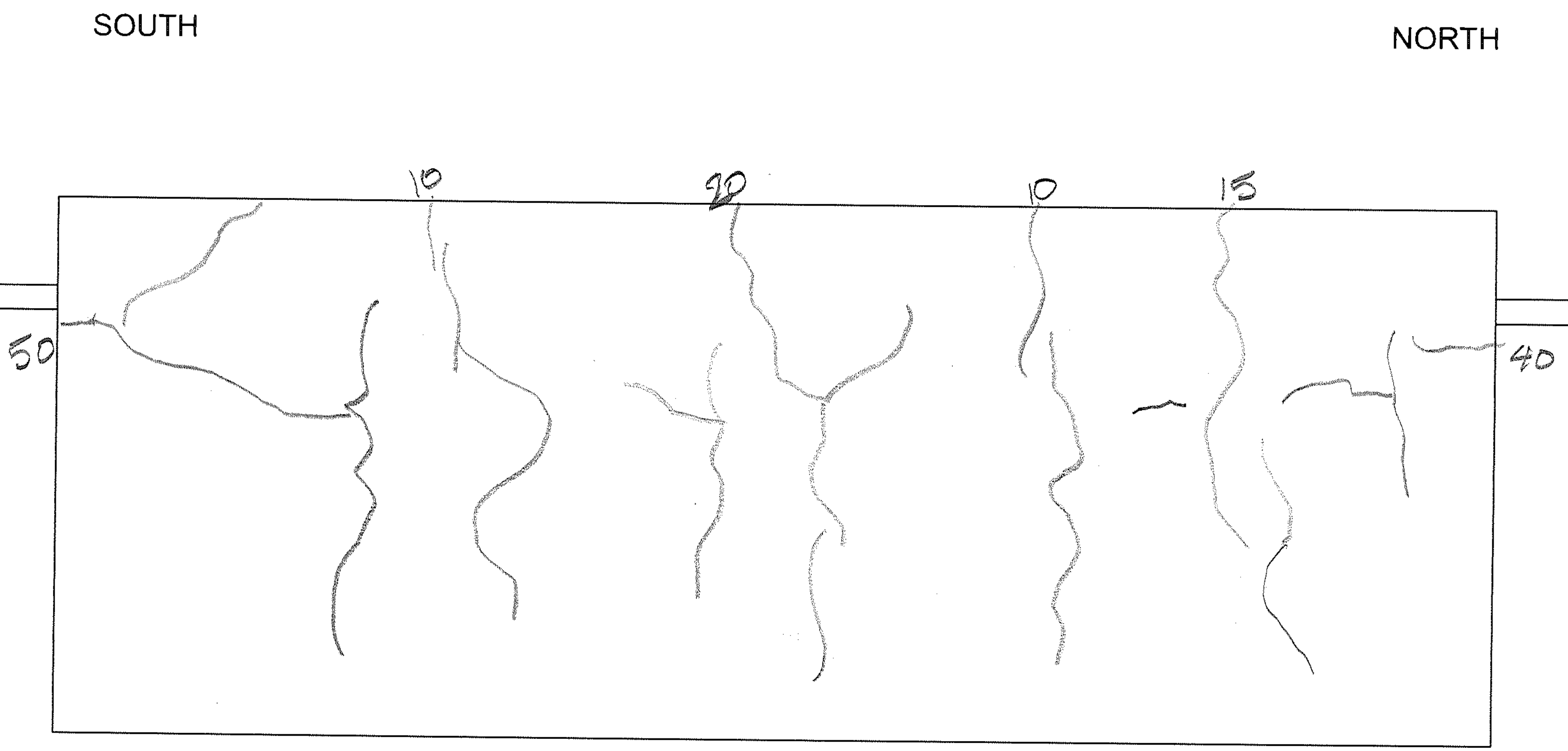


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1 of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by: KCS	Checked by:	SP
			Date:	11/16/2016	

D14 06/20/17

R110 K



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D15

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 6/22/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skiller	K Skiller	6/22/17
WILL POLLAZZI		6/22/17
Prateek Shah	P Shah	6/22/17
JONATHAN MONICAL		07/03/17

Recorded by: KCS

Checked by:

Checked by:

Test: D15

Date: 6/22/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0^K	3:49	0	0	0	0	0	0	—
20^K	3:57	20	20.9	0	0	0	0	—
40^K	4:01	40.6	40.7	0	0.001	0	0	—
60^K	4:03	59.9	59.9	0.003	0.008	0.001	0.001	0.008
80^K	4:07	79.7	80	0.011	0.017	0.005	0.012	0.017
100^K	4:12	98.6	99.5	0.020	0.026	0.010	0.023	0.026
110^K	4:18	107	108	0.035	0.042	0.015	0.035	0.042
112^K	4:24	110	110	0.047	0.055	0.021	0.050	0.055
113	4:26	112	112		0.060			
0^K	4:28	0^k	0	0.035	0.036	0.018	0.044	0.044

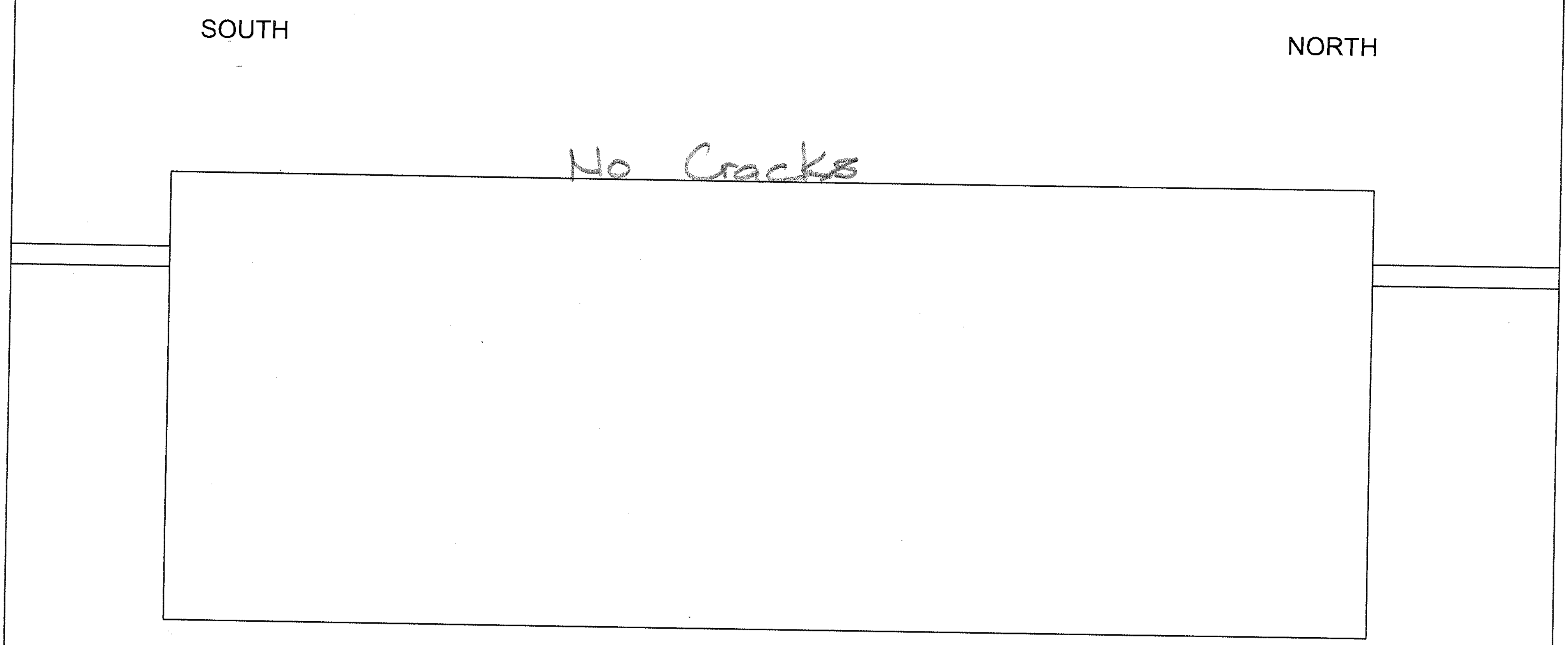
Notes:

Recorded by: Kinsey Skiller

Signature: K.C. Skiller

D15 06/22/17

20 K

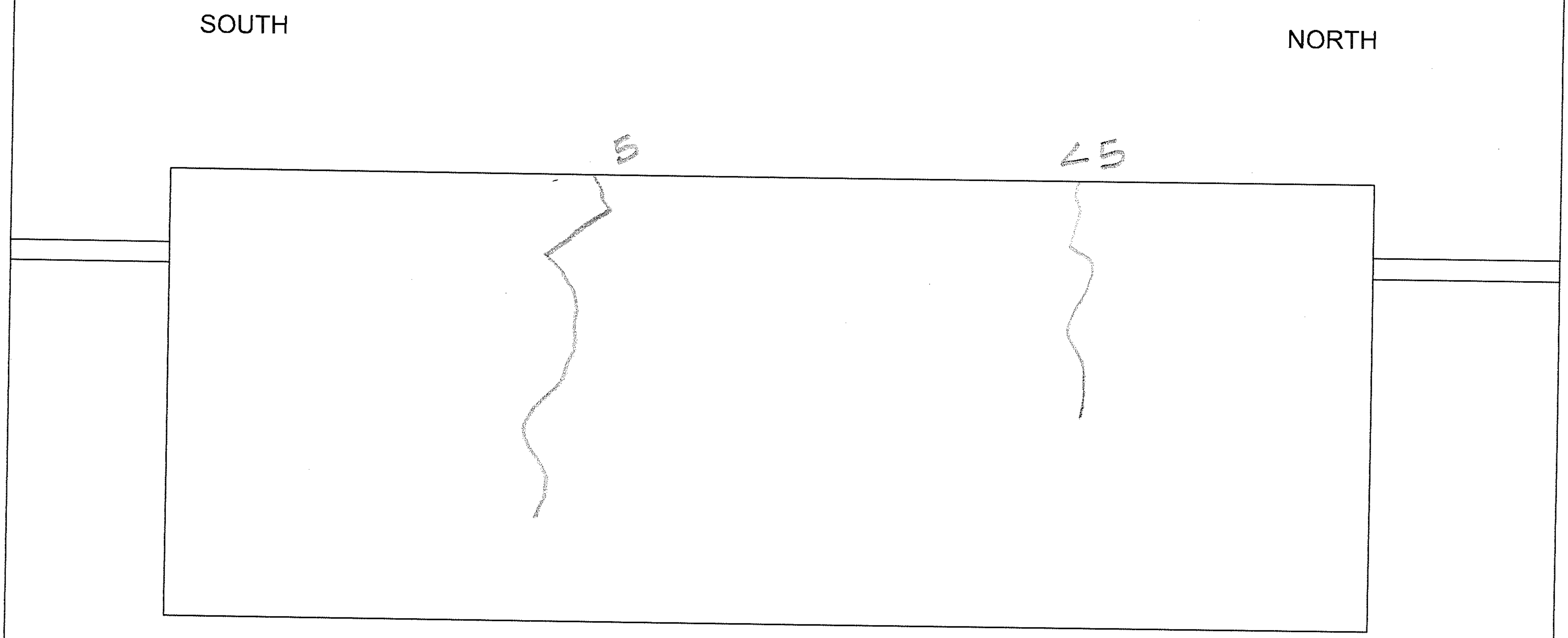


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D15 06/22/17

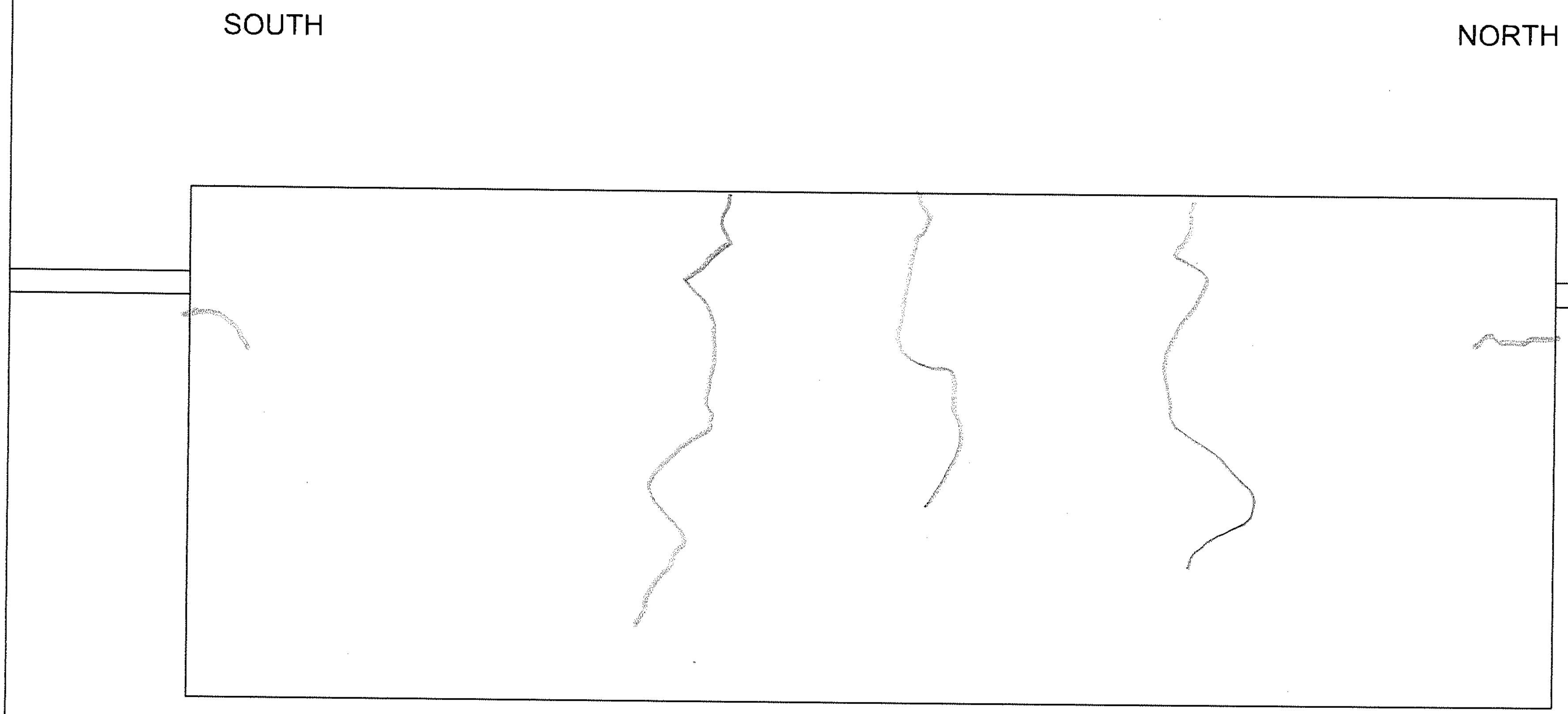
40 K



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

D15 06/22/17
60 K

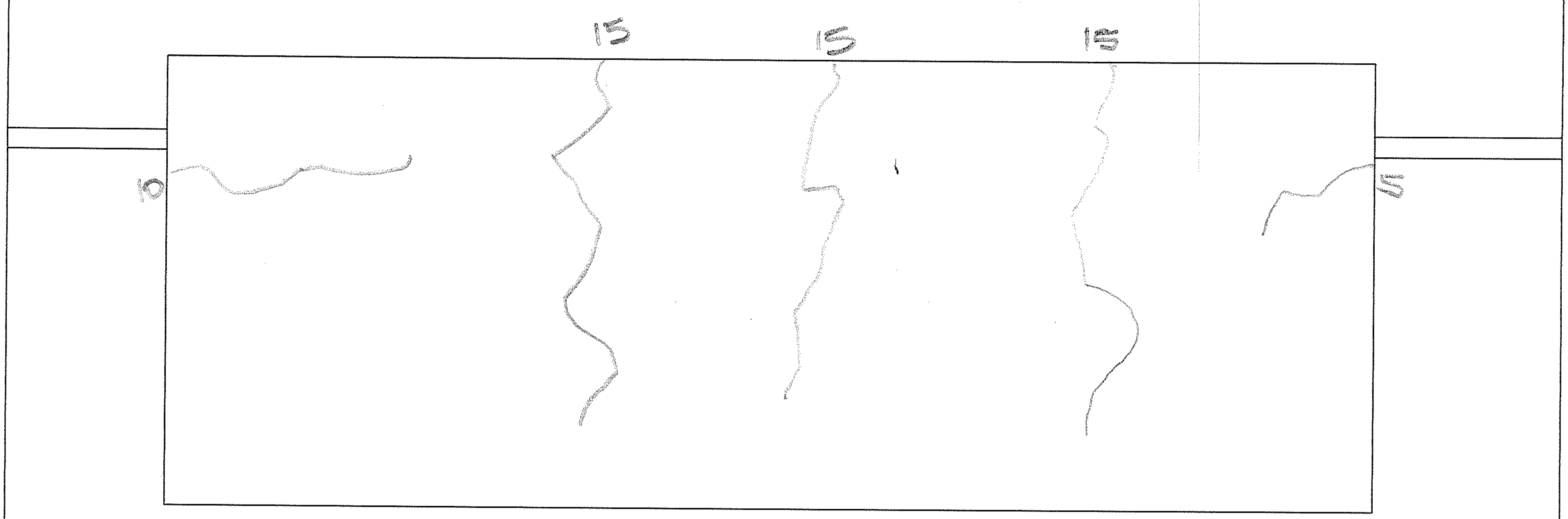


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D15 06/22/17

80 K

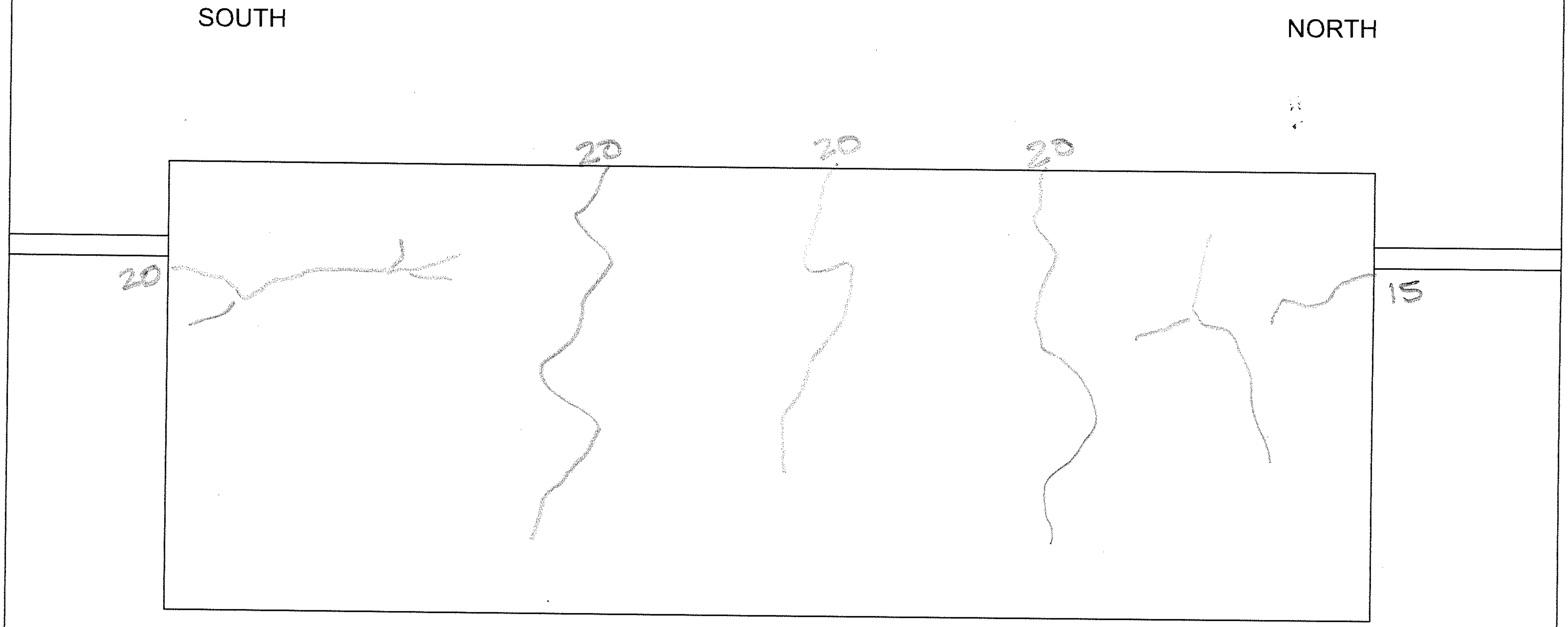


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D15 06/22/17

100K



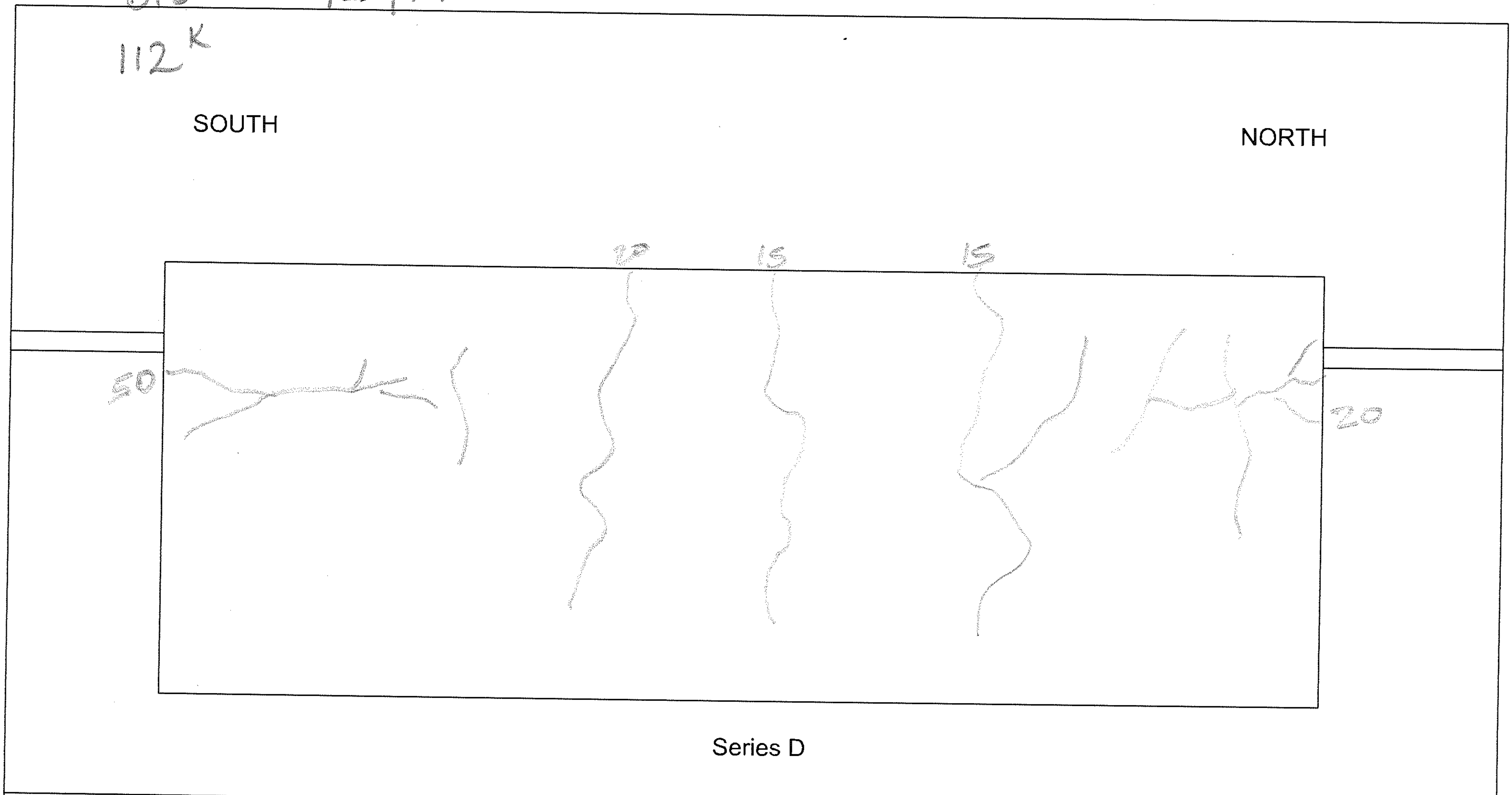
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D15 6/22/17

112^K



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	

Test: D15 w/ Anchor

Date: 6/23/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0^K	5:50	0^K	0^K	0.028	0.033	0.017	0.042	0.042
20^K	5:55	19.2	19.7	0.028	0.033	0.017	0.042	0.042
40^K	5:59	39.8	39.8	0.028	0.033	0.017	0.042	0.842
60^K	6:03	60.1	59.9	0.031	0.041	0.017	0.042	0.042
80^K	6:08	79.8	79.8	0.037	0.048	0.019	0.045	0.048
100^K	6:12	99.9	99.8	0.043	0.056	0.021	0.052	0.056
110^K	6:18	109.4	109.3	0.047	0.060	0.023	0.056	0.060
120^K	6:26	118.5	117	0.069	0.090	0.038	0.090	0.090
123^K	6:33	122	121	0.096	0.125	0.083	0.193	0.193

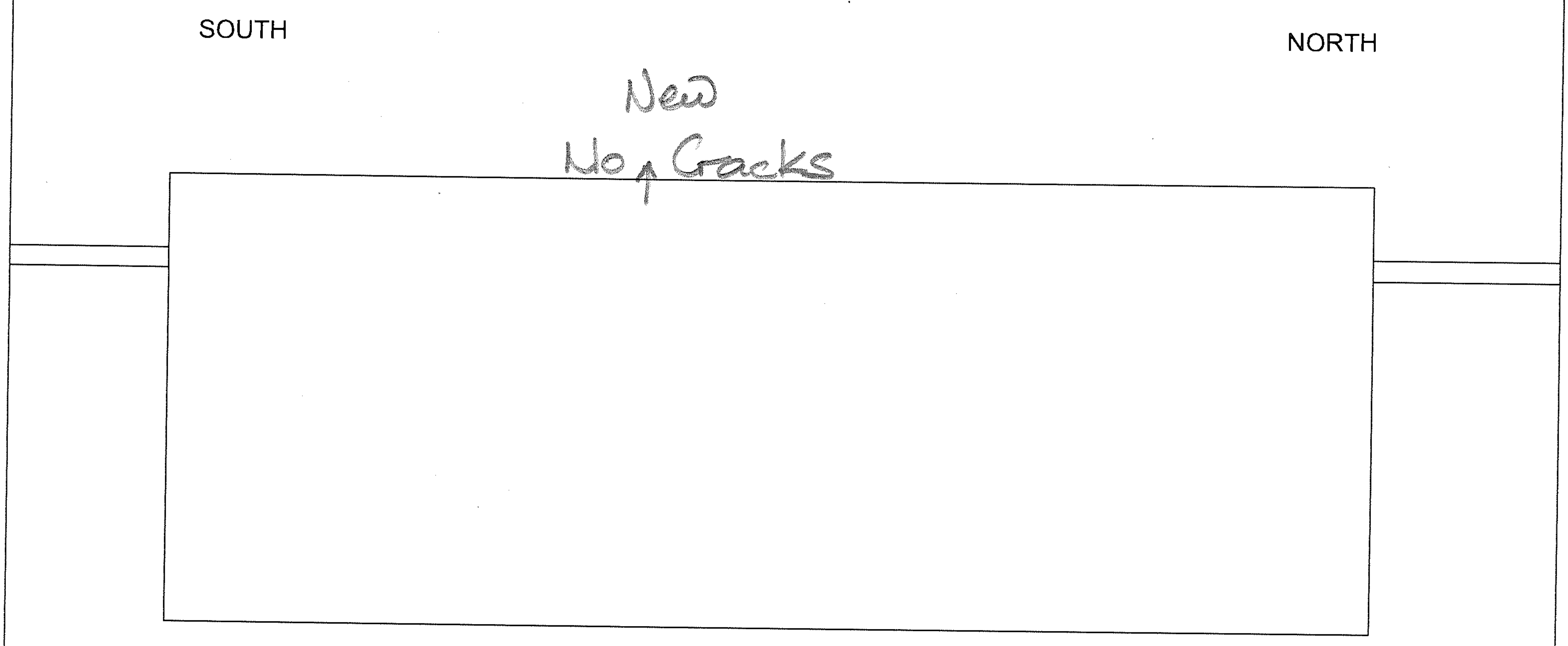
Notes:

Recorded by: Kinsey Skillen

Signature: K.C. Skillen

D15 06/23/17

R20 K



No New Cracks

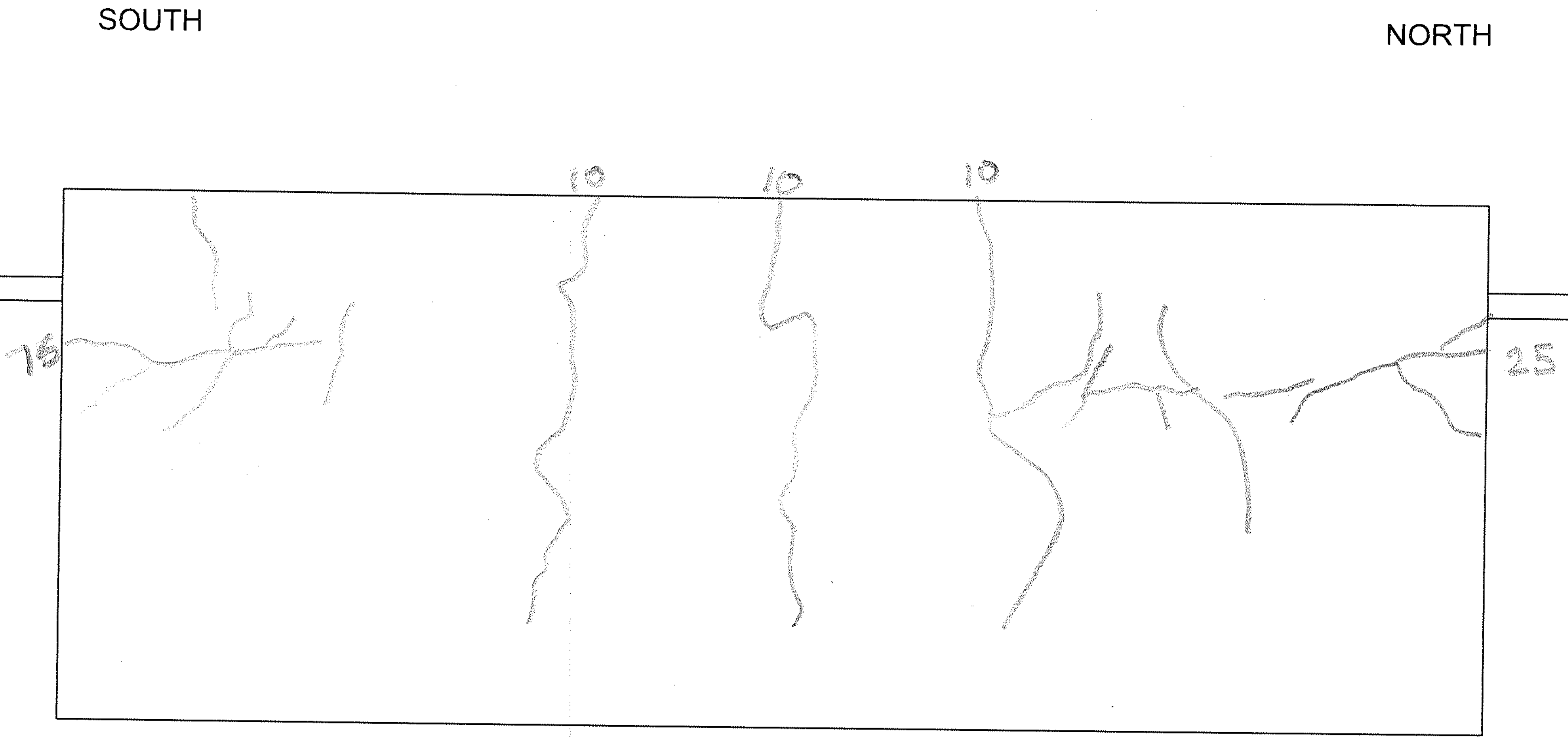
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D15 06/23/17

R40 K

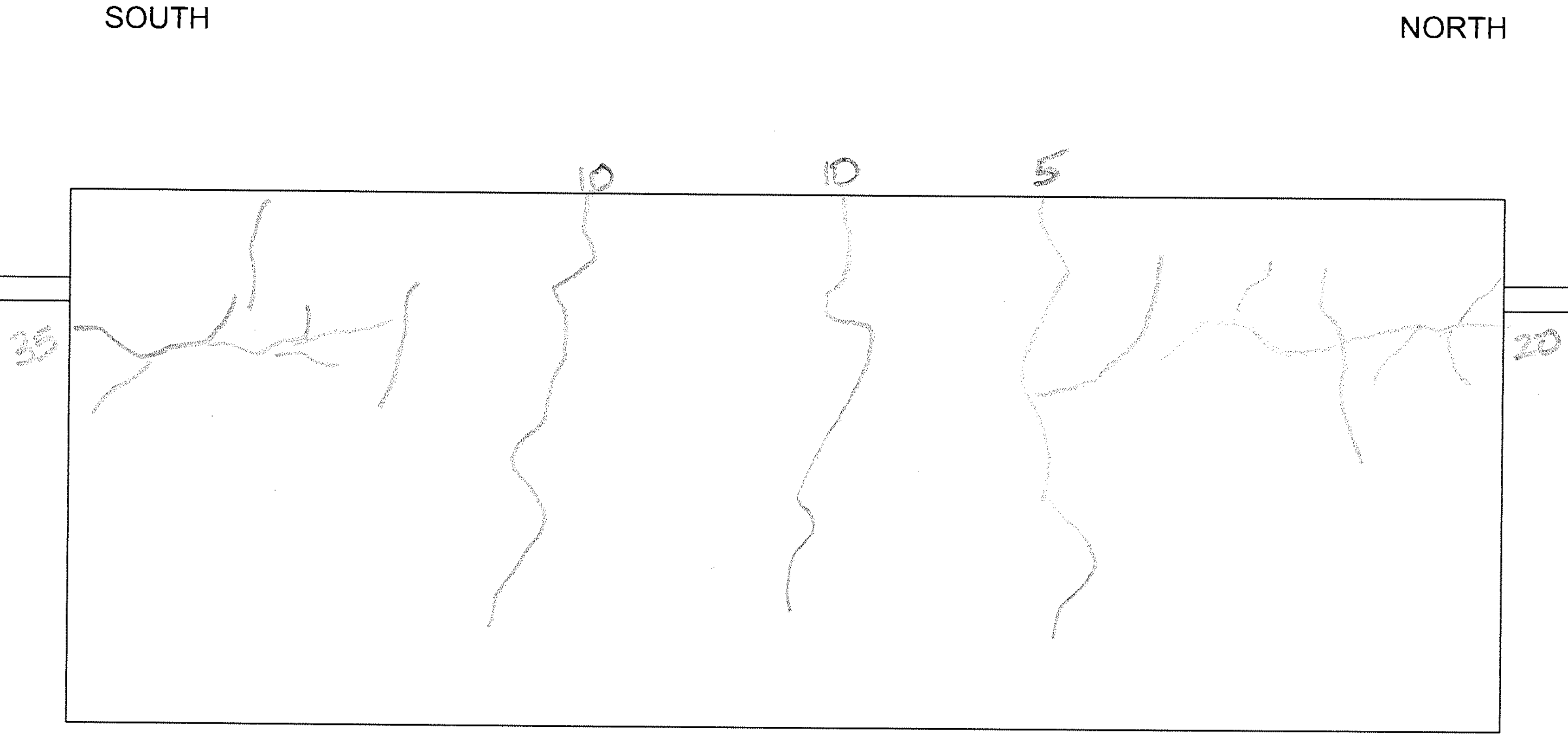


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D15 06/23/17

R60K



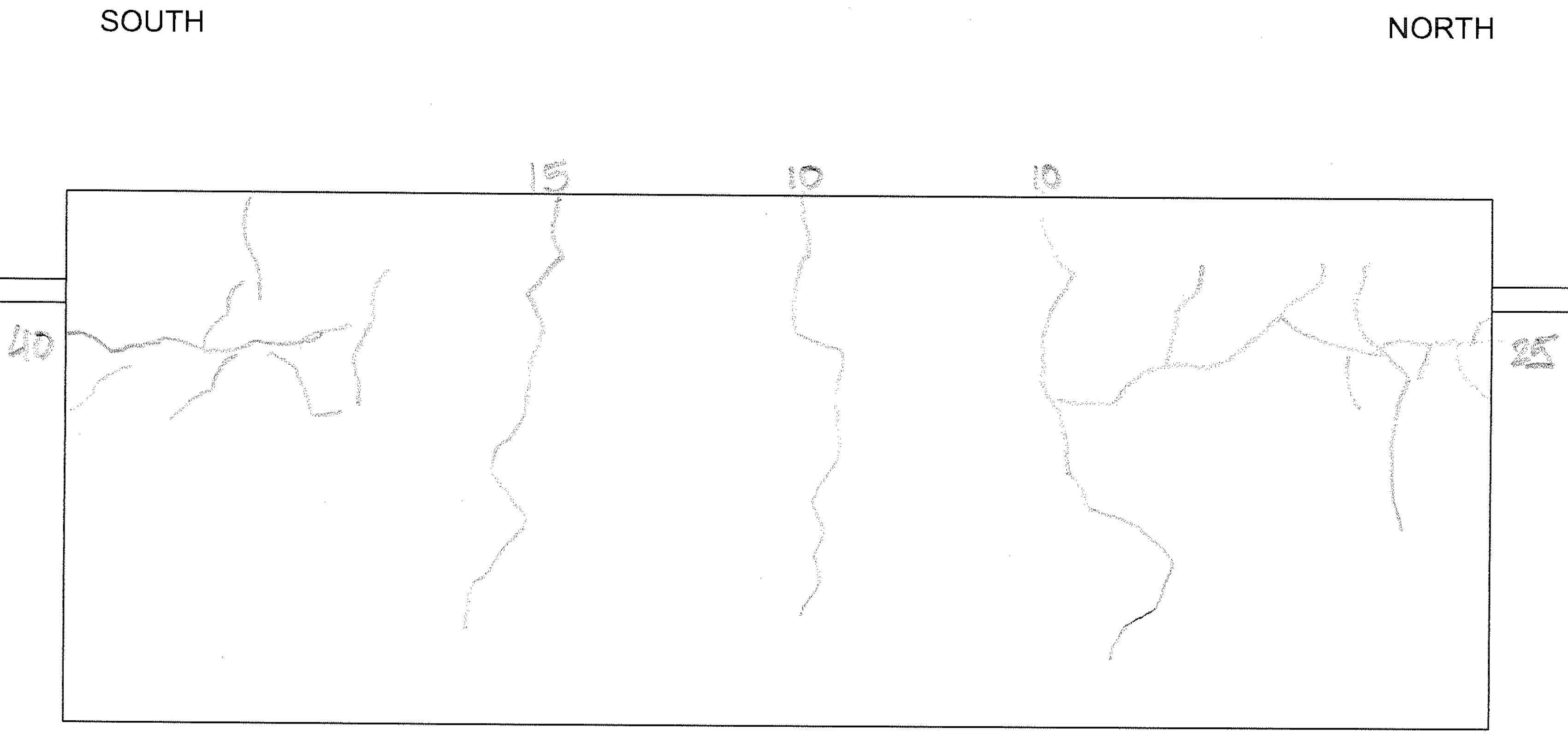
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D15

06/23/17

R80K



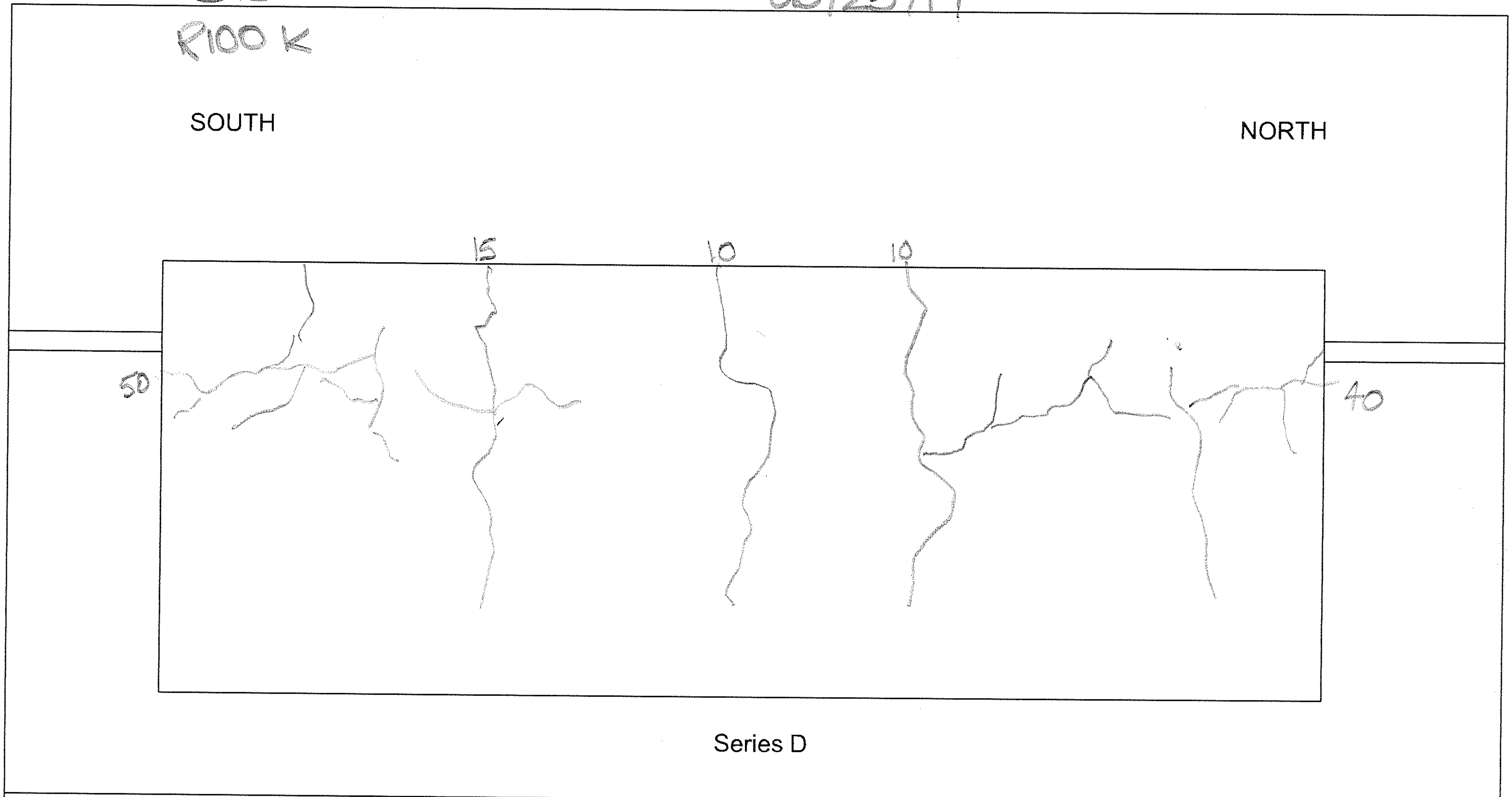
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D15

R100 K

06/23/17



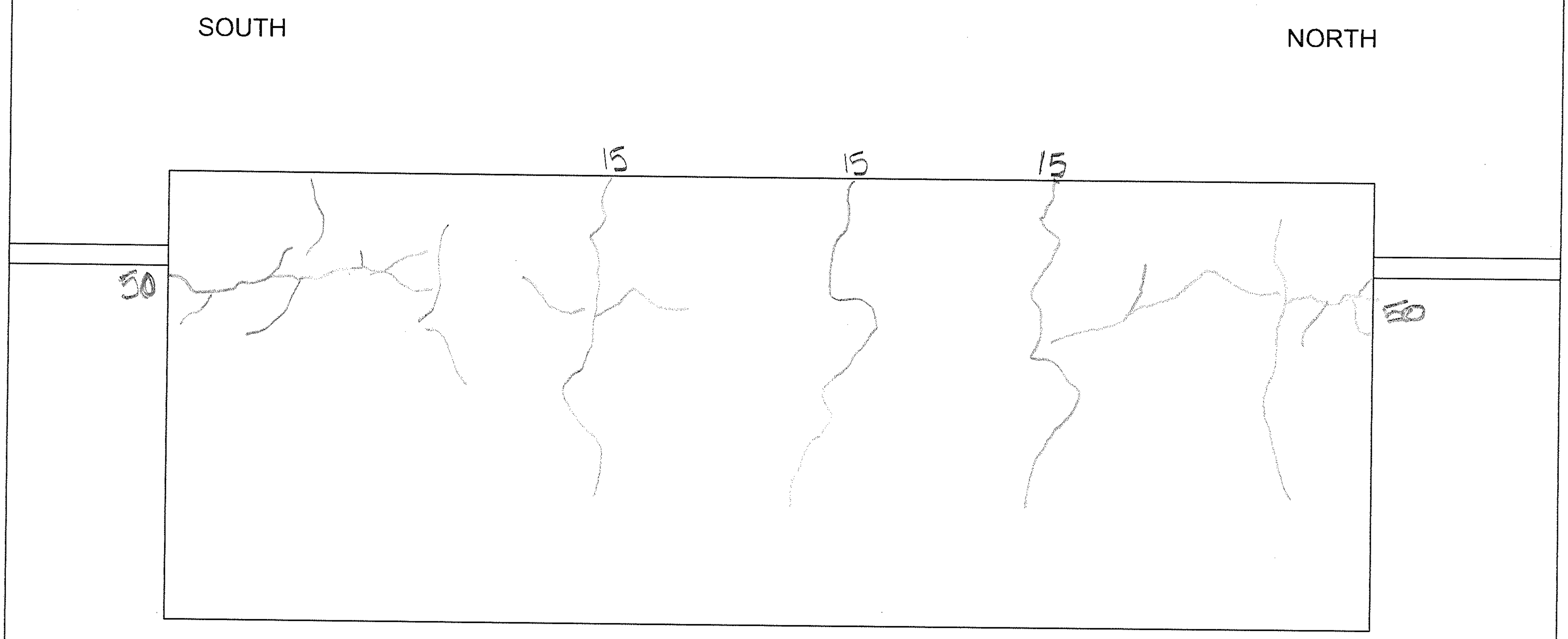
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D15

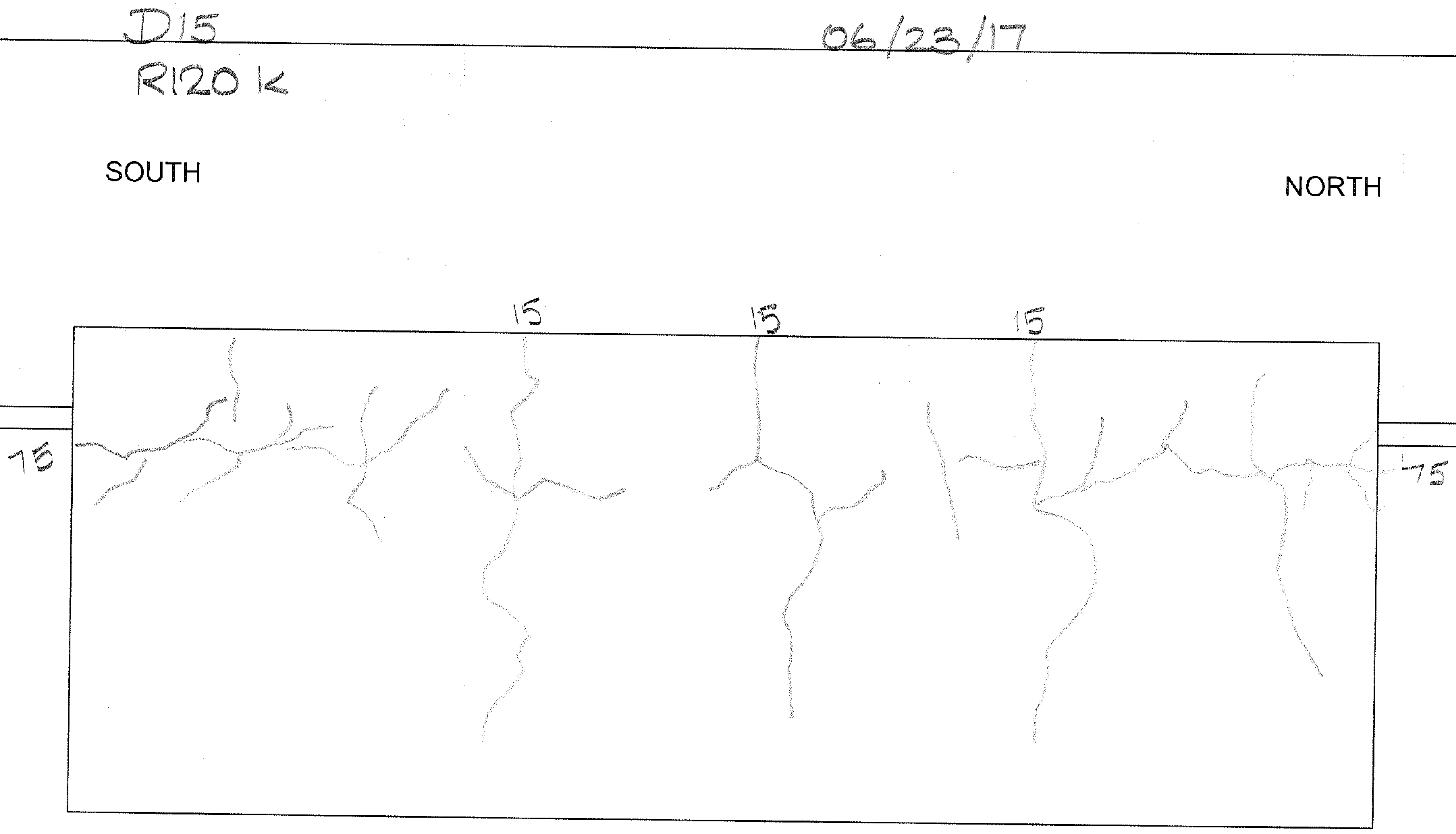
06/23/17

R110 K



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/16/2016	



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D16

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 6/29/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skiller	K C Skiller	6/29/17
WILL POLLALIS		6/29/17
Prateek Shah		6/29/17
JONATHAN MONICAL		07/03/17

Recorded by: KCS

Checked by:

Checked by:

Test: D16

Date: 6/29/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0^K	3:39	0	0	0	0	0	0	—
20^K	3:42	19.9	20.3	0	0	0	0	0
40^K	3:45	39.9	39.8	0	0	0	0	0
60^K	3:49	60.2	60.3	0.003	0.006	0	0.001	0.006
80^K	3:52	80.1	80.5	0.009	0.012	0.002	0.006	0.012
100^K	3:56	99.5	99.7	0.018	0.019	0.006	0.016	0.019
110^K	4:04	107.7	108.2	0.032	0.029	0.013	0.032	0.032

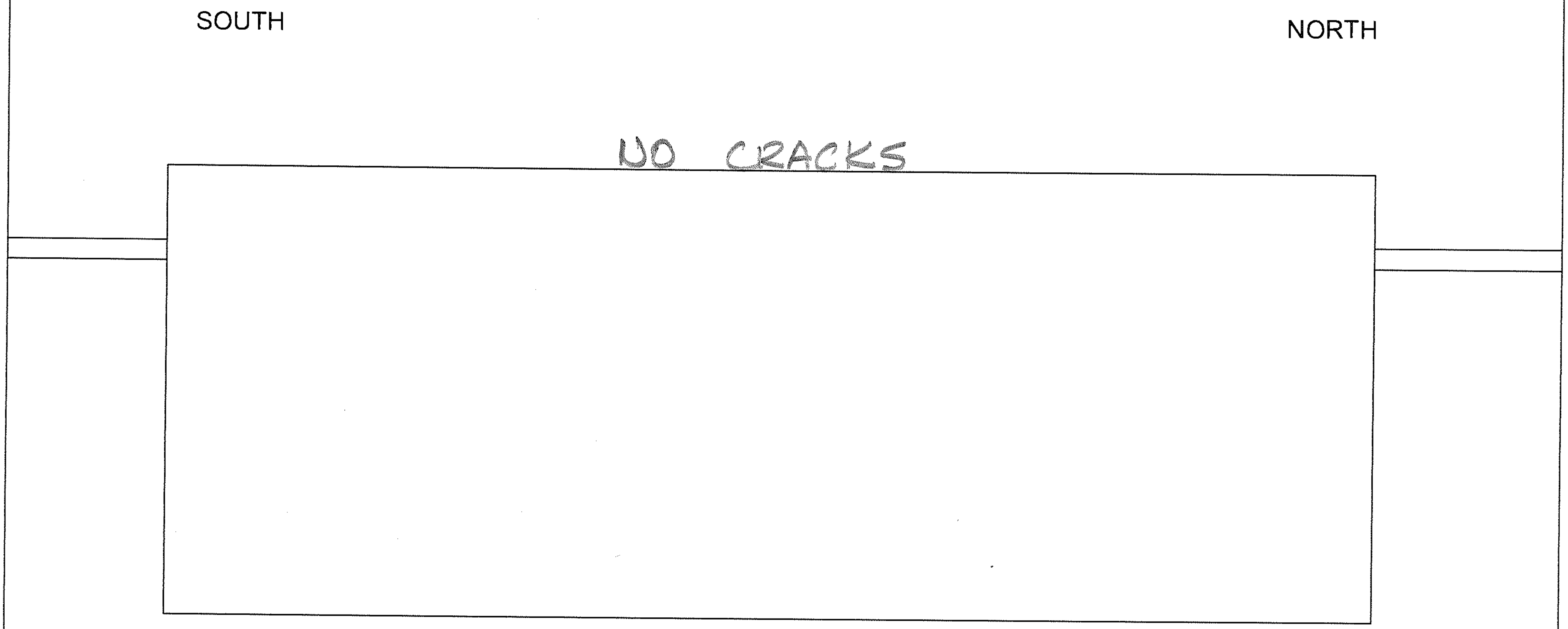
Notes:

Recorded by: Kinsey Skillen

Signature:

D16 06/29/17

20 K

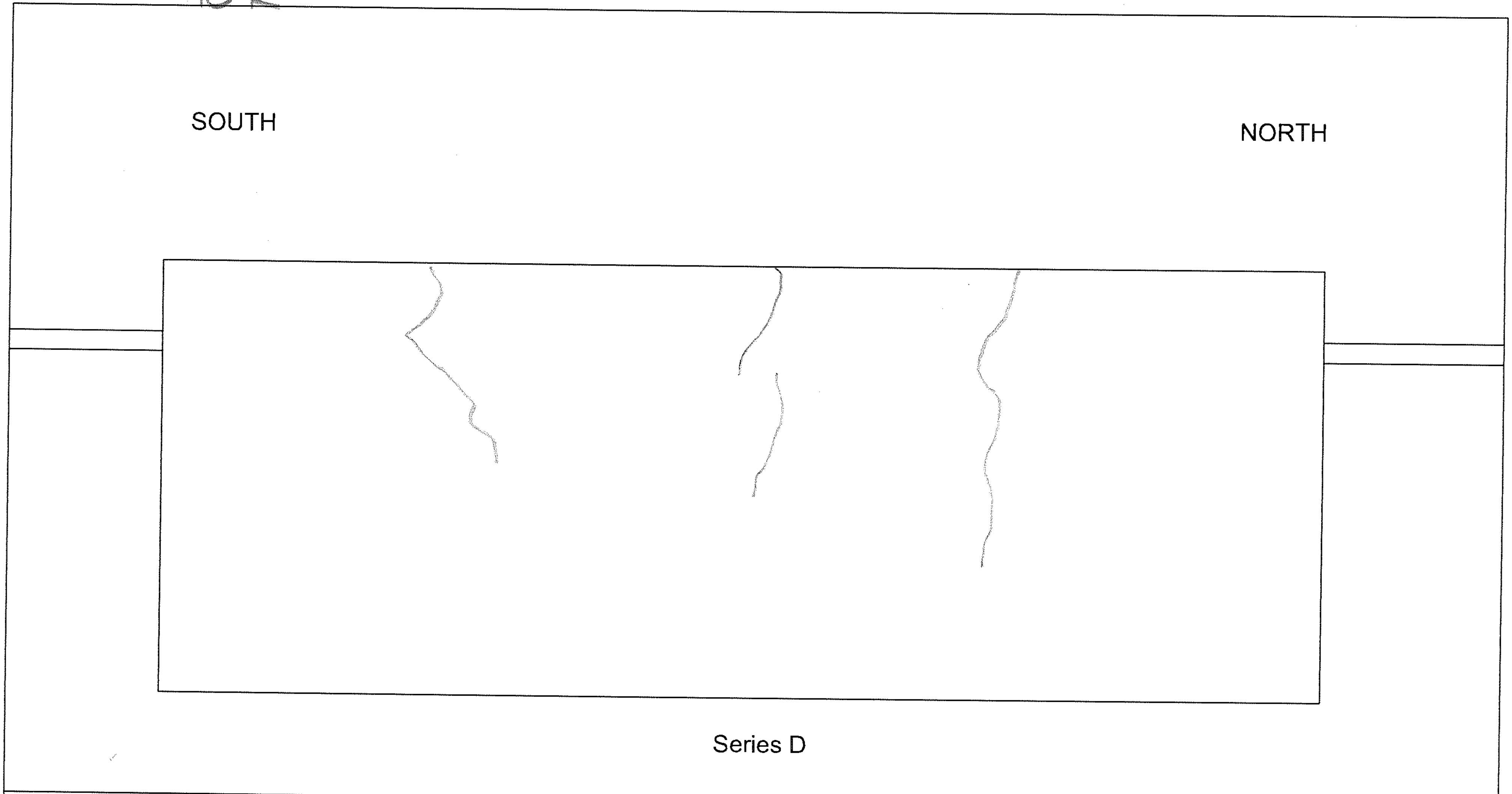


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D16 06/29/17

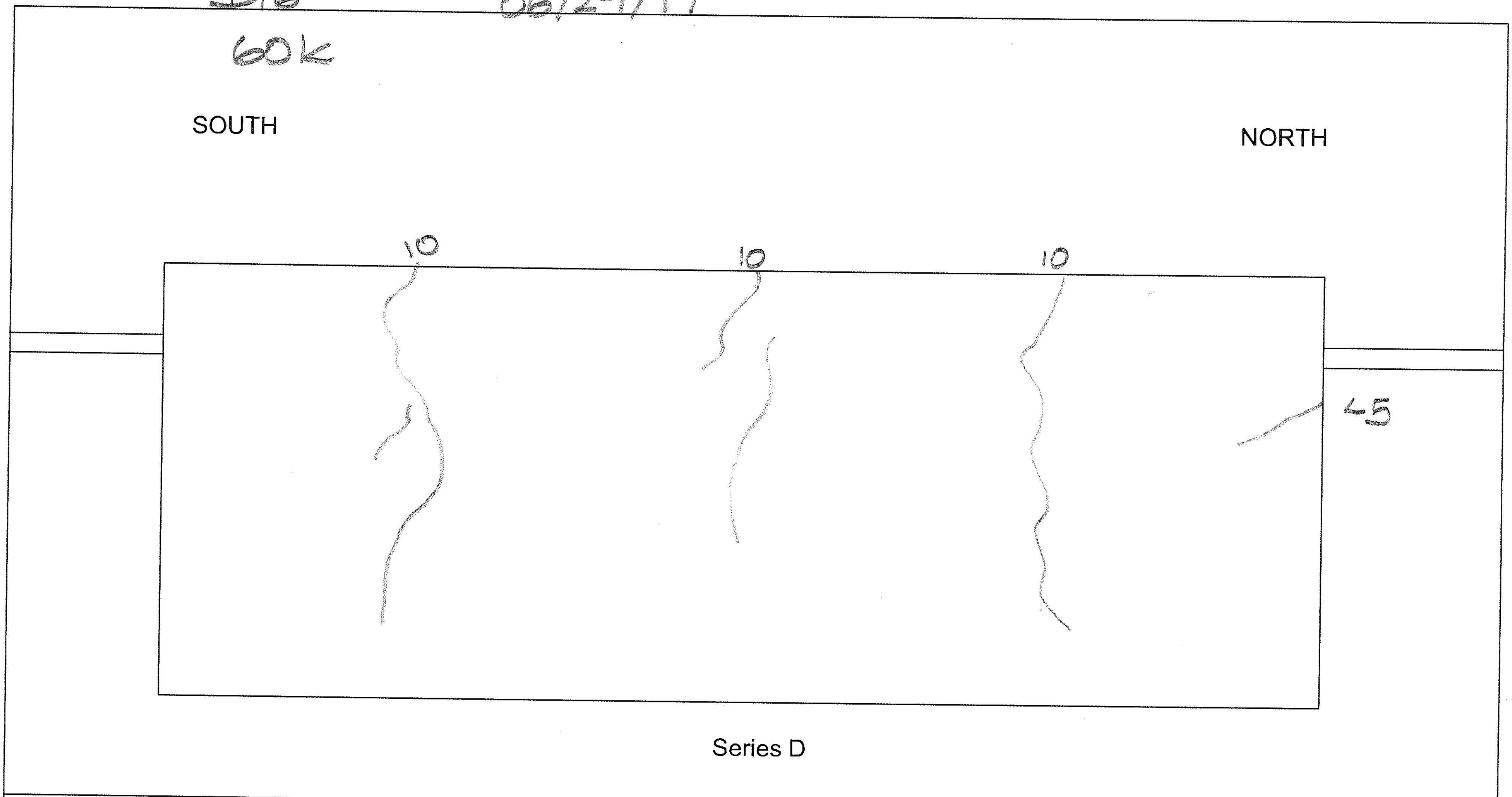
40 K



BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D16 06/29/17
60k



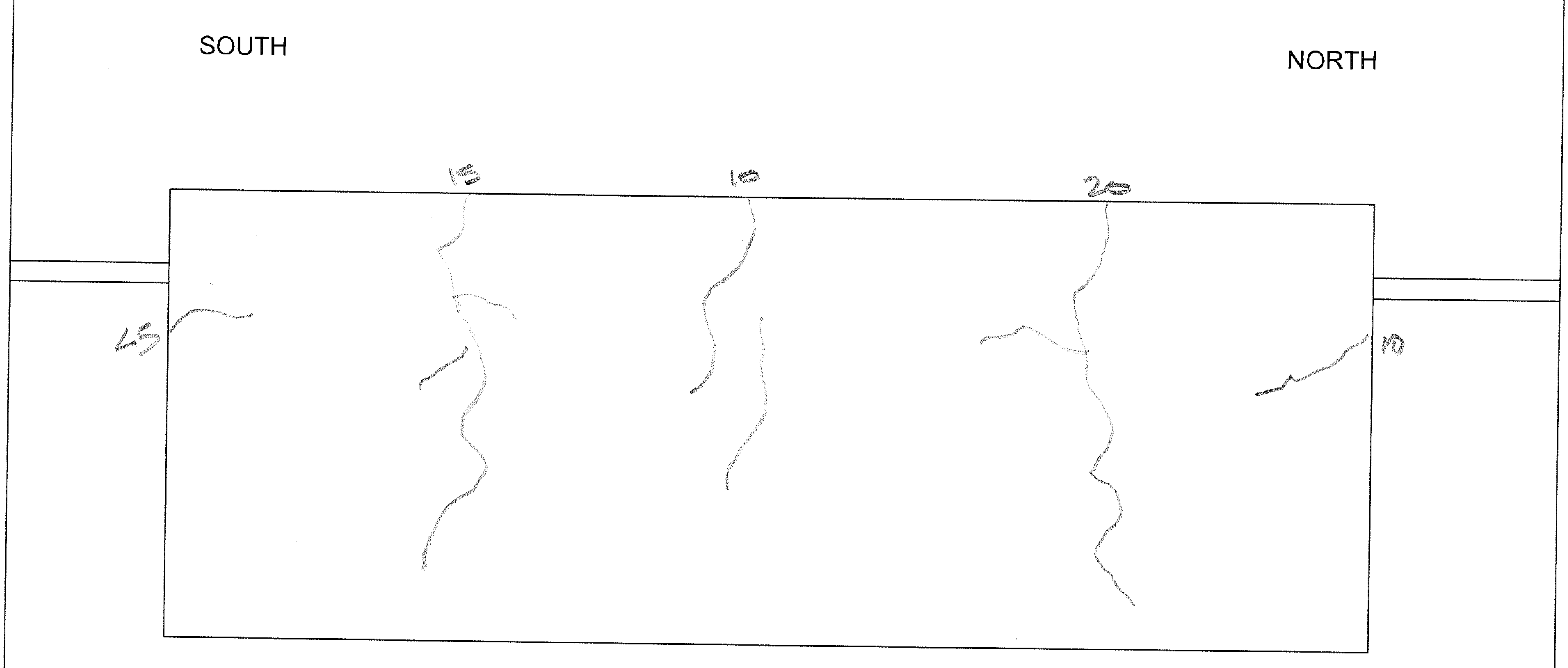
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D16 06/29/17

80k



Series D

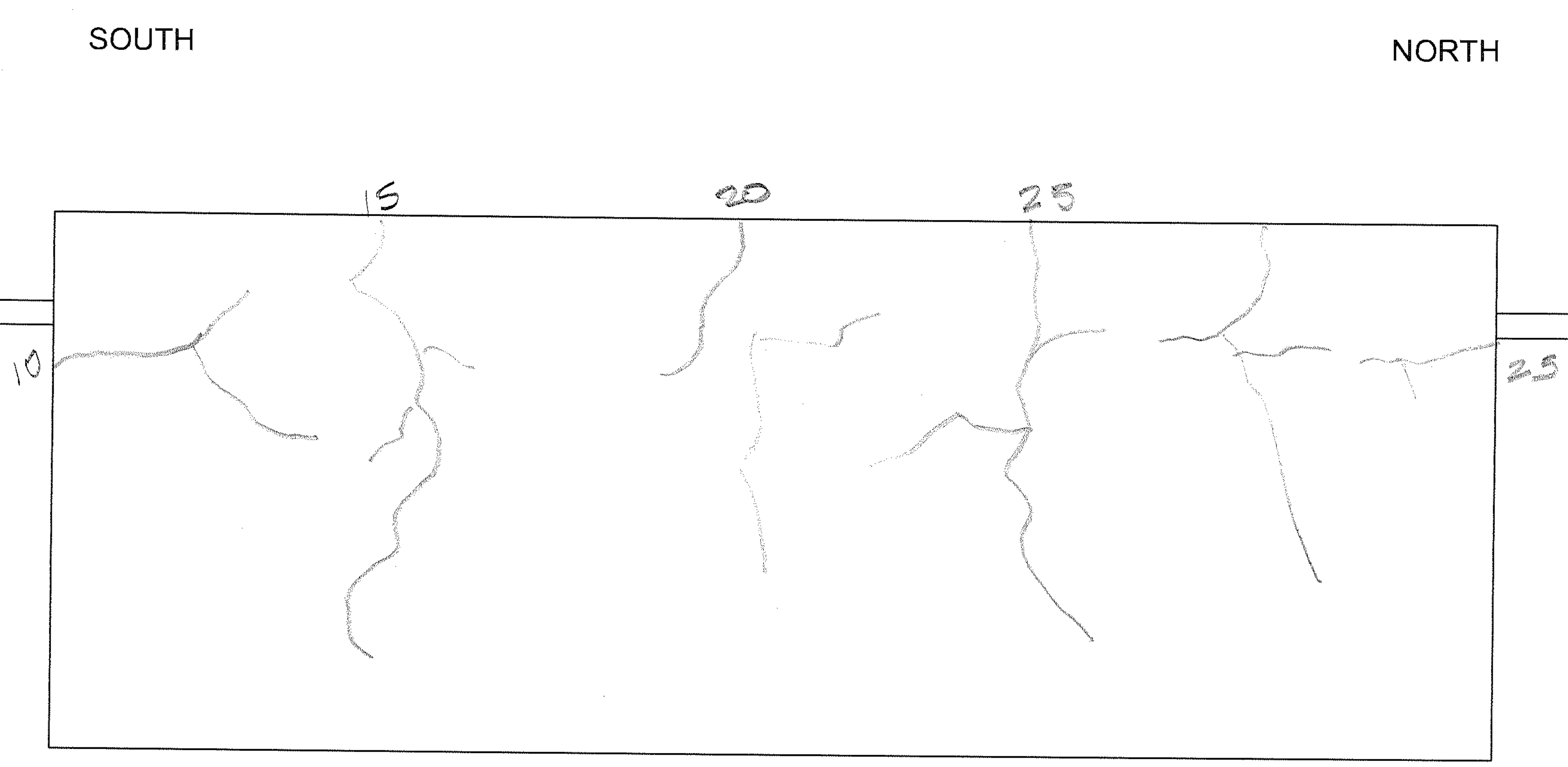
BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D16

100 k

06/29/17



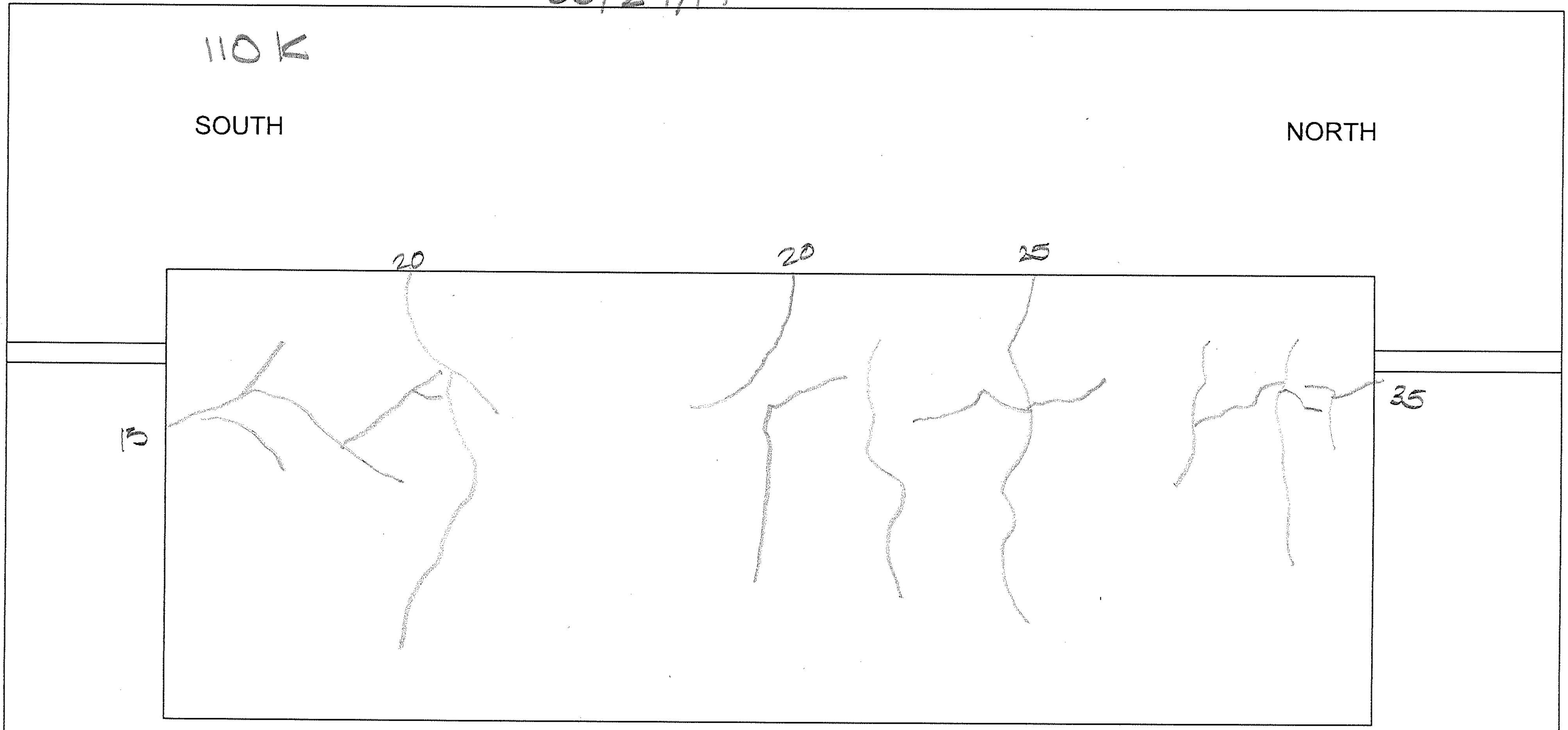
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D16

06/29/17

110K



Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

Test: D16 w/ Anchors

Date: 6/30/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0K	4:22	0	0	0.054	0.056	0.011	0.030	0.056
20K	4:26	20.1	20.5	0.054	0.056	0.011	0.030	0.056
40K	4:30	40.5	40.8	0.056	0.058	0.011	0.031	0.058
60K	4:34	60.5	60.7	0.063	0.064	0.013	0.035	0.064
80K	4:41	80	80.5	0.070	0.073	0.015	0.041	0.073
100K	4:44	100.5	100.3	0.081	0.083	0.018	0.048	0.083
110K	4:48	110.6	110.2	0.091	0.090	0.020	0.054	0.091
120K	4:53	117.8	117	0.149	0.138	0.036	0.102	0.149

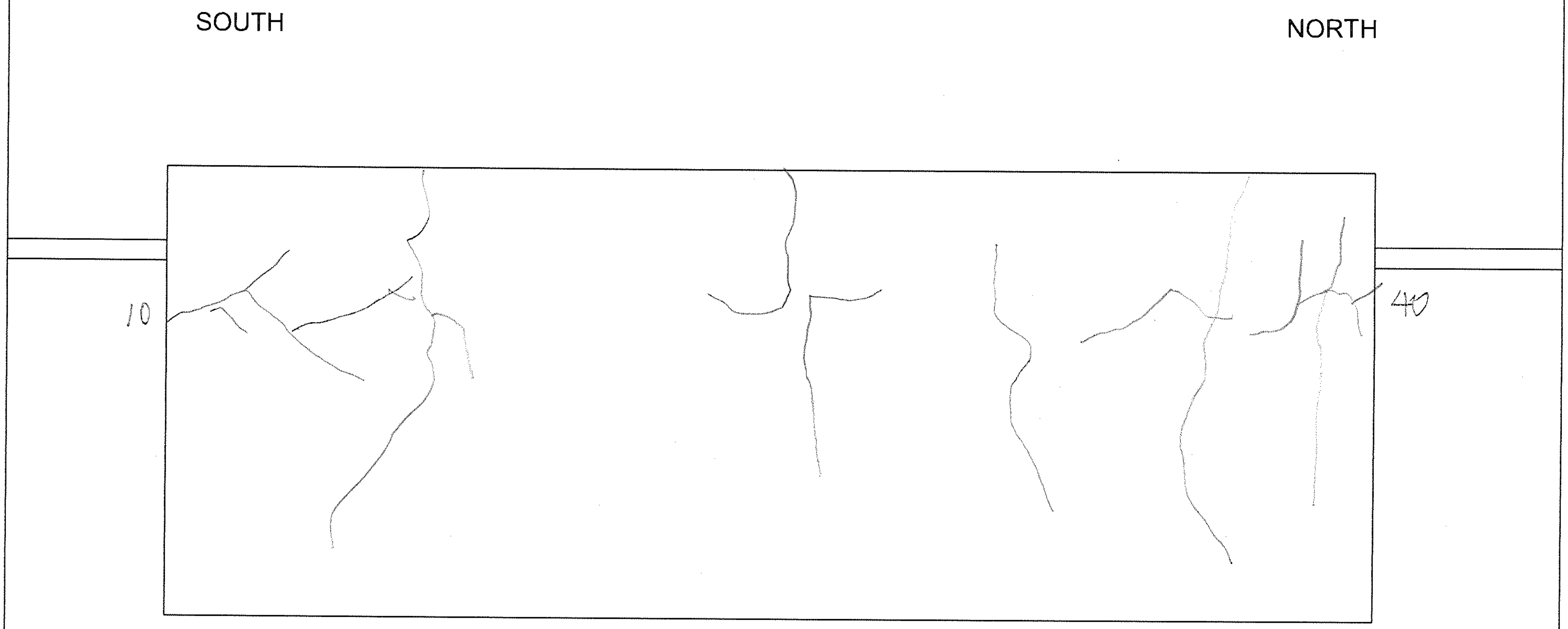
Notes:

Recorded by: Kinsey Skiller

Signature: KC Skiller

D16 06/30/17

R20 K

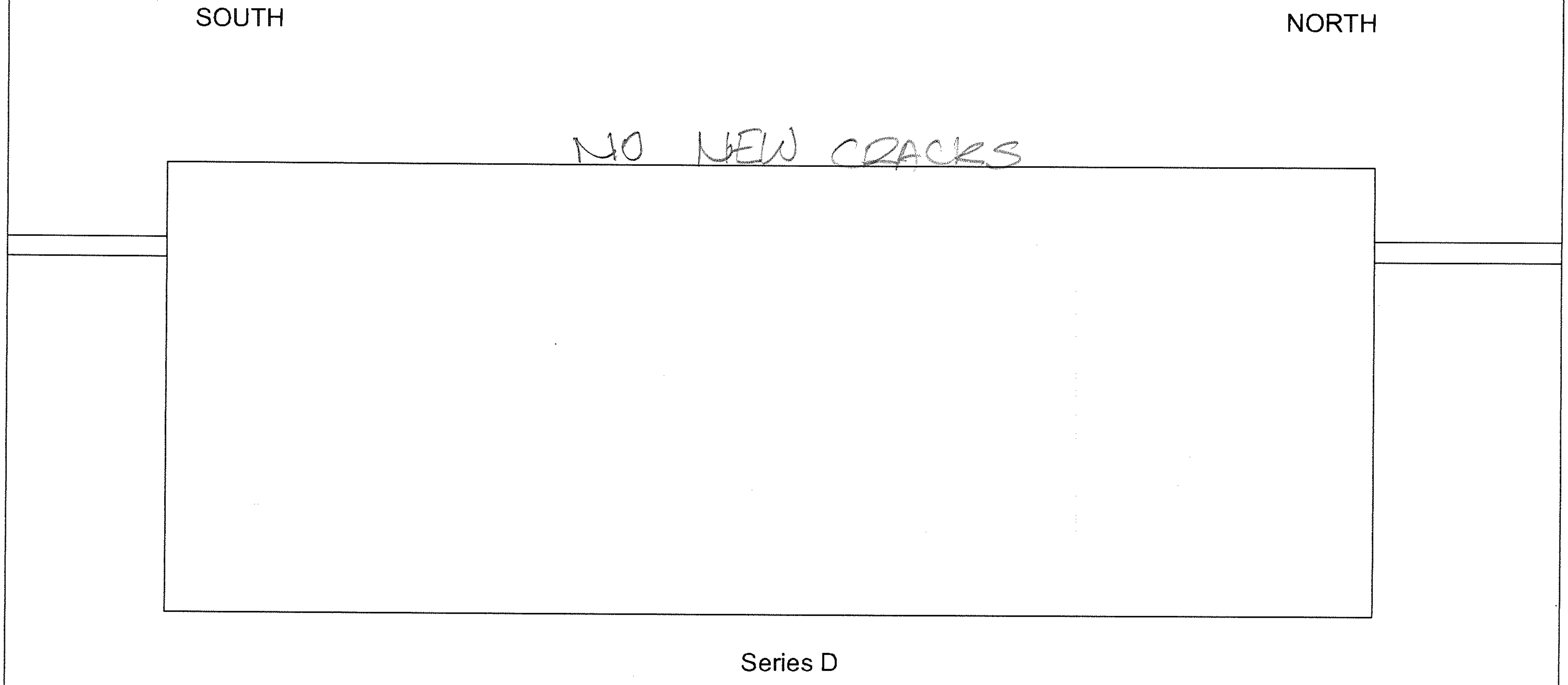


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D16 06/29/17

R40 K



NO NEW CRACKS

Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

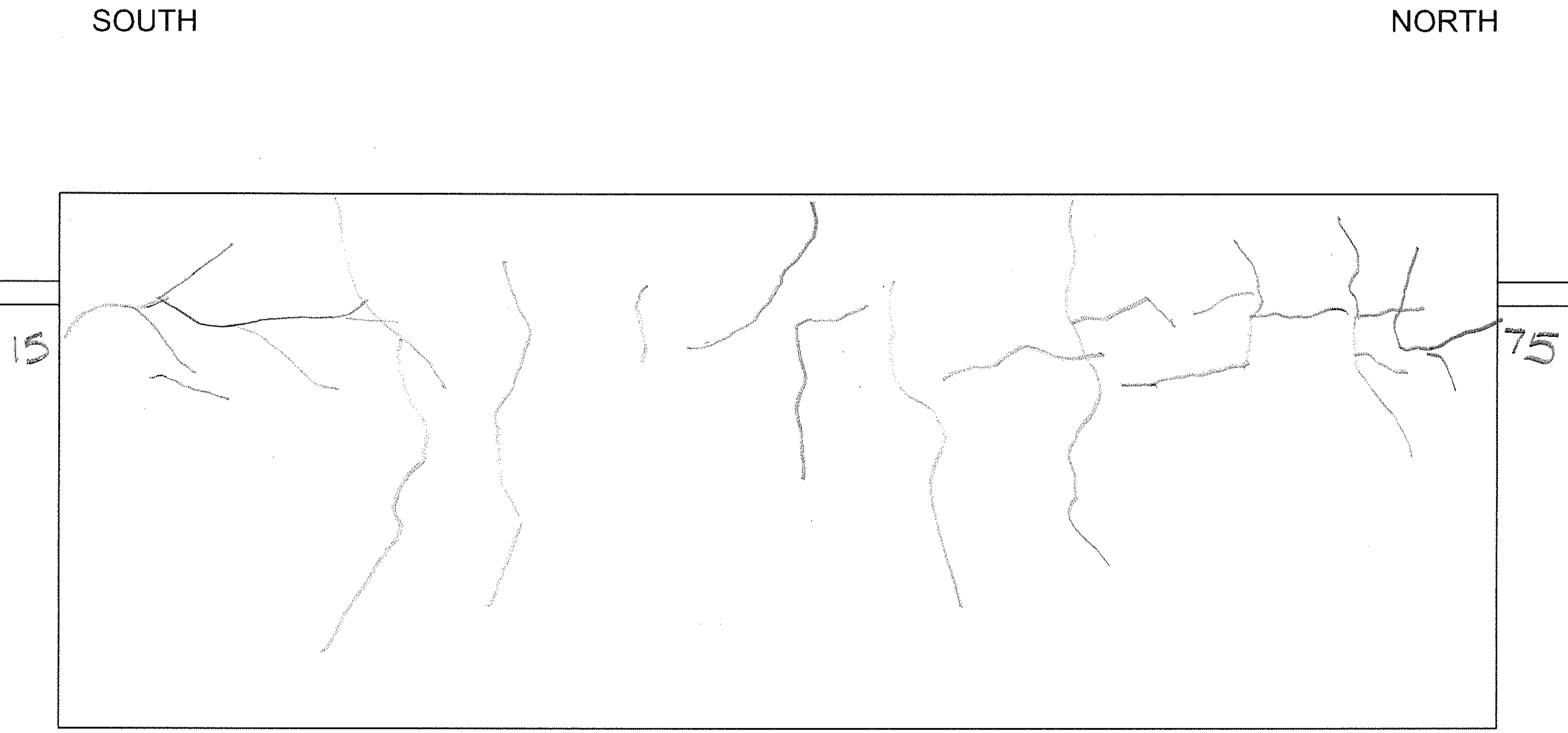
D16 06/29/17

R60 K

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D16 06/30/17

R80K

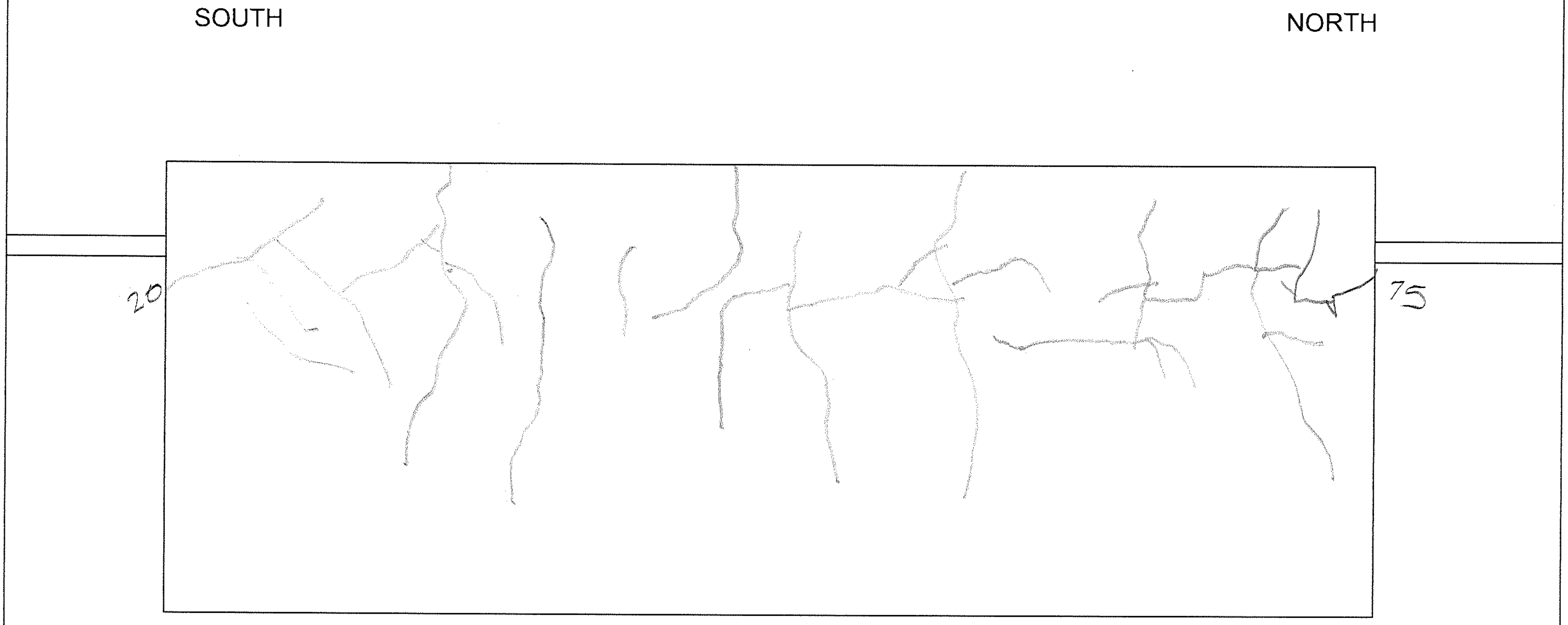


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D16 06/30/17

R100 K

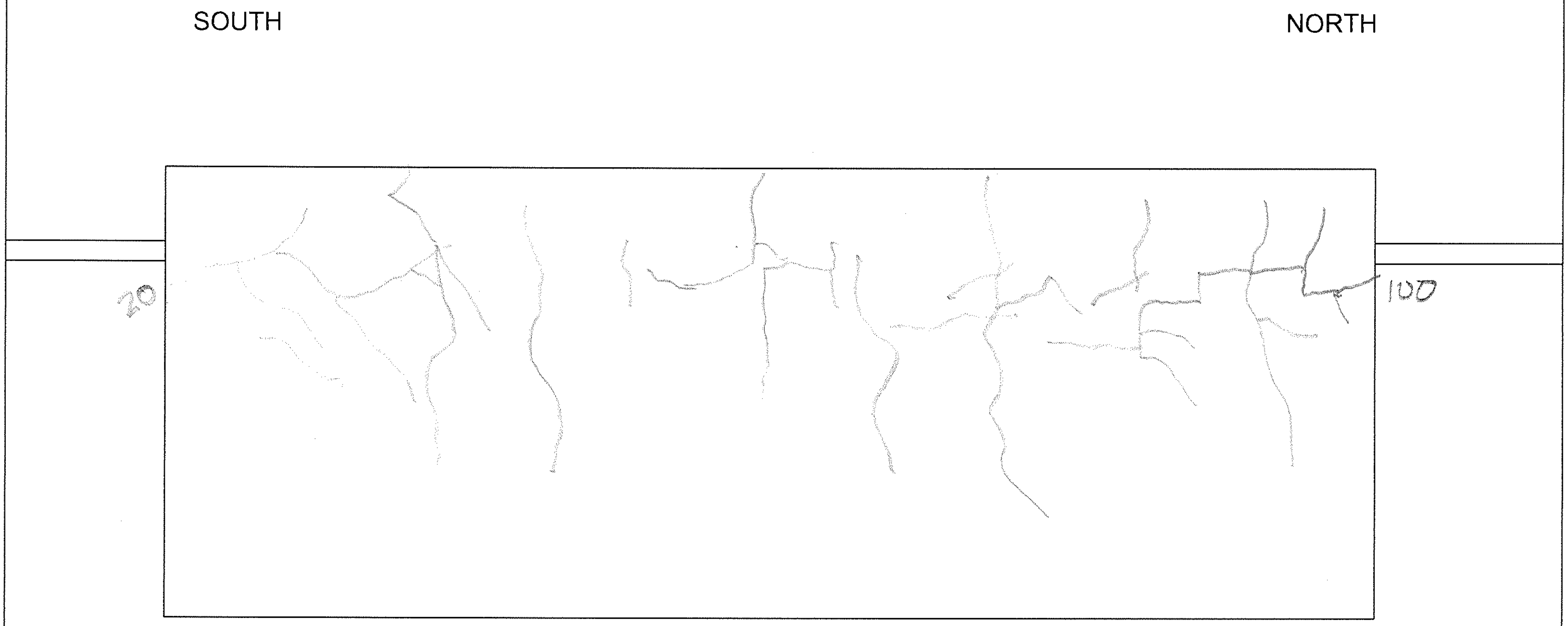


Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D16 06/30/17

R110K



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D17

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 7/5/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skillen	KCSkillen	7/5/17
Aishwarya Puranam	Aishwarya	07/05/17
Lucas Laughery	Lucas Laughery	5/July/2017

Recorded by: KCS

Checked by:

Checked by:

Test: D17

Date: 7/5/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0^{K}	2:29	0	0	0	0	0	0	—
20^{K}	2:32	20.4	20.4	0	0	0	0	0
40^{K}	2:35	40.8	40.1	0,002	0	0	0	0.002
60^{K}	2:38	59,9	60,1	0,005	0,002	0	0	0,005
80^{K}	2:42	80.2	80.5	0,012	0.008	0,001	0,001	0,012
100^{K}	2:47	99.6	99.4	0.023	0.016	0.004	0,006	0,023
110^{K}	2:55	108	108	0,029	0,026	0.010	0,016	0,029

Notes:

Recorded by: Kinsey Skiller

Signature: KC Skiller

D17

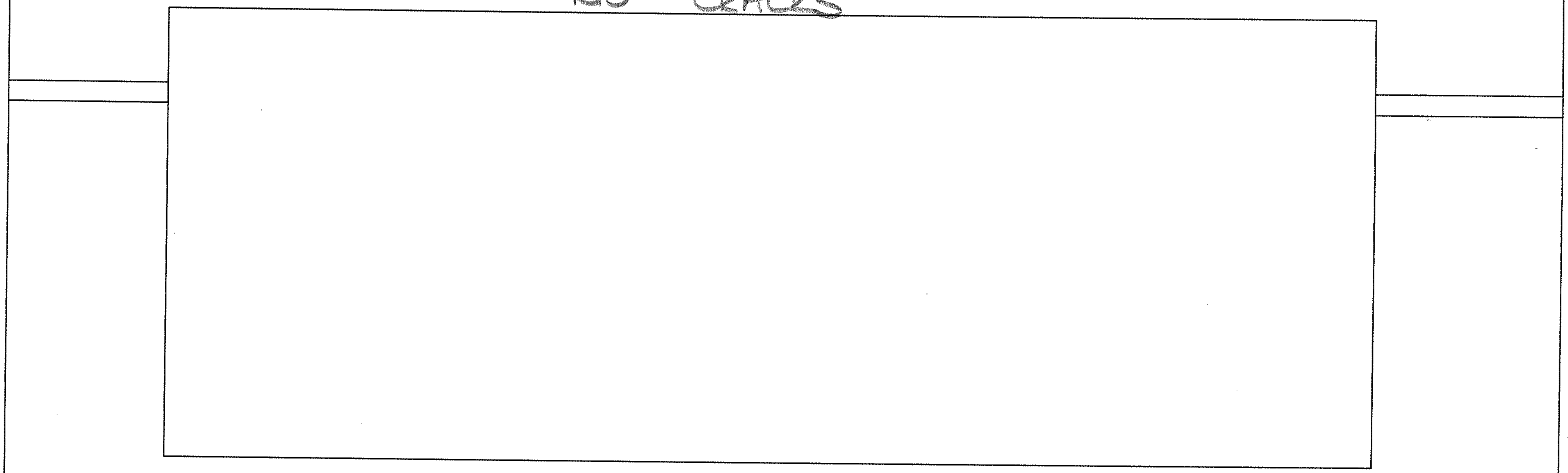
07/05/17

20K

SOUTH

NORTH

NO CRACKS



Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

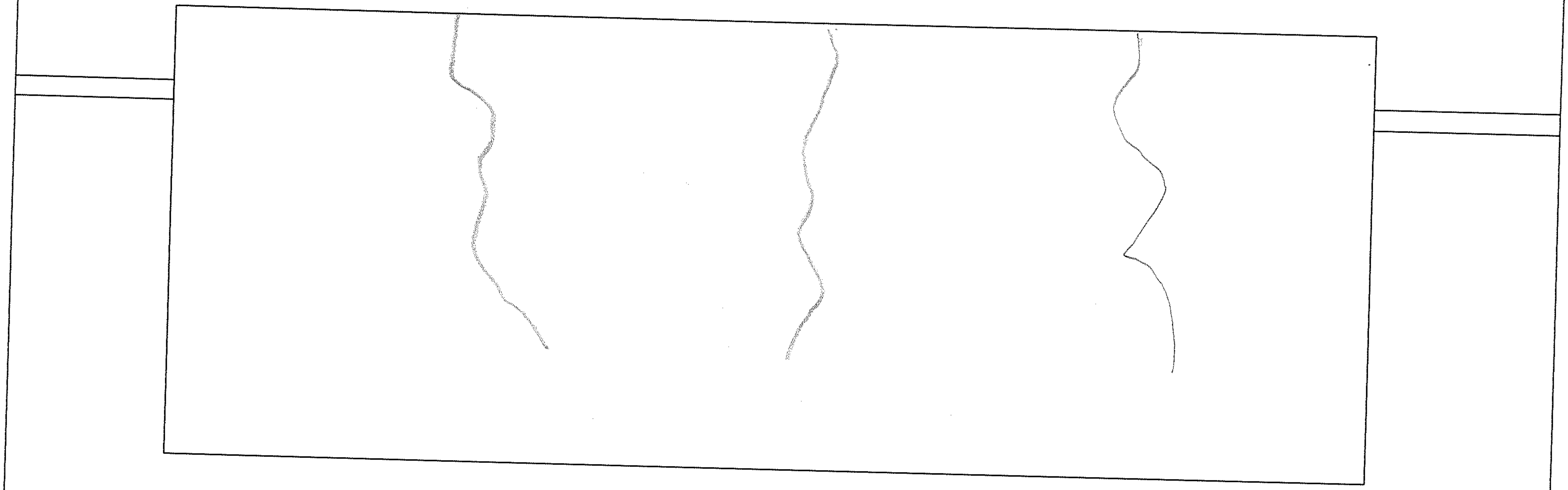
D17

07/05/17

40 K

SOUTH

NORTH



Series D

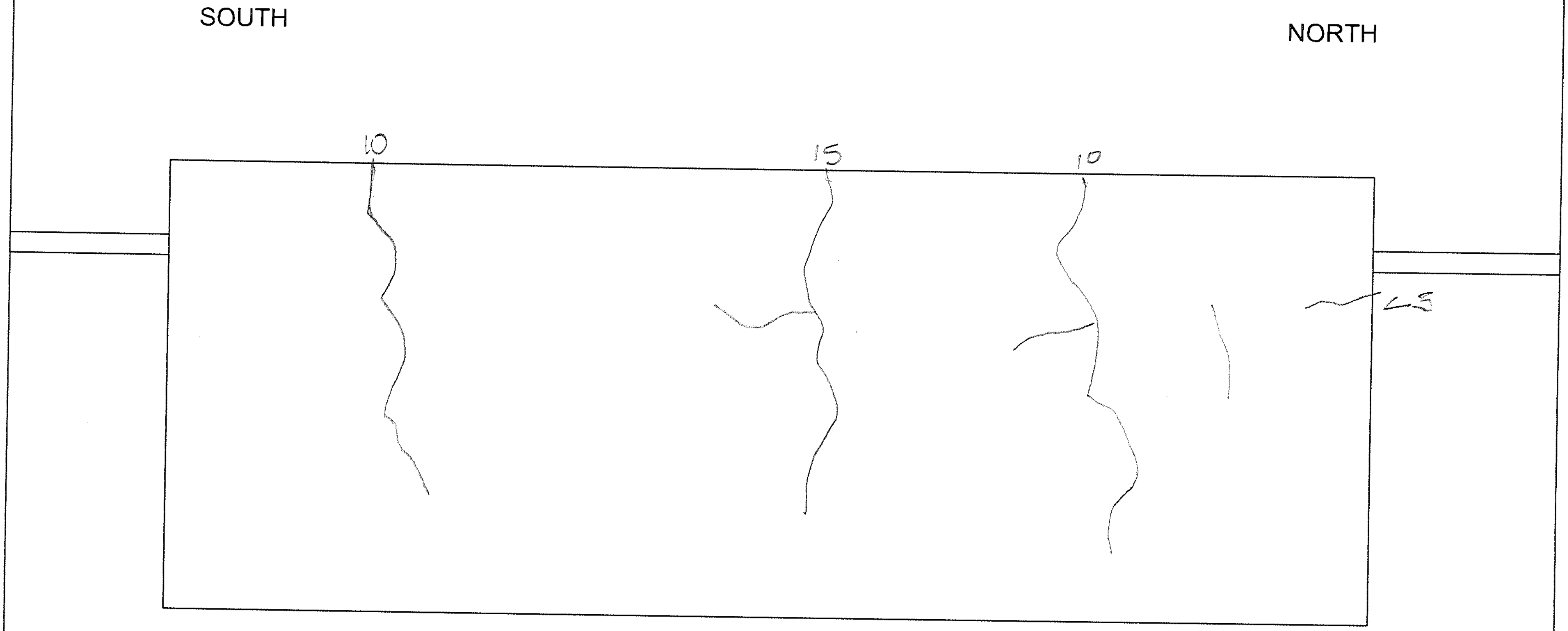
BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D17

07/05/17

60 K

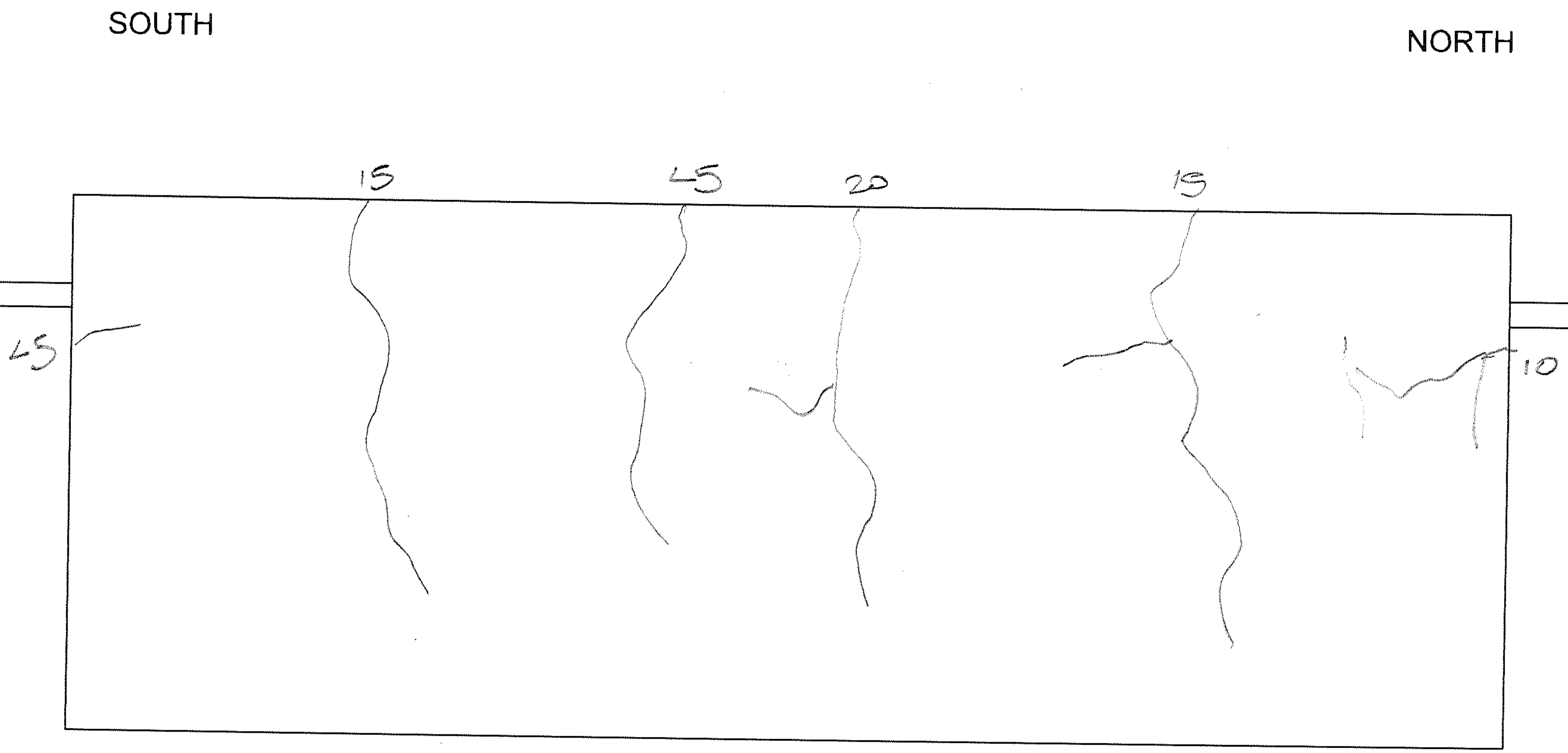


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D17 07/05/17

80 K



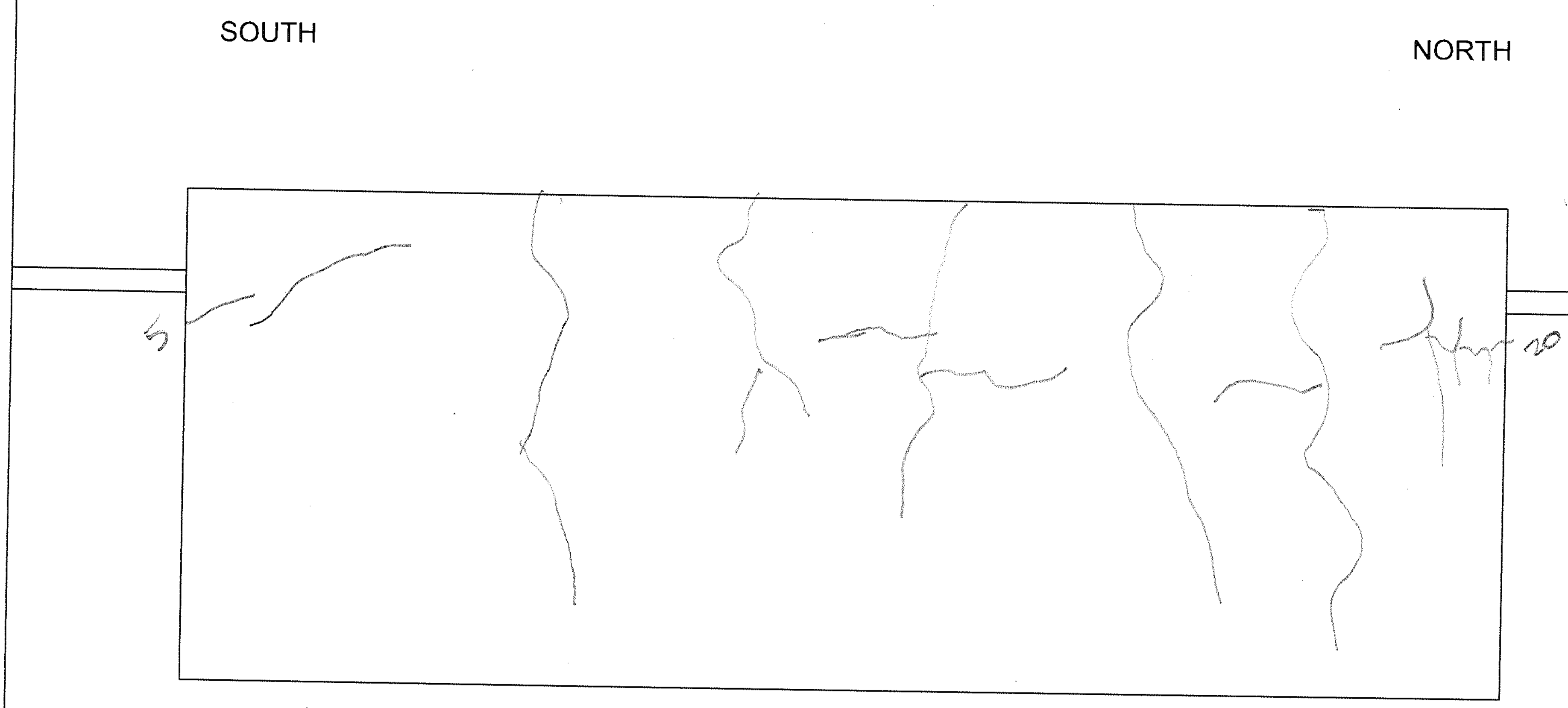
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D17 07/05/17

100k



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1 of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS Checked by:	SP
			Date:	11/16/2016	

Project: Tests to Determine the
Behavior of Spliced #11 Bars

Specimen: D18

Safety and Test Procedure Briefing Documentation

By signing your name below you acknowledge that you were briefed on the safety concerns and testing procedure for beam tests to determine the behavior of spliced No. 11 bars at Bowen Laboratory on: 7/6/17 prior to participation in the test:

Print Name	Sign Name	Date
Kinsey Skiller	KC Skiller	7/6/17
Prateek Shah	P Shah	7/6/17
EMRE KAHRAMAN		7/6/17
WILL POLLALIS		7/6/17
JASPAL SAINI	J Saini	7/6/17

Recorded by: KCS

Checked by:

Checked by:

Test: D18

Date: 7/6/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0K	2:15	0	0	0	0	0	0	0
20K	2:21	20.1	26.3	0	0	0	0	0
40K	2:23	40.6	40.4	0.004	0	0	0	0.004
60K	2:26	60.1	60.3	0.013	0	0	0	0.013
80K	2:30	79.6	80.1	0.027	0.002	0.003	0.002	0.027
100K	2:34	99.4	99.9	0.046	0.007	0.007	0.010	0.046
106K	2:40	105.6	105.4	0.060	0.012	0.010	0.013	0.060
0K	2:45	0	0	0.030	0.007	0.006	0.007	0.030

Notes:

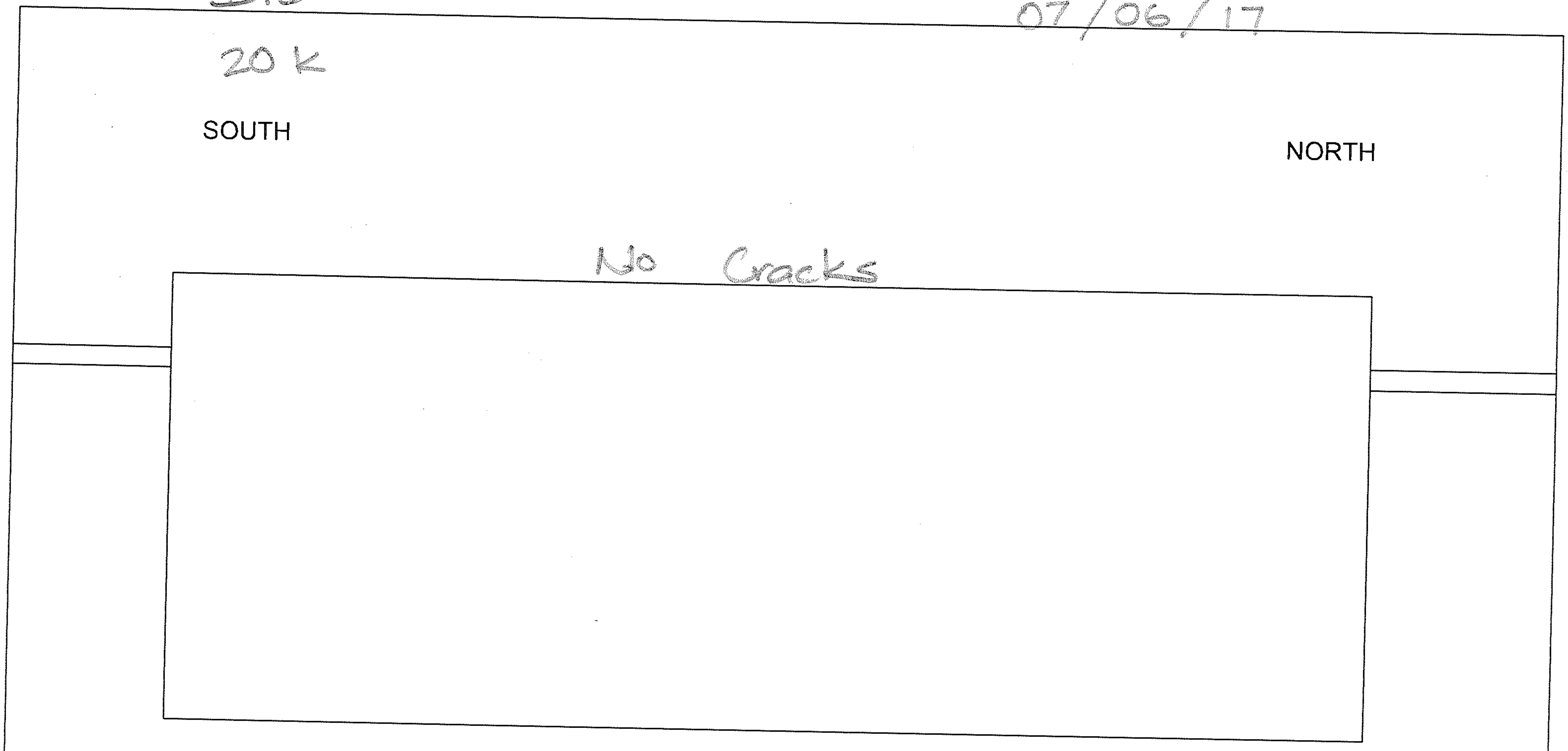
Recorded by: Kinsey Skiller

Signature: K.C. Skiller

D18

20 K

07/06/17



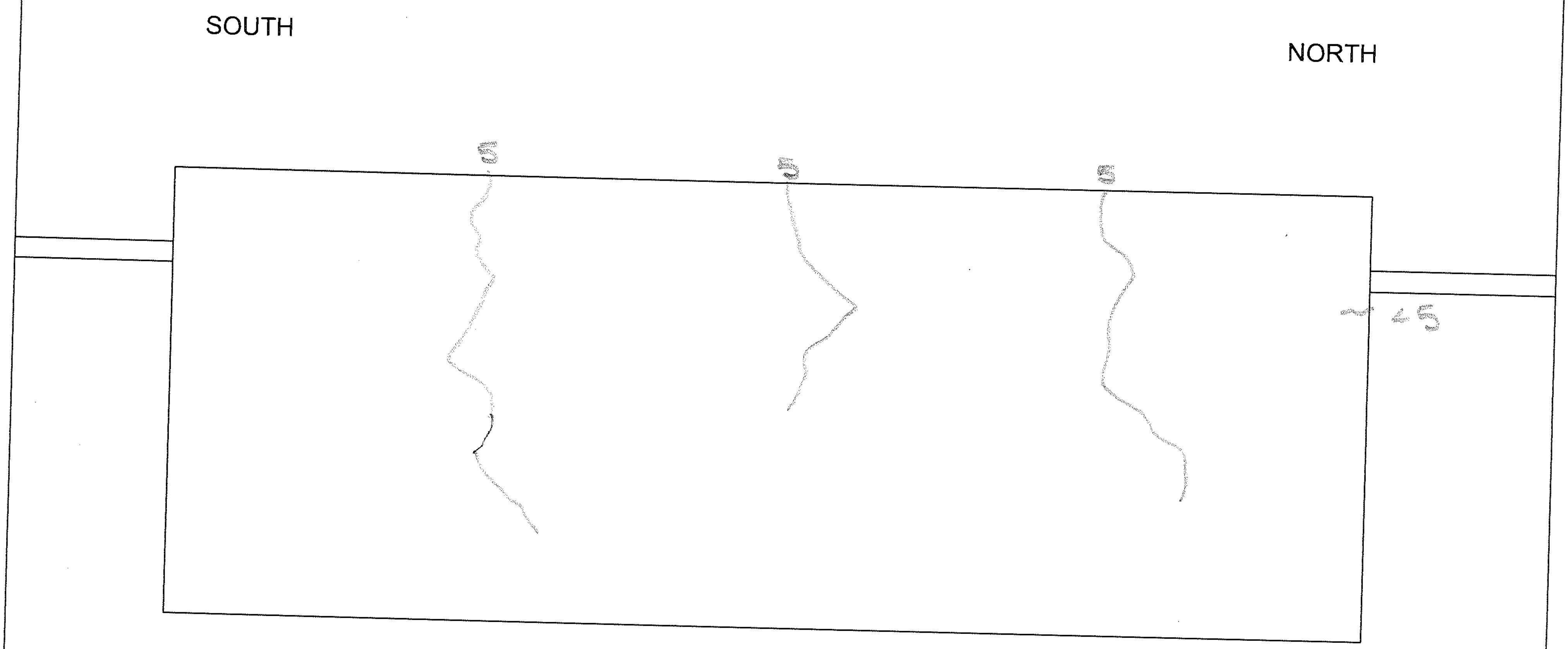
No Cracks

Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

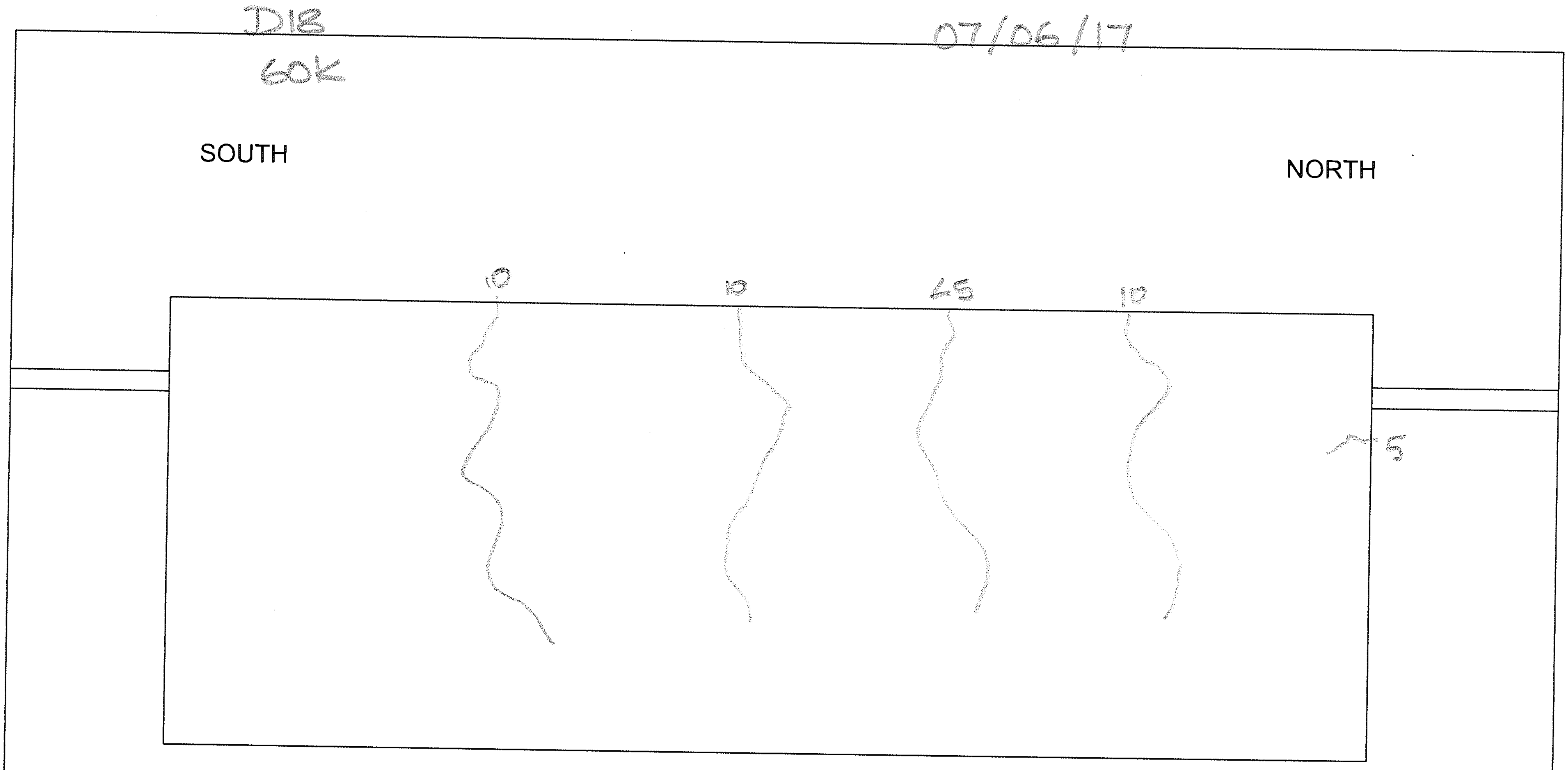
D16
40K

07/06/18



Series D

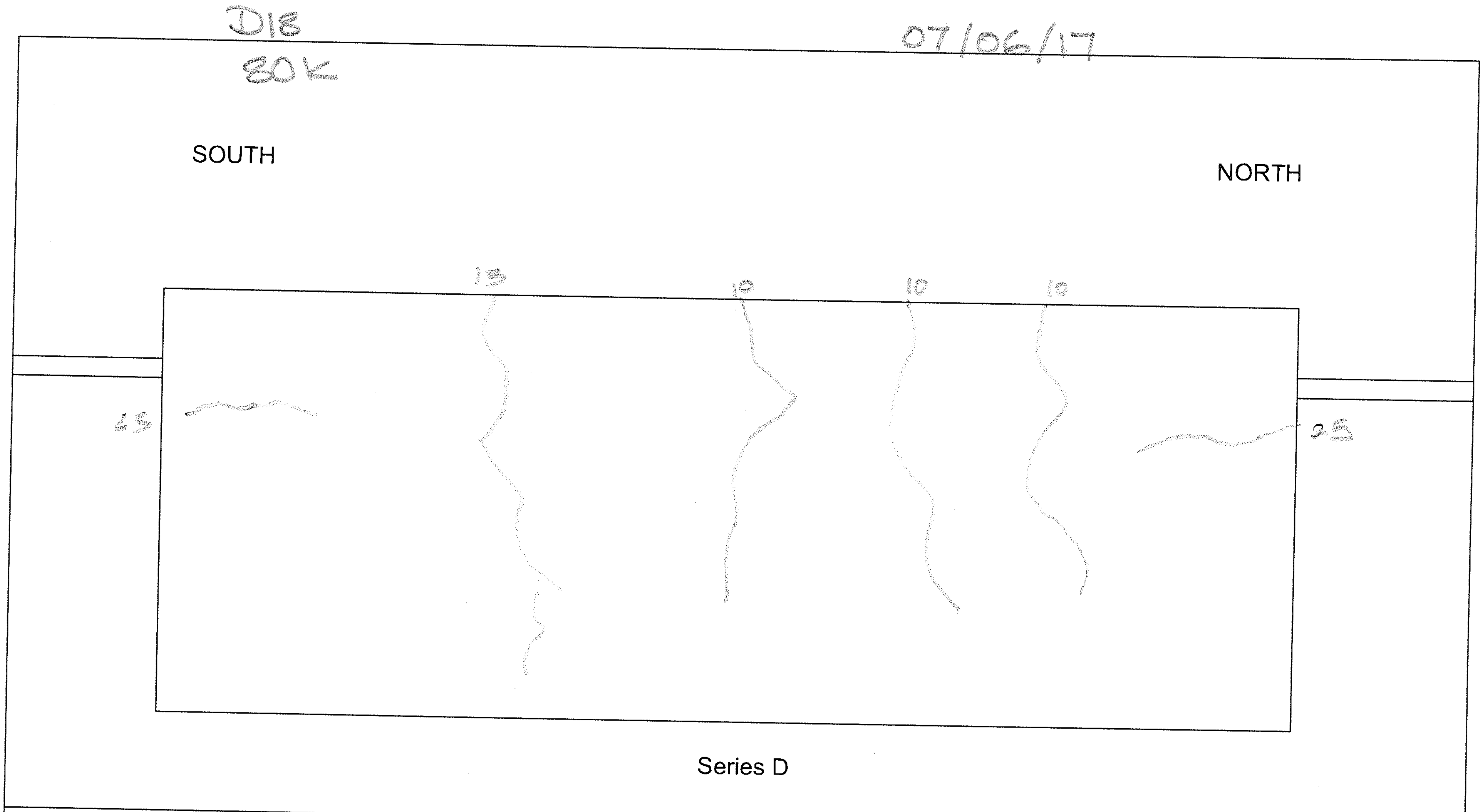
BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		


D18
60K
07/06/17

Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		



BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

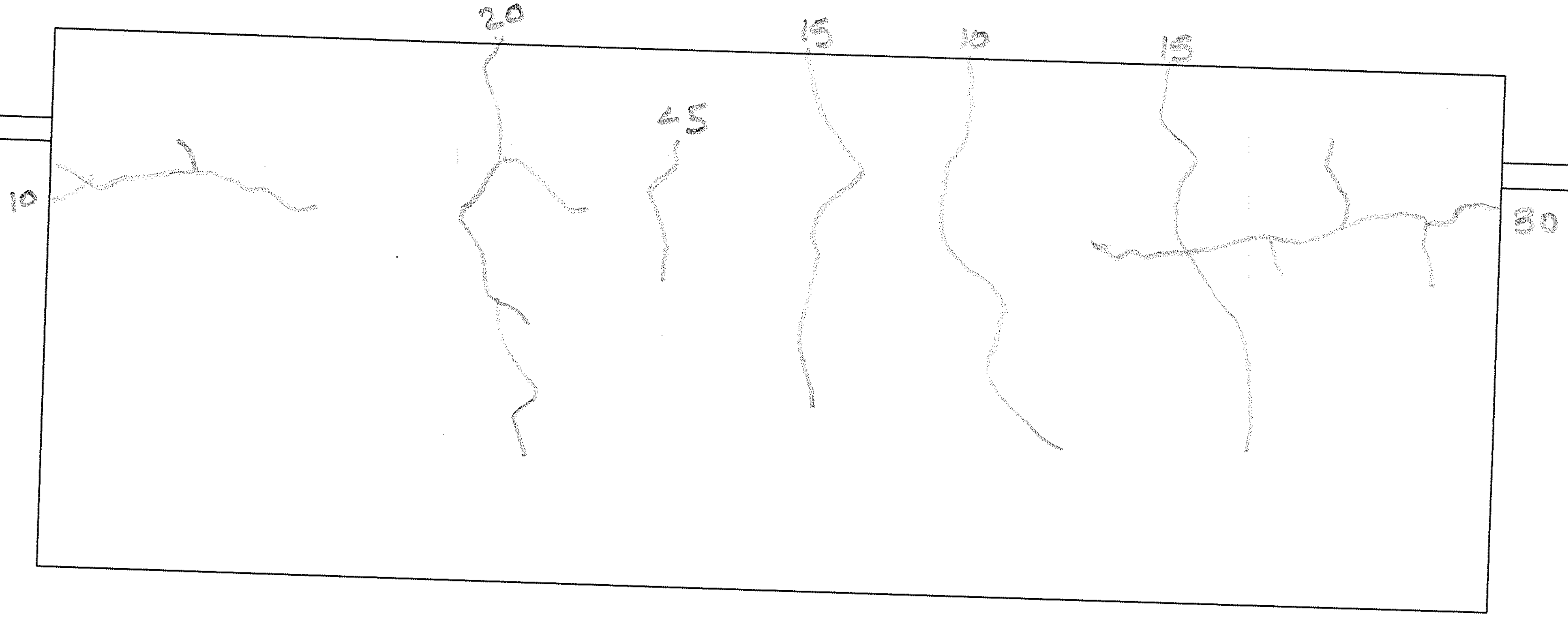
D18

100K

07/06/17

SOUTH

NORTH



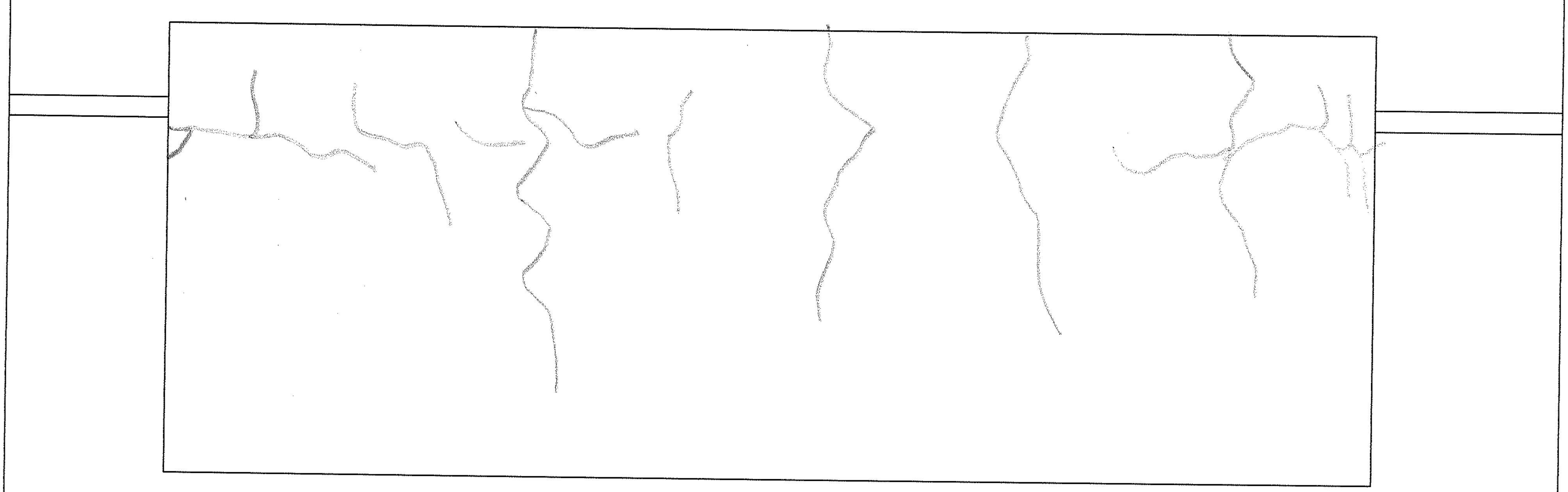
Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

D16
106 k

07/06/17



Series D

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

BOWEN LABORATORY
PURDUE UNIVERSITY

Test: D18 w/ Anchors

Date: 7/7/17

load step	time	LC E (kips)	LC W (kips)	LVDT NE (in)	LVDT NW (in)	LVDT SE (in)	LVDT SW (in)	Max crack width (in)
0K	3:15	0	0	0.027	0.005	0.005	0.007	0.027
20K	3:20	20.3	20.7	0.026	0.005	0.006	0.007	0.026
40K	3:23	40.6	40.7	0.032	0.005	0.006	0.007	0.032
60K	3:26	60.6	60.5	0.041	0.005	0.007	0.008	0.041
80K	3:31	80.7	80.1	0.050	0.009	0.009	0.011	0.050
100K	3:35	99.6	99.6	0.060	0.012	0.011	0.014	0.060
110K	3:40	108.3	108.2	0.073	0.016	0.014	0.017	0.073
120K	3:48	116.6	116.2	0.145	0.062	0.032	0.049	0.145

Notes:

Recorded by: Kinsey Skillen

Signature: KCSkillen

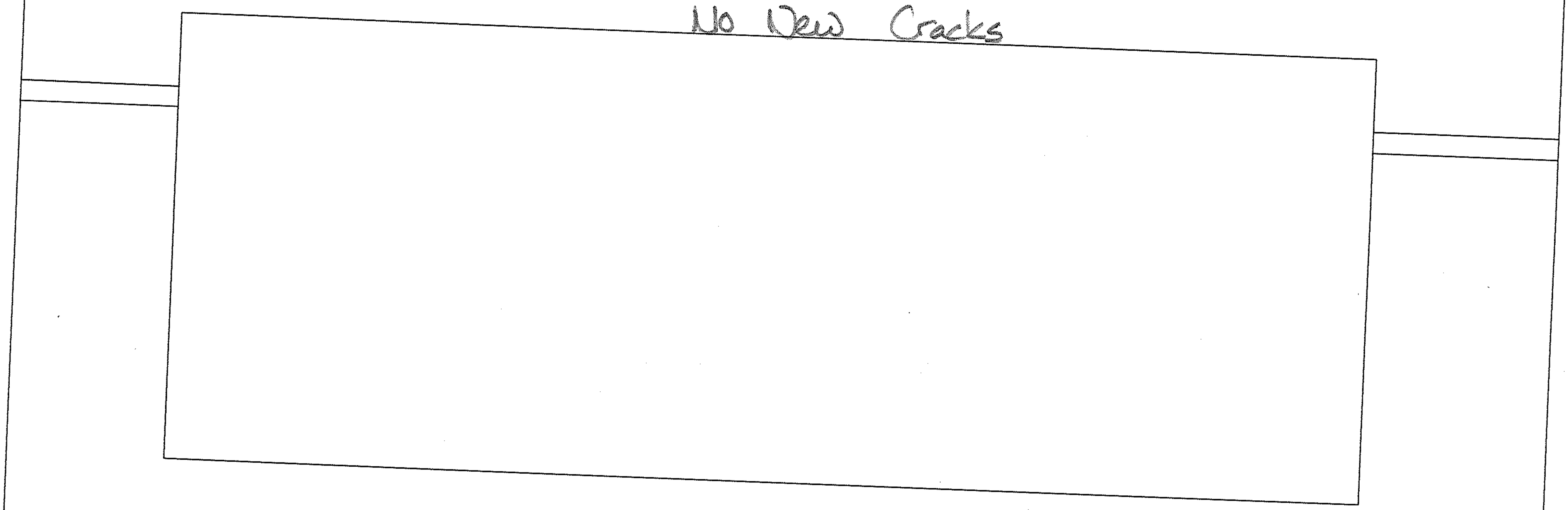
D18

R20

07/07/17

SOUTH

NORTH



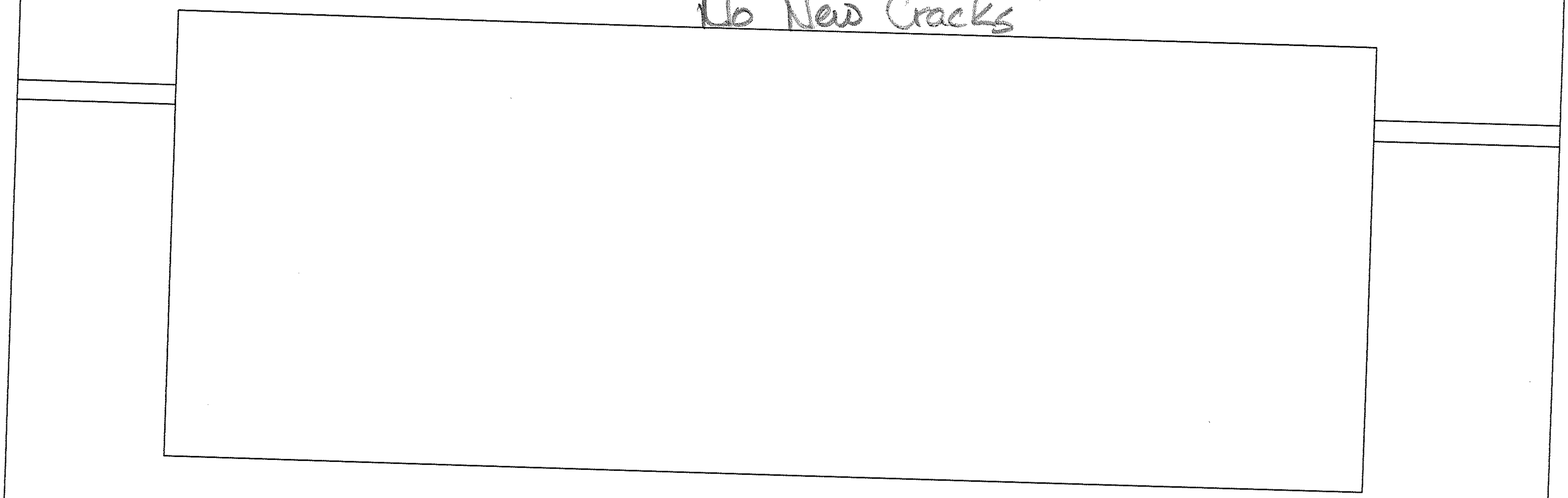
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D18

R40

7/7/17



No New Cracks

Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D18
R60

7/7/17

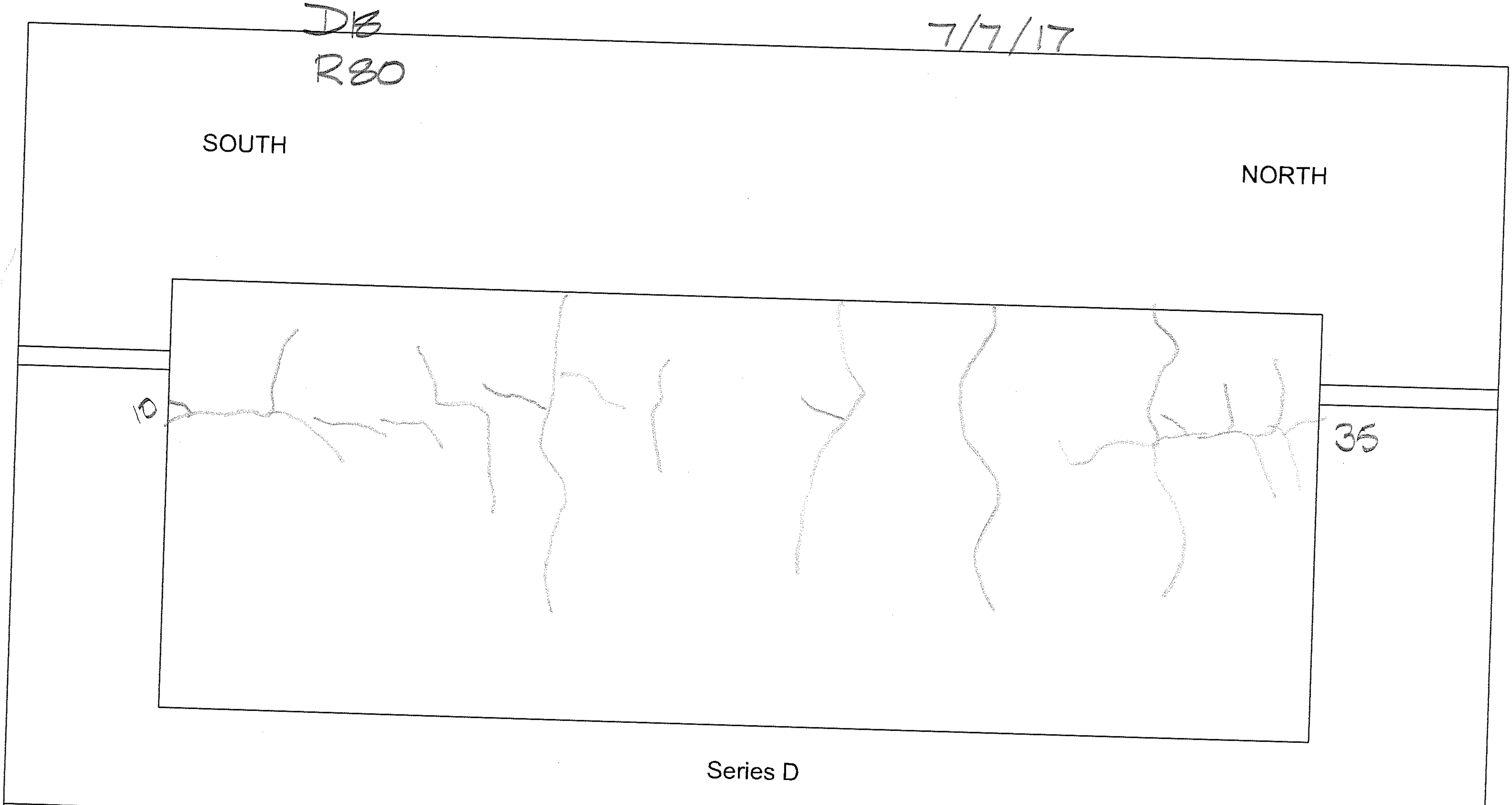
Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D13
R80

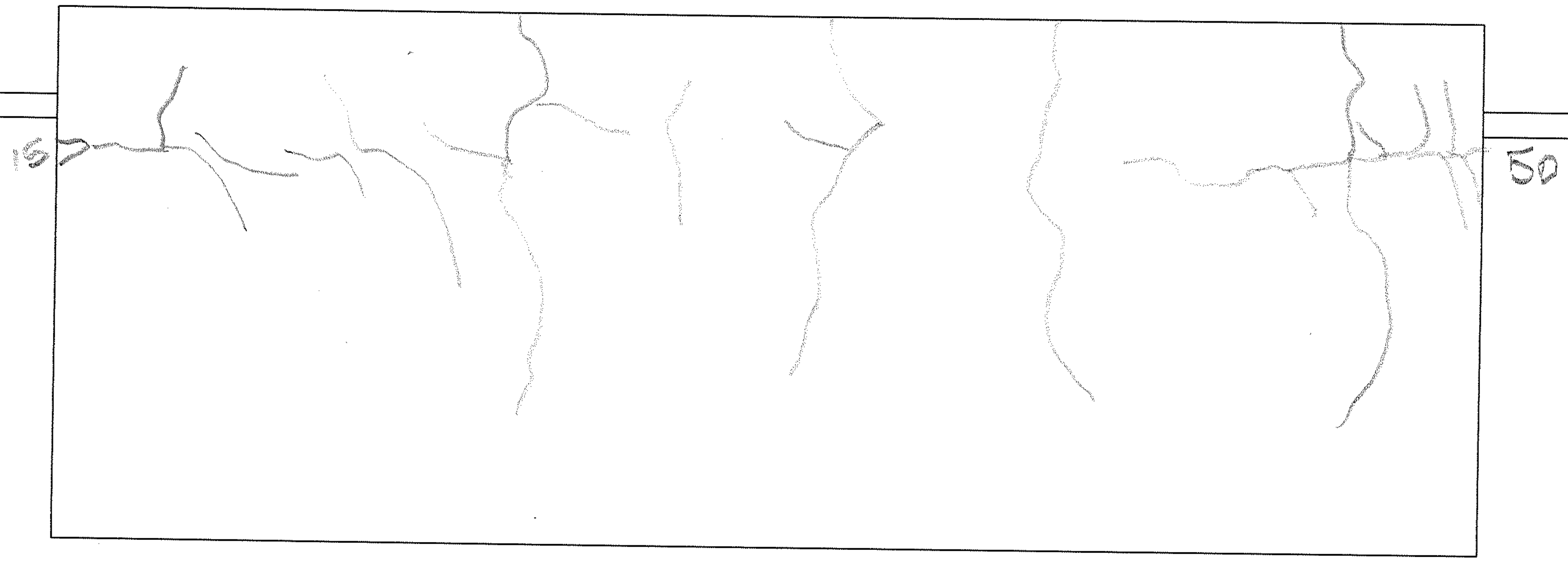
7/7/17



BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

D18
R100

7/7/17

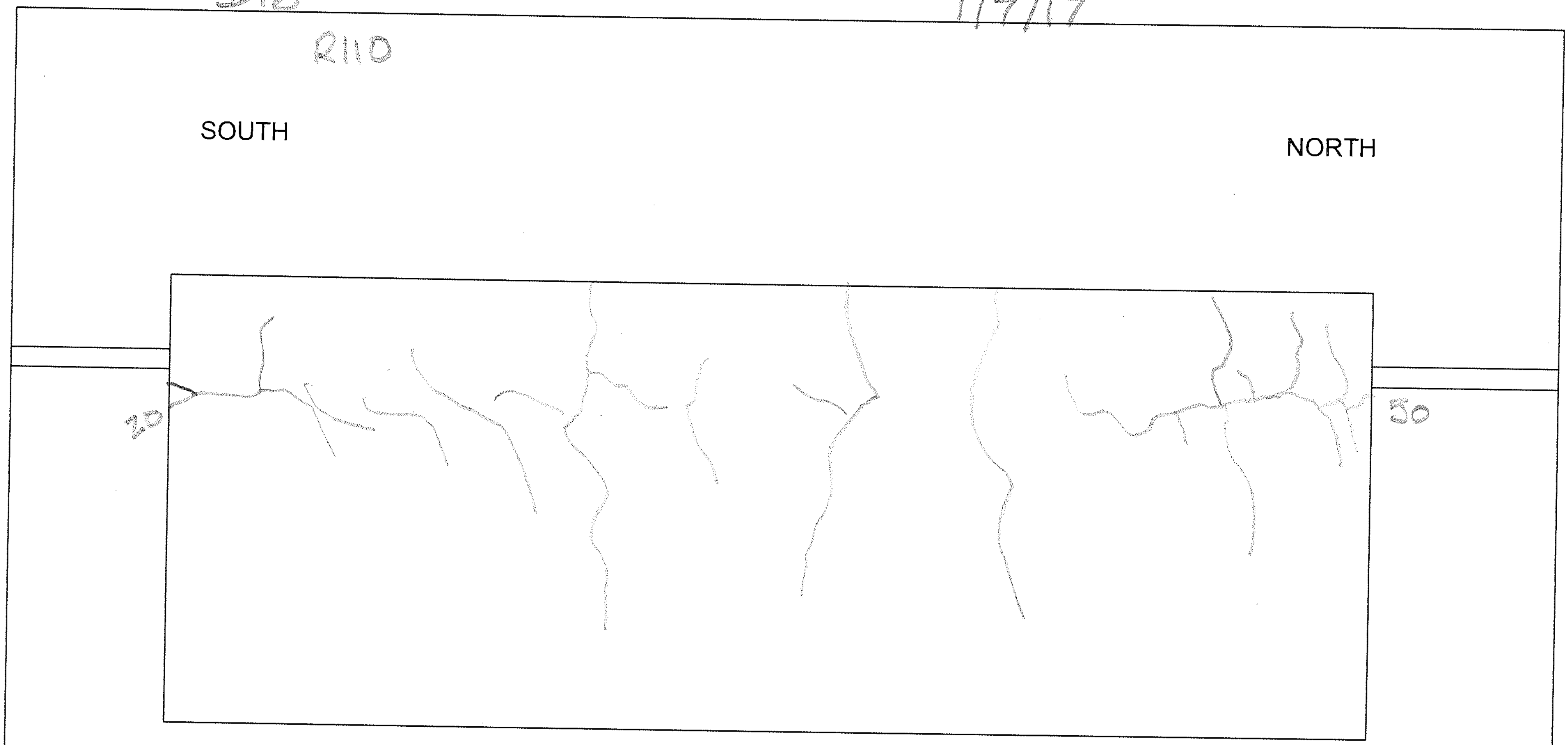


Series D

BOWEN LABORATORY
PURDUE UNIVERSITY

Drawing:	Series D crack map	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/16/2016		

D18 7/7/17



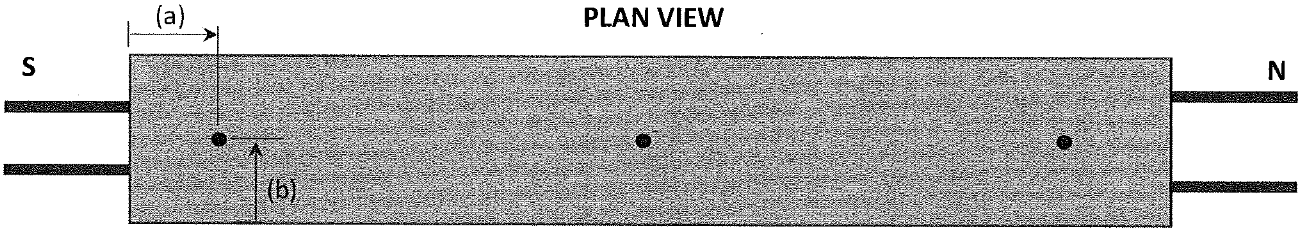
Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D crack map	Sheet:	1	of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/16/2016		

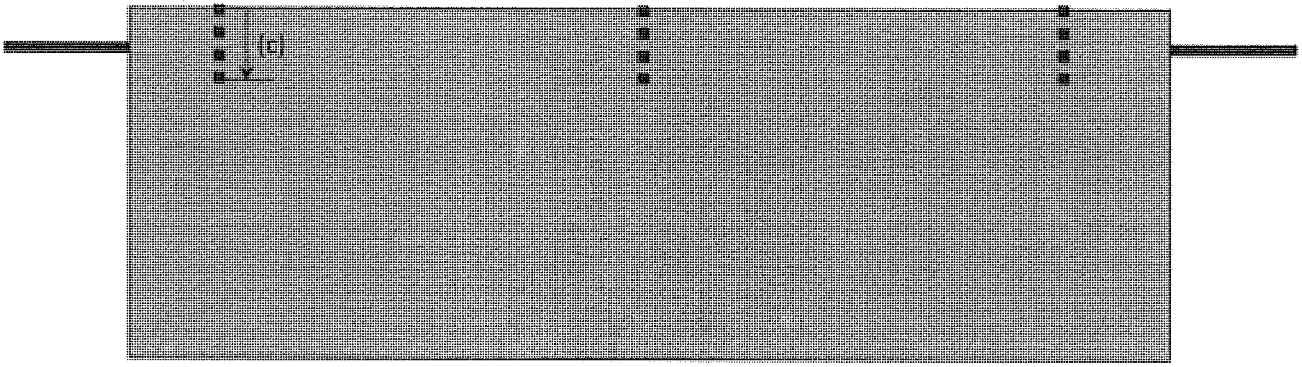
FENOC: SERIES D Repair As-Built Documentation

Specimen	As-Built Distance, in.								
	(a) from South face to CL			(b) from East face to CL			(c) Embedment Depth		
	Rod 1	Rod 2	Rod 3	Rod 1	Rod 2	Rod 3	Rod 1	Rod 2	Rod 3
D1	NOT APPLICABLE, NO REPAIR								
D2	NOT APPLICABLE, NO REPAIR								
D3	NOT APPLICABLE, NO REPAIR								
D4	20 in	60 in	N/A	8 3/4	8 3/4	N/A	10 in	10 in	N/A
D5	13 1/3	40 in	66 2/3	8 3/4	8 3/4	8 3/4	12 1/8 in	12 1/8 in	12 in
D6	13 1/2	66 1/2	N/A	8 5/8	8 3/4	N/A	12 1/4	12 3/8	N/A
D7	13 1/2	40	66 5/8	8 3/4	8 5/8	8 3/4	12 1/4	12	12 1/4
D8	13 1/2	39 3/4	66 1/2	8 3/4	9	8 5/8	19	19 1/4	19
D9	N/A →								→ Broke
D10	13 1/2	40	66 1/2	8 3/4	8 3/4	8 3/4	18 3/4	18 3/4	18 3/4
D11	N/A →								→ Broke
D12	13 1/2	40	66 1/2	8 3/4	8 3/4	8 5/8	18 3/4	18 3/4	18 3/4

PLAN VIEW



ELEVATION



Notes:

→ D8 - D12 → plate, nut, washers

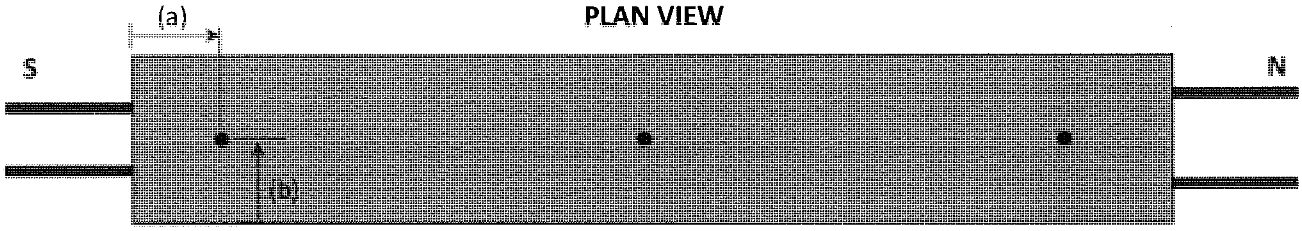
→ D9 + D11 broke before anchors could be installed

KCS → nuts torqued to 100 lbf-ft

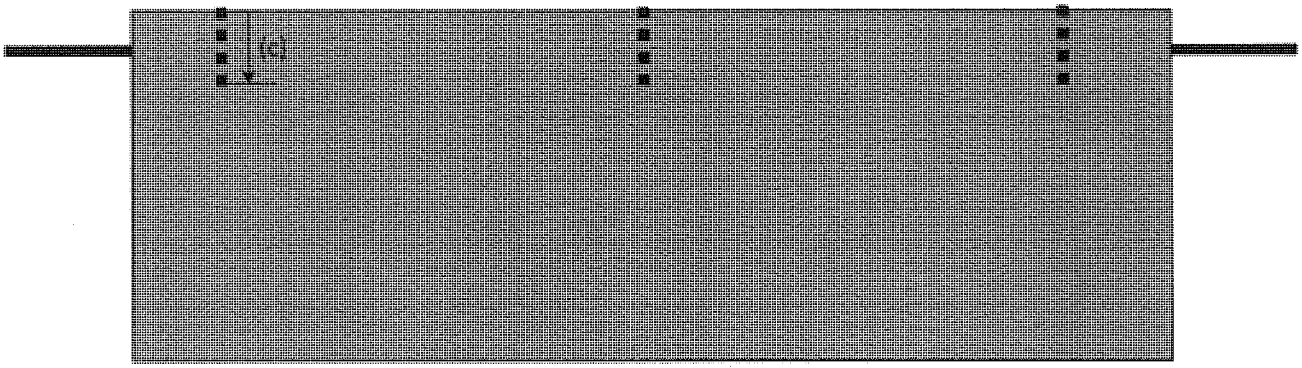
FENOC: SERIES D Repair As-Built Documentation

Specimen	As-Built Distance, in.								
	(a) from South face to CL			(b) from East face to CL			(c) Embedment Depth		
	Rod 1	Rod 2	Rod 3	Rod 1	Rod 2	Rod 3	Rod 1	Rod 2	Rod 3
D13	13 1/2"	40"	66-1/2"	8-3/4"	8-3/4"	8-3/4"	19"	19"	18-3/4"
D14	13-3/4"	40"	66-1/2"	8-3/4"	9"	9"	18-3/4"	19"	18-1/2"
D15	13-1/2"	39-3/4"	66-1/2"	9"	9"	9"	18-3/4"	18-1/2"	18-3/4"
D16	13-1/2"	40"	66-1/2"	9"	8-3/4"	9"	18-3/4"	18-3/4"	18-3/4"
D17	N/A								Broke
D18	13-1/2"	39-3/4"	66-1/2"	9"	9"	8-7/8"	19"	19-1/8"	18-7/8"

PLAN VIEW



ELEVATION



Notes :

→ D17 broke before anchor install

→ D13-D16, D18 → plate, nut washers

KCS → 100 lbf-ft torque

Adhesive Anchors Inspection Checklist for Concrete and Masonry

Periodic special must be performed where required in accordance with Section 1705.1.1 and Table 1705.3 of the 2012 IBC, or Section 1704.15 of the 2009 IBC and Table 1704.4 or Section 1704.13 of the 2006 or 2003 IBC, whereby periodic special inspection is defined in Section 1702.1 of the IBC and this report. (See Structural Drawings for Inspection requirements)

Project Name: D1-D3 N/A

Project Location: ______

Weather: ______ Air Temperature: ______ (°F / °C)

CODES

☐ IBC 2003

☐ IBC 2006

☐ IBC 2009

☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: ______

Lot No.: ______

ICC-ES Report No.: ______

Adhesive expiration Date: __/__/__ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: ______ (# trigger pulls)

Adhesive Tempature: ______ (°F / °C) Gel Time: ______ Cure Time: ______
(per manufacturers installation instructions)

Adhesive Element

Type: ☐ All-Thread ☐ Internally Threaded ☐ Torque-Controlled (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Rebar ☐ Other ______

Material: ☐ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: ______ Length: ______ (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☐ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ______

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ______

Base Material

Base Material Type: ☐ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ______

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☐ 4000 psi ☐ Other ______

Base Material Thickness: ______ (in/mm)

Base Material Temperature: ______ (°F / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: ______ (in/mm) Hole Depth: ______ (in/mm)
(core bit diameter, if approved)

Drill Bit Type: ☐ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ______

Hole Condition: ☐ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☐ Compressed Air ☐ Hand Pump ☐ Wire Brush ☐ Other ______

Hole cleaning in accordance with manufacturers' printed installation instructions: ☐ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☐ Tension ☐ Shear ☐ Overhead ☐ Other ______

Anchor insertion: ☐ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: ______ (in/mm) Edge Distance: ______ (in/mm)

Embedment (h_{ef}): ______ (in/mm) Installation Torque (if required): ______ (ft-lb/Nm)

Completed by: ______ (Signature) Date: __/__/__

______ (Print) Company: ______

______ (Title)

This form is for consideration for use by the responsible 3rd-party inspector.

Version 02.2014

HILTI Hilti. Outperform. Outlast.

Adhesive Anchors Inspection Checklist for Concrete and Masonry

Periodic special must be performed where required in accordance with Section 1705.1.1 and Table 1705.3 of the 2012 IBC, or Section 1704.15 of the 2009 IBC and Table 1704.4 or Section 1704.13 of the 2006 or 2003 IBC, whereby periodic special inspection is defined in Section 1702.1 of the IBC and this report. (See Structural Drawings for Inspection requirements)

Project Name: FENOC DH

Project Location: Bowen Lab Purdue

Weather: inside Air Temperature: 60 (°F / °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: Hilti HIT-RE 500 V3

Lot No.:

ICC-ES Report No.:

Adhesive expiration Date: ___/___/___ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: 3 (# trigger pulls)

Adhesive Tempature: 60° (°F / °C) Gel Time: ______ Cure Time: 24 hrs.
(per manufacturers installation instructions)

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Rebar ☐ Other ______

Material: ☑ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: ASTM A193 B7 Length: 15 in (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ______

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ______

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ______

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☑ 4000 psi ☐ Other ______

Base Material Thickness: 30 in (in/mm)

Base Material Temperature: 60 (°F / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8 in (in/mm) Hole Depth: 10 in (in/mm)
(core bit diameter, if approved)

Drill Bit Type: ☑ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ______

Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☑ Compressed Air ☐ Hand Pump ☑ Wire Brush ☑ Other Vacuum

Hole cleaning in accordance with manufacturers' printed installation instructions: ☑ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other ______

Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: 40 in (in/mm) Edge Distance: 8-3/4 in (in/mm)

Embedment (h_{ef}): 10 in (in/mm) Installation Torque (if required): ______ (ft-lb/Nm)

Completed by: ______ (Signature) Date: 2 / 20 / 17

Kinsey Skillen (Print) Company: ______

______ (Title)

This form is for consideration for use by the responsible 3rd-party inspector.

Version 02.2014

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Adhesive Anchors Inspection Checklist for Concrete and Masonry

Periodic special must be performed where required in accordance with Section 1705.1.1 and Table 1705.3 of the 2012 IBC, or Section 1704.15 of the 2009 IBC and Table 1704.4 or Section 1704.13 of the 2006 or 2003 IBC, whereby periodic special inspection is defined in Section 1702.1 of the IBC and this report. (See Structural Drawings for Inspection requirements)

Project Name: FENOC D5

Project Location: Bowen Lab

Weather: inside Air Temperature: 60 (°F / °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: Hilti HIT-RE 500 V3

Lot No.:

ICC-ES Report No.:

Adhesive expiration Date: __/__/__ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: 3 (# trigger pulls)

Adhesive Tempature: 60° (°F / °C) Gel Time: Cure Time: 24 hrs
(per manufacturers installation instructions)

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Rebar ☐ Other

Material: ☑ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: ASTM A193 B7 Length: 15 in (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☑ 4000 psi ☐ Other

Base Material Thickness: 30 in (in/mm)

Base Material Temperature: 60 °F (°F / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8" (in/mm) Hole Depth: 12 in (in/mm)
(core bit diameter, if approved)

Drill Bit Type: ☑ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other

Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☑ Compressed Air ☐ Hand Pump ☑ Wire Brush ☑ Other vacuum

Hole cleaning in accordance with manufacturers' printed installation instructions: ☑ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other

Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: 27 in (in/mm) Edge Distance: 8-3/4" (in/mm)

Embedment (h_{ef}): 12 in (in/mm) Installation Torque (if required): — (ft-lb/Nm)

Completed by: (Signature) Date: 2/22/17

Kinsey Skiller (Print) Company:

(Title)

This form is for consideration for use by the responsible 3rd-party inspector.

Version 02.2014

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Adhesive Anchors Inspection Checklist for Concrete and Masonry

Periodic special must be performed where required in accordance with Section 1705.1.1 and Table 1705.3 of the 2012 IBC, or Section 1704.15 of the 2009 IBC and Table 1704.4 or Section 1704.13 of the 2006 or 2003 IBC, whereby periodic special inspection is defined in Section 1702.1 of the IBC and this report. (See Structural Drawings for Inspection requirements)

Project Name: FENOG DG

Project Location: Bower Lab

Weather: inside Air Temperature: 60°F (°F / °C)

CODES

☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: Hilti HIT RE 500 V3

Lot No.:

ICC-ES Report No.:

Adhesive expiration Date: __/__/__ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: 3 (# trigger pulls)

Adhesive Tempature: 60° F (°F / °C) Gel Time: Cure Time: 24 hrs
(per manufacturers installation instructions)

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled ☐ Rebar ☐ Other
(Safeset™ only to be used with Hilti HIT-HY 200)

Material: ☑ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: ASTM A193 B7 Length: 15 in (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☑ 4000 psi ☐ Other

Base Material Thickness: 30 in (in/mm)

Base Material Temperature: 60 °F (°F / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8" (in/mm) Hole Depth: 12 in (in/mm)
(core bit diameter, if approved)

Drill Bit Type: ☑ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other

Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☑ Compressed Air ☐ Hand Pump ☑ Wire Brush ☑ Other vacuum

Hole cleaning in accordance with manufacturers' printed installation instructions: ☑ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other

Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: 53 in (in/mm) Edge Distance: (in/mm)

Embedment (h_{ef}): (in/mm) Installation Torque (if required): (ft-lb/Nm)

Completed by: KC Skiller (Signature) Date: 2/24/17

Kinsey Skiller (Print) Company:

(Title)

This form is for consideration for use by the responsible 3rd-party inspector.

Version 02.2014

Hilti. Outperform. Outlast.

Adhesive Anchors Inspection Checklist for Concrete and Masonry

Periodic special must be performed where required in accordance with Section 1705.1.1 and Table 1705.3 of the 2012 IBC, or Section 1704.15 of the 2009 IBC and Table 1704.4 or Section 1704.13 of the 2006 or 2003 IBC, whereby periodic special inspection is defined in Section 1702.1 of the IBC and this report. (See Structural Drawings for Inspection requirements)

Project Name: FENOC D7

Project Location: Purdue Bowen Lab

Weather: indoors Air Temperature: 60 °F (°F / °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: Hilti HIT-RE 500 V3

Lot No.:

ICC-ES Report No.:

Adhesive expiration Date: __/__/__ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: ____ (# trigger pulls)

Adhesive Tempature: 60 °F (°F / °C) Gel Time: ____ Cure Time: 48 hrs.
(per manufacturers installation instructions)

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Rebar ☐ Other ____

Material: ☑ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: ASTM A193 B7 Length: 15 in (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ____

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ____

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ____

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☑ 4000 psi ☐ Other ____

Base Material Thickness: 30 in (in/mm)

Base Material Temperature: 60 °F (°F / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8 in (in/mm) Hole Depth: 12 in (in/mm)
(core bit diameter, if approved)

Drill Bit Type: ☑ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ____

Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☑ Compressed Air ☐ Hand Pump ☑ Wire Brush ☑ Other vacuum

Hole cleaning in accordance with manufacturers' printed installation instructions: ☐ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other ____

Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: 26.5 in (in/mm) Edge Distance: 8-3/4 in (in/mm)

Embedment (h_{ef}): 12 in (in/mm) Installation Torque (if required): — (ft-lb/Nm)

Completed by: ____ (Signature) Date: 2/26/17 6:10 pm

Kinzey Skiller (Print) Company: ____

____ (Title)

This form is for consideration for use by the responsible 3rd-party inspector.

Version 02.2014

Adhesive Anchors Inspection Checklist for Concrete and Masonry

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Project Name: D8

Project Location:

Weather: ______ Air Temperature: 60°F (°F / °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: 500 V3

Lot No.:

ICC-ES Report No.:

Adhesive expiration Date: __/__/__ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: ______ (# trigger pulls)

Adhesive Tempature: 60° ([✓ °F] / °C) Gel Time: ______ Cure Time: 24 hrs
(per manufacturers installation instructions)

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled ☐ Rebar ☐ Other ______
(Safeset™ only to be used with Hilti HIT-HY 200)

Material: ☑ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: A193 Length: 24 in (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ______

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ______

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ______

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☑ 4000 psi ☐ Other ______

Base Material Thickness: 30 in (in/mm)

Base Material Temperature: 60 ([✓ °F] / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8 in (in/mm) Hole Depth: 19 in (in/mm)
(core bit diameter, if approved)

Drill Bit Type: ☑ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ______

Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☑ Compressed Air ☐ Hand Pump ☑ Wire Brush ☑ Other vacuum

Hole cleaning in accordance with manufacturers' printed installation instructions: ☑ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other ______

Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: 27 in (in/mm) Edge Distance: 9 in (in/mm)

Embedment (h_{ef}): 19 in (in/mm) Installation Torque (if required): 0 (ft-lb/Nm)

Completed by: ______ (Signature) Date: 3 / 6 / 17

Kinsey Skiller (Print) Company: ______

______ (Title)

This form is for consideration for use by the responsible 3rd-party inspector.

Version 02.2014

Adhesive Anchors Inspection Checklist for Concrete and Masonry

Periodic special must be performed where required in accordance with Section 1705.1.1 and Table 1705.3 of the 2012 IBC, or Section 1704.15 of the 2009 IBC and Table 1704.4 or Section 1704.13 of the 2006 or 2003 IBC, whereby periodic special inspection is defined in Section 1702.1 of the IBC and this report. (See Structural Drawings for Inspection requirements)

Project Name: D9 N/A

Project Location: ___

Weather: ___ Air Temperature: ___ (°F / °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: ___

Lot No.: ___

ICC-ES Report No.: ___

Adhesive expiration Date: ___/___/___ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: ___ (# trigger pulls)

Adhesive Tempature: ___ (°F / °C) Gel Time: ___ Cure Time: ___
(per manufacturers installation instructions)

Adhesive Element

Type: ☐ All-Thread ☐ Internally Threaded ☐ Torque-Controlled (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Rebar ☐ Other ___

Material: ☐ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: ___ Length: ___ (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☐ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ___

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ___

Base Material

Base Material Type: ☐ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ___

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☐ 4000 psi ☐ Other ___

Base Material Thickness: ___ (in/mm)

Base Material Temperature: ___ (°F / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: ___ (in/mm) Hole Depth: ___ (in/mm)
(core bit diameter, if approved)

Drill Bit Type: ☐ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ___

Hole Condition: ☐ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☐ Compressed Air ☐ Hand Pump ☐ Wire Brush ☐ Other ___

Hole cleaning in accordance with manufacturers' printed installation instructions: ☐ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☐ Tension ☐ Shear ☐ Overhead ☐ Other ___

Anchor insertion: ☐ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: ___ (in/mm) Edge Distance: ___ (in/mm)

Embedment (h_{ef}): ___ (in/mm) Installation Torque (if required): ___ (ft-lb/Nm)

Completed by: ___ (Signature) Date: ___/___/___

___ (Print) Company: ___

___ (Title)

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Version 02.2014

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Adhesive Anchors Inspection Checklist for Concrete and Masonry

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Project Name: D10
Project Location: Bowen Lab
Weather: inside Air Temperature: 60 (°F / °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: 500 V3
Lot No.:
ICC-ES Report No.:
Adhesive expiration Date: __/__/__ ☐ Specified Dispenser ☐ Specified Mixer
Discard Initial Adhesive: ____ (# trigger pulls)
Adhesive Tempature: ____ (°F / °C) (per manufacturers installation instructions) Gel Time: ____ Cure Time: 24 hrs.

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Rebar ☐ Other ____
Material: ☑ Standard ☐ Stainless Steel ☐ High Strength
Steel Grade/Coating: A193 B7 Length: 24 in (in/mm)
Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ____
Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ____

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ____
Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☑ 4000 psi ☐ Other ____
Base Material Thickness: 30 in (in/mm)
Base Material Temperature: 60 (°F / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8 in (in/mm) (core bit diameter, if approved) Hole Depth: 19 in (in/mm)
Drill Bit Type: ☑ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ____
Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water
Hole Cleaning: ☐ Compressed Air ☐ Hand Pump ☐ Wire Brush ☑ Other vacuum
Hole cleaning in accordance with manufacturers' printed installation instructions: ☑ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other ____
Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection
Anchor Spacing: 27 in (in/mm) Edge Distance: 9 in (in/mm)
Embedment (h_{ef}): 19 in (in/mm) Installation Torque (if required): 100 [✓ ft-lb]/Nm

Completed by: ____ (Signature) Date: 3/14/17
____ (Print) Company: ____
____ (Title)

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Version 02.2014

Adhesive Anchors Inspection Checklist for Concrete and Masonry

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Project Name: D11 N/A

Project Location: ____________________

Weather: ____________ Air Temperature: ________ (°F / °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: ____________________

Lot No.: ____________________

ICC-ES Report No.: ____________________

Adhesive expiration Date: ___/___/___ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: ________ (# trigger pulls)

Adhesive Tempature: ________ (°F / °C) Gel Time: ________ Cure Time: ________
(per manufacturers installation instructions)

Adhesive Element

Type: ☐ All-Thread ☐ Internally Threaded ☐ Torque-Controlled (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Rebar ☐ Other ________

Material: ☐ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: ________ Length: ________ (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☐ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ________

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ________

Base Material

Base Material Type: ☐ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ________

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☐ 4000 psi ☐ Other ________

Base Material Thickness: ________ (in/mm)

Base Material Temperature: ________ (°F / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: ________ (in/mm) Hole Depth: ________ (in/mm)
(core bit diameter, if approved)

Drill Bit Type: ☐ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ________

Hole Condition: ☐ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☐ Compressed Air ☐ Hand Pump ☐ Wire Brush ☐ Other ________

Hole cleaning in accordance with manufacturers' printed installation instructions: ☐ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☐ Tension ☐ Shear ☐ Overhead ☐ Other ________

Anchor insertion: ☐ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: ________ (in/mm) Edge Distance: ________ (in/mm)

Embedment (h_{ef}): ________ (in/mm) Installation Torque (if required): ________ (ft-lb/Nm)

Completed by: ____________________ (Signature) Date: ___/___/___

____________________ (Print) Company: ____________________

____________________ (Title)

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Version 02.2014

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Adhesive Anchors Inspection Checklist for Concrete and Masonry

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Project Name: D12

Project Location: Bowen Lab

Weather: inside Air Temperature: 60 ([✓ °F] / °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: 500 V3

Lot No.:

ICC-ES Report No.:

Adhesive expiration Date: __/__/__ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: _____ (# trigger pulls)

Adhesive Tempature: 60 ([✓ °F] / °C) Gel Time: _____ Cure Time: 24 hrs
(per manufacturers installation instructions)

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled ☐ Rebar ☐ Other
(Safeset™ only to be used with Hilti HIT-HY 200)

Material: ☑ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: A193 B7 Length: 24 in (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☑ 4000 psi ☐ Other

Base Material Thickness: 30 in (in/mm)

Base Material Temperature: 60 ([✓ °F] / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8 in (in/mm) Hole Depth: 19 in (in/mm)
(core bit diameter, if approved)

Drill Bit Type: ☑ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other

Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☑ Compressed Air ☐ Hand Pump ☑ Wire Brush ☑ Other vacuum

Hole cleaning in accordance with manufacturers' printed installation instructions: ☑ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other

Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: 27 in (in/mm) Edge Distance: 9 in (in/mm)

Embedment (h_{ef}): 19 in (in/mm) Installation Torque (if required): 100 ([✓ ft-lb] / Nm)

Completed by: _____ (Signature) Date: 3/22/17

Kinsey Skiller (Print) Company:

_____ (Title)

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Version 02.2014

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Adhesive Anchors Inspection Checklist for Concrete and Masonry

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Project Name: FENOC D13

Project Location: Purdue Bowen Lab

Weather: ______ Air Temperature: 80 ([✓ °F]/°C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: 500 V3

Lot No.: ______

ICC-ES Report No.: ______

Adhesive expiration Date: __/__/__ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: ______ (# trigger pulls)

Adhesive Tempature: 80 ([✓ °F]/°C) Gel Time: ______ Cure Time: 24 hrs
(per manufacturers installation instructions)

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Rebar ☐ Other ______

Material: ☑ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: A193 B7 Length: 24 in (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ______

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ______

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ______

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☐ 4000 psi ☑ Other 4500 psi

Base Material Thickness: 30 in (in/mm)

Base Material Temperature: 80 ([✓ °F]/°C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8 ([✓ in]/mm) Hole Depth: 19 ([✓ in]/mm)
(core bit diameter, if approved)

Drill Bit Type: ☑ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ______

Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☑ Compressed Air ☐ Hand Pump ☑ Wire Brush ☑ Other vacuum

Hole cleaning in accordance with manufacturers' printed installation instructions: ☑ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other ______

Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: 27 ([✓ in]/mm) Edge Distance: 9 in ([✓ in]/mm)

Embedment (h_{ef}): 19 ([✓ in]/mm) Installation Torque (if required): 100 ([✓ ft-lb]/Nm)

Completed by: ______ (Signature) Date: 6 / 14 / 17

Kinsey Skiller (Print) Company: ______

______ (Title)

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Adhesive Anchors Inspection Checklist for Concrete and Masonry

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Project Name: FENOC D14

Project Location: Purdue Bowen Lab

Weather: ______ Air Temperature: 80 ([✓ °F]/ °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: 500 V3

Lot No.: ______

ICC-ES Report No.: ______

Adhesive expiration Date: ___/___/___ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: ______ (# trigger pulls)

Adhesive Tempature: 80 ([✓ °F]/ °C) Gel Time: ______ Cure Time: 24 hrs
(per manufacturers installation instructions)

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Rebar ☐ Other ______

Material: ☑ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: A193 B7 Length: 24 in (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ______

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ______

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ______

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☐ 4000 psi ☑ Other 4500 psi

Base Material Thickness: 30 in (in/mm)

Base Material Temperature: 80 ([✓ °F] / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8 ([✓ in]/mm) Hole Depth: 19 ([✓ in]/mm)
(core bit diameter, if approved)

Drill Bit Type: ☑ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ______

Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☑ Compressed Air ☐ Hand Pump ☑ Wire Brush ☑ Other vacuum

Hole cleaning in accordance with manufacturers' printed installation instructions: ☑ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other ______

Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: 27 ([✓ in]/mm) Edge Distance: 9 ([✓ in]/mm)

Embedment (h_{ef}): 19 ([✓ in]/mm) Installation Torque (if required): 100 ([✓ ft-lb]/Nm)

Completed by: KCSkiller (Signature) Date: 6/19/17

Kinsey Skiller (Print) Company: ______

______ (Title)

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Version 02.2014

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Adhesive Anchors Inspection Checklist for Concrete and Masonry

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Project Name: FEWOC D15

Project Location: Purdue Bowen Lab

Weather: ______ Air Temperature: 80 ([✓ °F] / °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: 500 V3

Lot No.: ______

ICC-ES Report No.: ______

Adhesive expiration Date: ___/___/___ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: ______ (# trigger pulls)

Adhesive Tempature: 80 ([✓ °F] / °C) Gel Time: ______ Cure Time: 24 hrs
(per manufacturers installation instructions)

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled ☐ Rebar ☐ Other ______
(Safeset™ only to be used with Hilti HIT-HY 200)

Material: ☑ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: A193 B7 Length: 24 ([✓ in]/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ______

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ______

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ______

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☐ 4000 psi ☑ Other 4500 psi

Base Material Thickness: 30 ([✓ in]/mm)

Base Material Temperature: 80 ([✓ °F] / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8 ([✓ in]/mm) Hole Depth: 19 ([✓ in]/mm)
(core bit diameter, if approved)

Drill Bit Type: ☑ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ______

Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☑ Compressed Air ☐ Hand Pump ☑ Wire Brush ☑ Other vacuum

Hole cleaning in accordance with manufacturers' printed installation instructions: ☑ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other ______

Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: 27 ([✓ in]/mm) Edge Distance: 9 ([✓ in]/mm)

Embedment (h_{ef}): 19 ([✓ in]/mm) Installation Torque (if required): 100 ([✓ ft-lb]/Nm)

Completed by: ______ (Signature) Date: 6/22/17

Kinsey Skillen (Print) Company: ______

______ (Title)

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Adhesive Anchors Inspection Checklist for Concrete and Masonry

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Project Name: FENOC D16

Project Location: Purdue Bowen Lab

Weather: ______ Air Temperature: 80 ([✓ °F]/°C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: 500 V3

Lot No.: ______

ICC-ES Report No.: ______

Adhesive expiration Date: __/__/__ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: ______ (# trigger pulls)

Adhesive Tempature: 80 ([✓ °F]/°C) Gel Time: ______ Cure Time: 24 hrs
(per manufacturers installation instructions)

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled ☐ Rebar ☐ Other ______
(Safeset™ only to be used with Hilti HIT-HY 200)

Material: ☑ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: A193 B7 Length: 24 ([✓ in]/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ______

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ______

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ______

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☐ 4000 psi ☑ Other 4500 psi

Base Material Thickness: 30 ([✓ in]/mm)

Base Material Temperature: 80 ([✓ °F]/°C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8 ([✓ in]/mm) Hole Depth: 19 ([✓ in]/mm)
(core bit diameter, if approved)

Drill Bit Type: ☑ Carbide-Tip Drill Bit ☐ Diamond Core Bit ☐ Hollow Drill Bit ☐ Other ______
(ANSI B212.15-1994) (if appropriate and allowed) (Safeset™ only to be used with Hilti HIT-HY 200)

Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☑ Compressed Air ☐ Hand Pump ☑ Wire Brush ☑ Other vacuum

Hole cleaning in accordance with manufacturers' printed installation instructions: ☑ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other ______

Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: 27 ([✓ in]/mm) Edge Distance: 9 ([✓ in]/mm)

Embedment (h_{ef}): 17 ([✓ in]/mm) Installation Torque (if required): 100 ([✓ ft-lb]/Nm)

Completed by: KO Skiles (Signature) Date: 6/29/17

Kinsey Skiles (Print) Company: ______

______ (Title)

This form is for consideration for use by the responsible 3rd-party inspector.

Adhesive Anchors Inspection Checklist for Concrete and Masonry

Periodic special must be performed where required in accordance with Section 1705.1.1 and Table 1705.3 of the 2012 IBC, or Section 1704.15 of the 2009 IBC and Table 1704.4 or Section 1704.13 of the 2006 or 2003 IBC, whereby periodic special inspection is defined in Section 1702.1 of the IBC and this report. (See Structural Drawings for Inspection requirements)

Project Name: D17 N/A

Project Location: ____________

Weather: ____________ Air Temperature: ________ (°F / °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: ____________

Lot No.: ____________

ICC-ES Report No.: ____________

Adhesive expiration Date: __/__/__ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: ________ (# trigger pulls)

Adhesive Tempature: ________ (°F / °C) Gel Time: ________ Cure Time: ________
(per manufacturers installation instructions)

Adhesive Element

Type: ☐ All-Thread ☐ Internally Threaded ☐ Torque-Controlled (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Rebar ☐ Other ________

Material: ☐ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: ________ Length: ________ (in/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☐ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ________

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ________

Base Material

Base Material Type: ☐ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ________

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☐ 4000 psi ☐ Other ________

Base Material Thickness: ________ (in/mm)

Base Material Temperature: ________ (°F / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: ________ (in/mm) Hole Depth: ________ (in/mm)
(core bit diameter, if approved)

Drill Bit Type: ☐ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ________

Hole Condition: ☐ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☐ Compressed Air ☐ Hand Pump ☐ Wire Brush ☐ Other ________

Hole cleaning in accordance with manufacturers' printed installation instructions: ☐ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☐ Tension ☐ Shear ☐ Overhead ☐ Other ________

Anchor insertion: ☐ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: ________ (in/mm) Edge Distance: ________ (in/mm)

Embedment (h_{ef}): ________ (in/mm) Installation Torque (if required): ________ (ft-lb/Nm)

Completed by: ____________ (Signature) Date: __/__/__

____________ (Print) Company: ____________

____________ (Title)

This form is for consideration for use by the responsible 3rd-party inspector.

Version 02.2014

HILTI **Hilti. Outperform. Outlast.**

Adhesive Anchors Inspection Checklist for Concrete and Masonry

Periodic special must be performed where required in accordance with Section 1705.1.1 and Table 1705.3 of the 2012 IBC, or Section 1704.15 of the 2009 IBC and Table 1704.4 or Section 1704.13 of the 2006 or 2003 IBC, whereby periodic special inspection is defined in Section 1702.1 of the IBC and this report. (See Structural Drawings for Inspection requirements)

Project Name: FENOC Q18

Project Location: Purdu Bowen Lab

Weather: ______ Air Temperature: 80 ([✓ °F] / °C)

CODES
☐ IBC 2003
☐ IBC 2006
☐ IBC 2009
☐ IBC 2012

Seismic Zone/ Seismic Design Category

Adhesive

Product Name/Manufacturer: 500 V3

Lot No.: ______

ICC-ES Report No.: ______

Adhesive expiration Date: __/__/__ ☐ Specified Dispenser ☐ Specified Mixer

Discard Initial Adhesive: ______ (# trigger pulls)

Adhesive Tempature: 80 ([✓ °F] / °C) Gel Time: ______ Cure Time: 24 hrs
(per manufacturers installation instructions)

Adhesive Element

Type: ☑ All-Thread ☐ Internally Threaded ☐ Torque-Controlled (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Rebar ☐ Other ______

Material: ☑ Standard ☐ Stainless Steel ☐ High Strength

Steel Grade/Coating: A193 B7 Length: 24 ([✓ in]/mm)

Rod Diameter: ☐ 3/8" ☐ 1/2" ☐ 5/8" ☑ 3/4" ☐ 7/8" ☐ 1" ☐ 1-1/4" ☐ Other ______

Rebar: ☐ #3 ☐ #4 ☐ #5 ☐ #6 ☐ #7 ☐ #8 ☐ #9 ☐ Other ______

Base Material

Base Material Type: ☑ NW Concrete ☐ LW Concrete ☐ Brick ☐ CMU ☐ Other ______

Base Material Strength: ☐ 2000 psi ☐ 3000 psi ☐ 4000 psi ☑ Other 4500 psi

Base Material Thickness: 30 ([✓ in]/mm)

Base Material Temperature: 80 ([✓ °F] / °C)

Drilling & Hole Cleaning

Drill Bit Diameter: 7/8 ([✓ in]/mm) Hole Depth: 19 ([✓ in]/mm)
(core bit diameter, if approved)

Drill Bit Type: ☑ Carbide-Tip Drill Bit (ANSI B212.15-1994) ☐ Diamond Core Bit (if appropriate and allowed) ☐ Hollow Drill Bit (Safeset™ only to be used with Hilti HIT-HY 200) ☐ Other ______

Hole Condition: ☑ Dry ☐ Water Saturated ☐ Water Filled ☐ Under Water

Hole Cleaning: ☑ Compressed Air ☐ Hand Pump ☐ Wire Brush ☑ Other vacuum

Hole cleaning in accordance with manufacturers' printed installation instructions: ☑ Yes ☐ No

Application

Anchor Application: (please check all that apply) ☑ Tension ☐ Shear ☐ Overhead ☐ Other ______

Anchor insertion: ☑ Twisting motion ☐ Annular gap filled with adhesive ☐ Air Void Free Injection

Anchor Spacing: 27 ([✓ in]/mm) Edge Distance: 9 ([✓ in]/mm)

Embedment (h_{ef}): 19 ([✓ in]/mm) Installation Torque (if required): 100 ([✓ ft-lb]/Nm)

Completed by: KCSkille (Signature) Date: 7/7/17

Kinsey Skillen (Print) Company: ______

______ (Title)

This form is for consideration for use by the responsible 3rd-party inspector.

Version 02.2014

Tests to Determine the Behavior of #11 Bars with Lap Splices – TEST SERIES D

Bowen Laboratory
Purdue University
November 18, 2016

Test Procedure

This procedure refers to the test described in the proposal titled Experimental Study of The Effect of Laminar Cracks on Strength and Ductility 79-in Splices of #11 Reinforcing Bars submitted to FirstEnergy Corporation (Sozen & Pujol, 2016). Test procedures are specified in this document.

1. Fabrication

1.1 Formwork

The formwork shall be made using non-absorbent plywood. Its interior shall be caulked to prevent water leakage and it shall be covered with a thin layer of oil before casting. The dimensions of the formwork shall be checked and recorded using Form 1.

1.2 Reinforcement Cages

The steel reinforcement cages shall be built following the attached drawings and forms. Reinforcing bars shall be supported by steel chairs placed as shown in the drawings, Form 2. To ensure alignment, the bars shall be tied to chairs and to one another using 16-gage steel wire. The location of the reinforcement shall be recorded using Form 1. The locations of wire ties and reinforcement markings, if any, shall be recorded using Form 2.

Tolerances (within the test region) are:

3/16" for horizontal cover and horizontal spacing measured to the surface of the bar (excluding ribs)
1/4" for vertical distances shown in Form 1

All other tolerance shall follow ACI 117.

1.3 Casting

Fresh concrete properties to be measured include:

Unit Weight

Slump
Air Content

Each measurement will be performed by a third party using calibrated equipment. These measurements shall be made following ASTM C138, ASTM C143, ASTM C231 and recorded using Form 3.

Slump shall be measured before any other activity related to casting takes place to make sure that the delivered mix has satisfactory workability. The mixing truck shall deliver a ticket with the batched mix weights. These weights shall be examined to corroborate that the delivered mix has the specified proportions. Concrete shall not be accepted if it arrives more than 45 min. after leaving the batching plant. No water shall be added to the mix after the truck leaves the plant.

Specimens and cylinders shall be cast and vibrated in two lifts following ASTM C192. The vibrators to be used shall have the following cross-sectional dimensions:

For cylinders:	3/4" - 7/8"
For Larger Specimens:	1-3/4"

Their frequencies shall be between 50 and 200 Hz.

Excess concrete shall be removed off the formwork. The exposed surfaces of the specimens shall be finished using cast magnesium floats. Lifting inserts shall be inserted in the fresh concrete as soon as the finishing is completed.

Each test specimen shall be cast using concrete from a single mixing truck. A complete set of concrete samples (cylinders) shall be obtained from each truck. Test specimens and samples shall be marked with a number referring to the truck from which they were cast and the date of casting. In each casting day, trucks shall be numbered sequentially starting at 1. The number assigned to a truck shall be written clearly on the mix ticket describing the mix proportions for the batch. Test specimens shall be cast and tested oriented in the North-South axis of the laboratory. Specimen ends facing North during casting shall face North during testing. During finishing, the North end of each specimen shall be marked with the letter N.

These activities shall be documented using Form 3.

1.4 Curing

As soon as casting is completed all specimens shall be covered with impermeable sheets. When the concrete surface sets, wet burlap shall be inserted between these sheets and the exposed concrete. All formwork and molds shall be struck no later than three days after the cast.

All exposed concrete surfaces shall be covered by wet burlap and impermeable sheets for a total of at least seven days after casting.

Burlap shall be doused with water at least every other day during the curing period.

Curing activities shall be logged using Form 4.

Test cylinders shall be stored and cured next to the test specimens and under similar conditions of temperature and humidity.

The variation of concrete strength with time shall be monitored and recorded using Form 5 and 5B.

2. Calibration

Three types of measurements will be made: displacement, force, air content.

The apparatuses to be used to calibrate sensors to measure these quantities are:

Displacement Sensors: INSTRON Universal Testing Machine:
(S.N.:2630-115/590)
Load Sensors: INSTRON Universal Testing Machine
(S.N.: 120BTE502040)
Air Content: Calibrated Cylinder
(S.N.: To be provided by materials testing technician)

Load and displacement sensors will be calibrated following steps listed below:

1) Connect the sensor to the data-acquisition system that is going to be used in the test
2) Set and record the excitation voltage to the maximum possible value (not exceeding the maxima specified for the data-acquisition system and the sensor)
3) Set the data-acquisition equipment to record voltage
4) Set the gain of the data-acquisition system to the first available level lower than the ratio of the maximum range of the system to the maximum expected output from the sensor.
5) Mount the sensor on the universal testing machine
6) Apply a series of known displacement or force increments to the sensor ranging between 10% and 90% of the rated capacity of the sensor
7) Record the voltage read on the data-acquisition system at each known displacement or force increment
8) Create a plot of change in output voltage vs. change in force or displacement
9) Fit a line to the plot from 7) using “least squares”
10) Record the slope of the line from 8) (sensor sensitivity)

11) Label the cable used in the calibration with the serial number of the sensor

Sensors shall be calibrated before the first test and after the final test. Sensors will be calibrated using the same data acquisition system.

The apparatus used to measure air content of the fresh concrete shall be calibrated following the procedure described in ASTM C231 by a third party.

All calibrations shall be performed by at least two persons: one leading each step and the other checking the work of the first independently. A log of each calibration shall be made using Form 6 and it shall include an estimate of the accuracy of the sensor.

Sensors for which the sensitivity obtained in 9) above deviates by more than 10% from the nominal sensitivity (as reported by the manufacturer) shall not be used in any of the tests.

3. Setup

Each specimen shall be subjected to direct tension applied to the free ends of the bars protruding out of the test region.

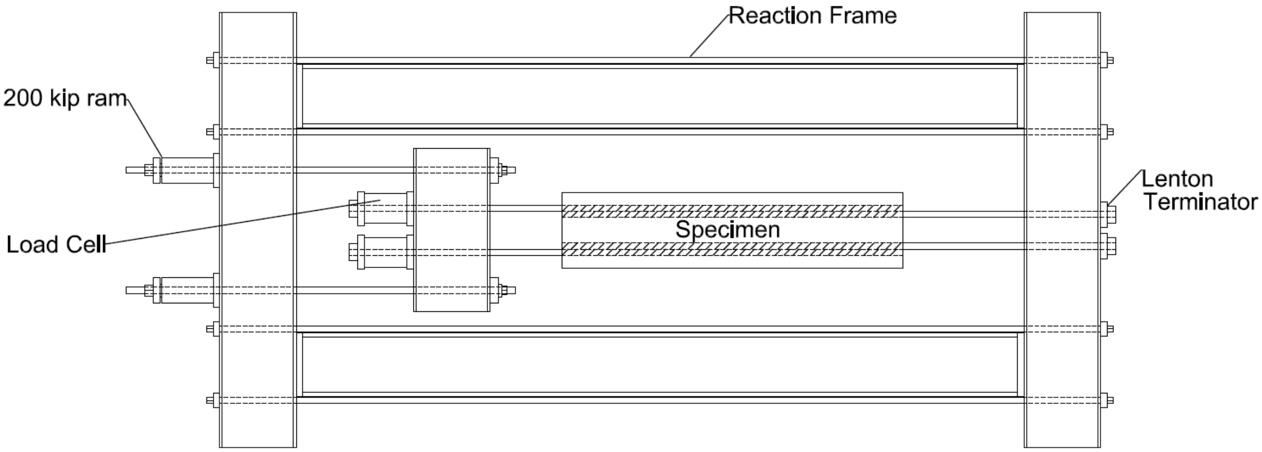


Figure 1. Test Setup plan view (anchors not shown for clarity).

The maximum deviation from nominal setup dimensions shall be ¼ in.

As-built external dimensions of each test specimen shall be recorded using Form 7. The maximum deviation from nominal dimensions in the test region shall be ¼ in.

Forces will be applied using two hydraulic rams (one per bar on one side of the specimen). The rams shall be connected to a single manifold and pump using 10,000-psi hydraulic hoses. All hoses and other hydraulic hardware shall be inspected visually and replaced –if defective- before testing.

4. Instrumentation

Displacement sensors shall be installed across the plane of the lap splices to measure the widths of laminar cracks.

Bar forces will be measured using two force transducers (one per bar) opposite to the hydraulic jacks used to apply load.

All sensors (displacement and force) shall be connected to the data acquisition system using the same cables used during calibration. The excitation voltage and gain shall also be set to the value used in calibration. The data acquisition system shall be set to record voltage changes caused by loading. Before applying load with the hydraulic rams, all sensors shall be set to read a voltage value between 10% and 90% of the voltage output of the sensor at its rated capacity. These voltages shall be referred to as the "zero offsets" of the sensors.

Set the data acquisition system to scan all sensors and save at least one record per sensor every 1 sec.

Record a file of "zero offsets" capturing at least 10 min. of data before any load is applied with the hydraulic system.

Means of initial voltages for all sensors (mean "zero offsets"), sensor serial numbers, the most recent sensitivity constants, excitation voltages, and the channels of the data-acquisition system used for each sensor shall be recorded using Form 8. The pairing of channels and sensors shall be checked by a second person working independently from the person making the initial connections.

Infrared targets used to measure displacements shall be glued to one face of the test specimen, and glued to the protruding bars of one splice using adhesive. The numbering sequence of these targets shall be recorded using Form 9.

Video cameras (one for long-time lapse video and one for high-speed video) will be positioned to capture the response of each specimen. To the extent possible, the location of the cameras shall be the same in all tests.

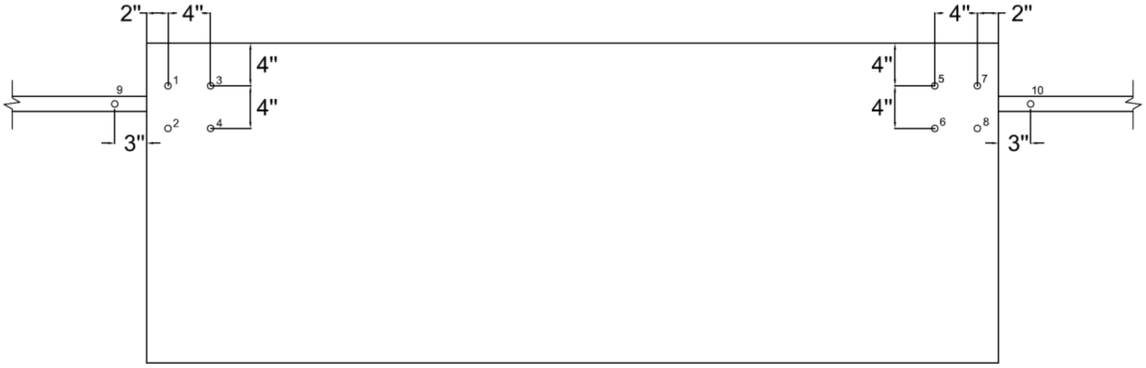


Figure 2) Layout of infrared targets.

5. Testing

The following test schedule shall be followed:

Test Schedule

	ANCHOR		
TEST	LENGTH	SPACING	INITIAL CRACK
1-2	NA	NA	0.06"
3	NA	NA	0.10”
4-5	10"	20"	0.06"
6	10"	20"	0.10"
7-8	10"	40"	0.06"
9	10"	40"	0.10"
10-11	15”	20" or 40"	0.06”
12	15”	20" or 40"	0.10”
13	NA	NA	0.06"
14-15	NA	NA	0.10"
16	10"	20"	0.06"
17-18	10"	20"	0.10"
19	10"	40"	0.06"
20-21	10"	40"	0.10"
22	15”	20" or 40"	0.06”
23-24	15”	20" or 40"	0.10”

Note: ten spare specimens shall be cast (six initially and four later) in case failure takes place before the target crack-width is reached.

Anchor length, spacing, etc. are preliminary and may be adjusted based on the results of testing. Any adjustment to the test schedule shall be as directed by Bechtel Engineering.

The following actions shall take place during each test:

Incremental loadings shall be applied by tensioning the reinforcing bar. The load shall be applied in 10 kip to 20 kip increments until the target crack-width is reached.

At the end of each loading increment:

Record the load.

Mark Cracks: All visible cracks shall be marked using black permanent markers. Cracks shall be marked by drawing lines parallel to them and with an offset of approximately 0.25 in.

Measure Crack Widths: Crack widths shall be measured using crack comparators or graduated handheld microscopes.

Measure coordinates of infrared coordinates: A set of coordinates shall be obtained using an OptoTrak System 600 Pro.

In-Test Data Backup: At every loading increment the data being produced by the data-acquisition system shall be copied to an external hard drive or USB memory.

Photographs: A set of high-resolution photographs shall be obtained after cracks are marked at each loading increment. The photographs shall include views of both elevations of the test specimen and the top concrete surface above lap splices.

The following data shall be recorded throughout each test:

Sensor readings: To be recorded on a hard drive in volts. Conversion to engineering units shall be done after the test as follows:

-Subtract zero offsets
-Divide the result by the sensitivity obtained in the most recent calibration

Lapse video photographs: To be obtained every 5 min.

Actions to be taken at failure

Trigger high-speed camera to record breaking away of the concrete cover and relative movement of the bars.

Actions to be taken after test

Generate a record of sensors that may have malfunctioned or been accidentally moved during the test

Remove from all files recordings from sensors for which the results of the after-test calibration differ by more than 5% from the before-test calibration.

The referenced proposal describes the test procedure. Each specimen shall be loaded until laminar cracks widths of approximately 0.06” and 0.1” are observed. The load shall then be removed and, when applicable (Specimens 4-12 and 16-24), transverse reinforcement (anchor bolts) shall be installed as explained in Section 5.1. Then the load shall be reapplied until failure is obtained.

5.1 Anchor Bolt Installation

ASTM-A193 ¾-in. diameter threaded rods shall be used as anchors. Anchors are to be installed using product HIT-RE 500 V3 1400 Jumbo by Hilti. Installer is to be trained by a representative from Hilti. Installation is to comply with manufacturer’s printed installation instructions (MPII), (Hilti, 2016). 15-in. long anchors are to include a nut and washer (to be torqued to 100 lbf-ft). 10-in. long anchors need not have a nut and a washer.

6. Reporting and Backup

Produce all the captured data in two ways:

By uploading data, photos, and video to datacenterhub.org or ftp.ecn.purdue.edu.

By recording all data, photos, and video on a magnetic hard drive

Reports shall be produced as described in the referenced proposal.

References

1. ASTM C192/C192M-16a Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory, ASTM International, West Conshohocken, PA, 2016.
2. ASTM C138/C138M-16a Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete, ASTM International, West Conshohocken, PA, 2016.
3. ASTM C143/C143M-15a Standard Test Method for Slump of Hydraulic-Cement Concrete, ASTM International, West Conshohocken, PA, 2015.
4. ASTM C231 / C231M-14, Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method, ASTM International, West Conshohocken, PA, 2014.
5. ACI-117, Specification for Tolerances for Concrete Construction and Materials (ACI117-10) and Commentary, American Concrete Institute, Farmington Hills, MI, 2010.
6. Hilti HIT-RE 500 V3 1400 Jumbo, Instructions for use, Doc-Nr: PUB / 5265274 / 000 / 00. Printed January 26, 2016.
7. Sozen M., Pujol S., “An Experimental Investigation of the Effect of Laminar Cracks on Strength of Unconfined 79-In. Lap Splices of #11 Reinforcing Bars.” Proposal to FENOC, Oak Harbor, Ohio. 30 Sep. 2016.

QUALITY CONTROL
SALES AND SERVICES, INC.
5803 West 73rd Street
Indianapolis, Indiana 46278
Phone (317) 299-8855
Fax (317) 299-8960
An ISO / IEC 17025 Calibration Laboratory

A2LA ACCREDITED
CALIBRATION CERT #1498.01

Calibration Report

Property Of: Purdue University
Lafayette, IN
P.O.#: N/A
Tolerance: ±0.00025

Mfr: Fowler
Mfr #: V1004+
Range: 40
Least Division: 0.00005
Unit of Measure: Inches (1 in = 25.4mm)

Serial #: HG01 / 1045483
Instrument: Height Gage
Report #: 170432-L
Page: 1 of 1

Nominal (OD)	As Found	As Found Error	As Left	As Left Error
0.200	0.19995	-0.00005	0.19995	-0.00005
0.400	0.39990	-0.00010	0.39990	-0.00010
0.600	0.60000	0.00000	0.60000	0.00000
0.800	0.80000	0.00000	0.80000	0.00000
1.000	1.00000	0.00000	1.00000	0.00000
2.000	1.99995	-0.00005	1.99995	-0.00005
3.000	3.00000	0.00000	3.00000	0.00000
4.000	4.00000	0.00000	4.00000	0.00000
5.000	4.99990	-0.00010	4.99990	-0.00010
6.000	6.00000	0.00000	6.00000	0.00000
7.000	6.99990	-0.00010	6.99990	-0.00010
8.000	8.00000	0.00000	8.00000	0.00000
10.000	9.99990	-0.00010	9.99990	-0.00010
12.000	11.99995	-0.00005	11.99995	-0.00005
16.000	16.00000	0.00000	16.00000	0.00000
20.000	19.99995	-0.00005	19.99995	-0.00005
24.000	24.00000	0.00000	24.00000	0.00000
30.000	30.00000	0.00000	30.00000	0.00000
36.000	36.00000	0.00000	36.00000	0.00000
40.000	39.99985	-0.00015	39.99985	-0.00015

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of K=2. ±0.000460".
We certify that these gages were compared to masters traceable to the International System of Units (SI) through the National Institute of Standards and Technology (NIST). Tolerances & Calibration in accordance with ISO /IEC 17025, ISO 10012-1, ANSI /NCSL Z540-1, & Git #14.0
Equipment Used: QC003 Dated 9/16, Due 9/18; QC1 Dated 9/16, Due 9/17.
Surface Plate 14997 Dated 12/16, Due 12/17.

As Found: Used.

Environment: Temperature: 67.6-68.6°F Humidity: 25-50%

Original Calibration: 4/22/2017
Your Suggested Recalibration: 4/22/2018
Factors may occur affecting the calibration before your suggested recalibration date.

Calibrated By:
David A. Kerr , Calibration Technician

Inspected By:

See reverse side for further explanations.

This report must not be reproduced, except in full, without written approval of QCSS.

QC15 Revision 9/12

CERTIFICATE OF CALIBRATION

ISSUED BY: INSTRON CALIBRATION LABORATORY

DATE OF ISSUE: 09-Dec-15 CERTIFICATE NUMBER: **340120915110036**

NVLAP Lab Code 200301-0

Instron
825 University Avenue
Norwood, MA 02062-2643
Telephone: (800) 473-7838
Fax: (781) 575-5750
Email: service_requests@instron.com

Page 1 of 4 pages

APPROVED SIGNATORY

Date of Calibration: **09-Dec-15** **Customer Requested Due Date:** **31-Dec-16**

* * * CALIBRATION RESULTS * * *

Type of Calibration: Strain **Relevant Standard:** ASTM E83-10a
System ID: 120BTE502040 **Transducer ID:** 2630-115/590

Indicator 1. - Digital Readout (strain)
PASSED Class B-1 - 100% Range in Tension mode

Customer

Name:	PURDUE UNIVERSITY
Address:	US 231 BOWEN LABORATORY WEST LAFAYETTE,IN 47907 KBROWER@PURDUE.EDU
P.O./Contract No.:	
Contact:	KEVIN BROWER

Machine

Manufacturer:	SATEC
Serial Number:	120BTE502040
System ID:	120BTE502040
Range Type:	Single

Transducer

Manufacturer:	INSTRON
Transducer ID:	2630-115/590
Extensometer Type:	Type 1
Travel (Tension):	1 in
Travel (Compression):	0.1 in
Gauge Length:	2 in
Mode:	Static (Tension/Compression)

Certification Statement

All indicators listed above were verified on-site at customer location by Instron in accordance with ASTM E83.

The verification and equipment used conform to a controlled Quality Assurance program which meets the specifications outlined in ANSI/NCSL Z540-1, ISO 10012, ISO 9001:2008 and ISO/IEC 17025:2005.

The testing machine was verified in the 'as found' condition.

Instron Calpro Version 3.30

The results indicated on this certificate and the following report relate only to the items verified. If there are methods or data included that are not covered by the NVLAP accreditation it will be identified in the comments. Any limitations of use as a result of this verification will be indicated in the comments. This report must not be used to claim product endorsement by NVLAP or the United States government. This report shall not be reproduced, except in full, without the approval of the issuing laboratory.

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915110036

Summary of Results

Indicator 1. - Digital Readout (strain)

Range Full Scale (%)	Tested Range (in)	Mode	System Class*	Resolution (strain)	Resolution Class	ASTM E83 Lower Limit (in)
100	0.1002 to 1.00369	Tension	B-1	0.00001	A	0.002

** System Class for a range is the worst of the following classes: gauge length class, resolution class, individual point error class, repeatability class and is also based on the measurement capability of the laboratory.*

Gauge Length Measurement and Classification

Nominal Gauge Length (in)	Actual Gauge Length (in)	Measurement Type	Relative Error of Gauge Length for Each Measurement Made (%)			ASTM E83 Gauge Length Class	Uncertainty of Measurement* (in)
2	1.99865	Indirect	-0.229	-0.117	0.143	B-1	0.0032

** The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%.*

Data Summary and Classification

Indicator 1. - Digital Readout (strain)

	Run 1 Error		**Run 2 Error**				
% of Range	Fixed (strain)	Relative (% of strain)	Fixed (strain)	Relative (% of strain)	Repeat Error (strain)	Worst Class	Uncertainty of Measurement* (strain)
100% Range (Full Scale: 1.00369 in)							
10	-0.00018	-0.354	-0.00010	-0.199	0.00008	B-1	0.000093
20	-0.00043	-0.427	-0.00047	-0.466	0.00004	B-1	0.00017
40	-0.00082	-0.406	-0.00097	-0.482	0.00015	B-1	0.00033
70	-0.00059	-0.168	-0.00035	-0.101	0.00024	B-1	0.00058
100	-0.00184	-0.367	-0.00156	-0.311	0.00028	B-1	0.00082

** The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%.*

Data

Indicator 1. - Digital Readout (strain)

	Run 1		**Run 2**	
% of Range	Indicated (strain)	Applied (in)	Indicated (strain)	Applied (in)
100% Range (Full Scale: 1.00369 in)				
	Run Temperature: 67.6 °F		Run Temperature: 69.8 °F	
0	0	-0.000001	0	0.000000
10	0.050027	0.100410	0.05	0.100200
20	0.1	0.200858	0.1	0.200936
40	0.2	0.401631	0.2	0.401937

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915110036

Data

Indicator 1. - Digital Readout (strain)

	Run 1		**Run 2**	
% of Range	Indicated (strain)	Applied (in)	Indicated (strain)	Applied (in)
100% Range (Full Scale: 1.00369 in)				
	Run Temperature: 67.6 °F		Run Temperature: 69.8 °F	
70	0.35	0.701182	0.35	0.700708
100	0.5	1.003686	0.5	1.003124

Verification Equipment

Make/Model	Serial Number	Description	Calibration Agency	Measurement Range	Cal Date	Cal Due
Extech 445580	1041758	temp. indicator	Masy Systems Inc.	NA	13-Feb-15	13-Feb-17
Epsilon 3590VHR	A5010 (ASTM)	disp. indicator	Epsilon Technology	2.00 in	29-Jan-15	29-Jan-16
Instron US Gauge Bar	I902 (ASTM)	gauge bar	A.A. Jansson	NA	29-May-14	29-May-16
Interface 9840	93112	force indicator	Instron	NA	24-Sep-14	24-Sep-16

Verification Equipment Usage

Measurement Type	Serial Number	Range (% of FS)	Mode	Percent(s) of Range	Accuracy (+/-)
Displacement	A5010 (ASTM)	100	T	10/ 20	0.00004 in
				40/ 70	0.000075 in
				100	0.00015 in
Gauge Length	93112	NA		NA*	0.015% of reading
	A5010 (ASTM)	NA		NA*	0.00004 in
	I902 (ASTM)	NA		NA*	0.00021 in
Temperature	1041758	All		All	1.8 °F

** Refer to Gauge Length Measurement and Classification section for usage.*

Instron standards are traceable to the SI (The International System of Units) through standards maintained by the National Institute of Standards and Technology (NIST) or other internationally recognized National Metrology Institutes (NMIs).

The accuracy of the verification equipment used was equal to or better than the accuracy indicated in the table above.

Comments

Verified by: Rich Binford
Field Service Engineer

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915110036

NOTE: Clause 9 of ASTM E-83 states; It is recommended that extensometer systems be verified annually or more frequently if required. In no case shall the time interval between verifications exceed 18 months (unless an extensometer is being used in a long-time test running beyond the 18 month period). An extensometer system shall not be used after an adjustment or repair that could affect its accuracy without first verifying its accuracy utilizing the procedure described in this practice.

CERTIFICATE OF CALIBRATION

ISSUED BY: INSTRON CALIBRATION LABORATORY

DATE OF ISSUE: 09-Dec-15 CERTIFICATE NUMBER: **340120915102905**

NVLAP Lab Code 200301-0

Instron
825 University Avenue
Norwood, MA 02062-2643
Telephone: (800) 473-7838
Fax: (781) 575-5750
Email: service_requests@instron.com

APPROVED SIGNATORY

Type of Calibration: **Force**
Relevant Standard: **ASTM E4-14**
Date of Calibration: **09-Dec-15** **Customer Requested Due Date:** **31-Dec-16**

Customer

Name:	PURDUE UNIVERSITY
Address:	US 231 BOWEN LABORATORY WEST LAFAYETTE,IN 47907 KBROWER@PURDUE.EDU
P.O./Contract No.:	
Contact:	KEVIN BROWER

Machine

Manufacturer:	SATEC
Serial Number:	120BTE502040
System ID:	120BTE502040
Range Type:	Single

Transducer

Manufacturer:	SATEC
Transducer ID:	120BTE502040
Capacity:	120000 lbf
Type:	Compression

Classification

1. Digital Readout - PASSED**

Certification Statement

This certifies that the forces verified with machine indicator(s) (listed above) that passed are WITHIN ±1% accuracy, 1% repeatability, and zero return tolerance.
All machine indicators were verified on-site at customer location by Instron in accordance with ASTM E4.
The certification is based on runs 1 and 2 only. A third run is taken to satisfy uncertainty requirements according to ISO 17025 specifications.
The verification and equipment used conform to a controlled Quality Assurance program which meets the specifications outlined in ANSI/NCSL Z540-1, ISO 10012, ISO 9001:2008 and ISO/IEC 17025:2005.

**** within ±0.5% accuracy and 0.5% repeatability.**

Method

The testing machine was verified in the 'as found' condition with no adjustments carried out.

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915102905

Summary of Results

Temperature at start of verification: 71.20 °F.

Indicator 1. - Digital Readout (lbf)

Range Full Scale (%)	Tested Force Range (lbf)	Mode	ASTM E4 Max Error (%)	ASTM E4 Max Repeat Error (%)	Zero Return	Resolution (lbf)	ASTM E4 Lower Limit (lbf)
100	-1196.65 to -119941.1	C	0.28	0.19	Pass	1	200

Temperature at end of verification: 71.20 °F.

Data Point Summary - Indicator 1. - Digital Readout (lbf)

COMPRESSION

% of Range	Run 1 Error (%)	Run 2 Error (%)	Run 3 Error (%)	ASTM E4 Repeat Error (%)	Relative Uncertainty* (%)	Uncertainty of Measurement* (± lbf)
100% Range (Full Scale: -119941.1 lbf)						
1	0.28	0.26	0.29	0.02	0.14	1.6
2	0.15	0.16	0.16	0.01	0.13	3.1
4	0.03	0.03	0.03	0.00	0.13	6.1
7	-0.02	-0.01	-0.01	0.01	0.13	11
10	0.11	0.11	0.12	0.00	0.13	15
20	0.14	0.14	0.15	0.00	0.13	31
40	0.10	0.10	0.10	0.00	0.13	61
70	0.21	0.05	0.07	0.16	0.16	137
100	0.24	0.05	0.07	0.19	0.18	211

** The reported expanded uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95%.*

Data - Indicator 1. - Digital Readout (lbf)

COMPRESSION

	Run 1		**Run 2**		**Run 3**	
% of Range	Indicated (lbf)	Applied (lbf)	Indicated (lbf)	Applied (lbf)	Indicated (lbf)	Applied (lbf)
100% Range (Full Scale: -119941.1 lbf)						
0 Return	4		3		12	
1	-1200	-1196.65	-1200	-1196.85	-1200	-1196.55
2	-2400	-2396.45	-2400	-2396.25	-2400	-2396.05
4	-4800	-4798.6	-4800	-4798.4	-4800	-4798.35
7	-8400	-8401.4	-8400	-8400.85	-8400	-8400.8
10	-12000	-11986.44	-12000	-11987.03	-12000	-11985.26
20	-24000	-23967.57	-24000	-23965.8	-24000	-23964.03
40	-48000	-47953.43	-48000	-47950.48	-48000	-47949.89
70	-84000	-83820.71	-84000	-83957	-84000	-83944.02
100	-120000	-119711	-120000	-119941.1	-120000	-119918.68

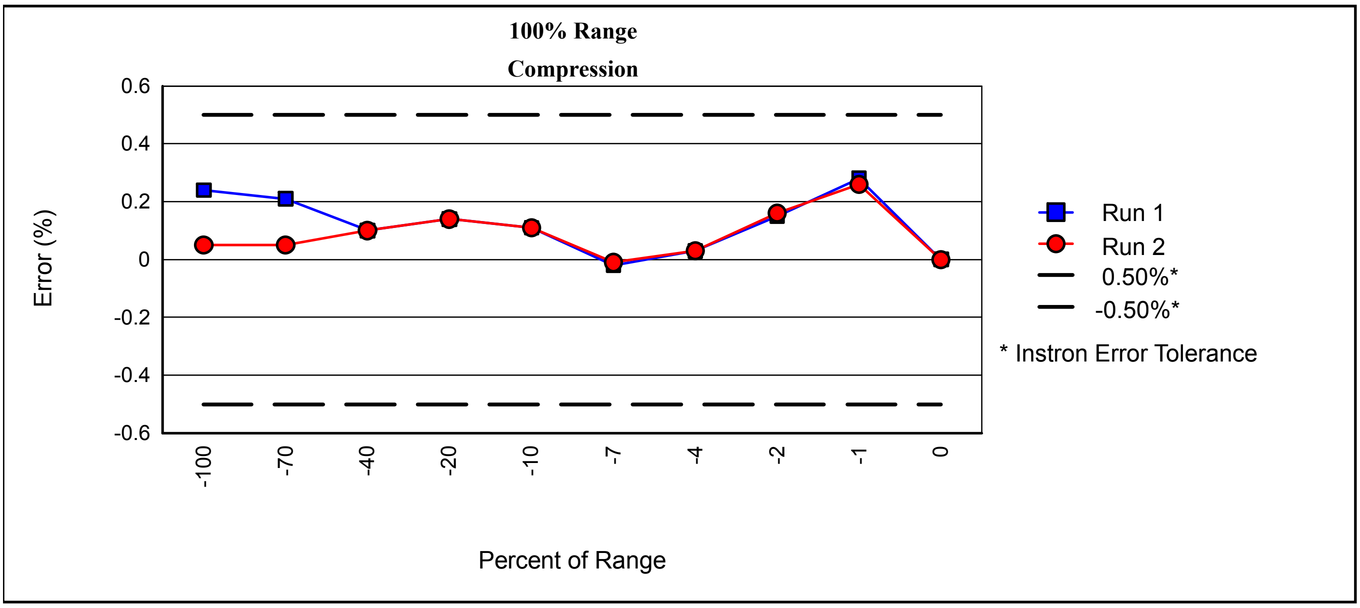
CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915102905

The Return to Zero tolerance is ± the indicator resolution, 0.1% of the maximum force verified in the range, or 1% of the lowest force verified in the range, whichever is greater.

Graphical Data - Indicator 1. - Digital Readout (lbf)



Verification Equipment

Make/Model	Serial Number	Description	Calibration Agency	Capacity	Cal Date	Cal Due
Extech 445580	1041758	temp. indicator	Masy Systems Inc.	NA	13-Feb-15	13-Feb-17
HBM 10KFRR	688077	load cell	Instron	12000 lbf	16-May-14	16-May-16
Interface 9840	93112	force indicator	Instron	NA	24-Sep-14	24-Sep-16
Strainsense 050530	050530	load cell	Instron	120000 lbf	16-Oct-14	16-Oct-16

Verification Equipment Usage

Range Full Scale (%)	Mode	Standard Serial Number	Percent(s) of Range	Lower Limit for Standard (lbf)	Accuracy (+/-)
100	C	688077	1/ 2/ 4/ 7	Class A1: 256	0.1% of reading
		050530	10/ 20/ 40/ 70/ 100	Class A1: 10552	0.1% of reading
All	C	1041758	All	NA	1.8 °F

CERTIFICATE OF CALIBRATION

NVLAP ACCREDITED CALIBRATION LABORATORY No. 200301-0

CERTIFICATE NUMBER:
340120915102905

Instron standards are traceable to the SI (The International System of Units) through standards maintained by the National Institute of Standards and Technology (NIST) or other internationally recognized National Metrology Institutes (NMIs).

The standard Class A lower limit is used for systems with an accuracy of +/-1.0% and the standard Class A1 lower limit is used for systems with an accuracy of +/-0.5%.

The accuracy of the force indicator used with elastic devices is incorporated into the devices stated accuracy.

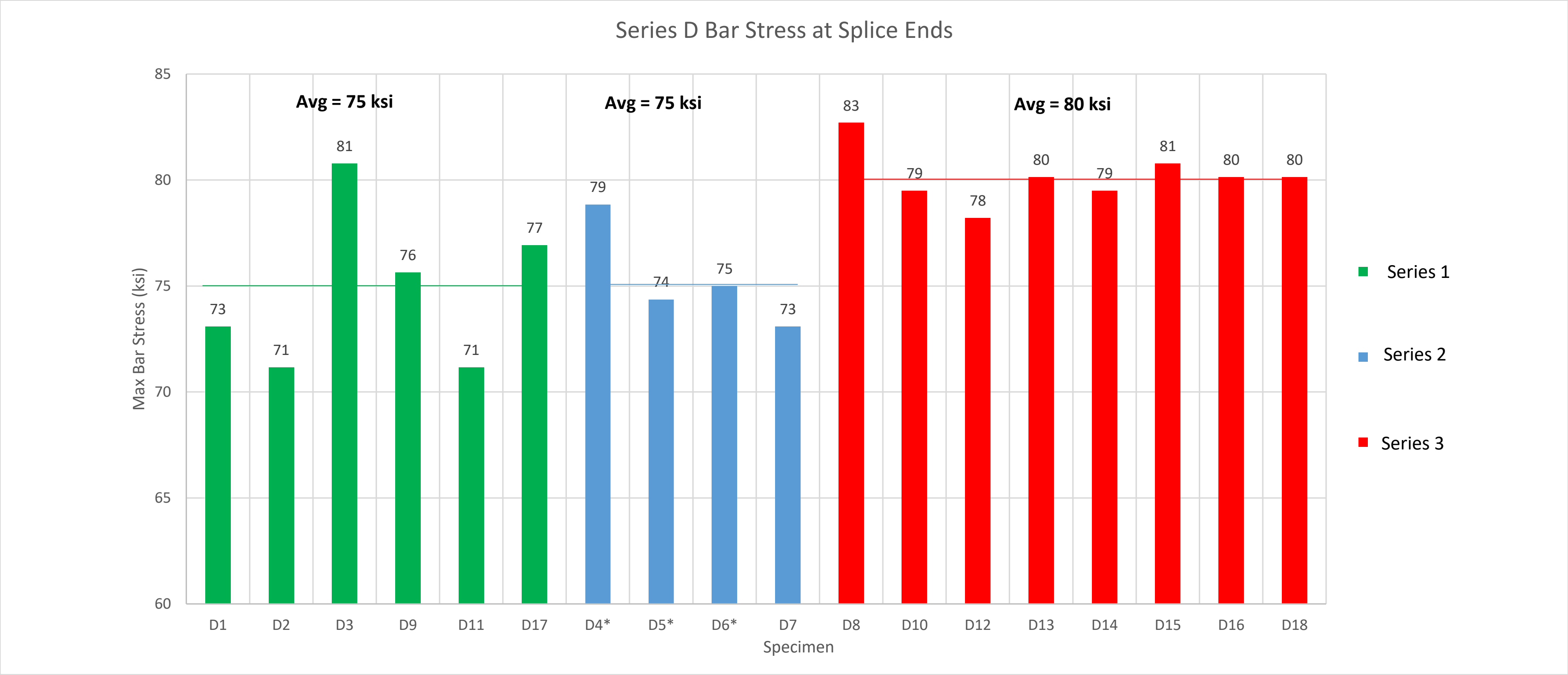
Standard forces have been temperature compensated as necessary.

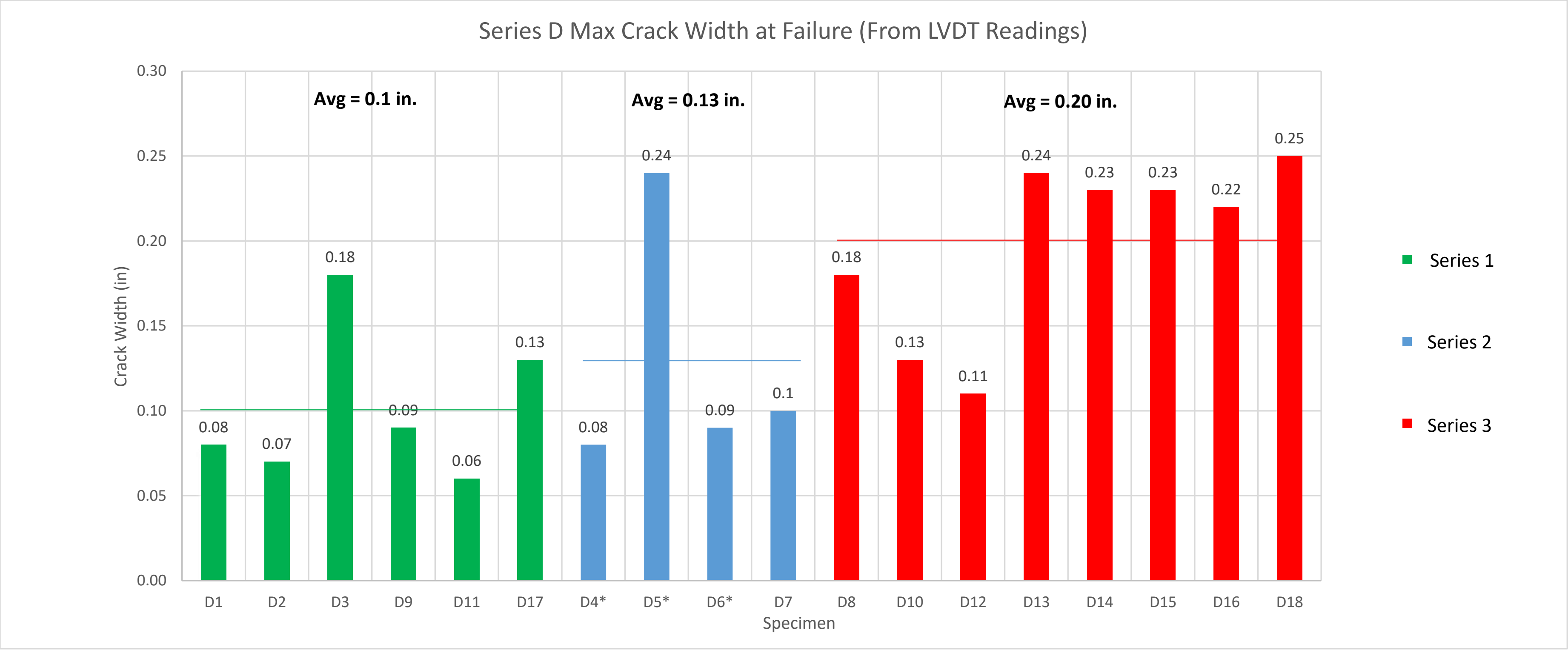
The accuracy of the verification equipment used was equal to or better than the accuracy indicated in the table above.

Comments

Verified by: Rich Binford
Field Service Engineer

NOTE: Clause 19 of ASTM E4 states; It is recommended that testing machines be verified annually or more frequently if required. In no case shall the time interval between verifications exceed 18 months (except for machines in which long term test runs beyond the 18 month period). Testing machines shall be verified immediately after repairs that may in any way affect the operation of the weighing system or values displayed. Verification is required immediately after a testing machine is relocated and where there is a reason to doubt the accuracy of the force indicating system, regardless of the time interval since the last verification.


Series D Bar Stress at Splice Ends
Max Bar Stress (ksi)
85
80
75
70
65
60
Avg = 75 ksi
Avg = 75 ksi
Avg = 80 ksi
73
71
81
76
71
77
79
74
75
73
83
79
78
80
79
81
80
80
D1
D2
D3
D9
D11
D17
D4*
D5*
D6*
D7
D8
D10
D12
D13
D14
D15
D16
D18
Specimen
Series 1
Series 2
Series 3


Series D Max Crack Width at Failure (From LVDT Readings)
Crack Width (in)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Avg = 0.1 in.
Avg = 0.13 in.
Avg = 0.20 in.
0.08
0.07
0.18
0.09
0.06
0.13
0.08
0.24
0.09
0.1
0.18
0.13
0.11
0.24
0.23
0.23
0.22
0.25
D1
D2
D3
D9
D11
D17
D4*
D5*
D6*
D7
D8
D10
D12
D13
D14
D15
D16
D18
Specimen
Series 1
Series 2
Series 3

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D1

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	78-7/8"	79"	80-1/8"	80"	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-3/4"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

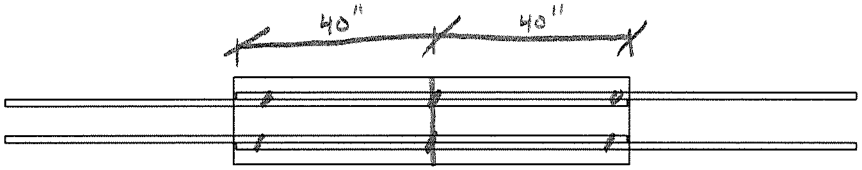
Recorded by:	Signature	Date	Time
Kinsey Skiller		1/11/17	9:35am
Checked by:	Signature	Date	Time
Prateek Shah		1/11/17	9:35am
Checked by:	Signature	Date	Time

Comments:

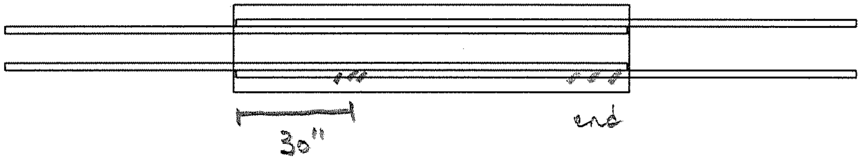
D1

SOUTH NORTH

Wire Ties, Chairs



Bar Marks



BOWEN LABORATORY **PURDUE UNIVERSITY**	Specimen:	Series D Formwork As-builts	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/2/2016	

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D2

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	78-7/8"	78-7/8"	80"	80"	NA	NA	NA	N/A
B-B	4-3/8"	6"	4-1/2"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3-1/8"	6-1/8"	3"	23-3/4"	23-3/4"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3-1/8"	23-5/8"	23-5/8"	30"	30"	17-3/4"

Recorded by:	Signature	Date	Time
Kirsey Skiller		1/11/17	9:40 am
Checked by:	Signature	Date	Time
Prateek Shah	PShah	1/11/17	9:40am
Checked by:	Signature	Date	Time

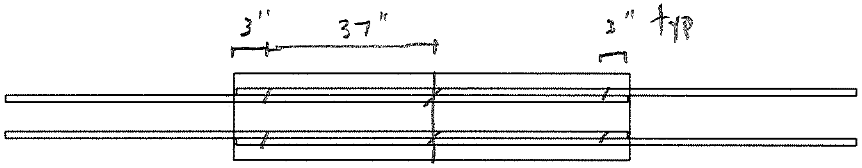
Comments:

D2

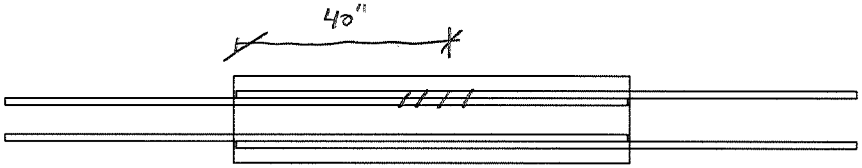
Wire Ties, Chairs

SOUTH

NORTH



Bar Marks



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	Series D Formwork As-builts	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/2/2016		

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D3

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	78-3/4"	79"	80"	80"	N/A	NA	NA	NA
B-B	4-3/8"	6"	4-1/2"	23-5/8"	23-5/8"	30-1/8"	30"	17-3/4"
C-C	3-1/8"	6-1/8"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/11/17	9:50 am
Checked by:	Signature	Date	Time
Prateek Shah		1/11/17	9:50am
Checked by:	Signature	Date	Time

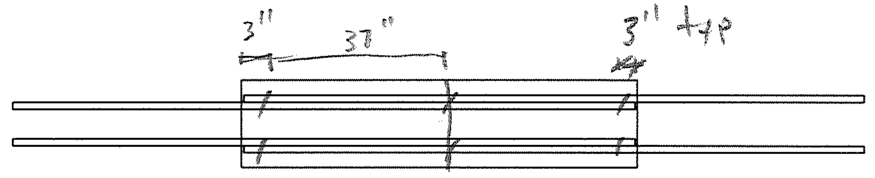
Comments:

D3

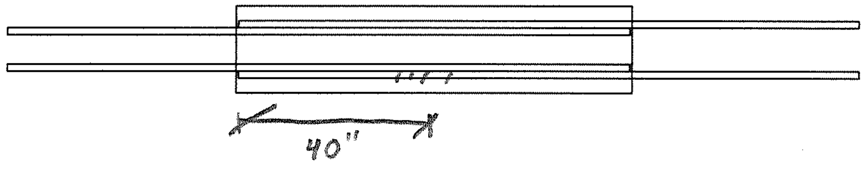
Wire Ties, Chairs

SOUTH

NORTH



Bar Marks



BOWEN LABORATORY PURDUE UNIVERSITY	Specimen:	Series D Formwork As-builts	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/2/2016	

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D4

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80"	NA	NA	NA	NA
B-B	4-3/8"	6"	4-3/8"	23-3/4"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3-1/8"	23-5/8"	23-3/4"	30"	30"	17-5/8"
D-D	3"	6"	3-1/8"	23-5/8"	23-5/8"	30"	30"	17-3/4"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/11/17	9:58 am
Checked by:	**Signature**	**Date**	**Time**
Prateek Shah		1/11/17	9:58am
Checked by:	**Signature**	**Date**	**Time**

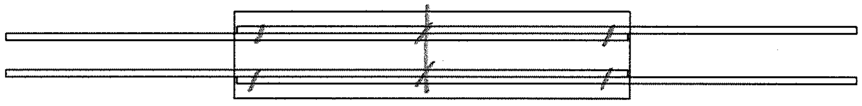
Comments:

D4

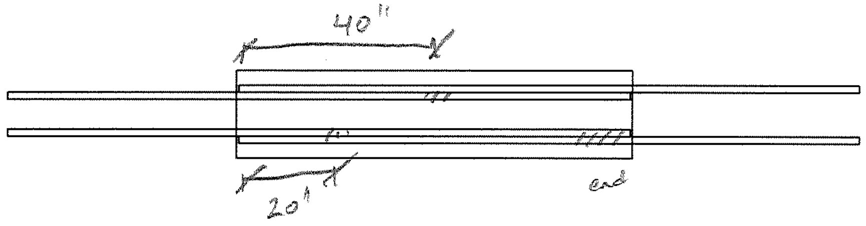
SOUTH

Wire Ties, Chairs

NORTH



Bar Marks



BOWEN LABORATORY PURDUE UNIVERSITY	Specimen:	Series D Formwork As-builts	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/2/2016	

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D5

Sheet 1 of

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79	78-3/4"	80-1/8"	80"	NA	NA	NA	NA
B-B	4-1/2"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3-1/8"	23-5/8"	23-3/4"	30-1/8"	30-1/8"	17-3/4"
D-D	3-1/8"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30-1/8"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/11/12	10:08 am
Checked by:	Signature	Date	Time
Prateek Shah	PShah	1/11/12	10:08 am
Checked by:	Signature	Date	Time

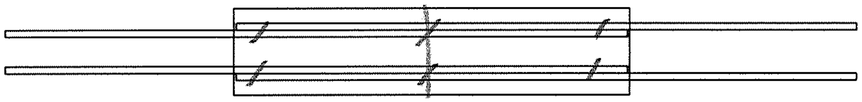
Comments:
All good

D5

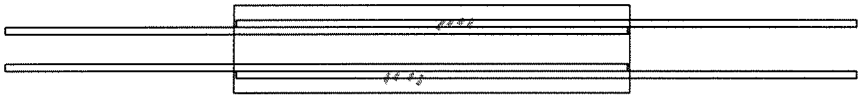
Wire Ties, Chairs

SOUTH

NORTH



Bar Marks



BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	Series D Formwork As-builts	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/2/2016		

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D6

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80-1/8"	80"	NA	NA	NA	NA
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30-1/8"	17-3/4"
C-C	3"	6"	3-1/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3-1/8"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/4"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/11/17	10:15 am
Checked by:	Signature	Date	Time
Prateek Shah		1/11/17	10:15am
Checked by:	Signature	Date	Time

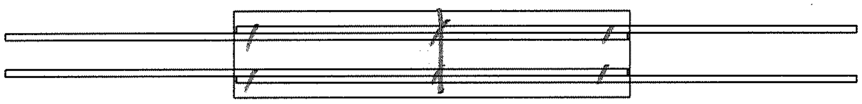
Comments:

D6

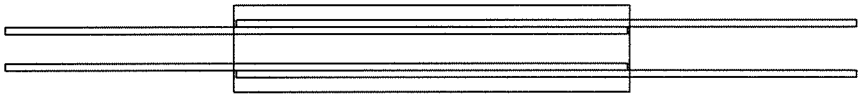
SOUTH

Wire Ties, Chairs

NORTH



Bar Marks



None

BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	Series D Formwork As-builts	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/2/2016		

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D7

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80"	NA	NA	NA	NA
B-B	4-3/8"	6"	4-3/8"	23-3/4'	23-3/4"	30"	30"	17-5/8"
C-C	3"	6-1/8"	3"	23-5/8"	23-3/4"	30"	30"	17-5/8"
D-D	3-1/8"	8-3/4"	3"	23-5/8"	23-3/4"	30-1/8"	30"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/11/17	10:20 am
Checked by:	Signature	Date	Time
Prateek Shah		1/11/17	10:20 am
Checked by:	Signature	Date	Time

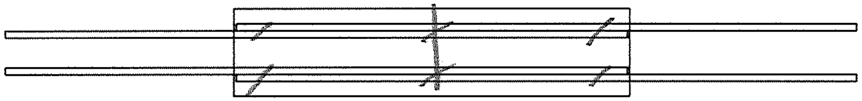
Comments:

D7

SOUTH

NORTH

Wire Ties, Chairs



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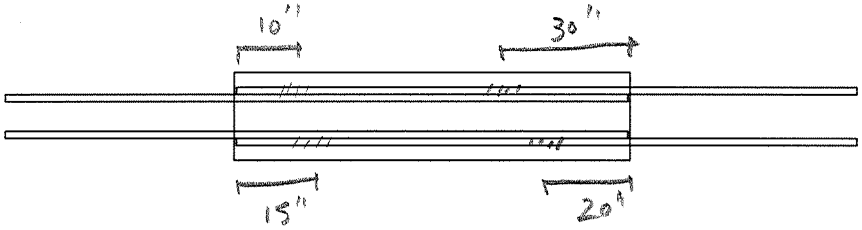


BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	Series D Formwork As-builts	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/2/2016		

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D8

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	78-3/4"	79"	80"	80"	NA	NA	NA	NA
B-B	4-3/8"	6"	4-1/2"	23-5/8"	23-5/8"	30"	30"	17-3/4"
C-C	3"	6"	3-1/8"	23-5/8"	23-3/4"	30"	30"	17-5/8"
D-D	3-1/8"	8-3/4"	3"	23-5/8"	23-3/4"	30"	30"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/11/17	10:32 am
Checked by:	Signature	Date	Time
Prateek Shah		1/11/17	10:32am
Checked by:	Signature	Date	Time

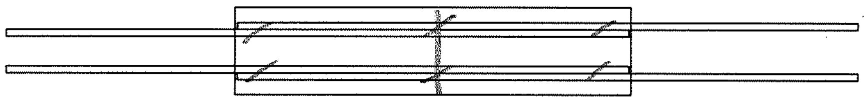
Comments:

D8

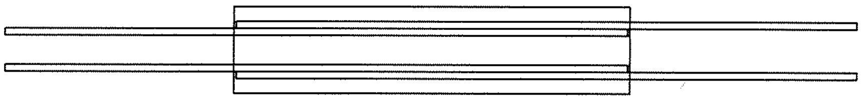
SOUTH

Wire Ties, Chairs

NORTH



Bar Marks



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BOWEN LABORATORY
PURDUE UNIVERSITY

Specimen:	Series D Formwork As-builts	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/2/2016		

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D9

Sheet 1 of

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	78 $\frac{7}{8}$"	79"	80"	80"	N/A	N/A	N/A	N/A
B-B	4-$\frac{1}{2}$"	6"	4-$\frac{3}{8}$"	23-$\frac{3}{4}$"	23-$\frac{5}{8}$"	30"	30"	17-$\frac{5}{8}$"
C-C	3"	6"	3"	23-$\frac{5}{8}$"	23-$\frac{5}{8}$"	30-$\frac{1}{8}$"	30"	17-$\frac{5}{8}$"
D-D	3"	8-$\frac{7}{8}$"	3"	23-$\frac{5}{8}$"	23-$\frac{5}{8}$"	30"	30"	17-$\frac{5}{8}$"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/11/17	11:10 am
Checked by:	Signature	Date	Time
Prateek Shah	PShah	1/11/17	11:10am
Checked by:	Signature	Date	Time

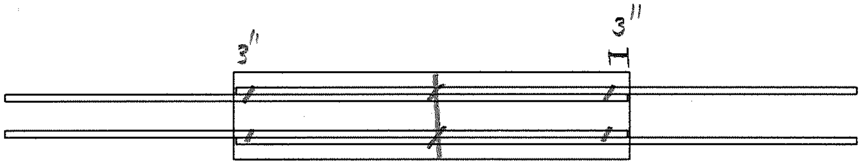
Comments:

D9

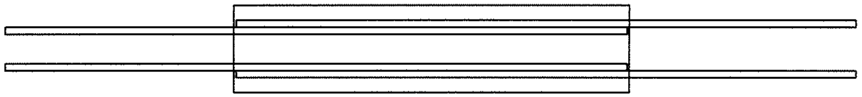
SOUTH

Wire Ties, Chairs

NORTH



Bar Marks



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Specimen:	Series D Formwork As-builts	Sheet:	1	of	1
Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
		Date:	11/2/2016		

PURDUE UNIVERSITY

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D10

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80-1/8"	NA	NA	NA	NA
B-B	4-1/2"	6"	4-1/2"	23-5/8"	23-5/8"	30"	30"	17-3/4"
C-C	3"	6"	3-1/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3-1/8"	8-5/8"	3-1/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skinner		1/11/17	11:15 am
Checked by:	Signature	Date	Time
Prateek Shah		1/11/17	11:15am
Checked by:	Signature	Date	Time

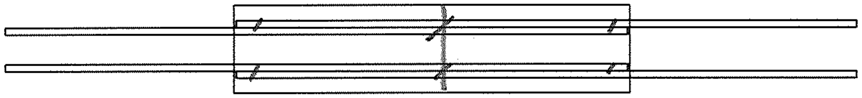
Comments:

D10

SOUTH

Wire Ties, Chairs

NORTH



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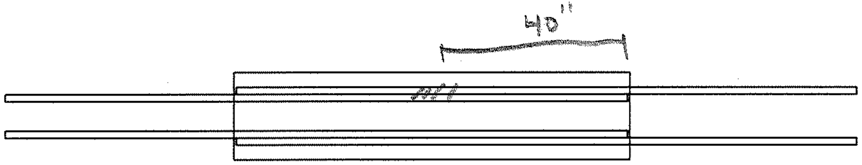


BOWEN LABORATORY PURDUE UNIVERSITY	Specimen:	Series D Formwork As-builts	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/2/2016	

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D11

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	78-7/8"	79"	80"	80"	NA	NA	NA	NA
B-B	4-1/2"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-3/4"
C-C	3"	6"	3-1/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3-1/8"	23-3/4"	23-3/4"	30"	30-1/8"	17-3/4"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/11/17	
Checked by:	Signature	Date	Time
Prateek Shah	PShah	1/11/17	
Checked by:	Signature	Date	Time

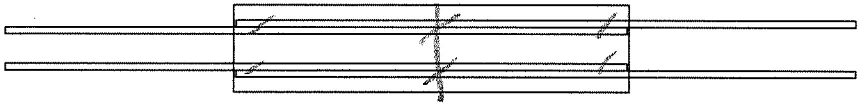
Comments:

L1

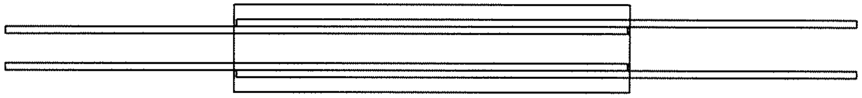
SOUTH

Wire Ties, Chairs

NORTH



Bar Marks



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BOWEN LABORATORY **PURDUE UNIVERSITY**	Specimen:	Series D Formwork As-builts	Sheet:	1	of 1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/2/2016	

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D12

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79"	78-7/8"	80"	80"	NA	NA	NA	NA
B-B	4-1/2"	6"	4-1/2"	23-5/8"	23-5/8"	30"	30-1/8"	17-5/8"
C-C	3-1/8"	6"	3-1/8"	23-5/8"	23-5/8"	30"	30"	17-3/4"
D-D	3"	8-7/8"	3"	23-5/8"	23-3/4"	30"	30-1/8"	17-3/4"

Recorded by:	Signature	Date	Time
Kinsey Skillen		1/11/17	
Checked by:	Signature	Date	Time
Prateek Shah		1/11/17	
Checked by:	Signature	Date	Time

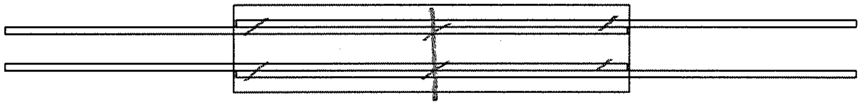
Comments:

D12

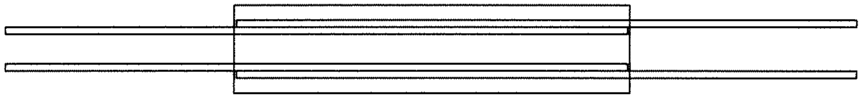
SOUTH

NORTH

Wire Ties, Chairs



Bar Marks



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BOWEN LABORATORY PURDUE UNIVERSITY	Specimen:	Series D Formwork As-builts	Sheet:	1 of	1
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by: SP
			Date:	11/2/2016	

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

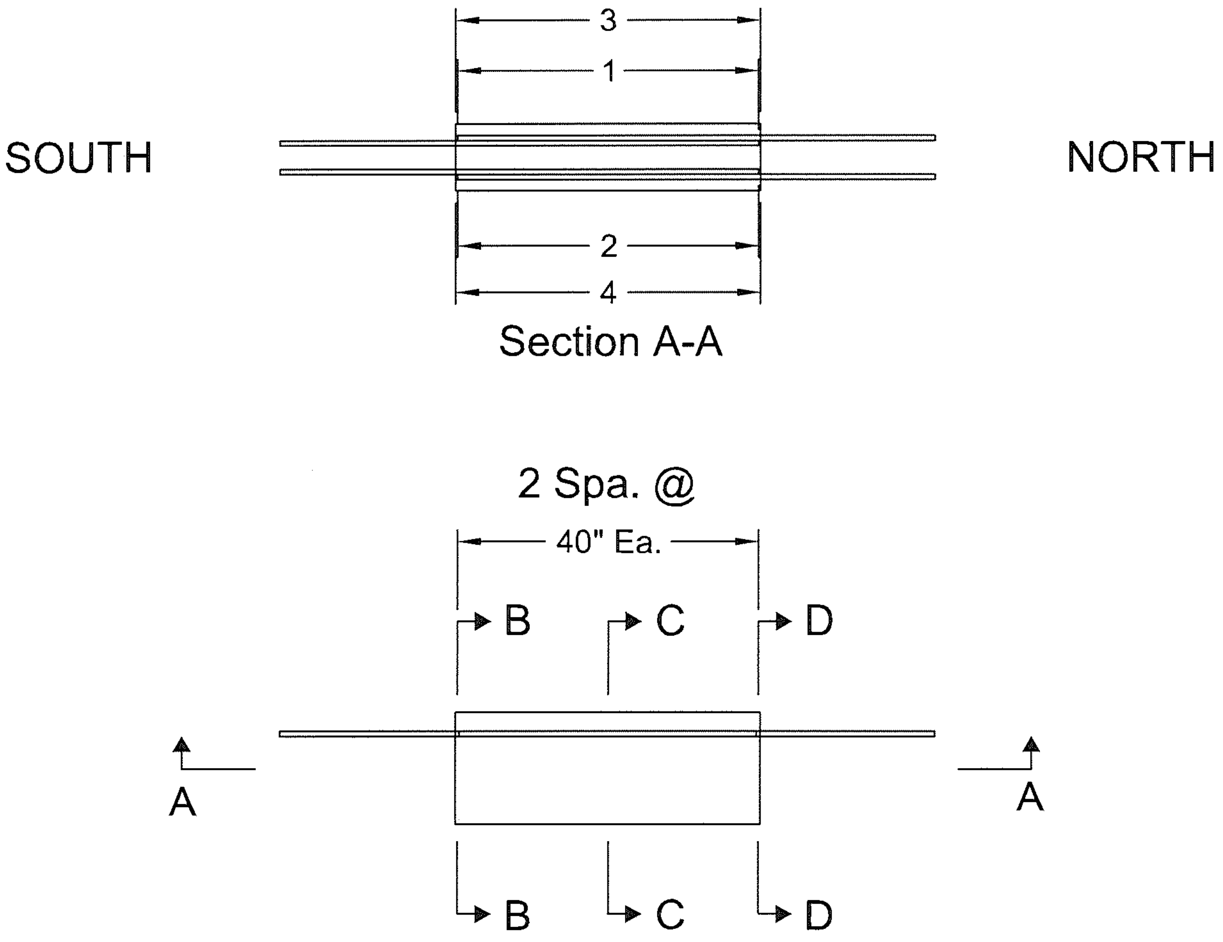
As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen:________________

Sheet 2 of 2

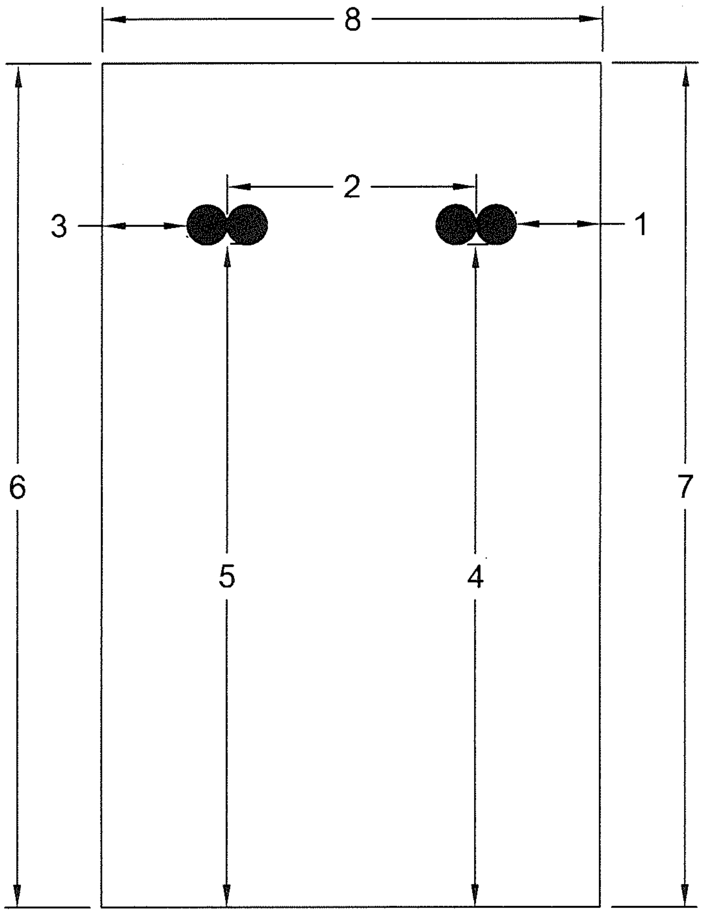
*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80"	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

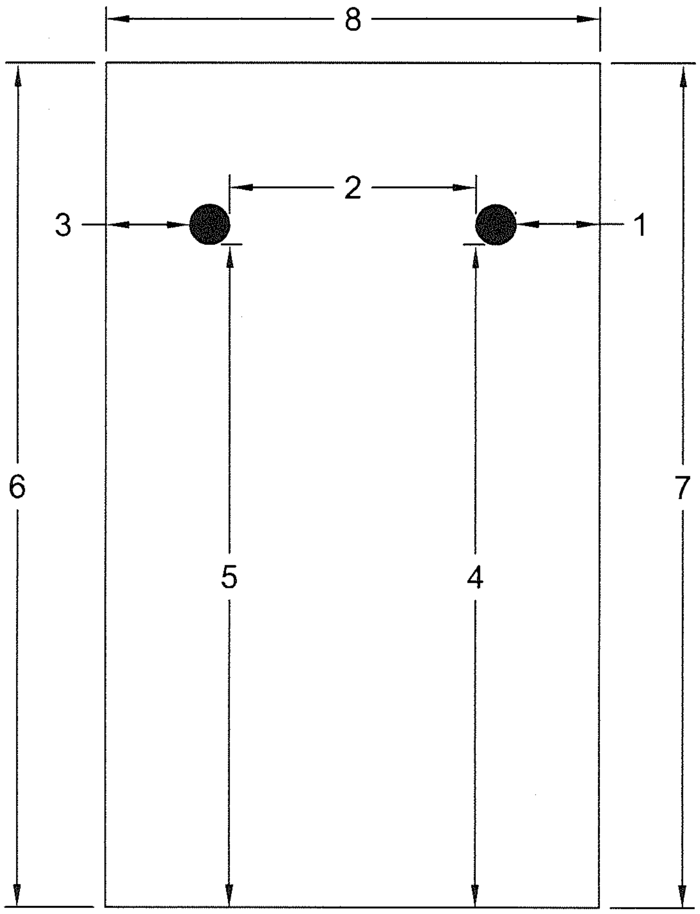


Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D Formwork As-builts	Sheet:	1	of	2
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/2/2016		



Section C-C
*Facing North



Section B-B, D-D
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D Formwork As-builts	Sheet:	2	of	2
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/2/2016		

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D13

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	78-3/4"	79"	80"	80"				
B-B	4-3/8"	6"	4-1/2"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3-1/8"	23-5/8"	23-5/8"	30"	30"	17-3/4"

Recorded by:	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	4/26/17	8:00 am
Checked by:	**Signature**	**Date**	**Time**
Checked by:	**Signature**	**Date**	**Time**

Comments:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D13

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80"	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D14

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80"	—	—	—	—
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-7/8"	3-1/8"	23-5/8"	23-5/8"	30"	30"	17-1/2"

Recorded by:	Signature	Date	Time
Kinsey Skiller	K. C. Skiller	4/26/17	8:12 am

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D14

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80"	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D15

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80"	—	—	—	—
B-B	4-1/2"	6"	4-1/2"	23-1/2"	23-5/8"	30"	30"	17-1/2"
C-C	3"	6"	3-1/8"	23-1/2"	23-5/8"	30-1/8"	30"	17-5/8"
D-D	3"	8-7/8"	7"	23-1/2"	23-5/8"	30"	30"	17-1/2"

Recorded by:	Signature	Date	Time
Kinsey Skillen	K.C. Skillen	4/26/17	8:30 am
Checked by:	**Signature**	**Date**	**Time**
Checked by:	**Signature**	**Date**	**Time**

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D15

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80"	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D16

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	78-7/8"	79"	80"	80"				
B-B	4-1/2"	6"	4-3/8"	23-1/2"	23-3/4"	30-1/8"	30"	17-1/2"
C-C	3"	6"	3-1/8"	23-1/2"	23-5/8"	30-1/8"	30-1/8"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	4/26/17	8:45 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D16

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80"	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D17

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79"	78-$\frac{7}{8}$"	80"	80"				
B-B	4-$\frac{3}{8}$"	6-$\frac{1}{8}$"	4-$\frac{1}{2}$"	23-$\frac{5}{8}$"	23-$\frac{5}{8}$"	30"	30"	17-$\frac{5}{8}$"
C-C	3"	6"	3-$\frac{1}{8}$"	23-$\frac{5}{8}$"	23-$\frac{1}{2}$"	30"	30"	17-$\frac{1}{2}$"
D-D	3"	8-$\frac{3}{4}$"	3"	23-$\frac{3}{4}$"	23-$\frac{3}{4}$"	30"	30"	17-$\frac{5}{8}$"

Recorded by:	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	4/26/17	9:15 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D17

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80"	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D18

Sheet 1 of 2

Section	Formwork As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79-1/8"	80-1/8"	80"	—	—	—	—
B-B	4-1/2"	6"	4-3/8"	23-5/8"	23-3/4"	30-1/8"	36"	17-5/8"
C-C	3"	6-1/8"	3"	23-1/2"	23-1/2"	36"	30"	17-1/2"
D-D	3"	8-3/4"	3-1/8"	23-5/8"	23-3/4"	36"	36"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	4/26/17	9:30 am

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

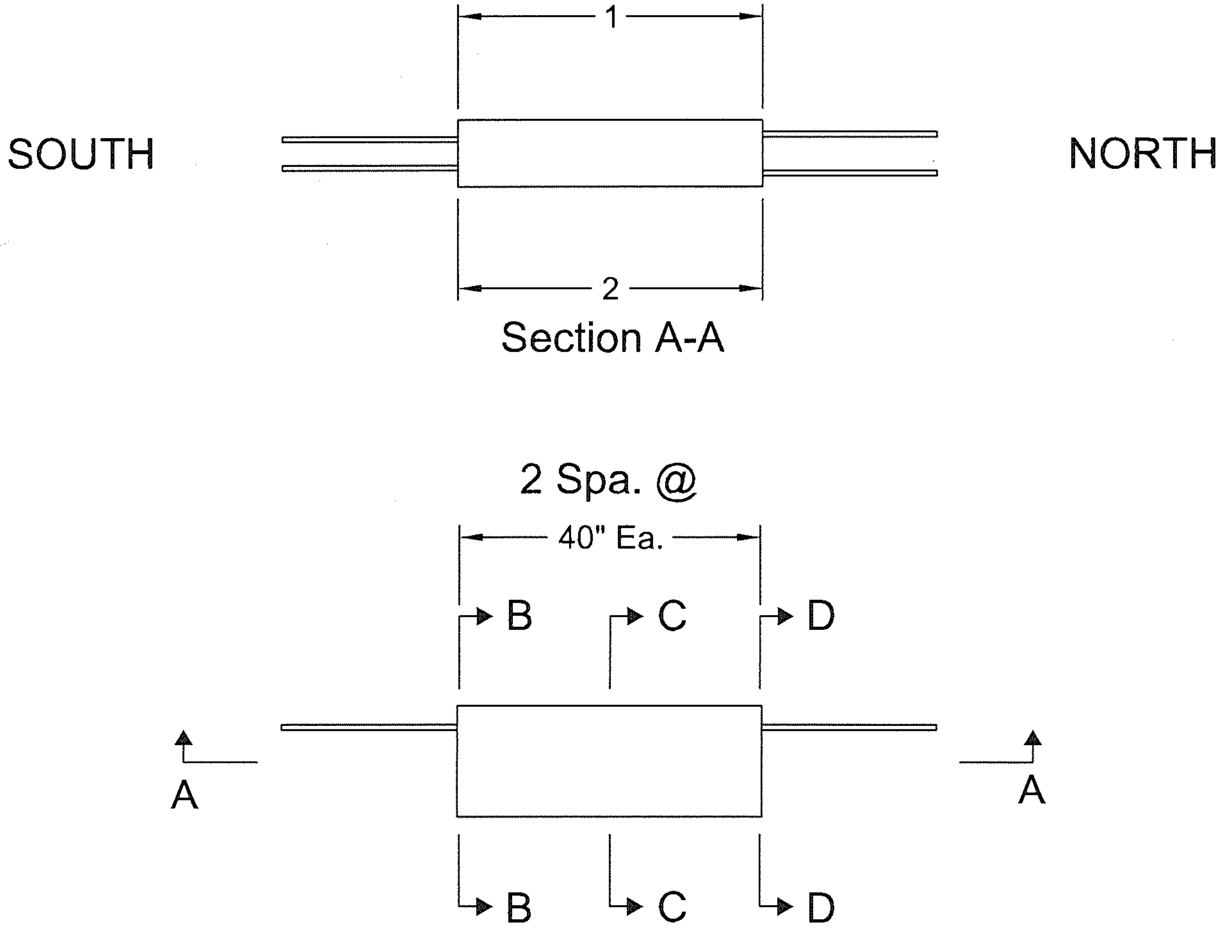
As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D1S

Sheet 2 of 2

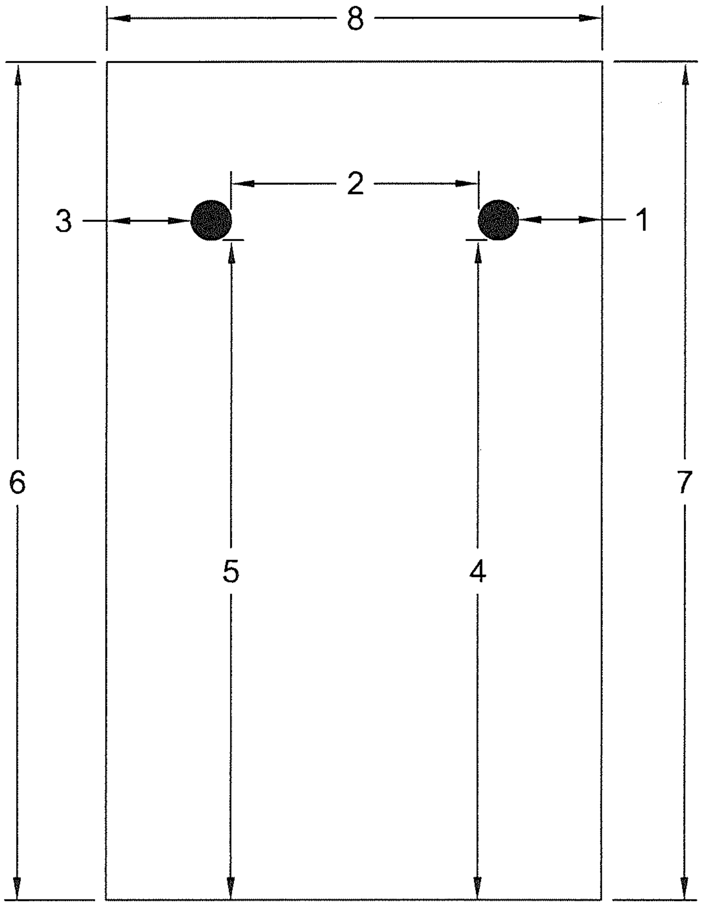
*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	79"	79"	80"	80"	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	3"	6"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"



Series D

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D Concrete As-builts	Sheet:	1	of	2
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/2/2016		



Section B-B, C-C
*Facing North

BOWEN LABORATORY PURDUE UNIVERSITY	Drawing:	Series D Concrete As-builts	Sheet:	2	of	2
	Project:	EXPERIMENTAL INVESTIGATION OF THE EFFECT OF LAMINAR CRACKS ON STRENGTH OF UNCONFINED 79-IN. LAP SPLICES OF #11 REINFORCING BARS	Drawn by:	KCS	Checked by:	SP
			Date:	11/2/2016		

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen:____________________

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"	N/A	N/A	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	N/A	N/A	N/A	N/A	N/A	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D1

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80-1/4"	80-1/8"	—	—	—	—	—	—
B-B	4-1/2"	5-7/8"	4-3/8"	23-3/4"	23-5/8"	30"	30"	17-1/2"
C-C	—	—	—	—	—	30"	30"	17-5/8"
D-D	2-7/8"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-1/2"

Recorded by:	Signature	Date	Time
Kinsey Skiles		1/18/17	6:45 pm
Checked by:	**Signature**	**Date**	**Time**
Checked by:	**Signature**	**Date**	**Time**

Comments:
⟷ See back for nominal dimensions, taken prior to testing.

⟷ depths see slight deviation from nominal value because of the screed + finishing process on the top face.

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D2

Sheet 1 of

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	79-$\frac{7}{8}$"	—	—	—	—	—	—
B-B	4-$\frac{1}{2}$"	6"	4-$\frac{3}{8}$"	23-$\frac{5}{8}$"	23-$\frac{1}{2}$"	30"	30"	17-$\frac{1}{2}$"
C-C	—	—	—	—	—	30"	30-$\frac{1}{8}$"	17-$\frac{5}{8}$"
D-D	3"	9"	2-$\frac{7}{8}$"	23-$\frac{5}{8}$"	23-$\frac{5}{8}$"	30$\frac{1}{8}$"	30"	17-$\frac{5}{8}$"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/18/17	7:00 pm

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D3

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"	—	—	—	—	—	—
B-B	4-3/8"	5-3/4"	4-1/2"	23-5/8"	23-1/2"	30-1/8"	30"	17-5/8"
C-C	—	—	—	—	—	30-1/8"	30"	17-1/2"
D-D	3"	8-3/4"	2-7/8"	23-1/2"	23-1/2"	30"	30"	17-1/2"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/18/17	7:08 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D4

Sheet 1 of

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"						
B-B	4-1/2"	5-7/8"	4-1/2"	23"	23-7/8"	30-1/8"	30-1/8"	17-1/2"
C-C						30"	30-1/8"	17-5/8"
D-D	3"	8-3/4"	2-7/8"	23-7/8"	23-15/16"	30-1/8"	30-1/8"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/13/17	7:19 pm

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D5

Sheet 1 of

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"						
B-B	4-3/8"	6"	4-1/2"	23-3/4"	23-15/16"	30"	30-1/8"	17-5/8"
C-C						30-1/4"	30 1/4"	17-1/2"
D-D	3"	8-7/8"	3"	23-3/4"	23-3/4"	30-1/8"	30"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/18/17	7:27 pm

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D6

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"						
B-B	4-1/2"	6"	4-3/8"	23-3/4"	23-3/4"	30"	30-1/8"	17-1/2"
C-C						30-1/4"	30-1/8"	17-1/2"
D-D	3"	8-7/8"	3"	23-3/4"	23-3/4"	30-1/8"	30"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/18/17	7:36 pm

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D7

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"						
B-B	4-3/8"	5-3/4"	4-3/8"	23-5/8"	23-3/4"	30"	30"	17-5/8"
C-C						30-1/8"	30-1/8"	17-3/4"
D-D	2-3/8"	9"	3"	23-3/4"	23-5/8"	30-1/8"	30"	17-1/2"

Recorded by:	Signature	Date	Time
Kinsey Skillen		1/18/17	8:00pm

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D8

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"						
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-3/4"	30-1/8"	30-1/8"	17-1/2"
C-C						30-1/4"	30-1/4"	17-3/4"
D-D	3"	8-7/8"	3"	23-3/4"	23-3/4"	30-1/4"	30-1/8"	17-1/2"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/18/17	9:00 pm

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D9

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80-1/8"	79-3/4"						
B-B	4-1/2"	6"	4-3/8"	23-3/4"	23-3/4"	30-1/4"	30"	17-1/2"
C-C						30-1/8"	30-1/8"	17-3/4"
D-D	3"	8-3/4"	2-7/8"	23-3/4"	23-1/2"	30-1/4"	30-1/8"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/18/17	9:00 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D10

Sheet 1 of 1

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	79-7/8"						
B-B	4-1/2"	5-7/8"	4-1/2"	25-3/4"	23-11/16"	30-1/8"	30-1/4"	17-5/8"
C-C						30-1/8"	30"	17-1/2"
D-D	2-7/8"	8-3/4"	3-1/8"	23-3/4"	23-3/4"	30"	30"	17-1/2"

Recorded by:	Signature	Date	Time
Kirsey Skiller		1/18/17	9:00 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D11

Sheet 1 of 1

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79-3/4	80"						
B-B	4-1/4"	6-1/8"	4-1/2"	23-3/4"	23-3/4"	30"	30"	17-1/2"
C-C						30-1/8"	30-1/4"	17-3/8"
D-D	2-7/8"	8-3/4"	3-1/8"	23-3/4"	23-5/8"	30"	30-1/4"	17-1/2"

Recorded by:	Signature	Date	Time
Kinsey Skiller		1/18/17	9:00 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D12

Sheet 1 of 1

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"						
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30-1/8"	30-1/8"	17-5/8"
C-C						30-1/8"	30"	17-1/2"
D-D	3"	8-3/4"	2-7/8"	23-5/8"	23-5/8"	30"	30-1/4"	17-1/2"

Recorded by:	Signature	Date	Time
Kinsey Skiller			9:00 pm
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D13

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"						
B-B	4-1/2"	6"	4-3/8"	23-1/2"	23-1/2"	30"	30"	17-1/2"
C-C						30-1/8"	30"	17-5/8"
D-D	3"	8-3/4"	2-7/8"	23-1/2"	23-1/2"	30"	30"	17-1/2"

Recorded by:	Signature	Date	Time
Kinsey Skiller	K. C. Skiller	5/5/17	9:00 am

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D13

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"	N/A	N/A	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	N/A	N/A	N/A	N/A	N/A	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D14

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79-7/8"	80"						
B-B	4-1/2"	6"	4-1/2"	23-1/2"	23-1/2"	70"	29-3/8"	17-1/2"
C-C						30-1/8"	70-1/8"	17-5/8"
D-D	3"	8-3/4"	3"	23-1/2"	23-1/2"	30"	30"	17-1/2"

Recorded by:	Signature	Date	Time
Kinsey Skiller	K. C. Skiller	5/5/17	9:20 am

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D14

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"	N/A	N/A	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	N/A	N/A	N/A	N/A	N/A	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D15

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	79-7/8"						
B-B	4-3/8"	6"	4-1/2"	23-5/8"	23-1/2"	30-1/8"	30"	17-1/2"
C-C						30"	30"	17-1/2"
D-D	3"	8-3/4"	2-7/8"	23-1/2"	23-1/2"	30"	30"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skillen	K. C. Skillen	5/5/17	9:45 am

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D15

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"	N/A	N/A	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	N/A	N/A	N/A	N/A	N/A	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D16

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80-1/8"						
B-B	4-3/8"	6"	4-1/2"	23-1/2"	23-1/2"	30"	30-1/8"	17-1/2"
C-C						30-1/8"	30"	17-5/8"
D-D	3-1/8"	8-3/4"	3"	23-5/8"	23-1/2"	30"	30"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skinner	K.C. Skinner	5/5/17	10:00 am
Checked by:	**Signature**	**Date**	**Time**
Checked by:	**Signature**	**Date**	**Time**

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: 1D16

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"	N/A	N/A	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	N/A	N/A	N/A	N/A	N/A	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D17

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79-7/8"	80"						
B-B	4-1/2"	6"	4-1/2"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C						30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-3/4"	23-3/4"	30-1/8"	30-1/8"	17-1/2"

Recorded by:	Signature	Date	Time
Kinsey Skiller	KC Skiller	5/5/16	10:15

Checked by:	Signature	Date	Time

Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D17

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"	N/A	N/A	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	N/A	N/A	N/A	N/A	N/A	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D18

Sheet 1 of 2

Section	Concrete As-built Dimensions Series D							
	1	2	3	4	5	6	7	8
A-A	79-7/8"	80"						
B-B	4-3/8"	6"	4-1/2"	23-3/4"	23-3/4"	30-1/8"	30"	17-1/2"
C-C						30"	30"	17-5/8"
D-D	3"	8-5/8"	3-1/8"	23-5/8"	23-5/8"	30-1/8"	30"	17-5/8"

Recorded by:	Signature	Date	Time
Kinsey Skillen	K.C Skillen	5/5/17	11:00 am
Checked by:	Signature	Date	Time
Checked by:	Signature	Date	Time

Comments:

Project: Effects of laminars cracks on 79-in
lap splices of #11 reinforcing bars.

As-built Dimensions v.1
(Rev. 11/2/2016)

Specimen: D18

Sheet 2 of 2

*See formwork as-built drawings for dimension locations

Section	Formwork As-built Dimensions Key - Series D							
	1	2	3	4	5	6	7	8
A-A	80"	80"	N/A	N/A	N/A	N/A	N/A	N/A
B-B	4-3/8"	6"	4-3/8"	23-5/8"	23-5/8"	30"	30"	17-5/8"
C-C	N/A	N/A	N/A	N/A	N/A	30"	30"	17-5/8"
D-D	3"	8-3/4"	3"	23-5/8"	23-5/8"	30"	30"	17-5/8"

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: 01
Sheet 1 of 1

Data Acquisition System:								
Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity	Zero Offset	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9902 mV/in	8878	W rotation	1" LVDT
4	1	30 V	LVDT	12838	40941 mV/in	6178 mV	NE	1/4" "
5	1	30 V	LVDT	23618	20349 mV/in	3336 mV	SE	1/2" "
6	1	30 V	LVDT	X00598	9911 mV/in	8623 mV	NW	1" "
7	1	30 V	LVDT	J4914	10003 mV/in	4400 mV	SW	1" "
8	1	30 V	LVDT	X0135	10097 mV/in	6410 mV	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillen		2/13/17	7:00 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity	Zero Offset	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9902 mV/in	-704 mV	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10000 mV/in	7985 mV	NE	1" "
5	1	30 V	LVDT	23618	20349 mV/in	8237 mV	SE	½" "
6	1	30 V	LVDT	X00598	9911 mV/in	7953 mV	NW	1" "
7	1	30 V	LVDT	J4914	10003 mV/in	7452 mV	SW	1" "
8	1	30 V	LVDT	X0135	10097 mV/in	9235 mV	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillen		2/15/17	8:00 am
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D3
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9802	7860	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	7943	NE	1" "
5	1	30 V	LVDT	23618	20349	8051	SE	½" "
6	1	30 V	LVDT	X00598	9911	8537	NW	1" "
7	1	30 V	LVDT	J4914	10003	7697	SW	1" "
8	1	30 V	LVDT	X0135	10097	8074	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller		2/15/17	6:30 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D4-1
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9902	7626	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	7823	NE	1" "
5	1	30 V	LVDT	23618	20349	7460	SE	½" "
6	1	30 V	LVDT	X00598	9911	8068	NW	1" "
7	1	30 V	LVDT	J4914	10003	7125	SW	1" "
8	1	30 V	LVDT	X0135	10097	7195	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillen		2/20/17	3:30 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D4-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9902	-793	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	7381	NE	1" "
5	1	30 V	LVDT	23618	20349	7460	SE	1/2" "
6	1	30 V	LVDT	X00598	9911	8059	NW	1" "
7	1	30 V	LVDT	J4914	10003	7156	SW	1" "
8	1	30 V	LVDT	X0135	10097	97	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillen		2/21/17	6:30 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:
no tare zero offset

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D5-1
Sheet 1 of 1

Data Acquisition System:								
Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	8084	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	8358	NE	1" "
5	1	30 V	LVDT	23618	20349	7874	SE	1/2" "
6	1	30 V	LVDT	X00598	9911	8220	NW	1" "
7	1	30 V	LVDT	J4914	10003	7979	SW	1" "
8	1	30 V	LVDT	X0135	10097	8351	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller		2/22/17	7:00 am
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D5-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	-2117	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	8390	NE	1" "
5	1	30 V	LVDT	23618	20349	7038	SE	1/2" "
6	1	30 V	LVDT	X00598	9911	8218	NW	1" "
7	1	30 V	LVDT	J4914	10003	7606	SW	1" "
8	1	30 V	LVDT	X0135	10097	9061	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillen		2/23/17	10:30 am
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D6-1
Sheet 1 of 1

Data Acquisition System:								
Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset(mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9902	8755	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	6942	NE	1" "
5	1	30 V	LVDT	23618	20349	6841	SE	1/2" "
6	1	30 V	LVDT	X00598	9911	7067	NW	1" "
7	1	30 V	LVDT	J4914	10003	7037	SW	1" "
8	1	30 V	LVDT	X0135	10097	7348	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller		2/23/16	6:00 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D6-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9802	2579	W rotation	1'' LVDT
4	1	30 V	LVDT	8702	10318	6678	NE	1'' "
5	1	30 V	LVDT	23618	20349	6043	SE	½'' "
6	1	30 V	LVDT	X00598	9911	6960	NW	1'' "
7	1	30 V	LVDT	J4914	10003	6924	SW	1'' "
8	1	30 V	LVDT	X0135	10097	3339	E rotation	1'' "

Operator	Signature	Date	Time
Kiasey Skiller		2/24/17	7:30 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D7-1
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity ($\frac{mV}{in}$)	Zero Offset(mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 $\frac{mV}{V}$	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 $\frac{mV}{V}$	0 mV	W	"
3	1	30 V	LVDT	X0167	9902	5125	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	7111	NE	1" "
5	1	30 V	LVDT	23618	20349	7155	SE	½" "
6	1	30 V	LVDT	X00598	9911	6741	NW	1" "
7	1	30 V	LVDT	J4914	10003	6877	SW	1" "
8	1	30 V	LVDT	X0135	10097	5208	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillen		2/26/17	3:30 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D7-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset(mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9802	2321	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	6975	NE	1" "
5	1	30 V	LVDT	23618	20349	6647	SE	½" "
6	1	30 V	LVDT	X00598	9911	6504	NW	1" "
7	1	30 V	LVDT	J4914	10003	6451	SW	1" "
8	1	30 V	LVDT	X0135	10097	-2097	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller		2/28/17	6:45 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D8-1
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity ($\frac{mV}{in}$)	Zero Offset(mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 $\frac{mV}{V}$	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 $\frac{mV}{V}$	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	8620	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10316	7384	NE	1" "
5	1	30 V	LVDT	23618	20349	5229	SE	$\frac{1}{2}$" "
6	1	30 V	LVDT	X00598	9911	7429	NW	1" "
7	1	30 V	LVDT	J4914	10003	3936	SW	1" "
8	1	30 V	LVDT	X0135	10097	8933	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller		3/6/17	1:00 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D8-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity ($\frac{mV}{in}$)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 $\frac{mV}{V}$	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 $\frac{mV}{V}$	0 mV	W	"
3	1	30 V	LVDT	X0167	9902	-3665	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	7052	NE	1" "
5	1	30 V	LVDT	23618	20349	4258	SE	½" "
6	1	30 V	LVDT	X00598	9911	8075	NW	1" "
7	1	30 V	LVDT	J4914	10003	3447	SW	1" "
8	1	30 V	LVDT	X0135	10097	2868	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller		3/7/17	4:30 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D9
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9802	8704	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	7046	NE	1" "
5	1	30 V	LVDT	23618	20349	6800	SE	½" "
6	1	30 V	LVDT	X00598	9911	6679	NW	1" "
7	1	30 V	LVDT	J4914	10003	6248	SW	1" "
8	1	30 V	LVDT	X0135	10097	8870	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller		3/10/17	1:30 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:
failed before anchors could be installed

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D10-1
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity ($\frac{mV}{in}$)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 $\frac{mV}{V}$	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 $\frac{mV}{V}$	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	6953	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	6528	NE	1" "
5	1	30 V	LVDT	23618	20349	5924	SE	½" "
6	1	30 V	LVDT	X00598	9911	7678	NW	1" "
7	1	30 V	LVDT	J4914	10003	7321	SW	1" "
8	1	30 V	LVDT	X0135	10097	7873	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillen		3/14/17	11:00 am
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D10-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity ($\frac{mV}{in}$)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 $\frac{mV}{V}$	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 $\frac{mV}{V}$	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	-3644 mV	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	6489 mV	NE	1" "
5	1	30 V	LVDT	23618	20349	5205	SE	½" "
6	1	30 V	LVDT	X00598	9911	7282	NW	1" "
7	1	30 V	LVDT	J4914	10003	6961	SW	1" "
8	1	30 V	LVDT	X0135	10097	448	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	3/15/17	2:00 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D11
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9802	7722	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	7632	NE	1" "
5	1	30 V	LVDT	23618	20349	5097	SE	½" "
6	1	30 V	LVDT	X00598	9911	6445	NW	1" "
7	1	30 V	LVDT	J4914	10003	7470	SW	1" "
8	1	30 V	LVDT	X0135	10097	5924	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller	KCSkiller	3/17/17	1:00 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D12-1
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity ($\frac{mV}{in}$)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 $\frac{mV}{V}$	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 $\frac{mV}{V}$	0 mV	W	''
3	1	30 V	LVDT	X0167	9902	8925	W rotation	1'' LVDT
4	1	30 V	LVDT	8702	10318	7016	NE	1'' ''
5	1	30 V	LVDT	23618	20349	6995	SE	½'' ''
6	1	30 V	LVDT	X00598	9911	6936	NW	1'' ''
7	1	30 V	LVDT	J4914	10003	6621	SW	1'' ''
8	1	30 V	LVDT	X0135	10097	8985	E rotation	1'' ''

Operator	Signature	Date	Time
Kinsey Skillen	KC Skillen	3/22/17	6:00 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D72-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9902	-558	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	6674	NE	1" "
5	1	30 V	LVDT	23618	20349	6436	SE	½" "
6	1	30 V	LVDT	X00598	9911	6786	NW	1" "
7	1	30 V	LVDT	J4914	10003	6238	SW	1" "
8	1	30 V	LVDT	X0135	10097	2488	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	3/23/17	9:00 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: 13-1
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9902	8278	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	5155	NE	1" "
5	1	30 V	LVDT	23618	20349	5827	SE	½" "
6	1	30 V	LVDT	X00598	9911	5145	NW	1" "
7	1	30 V	LVDT	J4914	10003	6490	SW	1" "
8	1	30 V	LVDT	X0135	10097	8897	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller	KC Skiller	6/14/17	3:00 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: 13-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	-662	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	4864	NE	1" "
5	1	30 V	LVDT	23618	20349	5692	SE	½" "
6	1	30 V	LVDT	X00598	9911	4888	NW	1" "
7	1	30 V	LVDT	J4914	10003	6211	SW	1" "
8	1	30 V	LVDT	X0135	10097	9842	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillen	KCSkillen	6/15/17	5:00 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: 14-1
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset(mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	8549	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	4276	NE	1" "
5	1	30 V	LVDT	23618	20349	7741	SE	½" "
6	1	30 V	LVDT	X00598	9911	6270	NW	1" "
7	1	30 V	LVDT	J4914	10003	3767	SW	1" "
8	1	30 V	LVDT	X0135	10097	1579	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller	KL Skiller	6/19/17	3:15 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: 14-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset(mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	6716	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	3782	NE	1" "
5	1	30 V	LVDT	23618	20349	7609	SE	½" "
6	1	30 V	LVDT	X00598	9911	5996	NW	1" "
7	1	30 V	LVDT	J4914	10003	3614	SW	1" "
8	1	30 V	LVDT	X0135	10097	-4167	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller	KC Skiller	6/20/17	4:30 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D15-1

Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	4093	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	4898	NE	1" "
5	1	30 V	LVDT	23618	20349	7510	SE	½" "
6	1	30 V	LVDT	X00598	9911	6812	NW	1" "
7	1	30 V	LVDT	J4914	10003	4684	SW	1" "
8	1	30 V	LVDT	X0135	10097	5233	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller	KC Skiller	6/22/17	4:00 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: D15-2
Sheet 1 of 1

Data Acquisition System:								
Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9802	-608	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	4611	NE	1" "
5	1	30 V	LVDT	23618	20349	7153	SE	1/2" "
6	1	30 V	LVDT	X00598	9911	6487	NW	1" "
7	1	30 V	LVDT	J4914	10003	4261	SW	1" "
8	1	30 V	LVDT	X0135	10097	-2049	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	6/23/17	5:45 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: 16-1
Sheet 1 of 1

Data Acquisition System:								
Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	5023	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	4877	NE	1" "
5	1	30 V	LVDT	23618	20349	6603	SE	1/2" "
6	1	30 V	LVDT	X00598	9911	7905	NW	1" "
7	1	30 V	LVDT	J4914	10003	6385	SW	1" "
8	1	30 V	LVDT	X0135	10097	3737	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillen	KCSkillen	6/29/17	3:30 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: 16-2
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	-1382	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	4320	NE	1" "
5	1	30 V	LVDT	23618	20349	6386	SE	½" "
6	1	30 V	LVDT	X00598	9911	7354	NW	1" "
7	1	30 V	LVDT	J4914	10003	6085	SW	1" "
8	1	30 V	LVDT	X0135	10097	-1727	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillin	K C Skillin	6/30/17	4:30 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

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(Rev. 11/1/2016)

Specimen: 17
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	7945	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	6365	NE	1" "
5	1	30 V	LVDT	23618	20349	6807	SE	1/2" "
6	1	30 V	LVDT	X00598	9911	7284	NW	1" "
7	1	30 V	LVDT	J4914	10003	8175	SW	1" "
8	1	30 V	LVDT	X0135	10097	8526	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillen	K.C. Skillen	7/5/17	2:45 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: 18-1
Sheet 1 of 1

Data Acquisition System:	

Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity (mV/in)	Zero Offset (mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 mV/V	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 mV/V	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	9800	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	7938	NE	1" "
5	1	30 V	LVDT	23618	20349	7319	SE	1/2" "
6	1	30 V	LVDT	X00598	9911	7073	NW	1" "
7	1	30 V	LVDT	J4914	10003	6746	SW	1" "
8	1	30 V	LVDT	X0135	10097	8789	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skiller	K.C. Skiller	7/6/17	2:15 pm
Checked by	**Signature**	**Date**	**Time**
Checked by	**Signature**	**Date**	**Time**

Notes:

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Instrumentation Documentation v.1
(Rev. 11/1/2016)

Specimen: 18-2
Sheet 1 of 1

Data Acquisition System:								
Channel #	Gain	Excitation V.	Sensor	S.N.	Sensitivity $\left(\frac{mV}{in}\right)$	Zero Offset(mV)	Location	Comments
1	1	10 V	LC	ALU03006	1.0767 $\frac{mV}{V}$	0 mV	E	full scale 112,400 lbf
2	1	10 V	LC	ALU03005	1.0779 $\frac{mV}{V}$	0 mV	W	"
3	1	30 V	LVDT	X0167	9702	5422	W rotation	1" LVDT
4	1	30 V	LVDT	8702	10318	7661	NE	1" "
5	1	30 V	LVDT	23618	20349	7206	SE	½" "
6	1	30 V	LVDT	X00598	9911	7016	NW	1" "
7	1	30 V	LVDT	J4914	10003	6676	SW	1" "
8	1	30 V	LVDT	X0135	10097	4795	E rotation	1" "

Operator	Signature	Date	Time
Kinsey Skillen	KC Skill	7/7/17	3:00 pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Notes:

Calibration Instrument Name and S.N.:	Instron 120BTE502040
Data Acquisition System:	Strainsmart 8000
Gain:	1
Excitation Voltage:	10V
Channel:	1
Sensor:	Load Cell East
Sensor S.N.:	ALU03006

Measurand (lbf)	Voltage (mV/V)	Measurand	Voltage (mV/V)	Measurand	Voltage
0	-.0525	109600	-1.063		
5100	-.1005	119700	-1.162		
19700	-.1925	124750	-1.211		
29700	-.2905				
40050	-.3915				
49900	-.4875				
60000	-.5857				
80000	-.7785				
90000	-.8765				
100200	-.975				

Operator	Signature	Date	Time
Kinsey Skiller	KRo Skiller	2/11/17	3:00pm

Checked by	Signature	Date	Time

Checked by	Signature	Date	Time

Results	Sensitivity	Accuracy
	103.2 Kip/(mV/V)	± 400 lbf

Calibration Instrument Name and S.N.:	Instron 120BTE502040
Data Acquisition System:	Strainsmart 8000
Gain:	1
Excitation Voltage:	10V
Channel:	2
Sensor:	Load Cell West
Sensor S.N.:	AHU03005

Measurand (lbf)	Voltage (mV ✓)	Measurand	Voltage	Measurand	Voltage
0	0	90000	-.857		
5200	-.0535	100600	-.9613		
9800	-.0903	110000	-1.05		
19800	-.1863	120000	-1.145		
30000	-.282	125000	-1.196		
40000	-.377				
50000	-.4763				
59400	-.568				
70000	-.668				
80000	-.7628				

Operator	Signature	Date	Time
Kinsey Skiller	KC	2/11/17	3:00 pm

Checked by	Signature	Date	Time

Checked by	Signature	Date	Time

	Sensitivity	Accuracy
Results	104.6 kip/mV ✓	± 500 lbf

Calibration Instrument Name and S.N.:	Instron 120BTE502040
Data Acquisition System:	Strainsmart 8000
Gain:	1
Excitation Voltage:	30 V
Channel:	4
Sensor:	LVDT NE
Sensor S.N.:	12838

Measurand (in)	Voltage (mV)	Measurand (in)	Voltage (mV)	Measurand (in)	Voltage (mV)
-.25	-10105	-.25	-10105		
-.2	-8140	-.2	-8125		
-.15	-6111	-.15	-6078		
-.1	-4026	-.1	-4027		
-.05	-2030	-.05	-2003	0	20
0	-8	0	5	.05	2013
		.05	2044	.1	4077
		.1	4115	.15	6150
		.15	6172	.2	8207
		.2 .25	8220 10220	.25	10220

Operator	Signature	Date	Time
Kinsey Skiller	K.C. Skille	2/11/17	3:45pm

Checked by	Signature	Date	Time

Checked by	Signature	Date	Time

	Sensitivity	Accuracy
Results	40748 mV/in	± .002 in

Calibration Instrument Name and S.N.:	Instron 1208TE502040
Data Acquisition System:	Strainsmart 8000
Gain:	1
Excitation Voltage:	30V
Channel:	5
Sensor:	LVDT SE
Sensor S.N.:	23618

Measurand (in)	Voltage (mV)	Measurand	Voltage	Measurand	Voltage
-.5	-10180	-.5	-10180		
-.375	-7620	-.375	-7624		
-.25	-5110	-.25	-5109		
-.125	-2560	-.125	-2558		
0	-1	0	-9	0	-10
		.125	2543	.125	2550
		.5	5110	.5	5115
		.375	7625	.375	7625
		.5	10154	.5	10150

Operator	Signature	Date	Time
Kinsey Skillin	K C Skillin	2/11/17	3:45pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Results	Sensitivity	Accuracy
	20350 mV/in	± .0014 in

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Calibration Documentation v.6
(Rev. 11/1/2016)

Bowen Lab - Purdue University
Appendix 12, Pg 5 of 6
Sheet 1 of 2

Calibration Instrument Name and S.N.:	Instron 120BTE502040
Data Acquisition System:	Strainsmart 8000
Gain:	1
Excitation Voltage:	30 V
Channel:	6
Sensor:	LVDT NW
Sensor S.N.:	X00598

Measurand (in)	Voltage (mV)	Measurand	Voltage	Measurand	Voltage
-.9	-8912	-.9	-8912		
-.75	-7420	-.75	-7421		
-.5	-4982	-.5	-4983		
-.25	-2512	-.25	-2520		
0	0	0	-3	0	-8
		.25	2500	.25	2500
		.5	4982	.5	4980
		.75	7437	.75	7433
		.9	8890	.9	8590

Operator	Signature	Date	Time
Kirsty Skiller	K. C	2/11/17	3:45 pm

Checked by	Signature	Date	Time

Checked by	Signature	Date	Time

Results	Sensitivity	Accuracy
	9911 mV/in	± .004 in

Project: Effects of laminars cracks on 79-in lap splices of #11 reinforcing bars.

Calibration Documentation v.6
(Rev. 11/1/2016)

Bowen Lab - Purdue University
Appendix 12, Pg 6 of 6
Sheet 1 of 2

Calibration Instrument Name and S.N.:	Instron 120BTE502040
Data Acquisition System:	Strainsmart 8000
Gain:	1
Excitation Voltage:	30V
Channel:	7
Sensor:	LVDT SW
Sensor S.N.:	

Measurand (in)	Voltage (mV)	Measurand (in)	Voltage (mV)	Measurand (in)	Voltage (mV)
-.9	-9014	-.9	-9014		
-.75	-7517	-.75	-7520		
-.5	-5043	-.5	-5051		
-.25	-2531	-.25	-2531		
0	-3	0	-13	0	-9
		.25	2520	.25	2510
		.5	5000	.5	5003
		.75	7474	.75	7471
		.9	8965	.9	8965

Operator	Signature	Date	Time
Kinsey Skillen	K.C.S	2/11/17	3:45pm
Checked by	Signature	Date	Time
Checked by	Signature	Date	Time

Results	Sensitivity	Accuracy
	1003 mV/in	± .005 in

25884-000-30R-C01R-00002, Rev. 000

APPENDIX D

“Purdue Memo for Phase II Tests”

TO: Javeed Munshi and Jaspal Saini
FROM: M. A. Sozen and S. Pujol
RE: Effect of Laminar-Crack Width on Strength of Unconfined Splices of # 11 Reinforcing Bars
DATE: 3 June 2016

This memorandum has been prepared to summarize the information contained in our report to the First Energy Nuclear Operating Company of Ohio[1].

In 2012, two series of tests were made to determine the effect of existing laminar cracks on strength of unconfined lap splices of #11 bars having 79-in. and 120-in. laps with the conclusion that such cracks did not prevent the splices from developing the yield stress of the bars.[2]

The current study reported in 2016 focused on the width of the cracks that would not affect the splice strength. Because it had been observed in the 2012 tests that the 120-in. splices were, as would be expected, consistently stronger than 79-in. splices, the current tests included six full-scale specimens with 79-in splices (and no specimens with 120-in. splices). The result was that 79-in. splices with an existing laminar crack having a width of 0.05 in. did not prevent the splice from developing the yield stress of the bar.

Properties of Test Specimen

Profile and cross section of the test specimen are shown in Fig. 1. To simulate the conditions of the splices in the Davis-Besse shell structure, the side cover was 3 in. and the clear distance between the two splices was 6 in. To have the laminar crack to the plane of the splices, the top cover was 5 in., 2 in. more than the side cover. The depth of the specimen was chosen so that the yield stress of the bar could be developed if the splice served its requisite function.

---

[1] M.A. Sozen and S. Pujol, “An Experimental Investigation of Laminar Cracks on Strength of Unconfined 79-in. Lap Splices of #11 Reinforcing Bars,” Bowen Laboratory, 8 June 2016.

[2] M. Sozen and S. Pujol, “An Investigation of The Effect of Laminar Cracks on Strength of Unconfined Lap Splices of #11 Reinforcing Bars,” Bowen Laboratory, 12 July 2012.

Concrete compressive strength at time of test ranged from 5200 to 5900 psi as shown in Table 1. Measured yield stress of the bars was 65 ksi.

Tests

The tests were planned to have two loadings. The first loading was carried out to develop laminar cracking at the plane of the splice. The second loading was carried out from zero applied load to failure (Fig. 2 to 7).

The laminar-crack width is influenced by the tensile strength of the concrete and the bond between the bar and the surrounding concrete. Because both of these properties are subject to strong variations, the measured maximum crack widths at the end of Loading 1 varied from 0.021 to 0.054 in. (Table 2). At failure the maximum stress attained at the end of the splice varied from 73 to 74 ksi (Table 1). In effect, in each test the attained stress in the spliced bars exceeded the yield stress of the bar.

Conclusion

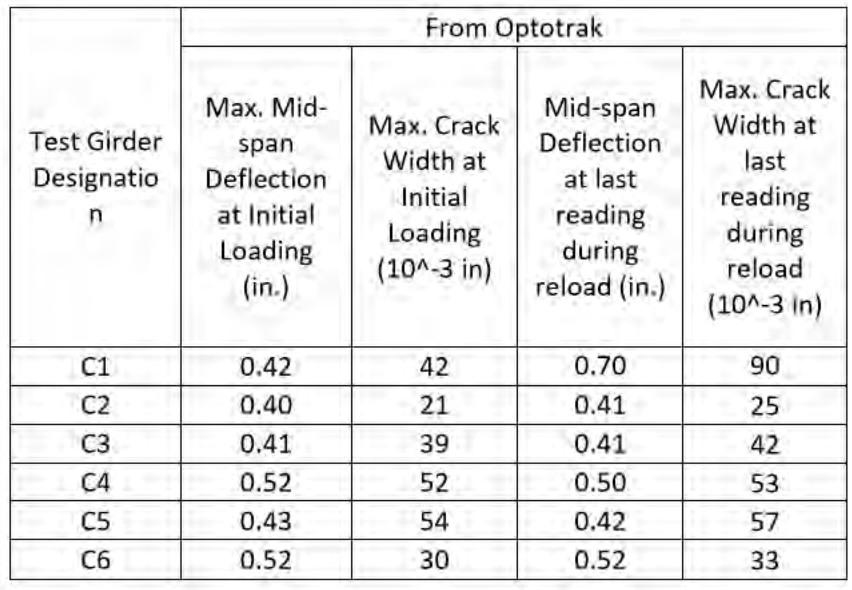
Based on the results of tests of Series C it is concluded that unconfined 79-in. splices of #11 bars with 0.05-in. laminar cracks, in their own plane, in concrete having a compressive strength of 5200 psi or more will develop more than the actual yield stress of the bars.

The test results indicate that the splice has the toughness required in the current design environment for structures to resist static and dynamic demands.

TABLE 1

Test Girder Designation	Concrete Compressive Strength (psi)	Concrete Splitting Strength (Tensile) (psi)	Maximum Applied Load (kip)	Maximum Midspan Deflection (in.)	Maximum Moment at Support (kip-ft)	Maximum Moment at Splice End (kip-ft)	Calc. Reinf. Stress at Support (ksi)	Calc. Reinf. Stress at Splice End (ksi)
C1	5300	500	39.7	0.70	427	419	74	73
C2	5200	450	40.0	0.85	430	422	75	74
C3	5900	500	40.4	0.79	434	426	76	74
C4	5700	500	40.9	0.83	439	431	76	75
C5	5600	500	40.2	0.82	432	424	75	74
C6	5300	400	40.7	0.92	437	429	76	75

TABLE 2



Test Girder Designation	From Optotrak			
	Max. Mid-span Deflection at Initial Loading (in.)	Max. Crack Width at Initial Loading (10^-3 in)	Mid-span Deflection at last reading during reload (in.)	Max. Crack Width at last reading during reload (10^-3 in)
C1	0.42	42	0.70	90
C2	0.40	21	0.41	25
C3	0.41	39	0.41	42
C4	0.52	52	0.50	53
C5	0.43	54	0.42	57
C6	0.52	30	0.52	33

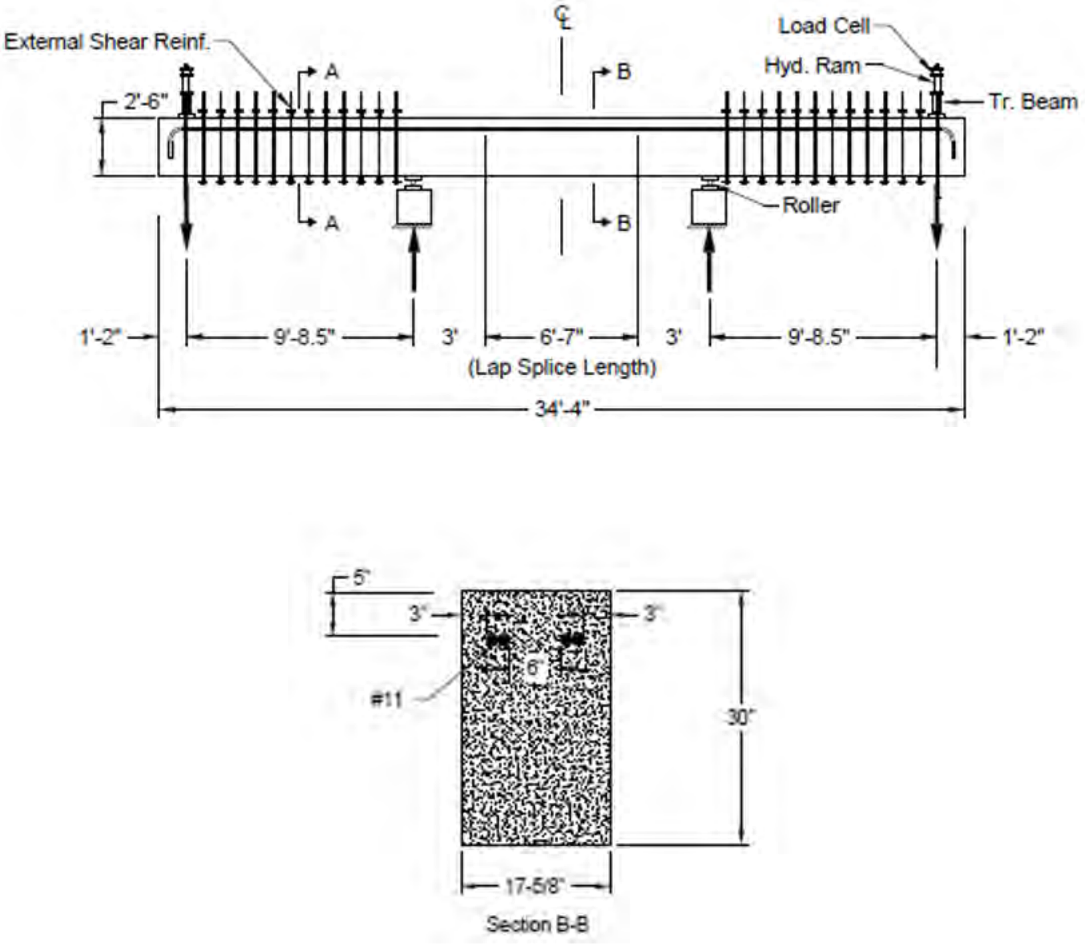

External Shear Reinf.
℄
A
B
Load Cell
Hyd. Ram
Tr. Beam
2'-6"
Roller
A
B
1'-2"
9'-8.5"
3'
6'-7"
3'
9'-8.5"
1'-2"
(Lap Splice Length)
34'-4"
5"
3"
3"
6"
#11
30"
17-5/8"
Section B-B

Figure 1


Test Girder C1

Figure 2

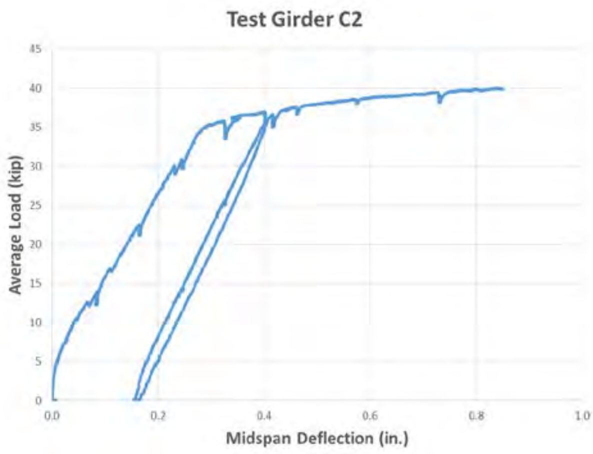

Test Girder C2

Figure 3

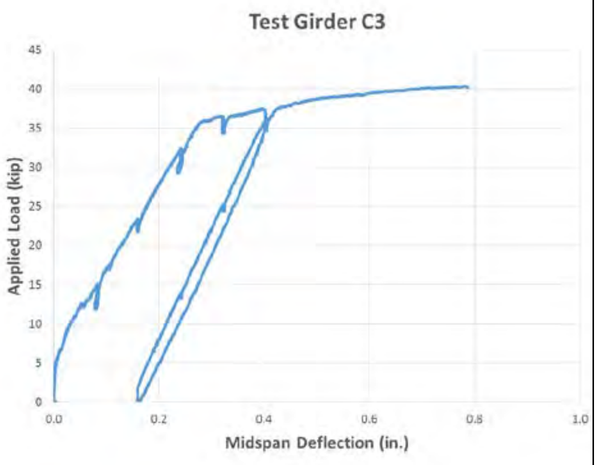

Test Girder C3

Figure 3


Test Girder C4

Figure 4

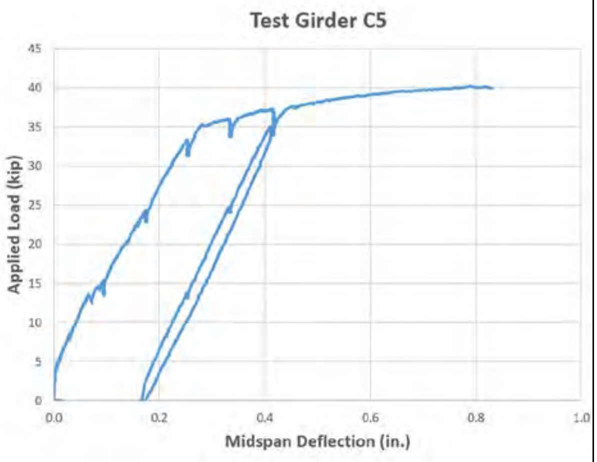

Test Girder C5

Figure 5


Test Girder C6

Figure 6

25884-000-30R-C01R-00002, Rev. 000

APPENDIX E

“Memo from Dr. Santiago Pujol”

UC
UNIVERSITY OF
CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

To: Energy Harbor Corporation

From: Santiago Pujol A. Pujol

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RE: Report 25884-000-30R-C01R-00002, Rev. 000 by Bechtel Co. on Effects of Laminar Cracks on Strength of Lap Splices of #11 Reinforcing Bars

Date: January 14, 2021

I confirm that the studies described in this report and its appendices indicate that laminar cracks with widths of up to 0.050” did not affect the strengths of test lap splices of #11 reinforcing bars representing lap splices in the Davis-Besse Shield Building. This conclusion is supported by tests conducted at Purdue University from 2012 to 2017. I was in charge of those tests together with the late Dr. Mete Sozen.

Repairs are recommended for areas affected by wider laminar cracks (with thicknesses exceeding 0.050”) as well as areas affected by corrosion.

Attachment 2

Updated Final Safety Analysis Report Markup

(3 pages follow)

3.8.2.2 Shield Building

3.8.2.2.1 Description

The Shield Building is a reinforced concrete structure of right cylinder configuration with a shallow dome roof. An annular space is provided between the steel containment vessel and the interior face of the concrete shield building of approximately 4.5 feet to permit construction operations and periodic visual inspection of the steel containment vessel. The volume contained within this annulus is approximately 678,700 cu. ft. The Shield Building has a height of 279.5 ft. measured from the top of the foundation ring to the top of the dome. The thicknesses of the wall and the dome are approximately 2.5 ft. and 2 ft., respectively. The design bases for shielding requirements for operational radiation protection are discussed in Chapter 12.

(ADD PARAGRAPH SHOWN ON NEXT PAGE)

3.8.2.2.2 Design Bases

The Shield Building completely encloses the Containment Vessel, the personnel access openings, the equipment hatch, and that portion of all penetrations that are associated with primary containment. The design of the Shield Building provides for (1) biological shielding, (2) controlled release of the annulus atmosphere under accident condition, and (3) environmental protection of the Containment Vessel.

Adequate reinforcing is placed in the concrete walls, dome, and foundation to control cracking due to concrete shrinkage and temperature gradients. The loading combinations, as stated in Subsection 3.8.2.2.4, provide a design basis to ensure that the Shield Building suffers no loss of shielding or containment function due to seismic or tornado events.

The design of the Shield Building ensures an elastic behavior of steel reinforcement during a Maximum Possible Earthquake controlling cracking of concrete and impairment of leaktight integrity.

The personnel and equipment hatch openings and the major piping penetrations through the Shield Building are designed such that all the anticipated loads are carried by frame action around the openings in accordance with Welding Research Council Bulletin #102. This frame action is achieved by adding sufficient reinforcement around the perimeter of the openings. Diagonal bars at each corner of the opening are added to provide the horizontal and vertical shear resistance.

Normal Operating Conditions:

The normal ambient temperature in the annular space is set by heat loss through the steel containment vessel shell and concrete shield building. The steel containment vessel metal temperature can be maintained above 30°F during reactor operation.

Loss of Coolant Accident Conditions:

Following a loss of coolant accident, heat transferred to the air in the annular space could cause a pressure rise. Conservative assumptions for temperature transmission to the space, and pressure drop in the Emergency Ventilation System are used in sizing the ventilation system. Following this initial pressure transient, the Shield Building is maintained at a minimum negative pressure of 1/4-inch water gauge. The Shield Building structure is analyzed also to ensure

ADD TO THE END OF SECTION 3.8.2.2.1 (page 3.8-55):

Laminar cracking has been identified in the plane of the outer reinforcement layer of the structure. Reference 107 provides the root-cause analysis for the development of laminar cracking in the Shield Building shell. Propagation of the laminar cracking has subsequently been identified. Reference 108 provides the root-cause analysis for the propagation of the laminar cracking.

Reference 109 evaluates laminar cracking up to 0.050” in width for acceptability. This Technical Report concludes that laminar cracking up to this width has no effect on the structural behavior or capacity of the Shield Building considering reinforcement engagement, composite action of the shell, overall structural response, and serviceability/long term durability of the structure. Therefore, laminar cracking less than and equal to 0.050” is considered to be acceptable and included in the licensing and design basis of the Shield Building. The Shield Building is to be analyzed per licensing and design basis codes (ACI 318-63 and 307-69) and methodology without the need to explicitly consider laminar cracking up to 0.050” in the analysis. Laminar cracking greater than 0.050” is to be repaired. Refer to Section 18.1.43 for monitoring of laminar cracking.

(97) NRC Letter from J. F. Stolz (NRC) to J. Williams (TED), Safety Evaluation of B&W Owners Group Reports Dealing with Elimination of Postulated Pipe Breaks in PWR Primary Main Loops, 2-18-86 (Log Number 1918).

(98) TED Letter, Comparison of Davis-Besse Reactor Coolant System Leak Detection Systems to Regulatory Guide 1.45, dated 11-09-90 (Serial Number 1849).

(99) AEC letter dated September 26, 1972, Docket No. 50-346, which requested a review of the Davis-Besse Station for potentially adverse affects to safety-related equipment from failures in non-Category I (seismic) equipment, such as flooding or the release of chemicals.

(100) C-NSA-000.02-011, Turbine Building HELB Environments.

(101) Safety Evaluation River Bend, Unit 1, License Amendment, Change the Method of Analysis for High Energy Line Break Analysis, U. S. Nuclear Regulatory Commission, dated May 20,2004, ADAMS ML041410566.

(102) Bechtel Calculation 58.010, “Flow Rate due to a Crack in the Make-up Pump Discharge and Flood Water Heights in Associated Rooms” 3/16/1987, with the associated Bechtel Letter BT17624, March 18, 1987.

(103) NUREG-0588, Revision 1, “Interim Staff Position on Environmental Qualification of Safety Related Electrical Equipment,” Issued: July 1981.

(104) NRC Letter from M. Mahoney (NRC) to B.S. Allen (FENOC), Approved License Amendment 281 and Safety Evaluation Report for Updated Davis-Besse Nuclear Power Station Leak-Before-Break (EBB) Evaluation, March 24, 2010. [ADAMS Accession No. ML100640506]

(104a) NRC Letter from M. Mahoney (NRC) to B.S. Allen (FENOC), Corrections of Typographical Errors [revised pages], Approved License Amendment 281 and Safety Evaluation Report for Updated Davis-Besse Nuclear Power Station Leak-Before-Break (LBB) Evaluation, April 9, 2010. [ADAMS Accession No. ML100970549]

(105) Structural Integrity Associates, Inc. (SIA), “Leak-Before-Break Evaluation of Reactor Coolant Pump Suction and Discharge Nozzle Weld Overlays for Davis-Besse Nuclear Power Station,” Report 0800368.404, Revision 1, January 11, 2010.

(106) Calculation C-CSS-099.20-044, Service Water Pump Room Tornado Depressurization Analysis.

ADD THE FOLLOWING:

(107) Performance Improvement International, “Root Cause Assessment Davis-Besse Shield Building Laminar Cracking,” Revision 2, 4/28/12 (Condition Report CR-2011-03346).

(108) Performance Improvement International, “Root Cause Analysis: Laminar Crack Condition of the Davis-Besse Shield Building,” Revision 0, 6/18/14 (Condition Report CR-2013-14097).

(109) Bechtel Report 25884-000-30R-C01R-00002, Revision 0, “Incorporating Laminar Cracks of up to 0.050 inch in the Design Basis of the Davis Besse Shield Building,” 2/3/21 (EER 601303393).