

FINAL REPORT
IN RESPONSE TO PETITION MADE BY
THE OFFICE OF THE ATTORNEY GENERAL, STATE OF ILLINOIS,
IN THE MATTER OF REINFORCING STEEL DAMAGED DURING
THE INSTALLATION OF CORED AND DRILLED HOLES
AND THE MATTER OF THE OFF- GAS BUILDING ROOF
FOR LASALLE COUNTY, UNITS 1 & 2

Commonwealth Edison Company
Chicago, Illinois

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The Office of the Attorney General, State of Illinois, has brought forward information alleging, "...that, during the construction of LaSalle County, Units 1 and 2, certain practices related to the drilling of holes in the concrete walls, floors and ceilings of the Units 1 and 2 buildings have created a potentially hazardous condition which, upon the operation of either unit at full power, may be injurious to the public health and safety." The subject petition contends that, as a matter of course, an unknown number of drilled holes, ranging in the order of thousands, were likely to have been cut through the reinforcing steel. The petition, which is based on the affidavit of Ernest Garrison, indicates that records of these situations were made at the time the alleged practices occurred, and that the practice of drilling through reinforcing steel was discontinued or subjected to the case-by-case approval of an engineer some time in late 1979, early 1980. The petition also states that the State of Illinois has no information which suggests that any engineering approval was ever obtained from Commonwealth Edison Company's engineering consultant prior to 1980. A second affidavit by Mr. Dale Bridenbaugh states that, if the reinforcing steel was damaged or severed without appropriate structural analysis, and if the drilling practice was wide-spread, "...it seems nearly certain that some safety related structures...would have been affected."

The office of the Attorney General, State of Illinois, also brought forward information alleging, "...that the concrete ceiling or roof of the Off-Gas Building was actually only 8" thick, even though the specifications called for this roof to be 12" thick." The subject petition further contends that this concrete roof has cracked substantially due to the number of anchor bolt holes drilled in it.

2.0 Response to Allegation Concerning Cored and Drilled Holes

2.1 Introduction

Commonwealth Edison Company, throughout the course of the LaSalle County, Units 1 and 2 construction, has controlled the drilling through concrete for both cored holes and the installation of concrete expansion anchors via appropriate quality control procedures, and has documented and assessed reinforcing steel reported as having been contacted (nicked or cut) during this operation.

Commonwealth Edison Company and their Consulting Engineers, Sargent & Lundy, met with representatives of the Nuclear Regulatory Commission staff in Bethesda, Maryland, at the request of Mr. Harold Denton on March 31, 1982. The purpose of the meeting was to:

- (A) present quality control and documentation procedures implemented by Commonwealth Edison Company throughout the project with regard to reporting reinforcing steel which was contacted during the coring and drilling operations,
- (B) present the engineering controls which were established to minimize reinforcing steel damage due to the coring and drilling operations, and

- (C) present the structural engineering assessment regarding the adequacy of the safety related concrete elements for all Unit 1 areas and those Unit 2 areas required for Unit 1 operation with regard to reinforcing steel damaged during the coring and drilling operations.

Subsequent to the meeting in Bethesda, Maryland, NRC representatives performed an audit at the LaSalle County site on April 7, 1982, to verify the corresponding field procedures, and also performed an audit at the Sargent & Lundy offices on April 8, 1982, to review and verify the engineering assessment of the effects of the damaged reinforcing steel.

2.2 Definition of Cored and Drilled Holes

2.2.1 Cored Holes

Cored holes in concrete are of the following two types:

- A. Holes which pass through a concrete element to allow for passage of an electrical or mechanical component, as illustrated in Figure 2.2-1. These holes vary from 1-1/4" to 22" in diameter.
- B. Holes which partially penetrate a concrete element for the installation of a grouted anchor bolt, as shown in Figure 2.2.-2. Grouted anchor bolts were utilized primarily to anchor

equipment foundations and/or pipe support baseplates to concrete elements. These holes vary from 1-1/2" to 3" in diameter.

2.2.2 Drilled Holes

Holes were drilled in concrete for the installation of concrete expansion anchors. The diameter of drilled holes varies with the diameter of the expansion anchor, and ranges between 1/4" to 1". Such holes vary from 1-1/4" to 8" in depth. See Figure 2.2-3 for an illustration of a drilled hole.

2.3 Classification of Damage to Reinforcing Steel due to Coring and Drilling Operations

2.3.1 Reinforcing Steel Damage due to Coring Operations

Cored holes were, typically, made using a diamond tipped core drill. This particular drill bit is capable of cutting through reinforcing steel. During a coring operation utilizing a core drill, three possibilities existed:

- A. No reinforcing steel was contacted.
- B. Reinforcing steel was partially contacted, and a segment of the bar was cut (see Figure 2.2-5).

C. Reinforcing steel was totally contacted by the core drill, and the reinforcing steel was completely severed (see Figure 2.2-5).

Where the diameter of the cored hole was less than the spacing of the reinforcing steel (typically, 9" to 12"), there was a probability that the reinforcing steel would not be contacted. The probability that a bar would be contacted decreases as the diameter of the cored hole decreases and/or the spacing of the reinforcing steel increases.

2.3.2 Reinforcing Steel Damage due to Drilling Operations

Drilling of holes in concrete for the installation of expansion anchors was typically performed with carbide tipped solid masonry bits, as specified in Form LS-CEA. These carbide tipped solid masonry bits are not capable of drilling through reinforcing steel. These bits can produce only a shallow, 1/16" deep and 1/4" wide smooth and well rounded depression in the rebar, called a "nick", as shown in Figure 2.2-4.

Based on laboratory testing and analytical assessment, it has been conclusively demonstrated that such rebar nicks do not impair the structural integrity of reinforced concrete elements (see Section 2.6.2).

Form LS-CEA, which controlled the drilling operations for concrete expansion anchors, allowed the contractor, in certain situations, to drill through reinforcing steel for the installation of a concrete expansion anchor using a diamond tipped core drill (see Section 2.6.2). This situation required the contractor to report the subsequent reinforcing steel damage to the Consulting Engineers.

2.4 Control Documentation and Engineering Assessment of Damaged Reinforcing Steel due to Cored Holes Passing Through Concrete Elements

2.4.1 Control Procedures for Cored Holes Passing Through Concrete Elements

The need for cored holes passing through concrete elements was determined by an electrical or mechanical designer during the office routing of the mechanical and electrical components, or by the field contractor in the case of field routed electrical and mechanical components. In the first situation, the cored holes were specified and located on the structural design drawings via a request from the electrical or mechanical designer. A structural engineer at Sargent & Lundy approved the location of the cored hole, and released the corresponding structural design drawing only after an assessment was made regarding the structural effects of reinforcing steel likely to be damaged by the coring operation. Section 2.4.3 describes this structural engineering assessment.

In the second situation, the contractor was required to submit a Field Change Request (FCR) requesting permission to install a cored hole for field routed mechanical and electrical components prior to the coring operation. Commonwealth Edison Company, on the recommendation of Sargent & Lundy, approved this request only after a structural assessment was made of the effects of any reinforcing steel which was likely to be removed or damaged during this operation. Section 2.4.3 describes this structural engineering assessment. These cored holes were, likewise, subsequently indicated on the structural design drawings.

2.4.2 Documentation Procedures for Cored Holes Passing Through Concrete Elements

A permanent record of all cored holes passing through concrete elements is maintained on the structural design drawings. These cored holes, either initiated in the office or in the field, are appropriately defined as cored holes on the structural design drawings. The contractor was not required to report reinforcing steel which may have been cut during this coring operation because the structural engineering assessment was performed prior to the release of the design drawings or FCR assuming the maximum number of bars likely to be damaged. This maximum number was a function of the diameter of the cored hole and the spacing of the reinforcing steel, both of which were specified on the structural design drawings. It is emphasized that this was conservative, since the maximum number of bars assumed to be damaged may, in

fact, not have been contacted during the coring operation. An example would be a 3" diameter core, drilled through a concrete element in which the reinforcing steel is spaced 9" on center. The probability of contacting a bar in this instance would be low; however, the engineering assessment assumed a minimum of two bars damaged (one each face).

2.4.3 Engineering Assessment of Cored Holes Passing Through Concrete Elements

Prior to releasing a structural design drawing or approving a field change request containing a cored hole, a structural engineer assessed the effects of any reinforcing steel likely to be damaged during the coring operation. As described in Section 2.4.2, this assessment conservatively assumed the maximum number of bars likely to be damaged as a function of the diameter of the core and the spacing of the reinforcing steel. The engineering assessment during this stage of construction consisted primarily of engineering judgement, in which a structural engineer reviewed the concrete element design margins and stress levels in the reinforcing steel assumed to be damaged. Engineering judgement was appropriate, since, in most cases, the assumed damaged reinforcing steel either had no stress or very low stress, and/or the design margin of the concrete element at the location of the assumed damaged reinforcing steel was sufficiently greater than 1.0. The design margin is defined as the ratio of the area of reinforcing steel actually provided in the concrete element to the area of the

reinforcing steel required to carry the design loads. A design margin as close to 1.0 as possible is desirable since it represents a safe as well as an economical structural design. There are many situations, however, in which considerations other than the design loads (such as minimum thickness requirements for shielding) governed the size of a concrete element. Such situations typically resulted in design margins greater than 1.0.

The design loads used were in accordance with the LaSalle County FSAR commitments, and included all normal operating, accident and severe and extreme environmental conditions, including LOCA and the Safe Shutdown Earthquake. Detailed structural calculations, which have been performed as described in Section 2.7, verified the appropriateness of the initial engineering judgement in this situation and verified that these cored holes have not impaired the structural integrity of any safety related area.

It should also be pointed out that the structural engineer, in reviewing an individual cored hole, had a complete record before him of all other cored holes in a given area as indicated on the structural design drawings. Therefore, when a request was made to add an additional cored hole, the structural engineering assessment took into consideration the aggregate effect of all other cored holes in a given area.

It is emphasized that, for all coring operations, engineering approval was obtained prior to the cutting of the reinforcing

steel. Where the structural engineering assessment had determined that it was required to minimize the cutting or damaging reinforcing steel during the installation of cored holes, this requirement was specified on the appropriate structural design drawing. The following are examples of this situation:

- A. General Note No. 44 on Drawing No. S-199 states that, "For cored holes marked E, less than 8" diameter, use metal detector to locate existing reinforcing prior to core drilling. In case of interference with rebar, holes may be cored in alternate location within 3" radius from location shown on drawing. (See Figure 2.4-1).
- B. Drawing No. S-213, concerning the Reactor Building floor framing plan at Elevation 761'-0", Note 11 requires the use of metal detectors to avoid cutting of reinforcing steel in this area. (See Figure 2.4-2)

Commonwealth Edison Company has verified that the contractors' procedures have addressed the use of metal detectors.

2.4.4 Summary of Reinforcing Steel Damage due to Cored Holes Passing Through Concrete Elements

Table 2.4-1 summarizes the reinforcing steel which has been conservatively assumed to have been damaged due to cored holes passing through concrete elements in all Unit 1 safety related

areas and in those Unit 2 safety related areas required for Unit 1 operation.

TABLE 2.4-1

Summary of Reinforcing Steel Damage Due to
Cored Holes Passing Thru Concrete

<u>Item</u>	<u>Unit 1 Areas</u>	<u>Unit 2 Areas Required for Unit 1 Operation</u>
Number of Cored Holes	844	127
Number of Reinforcing Bars Assumed to have been Damaged	3632	584
Number of Structural Drawings Indicating Cored Holes	76	22

It is, again emphasized that this is the maximum number of bars which could have been damaged by the coring operations. The actual number of damaged bars is expected to be less than this value. Section 2.7 addresses the detailed engineering assessment which was performed as a result of this assumed reinforcing steel damage.

There are no holes cored completely through the primary containment walls.

2.5 Control Documentation and Engineering Assessment of Damaged
Reinforcing Steel due to Cored Holes Partially Penetrating Concrete
Elements

2.5.1 Control Procedures for Cored Holes Partially Penetrating Concrete
Elements

The need for cored holes partially penetrating concrete elements for grouted anchor bolts used to anchor equipment foundations or pipe support baseplates was determined by a mechanical designer and/or electrical designer during the design phase in Sargent & Lundy's office. The cored holes for the mechanical pipe support baseplate assembly anchor bolts were indicated on the mechanical hanger pipe support drawings, and the cored holes for the mechanical equipment foundation anchor bolts were indicated on the mechanical equipment foundation design drawings. The cored holes for electrical equipment foundations were indicated on the structural design drawings. A structural engineer approved the location of these cored holes and returned the mechanical design drawing to the mechanical designer, and incorporated the cored holes for electrical equipment foundations on the structural design drawings only after an assessment was made regarding the structural effects of the reinforcing steel likely to be damaged by the coring operation. Section 2.5.3 describes this structural engineering assessment.

2.5.2 Documentation Procedures for Cored Holes Partially Penetrating Concrete Elements

A permanent record of all cored holes partially penetrating concrete elements for mechanical and electrical equipment foundation grouted anchor bolts is maintained on a separate set of drawings known as the cored hole drawings ("CHS" set). Cored holes for mechanical pipe support baseplate assembly anchor bolts have

not been plotted on this set, since the contractor was not permitted to damage reinforcing steel in this situation (see Section 2.5.3.2). The background for the CHS drawings is a reproduction of the structural design drawings. The contractor was not required to report reinforcing steel damage due to the coring operations for mechanical and electrical equipment foundation anchor bolts, because the structural assessment was performed prior to or coincident with the release of the mechanical and/or structural design drawings assuming the maximum number of bars likely to be damaged. This maximum number was, again, a function of the diameter of the cored hole and the spacing of the reinforcing steel. It is emphasized that this was conservative, since the maximum number of bars assumed to be damaged may, in fact, not have been contacted during the coring operation. The examples cited in Section 2.4.2 regarding the maximum number of assumed damaged bars is also applicable in this situation. The contractor was, however, required to report any reinforcing steel damaged during the coring operations for mechanical pipe support baseplate assembly anchor bolts, as referenced in Section 2.5.3.2.

2.5.3 Engineering Assessment of Cored Holes Partially Penetrating Concrete Elements

2.5.3.1 Grouted Anchor Bolts for Equipment Foundations

Prior to or coincident with the release of the mechanical and/or structural design drawings indicating a cored hole for a mechanical

or electrical equipment foundation anchor bolt, a structural engineer assessed the effects of any reinforcing steel likely to be damaged during the coring operation. As described in Section 2.5.2, this assessment conservatively assumed the maximum number of bars likely to be damaged as a function of the diameter of the core and the spacing of the reinforcing steel. A minimum of one damaged bar was always considered regardless of bar spacing or core diameter. The engineering assessment during this stage of construction consisted primarily of engineering judgement, in which a structural engineer reviewed the concrete element design margins and stress levels in the reinforcing steel assumed to be damaged. Engineering judgement in this situation was appropriate, since, in most cases, the assumed damaged reinforcing steel had no stress or very low stress, and/or the concrete element design margin at the location of the assumed damaged reinforcing steel was sufficiently greater than 1.0. The design margin for concrete elements has been defined in Section 2.4.3. Detailed structural calculations, which have been performed as described in Section 2.7, substantiated and verified the appropriateness of initial engineering judgement in this situation and have verified that these cored holes have not jeopardized the structural integrity of any safety related area.

2.5.3.2 Grouted Anchor Bolts for Mechanical Pipe Support Baseplate Assemblies

The installation of cored holes for grouted anchor bolts for the attachment of pipe support baseplate assemblies commenced during

the summer of 1980. Prior to these coring operations, Mechanical Drawing No. M-1100, Sheet 23, issued in January, 1980, placed strict controls on the coring operations to preclude reinforcing steel damage. (See Figure 2.4-3). This drawing required the contractor to carefully notch the concrete to expose the reinforcing steel in both directions prior to coring the hole to avoid damage to the reinforcing steel. This provision implicitly prohibited the contractor from cutting through the reinforcing steel in this situation. Commonwealth Edison Company has verified that the contractors have utilized this procedure.

2.5.4 Summary of Reinforcing Steel Damage due to Cored Holes Passing Through Concrete Elements

Table 2.5-1 summarizes the reinforcing steel which has been conservatively assumed to have been damaged due to cored holes partially penetrating concrete elements in all Unit 1 safety related areas, and in those Unit 2 safety related areas required for Unit 1 operation.

TABLE 2.5-1
Summary of Reinforcing Steel Damage Due to
Cored Holes Partially Penetrating Concrete

<u>Item</u>	<u>Unit 1 Areas</u>	<u>Unit 2 Areas Required for Unit 1 Operation</u>
Number of Cored Holes*	512	4
Number of Reinforcing Bars Assumed to have been Damaged	512	4
Number of CHS Drawings Indicating Cored Holes	12	1

*These cored holes are those associated with the mechanical and electrical equipment foundation anchor bolts. Cored holes for mechanical pipe support baseplate assemblies have not been plotted on the CHS set or included in the above tabulation, since damage to the reinforcing steel was not permitted.

It is, again, emphasized that this is the maximum number of bars which could have damaged by the coring operations. The actual number of damaged bars is expected to be less than this value. Section 2.7 addresses the detailed engineering assessment resulting from this assumed reinforcing steel damage.

2.6 Control Documentation and Engineering Assessment of Damaged Reinforcing Steel due to Drilling Operations for Concrete Expansion Anchors

2.6.1 Application and Use of Concrete Expansion Anchors

Concrete expansion anchor baseplate assemblies were used to support mechanical and electrical components, such as piping, conduits,

lighting fixtures, etc., only when no other means of attaching to the concrete elements were available. The most commonly used baseplate assemblies were 9"x9"x1/2" and 12"x12"x3/4" plates, each containing four concrete expansion anchors with diameters varying from 1/2" to 3/4".

Throughout the course of the project, all engineering disciplines were encouraged to attach to either existing structural steel framing or embedded plates, in lieu of using concrete expansion anchors. Numerous embedded plates were provided in most concrete elements on a regular grid pattern for this purpose. During the course of the project, however, it became increasingly difficult to route components and locate supports to attach to the existing steel framing or the existing embedded plates. The number of supports increased in the later stages of the project as a result of revised regulatory requirements, IE Bulletins, and changes in the state-of-the-art design which Commonwealth Edison Company and the nuclear industry chose to adopt. It became apparent to both Commonwealth Edison Company and Sargent & Lundy, in 1976, that the use of concrete expansion anchor baseplate assemblies could not be avoided. Commonwealth Edison Company and Sargent & Lundy recognized the possibility of reinforcing steel damage due to the installation of concrete expansion anchors and, therefore, issued strict control procedures in September 1976 to prevent any reinforcing steel damage. Commonwealth Edison Company and Sargent & Lundy continuously monitored the drilling operations throughout the course of the project, and revised the reinforcing steel procedures to immediately respond to changing conditions (see Section 2.6.2).

2.6.2

Control Procedures for Drilled Holes for Concrete Expansion Anchors

The drilling of holes for concrete expansion anchors was controlled by Form LS-CEA. This form was issued in September, 1976, and contained the following strict provisions for the protection of the reinforcing steel:

- A. The contractor was not permitted to drill through reinforcing steel (Refer to Section 4.1-1 of Form LS-CEA).
- B. The contractor was required to use a deep magnetic detector to locate the reinforcing steel in the concrete (see Section 4.1.2 of Form LS-CEA).
- C. The contractor was required to drill holes in the concrete with carbide tipped solid masonry bits (see Section 4.2.2a of Form LS-CEA). As mentioned in Section 2.3.2, carbide tipped solid masonry bits are not capable of drilling through reinforcing steel. These bits can produce only a shallow, 1/16" deep, smooth and well-rounded depression in the reinforcing steel referred to as a "nick" (see Figure 2.2-4).
- D. The contractor was prohibited from using concrete expansion anchors for any other work (i.e., work not indicated on the design drawings) without prior approval from the consulting engineers (see Section 1.1 of Form LS-CEA).

Commonwealth Edison Company recognized that these strict provisions were not feasible for the remainder of the project due to the anticipated number of expansion anchor baseplate assemblies. Form LS-CEA, Revision 1, was thereby issued on December 7, 1976, relaxing the reinforcing steel control provisions. The following is a summary of the revised requirements.

A. The following areas were identified for all concrete elements such as slabs, beams, walls, columns, foundations, etc. (see Table 38-2, and Figures 38-5 and 38-6 of Form LS-CEA):

1. Areas in which a metal detector was not required, and reinforcing steel was permitted to be cut.
2. Areas where a metal detector was required, and reinforcing steel was not permitted to be cut.

These areas of the various concrete elements were defined as a result of a structural engineering assessment performed by Sargent & Lundy for Commonwealth Edison Company. This structural engineering assessment entailed a review of the stress levels in the various areas of these concrete elements under all design load conditions, as referenced in the LaSalle County FSAR, including all normal operating, accident, and severe and extreme environmental conditions, including LOCA and Safe Shutdown Earthquake. The areas in which the reinforcing steel was permitted to be cut were those areas in

which the reinforcing steel was not required for the structural integrity of the concrete element under the design loads.

8. The contractor was required to report any reinforcing steel which was either cut or nicked in those areas where a metal detector was required to be used (see Note 2, Table 38-2 of Form LS-CEA). It should be noted, however, that the contractors, throughout the course of the drilling operations, reported reinforcing steel damage, regardless of the area, as specified in Table 38-2 (see Section 2.6.3).

C. The contractor was required to notify the consulting engineers when the metal detector indicated the presence of reinforcing steel at the location of an expansion anchor prior to cutting the bar (see Note 2, Table 38-2 of Form LS-CEA).

Revision 2 to Form LS-CEA was issued on November 29, 1978. However, it did not alter the reinforcing steel control provisions of Revision 1.

Revision 3 to Form LS-CEA was issued on July 20, 1979, and incorporated the following additional requirements with regard to the control procedures for the protection of reinforcing steel:

A. A standard form was provided for reporting damaged reinforcing steel (Form LS-CEA 1.0). Prior to this revision of LS-CEA,

each contractor utilized his own unique form for reporting reinforcing steel damage. Form LS-CEA 1.0 required that the contractor differentiate between a cut and a nicked bar. It was at this point in time that Commonwealth Edison Company and Sargent & Lundy had reviewed sufficient analytical and test data to indicate that nicked reinforcing steel may not be detrimental to structural integrity as previously assumed. It therefore, became advantageous to differentiate between a cut and a nicked bar at this time.

B. The provisions for cutting reinforcing steel were tightened in areas in which metal detection was not previously required (see Section 3.2.9 of Form LS-CEA):

1. The contractor was required to submit a damage report for any reinforcing steel contacted in these areas (see Section 3.2.9a of Form LS-CEA). As previously noted, contractors had in fact reported reinforcing steel damage, regardless of area.
2. The contractor was required to mark the location of damaged reinforcing steel on the concrete element in these areas to permit other contractors to identify the need for the use of a metal detector per the provisions of item 3 below (see Section 3.2.9a of Form LS-CEA).

3. The use of a metal detector was required for any further drilling operations in these areas once a reinforcing bar had been damaged. This requirement was predicated on the spacing of the reinforcing steel in the concrete element and its proximity to other damaged reinforcing bars (see Section 3.2.9C of Form LS-CEA).
4. The contractor was permitted to cut one reinforcing bar per concrete anchor baseplate assembly within these areas. However, once one bar was cut, the requirement for use of a metal detector for subsequent drilling was, thereby, invoked, and no more reinforcing steel was permitted to be damaged without prior approval of the consulting engineers (see Section 3.2.9d of Form LS-CEA).

Commonwealth Edison Company was continuously cognizant of the drilling operations and its associated effect on reinforcing steel and thereby invoked these additional procedures in the areas in which a metal detector was previously not required when it became apparent that the use of concrete expansion anchor baseplate assemblies would be greater than initially anticipated in 1976.

Revision 4 of Form LS-CEA was issued on September 7, 1979. This revision was made primarily in response to NRC IE Bulletin 79-02 regarding the capacity of installed anchors, and did not alter the previously instituted reinforcing steel control requirements. This

revision differentiated the documentation of the concrete expansion anchor inspection requirements by the following areas (see Section 1.1 of Form LS-CEA):

A. Safety Related Work in Safety Related Areas

The contractor was required to provide complete documentation of the installation and testing procedures for all concrete expansion anchor baseplate assemblies. This included submittal of all damage reports indicating nicked or cut reinforcing steel during the installation as previously required.

B. Non-Safety Related Work in Safety Related Areas

The contractor was required to provide complete documentation of the installation procedures for the concrete expansion anchor baseplate assemblies including the submittal of all damage reports indicating nicked or cut reinforcing steel during the installation as previously required. Only the documentation of the inspection of the installed anchor was waived.

C. Non-Safety Related Work in Non-Safety Related Areas

Most documentation of the installation and inspection procedures were waived. The contractor was not permitted to cut or damage reinforcing steel.

D. The contractor was required to use a diamond tipped bit to cut reinforcing steel where prior permission to do so had been granted (see Section 3.2.9e of Form LS-CEA).

Revision 5 to Form LS-CEA was issued on December 10, 1979. This revision gave the contractor additional flexibility in relocating concrete expansion anchor holes when reinforcing steel was encountered (see Section 3.2.14 of Form LS-CEA).

Revisions 6 and 7 to Form LS-CEA were issued on February 13, 1980 and October 27, 1980, respectively. These revisions, however, did not alter the prior reinforcing steel control provisions.

During the period 1978 through 1981, Commonwealth Edison Company conducted extensive investigations to determine the effect on reinforcing steel which is nicked during the installation of concrete expansion anchors. These investigations conclusively demonstrated that reinforcing steel, nicked by a carbide tipped drill bit during the installation of concrete expansion anchors, does not impair the structural integrity of reinforced concrete elements. This conclusion was based upon both laboratory testing and analytical assessment. Form LS-CEA, Revision 8, was subsequently issued on May 13, 1981, deleting the requirements for reporting of nicked reinforcing steel.

2.6.3

Documentation Procedures for Drilled Holes for Concrete Expansion Anchors

Contractors have been required to report any reinforcing steel which has been cut or nicked in specified areas during the installation of concrete expansion anchors, as referenced in Section 2.6.2. Commonwealth Edison Company has verified that, as a matter of course, all contractors, during the period 1976 through 1979, have also reported cut or nicked reinforcing steel which was not required to be reported by Table 38-2, Revision 2 of Form LS-CEA. As each report was received by Sargent & Lundy, it was logged in and assigned a unique number. The damaged reinforcing steel locations were then plotted on a separate set of reinforcing steel hit drawings ("RHS" set). The background for these drawings is a reproduction of the structural design drawings, and were initiated in 1977. A permanent record therefore exists of all reported reinforcing steel damaged due to the drilling operations. It is emphasized that these drawings also indicate non-detrimental nicks, since contractors were not required to differentiate between a cut and nick during the period 1976 thru 1979.

Commonwealth Edison Company, stated at the meeting in Bethesda, Maryland, on March 31, 1982, that the process of verifying that all reinforcing steel damage reports had been received by Sargent & Lundy and incorporated on the RHS drawings was still in progress. This verification is now complete. Table 2.6-1 summarizes the number of reinforcing steel damage reports generated by each site contractor and the number of reports received by Sargent & Lundy before and after March 29, 1982. Also summarized is the number of additional cut reinforcing bars which were identified and plotted

on the RHS drawings after the meeting. It can be seen that the total number of damage reports identified after the meeting, 216, is only 6.0% of the total number of damage reports for all Unit 1 safety related areas and those Unit 2 safety related areas required for Unit 1 operation.

It is also noted that there remain 4 reinforcing steel damage reports prepared by The Zack Company which cannot be located. The drilled holes for the concrete expansion anchor baseplate assemblies associated with these 4 reports have been plotted on the RHS drawings, and it was conservatively assumed that a bar was cut at each hole location.

2.6.4 Engineering Assessment of Drilled Holes for Concrete Expansion Anchors

A structural engineer reviewed the individual damaged reinforcing steel reports as they were submitted by the contractor. During the period 1976 through 1979, the contractors did not distinguish between a cut and a nicked bar. In these situations, the structural engineer conservatively assumed all reinforcing steel to be cut. The review of the individual damaged reinforcing steel consisted of a determination of the immediate, local impact of the damaged bar. This review, in most instances, consisted of engineering judgement based upon the existing stress levels in the damaged reinforcing steel. The existing stress levels were, again, determined as a function of the design loads in accordance with the

LaSalle County FSAR, as specified in Sections 2.4.3 and 2.5.3. In addition to reviewing the individual damaged reinforcing steel reports, a structural engineering assessment was periodically made, considering the overall effects of the accumulation of all damaged reinforcing steel. This entailed a review of the structural design drawings indicating the location of cored holes passing through concrete elements, the CHS drawings indicating the location of all cored holes for equipment foundation anchor bolts, and the RHS drawings for the drilled holes for concrete expansion anchors. This structural engineering assessment, again, consisted of engineering judgement, in which the structural engineer reviewed the stress levels in all the damaged reinforcing steel. During the final load check, which was completed just prior to initial fuel load, a final overall engineering assessment was again performed. Subsequent detailed structural calculations have substantiated and verified that the engineering judgement which was consistently used throughout the course of the project was appropriate (see Section 2.7) and have verified that these drilled holes have not jeopardized the structural integrity of any safety related area.

2.6.5 Summary of Reinforcing Steel Damage due to Drilled Holes for Concrete Expansion Anchors

Table 2.6-2 summarizes the number of holes and the number of reinforcing bars reported as being damaged due to the drilling operations for concrete expansion anchors in all Unit 1 safety related areas, and in those Unit 2 safety related areas required for Unit 1 operation.

TABLE 2.6-2

Summary of Reinforcing Steel Damage Due to
Drilling Operations

<u>Item</u>	<u>Unit 1 Areas</u>	<u>Unit 2 Areas Required for Unit 1 Operation</u>
Estimated Number of Drilled Holes	50,000	8,000
Number of Reported Damaged Reinforcing Bars*	3,498	213
Number of RHS Drawings Indicating Reinforcing Steel Damage	118	20

*This does not include those bars which are known to have been only nicked during the drilling operation.

It is emphasized that the number of damaged bars listed include bars which may have been only nicked but cannot be identified as such from the damage reports between the periods 1976 through 1979. Where a nick could not be clearly identified, the bar was assumed to be cut, and was totally discounted in the structural assessment.

2.7

Summary of Detailed Structural Assessment for Damaged Reinforcing Steel

Throughout the course of the project, the effects of damaged reinforcing steel were continuously reviewed by a structural engineer. As referenced in Sections 2.4, 2.5 and 2.6, this review was primarily based upon engineering judgement. As cored holes were incorporated on the structural design drawings and mechanical

drawings, and as the contractors submitted the damaged reinforcing steel reports for drilled holes, a complete record of all damaged reinforcing steel was maintained on the following documents:

- A. Damage due to cored holes passing through concrete - indicated on the structural design drawings.
- B. Damage due to cored holes partially penetrating concrete - indicated on the "CHS" drawings.
- C. Damage due to drilled holes for concrete expansion anchors - indicated on the "RHS" drawings.

A review of these three categories of drawings locating reinforcing steel damage indicated that the damage was sparse and randomly scattered throughout the safety related areas.

The engineering judgement which was utilized consisted of a review of the location of the damaged reinforcing steel in relation to the design stress levels in the reinforcing steel and the existing design margins in the concrete elements. During this review, the structural engineer had the benefit of the complete picture of the accumulation of all damaged reinforcing steel in a given area and this was taken into consideration in the assessment. It is Commonwealth Edison Company's belief that this review, based upon engineering judgement, satisfies the State of Illinois' concern that an assessment should be made on a case-by-case basis.

Sargent & Lundy stated in the hearing held in Bethesda, Maryland on March 31, 1982, that the amount of damaged reinforcing steel which could be tolerated in any one area was not a fixed percentage. The amount of damaged reinforcing steel which could be tolerated is a function of the design margins in the concrete elements and the stress levels in the reinforcing steel in relation to the location of the damaged reinforcing steel. The engineering assessment which was made continuously throughout the course of the project did, in fact, account for all damaged reinforcing steel on a case-by-case basis.

In response to the petition by the Attorney General, State of Illinois, however, a detailed set of structural calculations was made to further support this engineering judgement. Prior to the March 31, meeting, nine representative safety related concrete elements comprised of two slab panels, six wall panels, and one concrete beam were selected by Sargent & Lundy. These nine concrete elements which are located in the Unit 1 Reactor and Auxiliary Buildings, were selected because the RHS, CHS and structural design drawings indicated a relatively high concentration of reinforcing steel damage in these areas. Table 2.7-1 summarizes the results of detailed structural assessment. For each concrete element, the following data has been indicated:

- A. Design margin assuming no damaged reinforcing steel (Column j).

- B. Number of damaged reinforcing bar locations due to drilling operations (Column f)
- C. Total number of reinforcing bars damaged due to drilling operations (Column g)
- D. Total number of cored holes (Column h)
- E. Total number of reinforcing bars damaged due to cored holes (Column i)
- F. Design margin with reinforcing bar damage without taking credit for the actual in-place material strengths (Column k)
- G. Design margin with reinforcing bar damage considering actual material strengths (Column l)

It can be seen that, in all nine areas, the design margins were not reduced below 1.0. It is again pointed out that a design margin equal to 1.0 represents both an economical and safe structural design. It is Commonwealth Edison Company's and Sargent & Lundy's belief that these detailed calculations justify the use of prior engineering judgement.

A concern was raised at the conference in Bethesda, Maryland on March 31, 1982, that the sample selected was too small, and that there may be more critical concrete elements which only had

design margins close to 1.0 without considering the reinforcing steel damage. Subsequent to this meeting, detailed structural calculations were performed on all structural elements in all Unit 1 areas and in those Unit 2 areas required for Unit 1 operation where damaged reinforcing bars were identified during coring or drilling operation. These detailed calculations verified that the design margins in all concrete elements in these areas are greater than 1.0 with the damaged reinforcing steel considered.

Out of all elements reviewed in the affected areas, 30 elements were evaluated using actual material properties. This constituted only 1.49% of the total elements in Unit 1 and in Unit 2 required for Unit 1 operation. Additional conservatism is adherent in these calculations since a minimum component support load of one kip per square foot was utilized in all areas. In many cases, this load is less than one kip per square foot.

Table 2.7-2 summarizes the total number of concrete elements where damaged reinforcing was identified and for which detailed calculations were made, and also the corresponding total number of concrete elements in all Unit 1 areas and Unit 2 areas required for Unit 1 operation:

This evaluation verified that in no area have the design margins been reduced to a value less than 1.0, further substantiating that the engineering judgement used originally throughout the project was appropriate.

Approximately 2500 pages of detailed structural calculations were made as part of this evaluation. The following sample calculations are attached to illustrate the type of detailed structural calculation which was made for each concrete element:

- A. Figure 2.7-1 - Structural Calculations for Slab Panel
- B. Figure 2.7-2 - Structural Calculations for Wall Panel
- C. Figure 2.7-3 - Structural Calculations for Concrete Beam

The structural assessment, as mentioned throughout this report, considered those Unit 2 areas required for Unit 1 operation. It should be pointed out that, while the work at Unit 1 has been completed, work in Unit 2 areas will continue for approximately one year. It is anticipated that additional reinforcing steel may be damaged in these areas. However the program which has been implemented to control, document and assess any reinforcing steel damage in these areas will ensure that the safety and operability of Unit 1 will not be impaired in any manner as a result of continuing construction in Unit 2.

2.8 Conclusion in Response to Allegation on Cored and Drilled Holes

Commonwealth Edison Company has presented evidence, which has been subsequently audited by the NRC staff, to substantiate that the drilling and coring of holes in the LaSalle County, Unit 1 safety

related areas and in those Unit 2 safety related areas required for Unit 1 operation have not impaired the structural integrity or created a potentially hazardous condition which may be injurious to the public health and safety. Commonwealth Edison Company does not dispute Mr. Garrison's statement that he seldom failed to contact reinforcing steel in the coring operations. It has been pointed out that this loss of reinforcing steel was reviewed and assessed prior to the coring operations, and there was no requirement placed on the contractor to report the subsequent reinforcing steel damage. Commonwealth Edison Company, likewise, does not contest that a number of holes, ranging in the order of thousands, have been cut through the reinforcing steel. The total number of reported cut bars however are known, (See Table 2.7-3) and have been recorded as described in Sections 2.4, 2.5 and 2.6. Mr. Bridenbaugh stated that, if reinforcing steel was damaged or severed without appropriate structural analysis, that it was nearly certain that some safety related structures would have been affected. It has been pointed out that this structural engineering analysis was, in fact, performed throughout the course of the project, and that the structural integrity has not been impaired.

In conclusion, the drilling operations performed at LaSalle County, Units 1 and 2, have been accomplished maintaining design margins of safety related structures, above specified limits and the quality requirements imposed by the U.S. Code of Federal Regulation, 10CFR, Part 50, Appendix A, General Design Criteria for Nuclear Power Plants and Fuel Reprocessing Plants have been satisfied.

Commonwealth Edison Company has demonstrated that it has implemented appropriate procedures to control reinforcing steel damage, and has exercised sound engineering judgement and due precaution with regard to the drilling of concrete for cored holes and for the installation of concrete expansion anchors.

The petition brought forward by the Attorney General, State of Illinois, alleged that the Off-Gas Building roof was only 8" thick, whereas the design drawings required this roof to be 12" thick. It was also alleged that this roof had cracked substantially due to the number of expansion anchor bolts drilled in it. Commonwealth Edison Company presented data at the conference held in Bethesda, Maryland on March 31, 1982, substantiating that the roof was, in fact, poured to a nominal 12" thickness, and that the cracking which was observed was surficial in nature, and not due to reinforcing steel damage due to the installation of concrete expansion anchors.

A total of 55 damaged reinforcing steel reports were submitted by the contractors for the Off-Gas Building roof area (five panels, each 15'-0" by 37'-6"). None of the reports positively identified that any of the contacted reinforcing steel was cut. However, each report has been reviewed and it was conservatively assumed that each damage was a cut. Detailed structural calculations were made for the slab roof panel (panel area 15'-0" by 37'-6"), which had the greatest number of reported reinforcing steel damage. There were a total of 27 reinforcing damage steel reports in this area. This corresponded to a maximum of 47 reinforcing bars assumed to be damaged. The structural assessment indicated that the design margin was reduced from 4.7 to 2.79. The final design margin of 2.79 substantiates that the cracking which was observed in the roof

was surficial in nature (i.e., due to normal concrete shrinkage), and not due to reinforcing steel damaged by the installation of concrete expansion anchors.

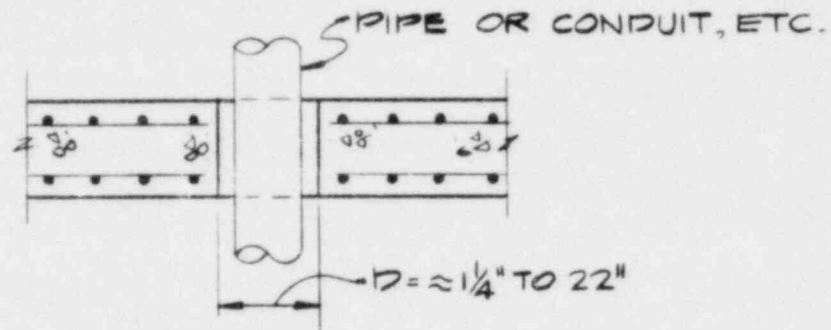


FIGURE 2.2-1

CORED HOLE PASSING THROUGH CONCRETE

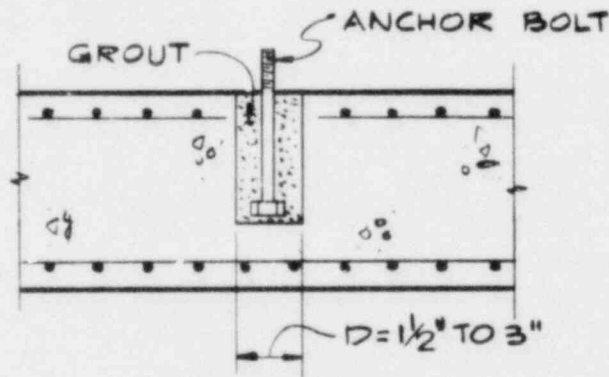


FIGURE 2.2-2

CORED HOLE PARTIALLY PENETRATING CONCRETE

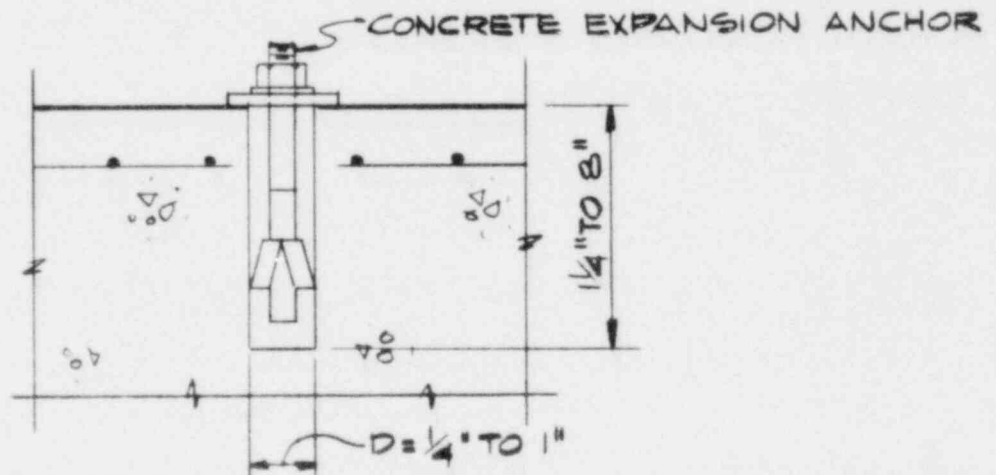
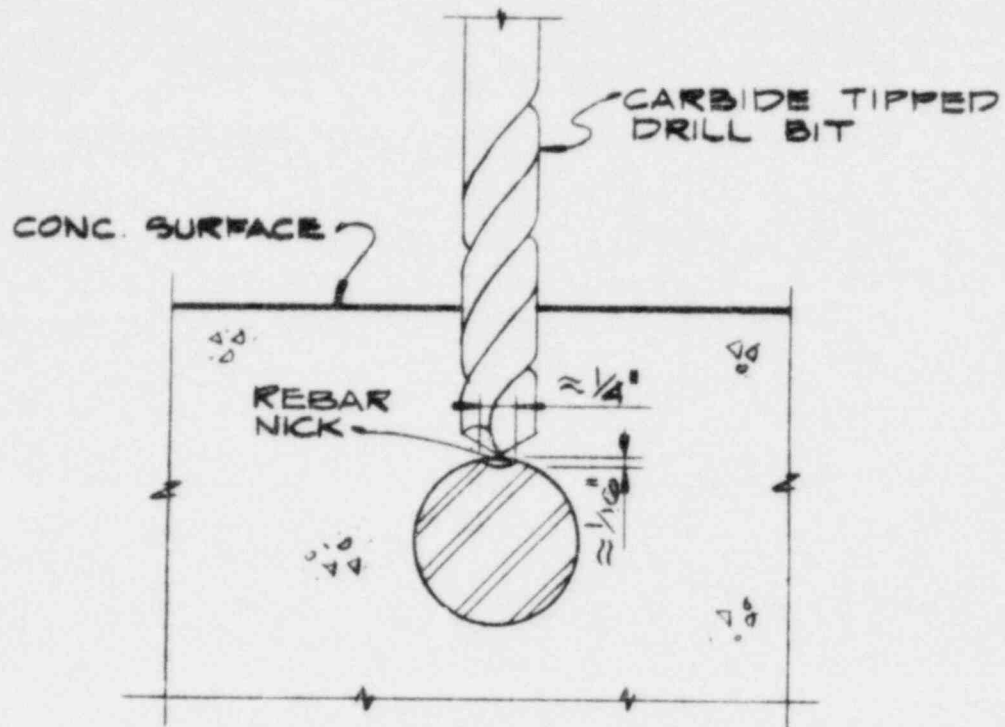


FIGURE 2.2-3

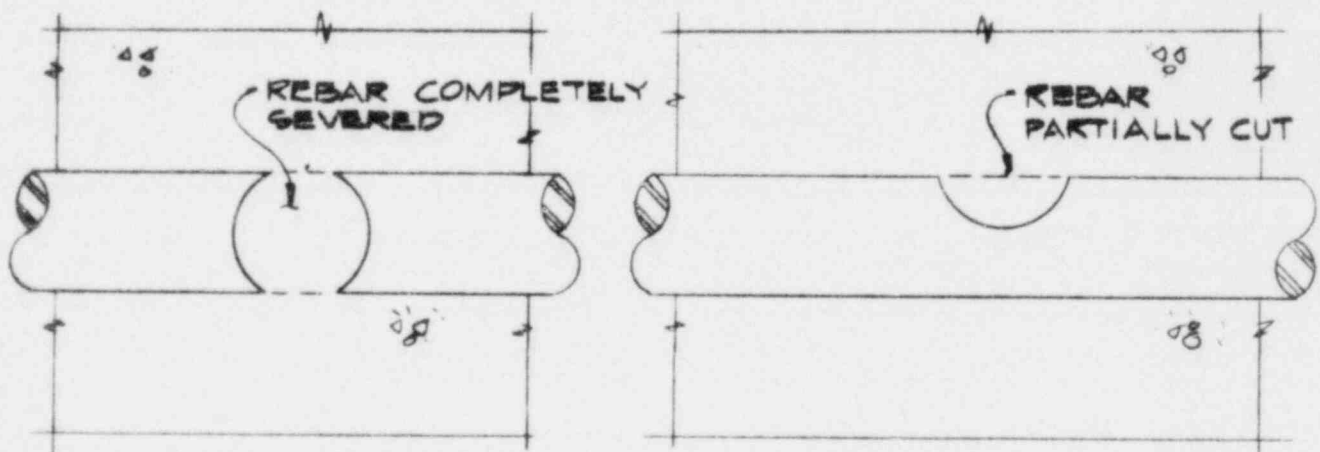
DRILLED HOLE IN CONCRETE FOR EXPANSION ANCHOR INSTALLATION



SECTION

FIGURE 2.2-4

NICKED REINFORCING STEEL



PLAN

FIGURE 2.2-5

CUT REINFORCING STEEL

CONCRETE GENERAL NOTES CONTINUED CC

40. ALL CONCRETE FILL AND MUD CLASS SHALL BE BASED UPON SPECIFICATION S-255E
41. ALL ELECTRICAL CONDUITS MARKED "C" SHALL BE INSTALLED IN ACCORDANCE WITH S-255E.
42. ALL ADDITIONAL REINFORCING AND NO OPENINGS IN SLAB SUPPORTED ON STRUCTURAL STEEL SEE DET 01 & DET 02 OF THE S-255E
43. FOR CORED HOLE DIAMETERS SEE SLEEVE SCHEDULES.
44. FOR CORED HOLES MARKED (E) LESS THAN 8" ϕ USE METAL DETECTOR TO LOCATE EXISTING REINF. PRIOR TO CORE DRILLING, IN CASE OF INTERFERENCE WITH REBAR, HOLES MAY BE CORED IN ALTERNATE LOCATION WITHIN 3' RADIUS FROM LOCATION SHOWN ON DWG.
45. EXISTING OPENINGS SHALL BE CLOSED WITH CONCRETE OR NON-SHRINK GROUT.
46. FOR TYPICAL MAINTENANCE SLEEVE PLUGS DETAIL SEE DWG. (S-255E).

R

FIGURE 2.4-1

AN EL 761'-0" WEST AREA

S-213

NOTES

1. FOR GENERAL NOTES SEE DWG. S-144.
2. ALL CONCRETE ON THIS WALL SHALL BE BA-40 UNLESS NOTED.
3. FOR COLUMN SCHEDULE SEE DWG. S-239.
4. FOR BEAM SCHEDULE SEE DWG. S-242.
5. FOR SLAB SCHEDULE SEE DWG. S-243 & S-244.
6. FOR EQUIPMENT FOUNDATION DOWELS SEE DWG. M-1562.
7. FOR EMBEDMENTS IN UNDERSLAB SEE DWG. S-308.
8. FOR EMBEDDED DOVETAILED REINFORCEMENT SEE DWG. A-234.
9. FOR SLEEVE SCHEDULES SEE DWG'S S-1177, S-1178 & S-1193.
10. THIS WALL IS TO BE FURRED AFTER INSTALLATION OF FURRING.
11. USE METAL DETECTOR TO LOCATE CORED HOLE TO AVOID CUTTING REINFORCING. VERIFY FINAL HOLE LOCATION IN FIELD.
12. OPENINGS MARKED THUS (*) NEED NOT BE CLOSED.

M1203

SHEET
EL 765

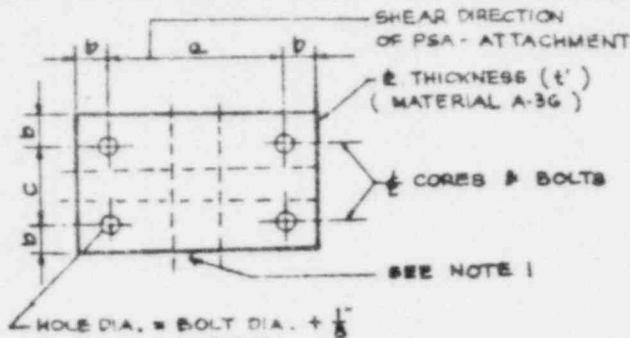
REV. SPEC.

AB 1-25-63

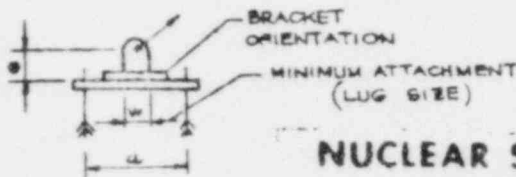
DRAWN:

Chadwick

FIGURE 2.4-2



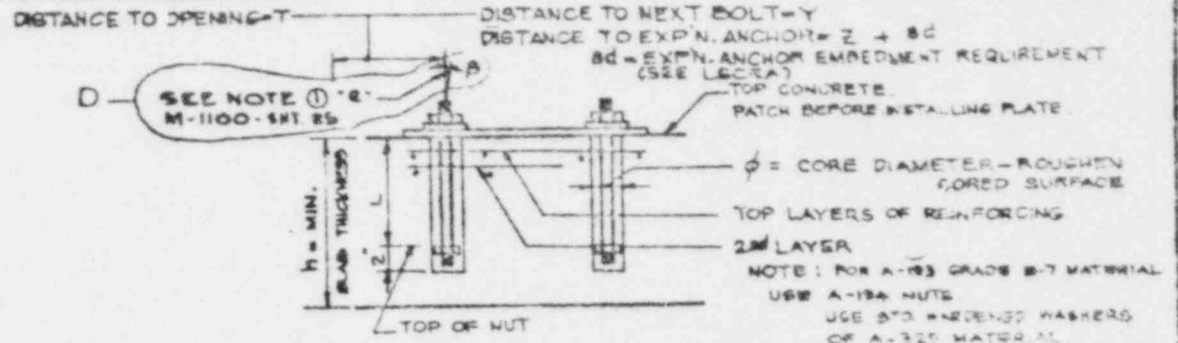
DETAIL "B" & "C"
PLAN OF PLATE



NUCLEAR SAFETY RELATED

ITEMS ARE SHOWN ON THIS DRAWING

STANDARD FOR CORE-DRILLED BOLTED PLATES



NOTES:

- (1) CAREFULLY NOTCH CONCRETE $\geq 1\frac{1}{2}$ " WIDE UNLESS MORE NEEDED IN BOTH DIR. TO LOCATE FB-BARS IN TOP LAYERS. LOCATE PLATE TO AVOID CUTTING EXPOSED REINFORCING. EXPOSE 2ND LAYER WHERE APPLICABLE.
- (2) ADD 6" TO "L" TO DETERMINE ROD LENGTH. THREAD ROD 6" TOP AND BOTTOM.
- (3) AFTER INSTALLING RODS, FILL CORES WITH "EMBECCO 63G GROUT" AS MANUFACTURED BY MASTER BUILDERS AND IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS. DO NOT TIGHTEN NUT OR APPLY TENSION TO RODS UNTIL AFTER 7 DAYS OF PLACING GROUT. NEATLY PATCH NOTCHES.
- (4) AFTER 7 DAYS FROM PLACING GROUT TIGHTEN NUTS FINGER TIGHT AND $\frac{1}{4}$ " TURN.
- (5) INSTALL ATTACHMENT AT ϕ OF PLATE ± 1 " TOLERANCE.
- (6) SEE GHT 25 FOR ANCHOR BOLT LOCATION AND INSTALLATION TOLERANCES.

PLATE SIZE	BOLT SIZE	BOLT MAT'L	L	ϕ	h	a	b	c	t	e	y	z	T	COMMON ATTACHMENT	LOAD (KIP)	W	IK
15" x 15"	$\frac{3}{4}$ "	ASTM A-193 B-7	12"	2 $\frac{1}{2}$ "	1'-6"	12"	1 $\frac{1}{2}$ "	12"	1 $\frac{1}{2}$ "	2 $\frac{3}{4}$ "	24"	12"	13"	PSA-10 OR EQUIV.	UPSET = 15 EMER. = 22.1	3"	DET. E
22" x 15"	$\frac{1}{2}$ "	ASTM A-193 B-7	22"	3"	2'-6"	18"	2"	9"	1 $\frac{1}{2}$ "	4 $\frac{1}{2}$ "	56"	18"	19"	PSA-35 OR EQUIV.	UPSET = 90 EMER. = 72.45	8"	DET. C

REFERENCE	DWG. NO.	REV.	DWG. NO.	REV.	DWG. NO.	REV.	DWG. NO.	REV.
DATE								

DRAWING RELEASE RECORD

REV.	SPEC. NO.	DATE	DRAWN	CHECKED	ENGR. APPROV.	FIRM	END REVIEW
A	J-2530	1-11-80	[Signature]	[Signature]	[Signature]	CEC-2404	
B	J-2530	4-1-80	[Signature]	[Signature]	[Signature]	CEC-2614	
C	J-2530	5-7-80	[Signature]	[Signature]	[Signature]	CEC-2680	
D	J-2530	7-1-80	[Signature]	[Signature]	[Signature]	CEC-2855	

REVISION DESCRIPTION: REV. D PER FOR 01450



P.T. SEAL

PROJECT NO.

4866-00
4867-00

LA SALLE COUNTY STATION
UNIT-1 & 2
COMMONWEALTH EDISON COMPANY
CHICAGO, ILLINOIS

COMPONENT SUPPORTS GENERAL
NOTES AND DETAILS

SARGENT & Lundy

DESIGNED BY

M-1100

SHEET 23 OF 24

FIGURE 2.7-1
STRUCTURAL CALCULATIONS FOR SLAB PANEL

Client CECO	Prepared by S. Sosa	Date 4/3/82
Project LASALLE COUNTY -1	Reviewed by A. Ta.1	Date 4/3/82
Proj. No. 4266-00 Equip. No.	Approved by SmKyzh	Date 4-3-82

1-RS-103

SLAB THICKNESS = **18"** ✓ (ONE WAY SLAB)
EAST-WEST DIRECTION

REFERENCE DWGS:

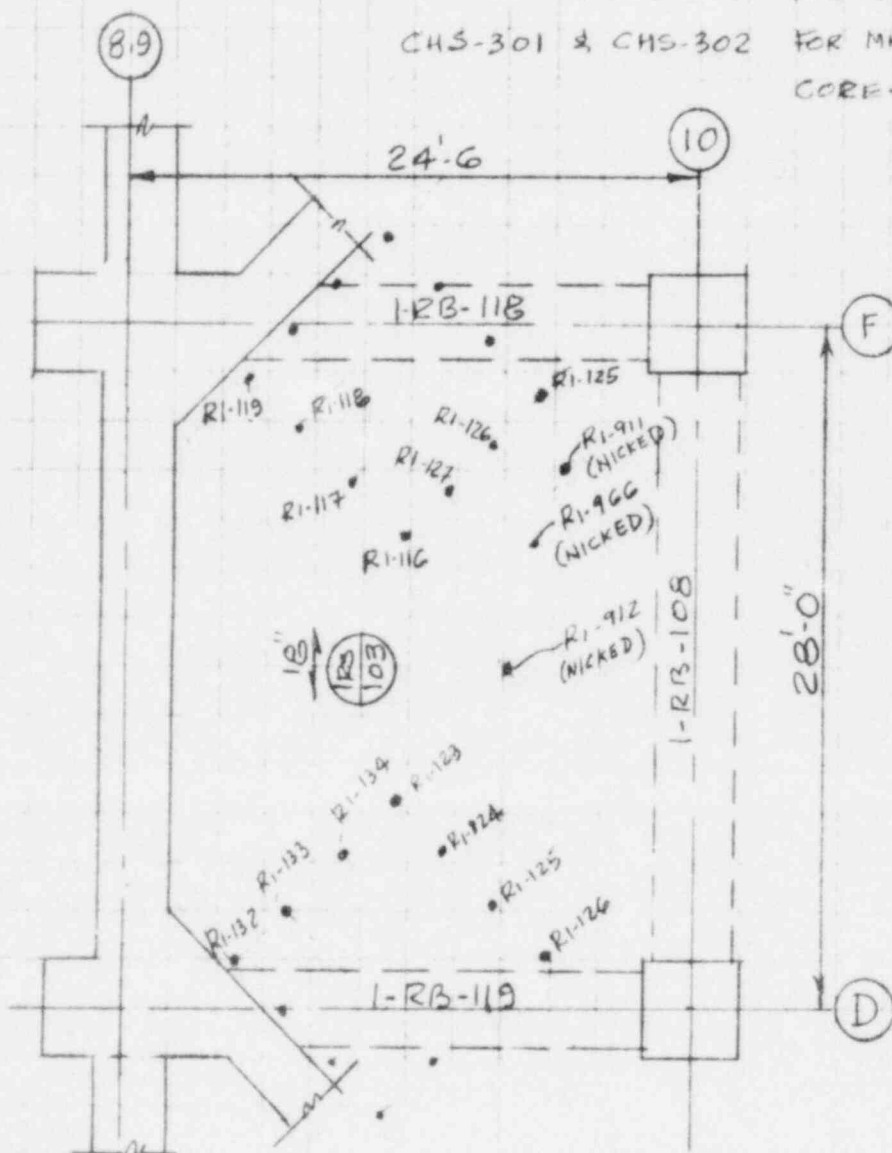
S-206 & S-207

RHS-206 & RHS-207

FOR REBAR CUT

CHS-301 & CHS-302

FOR MECH. EQUIP. FOUNDATION
CORE HOLES



PARTIAL PLAN

(DWG. **S-206 & 207**)

(DWG. **RHS-206 & 207**)

(DWG. **CHS 301 & 302**)

SARGENT & LUNDYENGINEERS
CHICAGO

Calcs. For RE-BAR CUT IN LAB.

EL. 694'-6

1-RS-103



Safety-Related

Non-Safety-Related

Calc. No. 516A

Rev. 0 Date 4/3/82

Page 14a of

Client CECO

Project LABALLE COUNTY -1

Proj. No. 4266-00 Equip. No.

Prepared by

Date 4/3/82

Reviewed by

Date 4/3/82

Approved by

Date 4-3-82

1-RS-103 CONT:R₁-911 - SEE MORRISON CONST CO. Report NO. 3075 DATED 3/3/80R₁-912 - SEE MORRISON CONST CO. Report NO. 3076 DATED 3/3/80R₁-966 - SEE MORRISON CONST CO. Report NO. 3096 DATED 3/15/80

PBC ABOVE REPORTS THERE IS NO REBAR CUTS ✓
ALL REBAR ARE NICKED. ✓

CHS-301 EAST END:

FOR C.S.C.S AREA COOLER & FAN FOUNDATION (SEE DWG M-1590 SHT. 8 NO (62))
3"Φ X 1'-2" CORED HOLES (MARKED ON DWG. CHS-301 - R₁-123, 124, 125, 126
132, 133 & 134 - 7 LOCATIONS)

DUE TO ABOVE CORED HOLES ONLY TOP RE-BARS ARE DAMAGED.
POSSIBLE TOTAL RE-BARS DAMAGED = 7

CHS-302 WEST END:

FOR C.S.C.S AREA COOLER & FAN FOUNDATION (SEE DWG M-1590 SHT. 8 NO (61))
3"Φ X 1'-2" CORED HOLES (MARKED ON DWG CHS-302 - R₁-116, 117, 118, 119, 125, 126 & 127
7 LOCATIONS)

DUE TO ABOVE CORED HOLES ONLY TOP RE-BARS ARE DAMAGED.
POSSIBLE TOTAL RE-BARS DAMAGED = 7 ✓

BOTH ENDS:- TOP REINFORCEMENT #8@6" ✓ (SEE DWG S-246)
(EAST & WEST)

AT SUPPORTS: MOMENT CAPACITY (#8@6") = -109.03'K ✓
NEGATIVE ACTUAL MOMENT DUE TO LOAD = -53.89'K ✓

FROM CALC. BOOK 916
(1 OF 2)
Page No. 102a.

ACTUAL MOMENT BASED ON FOLLOWING LOAD COMBINATION (COMBINE SEE
FOR DEAD LOAD, EQUIP. LOAD & HANGER LOAD. GOVERNS)

7.2 1.0D + 1.0E_{SS} + 1.0CHUGG. + 1.0SRVADSQ + 1.0PB - FROM CALC BOOK 916
WHERE D=DEAD LOAD E_{SS}=SEE SEISMIC CHUGG.=CHUGGING. Page. 2 (1 OF 2)

SRVADSQ=SAFETY RELIEF VALVE LOADS. PB=PRESSURE DUE TO PIPE BREAK
ADS=QUENCHER

SAFETY MARGIN FACTOR $\frac{109.03}{53.89} = 2.023$
WITHOUT RE-BAR CUT = 53.89

PAGE 2 OF 3

SARGENT & LUNDYENGINEERS
CHICAGO

Calcs. For RE-BAR CUT IN SLAB

EL. 694'-6

1-RS-103

Calc. No. 916A

Rev. 0

Date 4-3-82

✓ Safety-Related

Non-Safety-Related

Page 46 of

Client CECO

Project LABALLE COUNTY - 1

Proj. No. 4266-00 Equip. No.

Prepared by

S. Kesari

Date 4-3-82

Reviewed by

H. Fong

Date 4/3/82

Approved by

Smkuzni

Date 4-3-82

1-RS-103 CONT:EAST END SUPPORT:

DUE TO SLAB ABILITY TO REDISTRIBUTE MOMENT, DAMAGED RE-BAR MAY BE ASSUMED TO BE UNIFORMLY DISTRIBUTED ACROSS SLAB. ALSO, SLAB WILL ACT AS A UNIT.

FOR 20'-6" WIDTH OF SLAB TOTAL #8 RE-BARS = 42 NOS ✓

DAMAGED RE-BARS = 7 NOS ✓

#8 RE-BAR $A_s = 0.79 \text{ IN}^2$ DIA = $\frac{1}{2} \text{ IN}$ 35 NOS. ✓deff = $18 - 1.5 = 16.5$ ✓↑ $1" \text{ cov} + \frac{1}{2} \text{ DIA} = 1.5$ REDUCED AREA OF REINF. $A_s' = \left(\frac{35}{42} \right) \times 0.79 = 0.658 \text{ IN}^2$ ✓

DUE TO RE-BAR CUT

FOR 1'-0" WIDTH OF SLAB:

$$\text{REDUCED MOMENT CAPACITY} = \frac{\phi \times A_s' \times F_y}{\text{RE-BAR SPACING}} \left(\text{deff} - \frac{A_s' \times F_y}{2 \times 0.85 \times f_c \times b} \right)$$

(MA)

 $\phi = 0.9$ spacing = 6" ϕ deff = 16.5" $A_s' = 0.658 \text{ IN}^2$ $b = 12"$ $F_y = 60 \text{ ksi}$ $f_c = 4 \text{ ksi}$

$$\therefore M_a' = \frac{0.9 \times 0.658 \times 60}{6} \left(16.5 - \frac{0.658 \times 60}{2 \times 0.85 \times 4 \times 12} \right)$$

$$= 94.84 \text{ K} \checkmark$$

$$\text{SAFETY MARGIN FACTOR} = \frac{94.84}{53.89} = 1.76 > 1.0$$

WITH RE-BAR CUT

SO SLAB IS ADEQUATE.

WEST END SUPPORT: COMPARE WITH EAST END SUPPORT

(SAME RE-BAR CUT & SAME REINF.) ✓

 \therefore SLAB IS ADEQUATE

FIGURE 2.7-2
STRUCTURAL CALCULATIONS FOR WALL PANEL
SERIAL NO. 38



Calc. For LaSalle County Station - Unit 1
Design Safety Margins
☒ Safety-Related ☐ Non-Safety-Related

Calc. No. 1B
Rev. 0 Date 3/3/82
Page 196 of

Client CECO
Project LaSalle - Unit 1
Proj. No. 4266-00 Equip. No.

Prepared by H. FANG Date 3-31-82
Reviewed by [Signature] Date 4-2-82
Approved by [Signature] Date 4-5-82

Building	S-DWG No.	Wall along col. line No.	ABOVE ELEV.	Wall LOCATION PANEL No.	WALL SPRING LINE	NO OF DAMAGED REBARS	NO. OF CORRO HOLES	GOVERNING MARGINAL FACTOR	
								WITHOUT CUTS	WITH CUTS
Aux. Bldg.	S-576 (Plan) S-624 (Section)	N	768'-0" ~794'-0"	⑥ & ⑨	1405003	37 at east face	0	For wall ① & ⑧	panel betn.
						41 at west face		1.775	1.489
						78 total		For wall ⑤ & ⑨	panel betn.
						29 damaged rebars		1.812	1.624

Summary: From the above - the governing value w/ cuts is 1.489 betn. col. line ① & ⑧

SARGENT & LUNDYENGINEERS
CHICAGO

Calc. For S-624, Wall along sub line N

El. 768' ~ 794'

Aux. BLOQ



Safety-Related

Non-Safety-Related

Calc. No. B

Rev. 0

Date 4-1-82

Page 197 of

Client CECO

Project LaSalle - Unit 1

Proj. No. 4266-04

Equip. No.

Prepared by

H. FANG

Date 4-1-82

Reviewed by

L. Alta

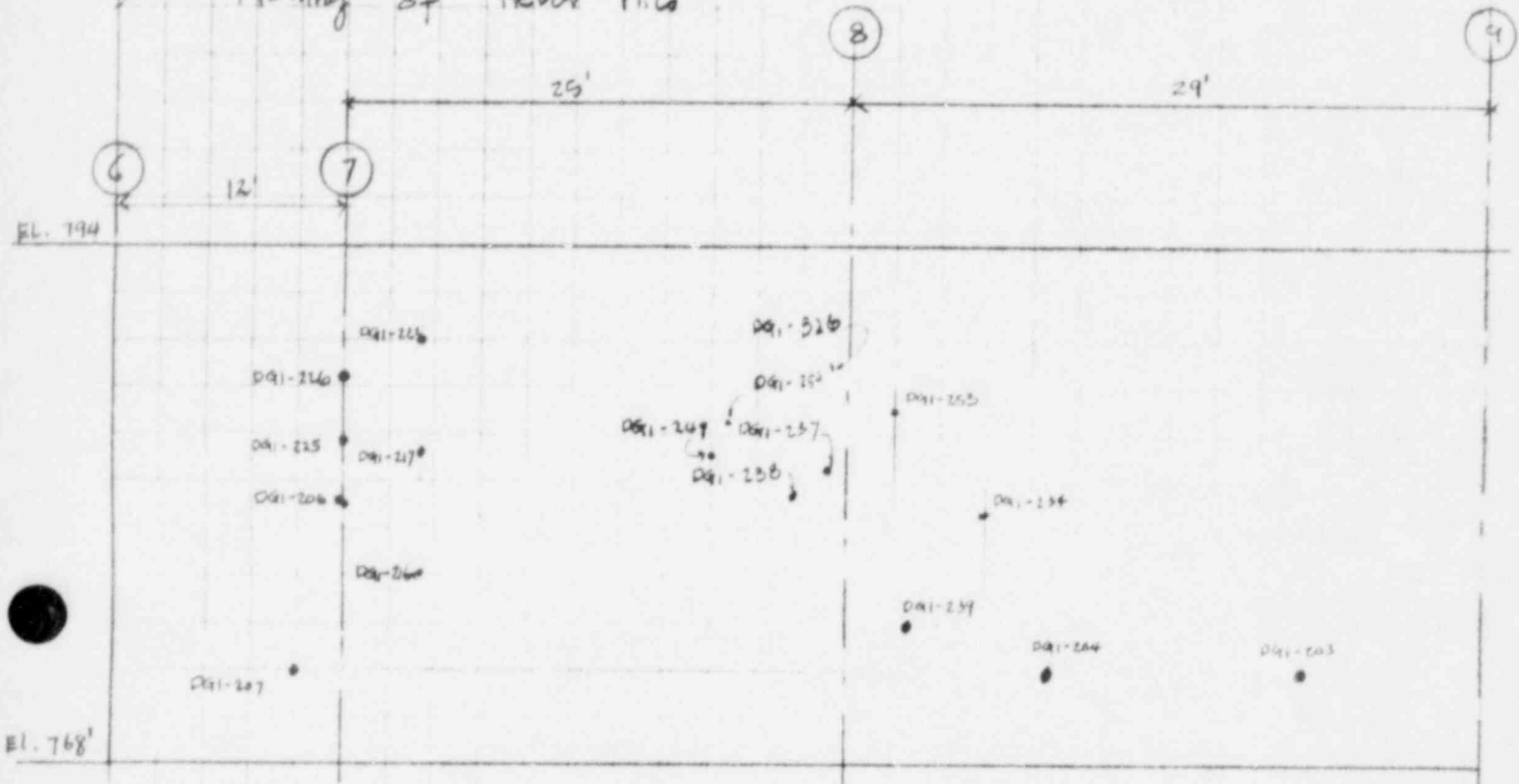
Date 4-1-82

Approved by

Smkaym

Date 4-2-82

Plotting of Rebar N.T.S.

EAST WALL
CRITICAL ELEVATION

FOR REBAR CUTS ON THE WEST SIDE SEE NOTE ON P. 198

- Ref. Draw. S-624

Client CECO
Project Lasalle - Unit 1
Proj. No. 41.66-00 Equip. No.

Prepared by H. FANG Date 4-3-82
Reviewed by K. Alt Date 4-5-82
Approved by Smkayuni Date 4-5-82

Summary of Rebar hit

RHS HIT NO	PANEL BETWEEN ⑥ ~ ⑦
	DG1-202
SKETCH	

NOTE: Rebar hits w/ A1- ARE AT WEST SIDE, i.e. non-critical.
Rebar hits w/ DG1- ARE AT EAST SIDE & THEY'RE CRITICAL.

H: Assumed horizontal rebar cuts quantity.
V: Assumed vertical rebar cuts quantity.
⊗ denotes rebar hit from reports

PANEL BETWEEN ⑦ ~ ⑧
SEE P. 197 FOR THE EXACT LOCATION OF THE FOLLOWING HITS

RHS HIT NO	DG1-220	DG1-225	DG1-206	DG1-222	DG1-217	DG1-216	DG1-249
	H=2, V=4	H=2, V=4	H=2, V=2	H=1, V=1	H=1, V=1	H=1, V=0	H=1, V=0
SKETCH							

RHS HIT NO	DG1-238	DG1-237	DG1-250	DG1-326
	H=0, V=2	V=1, H=0	H=1, V=1	H=1, V=1
SKETCH				

PANEL BETN. ⑧ ~ ⑨

RHS HIT NO	DG1-253	DG1-234	DG1-229	DG1-204	DG1-203
	H=0, V=1	H=2, V=2	H=0, V=1	H=1, V=0	H=1, V=2
SKETCH					

NOTES: 1. FOR WEST SIDE THE REBAR CUTS ARE LESS THAN EAST SIDE.
2. RHS drawing shows rebar hits from reports of different contractors.
PAGE 3 OF 12



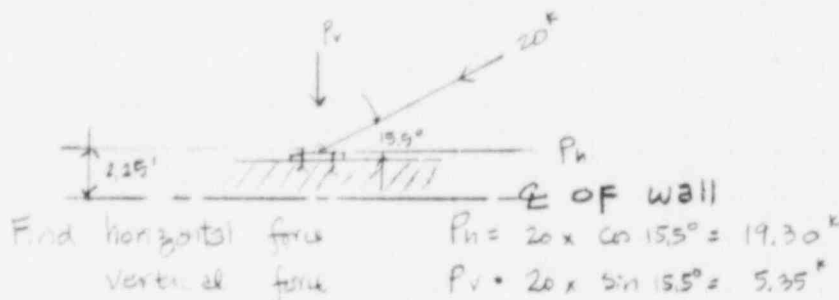
Calc. For S-624, Wall along line N	
EL 768 ~ 794	AUX Bldg
<input checked="" type="checkbox"/> Safety-Related	<input type="checkbox"/> Non-Safety-Related

Calc. No. 1E
Rev. 0 Date 4/1/82
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Client CECO
Project LaSalle - Unit 1
Proj. No. 4266-00 Equip. No.

Prepared by H. FANG	Date 4-1-82
Reviewed by	Date 4-2-
Approved by	Date 4-2-82

X Betn. Panel ① & ② Mech. HRR M-B034 has 20^k ssb loads acting on the wall (see drawing WLS-624)



The horizontal force will act on horizontal reinf. & concrete

$V_u = 19.30^k$, $b = 42"$ (2.5'), $l_w = 25'$ (conservatively assume only the width between col. line ① & ② will be effected by this local shear force)

Find shear stress

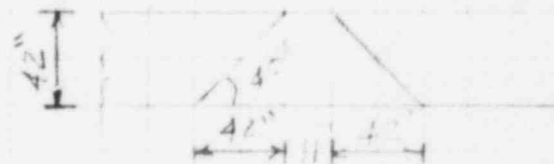
$$v_u = \frac{V_u}{144 \times 0.85 \times 0.8 \times b \times l_w} = \frac{19.30 \times 1000}{144 \times 0.85 \times 0.8 \times 35 \times 25} = 2.25 \text{ psi} \quad \left[\begin{array}{l} \text{Per ACI 318-77} \\ \text{Section 11.10.4} \end{array} \right]$$

$$A_{w \text{ in-plane}} = \frac{v_u \cdot b \cdot s}{1.4 f_y} = \frac{2.25 \times 35 \times 12 \times 12}{1.4 \times 60,000} = 0.0135 \text{ in}^2$$

Make the following assumption:

$$n \approx 1.25 \text{ (ACI 318-77)} \quad 43.4^k$$

$$1/ \quad 43.4 / 0.6 = 72^k / \text{ft}$$



NEGLECT

PAGE 1 OF 12

Client	CECO	Prepared by	H. FANG	Date	4-1-82
Project	LaSalle - Unit 1	Reviewed by	K. LIT	Date	
Proj. No.	4266-00	Equip. No.		Approved by	Dr. K. Yang
				Date	4-2-82

X Ref. Drawing S-624, RHS-624, RCS-624 & WLS-624 & S-576

For load combination, see p. 203a

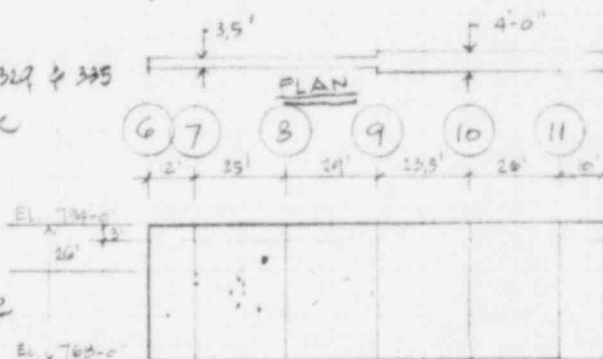
* Combined SSE govern, see Vol 143E, p. 329 & 335

* For location of individual cut, see each drawing & sketch at p. 197

* Original calcs summary, both for 1975 & 1977 output

* For impact, impingement calcs see Vol 144 p. 15

* SUMMARY FOR VERTICAL REINF.



COL. LINE	①-② (15'-6")	②-③ (15'-6")	③-④ (23'-6")	④-⑤ (40'-0")	REMARKS
Reference	Vol. 144	"	Vol. 144	Vol. 144	P 50 & P 69 From calcs 1977
Combination	150, P. 73	"	P. 59	P. 74	P. 73 & P. 74 " " 1975
Blowdown Force	590.2	590.2	590.2	751.67	
Thrust Force	369.2 / 184.8	369.2 / 184.8	590.2 / 295.1	751.67 / 206.82	
Impact Mu (Pipe Whip)	40.45 k'	40.45	65.42 k'	56.70 k'	
A _{req} for Mu	0.27 in ²	0.27 in ²	0.39 in ²	0.23	comp. w/ impingement, use larger value
Impingement Force	1057 P _i	1057 P _i		834.97 P _i	
Impingement Mu	118.41 k'	118.41 k'		150.81 k'	
A _{req} (2) for Mu	0.32	0.32		0.754 in ²	
PRESSURE	P _a = 3 Mu ¹	35.97 k'	35.97 k'	35.97 k'	23.27 k'
	A _{req} (3) for P _a	0.244	0.244	0.244	0.12
	P _a = 5 Mu ¹	65.93 k'	65.93 k'	65.93 k'	42.69 k'

L = 23' ORIGINAL POSITION USE 18.5' FOR ④-⑤

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SARGENT LUNDY

ENGINEERS
CHICAGO

Calcs. For S-624, Wall along Col. line N

EL. 768 ~ 794

See BLDG

☒ Safety-Related

☐ Non-Safety-Related

Calc. No. 13

Rev. 0

Date 4/1/82

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Client CEC
Project L. S. L. - L. S. L.
Proj. No. 4266-00 Equip. No.

Prepared by H. FANG

Date 4-1-82

Reviewed by

Date 4-1-82

Approved by E. K. K. K.

Date 4-2-82

Area for (4) 51"	0.45	0.45	0.45	0.21	
Area for (5) 51"	0.63	0.63	0.63	0.725	* SEISMIC from R. 143, (1.0 > SE)
Area for (6) 51"	1.09	1.67	1.26	1.59	Combined S&E case, see p. 204 (Absolute sum was used conservatively)
Area for (7) 51"	1.90	1.90	1.47	1.629	
No. of Bars Provided	#11 @ 6"	#11 @ 6"	#8 @ 12" #6 @ 12" #4 @ 12"	#9 @ 6"	
As provided	150 x 2 = 3.12	3.12 in ²	(0.70 + 0.40) x 2 = 2.40 in ²	20 in ²	one face only
Comments	OK	OK	OK	OK	Reinf. greater than min. Reinf. per ACI code

NOTE: SEISMIC LOAD IS CONSERVATIVE FOR VERTICAL REIF.

* AT 1977 (see cal 143C, p. 205) $V_u = 5988$, $M_u = 185491$

Calculate the shear wall reinf. requirement; Wall elev. 768 ~ 794

SPRING NO	b	L _w	V _u	V _u	$\frac{M_u}{V_u} \times 0.5$	V _c	V _u - V _c	A _v = $\frac{(V_u - V_c) \times L_w}{f_y}$	%	REMARK
1405003 Wall betn 5 - 6	3.5	68'	5988	126	0.046	126	0	—	—	SHEAR REIF

$$* V_{u2} = V_u + (1.4 \times 0.35 \times b \times L_w \times q)$$

(L_w = total shear wall length)

SPRING NO	b	L _w	P _u	M _u	$e = \frac{M_u}{P_u}$	$K = \frac{P_u}{f_y \times b \times L_w}$	P _{tm}	P _{tm} %	P _{tm} % of P_u	REMARK
1405003 Wall betn 6 - 7	3.5	68'	939	185491	19754	0.0034	0.005	0.02	0.00142	FLEXURE REIF.

SPRING NO	A _g	P _u	V _u	V _u - P _u	$f_y \times \frac{V_u - P_u}{0.5 \times A_g}$	REMARKS
1405003 Wall betn 7 - 8	67934	939	5788	5049	0.014146	HOR. CONST. JOINT - VERT. REIF.

SUMMARY OF VERTICAL REINF. (EL. 768 ~ 794, along col. line N)

SPRING	L _w	% TOTAL SHEAR REIF	Flexure	HORIZ. JOINT REIF	P _u * 10 ³	A _s * in ²	A _s provided	REMARKS
1405003 Wall betn 8 - 9	130'	—	0.00142	0.0014146	1.42 x 10 ³	1.26 1.44	3.12 in ² OK 2.40 in ²	OK.

* minimum req'd = 0.0025 — 2 face

0.00125 — 1 face

** minimum req'd govern

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Calc. For Wall along col. line 4

EL. 724' - 724'

Safety-Related

Non-Safety-Related

Calc. No. 18

Rev. 0 Date 4/1/82

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Client EGO

Prepared by M. FANG

Date 4-1-82

Project 4222-1 - Unit 1

Reviewed by K. Li

Date 4-2-82

Proj. No. 4222-22 Equip. No.

Approved by [Signature]

Date 4-2-82

Summary of horizontal reinf. requirement

SPRING NO.	b	L _w	A _v	V _u	A _{vf} = $\frac{V_u \cdot b \cdot s}{1.4 f_y}$	A _s provided	REMARKS
1006003	25'	60'	-	126	0.756	#11 @ 6" - Two face A _s = 6.24 in ²	at end
W. with ⑥ & ⑦	4'	62'	-		0.864	#8 @ 12" - Two face A _s = 1.52 in ²	at middle

 or #9 @ 12" A_s = 4.0 in²

- ✓ Check wall panel between col. line ⑥ & ⑦ with rebar damage
 From the sketch (at p. 197, 198) & report, there's only one rebar hit in this area, per p. 201. A_s prov = 3.12 in². A_s req'd = 1.90 in² max. we'd big marginal factor for this wall panel. O.K.

- ✓ Check wall panel betn. col. line ⑦ & ③ with rebar damage
 From the sketch (at p. 198) & report, we can conclude there will be max. 3 rebar cuts vertically & max. 3 rebar cuts horizontally.
 calculate remaining reinf. to resist the moment
 width betn. col. line ⑦ & ③ L = 25' w/ #11 @ 6" : 50 bars total
 50 - 3 = 42 rebars left ;
 • Vertical Reinf. Area left : Due to wall capacity to redistribute moment, damaged rebars are assumed to be uniformly distributed along length of the wall

$$1.56 \times 2 \times \frac{42}{50} = 2.62 \text{ in}^2/\text{ft} \dots \text{one face \& critical for this wall panel}$$

- Horizontal Reinf. Area left : Height = 25' #11 @ 6" at this area
 total 46 bars - 3 = 38 bars left ; Rebars are assumed to be uniformly distributed along height of wall

$$1.56 \times 2 \times \frac{38}{46} = 2.58 \text{ in}^2/\text{ft} \dots \text{one face \& it's not critical since impingement wall}$$

 & pressure loads are assumed to stress the vert. rebars only.

- Per project criteria, check reinf. req'd for both SSE & OBE cases

- a) Calculate inertia D.L. force SSE case

$$0.15 \times 3.5' = 0.525 \text{ Ksf}$$

$$\frac{0.030 \text{ Ksf}}{0.555 \text{ Ksf}} \times 1.25 = 0.694 \text{ Ksf}$$

Allowance for small piping, conduits, etc.

New from col. 18, p. 41 for SSE case

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Calcs. For S-624, Wall along col. line N

El. 768 ~ 794

Aux Bldg

Calc. No. 1B

Rev. 0 Date 4/1/82

Safety-Related

Non-Safety-Related

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Client CECO

Prepared by H. FANG

Date 4-1-82

Project LaSalle-Unit 1

Reviewed by *K. Ata*

Date 4-2-82

Proj. No. 4266-00 Equip. No.

Approved by *Sm. Kungu*

Date 4-2-82

Assume fixed at two ends & hanger M-B034 acting at the wall ($P = 5.35^k$, see p. 199 for checking locally)
 Assume $L = 23'$ for SSE case only. for OEE case $p = 0$
 Critical moment by inertia:

$$M = \frac{1}{12} w L^2 = \frac{1}{12} \times 0.694 \times 23^2 = 30.594^k \dots \textcircled{1}$$

Critical moment by hanger for SSE case, $P = 5.35^k$

$$M = \frac{1}{8} P L = \frac{5.35 \times 23}{8} = 15.38^k \dots \textcircled{2} \quad (\text{CONS.})$$

Calculate individual reinf. req't as follows:

$$M_u = 30.594^k \dots \text{inertia}$$

$$M_u = 15.380^k \dots \text{Hanger out-of-plane}$$

$$d = 42" - 1" - 1\frac{1}{2}" = 40.295" \quad \text{for 1' strip}$$

$$F = \frac{b d^2}{12000} = \frac{12 \times 40.295^2}{12000} = 1.624$$

$$K_u = \frac{M_u}{F} = \frac{30.594}{1.624} = 18.840 \text{ or } K_u = \frac{15.380}{1.624} = 9.470$$

$$\text{Since } \rho = \frac{A_s}{b d} = \frac{0.85 f'_c}{f_y} \left(1 - \sqrt{1 - \frac{2 K_u}{\phi (0.85 f'_c)}} \right)$$

From drawing S-199, $f'_c = 4000 \text{ psi}$, $f_y = 60,000 \text{ psi}$
 & LaSalle project design criteria

$$\rho = 0.05667 \left(1 - \sqrt{1 - 0.6536 \frac{K_u}{1000}} \right)$$

* NOTE: The above equation, see "Reinf. Concrete Design, 3rd edition" by Wang & Salmon p. 47. equ. (3.6.5)

For Inertia Load

$$\rho = 0.05667 \left(1 - \sqrt{1 - 0.6536 \frac{18.840}{1000}} \right) = 3.50 \times 10^{-4}$$

$$A_{s0} = \rho b d = 3.50 \times 10^{-4} \times 12 \times 40.295 = 0.170 \text{ in}^2/\text{ft}$$

For Hanger Load $\rho = 0.05667 \left(1 - \sqrt{1 - 0.6536 \frac{9.470}{1000}} \right) = 1.757 \times 10^{-4}$

$$A_{sH} = \rho b d = 1.757 \times 10^{-4} \times 12 \times 40.295 = 0.085 \text{ in}^2/\text{ft}$$

out-plane

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Calcs. For 5-624, wall along col. line M

EL 768'-794'

AUX. BLDG

Safety-Related

Non-Safety-Related

Calc. No. 1B

Rev. 0 Date 4/1/82

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Client CECO

Project LaSalle - Unit 1

Proj. No. 4266-00

Equip. No.

Prepared by H. FANG

Date 4/1/82

Reviewed by L. L. L.

Date 4/1/82

Approved by S. K. K.

Date 4-2-82

 B) loading description & Combinations used in calculating the reinf. area

(Per col. 1B, p. 39)

For COMP. SSE CASE

$$A_{s, req} = \sqrt{(A_{ES} + A_{H_{in-plane}})^2 + (A_{PS} + A_{GW} + A_{H_{out-plane}} + A_{PA} + A_{PR})^2}$$

For COMP. OBE CASE

eq. (3)

$$A_{s, req} = \sqrt{(1.4 A_{ES} + 1.4 A_{H_{in-plane}})^2 + (1.4 A_{PS} + A_{GW} + 1.4 A_{H_{out-plane}})^2}$$

NOTE: In col. 1B, the area of steel tabulated is based on 1.4 ES or 1.0 ES

eq. (4)

$$A_{s, req} = \sqrt{(1.25 A_{ES} + 1.25 A_{H_{in-plane}})^2 + (1.25 A_{PS} + A_{GW} + 1.25 A_{H_{out-plane}} + 1.25 A_{PA} + 1.0 A_{PR})^2}$$

SEE NOTE ABOVE

For accidental pressure load.

$$A_{s, req} = A_D + 1.5 A_{PA}$$

 A_{ES}: Reinf. area req'd for seismic, SSE loads (from shear wall design for in-plane loads)

 A_{ES}: Reinf. area req'd for seismic, OBE loads

 A_{H_{in-plane}}: Reinf. area req'd for hanger in-plane loads.

 A_{PS}: Reinf. area req'd due to lateral soil pressure loads.

 A_{GW}: Reinf. area req'd due to inertia loads (out-of-plane)

 A_{H_{out-plane}}: Reinf. area req'd due to hanger out-of-plane loads.

 A_{PA}: Reinf. area req'd due to accidental pressure loads.

 A_{PR}: Reinf. area req'd due to pipe break loads.

 A_D: Reinf. area req'd due to self-weight plus additional 30 psf for small pipe, conduit etc.

 Note: Inertia loads for A_{GW} already include load factor, see col.

Vol. 1B, p. 40

Calculate OBE & SSE loads according to the above definition of loading combinations.

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ii. For Comb. SSE case

$$A_{req} = \sqrt{(A_{ES} + A_{H_{in-plan}})^2 + (A_{ps} + A_{gw} + A_{H_{out-plan}} + A_{pa} + A_{RR})^2}$$

$$= \sqrt{\left(\frac{1.26}{2} + \frac{0.032}{2}\right)^2 + (0 + 0.170 + 0.035 + 0.45 + 0.32)^2}$$

$$= 1.653 \text{ in}^2 < 2.62 \text{ in}^2 \text{ --- provided reinf. see p. 201}$$

$$M.F. = \frac{2.62}{1.653} = 1.585$$

c) For Comb. OBE case, recalculate inertia loads (Note: Hanger M-B034 has NO loads in OBE case) allowance for small pipe, conduits, etc.

$$0.15 \times 3.5 = 0.525 \text{ ksf}$$

$$0.030 \text{ ksf}$$

$$0.555 \text{ ksf} \times 2.036 = 1.138 \text{ ksf}$$

9/16 E-W for OBE case, see cal #1 B, p. 41

• Critical moment by inertia

$$M^* = \frac{1}{12} w l^2 = \frac{1}{12} \times 1.138 \times 23^2 = 51.05 \text{ k'}$$

$$F = \frac{M^*}{12000} = 1.634 \text{ --- see calcs at SSE case}$$

$$K_{in} = M^* / F = 31.43$$

$$g = 0.05667 \left(1 - \sqrt{1 - 0.6536 \frac{K_{in}}{1000}}\right) = 5.352 \times 10^{-4}$$

$$A_{st} g b d = 0.283 \text{ in}^2 \text{ --- one face}$$

For OBE case, check eq. (a) (b) & (c) respectively

eq. (a)

$$A_{req} = \sqrt{(1.4 A_{EO} + 1.4 A_{in-plan})^2 + (1.4 A_{ps} + A_{gw} + 1.4 A_{H_{out-plan}})^2}$$

$$= \sqrt{\left(1.4 \times \frac{1.26}{2 \times 1.4} + 0\right)^2 + (0 + 0.283 + 0)^2} = 0.691 \text{ in}^2 < 2.62 \text{ in}^2$$

$$M.F. = \frac{2.62}{0.691} = 3.794$$

eq. (b)

$$A_{req} = \sqrt{(1.25 A_{EO} + 1.25 A_{in-plan})^2 + (1.25 A_{ps} + A_{gw} + 1.25 A_{H_{out-plan}} + 1.25 A_{pa} + 1.0 A_{RR})^2}$$

$$= \sqrt{\left(1.25 \times \frac{1.26}{2 \times 1.4} + 0\right)^2 + (0 + 0.283 + 0 + 1.25 \times 0.45 + 1.0 \times 0.32)^2}$$

$$= 1.760 \text{ in}^2$$

• A_{st}

$$M.F. = \frac{2.62}{1.760} = 1.489 \text{ --- critical}$$

0 + 1.5(1.45) = 2.175, 1.15 = ...

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Reviewed by _____ Date 4-1-82
Approved by [Signature] Date 4-2-82

ORIGINAL As w/o cuts $A_s = 3.12 \text{ in}^2$
 $A_{s req'd} = 1.760 \text{ in}^2$ OBE control

Wall panel betn (5) & (6) $\left\{ \begin{array}{l} M.F. = 3.12/1.76 = 1.773 \dots \text{w/o cuts} \\ M.F. = 2.62/1.76 = 1.489 \dots \text{w/ cuts} \end{array} \right.$

NOTE: Horizontal is not critical & is not calculated.

Check wall panel betn. col. line (8) & (9) with rebar damages

From the sketch on pages 197 & 198, we can conclude that there are 6 rebars cut at vertical direction & 3 rebar cuts at horizontal direction.

Vertical Reinf. Area Left: Width = 29'-0", #6 @ 12", two sides

Total SB bars, assume 3-#8 & 3-#6 rebars were cut

$$(0.79 + 0.44) \times 2 \times \frac{58.6}{58} = 2.205 \text{ in}^2 \text{ one face}$$

Horizontal Reinf. Area Left: Height = 23', #8 @ 12",

Total 23 rebars

$$0.79 \times 1 \times \frac{23-3}{23} = 0.637 \text{ in}^2 \text{ one face}$$

(2) For SSE case - vertical

NOTE: For this area, there are two bays, M-H140 & M-H159, loads are negligible see drawing S-624

$$A_{req} = \sqrt{(A_{es} + A_{H_{upper}})^2 + (A_{ps} + A_{gw} + A_{H_{lower}} + A_{pc} + A_{pe})^2}$$

$$= \sqrt{\left(\frac{1.26}{2} + 0\right)^2 + (0 + 0.170 + 0 + 0.45 + 0.39)^2} = 1.1904 < 2.205$$

$$M.F._v = \frac{2.205}{1.1904} = 1.852$$

(a) For OBE case - vertical

$$Eq. (a) = \sqrt{\left(\frac{1.41 \times 1.26}{2 \times 1.4} + 0\right)^2 + (0 + 0.283 + 0)^2} = 0.691 < 2.205$$

$$M.F._v = \frac{2.205}{0.691} = 3.191$$

$$Eq. (b) = \sqrt{\left(\frac{1.35 \times 1.26}{2 \times 1.4} + 0\right)^2 + (0 + 0.283 + 1.05 \times 0.45 + 1.0 \times 0.39)^2} = 1.3575 < 2.205$$

$$M.F._v = \frac{2.205}{1.3575} = 1.624$$

0.15 (0.45) = 0.0675

PRGF 1105-2

M.F. = 2.205 / 0.691 = 3.191

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Original M.F. w/o cuts

$$A_s = (0.79 + 0.44) \times 2 = 2.46 \text{ in}^2$$

$$A_{avg} = 1.3575 \text{ in}^2$$

~~X~~ Vertical

Wall panel between
cd. line ⑧ & ⑨

$$\left\{ \begin{array}{l} M.F. = \frac{2.46}{1.3575} = 1.812 \dots \text{w/o cuts} \\ M.F. = \frac{2.205}{1.3575} = 1.624 \dots \text{w/ cuts} \end{array} \right.$$

c) For SSE case - horizontal

$$A_{req} = \sqrt{\left(\frac{0.756}{2} + 0\right)^2 + (0 + 0 + 0 + 0 + 0)^2} = 0.378 \text{ in}^2 < 0.687 \text{ in}^2$$

$$M.F. = \frac{0.687}{0.378} = 1.817$$

d) For OBE case - horizontal:

Eq. (1) $A_{req} = \sqrt{\left(\frac{1.4 \times 0.756}{2 \times 1.4} + 0\right)^2 + (0 + 0 + 0)^2} = 0.378 \text{ in}^2 < 0.687$

$$M.F. = \frac{0.687}{0.378} = 1.817$$

Eq. (2) $A_{req} = \sqrt{\left(\frac{1.25 \times 0.756}{2 \times 1.4} + 0\right)^2 + (0 + 0 + 0 + 0)^2} = 0.3375 < 0.687$

Eq. (3) does not govern

$$M.F. = \frac{0.687}{0.3375} = 2.036$$

Original M.F. w/o cuts

$$A_s = 0.79 \times 1 = 0.79 \text{ in}^2$$

$$A_{avg} = 0.378 \text{ in}^2$$

~~X~~ Horizontal

Wall panel betn.
⑧ & ⑨

$$\left\{ \begin{array}{l} M.F. = \frac{0.79}{0.378} = 2.09 \dots \text{w/o cuts} \\ M.F. = \frac{0.687}{0.378} = 1.817 \dots \text{w/ cuts} \end{array} \right.$$

FIGURE 2.7-3
STRUCTURAL CALCULATIONS FOR CONCRETE BEAM



Calcs. For Reactor Bldg		RB-511
col. 14	(E) ~ (D)	EL. 736'-6"
<input checked="" type="checkbox"/> Safety-Related	<input type="checkbox"/> Non-Safety-Related	

Calc. No.	716A
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Client	CECO
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Prepared by	S. Jung	Date	3-29-82
Reviewed by	H. Fay	Date	4-2-82
Approved by	Franklyn	Date	4-2-82

CONGESTED AREA (3)

FLOOR ELEV.	BEAM NO	MARGINAL FACTOR			NO. OF DAMAGED REBARS	NO. OF CORRO HOLES	REMARKS
		M capacity / M actual		$\left(\frac{L_{allow}}{L_{actual}}\right)^2$			
		SUPPORT	MIDDLE				
786'-0"	1RB-511	3.17	1.961		5 location	0	
"	"	3.17	2.593		max. 2 cuts		
Summary: From the above, the governing value for safety margin w/ cut = 1.961 (@ middle govern)							

Client CECO

Prepared by H. FANG

Date 4-2-82

Project LaSalle - Unit 1

Reviewed by S. Bhattacharya

Date 4-2-82

Proj. No. 4266-00 Equip. No.

Approved by *[Signature]*

Date 4-2-82

- ☒ Ref. Drawings: S-215, RH5-215, RGS-215,
 • Location: see sketch. All hits were located at B/beam.
 • Rebar hit Report summary.

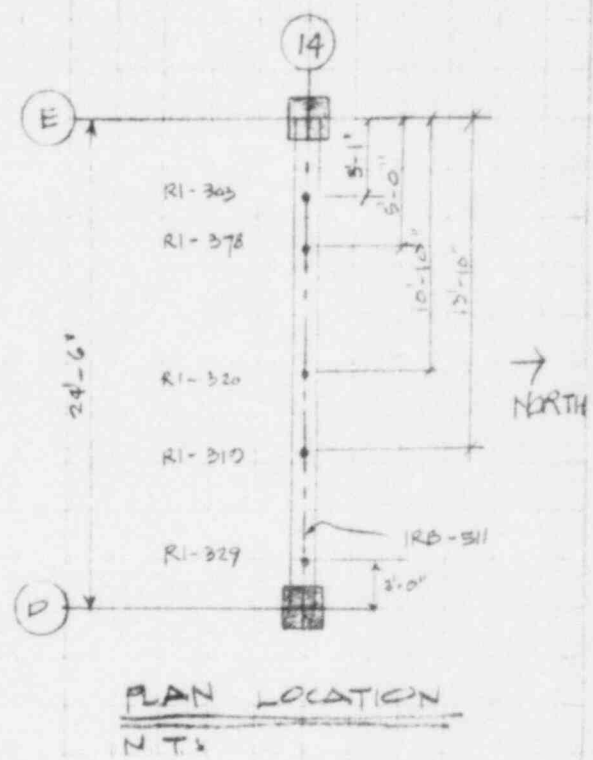
Report No.	R1-323	R1-370	R1-320	R1-319	R1-329
SKETCH	<i>[Sketch: 2 hits]</i>	<i>[Sketch: 1 hit]</i>	<i>[Sketch: 2 hits]</i>	<i>[Sketch: 1 hit]</i>	<i>[Sketch: 3 hits]</i>

☒ Bar hit & assumed cut

- For calculation, see following calcs by S. Jung.

From the summary, we should assume 3-rebar cut for conservative purpose

- Final. OK, for marginal factors see p. 365





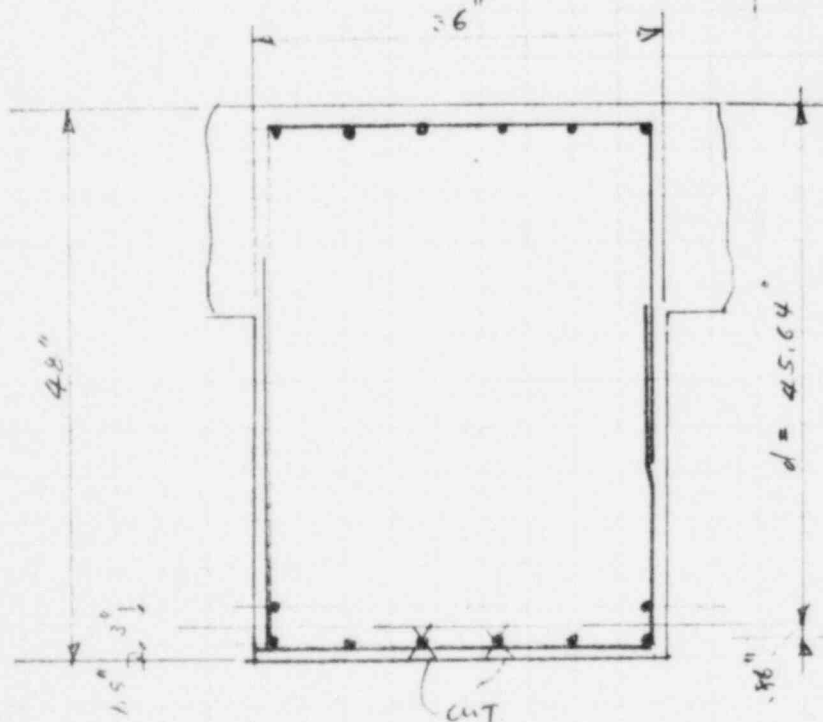
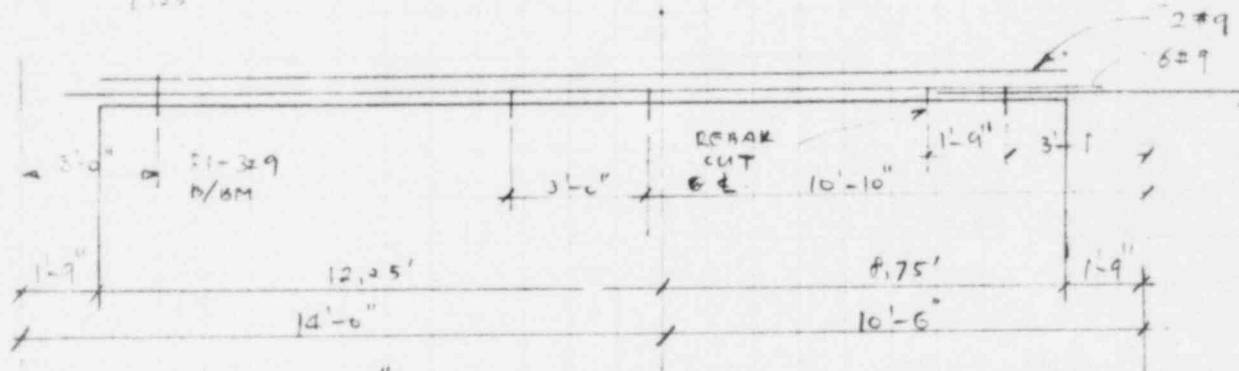
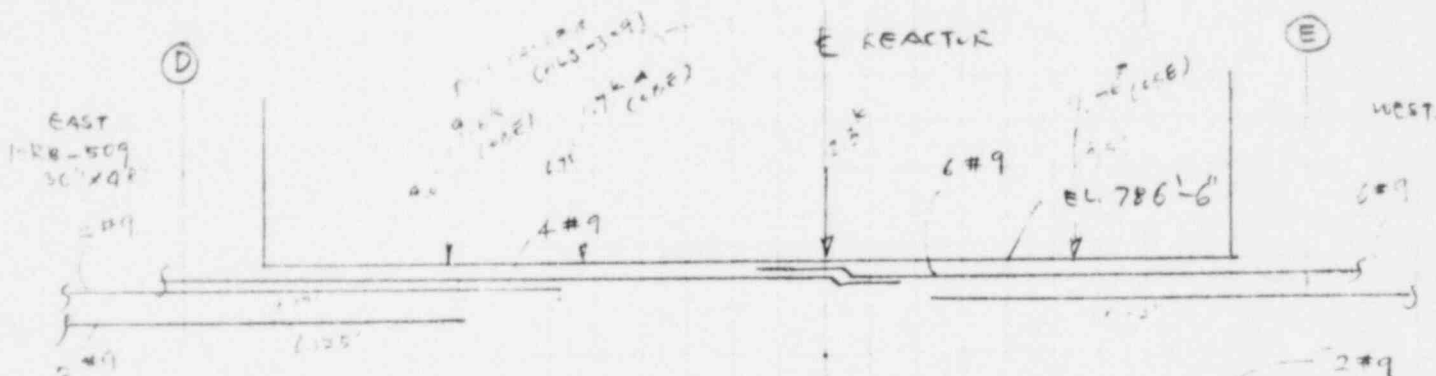
Calcs. For EVALUATION OF REBAR CUT	
OF BEAM 1RB-511 (H, B, E) S-215	
<input checked="" type="checkbox"/> Safety-Related	<input type="checkbox"/> Non-Safety-Related

Calc. No. 916A
Rev. 0 Date 3-29-82
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Client C E 10
Project LASALLE #1
Proj. No. 4266-00 Equip. No.

Prepared by S. JUNY	Date 3-29-82
Reviewed by S. R. [unclear]	Date 3-29-82
Approved by [Signature]	Date 3-20-82

1-KB-511 (36" x 48") TYPE 2



- For Ref. Drawing & Rebar Hits description, see page 364 for details
- Hanger location comes from drawing HLS-309

PAGE 3 OF 7

SECTION AT MIDDLE OF SPAN

Client **CECO**
Project **LASALLE #1**
Proj. No. **4266-00** Equip. No.

Prepared by **S. JUNG** Date **3-29-82**
Reviewed by **S. Bhattacharya** Date **3-30-82**
Approved by **Frank Kuzni** Date **3-30-82**

(1RB-511 CONT'D)

Max. 2 rebar cuts
see p. 364 for
rebar cuts/lists
description

SINCE ALL OF THE REBAR CUT AT
BOTTOM OF BEAM ARE LOCATED
@ E OF BEAM. ASSUME ONLY
ONLY ONE BAR WAS CUT AT BOTTOM
AND TENSION AREA.

USE **5 #9** & **2 #9 @ 2nd**
Layer. total $A_s = 6 \times 1.0 \text{ in}^2 = 6 \text{ in}^2$

BY IGNORING COMPRESSION BAR AT
TOP.

POSITIVE MOMENT CAPACITY

CAPACITY OF BEAM @ MIDDLE.

$$M_u = \phi A_s F_y (d - \frac{a}{2})$$

$$a = \frac{F_y A_s}{0.85 f_c b}$$

$$F_y = 60 \text{ ksi}, A_s = 6.0 \text{ in}^2$$

$$f_c = 4 \text{ ksi}, b = 36 \text{ in}$$

$$M_u @ \text{E} = 0.9 \times 7 \times 60 \left(45.64 - \frac{3.93}{2} \right) \times \frac{1}{12}$$

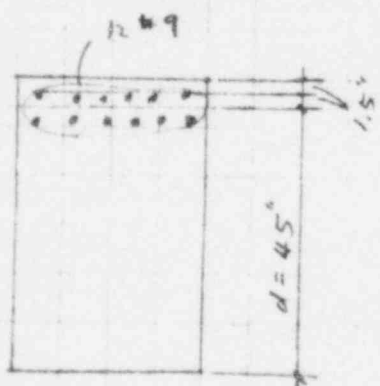
$$a = \frac{60 \times 6}{0.85 \times 4 \times 36} = 2.94 \text{ in}$$

$$= +1192.60 \text{ K'}$$

$$= +1383.6 \text{ K'}$$

NEGATIVE MOMENT CAPACITY

CAPACITY OF BEAM @ WEST END. (NO CUT.)



$$M_u = 0.9 \times 12 \times 60 \left(45 - \frac{5.88}{2} \right) \times \frac{1}{12}$$

$$a = \frac{60 \times 12}{0.85 \times 4 \times 36} = 5.88 \text{ in}$$

$$= -2271.2 \text{ K'}$$

Client **CE Co**

Project **LASALLE -1**

Proj. No. **4266-00** Equip. No.

Prepared by **S. JUNG**

Date **3-29-82**

Reviewed by **S. Phallachung**

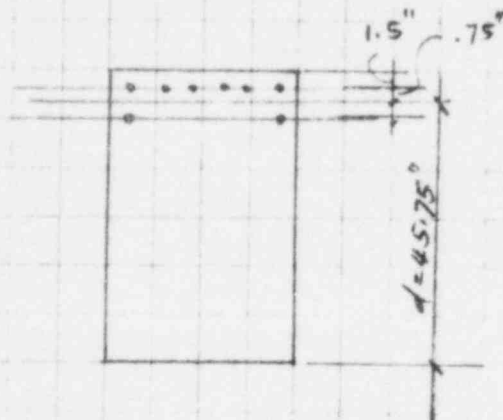
Date **3-30-82**

Approved by **Sm Kanyani**

Date **3-30-82**

(1RB-54 CONT'D)
NEGATIVE MOMENT CAPACITY

CAPACITY OF BEAM @ EAST END. (No cut.)



$$M_u @ \text{EAST END} = 0.9 \times 8 \times 60^{AST} \left(45.75 - \frac{3.92}{2} \right) \times \frac{1}{12}$$

$$a = \frac{60^{AST} \times 8}{0.85 \times 4 \times 36} = 3.92"$$

$$= -1576.4 \text{ K'}$$

ACTUAL MOMENTS:

OBE LOADS 1.4D + 1.7LR + 1.5SRV_{ALL}

The above Load Comb. in g-value = 1.95

Including pipe hanger DL $\frac{1}{2} \times 10^{AST}$ FOR SMALL PIPING;
↓ conduits, etc

$$g_{OBE} = 1.95 \downarrow$$

(see p. 49, Vol 916)

SSE LOADS 1.0D + 1.0LR + 1.0Es + 1.0SRV_{ALL} + 1.0Co

The above Load Comb. in g-value = 1.923

DEAD LOAD; SMALL PIPE $10^{AST} \times 1.923 = 0.019 \text{ K'}$

$$g_{SSE} = 1.923 \downarrow$$

(see p. 42, Vol 916)

$$\text{SLAB } \left(1.5' \times 1.5' \times \frac{23' + 9'}{2} \right) \times 1.923 = 6.723 \text{ K'}$$

$$\text{BEAM } (3' \times 4' \times 1.5') \times 1.923 = 3.461 \text{ K'}$$

$$\text{TOTAL SSE } W_u = 10.40 \text{ K'}$$

$$\text{HANGERS } P \times 1.923 = 1.923 \text{ (P)}$$

D = dead load

LR = Reduced Live Load

SRV_{ALL} = Safety Relief Valve All-Quencher

Es = Seismic Load

Co = Condensation Oscillation Load

Conclusion → OBE GOVERNS.

SARGENT & LUNDY

ENGINEERS
CHICAGO

Calcs. For EVALUATION OF REBAR CUT
OF BEAM IRB-511, (X) (E) 5-215

X Safety-Related

Non-Safety-Related

Calc. No. 9/6A

Rev. 17 Date 3-29-82

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Client CECO

Project LASALLE - I

Proj. No. 4266-00 Equip. No.

Prepared by S. JUNG

Date 3-29-82

Reviewed by S. Bhattacharya

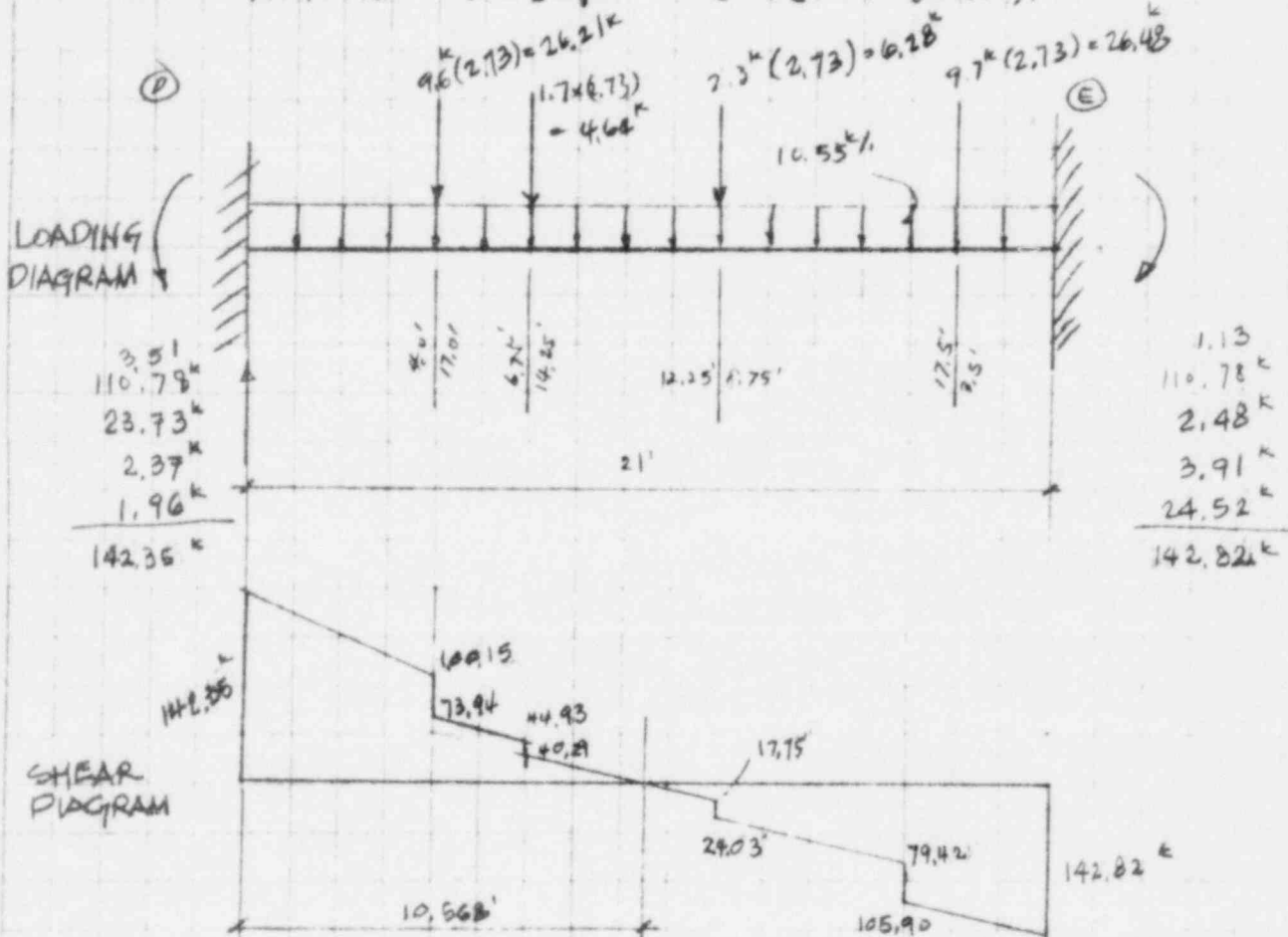
Date 3-30-82

Approved by *[Signature]*

Date 3-30-82

(IRB-511 (CONT'D.))

ACTUAL MOMENTS (CBE GUESS)



FIX-END MOMENT AT ENDS.

$$M_u @ D = \frac{10.55(21)^2}{12} + \frac{26.21(4)(17)^2}{21^2} + \frac{6.28(12.25)(17.75)^2}{21^2} + \frac{26.48(17.5)(17.5)^2}{21^2} + \frac{4.68 \times 6.75 \times 14.25^2}{21^2}$$

$$= 497.06^k \checkmark$$

$$M_u @ E = \frac{10.55(21)^2}{12} + \frac{26.21(4^2)(17)}{21^2} + \frac{6.28(12.25^2)(17.75)}{21^2} + \frac{26.48(17.5^2)(17.5)}{21^2} + \frac{4.68 \times 14.25 \times 6.75^2}{21^2}$$

$$= 493.77^k \checkmark$$

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Calcs. For EVALUATION OF REBAR CUT OF	
BEAM IRB-5" (E-D) S-215	
<input checked="" type="checkbox"/> Safety-Related	<input type="checkbox"/> Non-Safety-Related

Calc. No.	916A
Rev.	0
Date	3-29-82
Page	369 of

Client	CECO
Project	LASALLE #1
Proj. No.	4266-02
Equip. No.	

Prepared by	S. JUNY	Date	3-29-82
Reviewed by	S. Bhattacharya	Date	3-30-82
Approved by	frank	Date	3-30-82

(IRB-5" CONT'D)

MAX. MOMENT AT MIDDLE (V=0)

$$M_{UEV=0} = 497.06 \text{ k'} - 1504.35 \text{ k'} - 172.15 \text{ k'} + \frac{589.13 \text{ k'} \cdot 11.53 \text{ (10.568')}}{2} - 17.72 \text{ k'} - 4.64(2.818) \text{ k'}$$

$$= -608.03 \text{ k'}$$

Capacity w/o CUT: $M_{UE0} = 1576.4 \text{ k'}$ $M_{UEE} = 2271.2 \text{ k'}$

$M_{UEd} = 1576.4 \text{ k'}$

FACTOR OF SAFETY;

	(A) D	(B) MIDDLE	(C) E support
w/ CUTS;	$\frac{1576.4 \text{ k'}}{497.06 \text{ k'}} = 3.17$	$\frac{1142.60 \text{ k'}}{608.03 \text{ k'}} = 1.87$	$\frac{2271.2 \text{ k'}}{493.77 \text{ k'}} = 4.60$
w/o CUT;	$\frac{1576.4 \text{ k'}}{497.06 \text{ k'}} = 3.17$	$\frac{1576.4 \text{ k'}}{608.03 \text{ k'}} = 2.593$	$\frac{2271.2 \text{ k'}}{493.77 \text{ k'}} = 4.60$

Note: By using actual material strengths, multiply ratios 1.109 (see p. 514, Vol 916A)

$1.961 \times 1.109 = 2.170$

check shear: max. react. @ E

$R_E = 142.82 \text{ k'}$

$\phi = 0.85, b = 36", d = 45.75"$

$$V_u = \frac{R_E}{\phi b d} = \frac{142.82 \times 1000}{0.85 \times 36 \times 45.75} = 102.02 \text{ psi}$$

Allowable per ACI code $= 2\sqrt{f'_c} = 2\sqrt{4000} = 126.2 \text{ psi} > 102.02 \text{ psi}$

OK
PAGE 7 OF 7

TABLE 2.6-1
SUMMARY LOG OF REINFORCING STEEL DAMAGE REPORTS RECEIVED BY SARGENT & LUNDY
BEFORE AND AFTER MARCH 29, 1982 FOR LASALLE COUNTY, UNIT 1 AND
UNIT 2 REQUIRED FOR UNIT 1 OPERATION

Contractor	Number of Damage Reports Sent to S&L as Reported by Contractors	Number of Reports Received by S&L			Total Missing Reports	Number of Cut Bars Associated with Reports Received After 3-29-82
		Received Prior to 3-29-82	Received After 3-29-82	Total Received		
Walsh Construction	79	Unit 1 68 Unit 2 11 Total 79	0	79	0	0
Reactor Control	88	87	1	88	0	1
Commonwealth Electric Company	55	Unit 1 43 Unit 2 12 Total 55	0	55	0	0
Mid-City Company	6	6	0	6	0	0
H. P. Foley	2,584	2,442	142	2,584	0	298
M. C. C. Powers	9	None	9	9	0	36
Morrison Company	687	681	6	687	0	6
The Zack Company	62	None	58	58	4	249*
TOTAL	3,570	3,350	216	3,566	4	590

*The number includes assumed cuts for four missing reports.

TABLE 2.7-1¹

MARGINS IN SAMPLE AREAS WITH CONGESTED REBAR HITS FOR LASALLE COUNTY, UNIT 1

Area No.	Building	Slab/Wall (Panel Size)	Elevation	Wall Location Slab Panel Number	Number of Damaged Rebar Locations due to Drilling Operations ²	Total Number of Rebars Damaged due to Drilling	Number of Cored Holes	Maximum Number of Damaged Bars due to Cored Holes	Margin without Holes based on Specified Minimum Material Strength	Margin with Holes based on Specified Minimum Material Strength	Margin with Holes Considering Actual Material Strength Determined by ACI Code ³
(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)
1	Reactor (S-201)	Wall 19.67'x56'	Above 673'-4"	Diagonal Wall at Column C & 14	12	8	7	24	1.250	1.050	1.170
2	Reactor (S-211)	Slab 12.5'x32'	740'-0"	56" Slab Between Column J & H, 11.2 & 12.8	39 ⁴	15	0	0	1.300	1.013	1.150
3	Reactor (S-215)	Beam 3'x24.5'	786'-6"	Beam at Line 14 Between Column D & E	5	2	0	0	2.590	1.960	2.170
4	Reactor (S-219)	Slab 10'x26' Each	820'-6"	IRS	719	0	1	4	1.710	1.430	1.460
					720	3	0	0	1.620	1.370	1.410
5	Reactor (S-219)	Wall 14.7'x33'	Above 820'-6"	Between 11 & 13 and Column J & G	16	17	1	4	2.130	1.130	1.160
6	Reactor (S-223)	Wall 21.2'x27'	Between 673'-0" & 694'-6"	Column Row J Between 14 & 15	19	18	2	4	4.000	3.000	3.330
7	Reactor (S-237)	Wall 19.17'x28'	Between 673'-0" & 694'-6"	Row 15	10	10	0	0	2.850	2.530	2.740
8	Reactor (S-274)	Wall 19.17'x27'	Between 673'-4" & 694'-6"	At Line 8.9 Between Column J & G	22	25	0	0	1.730	1.030	1.110
9	Auxiliary (S-572)	Wall 18'x25'	Above 731'-0"	At Line 11.3 Running Between Column J & L	10	15	0	0	1.280	1.070	1.160

¹ These areas were presented in Bethesda, Maryland on March 31, 1982.² The determination of actual material strength utilizing material test reports from LaSalle Station is based on ACI Code (318-77) provisions, as delineated in Section 4.3.1.³ All these bar's damages are in top of slab scattered in the entire bay.⁴ When the damage in Column F exceeds the damage reported in Column G, it indicates that a reinforcing bar was damaged by more than one hole. This would occur in a concrete expansion anchor baseplate assembly where one reinforcing bar would be coincident with a row of concrete expansion anchors.

TABLE 2.7-2

SUMMARY OF NUMBER OF CONCRETE ELEMENTS FOR WHICH DETAILED CALCULATIONS WERE MADE

Concrete Elements	Total Number of Concrete Elements		Number of Concrete Elements Where Rebar Damages Are Identified		Number of Concrete Elements Reviewed In Detail		Percent of Concrete Elements for Which Detailed Calculations Were Made
	Unit 1 Areas	Unit 2 Areas Required for Unit 1 Operation	Unit 1 Areas	Unit 2 Areas Required for Unit 1 Operation	Unit 1 Areas	Unit 2 Areas Required for Unit 1 Operation	
Slabs	894	81	285	50	285	50	100
Walls	390	76	170	36	170	36	100
Beams	308	22	38	0	38	0	100
Columns	214	20	68	0	68	0	100
TOTAL	1,806	199	561	86	561	86	100

TABLE 2.7-3

SUMMARY OF ALL REINFORCING STEEL DAMAGE FOR UNIT 1
SAFETY RELATED AREAS AND THOSE UNIT 2 AREAS REQUIRED
FOR UNIT 1 OPERATION

Type of Hole	Total Damaged Bars in Unit 1 Safety Related Areas	Total Damaged Bars in Unit 2 Safety Related Areas Required for Unit 1 Operation
Cored Holes Passing Thru Concrete	3632	584
Cored Holes Partially Penetrating Concrete	512	4
Drilled Holes for Concrete Expansion Anchors	3498	213
Total	7642	801