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RENBERGER,D.L. Washington Public Power Supply System
RECIP.NAME RECIPIENT AFFILIATION
ENGELKEN,R.H. Region 5, San Francisco, Office of the Director

SUBJECT: Advises that corrective action plan for sacrificial shield wall finalized.Forwards Burns & Roe Technical Memo 1173 justifying use of partial penetration welds.

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K. Stello
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G02-80-79
March 25, 1980

Docket No. 50-397

Mr. R. H. Engelken, Director
NRC Region V
Suite 202, Walnut Creek Plaza
1990 N. California Boulevard
Walnut Creek, California 94596

Subject: WPPSS NUCLEAR PROJECT NO. 2
DOCKET NUMBER 50-397
SACRIFICIAL SHIELD WALL (SSW)
CORRECTIVE ACTION PLAN

Reference: NRC Region V Letter, R. H. Engelken to N. O. Strand, WNP-2 Pipe Whip Restraints and Sacrificial Shield Wall, dated February 8, 1980

Dear Mr. Engelken:

The corrective action plan for the sacrificial shield wall (SSW) has been finalized. It consists of providing justification for the slot weld replacement by the partial penetration weld, performing a welding defect/structural impact assessment to evaluate the SSW as-built structural capabilities, selection and qualification of the shield material for shim gaps and concrete voids, and a final report at a later date discussing all items of concern on a case-by-case basis.

The interim welding defect/structural assessment is being performed in a conservative, bounding manner with the following considerations:

- Welding defects identified by the recent Burns and Roe SSW visual inspection of 100% of accessible welds,
- Welding defects identified by magnetic particle examinations performed on the SSW by site contractors,
- Welding defects identified by ultrasonic examinations performed on the SSW by site contractors and Leckenby,
- The SSW welding defect and repair history experienced by Leckenby during fabrication,

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- Assessment of Leckenby NDE credibility, welding procedures and welder qualifications/capabilities,

- Lamellar tearing,

- The use of cold forming and heat straightening processes during SSW fabrication,

- SSW as-built dimension considerations with respect to the partial penetration weld at El. 541'-5", and

- The impact of the known welding defects and defect history and their extrapolation to the remainder of the SSW in conjunction with other welding related concerns mentioned above on the SSW functional capabilities.

This technical evaluation will establish the SSW acceptability as-is with appropriate justification or will identify corrective action/ repair as necessary. This evaluation will be performed in a typical engineering manner, i.e., independent checking of the technical results.

The replacement of the slot welds by the partial penetration weld at El. 541'-5" is considered to be an equal and alternate method of achieving the horizontal shear design requirements. We do not view it as a change in design requiring prior NRC approval in that it is not an unreviewed safety question or change in technical specifications.

Attachment 1, Burns and Roe Technical Memorandum No. 1173, provides justification for the use of the partial penetration weld between SSW rings 3 and 4 including SSW as-built dimension considerations. Attachments 2, 3, 4 and 5 provide details for the joint preparation and welding of the partial penetration weld. The preparation of this joint will provide additional information about the material in this area of the SSW; it does not preclude any investigative work.

Considering the above and the reference, it is requested that the Supply System at this time be allowed to commence preparation of the joint for the weld joining SSW rings 3 and 4.

A subsequent letter to NRC Region V will specifically address the proposed shield material and request your concurrence to proceed with shim gap shielding repair and welding of rings 3 and 4.

Very truly yours,

D L Renberger

D. L. Renberger
Assistant Director,
Technology

DLR:DCT:der

Attachments:
(1) Burns and Roe Technical Memorandum No. 1173, dated March 19, 1980
(2) Project Engineering Directive (PED) No. 215-W-1604
(3) PED No. 215-CS-2741
(4) PED No. 215-W-2742
(5) PED No. 215-W-2749

cc w/att:
V. Stello, NRC
N.D. Lewis, EFSEC, Olympia
J.R. Lewis, BPA
J.J. Verderber, B&R N.Y.
R.C. Root, B&R Site
WNP-2 Files

TECHNICAL MEMORANDUM

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DATE 3/19/80

TO R. E. Snaith

FROM M. N. Fialkow

SUBJECT W. O. 2808
Washington Public Power Supply System
WPPSS Nuclear Project No. 2
Sacrificial Shield Wall - Assessment Program
Connection of Upper and Lower Wall Segments
TECHNICAL MEMORANDUM NO. 1173

REFERENCES:

1. NRC Letter from R. H. Engelken to N. O. Strand dated 2/8/80, Subject: Washington Nuclear Project No. 2, Pipe Whip Restraints and Sacrificial Shield Wall.

2. WPPSS Letter WPBR-80-96 from R. M. Foley to J. J. Verderber, dated 3/6/80, Subject: WPPSS Nuclear Project No. 2, Sacrificial Shield Wall (SSW) Assessment Program.

3. Calculation No. 6.19.37, Book No. SV 489 Pages 45 - 61 Title: WPPSS-Hanford No. 2 - Reactor Bldg. - Sacrificial Shield Wall, Subject: Correction Measures at Interface El. 541'-5".

4. Washington Public Power Supply System Nuclear Project No. 2 Report No. WPPSS-74-2-R2-B, "Sacrificial Shield Wall Design Supplemental Information".

5. ASCE Manual No. 41, "Plastic Design in Steel", 2nd Edition, 1971, Chapter 10: Multistory Frames, pp. 246-247: PΔ Effects.

INTRODUCTION:

It has been determined that the horizontal rings in the Sacrificial Shield Wall (SSW), located above and below the interface at Elevation 541'-5", are not welded together as shown on the contract drawings. Correction measures to transmit the design horizontal shear between the channel ring above the interface and the box ring below the interface are required.

The contract requires that at each of 24 locations around the SSW, four slot welds are to be provided in the web of the upper channel ring connecting to the lower box ring. In lieu of this unfulfilled requirement, it is proposed to install a partial penetration groove weld along the exterior circumference between the two rings.

Structural analysis in justification of the proposed correction has been accomplished (Reference 3). This memorandum furnishes pertinent information relative to this analysis in compliance with letters from USNRC and WPPSS (References 1, 2). The following is included:

a. Description of correction weld
b. Design considerations
c. Analysis based on the design SSW configuration
d. Analysis for as-built SSW dimensions.

DESCRIPTION OF CORRECTION WELD

The correction weld is a partial penetration groove weld with fillet weld reinforcement to be installed along the exterior circumference between the rings above and below the interface at Elevation 541'-5". The location and extent of the weld are shown in Figure 1; weld details are shown in Figure 2.

As shown in the figures, the correction weld is to be installed in each of the 24 panels around the SSW for the width available between the column splice plates. Preparation for the groove weld requires removal of material from the channel ring. The specific configuration of the weld in each panel, including the groove depth and the size of the fillet weld reinforcement, depends on the width of ledge at the interface. From the design viewpoint, a minimum overall weld depth of 2 inches, corresponding to an effective weld throat of 1 7/8 inches, is maintained in all configurations.

DESIGN CONSIDERATIONS FOR CORRECTION WELD

1. Basic Data

The analysis and design of the proposed correction weld utilizes the values of the stress resultants in the members and skin plates obtained in the analysis of the overall sacrificial shield wall. A description of the analysis and design of the SSW including loads, load combinations, and acceptance criteria was submitted to NRC by Report No. WPPSS-74-2-R2-B (Reference 4) and approved by NRC by letter dated October 15, 1975.

The analysis and design of the correction weld is in conformance with NRC Standard Review Plan (SRP) 3.8.3. In particular, requirements relative to loads, load combinations, and acceptance criteria are complied with. The basis of design is the elastic working stress method, Part 1 of the 1969 AISC design specification.

2. Significant Loads

The following significant loads, considered in the analysis and design of the sacrificial shield wall, are applicable to the correction measures:

Dead and live loads
Seismic loads: OBE and SSE
Pressurization of the annulus between RPV and SSW
Reactions due to pipe break

Annulus pressurizations include those due to postulated pipe breaks in the following lines:

Recirculation outlet lines
Recirculation inlet lines
Feedwater lines
RHR/LPCI lines

Pipe break reactions include those due to the preceding breaks and due to other severe postulated breaks occurring in the drywell proper. Ten controlling breaks in the drywell are included.

3. Controlling Loading and Load Combination

The significant loads are considered in the load combinations of SRP 3.8.3 with regard to horizontal loads at the interface. The controlling loading with associated acceptance criteria with regard to horizontal loading per panel is noted below:

SRP Combination 5: $1.6S \geq D + L + P_a + Y_r + E$

D, L: dead, live load

P_a: annulus pressure due to break in feedwater line at azimuth 90°.

Y_r: pipe reaction due to the feedwater line break

E: combined effect (by SRSS) due to OBE seismic events in the easterly, northerly, and vertical directions.

ANALYSIS BASED ON DESIGN SSW CONFIGURATION

1. Design Concept

The correction weld carries the horizontal shear loads which are transmitted between the ring channel above the interface and the ring box member below the interface. The horizontal loads from the channel are due to horizontal reactions from the skin plates and columns which connect to the channel from above. Reactions from the analysis of the SSW in its design configuration are used. The shear loads from the skin plates are tangential (circumferential) in direction. Shear loads from the columns have tangential and radial components. The connection design is based on the largest combined shear load in any one panel due to the associated skin plates and columns. The same correction is applied to all panels.

2. Design Loads

The largest combination of shear loads per panel in the controlling load combination 5 has magnitudes as listed below:

Skin plates:	Tangential shear	= 318.1 kips
Column:	Tangential shear	= 8.9 kips
	Radial shear	= 27.4 kips

The total panel tangential shear, 327.0 kips, is taken to act with half applied along each flange of the ring channel. The total panel radial shear, 27.4 kips, is taken to act along the line of the column web.

3. Weld Design Criteria

Welding procedures will be qualified in accordance with the requirements of the Structural Welding Code AWSD1.1. Weld design is based on allowable stresses associated with partial penetration groove welds.

4. Correction Weld Stress Analysis

The panel design loads result in tangential and radial shear resisting forces in the panel correction weld. The total panel tangential load causes a uniform tangential force in the weld of 9.9 kips per inch. A radial weld force which varies linearly between extreme values at the ends of the weld resists the moment on the weld due

to the eccentricity of the applied tangential load along the interior face; the maximum value of this radial force is 21.6 kips per inch. An additional radial weld force with constant magnitude equal to 2.7 kips per inch acts over a limited portion of the weld near its end to resist the applied radial load along the column web line. The maximum value of the resultant weld force occurs at the end of the weld and is equal to 26.3 kips per inch.

5. Controlling Design Margin

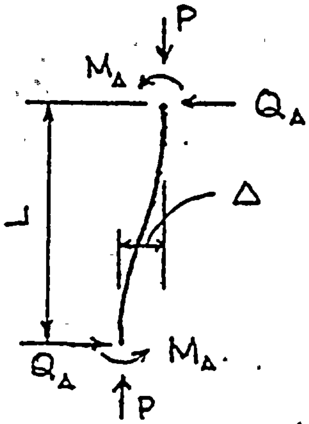
The design margin, which is the ratio of the permissible stress to the actual stress, equals 2.3 for the above maximum value of the weld force.

ANALYSIS FOR AS-BUILT SSW DIMENSIONS

1. Concept for Analysis

As-built deviations of the SSW which affect the proposed correction weld at interface Elevation 541'-5" are illustrated in Figure 3. As shown in the figure, the deviations from verticality of the columns above the interface and the deviations from the design circularity of the ring channel members above the interface are involved.

The lateral displacement of one end of a member, Δ, relative to the other end in conjunction with the primary axial load in the member, P, results in additional (secondary) shears and moments in the member (reference 5). This $P\Delta$ effect with the associated end bending moments and shears is shown below:



From equilibrium considerations, it is determined that:

$$P\Delta = Q_\Delta L + 2M_\Delta$$

Conservatively, the additional end moment M_{Δ} and the additional end shear Q_{Δ} are each evaluated as though the other is non-existent. This is done in the following equations.

$$M_{\Delta} = .5 P\Delta$$

$$Q_{\Delta} = P\Delta / L$$

2. Design Loads

The controlling axial loads in the columns and ring channels are due to the same applied loads taken in SRP Combination 5 which control for the transmission of shear across the interface. The axial force in the ring channel is taken equal to the design panel tangential shear of 327.0 kips. The axial force in the column is taken as the total panel vertical load due to both column and skin plate reactions. Conservatively, the maximum vertical loads in the column and skin plates are used even though these are not located in the same panel as the panel which controls for shear. The design vertical axial load is 316.5 kips.

3. Effect on Annulus Pressurization

With respect to the effect of as-built SSW dimensions on annulus pressurization calculations, the following is noted:

a. The measurements of concern apply to the annulus space between the sacrificial shield wall and the reflective insulation. These measurements are very difficult to obtain and are not available. However, it is noted that the insulation support system is mounted on the SSW so that the dimension between insulation and wall would tend to be unaffected by the as-built deviations.

b. For the design of the wall, NRC required that calculated annulus pressurization loads be increased by 40 percent. One of the reasons for this requirement was to account for as-built conditions being different from the conditions assumed in the analysis.

4. Magnitude of As-Built Deviations

The as-built deviations used in the analysis are based on the most conservative interpretation of the revised erection tolerances which were adopted for the erection of the SSW together with a supplementary field check of the deviations.

Prior to erection of the wall, the contractor requested and was granted relaxation of the original contract requirements on erection tolerances. The maximum permissible deviation from circularity was changed to ± 0.90 inches in lieu of the original ± 0.125 inches. The maximum horizontal deviation at the top of the wall from the vertical line through the corresponding point in the base of the wall was revised to ± 0.90 inches in lieu of the original ± 0.25 inches.

The most conservative interpretation of the adopted tolerances results in the deviation values noted below. These values are used in the analysis.

a. Circularity - The maximum tolerance is taken to occur at one column relative to the adjacent columns on either side.
Referring to Figure 3,

$$\Delta_{Ci} - \Delta_{Ci+1} = \Delta_{Ci} - \Delta_{Ci-1} = 0.90 - (-0.90) = 1.80 \text{ inches}.$$

b. Verticality - The maximum tolerance is taken to occur at a column between Elevation 541'-5" and Elevation 549'-5¼". Using the terminology of Figure 3,

$$\Delta_V = 0.90 - (-0.90) = 1.80 \text{ inches}.$$

Field measurements pertinent to the vertical and circular deviations have recently been made. The magnitudes of Δ_v as defined in Figure 3 were determined around the shield wall. However, precise determination of the circular deviation is not practical due to interference of existing construction. As a measure of the circular deviation, the radial deviation between the ring box member below the interface and the ring channel above the interface is used.

Comparison of the deviations from field measurements with those based on the tolerances makes apparent the conservative basis of the analysis. Thus the analysis uses Δ_v = 1.8 inches compared to a maximum measured value of 0.625 inches. Also, the analysis uses $\Delta_{Ri} - \Delta_{Ri+1}$ = 1.8 inches compared to a corresponding value of 0.875 inches based on field data.

5. Correction Weld Stress Analysis

As noted in the Concept for Analysis, the design axial loads acting with the adopted design deviations result in additional end moments and shears in the columns and ring channels located above the interface.

The additional end moments in the column and ring channel are 285.0 inch kips and 294.3 inch kips respectively. The associated increases in flexural stress in the members are less than 0.7 kips per square inch. This increase in stress is relatively small and is within the capacity of the wall members.

The additional column radial shear is 5.9 kips. The additional radial shear in each of the two ring members at the column is 13.4 kips. Thus, a total of 32.7 kips of additional radial shear results due to the design deviations. Conservatively, this additional radial shear is taken to occur in the controlling panel used for the design of the correction weld. The total panel radial shear is increased to 60.1 kips and the resulting local radial weld force increases to 6.0 kips per inch from the previous value of 2.7 kips per inch in the Analysis Based on Design SSW Configuration.

6. Design Margin

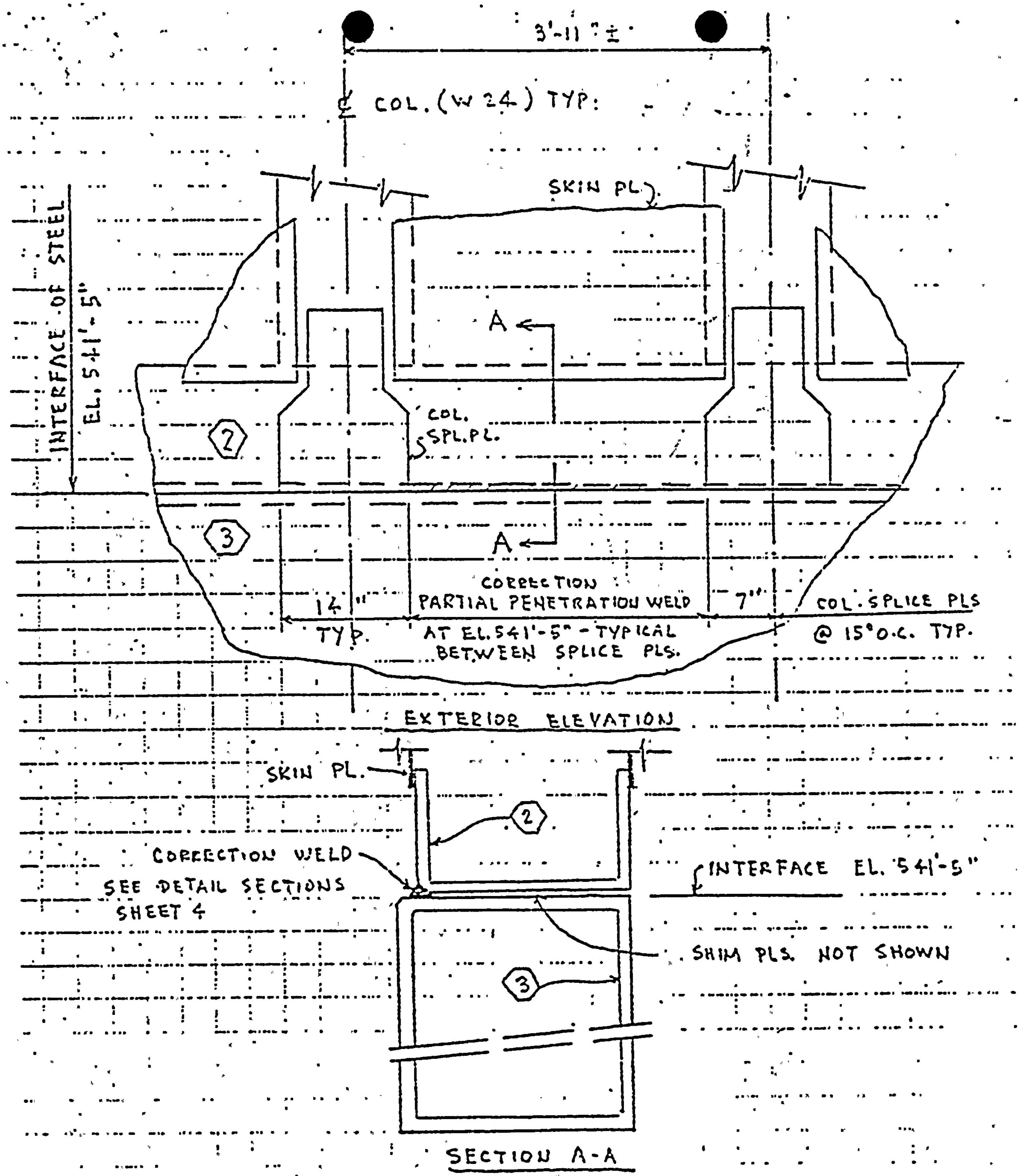
With the above increase in panel radial shear, the design margin is 2.1 as compared to the previous value of 2.3.

CONCLUSION

Based on the preceeding analysis, the proposed correction weld at interface Elevation 541'-5" has sufficient capacity to sustain the required loads. The correction provides a design margin in excess of 2.1.

Prepared by: M. N. Fialkow
M.N. Fialkow

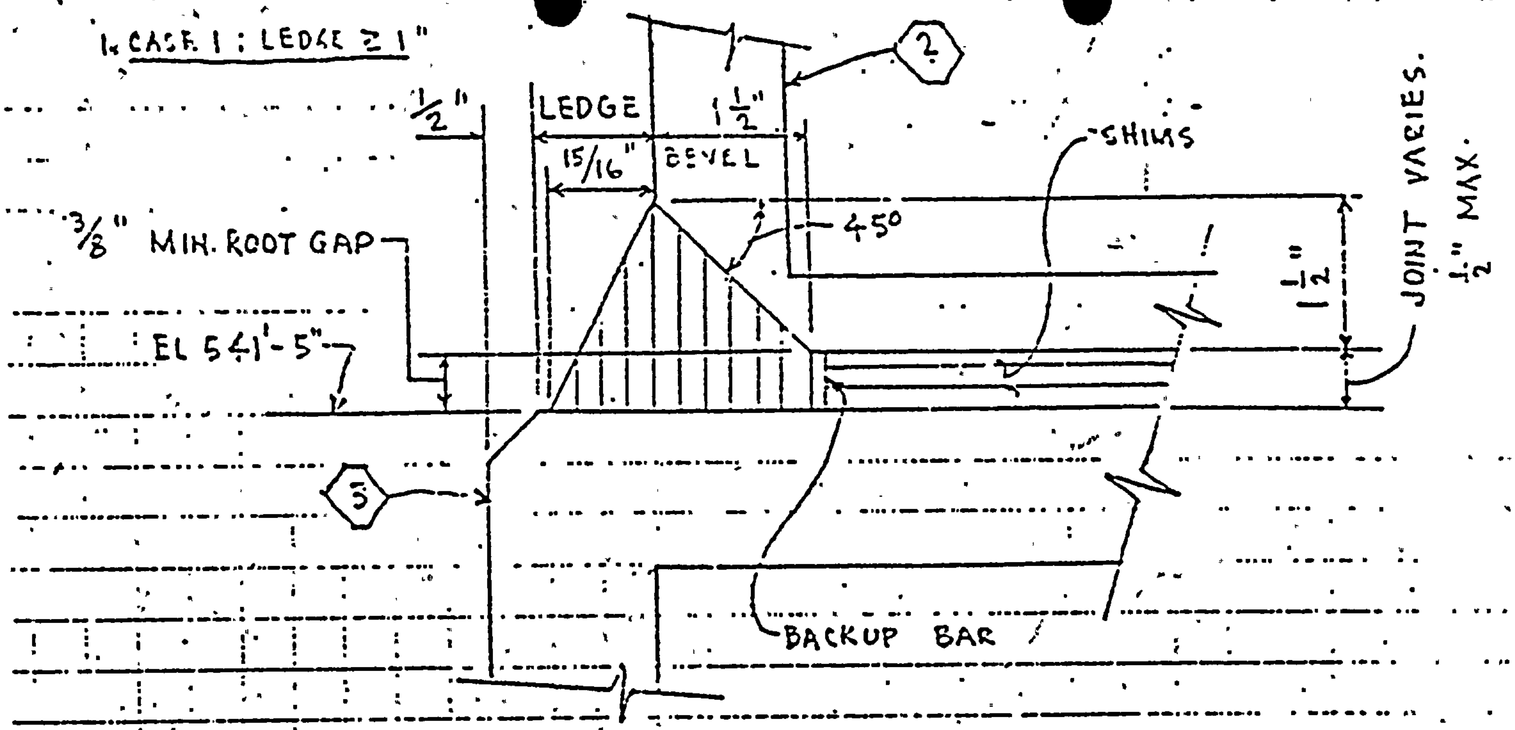
Approved by: J. F. O'Donnell
J. F. O'Donnell



ELEVATION AND SECTION OF SSW SHOWING CORRECTION WELD

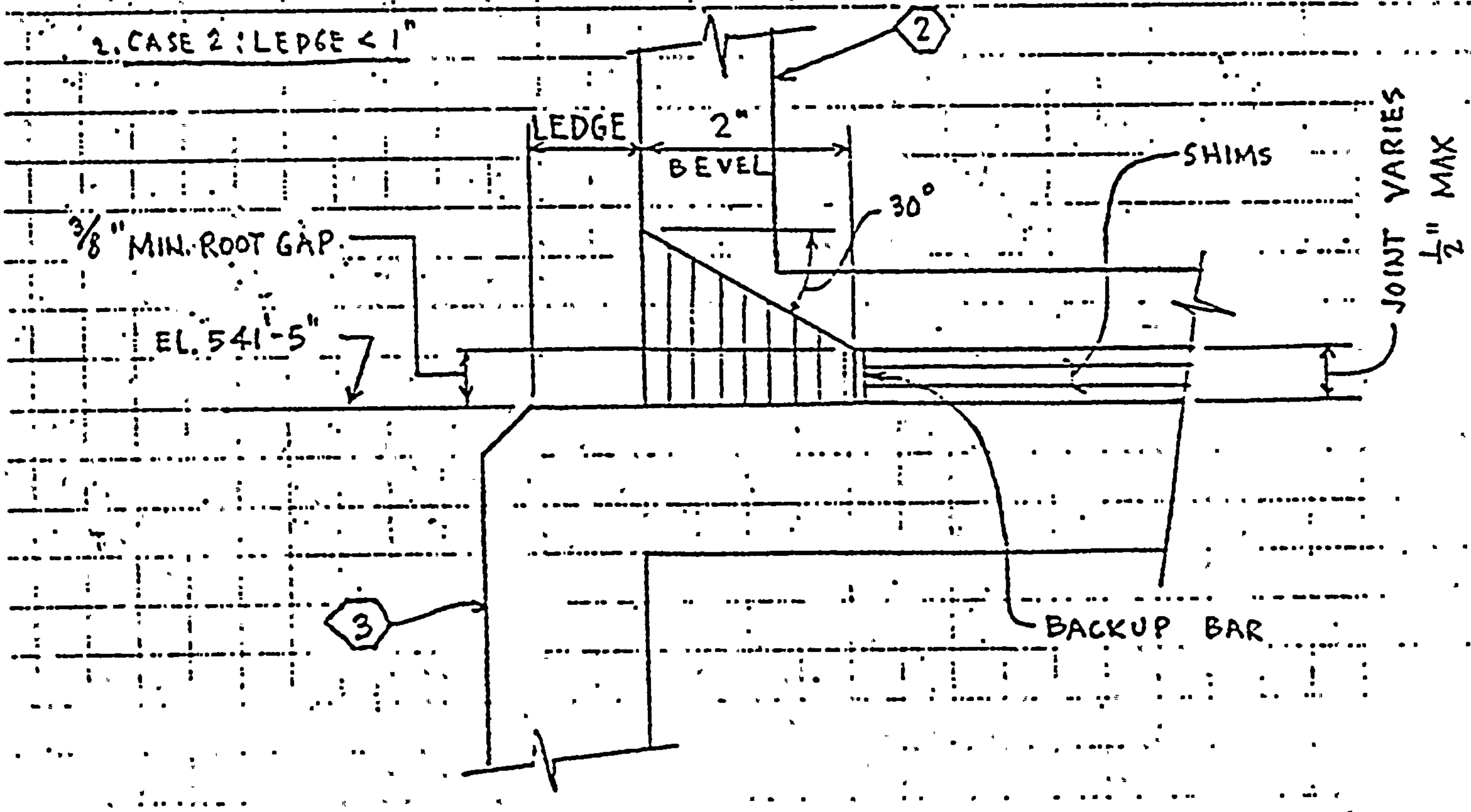
FIGURE 1

1. CASE 1 : LEDGE ≥ 1"



SECTION WHERE LEDGE IS A MINIMUM OF 1" WIDE

2. CASE 2 : LEDGE < 1"



SECTION WHERE LEDGE IS LESS THAN 1" WIDE

REINFORCING FILLET TO BE ADDED AS SHOWN ON SHEET 5 OF PED-215-CS-2741.

CORRECTION WELD DETAILS

FIGURE 2

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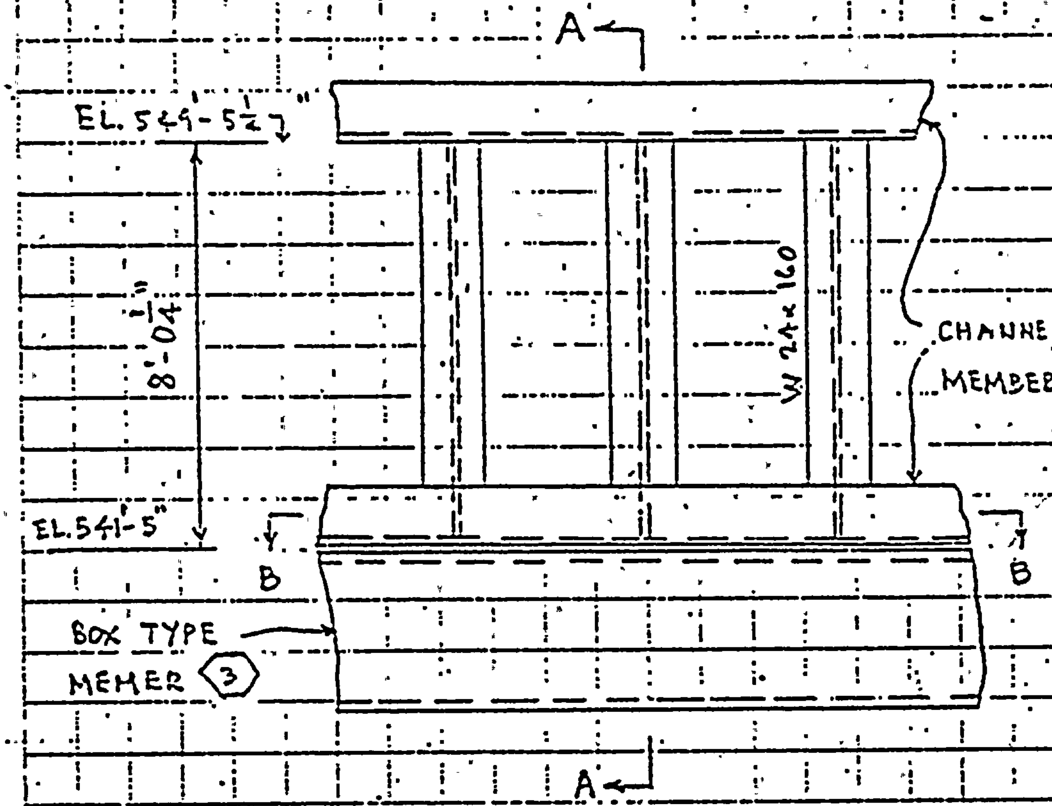
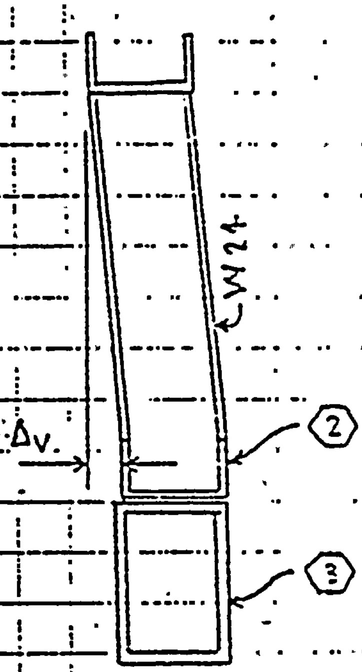
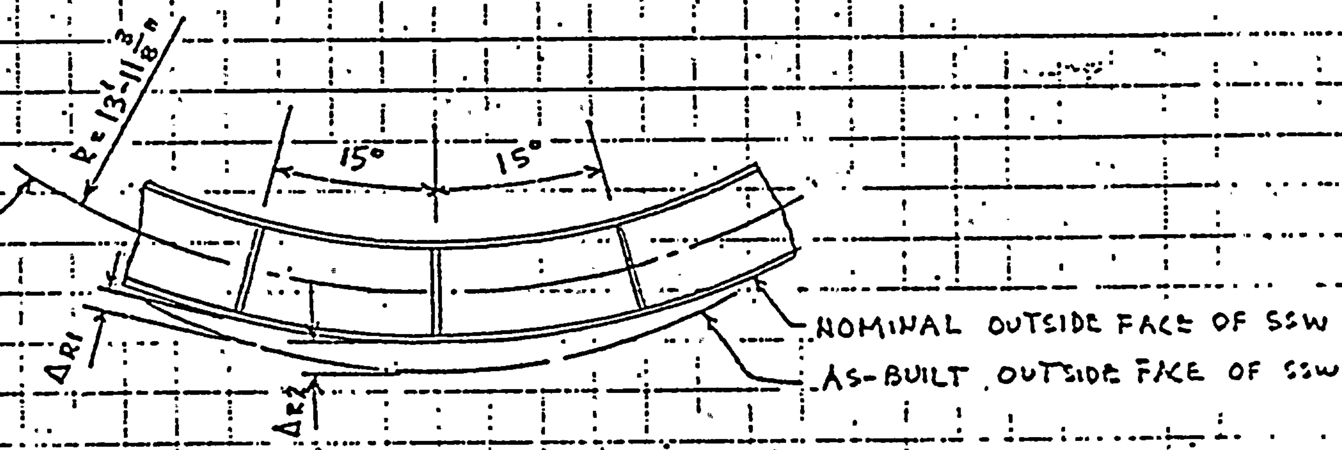


ELEVATION OF SSW SHOWING MEMBERS



SECTION A-A

SHOWING VERTICAL DEVIATION



SECTIONAL PLAN B-B

SHOWING DEVIATION FROM CIRCLE

DIAGRAM ILLUSTRATING AS-BUILT DEVIATIONS

FIGURE 3