Appendix 3A Dynamic Structural Analysis of the NuScale Power Module

3A.1 Seismic Analysis

The dynamic analysis of the NuScale Power Module (NPM) uses a complete system model to represent the dynamic coupling of the reactor pressure vessel (RPV), containment vessel (CNV), reactor internals and core support, reactor core, surrounding pool water, and structures, systems, and components (SSC) supported by the NPM. The dynamic analysis of the complete NPM system is performed using time history dynamic analysis methods and a three dimensional (3-D) ANSYS (Section 3.9.1.2) finite element model. The NPM system model includes acoustic elements to represent the effects of fluid-structure interaction (FSI) due to pool water found between the CNV and pool floor and walls.

To account for possible dynamic coupling of the NPMs and the reactor building (RXB) system, a model of each of the NPMs is included in the RXB system model as described in Section 3.7.2.

The Reactor Building (RXB) system model, with representation of the NPMs, is analyzed for soil-structure interaction (SSI) in the frequency domain using computer code SASSI2010 (Section 3.7.5.3). Results from the RXB seismic system analysis include in-structure time histories at each NPM support location and the pool walls and floor surrounding the NPM. In-structure response spectra (ISRS) are also calculated. Results are shown in Section 3.7.2.

The detailed dynamic analysis of the NPM subsystem is performed using a 3D NPM system model using ANSYS. The NPM dynamic analysis provides in-structure time histories and in-structure response spectra for qualification of equipment supported on the NPM and time histories at core support locations for seismic qualification of fuel assemblies.

The seismic analysis of the NPM is provided in technical report TR-0916-51502, "NuScale Power Module Seismic Analysis."

3A.2 Blowdown Analysis

The blowdown analysis addresses events caused by the failure or actuation of piping and valves, including high-energy line breaks inside the CNV. These short term transient events result in system internal pressure waves and asymmetric cavity pressurization waves external to the pipe break or valve outlet.

Short term transient events require special treatment due to their rapidly changing thermal hydraulic conditions and resulting dynamic mechanical loads. In addition to the rapid nature of these transients, fluid-structure interactions are influential and are therefore also considered.

The blowdown analysis of the NPM is provided in technical report TR-1016-51669, "NuScale Power Module Short-Term Transient Analysis."

Appendix 3B Design Reports and Critical Section Details

This appendix summarizes the structural design and analysis of the Reactor Building (RXB) and Control Building (CRB). Section 3.8.4 and Section 3.8.5 describe these structures, their foundations, and the primary loads and load combinations. This appendix describes how those loads are combined and how the design is checked for adequacy. In addition, a selection of structural elements are described in detail. These elements are critical sections in that they represent parts of the structure that: (1) perform a safety-critical function, (2) are subjected to large stress demands, (3) are considered difficult to design or construct, or (4) are considered to be representative of the structural design. Within the safety related structures, the only true critical sections are those associated with the bays that contain the NuScale Power Modules (NPMs). The walls and slab at the NPM bays satisfy the first three criteria. To present a representative overview of the buildings, an additional 10 sections in the RXB and 7 in the CRB are provided as critical sections.

Section 3B.1 discusses the design methodology used for both buildings. Section 3B.2 provides the design report and critical section details for the RXB, and Section 3B.3 provides that information for the CRB.

The following critical sections are presented for the RXB:

<u>Walls</u>

- Wall at grid line 1 - West outer perimeter wall at foundation level
- Wall at grid line 3 - Interior weir wall and upper stiffener
- Wall at grid line 4 - Interior wall of RXB with two different thicknesses
- Wall at grid line 6 - Pool wall and upper stiffener wall
- Wall at grid line E - South exterior wall extending upward from foundation level

<u>Slabs</u>

- Slab at EL. 100'-0" - Slab at grade
- Slab at EL. 181'-0" - Slab at roof

<u>Pilasters</u>

- Pilasters at grid line A

<u>Beams</u>

- Beam at EL. 75'-0"

<u>Buttresses</u>

- Buttress at EL. 126'-0"

<u>NPM Bay</u>

- West wing wall
- Pool wall

- NPM support skirt
- NPM lug restraint

The following critical sections are presented for the CRB:

<u>Walls</u>

- Wall at grid line 3 - Interior structural wall
- Wall at grid line 4 - East exterior structural wall
- Wall at grid line A - North exterior structural wall

<u>Slabs</u>

- Basemat foundation
- Slab at EL. 100'-0" - Slab at grade

<u>Pilasters</u>

- Pilasters at grid line 1

<u>T- Beams</u>

- T-Beam at EL. 120'-0"

Table 3B-54 and Table 3B-55 outline the critical sections and details for the RXB and CRB.

Section 1.2 contains architectural drawings of the RXB and CRB. Figure 1.2-10 through Figure 1.2-20 are for the RXB and Figure 1.2-21 through Figure 1.2-27 are for the CRB.

The concrete design process is organized by defining each wall, slab, pilaster, buttress and T-beam into several small zones on the structure and assigning identification names to these regions. The zone definitions are labeled according to the naming conventions below:

<u>Wall Zone Definition Name: "A";"B";"C-D";"E-F"</u>

where,

"A" = Building name

"B" = Grid line ID designation

"C-D" = Wall zone grid line ID range in the horizontal direction

"E-F" = Wall zone elevation range

For example a zone labeled as "RXB;1;E-D;100-120" is a RXB wall zone on grid line 1, between grid lines E and D, and located between elevations 100' and 120'.

Slab Zone Definition Name: "A";"B";"C-D";"E-F"

where,

"A" = Building name

"B" = TOC elevation designation

"C-D" = Slab zone grid line ID range in the E-W direction

"E-F" = Slab zone grid line ID range in the N-S direction

For example, a zone labeled as "RXB;100;1-2;A-B" is an RXB slab zone at the 100' elevation between grid lines 1 and 2, and between grid lines A and B.

Pilaster Zone Definition Name: "A";"B";"CD";"E-F"

where,

"A" = Building name

"B" = Pilaster abbreviation

"C" = the wall grid line ID where the pilaster is located

"D" = the grid line that represents the centerline of where the pilaster is located

"E-F" = Elevation IDs that represent where the pilaster is between in the vertical direction

For example, a zone labeled as "RXB;PI;A2;75 - 100" is a RXB pilaster on wall grid line A, on grid centerline 2, between elevations 75' 100'.

T-Beam Zone Definition Name: "A";"B";"C";"D-E";"F-G"

where,

"A" = Building name

"B" = T-beam abbreviation

"C" = Elevation designation

"D-E" = Slab zone grid line range in the E-W direction

"F-G" = Slab zone grid line range in the N-S direction

For example, a zone labeled as "RXB;TB;100;1-2;A-B" is a RXB T-beam at Elevation 100', between grid lines 1 and 2, and between grid lines A and B. If multiple zones lie between two grid lines, the numbering of (1), (2), or (3) is added to the end of the definition name.

Buttress Zone Definition Name: "A";"B";"C";"D";"E-F"

where,

"A" = Building name

"B" = Buttress abbreviation

"C" = the wall grid line ID where the buttress is located

"D" = Elevation designation

"E-F" = Grid line IDs that represent the buttress range in the horizontal direction

For example, a zone labeled as "RXB;B;A;145.5;1-2" is a RXB buttress on wall grid line A, at elevation 145’-6”, between grid lines 1 and 2.

In addition to the zone names, figures are included in Section 3B.2 and Section 3B.3 that visually place the section within the building.

3B.1 Methodology

SAP2000 (Reference 3B-1) and SASSI2010 (Reference 3B-2) are used to develop the static and dynamic loads as described in Section 3.7 and 3.8. The methodology and equations from ACI-349 (Reference 3B-3) are used to develop the forces and moments used for the design of the RXB and CRB, unless otherwise noted. The predominant governing load combination is Combination 10 from Table 3.8.4-1 (ACI 349 Load Equation 9-6). The demand forces and moments have been increased by 5 percent to account for the effect of accidental torsion as described in Section 3.7.2.11. The strength reduction factors used for the reinforced concrete design are provided in Table 3B-53.

3B.1.1 Wall and Slab Design Methodology

The standard global and local axis orientation is shown below.

- Global X- Axis - east-west direction
- Global Y- Axis - north-south direction
- Global Z- Axis - vertical direction
- Local "x" axis - always horizontal
- Local "y" axis - parallel to global y for slab or parallel to global z for wall
- Local "z" axis - perpendicular to the x and y axes by the right-hand rule

The total area of the longitudinal reinforcing steel provided in an element is the sum of the steel required for (i) membrane tension, (ii) in-plane shear, and (iii) out-of-plane moment. The maximum compression in an element is a combination of flexural compression (out-of-plane moment) and membrane compression. A simplified approach is used for addressing combined effects of flexural and membrane compression. For the simplified method, the sectional area, defined by (b =12")*(a), provides for flexural compression. The net sectional area, defined by (b=12")*(h-a), is available for carrying membrane compression. The maximum membrane compressive stress is calculated to be (S_{xx} or S_{yy})/[12(h-a)]. The Whitney stress block defines parameters "a" and "h" as shown in Figure 3B-1. The maximum membrane compressive stress is less than the allowable compressive strength for membrane compression.

3B.1.1.1 Averaging Demand Forces and Moments

The finite element models often show highly localized forces and moments that are not representative of the average demand forces and moments over the wall and slab sections. Therefore, the design zones with demand/capacity (D/C) ratio exceedances over a single finite element are averaged with adjacent elements to show a more realistic value. When necessary for averaging purposes of finite element analysis generated element forces and moments, the length of the failure plane considered is taken approximately 4 times the thickness of the element.

For the in-plane shear stress check used to demonstrate acceptable wall and slab thickness, average demand shear stresses over the full available section length of wall or slab cross-sections are used. The cross-sectional areas used for the stress check also include the presence of pilasters and T-beams.

3B.1.1.2 Wall and Slab Design Forces and Moments

For each element in the analysis models, static forces and moments are obtained from SAP2000 analysis for non-seismic loads. The direction of the loads result in either compression (negative) or tension (positive) membrane forces due to the static forces and moments being monotonic. The forces and moments for SAP2000 analysis are listed below and are shown in Figure 3B-2 and Figure 3B-3.

- F11, F22 Membrane forces
- F12 In-plane shear
- M11, M22 Out-of-plane moment
- M12 Torsional moment
- V13, V23 Out-of-plane shear

Similarly, for each element in the analysis models, dynamic forces and moments are obtained from SASSI2010 soil-structure interaction analysis for seismic loads. The dynamic forces and moments are reversible (not monotonic) and therefore consider the direction that is most adverse in a load combination. The SASSI2010 x- and y-components of membrane tension or compression, out-of-plane moment, and out-of-plane shear are enveloped in order to ensure compliance with the local axes of SAP2000. The forces and moments from SASSI2010 are listed below and shown in Figure 3B-4.

- S_{xx}, S_{yy} Membrane forces
- S_{xy} In-plane shear
- M_{xx}, M_{yy} Out-of-plane moment

- M_{xy} Torsional moment
- V_{xz}, V_{yz} Out-of-plane shear

3B.1.1.3 Wall and Slab Design Approach

The design check approach uses load combinations that involve both static and dynamic load cases from SAP2000 and SASSI2010 to get combined element forces and moments. The shell element forces and moments from the two analyses are shown in Table 3B-1. Additional terms used in this analysis combined are shown below:

- S_{xx} Membrane tension/compression in local x direction
- S_{yy} Membrane tension/compression in local y direction
- S_{xy} In-plane shear acting along both faces
- $(M_{xx} + M_{xy})$ Out-of-plane moment about local y-axis
- $(M_{yy} + M_{xy})$ Out-of-plane moment about local x-axis
- V_{xz} Out-of-plane shear in local z direction on local x face
- V_{yz} Out-of-plane shear in local z direction on local y face

The terms in-plane and out-of plane are abbreviated as IP and OOP in tables and figures. The following paragraphs describe the design check approach for a structural wall. The approach is equally applicable for slabs.

The design forces and moments that produce tensile, shear and flexural stress are resisted by the reinforcing steel and stirrups in the following manner:

1) The main reinforcing steel is provided at the face of the wall (such as 1 layer #9 @ 12″ centers = 2.00 in^2) and considered for the resistance of membrane tension forces (S_{xx} or S_{yy}), out-of-plane moments($(M_{xx} + M_{xy})$ or $(M_{yy} + M_{xy})$), and in- plane shear(S_{xy}).

2) The out-of-plane shear forces on the section are resisted by the strength of concrete and, if required, the addition of stirrups (such as 1 leg #6 stirrups @ 12″ centers).

3) The design forces and moments that produce compressive stress, namely membrane compression and flexural compression, are resisted by the strength of concrete.

Design for Horizontal Reinforcement (Local X)

The area of horizontal reinforcing steel due to membrane tension, in-plane shear and out-of-plane moment are calculated as follows. In the calculation of the required in-plane shear steel required, V_{conc} is the in-plane shear resisted by concrete and is calculated using a shear wall coefficient of 2.

Area of steel required due to membrane tension:

$$A_{s1x} = \frac{S_{xx}}{\phi_m f_y} \quad \text{Eq. 3.B-1}$$

Area of steel required due to in-plane shear:

$$A_{s2x} = \frac{S_{xy} - V_{conc}}{\phi_v f_y} \quad \text{Eq. 3.B-2}$$

Area of steel required due to out-of-plane moment:

$$A_{s3x} = \frac{M_{xx} + M_{xy}}{\phi_m j d f_y} \quad \text{Eq. 3.B-3}$$

where,

V_{conc} is the factored capacity of concrete,

jd is the lever arm, the distance between the resultant compressive force and the resultant tensile force (in), and

j is a dimensionless ratio used to define the lever arm, jd. It varies depending on the moment acting on the wall section.

The sum of membrane tension, in-plane shear, and out-of-plane moment steel areas must be less than that provided by the chosen horizontal reinforcement.

Area of total horizontal reinforcing steel:

$$A_{S\ Horiz} = A_{s1x} + A_{s2x} + A_{s3x} \quad \text{Eq. 3.B-4}$$

D/C ratio:

$$D/C_{HorizReinf} = \frac{A_{S\ Horiz}}{A_{S\ Provided\ H}} \quad \text{Eq. 3.B-5}$$

Total horizontal reinforcing steel provided ($A_{S\ Provided\ H}$) is divided equally on each face.

Horizontal membrane compressive stress:

$$f_{xx} = \frac{S_{xx}}{b(h-a)} \quad \text{Eq. 3.B-6}$$

Membrane compression strength:

$$\sigma_{all} = \frac{0.8\phi_c[0.85f'_c(A_g - A_s) + f_y A_s]}{A_g} \qquad \text{Eq. 3.B-7}$$

The horizontal membrane compressive stress must be less than the membrane compressive strength.

Membrane compression D/C ratio:

$$D/C_{Horiz\ Comp} = \frac{f_{xx}}{\sigma_{all}} \qquad \text{Eq. 3.B-8}$$

Design for Vertical Reinforcement (Local Y)

The area of vertical reinforcing steel due to membrane tension, in-plane shear, and out-of-plane moment are calculated as follows. In the calculation of in-plane shear steel required, V_{conc} is the in-plane shear resisted by concrete and is calculated using a shear wall coefficient of 2.

Area of steel required due to membrane tension:

$$A_{s1y} = \frac{S_{yy}}{\phi_m f_y} \qquad \text{Eq. 3.B-9}$$

Area of steel required due to in-plane shear:

$$A_{s2y} = \frac{S_{xy} - V_{conc}}{\phi_v f_y} \qquad \text{Eq. 3.B-10}$$

Area of steel required due to out-of-plane moment:

$$A_{s3y} = \frac{M_{yy} + M_{xy}}{\phi_m jdf_y} \qquad \text{Eq. 3.B-11}$$

where,

V_{conc} is the factored capacity of concrete,

jd is the lever arm, the distance between the resultant compressive force and the resultant tensile force (in), and

j is a dimensionless ratio used to define the lever arm, jd. It varies depending on the moment acting on the wall section.

The sum of membrane tension, in-plane shear, and out-of-plane moment steel areas must be less than that provided by the chosen vertical reinforcement shown below:

Total vertical reinforcing steel:

$$A_{S\ Vert} = A_{s1y} + A_{s2y} + A_{s3y} \qquad \text{Eq. 3.B-12}$$

D/C ratio:

$$D/C_{Vert\ Reinf} = \frac{A_{S\ Vert}}{A_{S\ Provided\ V}} \qquad \text{Eq. 3.B-13}$$

Total vertical reinforcing steel provided ($A_{S\ Provided\ V}$) is divided equally on each face.

Vertical membrane compressive stress:

$$f_{yy} = \frac{S_{yy}}{b(h-a)} \qquad \text{Eq. 3.B-14}$$

Membrane compression strength:

$$\sigma_{all} = \frac{0.8\phi_c[0.85f'_c(A_g - A_s) + f_y A_s]}{A_g} \qquad \text{Eq. 3.B-15}$$

Membrane compression D/C ratio:

$$D/C_{Vert\ Comp} = \frac{f_{yy}}{\sigma_{all}} \qquad \text{Eq. 3.B-16}$$

Shear Friction in the X Plane

The design check for shear friction is based on a coefficient of friction of $\mu=1$. The XZ plane shear friction area of steel is the sum of the in-plane shear and out-of-plane moment. The in-plane shear S_{xy} must be less than the nominal shear friction capacity.

XZ plane shear friction:

$$A_{vfx} = A_{S\ Provided\ V} + A_{s1x} \qquad \text{Eq. 3.B-17}$$

Nominal shear friction capacity:

$$\phi V_{nx} = \phi_v A_{vfx} f_y \mu \qquad \text{Eq. 3.B-18}$$

Shear friction check:

$$S_{xy} < \phi_v V_{nx} \quad \text{Eq. 3.B-19}$$

Shear Friction in the Y Plane

The design check for shear friction is based on a coefficient of friction of μ=1. The YZ plane shear friction area of steel is the sum of the in-plane shear and out-of-plane moment. The in-plane shear S_{xy} must be less than the nominal shear friction capacity.

YZ plane shear friction:

$$A_{vfy} = A_{S\ Provided\ H} + A_{s1y} \quad \text{Eq. 3.B-20}$$

Nominal shear friction capacity:

$$\phi V_{ny} = \phi_v A_{vfy} f_y \mu \quad \text{Eq. 3.B-21}$$

Shear friction check:

$$S_{xy} < \phi_v V_{ny} \quad \text{Eq. 3.B-22}$$

In-Plane Shear Check

The area of reinforcing steel required for the in-plane shear stress (S_{xy}) is always added to the total steel area for the horizontal and vertical reinforcement. The added in-plane shear areas are A_{S2x} and A_{S2y}.

However, another design check for the in-plane shear forces, which is independent of the amount of the reinforcing steel but dependent upon having sufficient thickness of the concrete section, can be performed. The maximum in-plane shear capacity is the maximum allowable shear on a given section based on the dimensional properties and concrete compressive strength. For the nominal in-plane shear strength, the coefficient defining the relative contribution to nominal wall shear strength is a conservative value of 2 when calculating the nominal in-plane shear strength.

Maximum in-plane shear capacity:

$$\phi_v V_n = \phi_v 8 A_{cv} \sqrt{f'_c} \quad \text{Eq. 3.B-23}$$

Nominal in-plane shear strength:

$$\phi_v V_n = \phi_v A_{cv}(\alpha_c \sqrt{f'_c} + \rho_t f_y) \quad \text{Eq. 3.B-24}$$

In-plane shear check:

$$S_{xy} < \phi_v V_n \quad \text{Eq. 3.B-25}$$

The averaging for in-plane shear can be done on the entire span of the wall.

Out-of-Plane Shear in XZ Plane

Out-of-plane shear capacity is based on a shear strength reduction factor of ϕ_v = 0.75. The shear capacity is adjusted when the section is subjected to membrane compression or tension.

See Figure 3B-2 through Figure 3B-5 for SAP2000/SASSI2010 sign convention of positive forces and moments.

Capacity of concrete for elements subjected to axial compression (S_{xx} is positive):

$$\phi V_{C,XZ} = 2\phi_v\left(1 + \frac{S_{xx}}{2000A_g}\right)\sqrt{f'_c}b_w d \quad \text{Eq. 3.B-26}$$

Capacity of concrete for elements subjected to axial tension (S_{xx} is negative):

$$\phi V_{C,XZ} = 2\phi_v\left(1 + \frac{S_{xx}}{500A_g}\right)\sqrt{f'_c}b_w d \quad \text{Eq. 3.B-27}$$

Out-of-plane shear D/C ratio:

$$D/C_{XZ} = \frac{V_{XZ}}{\phi V_{C,XZ} + \phi V_S} \quad \text{Eq. 3.B-28}$$

Out-of-Plane Shear in YZ Plane

Out-of-plane shear capacity is based on a shear strength reduction factor of ϕ_v = 0.75. The shear capacity is adjusted when the section is subjected to membrane compression or tension.

Capacity of concrete for elements subjected to axial compression (S_{yy} is positive):

$$\phi V_{C,YZ} = 2\phi\left(1 + \frac{S_{yy}}{2000A_g}\right)\sqrt{f'_c}b_w d \quad \text{Eq. 3.B-29}$$

Capacity of concrete for elements subjected to axial tension (S_{yy} is negative):

$$\phi V_{C,YZ} = 2\phi\left(1 + \frac{S_{yy}}{500A_g}\right)\sqrt{f'_c}\,b_w d \qquad \text{Eq. 3.B-30}$$

Out-of-plane shear D/C ratio:

$$D/C_{YZ} = \frac{V_{YZ}}{\phi V_{C,YZ} + \phi V_S} \qquad \text{Eq. 3.B-31}$$

3B.1.1.4 Basemat Foundation Design Force and Moments

The design check considers bounding demand forces and moments for the basemat.

The demand forces and moments of the design check consist of:

- Out-of-plane moment, in kip-ft per unit length in feet: maximum out-of-plane moment in either of the two perpendicular directions in-plane
- Out-of-plane shear force, in kips per unit length in feet: maximum out-of-plane shear force from either of the planes XZ or YZ
- In-plane shear force, in kips per unit length in feet: maximum in-plane shear force
- Axial force along x- or y-direction in kips per unit length in feet: maximum axial tension along the x- or y-axis

The SASSI2010 program calculates the dynamic stresses due to a seismic excitation at the centroid of a solid element. These stresses are post-processed to obtain the forces and bending moments in the basemat foundation. The dynamic forces and moments in a solid element are combined with the corresponding static forces and moments calculated with SAP2000. For a solid element, the SAP2000 program calculates only the nodal forces at all eight nodes of the solid element. Therefore, these nodal forces also require post-processing to convert to forces and moments.

3B.1.2 T-Beam, Buttress and Pilaster Methodology

These frame elements increase the stiffness of the walls or slabs which helps to mitigate the effects of out-of-plane seismic loads. The design check determines the D/C ratios for strong axis and weak axis bending, shear along both axes, torsion and compression/tension based on the combined demand forces and moments.

An iterative design check approach is used to determine major axis bending reinforcement based on the maximum combined design forces and moments. The other components are checked during this process to ensure compliance.

3B.1.2.1 T-Beam, Buttress and Pilaster Design Forces and Moments

The SAP2000 analysis for non-seismic loads provides the static forces and moments for the frame elements in the analysis models. The direction of the loads are specific resulting in either compression (negative) or tension (positive) forces due to the static forces being monotonic. Figure 3B-5 defines the frame element forces and moments for SAP2000 shown below.

- P Axial force
- V2 Shear force in the 1-2 plane
- V3 Shear force in the 1-3 plane
- T Axial torque (about the 1-axis)
- M2 Bending moment in the 1-3 plane (about the 2-axis)
- M3 Bending moment in the 1-2 plane (about the 3-axis)

The SASSI2010 soil-structure interaction analysis for seismic loads provides the dynamic forces and moments for frame elements in the analysis models. The dynamic forces and moments consider the direction that is most adverse in a load combination due to the fact that they are reversible (not monotonic). Figure 3B-6 defines the forces and moments extracted from SASSI2010 listed below.

- P1 Axial force
- P2 Shear force in the 1-2 plane
- P3 Shear force in the 1-3 plane
- M1 Axial torque (about the 1-axis)
- M2 Bending moment in the 1-3 plane (about the 2-axis)
- M3 Bending moment in the 1-2 plane (about the 3-axis)

The combined resultant force or moment obtained from the combination of these loads uses the SAP2000 naming convention.

3B.1.2.2 T-Beam, Buttress and Pilaster Design Approach

The frame design check approach uses load combinations of both static and dynamic load cases to get combined element forces and moments. The frame element forces and moments are shown in Table 3B-1. The SAP2000 terminology is used.

The design of reinforced concrete T-beam and pilaster sections uses the following methodology for frame elements.

Design for Strong Axis Bending

The strong axis bending of the frame element governs the design. Iterations of the moment determine the required amount of strong axis bending rebar. The design of the frame element uses the equation for the nominal moment capacity shown below. The total combined static and dynamic moment must be less than the factored nominal moment capacity.

Nominal moment capacity:

$$\phi M_{n3} = \phi_m A_s f_y\left(d_{A2} - \frac{a}{2}\right) \qquad \text{Eq. 3.B-32}$$

Strong axis bending D/C ratio:

$$D/C_3 = \frac{M3}{\phi M_{n3}} \qquad \text{Eq. 3.B-33}$$

Design for Weak Axis Bending

The weak axis bending of the frame element verifies the demand forces and moments do not exceed the capacity. The total combined static and dynamic moment must be less than the factored nominal moment capacity.

Nominal moment capacity:

$$\phi M_{n2} = \phi_m A_s f_y\left(d_{A3} - \frac{a}{2}\right) \qquad \text{Eq. 3.B-34}$$

Weak axis bending D/C ratio:

$$D/C_2 = \frac{M2}{\phi M_{n2}} \qquad \text{Eq. 3.B-35}$$

Design for Axial Torsion

The axial torsion of the frame element verifies that the demand forces and moments do not exceed the capacity. The torsional effects can be neglected if the obtained torsion threshold does not exceed the combined static and dynamic load.

Threshold torsion for non-prestressed members:

$$\phi T_n = \phi_v \sqrt{f'_c}\left(\frac{A_g^2}{p_{cp}}\right) \qquad \text{Eq. 3.B-36}$$

Threshold torsion check:

$$T < \phi T_n \qquad \text{Eq. 3.B-37}$$

Design for Weak Axis Shear

The weak axis shear capacity uses a shear strength reduction factor of ϕ_v=0.75.

The shear capacity is adjusted when the section is subjected to membrane compression or tension.

Capacity of concrete for elements
subjected to axial compression (P is positive):

$$\phi V_{C,3} = 2\phi_v\left(1 + \frac{p}{2000A_g}\right)\sqrt{f'_c}b_w d \qquad \text{Eq. 3.B-38}$$

Capacity of concrete for elements
subjected to axial tension (P is negative):

$$\phi V_{C,3} = 2\phi_v\left(1 + \frac{P}{500A_g}\right)\sqrt{f'_c}b_w d \qquad \text{Eq. 3.B-39}$$

The weak axis shear demand must be less than the combined capacity of concrete and stirrups.

Out-of-plane shear D/C ratio:

$$D/C_3 = \frac{V3}{\phi V_{C,3} + \phi V_S} \qquad \text{Eq. 3.B-40}$$

Design for Strong Axis Shear

The strong axis shear capacity uses a shear strength reduction factor of ϕ_v=0.75.

The shear capacity is adjusted when the section is subjected to membrane compression or tension.

Capacity of concrete for elements
subjected to axial compression (P is positive):

$$\phi V_{C,2} = 2\phi_v\left(1 + \frac{P}{2000A_g}\right)\sqrt{f'_c}b_w d \qquad \text{Eq. 3.B-41}$$

Capacity of concrete for elements
subjected to axial tension (P is negative):

$$\phi V_{C,2} = 2\phi_v\left(1 + \frac{P}{500A_g}\right)\sqrt{f'_c}b_w d \qquad \text{Eq. 3.B-42}$$

The strong axis shear demand must be less than the combined capacity of concrete and stirrups.

Out-of-plane shear D/C ratio:

$$D/C_2 = \frac{V2}{\phi V_{C,2} + \phi V_S} \qquad \text{Eq. 3.B-43}$$

Design for Compression or Tension (Axial Force)

With the exception for the dynamic axial force, the design SAP2000 axial force is known to be in tension or compression. The dynamic axial load is both added and subtracted from the static axial load to create a minimum and maximum value. Compression is not checked if both the minimum and maximum values are positive and tension is not checked if both values are negative.

Axial compression capacity:

$$\phi P_C = \phi_c 0.8 f'_c A_g \qquad \text{Eq. 3.B-44}$$

Compression D/C ratio:

$$D/C_C = \frac{P}{\phi P_C} \qquad \text{Eq. 3.B-45}$$

Axial tension capacity:

$$\phi P_T = \phi_m f_y A_s \qquad \text{Eq. 3.B-46}$$

Tension D/C ratio:

$$D/C_T = \frac{P}{\phi P_T} \qquad \text{Eq. 3.B-47}$$

3B.2 Reactor Building

3B.2.1 Design Report

Structural Description and Geometry

The RXB is a Seismic Category I concrete structure. For a detailed description of the RXB, see Section 3.8.4.1.1. The RXB geometry and floor layout are shown in Figure 1.2-11 through Figure 1.2-20.

Structural Material Requirements

The RXB design is based on the following material properties:

- Concrete
  - Compressive Strength - 5 ksi (7 ksi for exterior walls of the RXB above grade)
  - Modulus of Elasticity - 4, 031 ksi
  - Shear Modulus - 1,722 ksi
  - Poisson's Ratio - 0.17
- Reinforcement
  - Yield Stress - 60 ksi (ASTM A615 Grade 60 or ASTM A706 Grade 60)
  - Tensile Strength - 90 ksi (A615 Grade 60), 80 ksi (A706 Grade 60)
  - Elongation - See ASTMs A615 and A706
- Structural Steel
  - Grade - ASTM A992 (W shapes), ASTM A500 Grade B (Tube Steel), ASTM A36 (plates)
  - Ultimate Tensile Strength - 65 ksi A992, 58 ksi A500 Grade B and A36
  - Yield Stress - 50 ksi A992, 46 ksi A500 Grade B, 36 ksi A36
- Foundation Media

For a description of the soils considered in the design of the RXB, see Section 3.7.1.3.1.

Structural Loads

The structural loads for the RXB are discussed in detail in Sections 3.7.1 and 3.8.4 for seismic and non-seismic loads, respectively.

Structural Analysis and Design

- Design Computations of Critical Elements

  The design methodology of RXB related Critical Elements is discussed in Section 3B.1. Specific RXB Critical Elements analyzed are discussed in Section 3B.2.
- Stability Calculations

  Stability of the RXB is addressed in Section 3.8.5.4.1, Section 3.8.5.5, and Section 3.8.5.6.1.

Summary of Results

See Section 3B.2.2 through Section 3B.2.7.

Conclusions

The D/C ratios presented are all less than 1.0. Therefore, the Critical Elements satisfy the design criteria for the investigated loading.

3B.2.2 Design Approach -Walls

The combined SAP2000 and SASSI2010 design forces and moments are used in the element-based design check. The design check determines the D/C ratios for the horizontal and vertical wall reinforcement including the various shear failure modes based on the combined demand forces and moments.

An iterative design check approach is used to determine the appropriate uniform reinforcement pattern for a given structural wall section based on the maximum combined design forces and moments. A representative wall shell element within the design check zone is selected to demonstrate the element-based design check that is repeated for all shell elements within the wall.

This design approach is used for each structural wall. A summary of the D/C ratios for each wall is presented using specified uniform reinforcement. If all elements pass, then the wall section is considered acceptable. The general design goal is to achieve D/C ratios below 0.8. Demand/Capacity ratios higher than 0.8 but less than 1.0 are also acceptable, however case by case justifications are provided.

When individual elements exceed design requirements, the region is evaluated. Often, more accurate design moments and forces are obtained by averaging the results of several elements. If this approach is inappropriate for the location (or does not produce acceptable results) additional reinforcing is added to increase section capacity.

The summary tables of D/C ratios at each gridline shows the maximum D/C ratios within each design check zone. If necessary, a separate check of averaging for walls that contain elements exceeding the in-plane shear limit, or contain elements that exceed shear friction limits is performed to ensure the D/C ratios are acceptable.

In-plane shear for the adequacy of concrete wall thickness is checked for all elements in the RXB. Several individual elements in the wall at grid line 3 encountered In-plane shear exceedances. Where individual elements in the wall exceed in-plane shear limits, the elements are averaged as shown in Table 3B-50. The cross-section was checked based on calculating the average in plane shear over the entire wall section, and is acceptable. Note that the example in Table 3B-50 is a different element than shown in Table 3B-4 through Table 3B-6.

Shear friction is also checked for all elements in the RXB. Some individual elements in the wall at grid line 3 encountered shear friction exceedances. An example of averaging over additional elements is shown in Table 3B-51. The example in Table 3B-51 is a different element than shown in Table 3B-4 through Table 3B-6.

3B.2.2.1 Wall at Grid Line 1

The wall at grid line 1 is an exterior structural wall on the west side of the RXB. This wall is 5 feet thick. The SAP2000 analysis model elevation view is shown in Figure 3B-7, along with the shell element labels.

This wall uses 5000 psi concrete below grade and 7000 psi concrete above grade.

Reinforcement drawings and section details are presented in Figure 3B-8 and Figure 3B-9.

A summary table of the element-based design check results for the wall at grid line 1 is presented in Table 3B-2. This summary table shows the maximum D/C ratios within each design check zone. All design check zones have no D/C exceedances. Based on the above results and evaluations, the wall is acceptable.

3B.2.2.2 Wall at Grid Line 3

The wall at grid line 3 consists of a 5 foot thick weir wall for the pool and a 4 foot thick upper stiffener located near the roof level. The SAP2000 analysis model elevation view is shown in Figure 3B-10, along with the shell element labels.

Reinforcement drawings and section details are presented in Figure 3B-11 through Figure 3B-13.

A summary table of the element-based design check results for the wall at grid line 3 is presented in Table 3B-3. This summary table shows the maximum D/C ratios within each design check zone and highlights those design check zones that exceed a D/C ratio of 0.8. Table 3B-4, Table 3B-5, and Table 3B-6 show the element averaging for the horizontal reinforcement, the horizontal membrane compression stress, and the vertical reinforcement, respectively. Table 3B-7 provides a summary of D/C ratios after averaging the affected elements. The method of averaging of the demand membrane forces, in-plane shear and out-of-plane moments (used for determination of D/C ratios in terms of reinforcing steel), and out-of-plane shears (used for determination of D/C ratios for shear) over a length of nominally 4 times the thickness of the wall is described in Section 3B.1.1.1. As shown in Table 3B-7, with this further distribution of demand, all D/C ratios are acceptable.

3B.2.2.3 Wall at Grid Line 4

The wall at grid line 4 is an interior wall of the RXB with two different thicknesses. The SAP2000 analysis model elevation view is shown in Figure 3B-14, along with the shell element labels.

Reinforcement drawings and section details are presented in Figure 3B-15 through Figure 3B-17.

A summary table of the element-based design check results for the wall at grid line 4 is presented in Table 3B-8. This summary table shows the maximum D/C ratios within each design check zone and highlights those design check zones that exceed a D/C ratio of 0.8. Table 3B-9 shows the element averaging for the horizontal reinforcement exceedance indicated in Table 3B-8. Table 3B-10 provides a summary of D/C ratios after averaging. As shown in Table 3B-10, with this further distribution of demand, all D/C ratios are acceptable.

3B.2.2.4 Wall at Grid Line 6

The walls at grid line 6 consist of several wall thicknesses. The upper stiffener wall located near the roof is 4 feet thick. The pool wall section has two section thicknesses, 7.5 feet and 5 feet. The SAP2000 analysis model elevation view is shown in Figure 3B-18, along with the shell element labels.

Reinforcement drawings and section details are presented in Figure 3B-19 through Figure 3B-21.

A summary table of the element-based design check results for the wall at grid line 6 is presented in Table 3B-11. This summary table shows the maximum D/C ratios within each design check zone. The highlighted entries indicate those D/C ratios that exceed 1.0. Table 3B-12 shows the element averaging for the horizontal reinforcement exceedance in Table 3B-11. Table 3B-13 provides a summary of D/C ratios after averaging. As shown in Table 3B-13, with this further distribution of demand, all D/C ratios are acceptable.

3B.2.2.5 Wall at Grid Line E

The wall at grid line E is an exterior structural wall on the south side of the RXB that is 5 feet thick. The SAP2000 analysis model elevation view is shown in Figure 3B-22, along with the shell element labels.

Reinforcement drawings, details, and sketches are presented in Figure 3B-23 and Figure 3B-24.

A summary table of the element-based design check results for the wall at grid line E is presented in Table 3B-14. This summary table shows the maximum D/C ratios within each design check zone. All design check zones have no D/C exceedances. Based on the above results and evaluations, the wall is acceptable.

3B.2.3 Design Approach - Slabs

The slabs are designed using the same methodology as was used for the walls in Section 3B.1.1. The design check determines the D/C ratios for the north-south and east-west slab reinforcement including the various shear failure modes based on the combined demand forces and moments.

An iterative design check approach is used to determine the appropriate uniform reinforcement pattern for a given slab section based on the maximum combined design forces and moments. A representative slab shell element within the design check zone selected to demonstrate the element-based design check that is repeated for all shell elements within this slab. The demand forces and moments for the shell element in the design check zone combines the non-seismic (SAP2000) and seismic (SASSI2010) design value for performing the element-based design check.

The summary table of D/C ratios at each slab elevation shows the maximum D/C ratios within each design check zone. A separate check of averaging for slabs that contain elements exceeding the in-plane shear limit, or that contain elements exceeding shear friction limits is performed to ensure the D/C ratios are acceptable.

3B.2.3.1 Slab at EL. 100'-0"

The slab at EL. 100'-0" is at grade level and is 3 feet thick. The outer and inner perimeter of the slab is reinforced with shear reinforcement. The SAP2000 analysis model elevation view is shown in Figure 3B-25, along with the shell element labels.

Reinforcement drawings and section details is presented in Figure 3B-26 and Figure 3B-27.

A summary table of the element-based design check results for the slab at EL 100'-0" is presented in Table 3B-15. This summary table shows the maximum D/C ratios within each design check zone and highlights the XZ plane shear exceedance. Table 3B-16 shows the element averaging for that exceedance. Table 3B-17 provides a summary of D/C ratios after averaging. Based upon the results shown in Table 3B-17, the slab at EL. 100'-0" is acceptable.

3B.2.3.2 Slab at EL. 181'-0"

The roof slab is a 4 foot thick slab that begins at EL. 163'-0", slopes inward for 29.5 feet, and is flat at EL. 181'-0". The SAP2000 analysis model elevation view is shown in Figure 3B-28, along with the shell element labels.

Reinforcement drawings and section details are presented in Figure 3B-29 and Figure 3B-30.

A summary table of the element-based design check results for the roof slab is presented in Table 3B-18. This summary table shows the maximum D/C ratios within each design check zone. All design check zones have no D/C exceedances. Based on the above results and evaluations, the roof slab is acceptable.

3B.2.3.3 Pilasters

Pilasters are added to the exterior walls of the RXB structure to increase the capacity at the corners and stiffness of the walls between the corners.

In the finite element model, the pilasters are modeled with frame elements with stiffness properties that represent the combined action of the walls (modeled with shell elements) and the pilasters. The forces in the artificially stiffened frame elements could be distributed to the pilaster and wall elements but for a conservative evaluation of the pilaster, the moments and the out of plane shear forces corresponding to the strong axis are compared to the capacity of the pilaster alone. Bending about the weak axis does not need to be evaluated because the pilaster is an integral part of the wall and bending in that direction is not local behavior. It is part of the in-plane behavior of the wall and the shell elements in this area have adequate reinforcing. The shear in the weak axis direction, parallel to the wall, does not need to be evaluated because the in-plane capacity of the wall is capable of accommodating the minor increase.

If the 5 feet by 10 feet pilaster can resist the resulting loads on its own, the pilaster is considered qualified. If the demand exceeds the capacity of the pilaster using the conservative approach mentioned above, the adjacent wall elements are combined with the pilaster frame element and their combined capacity is compared to the combined demand for a more accurate evaluation.

The qualification of the pilasters compares the capacities of selected members with the demands and determines the demand to capacity ratios. In the structural model, the frame elements used to represent the pilasters are located at the center of the walls. Since the centroid of the pilaster is actually 2.5 feet outside the center of the wall, the strong axis bending moment is increased to account for this eccentricity by adding a moment equal to the axial force in the pilaster times the 2.5 feet offset. Also the moment in the frame element is at the top of the element which is at the centroid of a 3 feet thick slab. The moment for design should be taken at the bottom of the slab. The two effects are minor, tend to offset one another and therefore are not included in the design checks.

The capacity of the pilaster is based on the reinforcing steel in the 5 feet by 10 feet zone. While the pilaster does interact with the wall, the additional capacity gained by considering the interaction is relatively small and if some of the reinforcing in the walls were to be used, the demand to capacity ratio for the wall would be reduced.

A detailed explanation of the methodology for the design evaluation of the walls and slabs, also applicable to the pilasters in the RXB is presented in Section 3B.1.2. The SAP2000 and SASSI2010 combined design forces and moments are used for the design check. The design check determines the D/C ratios for the various failure modes based on the combined demand forces and moments.

An iterative design check approach is used to determine the appropriate uniform reinforcement pattern on each pilaster type based on the maximum combined design forces and moments. A representative pilaster frame element within the design check zone is selected to demonstrate the frame element design check that is repeated for all frame pilaster elements within this wall.

The pilasters in the RXB are designed for strong axis bending and strong axis shear only. This is due to the very long span in the weak axis direction (along the plane of the walls) that prevents the pilasters from failing. Similarly, the pilasters cannot realistically fail in torsion due to the fact that they are embedded into the 5 foot thick RXB walls. Therefore, torsion is also not considered. The following section presents a pilaster qualification using the pilaster section with the highest loads.

3B.2.4 Pilasters at Grid Line A

The pilasters on the wall at grid line A consist of five types of pilaster. The SAP2000 analysis model elevation view is shown in Figure 3B-31, along with the pilaster frame element labels.

Reinforcement details are presented in Figure 3B-32 through Figure 3B-36 for the five pilaster types.

A summary table of the design check results for the pilasters on the wall at grid line A is presented in Table 3B-19. This summary table shows the maximum D/C ratios within each design check zone. All design check zones have no D/C exceedances and the results acceptable.

3B.2.5 Beams

A detailed explanation of the methodology for the design evaluation of the concrete walls and slabs, also applicable to the beams in the RXB is presented in Section 3B.1.2. The SAP2000 and SASSI2010 combined design forces and moments are used in the design check. The design check determines the D/C ratios for the various failure modes based on the combined demand forces and moments.

An iterative design check approach is used to determine the appropriate uniform reinforcement pattern on each beam type based on the maximum combined design forces and moments. A representative beam frame element within the design check zone is selected to demonstrate the frame element design check that is repeated for all beam frame elements within this group.

The beams in the RXB are designed for strong axis bending and strong axis shear only. This is due to the very long span in the weak axis direction (along the plane of the slabs) that prevents the beams from failing. Similarly, the beams cannot realistically fail in torsion due to the fact that they are embedded into the 3 foot thick RXB slabs. Therefore, torsion is also not considered.

The summary table of D/C ratios at each slab elevation shows the maximum D/C ratios within each design check zone.

3B.2.5.1 Beam at EL. 75'-0"

The slab at EL. 75′-0″ contains six beam sections running east-west and 22 beam sections running north-south. The SAP2000 analysis model plan view is shown in Figure 3B-37, along with the frame element labels.

The reinforcement details are shown in Figure 3B-38 and Figure 3B-39.

A summary table of the design check results for the beams at EL. 75′-0" is presented in Table 3B-20. This summary table shows the maximum D/C ratios within each design check zone. The D/C ratios are less than 1.0 and therefore the beams are acceptable.

3B.2.6 Buttresses

A detailed explanation of the methodology for the design evaluation of the walls and slabs, also applicable to the buttresses in the RXB is presented in Section 3B.1.2. The SAP2000 analysis model is used to determine the maximum non-seismic demand results for each buttress frame element. Similarly, the SASSI2010 analysis model is used to determine the seismic demand results, which are then combined with the SAP2000 results for each buttress frame element. The SAP2000 and SASSI2010 combined design forces and moments are used in the design check. The design check determines the D/C ratios for the various failure modes based on the combined demand forces and moments.

An iterative design check approach is used to determine the appropriate uniform reinforcement pattern on each buttress type based on the maximum combined design forces and moments. A representative element within the design check zone is selected to demonstrate the frame element design check that is repeated for all elements within this group.

The buttresses in the RXB are designed for strong axis bending and strong axis shear only. This is due to the very long span in the weak axis direction (along the plane of the slabs) that prevents the buttresses from failing. Similarly, the buttresses cannot realistically fail in torsion due to the fact that they are embedded into the 5 foot thick RXB slabs. Therefore, torsion is also not considered.

3B.2.6.1 Buttress at EL. 126'-0"

The wall at grid line 1 has two buttresses. These are at elevations 126'-0" and 145'-6". The buttress at EL. 126'-0" is evaluated. The SAP2000 analysis model plan view is shown in Figure 3B-40, along with the frame element labels.

The reinforcement details are shown in Figure 3B-41.

A summary table of the design check results for the beams at elevation 126-0" is presented in Table 3B-21. This summary table shows the maximum D/C ratios within each design check zone. The D/C ratios are less than 1.0 and therefore the buttress is acceptable.

3B.2.7 NuScale Power Module Bay

The NPM bays are 3-walled compartments located in the reactor pool and are designed to house the NPMs during operation. Each bay is 20'-6" wide in the north-south direction and 19'-7" deep in the east-west direction, and extends from the pool floor at EL. 25'-0" up to EL. 125'-0". The bottom of the bay is the RXB foundation slab. The walls which make up the bay are 5 feet thick reinforced concrete. The top of the bay is capped with the Bioshield during operation. The bay provides restraints to prevent the NPM from moving laterally. Restraint is provided via a NPM skirt restraint located at EL. 25’-0" and lug restraints located on the three bay walls at EL. 71'-7".

3B.2.7.1 West Wing Wall

The west wing wall is one of the walls at grid line 4. The SAP2000 analysis model elevation view is shown in Figure 3B-42, along with the shell element labels. The west wing walls have the refueling pool on one side and an NPM located on the other. (See Figure 3B-52). Because of this location, it experiences the highest forces of the NPM bay wing walls.

Reinforcement drawings and section details are presented in Figure 3B-43 and Figure 3B-44.

A summary table of the element-based design check results for the wall at Grid Line 4 is presented in Table 3B-22. This summary table shows the maximum D/C ratios within each design check zone. All design check zones have no D/C exceedances. Based on the above results and evaluations, the west wing wall is acceptable.

3B.2.7.2 Pool Wall

The portion of the pool wall that supports the NPMs is part of the wall at grid line B. This is an interior wall of the RXB that is 5 feet thick. The SAP2000 analysis model elevation view is shown in Figure 3B-45, along with the shell element labels.

Reinforcement drawings and section details are presented in Figure 3B-46 and Figure 3B-47.

A summary table of the element-based design check results for the wall at grid line B is presented in Table 3B-23. This summary table shows the maximum D/C ratios within each design check zone and highlights the YZ plane shear exceedance. Table 3B-24 shows the element averaging for that exceedance. Table 3B-25 provides a summary of D/C ratios after averaging.

3B.2.7.3 NuScale Power Module Passive Support Ring Assembly

The base of the NPM is located at the bottom of the RXB pool at EL. 25'-0". There are up to 12 NPMs located in the RXB pool in their respective bays. The pool floor liner in the NPM bay is made of half-inch thick stainless steel whereas the wall liner is made of quarter-inch stainless steel.

The NPM is vertically supported for the dead load and seismic loads acting downwards at the base, but free to move up vertically for any uplifting forces (such as seismic load acting upwards and buoyant forces due to the water in the reactor pool). The NPM is also laterally restrained against seismic forces at the base.

The details of the NPM base support are shown in Figure 3B-48 through Figure 3B-50. The NPM base support includes the following:

- The skirt of the NPM is supported on a 14.5 ft square, 4 in. thick bearing plate embedded in the basemat. This plate is made of austenitic stainless steel that is anchored to the concrete base mat through 36 concrete anchors welded to the bottom of the plate. The liner plate is discontinuous in the area around the

NPM. A leaktight boundary is ensured by a seal weld between the liner plate and the embedded plate. Figure 3B-50 shows the details of the 4 in. thick bearing plate. The NPM is free to move upward vertically, and the vertical NPM load is transferred to the concrete basemat in bearing.

- The NPM is laterally restrained by an 8-in.-thick passive support ring made of stainless steel bolted to the underlying bearing plate. At the inside periphery of the passive ring, a beveled edge at the top is provided in order to guide the NPM at initial placement and during its removal and replacement for refueling operation. If the NPM impacts the passive support ring, the resulting upward vertical load will be resisted by the concrete anchors. Figure 3B-48 and Figure 3B-49 show the details of the passive support ring.

NuScale Power Module Model:

A separate ANSYS model is used to perform a non-linear dynamic analysis of the NPM. This model only includes the pool water and one NPM (1 or 6). The analysis results are based on the envelope of the six runs shown in Table 3B-52. The static reaction force, including the dead weight and the static buoyancy, is 1,090.4 kips in the vertical direction. The maximum vertical seismic reaction force, which does not include the static reaction force is 3,231 kips. The maximum uplift displacement of the module from the floor is less than 0.125 inch.

Envelope Loads:

- Vertical downward load, P = 5,227 kips. This load includes dead load, fluid pressure load, and seismic load. Dead load is the static buoyancy load described above and is equal to 1,090.4 kips. The fluid pressure load is determined by the product of the baseplate area (14.5' x 14.5'), the fluid density (62.4 pcf), and the normal operating reactor pool depth (69') and is equal to 905.3 kips. The downward seismic load is 3,231 kips, as stated above.
- The vertical displacement is less than 0.125 inch. The passive support ring is 4.5 inches thick below the bevel, therefore, there will always be lateral support from the passive support ring.
- Lateral load:
  - East-West seismic load = 703 kips
  - North-South seismic load = 1,164 kips
  - Square Root Sum of Squares horizontal seismic load = $\sqrt{(703^2 + 1{,}164^2)} = 1{,}360$ kips

It is possible for the support ring and anchors to experience an upward vertical force if the NPM were to strike the support ring during a seismic event. Because this force is of extremely short duration and the contact surface small, only a limited amount of force is transferred to the support ring. A coefficient of friction value between wet steel and steel of 0.2 is multiplied by the square root sum of squares of east-west and north-south seismic loads to determine this force.

$$V_{uplift} = 0.2 \times 1{,}360 \text{ kips} = 272 \text{ kips}$$

Materials and Material Strength:

- Stainless Steel: The stainless steel used for the liner plate conforms to ASTM A-167 or ASTM A-240 Type 304L and has a 0.2 percent offset yield strength of 25 ksi, and ultimate tensile strength 70 ksi.
- Austenitic Stainless: The steel used for the 4-in.-thick bearing plate that supports the NPMs vertically is ASTM A965 Grade F304 with a yield strength of 23.6 ksi and ultimate tensile strength of 61.4 ksi at a design temperature of 300 degrees Fahrenheit.
- Concrete for Basemat: The concrete strength, f'_c is 5000 psi

A total of 36, 3/4 in. diameter, ASTM F1554, Grade 55 concrete anchors are used to anchor the passive support ring and embedded plate assembly. These anchors have a yield strength of 55 ksi and designations of S1 (weldable) and S4 (Charpy test).

A total of 30, 1.5 in. thread diameter, ASTM A479, Type UNS S21800 bolts fasten the passive support ring to the embedded plate.

Load Path:

- The vertical load is resisted by the 14.5 ft square, 4 in. thick bearing ring plate.
- The lateral load is resisted by bolts that connect the passive support ring to the embedded bearing plate. The bolts transfer the lateral load to the bearing plate, which, in turn, transfers the load, via bearing, to the concrete basemat.

Evaluation:

Vertical Load Bearing Capacity

- Area of concrete in bearing, A_{brg}, is 4310 in^2, therefore the bearing pressure (P_V/ A_{brg}) is 1.21 ksi
- Allowable bearing pressure = (Φ)(0.85f'c) = 2.76 ksi [Φ = 0.65]
- Vertical bearing D/C Ratio: = 0.44
- The maximum D/C ratio of the anchor bolts is due to concrete breakout in tension and is equal to 0.64.

Lateral Load Resistance

- SRSS Lateral Load is 1,360 kips
- The D/C ratio of the bolts in shear and tension is 0.68.
- The maximum D/C ratio for concrete bearing due to lateral load transferred from the bearing plate is 0.71.

3B.2.7.4 Nuscale Power Module Lug Restraint

The NPM lug restraint design consists of a stainless steel bumper comprised of 2″ thick plates with 2″ thick stiffener plates. The bumpers are welded to 2″ thick stainless steel liner plates. On the inside of the liner plate there are 3″ thick, 5″ wide (48″ depth) steel shear lugs to transfer the lateral shear loads into the wall. Finally, the two bumpers on either side of the lug on the pool walls are bolted together with through-bolts to withstand tensile loads due to moments from the eccentric lateral shear loads. The design layout for the support system for the NPM lug restraints is shown in Figure 3B-51.

The bumpers are Stainless Steel Type 630 - H1150, with a yield strength of 100.8 ksi, and an ultimate strength of 135 ksi. The shear lugs are carbon steel ASTM A572 GR 50, with a yield strength of 50 ksi, and an ultimate strength of 65 ksi. The through-bolts are ASTM A193 GR B7, with a yield strength of 105 ksi, and an ultimate strength of 125 ksi.

A separate local SAP2000 model is used to analyze the support system for an assumed demand of 3500 kips. The NPM lug restraint model is a comprehensive finite element model of half of a single NPM wing wall. The wall is 2.5′ thick and has one support lug for analysis. The load is distributed as point loads to one of the lugs. The wing wall is modeled with solid elements, the liner plate and the stainless steel lug are modeled with shell elements. The stiffeners are also modeled with shell elements.

The NPM bay walls and location of the NPM lugs is shown in Figure 3B-52. The NPM lug restraint model is shown in Figure 3B-53 and Figure 3B-54. The liner plate and shear lugs are modeled as shell elements and are shown in Figure 3B-55 and Figure 3B-56. In Figure 3B-57, the outside of the bumper is removed in order to display the stiffener plates inside.

The demand reactions are based on two cases of Soil Type 7 (CSDRS) and Soil Type 9 (CSDRS-HF). These two cases, in general, provide the highest structural responses. The capacity is based on the assumed value of 3500 kips, that the lugs are designed for, however, due to the extra margin in the design, the actual strength is 4500 kips which is higher than the maximum demand of 3726 kips. The demand to capacity ratios in calculations for the lug components are derived and shown to be less than one, which shows the lugs are qualified.

Section cuts were used to extract forces and moments for design of the NPM lug support. Table 3B-26 displays the forces and moments for the two 3500 kip load cases: W-Lug-PY+ (shown in Figure 3B-58) and W-Lug-PY+ (shown in Figure 3B-59). Figure 3B-60 shows the liner plate section cuts at the intersection of the inside face of the bumper to the liner plate. These cuts are used to find the design moment (M1) due to design loading. Figure 3B-61 shows the shear lug section cuts (fins) that occur between the liner plate and shear lugs. The shear (F2) from these cuts is summed to verify that the total 3500 kip load is being transferred to the wall as shown in Table 3B-26. Finally, maximum tension load of 804 kips occurs on the shear lug directly below the 2″ plate and the maximum shear of 790 kips occurs in the shear lug at X=88.20 inches. The sign of the F1 force for the fin at X=16.25" is negative but the deflected shape of the lug support system clearly shows this is a tension force (Figure 3B-62). These values are utilized in the shear lug evaluation.

3B.2.7.4.1 Shear Lug Evaluation

Shear lugs comprising of steel bar fins are used for the transfer of the NPM lug restraint l loads to the concrete walls by shear. The shear lugs are rectangular shaped fins having dimensions 3″ wide x 5″ bar and 4 feet long embedded in the concrete.

The shear lugs are made of carbon steel (ASTM A572 Gr. 50) having a yield strength of 50 ksi and ultimate strength of 70 ksi. The 28 day strength of concrete in the walls is 5000 psi.

In addition to the shear there will be tensile load on the fins. This is because the NPM lug load is applied with an eccentricity causing moment that results in a tensile load on some of the fins. The tensile loads are design to be resisted by through-bolts made of ASTM A193 Gr B7 material having a yield strength of 105 ksi and an ultimate strength of 125 ksi.

Figure 3B-51 shows a layout of the shear lugs and the through-bolts. There are 32 through-bolts that correspond to each lug of the NPM as shown in Figure 3B-51. The through-bolt is 2.5″ in diameter and fabricated from ASTM A193 GR B7 Steel, F_y=105 ksi. The total shear capacity of the through-bolts is 5573 kips. This results in a D/C ratio (assuming a design load of 3500 kips) of 0.63.

The tensile capacity of the through bolts is the smaller of the bolt steel strength and the concrete strength.

The through-bolt is 2.5″ in diameter and fabricated from ASTM A193 GR B7 Steel. The through-bolt tensile D/C ratio (assuming a design load of 3500 kips) is 0.51. This D/C ratio is from the most highly stressed fin in tension. Therefore the through-bolts are acceptable and will exhibit ductile behavior.

The D/C ratio for punching shear on the wing wall has been determined to be 0.26. For the pool wall, this ratio is 0.20. The D/C ratio for the concrete bearing strength is 0.40.

The bending stress in the 2" thick liner plate can be bounded by considering the moment at the base of highest loaded shear lug as an upper bound moment in the liner plate.

From Table 3B-26, the maximum moment on the plate occurs at the shear lug at Y = 88.2" for lug load in the +Y direction. This moment produces a bending stress in the liner of 23.12 ksi. This is much less than the 100.8 ksi yield strength of the liner. The resulting D/C is 0.23.

3B.2.7.4.2 Overall Lug Restraint Reaction

Table 3B-27 presents the maximum lug reactions for all twelve bays using Soil Type 7 for CSDRS and Soil Type 9 for CSDRS-HF using the cracked RXB model with 4 percent structural damping. Since these maximum lug reactions are below the lug support design capacity of 3,500 kips, the design is acceptable.

3B.3 Control Building

3B.3.1 Design Report

Structural Description and Geometry

The CRB is a Seismic Category I concrete structure at elevation 120'-0" and below, except as noted in Section 1.2.2.2. Above EL 120'-0" the CRB is a Seismic Category II steel structure. For a detailed description of the CRB, see Section 3.8.4.1.2. The CRB geometry and floor layout are shown in Figure 1.2-21 through Figure 1.2-27.

Structural Material Requirements

The CRB design is based on the following material properties:

- Concrete
  - Compressive Strength - 5 ksi
  - Modulus of Elasticity - 4, 031 ksi
  - Shear Modulus - 1,722 ksi
  - Poisson's Ratio - 0.17
- Reinforcement
  - Yield Stress - 60 ksi (ASTM A615 Grade 60 or ASTM A706 Grade 60)
  - Tensile Strength - 90 ksi (A615 Grade 60), 80 ksi (A706 Grade 60)
  - Elongation - See ASTMs A615 and A706
- Structural Steel
  - Grade - ASTM A992 (W shapes), ASTM A500 Grade B (Tube Steel), ASTM A36 (plates)
  - Ultimate Tensile Strength - 65 ksi A992, 58 ksi A500 Grade B and A36
  - Yield Stress - 50 ksi A992, 46 ksi A500 Grade B, 36 ksi A36
- Foundation Media

For a description of the soils considered in the design of the CRB, see Section 3.8.5.4.2 and Section 3.7.1.3.1.

Structural Loads

The structural loads for the CRB are discussed in detail in Sections 3.7.1 and 3.8.4 for seismic and non-seismic loads respectively.

Structural Analysis and Design

- Design Computations of Critical Elements

  The design methodology of CRB related Critical Elements is discussed in Section 3B.1. Specific CRB Critical Elements analyzed are discussed in Section 3B.3.

- Stability Calculations

  Stability of the CRB is addressed in Section 3.8.5.4.1.3, Section 3.8.5.4.1.4, Section 3.8.5.5, and Section 3.8.5.6.2.

Summary of Results

See Section 3B.3.2 through Section 3B.3.5

Conclusions

The D/C ratios presented are all less than 1.0. Therefore, the Critical Elements satisfy the design criteria for loading investigated.

3B.3.2 Walls

3B.3.2.1 Wall at Grid Line 3

The wall at grid line 3 is an interior structural wall between EL. 50'-0" and EL. 120'-0" of the CRB. This wall is 2 feet thick. The SAP2000 analysis model elevation view is shown in Figure 3B-65, along with the shell element labels.

Reinforcement drawings and details are presented in Figure 3B-66 and Figure 3B-67.

A summary table of the element-based design check results for the wall at grid line 3 is presented in Table 3B-28. This summary table shows the maximum D/C ratios within each design check zone. As shown in Table 3B-28, all design check zones have no D/C exceedances. Based on the above results and evaluations, the wall is acceptable.

3B.3.2.2 Wall at Grid Line 4

The wall at grid line 4 is an exterior structural wall on the east side of the CRB that is 3 feet thick. The SAP2000 analysis model elevation view is shown in Figure 3B-68, along with the shell element labels.

Reinforcement drawings and details are presented in Figure 3B-69 and Figure 3B-70.

A summary table of the element-based design check results for the wall at grid line 4 is presented in Table 3B-29. This summary table shows the maximum D/C ratios within each design check zone. As shown in Table 3B-29, certain design check zones have D/C ratios in excess of 1.0.

The wall at grid line 4 was experiencing out of plane shear exceedances in the YZ plane as shown in Table 3B-29. In order to satisfy the demand, the section experiencing high out of plane shear was reinforced with an additional #6 stirrup leg. This is shown in Figure 3B-70. Table 3B-30 shows the design check of the worst shell element in the section, number 786, with the additional shear reinforcement. The final design check is provided in Table 3B-30. Based on Table 3B-31, where the capacity includes the added reinforcement, the wall at grid line 4 is acceptable.

3B.3.2.3 Wall at Grid Line A

The wall at grid line A is an exterior structural wall on the north side of the CRB that is 3 feet thick. The SAP2000 analysis model elevation view is shown in Figure 3B-71, along with the shell element labels.

Reinforcement drawings and details are presented in Figure 3B-72 and Figure 3B-73.

A summary table of the element-based design check results for the wall at grid line A are presented in Table 3B-32. This summary table shows the maximum D/C ratios within each design check zone. Based on Table 3B-32, all design check zones have no D/C exceedances. Based on the above results and evaluations, the wall is acceptable.

In-plane shear for the adequacy of concrete wall thickness was checked for all elements in the CRB. Several individual elements in the walls encountered in-plane shear exceedances. Where individual elements in the wall at grid line A exceed in-plane shear limits, the elements are averaged as shown in Table 3B-33. The cross-section was checked based on calculating the average in-plane shear over the entire wall section, and is acceptable.

3B.3.3 Slabs

3B.3.3.1 Basemat Foundation

The reinforced concrete section for the basemat is comprised of a 5 foot thick concrete slab with 3 layers of #11 bars at 12" centers each way top and bottom for main reinforcing steel, and 2 legged stirrups of #6 bars at 12" centers each way. The perimeter of the main slab contains 4 layers of #11 bars at 12" centers each way top and bottom for main reinforcing steel, and 2 legged stirrups of #6 bars at 12" centers each way. The capacity of the sections used is presented Table 3B-34 and Table 3B-35.

Figure 3B-74 shows the three zones: Tunnel Area, Perimeter Area and Interior Area, used for design of the basemat. Figure 3B-74 also shows the CRB basemat solid element numbering in the CRB finite element model. Reinforcement drawings are shown in Figure 3B-75 and Figure 3B-76.

For evaluation, total area of reinforcing steel required for axial tension, in-plane shear, and out-of-plane moment is considered. In addition, reduction of out-of-plane shear capacity of concrete due to axial tension is considered.

For the design check, bounding demand forces and moments for the basemat are considered at the following locations:

1) Basemat for the perimeter of the main CRB structure

2) Basemat for the interior of the main CRB structure

3) Basemat for CRB tunnel

Table 3B-36 shows the magnitudes of bounding demand forces and moments used for the design check of the perimeter of the basemat of the CRB structure. Table 3B-37 shows the magnitudes of bounding demand forces and moments used for the design check of the interior of the basemat of the main CRB structure. Table 3B-38 provides the magnitudes of bounding demand for the basemat of the CRB tunnel.

The demand forces and moments for the perimeter of the main CRB foundation evaluation are listed in Table 3B-36. The design check for the various failure modes of the main CRB foundation perimeter are shown in Table 3B-39.

The demand forces and moments for the main interior part of the CRB foundation evaluation are listed in Table 3B-37. The design check for the various failure modes of the main CRB foundation interior are shown in Table 3B-40.

Likewise, the demand forces and moments for the CRB foundation tunnel are listed in Table 3B-38. The design check for the various failure modes of the CRB foundation tunnel are shown in Table 3B-41.

3B.3.3.2 Slab EL. 100'-0"

The slab at EL. 100'-0" is at grade and houses the main technical support and data area for the CRB. This elevation consists of a 3' slab and 2' slab along with a 3' tunnel slab. The SAP2000 analysis model elevation view is shown in Figure 3B-77, along with the shell element labels.

Reinforcement drawings and details are presented in Figure 3B-78 and Figure 3B-79.

A summary table of the element-based design check results for the slab at EL. 100'-0" is presented in Table 3B-42. This summary table shows the maximum D/C ratios within each design check zone. Table 3B-46 provides a summary of D/C ratios after averaging. The tables showing the averaging performed are Table 3B-43 through Table 3B-45.

Shear friction was checked for all elements in the CRB. Some individual elements in the slabs encountered shear friction exceedances. For elements that exceed shear friction limits in the slab at EL. 100'-0", their averaging is shown in Table 3B-47.

3B.3.4 Pilasters

3B.3.4.1 Pilasters Grid Line 1

The pilasters on the wall at grid line 1 consist of two types of pilasters. The SAP2000 analysis model elevation view is shown in Figure 3B-80, along with the pilaster frame element labels.

Reinforcement details are presented in Figure 3B-81 and Figure 3B-82 for pilaster Type 1 and Type 2, respectively.

A summary table of the design check results for the pilasters on the wall at Grid Line 1 is presented in Table 3B-48. This summary table shows the maximum D/C ratios within each design check zone. As noted in Table 3B-48, all design check zones have D/C ratios that are less than 1.0; and therefore, the pilasters are acceptable.

3B.3.5 T-Beams

3B.3.5.1 T-Beams at EL. 120'-0"

The slab at elevation 120'-0" contains six T-beam sections running east-west and two T-beam sections running north-south. The SAP2000 analysis model plan view is shown in Figure 3B-83, along with the frame element labels.

The reinforcement details are shown in Figure 3B-84 and Figure 3B-85 for Type 1 and Type 2, respectively.

A summary table of the design check results for the beams at elevation 120'-0" is presented in Table 3B-49. This summary table shows the maximum D/C ratios within each design check zone. As shown in Table 3B-49, all design check zones have D/C ratios that are less than 1.0; therefore the T-Beams at elevation 120'-0" are all acceptable.

3B.4 References

3B-1 SAP2000 Advanced Version 17.1.1, 2015, Computers and Structures, Inc., Walnut Creek, California.

3B-2 SASSI2010 Version 1.0, May 2012, Berkeley, California.

3B-3 American Concrete Institute, ACI 349-06, "Code Requirements for Nuclear Safety-Related Concrete Structures & Commentary," American Concrete Institute, Farmington Hills, MI.

3B-4 American National Standards Institute/American Institute of Steel Construction, N690-12, "Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities", American Institute of Steel Construction, 2012.

3B-5 ANSI/AISC 360-10, "Specification for Structural Steel Buildings", American Institute of Steel Construction, 2010.

Table 3B-1: Identification of SAP2000 and SASSI2010 Loads

Designation	SAP2000 Output	SASSI2010 Output
Shell Element Loads		
Membrane Tension/Compression in Local X direction	F11	S_{xx}
Membrane Tension/Compression in Local Y direction	F22	S_{yy}
Maximum In-Plane Shear on all faces	F12	S_{xy}
Out-of-Plane Moment about Local Y Axis	M11	M_{xx}
Out-of-Plane Moment about Local X Axis	M22	M_{yy}
Maximum Twisting Moment on all faces	M12	M_{xy}
Out-of-Plane Shear on Local X Face	V13	V_{xz}
Out-of-Plane Shear on Local Y Face	V23	V_{yz}
Frame Element Loads		
Axial Tension or Compression	P	P1
Strong Axis Shear	V2	P2
Weak Axis Shear	V3	P3
Axial Torque	T	M1
Weak Axis Bending	M2	M2
Strong Axis Bending	M3	M3

Table 3B-2: Summary of D/C Ratios for Reactor Building Wall at Grid Line 1

Section		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
		Demand/Capacity Ratios						
RXB;1;E-D;24-50	D/C Ratio	0.35	0.11	0.62	0.49	0.49	0.39	20
	Element	2580	2581	2578	2577	3902	2578	
RXB;1;D-C;24-50	D/C Ratio	0.26	0.10	0.30	0.32	0.33	0.47	24
	Element	3907	3221	2583	2583	3221	2583	
RXB;1;C-B;24-50	D/C Ratio	0.25	0.08	0.28	0.32	0.36	0.51	24
	Element	3918	2593	2592	2592	3232	2591	
RXB;1;B-A;24-50	D/C Ratio	0.34	0.11	0.53	0.44	0.54	0.37	20
	Element	2595	3923	2597	2598	3923	2595	
RXB;1;E-D;50-75	D/C Ratio	0.32	0.09	0.41	0.36	0.41	0.07	20
	Element	7729	5575	7725	5575	5575	7727	
RXB;1;D-C;50-75	D/C Ratio	0.30	0.07	0.32	0.23	0.28	0.34	24
	Element	7730	5581	7735	5585	6139	7734	
RXB;1;C-B;50-75	D/C Ratio	0.35	0.08	0.39	0.23	0.28	0.31	24
	Element	7737	5590	7736	5591	6150	5588	
RXB;1;B-A;50-75	D/C Ratio	0.29	0.09	0.46	0.38	0.44	0.18	20
	Element	7746	5596	7746	6155	5596	5593	
RXB;1;E-D;75-100	D/C Ratio	0.38	0.15	0.62	0.40	0.33	0.09	14
	Element	8843	8843	10386	10386	8839	11155	
RXB;1;D-C;75-100	D/C Ratio	0.45	0.14	0.46	0.27	0.19	0.37	24
	Element	10391	10391	10392	10392	10391	10391	
RXB;1;D-C;75-100	D/C Ratio	0.45	0.14	0.46	0.27	0.19	0.37	24
	Element	10391	10391	10392	10392	10391	10392	
RXB;1;C-B;75-100	D/C Ratio	0.83	0.29	0.71	0.25	0.13	0.31	22
	Element	11167	11167	11167	9442	11166	10393	
RXB;1;B-A;75-100	D/C Ratio	0.36	0.12	0.45	0.36	0.34	0.15	20
	Element	11172	11172	11176	8860	8860	11173	
RXB;1;E-D;100-126	D/C Ratio	0.33	0.04	0.41	0.19	0.17	0.08	20
	Element	12319	12318	12316	12315	12315	12315	
RXB;1;D-C;100-126	D/C Ratio	0.47	0.10	0.42	0.09	0.10	0.08	24
	Element	13542	13542	12322	12320	13537	12325	

Table 3B-2: Summary of D/C Ratios for Reactor Building Wall at Grid Line 1 (Continued)

Section		Demand/Capacity Ratios						
		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;1;C-B;100-126	D/C Ratio	0.64	0.19	0.87	0.41	0.10	0.14	8
	Element	12326	12326	13544	13544	13544	12326	
RXB;1;B-A;100-126	D/C Ratio	0.45	0.10	0.49	0.20	0.21	0.09	20
	Element	13545	13545	12717	12332	12331	12331	
RXB;1;E-D;126-145	D/C Ratio	0.22	0.02	0.27	0.12	0.32	0.27	20
	Element	14613	15238	14612	14609	15580	15580	
RXB;1;D-C;126-145	D/C Ratio	0.37	0.10	0.31	0.09	0.17	0.15	24
	Element	14619	14619	14614	14929	15581	15581	
RXB;1;C-B;126-145	D/C Ratio	0.62	0.15	0.66	0.29	0.21	0.24	24
	Element	14621	14621	14625	14625	15592	15592	
RXB;1;B-A;126-145	D/C Ratio	0.30	0.09	0.31	0.16	0.35	0.33	20
	Element	14626	14626	14626	14936	15593	15593	
RXB;1;E-D;145-163	D/C Ratio	0.20	0.01	0.23	0.07	0.32	0.08	20
	Element	16645	16944	16046	16044	16047	16047	
RXB;1;D-C;145-163	D/C Ratio	0.33	0.01	0.34	0.08	0.12	0.08	24
	Element	16651	16950	16352	16048	16048	16048	
RXB;1;C-B;145-163	D/C Ratio	0.46	0.03	0.51	0.12	0.11	0.09	24
	Element	16058	16059	16058	16059	16059	16059	
RXB;1;B-A;145-163	D/C Ratio	0.26	0.02	0.31	0.11	0.35	0.08	20
	Element	16658	16359	16359	16060	16060	16060	
RXB;1;E-D;163-181	D/C Ratio	0.20	0.03	0.20	0.06	0.16	0.18	14
	Element	17248	14893	17245	17245	17245	17245	
RXB;1;D-C;163-181	D/C Ratio	0.38	0.04	0.43	0.07	0.13	0.16	24
	Element	17949	17949	17949	17949	17944	17948	
RXB;1;C-B;163-181	D/C Ratio	0.40	0.03	0.47	0.08	0.14	0.16	24
	Element	17257	17950	17950	17950	17955	17951	
RXB;1;B-A;163-181	D/C Ratio	0.24	0.08	0.23	0.07	0.14	0.05	14
	Element	17541	15191	17261	17264	17956	17570	

Table 3B-3: Summary of D/C Ratios for Reactor Building Wall at Grid Line 3

Section		Demand/Capacity Ratios						
		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;3;D-C;24-50	D/C Ratio	1.44	1.04	1.40	0.72	0.60	0.26	84
	Element	4951	4942	4951	4951	4942	4946	
RXB;3;E-D;126-145	D/C Ratio	0.29	0.07	0.43	0.14	0.05	0.09	2
	Element	15318	15318	15318	15318	15655	15655	
RXB;3;B-A;126-145	D/C Ratio	0.29	0.07	0.44	0.15	0.05	0.08	2
	Element	15319	15319	15319	15319	15656	15656	
RXB;3;E-D;145-163	D/C Ratio	1.19	0.60	0.71	0.16	0.10	0.06	16
	Element	16128	16128	16128	16131	16128	16131	
RXB;3;B-A;145-163	D/C Ratio	1.20	0.60	0.72	0.16	0.09	0.06	16
	Element	16135	16135	16135	16132	16135	16132	
RXB;3;E-D;163-181	D/C Ratio	0.25	0.10	0.44	0.08	0.08	0.05	10
	Element	14897	17545	15226	17545	17707	17573	
RXB;3;B-A;163-181	D/C Ratio	0.29	0.10	0.43	0.08	0.08	0.05	10
	Element	14898	17546	15227	17546	17708	17574	

Note:
Highlighted items indicate those design check zones that exceed a D/C ratio of 0.8.

Table 3B-4: Element Averaging of Horizontal Reinforcement Exceedance for Reactor Building Wall at Grid Line 3

Average of Shell Elements 4951/4431/4421: Design Check					
Horizontal Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Horizontal Reinf. D/C Ratio
11.416	7.563	1.938	20.917	28.080	0.745
			Horiz. Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			1.39	3.34	0.416
Vertical Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Vertical Reinf. D/C Ratio
9.867	7.563	0.821	18.251	28.080	0.650
			Vertical Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			1.15	3.34	0.345
Shear Friction			**IP Shear**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
16.664	36,000.0	OK	FAIL†	129.8	0.374
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
18.213	36,000.0	OK		129.8	0.162

Note:

† See Section 3B.2.2.2 and Table 3B-50.

Table 3B-5: Element Averaging of Horizontal Membrane Compression Stress for Reactor Building Wall at Grid Line 3

Average of Shell Elements 4942/4422: Design Check					
Horizontal Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Horizontal Reinf. D/C Ratio
4.031	11.149	1.790	16.971	28.080	0.604
			Horiz. Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			2.03	3.34	0.609
Vertical Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Vertical Reinf. D/C Ratio
1.574	11.149	0.836	13.559	28.080	0.483
			Vertical Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.97	3.34	0.291
Shear Friction			**IP Shear**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
24.049	36,000.0	FAIL†	FAIL††	151.9	0.371
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
26.506	36,000.0	FAIL†		172.4	0.141

Notes:

† See Section 3B.2.2.2 and Table 3B-51.

†† See Section 3B.2.2.2 and Table 3B-50.

Table 3B-6: Element Averaging of Vertical Reinforcement Exceedance for Reactor Building Wall at Grid Line 3

Average of Shell Elements 4951/4950/4949: Design Check					
Horizontal Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Horizontal Reinf. D/C Ratio
15.978	7.614	1.497	25.089	28.080	0.893
			Horiz. Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			1.91	3.34	0.572
Vertical Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Vertical Reinf. D/C Ratio
11.479	7.614	0.604	19.698	28.080	0.701
			Vertical Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			1.25	3.34	0.374
Shear Friction			**IP Shear**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
12.102	36,000.0	OK	FAIL†	129.8	0.473
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
16.601	36,000.0	OK		129.8	0.117

Note:

† See Section 3B.2.2.2 and Table 3B-50.

Table 3B-7: Summary of D/C Ratios for Reactor Building Wall at Grid Line 3 After Averaging Affected Elements

Section		Demand/Capacity Ratios: Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;3;D-C;24-50	D/C Ratio	0.75	0.61	0.70	0.72	0.60	0.26	84
	Element	4951	4942	4951	4951	4942	4946	
RXB;3;E-D;126-145	D/C Ratio	0.29	0.07	0.43	0.14	0.05	0.09	2
	Element	15318	15318	15318	15318	15655	15655	
RXB;3;B-A;126-145	D/C Ratio	0.29	0.07	0.44	0.15	0.05	0.08	2
	Element	15319	15319	15319	15319	15656	15656	
RXB;3;E-D;145-163	D/C Ratio	0.75	0.60	0.71	0.16	0.10	0.06	16
	Element	16128	16128	16128	16131	16128	16131	
RXB;3;B-A;145-163	D/C Ratio	0.75	0.60	0.72	0.16	0.09	0.06	16
	Element	16135	16135	16135	16132	16135	16132	
RXB;3;E-D;163-181	D/C Ratio	0.25	0.10	0.44	0.08	0.08	0.05	10
	Element	14897	17545	15226	17545	17707	17573	
RXB;3;B-A;163-181	D/C Ratio	0.29	0.10	0.43	0.08	0.08	0.05	10
	Element	14898	17546	15227	17546	17708	17574	

Note:
The highlighted values of the D/C ratios for the corresponding element shown in this table is based on the averaged demand values using methodology shown in Section 3B.1.1.1. It should be noted that the D/C ratios of all other elements shown in this table will be proportionally reduced if the same averaging methodology is used.

Table 3B-8: Summary of D/C Ratios for Reactor Building Wall at Grid Line 4

Section		Demand/Capacity Ratios: Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;4;D-C;24-50	D/C Ratio	0.40	0.19	0.68	0.76	0.24	0.83	16
	Element	4638	4638	3071	3071	4638	3071	
RXB;4;C-B;24-50	D/C Ratio	0.38	0.17	0.67	0.74	0.25	0.82	16
	Element	4645	4645	3072	3072	4645	3072	
RXB;4;D-C;50-75	D/C Ratio	0.38	0.22	0.62	0.42	0.46	0.39	20
	Element	8070	8070	8073	5781	7300	7300	
RXB;4;C-B;50-75	D/C Ratio	0.40	0.22	0.62	0.42	0.50	0.42	20
	Element	8077	8077	8074	5782	7307	7307	
RXB;4;D-C;75-100	D/C Ratio	0.32	0.18	0.61	0.40	0.39	0.41	16
	Element	11582	9082	9678	9678	11582	11585	
RXB;4;C-B;75-100	D/C Ratio	0.33	0.18	0.61	0.41	0.41	0.44	16
	Element	11589	9089	9679	9679	11589	11586	
RXB;4;D-C;100-126	D/C Ratio	0.95	0.35	0.48	0.29	0.38	0.28	16
	Element	13686	13686	13686	12459	12456	12459	
RXB;4;C-B;100-126	D/C Ratio	0.96	0.36	0.48	0.30	0.40	0.30	16
	Element	13693	13693	13693	12460	12463	12460	
RXB;4;E-D;126-145	D/C Ratio	0.35	0.11	0.49	0.22	0.06	0.12	2
	Element	15364	15364	15364	15364	15701	15701	
RXB;4;B-A;126-145	D/C Ratio	0.35	0.11	0.49	0.22	0.06	0.12	2
	Element	15365	15365	15365	15365	15702	15702	
RXB;4;E-D;145-163	D/C Ratio	1.07	0.76	0.64	0.21	0.08	0.08	16
	Element	16180	16180	16180	16183	16180	16183	
RXB;4;B-A;145-163	D/C Ratio	1.07	0.75	0.64	0.21	0.09	0.08	16
	Element	16187	16187	16187	16184	16187	16184	
RXB;4;E-D;163-181	D/C Ratio	0.23	0.11	0.34	0.11	0.05	0.04	10
	Element	17547	17547	15228	17547	17709	17709	
RXB;4;B-A;163-181	D/C Ratio	0.27	0.11	0.32	0.11	0.05	0.04	10
	Element	14900	17548	15229	17548	17710	17710	

Note:
Highlighted items indicate those design check zones that exceed a D/C ratio of 0.8.

Table 3B-9: Element Averaging of Reinforcement Exceedance for Reactor Building Wall at Grid Line 4

Average of Shell Elements 16180/16479/16778: Design Check					
Horizontal Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Horizontal Reinf. D/C Ratio
4.504	5.537	0.367	10.408	18.720	0.556
			Horiz. Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.96	3.15	0.304
Vertical Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Vertical Reinf. D/C Ratio
2.174	5.537	0.089	7.800	18.720	0.417
			Vertical Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.38	3.15	0.120
Shear Friction			**IP Shear**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
14.216	28,800.0	OK	FAIL†	130.6	0.061
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
16.546	28,800.0	OK		151.4	0.030

Note:

† See Section 3B.2.2.2 and Table 3B-50.

Table 3B-10: Summary of D/C Ratios for RXB Wall at Grid Line 4 After Averaging Affected Elements

Section		Demand/Capacity Ratios: Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;4;D-C;24-50	D/C Ratio	0.40	0.19	0.68	0.76	0.24	0.83	16
	Element	4638	4638	3071	3071	4638	3071	
RXB;4;C-B;24-50	D/C Ratio	0.38	0.17	0.67	0.74	0.25	0.82	16
	Element	4645	4645	3072	3072	4645	3072	
RXB;4;D-C;50-75	D/C Ratio	0.38	0.22	0.62	0.42	0.46	0.39	20
	Element	8070	8070	8073	5781	7300	7300	
RXB;4;C-B;50-75	D/C Ratio	0.40	0.22	0.62	0.42	0.50	0.42	20
	Element	8077	8077	8074	5782	7307	7307	
RXB;4;D-C;75-100	D/C Ratio	0.32	0.18	0.61	0.40	0.39	0.41	16
	Element	11582	9082	9678	9678	11582	11585	
RXB;4;C-B;75-100	D/C Ratio	0.33	0.18	0.61	0.41	0.41	0.44	16
	Element	11589	9089	9679	9679	11589	11586	
RXB;4;D-C;100-126	D/C Ratio	0.95	0.35	0.48	0.29	0.38	0.28	16
	Element	13686	13686	13686	12459	12456	12459	
RXB;4;C-B;100-126	D/C Ratio	0.96	0.36	0.48	0.30	0.40	0.30	16
	Element	13693	13693	13693	12460	12463	12460	
RXB;4;E-D;126-145	D/C Ratio	0.35	0.11	0.49	0.22	0.06	0.12	2
	Element	15364	15364	15364	15364	15701	15701	
RXB;4;B-A;126-145	D/C Ratio	0.35	0.11	0.49	0.22	0.06	0.12	2
	Element	15365	15365	15365	15365	15702	15702	
RXB;4;E-D;145-163	D/C Ratio	0.56	0.76	0.64	0.21	0.08	0.08	16
	Element	16180	16180	16180	16183	16180	16183	
RXB;4;B-A;145-163	D/C Ratio	0.56	0.75	0.64	0.21	0.09	0.08	16
	Element	16187	16187	16187	16184	16187	16184	
RXB;4;E-D;163-181	D/C Ratio	0.23	0.11	0.34	0.11	0.05	0.04	10
	Element	17547	17547	15228	17547	17709	17709	
RXB;4;B-A;163-181	D/C Ratio	0.27	0.11	0.32	0.11	0.05	0.04	10
	Element	14900	17548	15229	17548	17710	17710	

Note:
The highlighted values of the D/C ratios for the corresponding element shown in this table is based on the averaged demand values using methodology shown in Section 3B.1.1.1. It should be noted that the D/C ratios of all other elements shown in this table will be proportionally reduced if the same averaging methodology is used.

Table 3B-11: Summary of D/C Ratios for RXB Wall at Grid Line 6

Demand/Capacity Ratios								
Section		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;6;D-C.5;24-50	D/C Ratio	0.23	0.09	0.47	0.35	0.22	0.28	12
	Element	3745	4884	3164	3164	4884	4885	
RXB;6;C.5-C;24-50	D/C Ratio	0.29	0.07	0.35	0.28	0.09	0.28	12
	Element	4887	4887	4887	3167	4357	4889	
RXB;6;C-B.5;24-50	D/C Ratio	0.29	0.07	0.33	0.28	0.10	0.29	12
	Element	4892	4892	4891	3172	4362	4890	
RXB;6;B.5-B;24-50	D/C Ratio	0.30	0.11	0.50	0.38	0.24	0.58	15
	Element	2060	2060	2060	2060	4895	2060	
RXB;6;D-C.5;50-75	D/C Ratio	0.38	0.17	0.33	0.26	0.38	0.42	15
	Element	7463	8202	6577	6577	8202	8203	
RXB;6;C-5-C;50-75	D/C Ratio	0.32	0.09	0.34	0.20	0.16	0.27	15
	Element	7151	8205	7467	6026	6580	8205	
RXB;6;C-B.5;50-75	D/C Ratio	0.36	0.11	0.34	0.21	0.07	0.26	15
	Element	8209	8209	7470	6029	7470	8210	
RXB;6;B.5-B;50-75	D/C Ratio	0.35	0.14	0.31	0.26	0.31	0.50	15
	Element	7473	8212	6032	8213	6032	8213	
RXB;6;D-C.5;75-100	D/C Ratio	0.33	0.13	0.28	0.19	0.28	0.21	12
	Element	9362	9362	9362	9362	9955	11678	
RXB;6;C.5-C;75-100	D/C Ratio	0.40	0.08	0.39	0.15	0.04	0.11	12
	Element	11681	9365	11682	9365	9958	11681	
RXB;6;C-B.5;75-100	D/C Ratio	0.41	0.08	0.39	0.15	0.04	0.11	12
	Element	11686	9963	11685	9370	9963	11686	
RXB;6;B.5-B;75-100	D/C Ratio	0.33	0.13	0.28	0.19	0.28	0.21	12
	Element	9373	9373	9373	9373	9966	11689	
RXB;6;D-C.5;100-126	D/C Ratio	0.48	0.09	0.44	0.14	0.20	0.15	12
	Element	13878	13878	13468	13878	13878	13466	
RXB;6;C.5-C;100-126	D/C Ratio	0.53	0.09	0.58	0.14	0.04	0.15	11
	Element	13469	12986	13470	12986	13881	13469	
RXB;6;C-B.5;100-126	D/C Ratio	0.53	0.09	0.58	0.14	0.04	0.15	11
	Element	13471	12991	13471	12991	13886	13472	

Table 3B-11: Summary of D/C Ratios for RXB Wall at Grid Line 6 (Continued)

Section		Demand/Capacity Ratios						
		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;6;B.5-B;100-126	D/C Ratio	0.48	0.09	0.44	0.15	0.20	0.15	12
	Element	13889	13889	13473	13889	13889	13475	
RXB;6;E-D;126-145	D/C Ratio	0.61	0.20	0.64	0.22	0.12	0.12	2
	Element	15845	15845	15845	15845	15845	15845	
RXB;6;D-C;126-145	D/C Ratio	1.27	0.59	0.40	0.19	0.33	0.14	24
	Element	15846	15846	15495	15137	15846	14842	
RXB;6;C-B;126-145	D/C Ratio	1.27	0.59	0.39	0.19	0.33	0.13	24
	Element	15857	15857	15506	15148	15857	14851	
RXB;6;B-A;126-145	D/C Ratio	0.61	0.20	0.64	0.22	0.12	0.12	2
	Element	15858	15858	15858	15858	15858	15858	
RXB;6;E-D;145-163	D/C Ratio	1.46	0.61	0.60	0.18	0.17	0.06	16
	Element	16295	16295	16295	16594	16295	17189	
RXB;6;B-A;145-163	D/C Ratio	1.47	0.61	0.60	0.18	0.17	0.05	16
	Element	16296	16296	16296	16595	16296	17196	
RXB;6;E-D;163-181	D/C Ratio	0.28	0.12	0.35	0.16	0.20	0.11	10
	Element	14903	14903	17385	14903	17713	17579	
RXB;6;B-A;163-181	D/C Ratio	0.28	0.12	0.35	0.16	0.20	0.11	10
	Element	14904	15201	17390	15201	17714	17580	

Note:
Highlighted items indicate those design check zones that exceed a D/C ratio of 0.8.

Table 3B-12: Element Averaging of Horizontal Reinforcement Exceedance for RXB Wall at Grid Line 6

Average of Shell Elements 16296/16595: Design Check					
Horizontal Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Horizontal Reinf. D/C Ratio
10.227	5.549	1.198	16.975	18.720	0.907
			Horiz. Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			1.19	3.15	0.376
Vertical Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Vertical Reinf. D/C Ratio
3.630	5.549	0.309	9.488	18.720	0.507
			Vertical Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.49	3.15	0.156
Shear Friction			**IP Shear**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
8.493	28,800.0	OK	FAIL†	123.2	0.139
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
15.090	28,800.0	OK		138.4	0.036

Note:
† See Section 3B.2.2.2 and Table 3B-51.

Table 3B-13: Summary of D/C Ratios for Reactor Building Wall at Grid Line 6 after Averaging Affected Elements

Demand/Capacity Ratios								
Section		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;6;D-C.5;24-50	D/C Ratio	0.23	0.09	0.47	0.35	0.22	0.28	12
	Element	3745	4884	3164	3164	4884	4885	
RXB;6;C.5-C;24-50	D/C Ratio	0.29	0.07	0.35	0.28	0.09	0.28	12
	Element	4887	4887	4887	3167	4357	4889	
RXB;6;C-B.5;24-50	D/C Ratio	0.29	0.07	0.33	0.28	0.10	0.29	12
	Element	4892	4892	4891	3172	4362	4890	
RXB;6;B.5-B;24-50	D/C Ratio	0.30	0.11	0.50	0.38	0.24	0.58	15
	Element	2060	2060	2060	2060	4895	2060	
RXB;6;D-C.5;50-75	D/C Ratio	0.38	0.17	0.33	0.26	0.38	0.42	15
	Element	7463	8202	6577	6577	8202	8203	
RXB;6;C-5-C;50-75	D/C Ratio	0.32	0.09	0.34	0.20	0.16	0.27	15
	Element	7151	8205	7467	6026	6580	8205	
RXB;6;C-B.5;50-75	D/C Ratio	0.36	0.11	0.34	0.21	0.07	0.26	15
	Element	8209	8209	7470	6029	7470	8210	
RXB;6;B.5-B;50-75	D/C Ratio	0.35	0.14	0.31	0.26	0.31	0.50	15
	Element	7473	8212	6032	8213	6032	8213	
RXB;6;D-C.5;75-100	D/C Ratio	0.33	0.13	0.28	0.19	0.28	0.21	12
	Element	9362	9362	9362	9362	9955	11678	
RXB;6;C.5-C;75-100	D/C Ratio	0.40	0.08	0.39	0.15	0.04	0.11	12
	Element	11681	9365	11682	9365	9958	11681	
RXB;6;C-B.5;75-100	D/C Ratio	0.41	0.08	0.39	0.15	0.04	0.11	12
	Element	11686	9963	11685	9370	9963	11686	
RXB;6;B.5-B;75-100	D/C Ratio	0.33	0.13	0.28	0.19	0.28	0.21	12
	Element	9373	9373	9373	9373	9966	11689	
RXB;6;D-C.5;100-126	D/C Ratio	0.48	0.09	0.44	0.14	0.20	0.15	12
	Element	13878	13878	13468	13878	13878	13466	
RXB;6;C.5-C;100-126	D/C Ratio	0.53	0.09	0.58	0.14	0.04	0.15	11
	Element	13469	12986	13470	12986	13881	13469	

Table 3B-13: Summary of D/C Ratios for Reactor Building Wall at Grid Line 6 after Averaging Affected Elements (Continued)

Section		Demand/Capacity Ratios: Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;6;C-B.5;100-126	D/C Ratio	0.53	0.09	0.58	0.14	0.04	0.15	11
	Element	13471	12991	13471	12991	13886	13472	
RXB;6;B.5-B;100-126	D/C Ratio	0.48	0.09	0.44	0.15	0.20	0.15	12
	Element	13889	13889	13473	13889	13889	13475	
RXB;6;E-D;126-145	D/C Ratio	0.61	0.20	0.64	0.22	0.12	0.12	2
	Element	15845	15845	15845	15845	15845	15845	
RXB;6;D-C;126-145	D/C Ratio	0.91	0.59	0.40	0.19	0.33	0.14	24
	Element	15846	15846	15495	15137	15846	14842	
RXB;6;C-B;126-145	D/C Ratio	0.91	0.59	0.39	0.19	0.33	0.13	24
	Element	15857	15857	15506	15148	15857	14851	
RXB;6;B-A;126-145	D/C Ratio	0.61	0.20	0.64	0.22	0.12	0.12	2
	Element	15858	15858	15858	15858	15858	15858	
RXB;6;E-D;145-163	D/C Ratio	0.91	0.61	0.60	0.18	0.17	0.06	16
	Element	16295	16295	16295	16594	16295	17189	
RXB;6;B-A;145-163	D/C Ratio	0.91	0.61	0.60	0.18	0.17	0.05	16
	Element	16296	16296	16296	16595	16296	17196	
RXB;6;E-D;163-181	D/C Ratio	0.28	0.12	0.35	0.16	0.20	0.11	10
	Element	14903	14903	17385	14903	17713	17579	
RXB;6;B-A;163-181	D/C Ratio	0.28	0.12	0.35	0.16	0.20	0.11	10
	Element	14904	15201	17390	15201	17714	17580	

Note:
The highlighted values of the D/C ratios for the corresponding element shown in this table is based on the averaged demand values using methodology shown in Section 3B.1.1.1. It should be noted that the D/C ratios of all other elements shown in this table will be proportionally reduced if the same averaging methodology is used.

Table 3B-14: Summary of D/C Ratios for Reactor Building Wall at Grid Line E

Section		Demand/Capacity Ratios						
		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;E;1-2;24-50	D/C Ratio	0.38	0.10	0.53	0.43	0.57	0.54	24
	Element	2642	3257	2599	2599	3924	4526	
RXB;E;2-3;24-50	D/C Ratio	0.33	0.11	0.59	0.51	0.26	0.60	28
	Element	2666	4005	2659	2654	2666	4559	
RXB;E;3-4;24-50	D/C Ratio	0.51	0.11	0.55	0.35	0.19	0.57	44
	Element	2669	2680	2669	2680	3424	2684	
RXB;E;4-5;24-50	D/C Ratio	0.21	0.09	0.26	0.34	0.21	0.61	48
	Element	2822	2722	2802	2774	3570	2794	
RXB;E;5-6;24-50	D/C Ratio	0.24	0.08	0.35	0.35	0.20	0.55	48
	Element	2940	2952	2940	2940	3586	2840	
RXB;E;6-7;24-50	D/C Ratio	0.23	0.09	0.30	0.35	0.34	0.48	20
	Element	2962	2962	4372	4916	4916	2962	
RXB;E;1-2;50-75	D/C Ratio	0.35	0.08	0.65	0.38	0.49	0.28	24
	Element	5613	5597	7747	6738	5597	5630	
RXB;E;2-3;50-75	D/C Ratio	0.36	0.10	0.49	0.33	0.30	0.42	28
	Element	7787	5662	5670	5670	7785	7789	
RXB;E;3-4;50-75	D/C Ratio	0.31	0.08	0.35	0.26	0.21	0.42	44
	Element	5698	5730	6262	5718	7797	7807	
RXB;E;4-5;50-75	D/C Ratio	0.18	0.06	0.24	0.26	0.13	0.44	48
	Element	5883	5810	7843	5889	6445	7843	
RXB;E;5-6;50-75	D/C Ratio	0.19	0.06	0.30	0.29	0.13	0.43	48
	Element	5913	5961	6559	6011	6463	7885	
RXB;E;6-7;50-75	D/C Ratio	0.24	0.06	0.43	0.36	0.34	0.39	20
	Element	7166	6062	7168	6062	6620	7899	
RXB;E;1-2;75-100	D/C Ratio	0.37	0.04	0.78	0.36	0.41	0.26	24
	Element	11177	9495	9453	8861	8861	8902	
RXB;E;2-3;75-100	D/C Ratio	0.35	0.09	0.41	0.21	0.30	0.41	28
	Element	8926	8921	10438	8916	8921	8966	
RXB;E;3-4;75-100	D/C Ratio	0.27	0.09	0.32	0.17	0.21	0.47	44
	Element	11267	11267	10486	9072	11241	9072	

Table 3B-14: Summary of D/C Ratios for Reactor Building Wall at Grid Line E (Continued)

Section		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
		Demand/Capacity Ratios						
RXB;E;4-5;75-100	D/C Ratio	0.28	0.09	0.33	0.17	0.16	0.46	48
	Element	11269	11269	10576	9210	10560	9094	
RXB;E;5-6;75-100	D/C Ratio	0.21	0.05	0.37	0.23	0.13	0.41	48
	Element	10654	11301	10728	9350	10652	9234	
RXB;E;6-7;75-100	D/C Ratio	0.23	0.04	0.48	0.32	0.28	0.33	20
	Element	9386	9406	10748	9406	9406	9378	
RXB;E;1-2;100-126	D/C Ratio	0.31	0.03	0.70	0.19	0.20	0.26	24
	Element	12333	13584	12333	12333	12333	13584	
RXB;E;2-3;100-126	D/C Ratio	0.30	0.06	0.40	0.15	0.24	0.39	26
	Element	13596	13623	12375	12375	13173	12395	
RXB;E;3-4;100-126	D/C Ratio	0.47	0.12	0.31	0.08	0.20	0.43	44
	Element	13660	13660	12415	12819	12399	13269	
RXB;E;4-5;100-126	D/C Ratio	0.36	0.08	0.25	0.09	0.13	0.34	48
	Element	13283	13695	13771	12527	13777	13695	
RXB;E;5-6;100-126	D/C Ratio	0.25	0.05	0.33	0.15	0.14	0.25	48
	Element	13797	13791	12599	12599	13791	12539	
RXB;E;6-7;100-126	D/C Ratio	0.19	0.01	0.46	0.18	0.18	0.16	20
	Element	13025	13891	13025	12655	13488	13025	
RXB;E;1-2;126-145	D/C Ratio	0.26	0.05	0.42	0.12	0.35	0.38	24
	Element	15613	15613	14631	14631	15613	15608	
RXB;E;2-3;126-145	D/C Ratio	0.39	0.10	0.23	0.07	0.21	0.37	28
	Element	15651	15651	14661	14661	14669	14685	
RXB;E;3-4;126-145	D/C Ratio	0.47	0.13	0.27	0.06	0.26	0.69	44
	Element	15348	15348	15697	15697	15697	15360	
RXB;E;4-5;126-145	D/C Ratio	0.42	0.11	0.31	0.07	0.20	0.65	48
	Element	15703	15366	15766	15766	15766	14791	
RXB;E;5-6;126-145	D/C Ratio	0.44	0.09	0.38	0.11	0.22	0.65	48
	Element	15779	15779	15779	15841	15779	14795	
RXB;E;6-7;126-145	D/C Ratio	0.13	0.03	0.35	0.13	0.13	0.20	20
	Element	15859	15859	14859	14859	14859	14853	

Table 3B-14: Summary of D/C Ratios for Reactor Building Wall at Grid Line E (Continued)

Demand/Capacity Ratios								
Section		**Horizontal Reinf.**	**Horiz. Comp. Stress**	**Vertical Reinf.**	**Vert. Comp. Stress**	**XZ-Plane Shear**	**YZ-Plane Shear**	**# Elems Checked**
RXB;E;1-2;145-163	D/C Ratio	0.34	0.09	0.21	0.06	0.31	0.27	24
	Element	16985	16985	16065	16065	16088	16387	
RXB;E;2-3;145-163	D/C Ratio	0.60	0.16	0.25	0.04	0.21	0.46	28
	Element	17021	17021	16124	16100	16124	16423	
RXB;E;3-4;145-163	D/C Ratio	0.59	0.16	0.29	0.04	0.36	0.57	44
	Element	17033	17049	16176	16176	16176	16475	
RXB;E;4-5;145-163	D/C Ratio	0.54	0.15	0.32	0.04	0.32	0.56	48
	Element	17105	17101	16232	16188	16188	16531	
RXB;E;5-6;145-163	D/C Ratio	0.54	0.12	0.43	0.09	0.31	0.54	48
	Element	16543	17153	16244	16288	16244	16543	
RXB;E;6-7;145-163	D/C Ratio	0.29	0.04	0.36	0.10	0.18	0.19	20
	Element	16898	17205	16300	16300	17197	16599	

Table 3B-15: Summary of D/C Ratios for Reactor Building Slab at EL. 100′-0″

Section		Demand/Capacity Ratios						
		East-West Reinf.	E-W Comp. Stress	North-South Reinf.	N-S Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;100;1-2;D-E.a	D/C Ratio	0.49	0.08	0.53	0.34	1.30	0.90	17
	Element	11738	11758	11760	11782	11738	11704	
RXB;100;2-3;D-E.a	D/C Ratio	0.47	0.12	0.68	0.22	0.23	0.46	31
	Element	11810	11818	11804	11804	11810	11857	
RXB;100;3-4;D-E.a	D/C Ratio	0.37	0.07	0.87	0.27	0.25	0.81	55
	Element	11960	11966	11970	11970	11937	11966	
RXB;100;4-5;D-E.a	D/C Ratio	0.18	0.06	0.67	0.25	0.28	0.79	60
	Element	11990	11976	11980	11980	11978	11976	
RXB;100;5-6;D-E.a	D/C Ratio	0.18	0.07	0.51	0.19	0.16	0.52	60
	Element	12200	12210	12100	12100	12209	12210	
RXB;100;6-7;D-E.a	D/C Ratio	0.18	0.11	0.25	0.16	0.19	0.46	18
	Element	12280	12220	12242	12220	12296	12220	
RXB;100;1-2;C-D.a	D/C Ratio	0.62	0.15	0.64	0.35	0.24	0.44	36
	Element	11788	11788	11783	11783	11788	11690	
RXB;100;6-7;C-D.a	D/C Ratio	0.18	0.10	0.17	0.09	0.19	0.22	30
	Element	12301	12221	12243	12221	12222	12224	
RXB;100;1-2;B-C.a	D/C Ratio	0.61	0.15	0.66	0.35	0.27	0.94	36
	Element	11789	11789	11794	11794	11696	11697	
RXB;100;6-7;B-C.a	D/C Ratio	0.17	0.10	0.17	0.09	0.19	0.23	30
	Element	12254	12232	12254	12232	12231	12229	
RXB;100;1-2;A-B.a	D/C Ratio	0.40	0.12	0.44	0.30	1.06	0.42	21
	Element	11755	11755	11717	11795	11755	11775	
RXB;100;2-3;A-B.a	D/C Ratio	0.36	0.06	0.52	0.18	0.20	0.45	35
	Element	11805	11807	11805	11805	11864	11864	
RXB;100;3-4;A-B.a	D/C Ratio	0.35	0.07	0.87	0.27	0.25	0.82	55
	Element	11961	11975	11971	11971	11944	11975	
RXB;100;4-5;A-B.a	D/C Ratio	0.18	0.07	0.67	0.25	0.27	0.80	60
	Element	11991	11985	11981	11981	11983	11985	
RXB;100;5-6;A-B.a	D/C Ratio	0.19	0.08	0.51	0.19	0.16	0.53	60
	Element	12201	12211	12101	12101	12212	12211	

Table 3B-15: Summary of D/C Ratios for Reactor Building Slab at EL. 100’-0” (Continued)

Demand/Capacity Ratios								
Section		East-West Reinf.	E-W Comp. Stress	North-South Reinf.	N-S Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;100;6-7;A-B.a	D/C Ratio	0.18	0.11	0.26	0.17	0.19	0.47	18
	Element	12295	12233	12233	12233	12311	12233	

Note:
Highlighted items indicate those design check zones that exceed a D/C ratio of 0.8.

Table 3B-16: Element Averaging of XZ Plane Shear Exceedance for Reactor Building Slab at EL. 100'-0"

Average of Shell Elements 11738/11739: Design Check					
East-West Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	East-West Reinf. D/C Ratio
1.310	1.747	0.885	3.942	9.360	0.421
			E-W Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.17	2.84	0.060
North-South Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	North-South Reinf. D/C Ratio
0.590	1.747	1.144	3.482	9.360	0.372
			N-S Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.30	2.84	0.107
Shear Friction			**IP Shear**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
8.050	21,600.0	OK	OK	122.9	0.727
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
8.770	21,600.0	OK		129.7	0.121

Table 3B-17: Summary of D/C Ratios for Reactor Building Slab at EL. 100'-0" After Averaging Affected Elements

Section		Demand/Capacity Ratios						
		East-West Reinf.	E-W Comp. Stress	North-South Reinf.	N-S Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;100;1-2;D-E.a	D/C Ratio	0.49	0.08	0.53	0.34	0.73	0.90	17
	Element	11738	11758	11760	11782	11738	11704	
RXB;100;2-3;D-E.a	D/C Ratio	0.47	0.12	0.68	0.22	0.23	0.46	31
	Element	11810	11818	11804	11804	11810	11857	
RXB;100;3-4;D-E.a	D/C Ratio	0.37	0.07	0.87	0.27	0.25	0.81	55
	Element	11960	11966	11970	11970	11937	11966	
RXB;100;4-5;D-E.a	D/C Ratio	0.18	0.06	0.67	0.25	0.28	0.79	60
	Element	11990	11976	11980	11980	11978	11976	
RXB;100;5-6;D-E.a	D/C Ratio	0.18	0.07	0.51	0.19	0.16	0.52	60
	Element	12200	12210	12100	12100	12209	12210	
RXB;100;6-7;D-E.a	D/C Ratio	0.18	0.11	0.25	0.16	0.19	0.46	18
	Element	12280	12220	12242	12220	12296	12220	
RXB;100;1-2;C-D.a	D/C Ratio	0.62	0.15	0.64	0.35	0.24	0.44	36
	Element	11788	11788	11783	11783	11788	11690	
RXB;100;6-7;C-D.a	D/C Ratio	0.18	0.10	0.17	0.09	0.19	0.22	30
	Element	12301	12221	12243	12221	12222	12224	
RXB;100;1-2;B-C.a	D/C Ratio	0.61	0.15	0.66	0.35	0.27	0.94	36
	Element	11789	11789	11794	11794	11696	11697	
RXB;100;6-7;B-C.a	D/C Ratio	0.17	0.10	0.17	0.09	0.19	0.23	30
	Element	12254	12232	12254	12232	12231	12229	
RXB;100;1-2;A-B.a	D/C Ratio	0.40	0.12	0.44	0.30	0.73	0.42	21
	Element	11755	11755	11717	11795	11755	11775	
RXB;100;2-3;A-B.a	D/C Ratio	0.36	0.06	0.52	0.18	0.20	0.45	35
	Element	11805	11807	11805	11805	11864	11864	
RXB;100;3-4;A-B.a	D/C Ratio	0.35	0.07	0.87	0.27	0.25	0.82	55
	Element	11961	11975	11971	11971	11944	11975	
RXB;100;4-5;A-B.a	D/C Ratio	0.18	0.07	0.67	0.25	0.27	0.80	60
	Element	11991	11985	11981	11981	11983	11985	

Table 3B-17: Summary of D/C Ratios for Reactor Building Slab at EL. 100′-0″ After Averaging Affected Elements (Continued)

Section		Demand/Capacity Ratios						
		East-West Reinf.	E-W Comp. Stress	North-South Reinf.	N-S Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;100;5-6;A-B.a	D/C Ratio	0.19	0.08	0.51	0.19	0.16	0.53	60
	Element	12201	12211	12101	12101	12212	12211	
RXB;100;6-7;A-B.a	D/C Ratio	0.18	0.11	0.26	0.17	0.19	0.47	18
	Element	12295	12233	12233	12233	12311	12233	

Note:
The highlighted values of the D/C ratios for the corresponding element shown in this table is based on the averaged demand values using methodology shown in Section 3B.1.1.1. It should be noted that the D/C ratios of all other elements shown in this table will be proportionally reduced if the same averaging methodology is used.

Table 3B-18: Summary of D/C Ratios for RXB Roof Slab

Section		Demand/Capacity Ratios: East-West Reinf.	E-W Comp. Stress	North-South Reinf.	N-S Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;181;1-2;D.3-E	D/C Ratio	0.26	0.12	0.26	0.04	0.11	0.24	24
	Element	17275	17275	17967	17275	17583	17967	
RXB;181;2-3;D.3-E	D/C Ratio	0.42	0.21	0.34	0.07	0.18	0.42	28
	Element	17295	17295	17981	17295	17755	17981	
RXB;181;3-4;D.3-E	D/C Ratio	0.37	0.21	0.34	0.08	0.29	0.51	44
	Element	17305	17309	17983	17303	17777	18003	
RXB;181;4-5;D.3-E	D/C Ratio	0.39	0.20	0.41	0.07	0.26	0.49	48
	Element	17653	17339	18027	17331	17779	18005	
RXB;181;5-6;D.3-E	D/C Ratio	0.38	0.16	0.42	0.08	0.23	0.48	48
	Element	17677	17367	18049	17677	17803	18029	
RXB;181;6-7;D.3-E	D/C Ratio	0.19	0.07	0.27	0.07	0.22	0.29	20
	Element	18053	18053	18053	17679	17391	17391	
RXB;181;1-2;C-D.3	D/C Ratio	0.63	0.08	0.49	0.04	0.36	0.27	42
	Element	18083	18147	18147	18083	18083	18147	
RXB;181;2-3;C-D.3	D/C Ratio	0.43	0.12	0.54	0.05	0.09	0.44	49
	Element	18161	18245	18245	18245	18167	18245	
RXB;181;3-4;C-D.3	D/C Ratio	0.36	0.13	0.54	0.05	0.07	0.48	77
	Element	18259	18399	18259	18259	18399	18399	
RXB;181;4-5;C-D.3	D/C Ratio	0.37	0.13	0.61	0.05	0.08	0.48	84
	Element	18567	18413	18567	18413	18567	18567	
RXB;181;5-6;C-D.3	D/C Ratio	0.43	0.10	0.59	0.06	0.10	0.48	84
	Element	18735	18581	18735	18735	18735	18581	
RXB;181;6-7;C-D.3	D/C Ratio	0.50	0.07	0.49	0.06	0.34	0.29	35
	Element	18811	18749	18749	18749	18811	18749	
RXB;181;1-2;A.7-C	D/C Ratio	0.63	0.08	0.49	0.04	0.36	0.27	42
	Element	18084	18160	18160	18084	18084	18160	
RXB;181;2-3;A.7-C	D/C Ratio	0.43	0.12	0.54	0.05	0.09	0.45	49
	Element	18174	18258	18258	18258	18168	18258	
RXB;181;3-4;A.7-C	D/C Ratio	0.36	0.13	0.54	0.05	0.07	0.47	77
	Element	18272	18412	18272	18272	18412	18412	

Table 3B-18: Summary of D/C Ratios for RXB Roof Slab (Continued)

Section		Demand/Capacity Ratios						
Section		East-West Reinf.	E-W Comp. Stress	North-South Reinf.	N-S Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
RXB;181;4-5;A.7-C	D/C Ratio	0.37	0.13	0.60	0.04	0.07	0.48	84
	Element	18580	18426	18580	18426	18580	18580	
RXB;181;5-6;A.7-C	D/C Ratio	0.43	0.11	0.59	0.06	0.10	0.47	84
	Element	18748	18594	18748	18748	18748	18594	
RXB;181;6-7;A.7-C	D/C Ratio	0.50	0.08	0.49	0.06	0.34	0.29	35
	Element	18812	18762	18762	18762	18812	18762	
RXB;181;1-2;A-A.7	D/C Ratio	0.28	0.13	0.28	0.05	0.10	0.24	24
	Element	17276	17276	17968	17276	17584	17968	
RXB;181;2-3;A-A.7	D/C Ratio	0.42	0.20	0.34	0.08	0.18	0.42	28
	Element	17296	17296	17982	17296	17756	17982	
RXB;181;3-4;A-A.7	D/C Ratio	0.38	0.21	0.35	0.08	0.29	0.51	44
	Element	17306	17312	17984	17304	17778	18004	
RXB;181;4-5;A-A.7	D/C Ratio	0.39	0.20	0.41	0.06	0.26	0.49	48
	Element	17654	17340	18028	17332	17780	18006	
RXB;181;5-6;A-A.7	D/C Ratio	0.38	0.16	0.42	0.08	0.23	0.48	48
	Element	17678	17368	18050	17678	17804	18030	
RXB;181;6-7;A-A.7	D/C Ratio	0.18	0.07	0.27	0.07	0.22	0.30	20
	Element	18054	18054	18054	17680	17392	17392	

Table 3B-19: Summary of D/C Ratios for Reactor Building Pilasters on Grid Line A Wall

Section		Demand/Capacity Ratios				
		Moment Axis 2	Shear Axis 3	Compression	Tension	# Elems Checked
RXB;PI;A2;24-50	D/C Ratio	0.66	0.70	0.20	0.13	4
	Element	879	2030	1320	2030	
RXB;PI;A2;50-75	D/C Ratio	0.38	0.31	0.18	0.15	4
	Element	3060	2348	2348	2348	
RXB;PI;A2;75-100	D/C Ratio	0.62	0.28	0.14	0.13	4
	Element	5147	3803	3803	5147	
RXB;PI;A2;100-126	D/C Ratio	0.60	0.42	0.08	0.16	4
	Element	5342	5431	5342	5342	
RXB;PI;A2;126-163	D/C Ratio	0.61	0.45	0.06	0.11	8
	Element	6106	6258	5668	5872	
RXB;PI;A3;24-50	D/C Ratio	0.66	0.63	0.19	0.08	4
	Element	897	2036	897	2036	
RXB;PI;A3;50-75	D/C Ratio	0.44	0.31	0.17	0.09	4
	Element	3440	2378	2378	2641	
RXB;PI;A3;75-100	D/C Ratio	0.73	0.40	0.10	0.04	4
	Element	5151	3833	3833	3833	
RXB;PI;A3;100-126	D/C Ratio	0.45	0.71	0.05	0.02	4
	Element	5344	5433	5433	5628	
RXB;PI;A3;126-163	D/C Ratio	0.68	0.53	0.05	0.03	8
	Element	5874	6260	5874	5874	
RXB;PI;A4;24-50	D/C Ratio	0.42	0.47	0.17	0.00	4
	Element	935	935	935	2039	
RXB;PI;A4;50-75	D/C Ratio	0.39	0.26	0.13	0.02	4
	Element	2679	3442	2418	3442	
RXB;PI;A4;75-100	D/C Ratio	0.58	0.49	0.09	0.02	4
	Element	4719	3911	3911	5159	
RXB;PI;A4;100-126	D/C Ratio	0.63	0.58	0.05	0.03	4
	Element	5366	5630	5366	5630	
RXB;PI;A4;126-163	D/C Ratio	0.71	0.63	0.06	0.05	8
	Element	6110	5876	5876	5876	

Table 3B-19: Summary of D/C Ratios for Reactor Building Pilasters on Grid Line A Wall (Continued)

Demand/Capacity Ratios						
Section		**Moment Axis 2**	**Shear Axis 3**	**Compression**	**Tension**	**# Elems Checked**
RXB;PI;A5;24-50	D/C Ratio	0.44	0.44	0.17	0.01	4
	Element	1009	1009	1009	2085	
RXB;PI;A5;50-75	D/C Ratio	0.63	0.31	0.14	0.05	4
	Element	2733	3458	2476	3458	
RXB;PI;A5;75-100	D/C Ratio	0.65	0.42	0.09	0.03	4
	Element	5169	3993	3993	5169	
RXB;PI;A5;100-126	D/C Ratio	0.53	0.36	0.06	0.05	4
	Element	5368	5441	5632	5632	
RXB;PI;A5;126-163	D/C Ratio	0.72	0.68	0.07	0.07	8
	Element	6112	5782	5878	5878	
RXB;PI;A6;24-50	D/C Ratio	0.36	0.44	0.18	0.07	4
	Element	1500	1087	1087	2144	
RXB;PI;A6;50-75	D/C Ratio	0.51	0.31	0.17	0.14	4
	Element	2797	3478	2544	3478	
RXB;PI;A6;75-100	D/C Ratio	0.52	0.27	0.14	0.17	4
	Element	4883	4077	4077	4883	
RXB;PI;A6;100-126	D/C Ratio	0.51	0.18	0.11	0.26	4
	Element	5385	5385	5385	5385	
RXB;PI;A6;126-163	D/C Ratio	0.55	0.33	0.10	0.26	8
	Element	5880	5784	5880	5880	

Table 3B-20: Summary of D/C Ratios for Reactor Building Beams on EL. 75'-0" Slab

		Demand/Capacity Ratios				
Section		Moment Axis 3	Shear Axis 2	Compression	Tension	# Elems Checked
RXB;TB;75;A-B;2-2	D/C Ratio	0.36	0.23	0.21	0.14	5
	Element	3658	3657	3654	3654	
RXB;TB;75;A-B;2-3	D/C Ratio	0.20	0.10	0.06	0.06	5
	Element	3664	3668	3668	3668	
RXB;TB;75;A-B;3-3	D/C Ratio	0.33	0.30	0.08	0.12	5
	Element	3678	3674	3678	3678	
RXB;TB;75;A-B;3-4	D/C Ratio	0.39	0.51	0.05	0.06	5
	Element	3684	3684	3688	3688	
RXB;TB;75;A-B;4-4	D/C Ratio	0.35	0.58	0.14	0.13	5
	Element	3694	3694	3694	3698	
RXB;TB;75;A-B;4-5(1)	D/C Ratio	0.45	0.48	0.11	0.07	5
	Element	3704	3704	3704	3708	
RXB;TB;75;A-B;4-5(2)	D/C Ratio	0.48	0.52	0.09	0.08	5
	Element	3714	3714	3714	3718	
RXB;TB;75;A-B;5-5	D/C Ratio	0.46	0.51	0.11	0.16	5
	Element	3724	3724	3728	3728	
RXB;TB;75;A-B;5-6(1)	D/C Ratio	0.39	0.44	0.09	0.08	5
	Element	3734	3734	3734	3736	
RXB;TB;75;A-B;5-6(2)	D/C Ratio	0.40	0.48	0.08	0.06	5
	Element	3744	3744	3744	3748	
RXB;TB;75;A-B;6-6	D/C Ratio	0.38	0.58	0.18	0.21	5
	Element	3754	3754	3754	3754	
RXB;TB;75;6-7;B-C	D/C Ratio	0.38	0.22	0.07	0.06	5
	Element	3773	3773	3767	3767	
RXB;TB;75;6-7;C-C	D/C Ratio	0.50	0.26	0.06	0.04	5
	Element	3772	3772	3772	3760	
RXB;TB;75;6-7;C-D	D/C Ratio	0.41	0.22	0.07	0.05	5
	Element	3771	3771	3765	3765	
RXB;TB;75;D-E;2-2	D/C Ratio	0.26	0.14	0.20	0.11	5
	Element	3653	3653	3653	3653	

Table 3B-20: Summary of D/C Ratios for Reactor Building Beams on EL. 75'-0" Slab (Continued)

Demand/Capacity Ratios						
Section		**Moment Axis 3**	**Shear Axis 2**	**Compression**	**Tension**	**# Elems Checked**
RXB;TB;75;D-E;2-3	D/C Ratio	0.29	0.18	0.16	0.16	5
	Element	3663	3659	3660	3659	
RXB;TB;75;D-E;3-3	D/C Ratio	0.70	0.55	0.10	0.18	5
	Element	3673	3673	3669	3669	
RXB;TB;75;D-E;3-4	D/C Ratio	0.41	0.54	0.06	0.07	5
	Element	3683	3683	3679	3679	
RXB;TB;75;D-E;4-4	D/C Ratio	0.37	0.59	0.14	0.13	5
	Element	3693	3693	3693	3689	
RXB;TB;75;D-E;4-5(1)	D/C Ratio	0.46	0.48	0.11	0.07	5
	Element	3703	3703	3703	3699	
RXB;TB;75;D-E;4-5(2)	D/C Ratio	0.48	0.53	0.09	0.10	5
	Element	3713	3713	3713	3711	
RXB;TB;75;D-E;5-5	D/C Ratio	0.46	0.51	0.11	0.16	5
	Element	3723	3723	3719	3719	
RXB;TB;75;D-E;5-6(1)	D/C Ratio	0.38	0.44	0.08	0.08	5
	Element	3733	3733	3733	3731	
RXB;TB;75;D-E;5-6(2)	D/C Ratio	0.40	0.48	0.08	0.06	5
	Element	3743	3743	3743	3739	
RXB;TB;75;D-E;6-6	D/C Ratio	0.28	0.59	0.18	0.21	5
	Element	3753	3753	3753	3753	
RXB;TB;75;1-2;B-C	D/C Ratio	0.16	0.10	0.04	0.05	6
	Element	3633	3633	3648	3648	
RXB;TB;75;1-2;C-C	D/C Ratio	0.22	0.18	0.09	0.15	6
	Element	3647	3647	3647	3647	
RXB;TB;75;1-2;C-D	D/C Ratio	0.19	0.09	0.03	0.05	6
	Element	3646	3646	3643	3646	

Table 3B-21: Summary of D/C Ratios for Reactor Building Buttress at Grid Line 1 on EL. 126'-0" Slab

		Demand/Capacity Ratios				
Section		Moment Axis 2	Shear Axis 3	Compression	Tension	# Elems Checked
RXB;B;1;126;B-A	D/C Ratio	0.35	0.17	0.08	0.30	5
	Element	5657	5658	5657	5657	
RXB;B;1;126;C-B	D/C Ratio	0.43	0.24	0.16	0.58	6
	Element	5656	5655	5652	5652	
RXB;B;1;126;D-C	D/C Ratio	0.43	0.18	0.10	0.36	6
	Element	5645	5646	5650	5650	
RXB;B;1;126;E-D	D/C Ratio	0.38	0.25	0.01	0.06	5
	Element	5644	5644	5640	5640	

Table 3B-22: Summary of D/C Ratios for West Wing Wall at Grid Line 4

Section		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
		Demand/Capacity Ratios						
RXB;4;D-C;24-50	D/C Ratio	0.40	0.19	0.68	0.76	0.24	0.83	16
	Element	4638	4638	3071	3071	4638	3071	
RXB;4;C-B;24-50	D/C Ratio	0.38	0.17	0.67	0.74	0.25	0.82	16
	Element	4645	4645	3072	3072	4645	3072	
RXB;4;D-C;50-75	D/C Ratio	0.38	0.22	0.62	0.42	0.46	0.39	20
	Element	8070	8070	8073	5781	7300	7300	
RXB;4;C-B;50-75	D/C Ratio	0.40	0.22	0.62	0.42	0.50	0.42	20
	Element	8077	8077	8074	5782	7307	7307	
RXB;4;D-C;75-100	D/C Ratio	0.32	0.18	0.61	0.40	0.39	0.41	16
	Element	11582	9082	9678	9678	11582	11585	
RXB;4;C-B;75-100	D/C Ratio	0.33	0.18	0.61	0.41	0.41	0.44	16
	Element	11589	9089	9679	9679	11589	11586	
RXB;4;D-C;100-126	D/C Ratio	0.95	0.35	0.48	0.29	0.38	0.28	16
	Element	13686	13686	13686	12459	12456	12459	
RXB;4;C-B;100-126	D/C Ratio	0.96	0.36	0.48	0.30	0.40	0.30	16
	Element	13693	13693	13693	12460	12463	12460	

Table 3B-23: Summary of D/C Ratios for Reactor Building Pool Wall at Grid Line B

Section		Demand/Capacity Ratios						
		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	Elems Checked
RXB;B;1-2;24-50	D/C Ratio	0.35	0.18	0.43	0.40	0.18	0.28	20
	Element	3971	3971	2613	2634	4528	4528	
RXB;B;2-3;24-50	D/C Ratio	0.40	0.12	0.65	0.34	0.28	0.54	28
	Element	3016	4545	3016	3016	4545	4578	
RXB;B;3-4;24-50	D/C Ratio	0.57	0.07	0.55	0.22	0.97	0.58	44
	Element	4596	3046	4046	3057	4584	4596	
RXB;B;4-5;24-50	D/C Ratio	0.32	0.06	0.41	0.19	0.28	0.46	48
	Element	4116	3077	3077	4650	4650	4650	
RXB;B;5-6;24-50	D/C Ratio	0.37	0.12	0.63	0.37	0.33	0.35	48
	Element	3161	4878	3163	3163	4878	4878	
RXB;B;1-2;50-75	D/C Ratio	0.34	0.16	0.50	0.31	0.47	0.20	21
	Element	6774	6770	6130	5621	6774	6130	
RXB;B;2-3;50-75	D/C Ratio	0.41	0.12	0.52	0.25	0.40	0.54	35
	Element	5651	8010	5651	5651	8010	5651	
RXB;B;3-4;50-75	D/C Ratio	0.60	0.10	0.39	0.28	0.59	0.42	55
	Element	7294	8068	5770	5701	5701	8068	
RXB;B;4-5;50-75	D/C Ratio	0.54	0.10	0.43	0.21	0.45	0.96	60
	Element	7314	7314	5892	8080	7314	8084	
RXB;B;5-6;50-75	D/C Ratio	0.46	0.13	0.67	0.32	0.42	0.65	60
	Element	7457	6014	6014	6014	6014	6014	
RXB;B;1-2;75-100	D/C Ratio	0.41	0.11	0.37	0.23	0.34	0.32	20
	Element	11377	10434	10788	8894	11377	11377	
RXB;B;2-3;75-100	D/C Ratio	0.54	0.09	0.55	0.20	0.39	0.38	28
	Element	11536	8919	11536	8919	11536	8919	
RXB;B;3-4;75-100	D/C Ratio	0.46	0.08	0.35	0.22	0.55	0.44	44
	Element	9075	9075	9075	9075	9075	9075	
RXB;B;4-5;75-100	D/C Ratio	0.35	0.06	0.35	0.23	0.43	0.41	48
	Element	10858	9121	9214	9214	11591	9096	
RXB;B;5-6;75-100	D/C Ratio	0.44	0.13	0.59	0.26	0.39	0.54	48
	Element	9947	9354	9354	9354	9354	9354	

Table 3B-23: Summary of D/C Ratios for Reactor Building Pool Wall at Grid Line B (Continued)

Section		Demand/Capacity Ratios						
		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	Elems Checked
RXB;B;1-2;100-126	D/C Ratio	0.43	0.10	0.45	0.23	0.27	0.49	20
	Element	13171	13171	13554	13554	12337	13554	
RXB;B;2-3;100-126	D/C Ratio	0.32	0.09	0.58	0.28	0.27	0.36	28
	Element	12371	13176	12371	12371	12371	12371	
RXB;B;3-4;100-126	D/C Ratio	0.49	0.06	0.52	0.19	0.77	0.54	44
	Element	13683	12450	13683	12450	13683	12450	
RXB;B;4-5;100-126	D/C Ratio	0.40	0.05	0.37	0.20	0.63	0.51	48
	Element	13715	13747	13779	12517	13697	12469	
RXB;B;5-6;100-126	D/C Ratio	0.57	0.09	0.39	0.20	0.45	0.35	48
	Element	13875	13875	13463	12541	13793	12541	
RXB;B;1-2;126-145	D/C Ratio	0.72	0.12	0.39	0.21	0.42	0.22	24
	Element	15601	15601	14634	14634	15601	15601	
RXB;B;2-3;126-145	D/C Ratio	0.24	0.07	0.36	0.12	0.15	0.38	28
	Element	15633	15641	15649	14997	14997	14997	
RXB;B;3-4;126-145	D/C Ratio	0.32	0.05	0.53	0.23	0.58	1.00	44
	Element	15699	15683	14739	14739	14739	14739	
RXB;B;4-5;126-145	D/C Ratio	0.46	0.13	0.58	0.27	0.50	0.93	54
	Element	15401	12682	15713	14761	15738	14746	
RXB;B;5-6;126-145	D/C Ratio	0.63	0.12	0.47	0.21	0.90	0.76	51
	Element	12688	12688	15786	15094	15440	14797	
RXB;B;6-7;126-145	D/C Ratio	0.49	0.10	0.43	0.14	0.42	0.68	19
	Element	14855	14855	14855	15510	15861	15861	

Note:
Highlighted items indicate those design check zones that exceed a D/C ratio of 0.8.

Table 3B-24: Element Averaging of YZ Plane Shear Exceedance for Reactor Building Pool Wall at Grid Line B

Average of Shell Elements 14739/14746: Design Check					
Horizontal Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Horizontal Reinf. D/C Ratio
1.086	0.914	1.499	3.500	12.480	0.280
			Horiz. Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.09	2.77	0.033
Vertical Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Vertical Reinf. D/C Ratio
2.994	0.914	2.399	6.307	12.480	0.505
			Vertical Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.61	2.77	0.220
Shear Friction			**IP Shear**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
11.394	32,400.0	OK	OK	195.0	0.503
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
9.486	32,400.0	OK		176.8	0.960

Table 3B-25: Summary of D/C Ratios for Reactor Building Pool Wall at Grid Line B After Averaging Affected Elements

Section		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	Elems Checked
		Demand/Capacity Ratios						
RXB;B;1-2;24-50	D/C Ratio	0.35	0.18	0.43	0.40	0.18	0.28	20
	Element	3971	3971	2613	2634	4528	4528	
RXB;B;2-3;24-50	D/C Ratio	0.40	0.12	0.65	0.34	0.28	0.54	28
	Element	3016	4545	3016	3016	4545	4578	
RXB;B;3-4;24-50	D/C Ratio	0.57	0.07	0.55	0.22	0.97	0.58	44
	Element	4596	3046	4046	3057	4584	4596	
RXB;B;4-5;24-50	D/C Ratio	0.32	0.06	0.41	0.19	0.28	0.46	48
	Element	4116	3077	3077	4650	4650	4650	
RXB;B;5-6;24-50	D/C Ratio	0.37	0.12	0.63	0.37	0.33	0.35	48
	Element	3161	4878	3163	3163	4878	4878	
RXB;B;1-2;50-75	D/C Ratio	0.34	0.16	0.50	0.31	0.47	0.20	21
	Element	6774	6770	6130	5621	6774	6130	
RXB;B;2-3;50-75	D/C Ratio	0.41	0.12	0.52	0.25	0.40	0.54	35
	Element	5651	8010	5651	5651	8010	5651	
RXB;B;3-4;50-75	D/C Ratio	0.60	0.10	0.39	0.28	0.59	0.42	55
	Element	7294	8068	5770	5701	5701	8068	
RXB;B;4-5;50-75	D/C Ratio	0.54	0.10	0.43	0.21	0.45	0.96	60
	Element	7314	7314	5892	8080	7314	8084	
RXB;B;5-6;50-75	D/C Ratio	0.46	0.13	0.67	0.32	0.42	0.65	60
	Element	7457	6014	6014	6014	6014	6014	
RXB;B;1-2;75-100	D/C Ratio	0.41	0.11	0.37	0.23	0.34	0.32	20
	Element	11377	10434	10788	8894	11377	11377	
RXB;B;2-3;75-100	D/C Ratio	0.54	0.09	0.55	0.20	0.39	0.38	28
	Element	11536	8919	11536	8919	11536	8919	
RXB;B;3-4;75-100	D/C Ratio	0.46	0.08	0.35	0.22	0.55	0.44	44
	Element	9075	9075	9075	9075	9075	9075	
RXB;B;4-5;75-100	D/C Ratio	0.35	0.06	0.35	0.23	0.43	0.41	48
	Element	10858	9121	9214	9214	11591	9096	

Table 3B-25: Summary of D/C Ratios for Reactor Building Pool Wall at Grid Line B After Averaging Affected Elements (Continued)

Section		Demand/Capacity Ratios: Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	Elems Checked
RXB;B;5-6;75-100	D/C Ratio	0.44	0.13	0.59	0.26	0.39	0.54	48
	Element	9947	9354	9354	9354	9354	9354	
RXB;B;1-2;100-126	D/C Ratio	0.43	0.10	0.45	0.23	0.27	0.49	20
	Element	13171	13171	13554	13554	12337	13554	
RXB;B;2-3;100-126	D/C Ratio	0.32	0.09	0.58	0.28	0.27	0.36	28
	Element	12371	13176	12371	12371	12371	12371	
RXB;B;3-4;100-126	D/C Ratio	0.49	0.06	0.52	0.19	0.77	0.54	44
	Element	13683	12450	13683	12450	13683	12450	
RXB;B;4-5;100-126	D/C Ratio	0.40	0.05	0.37	0.20	0.63	0.51	48
	Element	13715	13747	13779	12517	13697	12469	
RXB;B;5-6;100-126	D/C Ratio	0.57	0.09	0.39	0.20	0.45	0.35	48
	Element	13875	13875	13463	12541	13793	12541	
RXB;B;1-2;126-145	D/C Ratio	0.72	0.12	0.39	0.21	0.42	0.22	24
	Element	15601	15601	14634	14634	15601	15601	
RXB;B;2-3;126-145	D/C Ratio	0.24	0.07	0.36	0.12	0.15	0.38	28
	Element	15633	15641	15649	14997	14997	14997	
RXB;B;3-4;126-145	D/C Ratio	0.32	0.05	0.53	0.23	0.58	0.96	44
	Element	15699	15683	14739	14739	14739	14739	
RXB;B;4-5;126-145	D/C Ratio	0.46	0.13	0.58	0.27	0.50	0.93	54
	Element	15401	12682	15713	14761	15738	14746	
RXB;B;5-6;126-145	D/C Ratio	0.63	0.12	0.47	0.21	0.90	0.76	51
	Element	12688	12688	15786	15094	15440	14797	
RXB;B;6-7;126-145	D/C Ratio	0.49	0.10	0.43	0.14	0.42	0.68	19
	Element	14855	14855	14855	15510	15861	15861	

Note: The highlighted values of the D/C ratios for the corresponding element shown in this table is based on the averaged demand values. It should be noted that the D/C ratios of all other elements shown in this table will be proportionally reduced if the same averaging methodology is used.

Table 3B-26: NuScale Power Module Lug Support Model Cut Section Forces and Moments

TABLE: Section Cut Forces - Analysis								
SectionCut	**OutputCase**	**CaseType**	**F1**	**F2**	**F3**	**M1**	**M2**	**M3**
Text	Text	Text	Lb	Lb	Lb	Lb-in	Lb-in	Lb-in
2"PL_Y=-16.25"	W-Lug-PY-	LinStatic	-55,982	-1,194,526	341	11,300	620	557,494
2"PL_Y=16.25"	W-Lug-PY-	LinStatic	5,454	884,513	756	-19,923	381	37,563
Fin_Y=00.00"	W-Lug-PY-	LinStatic	-50,509	-309,993	1,097	-1,879	1,000	-403,151
Fin_Y=-16.25"	W-Lug-PY-	LinStatic	-803,922	-375,879	1,056	-13,850	7,480	-312,109
Fin_Y=16.25"	W-Lug-PY-	LinStatic	-67,116	-154,332	1,157	10,798	10,194	-205,216
Fin_Y=-32.24"	W-Lug-PY-	LinStatic	-33,420	-468,831	691	-23,053	4,726	-540,523
Fin_Y=32.24"	W-Lug-PY-	LinStatic	37,226	-121,274	745	22,770	7,199	-154,530
Fin_Y=-48.23"	W-Lug-PY-	LinStatic	150,232	-488,802	71	-30,142	660	-584,991
Fin_Y=48.23"	W-Lug-PY-	LinStatic	53,268	-132,962	110	35,642	2,789	-165,157
Fin_Y=-64.22"	W-Lug-PY-	LinStatic	258,209	-483,067	-767	-34,319	-1,405	-576,203
Fin_Y=64.22"	W-Lug-PY-	LinStatic	52,628	-181,955	-779	50,037	-2,294	-225,438
Fin_Y=-88.20"	W-Lug-PY-	LinStatic	484,861	-488,810	-1,391	-33,526	-12,081	-594,724
Fin_Y=88.20"	W-Lug-PY-	LinStatic	-81,465	-293,957	-1,989	65,712	-18,272	-324,996
			Total	-3,499,861				
2"PL_Y=-16.25"	W-Lug-PY+	LinStatic	7,442	-424,764	-279	-44,910	-433	-60,054
2"PL_Y=16.25"	W-Lug-PY+	LinStatic	-52,098	722,175	234	43,923	576	-519,329
Fin_Y=00.00"	W-Lug-PY+	LinStatic	-44,640	297,392	-45	7,337	143	388,025
Fin_Y=-16.25"	W-Lug-PY+	LinStatic	-16,757	144,367	8	7,183	433	182,939
Fin_Y=16.25"	W-Lug-PY+	LinStatic	-742,945	361,735	-145	6,587	682	305,731
Fin_Y=-32.24"	W-Lug-PY+	LinStatic	8,663	92,366	231	6,948	-64	115,492
Fin_Y=32.24"	W-Lug-PY+	LinStatic	-65,131	477,854	-7	3,244	-1,629	555,769
Fin_Y=-48.23"	W-Lug-PY+	LinStatic	11,264	70,026	301	7,001	346	86,663
Fin_Y=48.23"	W-Lug-PY+	LinStatic	98,943	540,322	104	-2,716	-2,074	649,873
Fin_Y=-64.22"	W-Lug-PY+	LinStatic	8,318	62,330	222	7,076	-590	76,984
Fin_Y=64.22"	W-Lug-PY+	LinStatic	198,163	608,247	242	-11,824	-424	732,111
Fin_Y=-88.20"	W-Lug-PY+	LinStatic	-18,932	55,657	-483	5,903	307	62,272
Fin_Y=88.20"	W-Lug-PY+	LinStatic	563,052	789,567	-427	-23,311	2,871	924,761
			Total	3,499,864				

Table 3B-27: SASSI Maximum Lug Reactions for RXB Cracked Model using Soil Type 7 (CSDRS) and Soil Type 9 (CSDRS-HF)

Input Case	East Wing Wall N-S Lug Reaction (kips)	Pool Wall E-W Lug Reaction (kips)	West Wing Wall N-S Lug Reaction (kips)
Soil Type 7 CSDRS	1,819	2,320	1,957
D/C ratio (to 3500 kip load)	0.52	0.66	0.56
Soil Type 9 CSDRS-HF	1,784	2,249	1,930
D/C ratio (to 3500 kip load)	0.51	0.64	0.55

Table 3B-28: Summary of D/C Ratios for Control Building Wall at Grid Line 3

Section		Demand/Capacity Ratios						
		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
CRB;3;B-A;50-76	D/C Ratio	0.39	0.06	0.37	0.17	0.38	0.43	15
	Element	714	927	716	714	1487	1488	
CRB;3;B-A;76-100	D/C Ratio	0.43	0.07	0.46	0.10	0.30	0.43	15
	Element	2178	2178	2029	2029	2030	2482	
CRB;3;B-A;100-120	D/C Ratio	0.34	0.06	0.43	0.11	0.22	0.70	11
	Element	3131	3275	2994	3276	3276	3276	
CRB;3;B-A;120-141	D/C Ratio	0.27	0.06	0.38	0.07	0.34	0.94	6
	Element	3712	3712	3712	3777	3712	3712	
CRB;3;C-B;50-76	D/C Ratio	0.60	0.09	0.41	0.17	0.26	0.36	29
	Element	709	709	711	710	1479	1479	
CRB;3;C-B;76-100	D/C Ratio	0.49	0.07	0.55	0.20	0.13	0.49	28
	Element	2028	2176	2028	2026	2175	2026	
CRB;3;C-B;100-120	D/C Ratio	0.38	0.06	0.51	0.13	0.16	0.61	22
	Element	2993	3127	2993	2993	3268	2993	
CRB;3;D-C;50-76	D/C Ratio	0.52	0.07	0.42	0.14	0.28	0.33	7
	Element	708	916	708	708	1476	1476	
CRB;3;D-C;76-100	D/C Ratio	0.42	0.08	0.35	0.10	0.20	0.33	7
	Element	2169	2169	2024	2024	2471	2024	
CRB;3;D-C;100-120	D/C Ratio	0.21	0.03	0.21	0.06	0.28	0.25	5
	Element	3121	3121	2987	2987	3264	2987	
CRB;3;E-D;50-76	D/C Ratio	0.52	0.09	0.47	0.16	0.22	0.34	18
	Element	706	706	705	705	1471	1472	
CRB;3;E-D;76-100	D/C Ratio	0.33	0.06	0.37	0.08	0.15	0.31	20
	Element	2022	2167	2022	2021	2318	2023	
CRB;3;E-D;100-120	D/C Ratio	0.13	0.04	0.13	0.05	0.15	0.18	14
	Element	3120	3120	2986	3259	3263	3263	

Table 3B-29: Summary of D/C Ratios for Control Building Wall at Grid Line 4

Section		Demand/Capacity Ratios						
		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
CRB;4;B-A;50-76	D/C Ratio	0.63	0.11	0.78	0.21	0.55	1.16	24
	Element	790	793	789	789	793	788	
CRB;4;B-A;76-100	D/C Ratio	0.28	0.06	0.22	0.13	0.42	0.34	24
	Element	2233	2082	2382	2082	2082	2077	
CRB;4;B-A;100-120	D/C Ratio	0.20	0.05	0.28	0.10	0.34	0.32	17
	Element	3328	3327	3043	3043	3185	3043	
CRB;4;B-A;120-140	D/C Ratio	0.18	0.05	0.18	0.07	0.20	0.15	8
	Element	3937	3937	3750	3750	3937	3749	
CRB;4;C-B;50-76	D/C Ratio	0.48	0.09	0.77	0.24	0.40	1.38	32
	Element	781	781	786	786	999	786	
CRB;4;C-B;76-100	D/C Ratio	0.22	0.03	0.29	0.08	0.16	0.35	32
	Element	2524	2076	2221	2221	2372	2528	
CRB;4;C-B;100-120	D/C Ratio	0.18	0.04	0.13	0.03	0.17	0.20	23
	Element	3324	3324	3032	3032	3173	3038	
CRB;4;D-C;50-76	D/C Ratio	0.33	0.06	0.43	0.15	0.36	0.65	8
	Element	779	778	778	778	778	779	
CRB;4;D-C;76-100	D/C Ratio	0.20	0.03	0.17	0.09	0.25	0.19	8
	Element	2218	2068	2067	2067	2218	2523	
CRB;4;D-C;100-120	D/C Ratio	0.12	0.02	0.14	0.04	0.18	0.34	5
	Element	3172	3172	3031	3031	3315	3031	
CRB;4;E-D;50-76	D/C Ratio	0.58	0.09	0.53	0.22	0.49	0.59	28
	Element	777	777	775	775	1341	774	
CRB;4;E-D;76-100	D/C Ratio	0.30	0.06	0.24	0.12	0.46	0.27	28
	Element	2211	2060	2367	2060	2060	2064	
CRB;4;E-D;100-120	D/C Ratio	0.25	0.05	0.23	0.09	0.43	0.28	20
	Element	3310	3309	3025	3025	3165	3030	
CRB;4;E-D;120-140	D/C Ratio	0.26	0.06	0.18	0.06	0.25	0.14	8
	Element	3740	3928	3740	3739	3928	3740	

Table 3B-30: Control Building Wall at Grid Line 4 - Shell Element 786 with added Shear Reinforcement

Shell Element 786 in Section [CRB;4;C-B;50-76]: Design Check					
Horizontal Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Horizontal Reinf. D/C Ratio
1.016	1.581	0.310	2.908	6.240	0.466
			Horiz. Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.21	2.63	0.080
Vertical Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	Vertical Reinf. D/C Ratio
2.559	1.581	0.694	4.835	6.240	0.775
			Vertical Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.62	2.63	0.236
Shear Friction			**Code Check**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
5.224	19,589.8	OK	OK	122.1	0.086
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
3.681	13,802.6	OK		108.0	0.775

Table 3B-31: Summary of D/C Ratios for Control Building Wall at Grid Line 4 After Averaging Affected Elements

Section		Demand/Capacity Ratios						
		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
CRB;4;B-A;50-76	D/C Ratio	0.63	0.11	0.78	0.21	0.55	0.78	24
	Element	790	793	789	789	793	788	
CRB;4;B-A;76-100	D/C Ratio	0.28	0.06	0.22	0.13	0.42	0.34	24
	Element	2233	2082	2382	2082	2082	2077	
CRB;4;B-A;100-120	D/C Ratio	0.20	0.05	0.28	0.10	0.34	0.32	17
	Element	3328	3327	3043	3043	3185	3043	
CRB;4;B-A;120-140	D/C Ratio	0.18	0.05	0.18	0.07	0.20	0.15	8
	Element	3937	3937	3750	3750	3937	3749	
CRB;4;C-B;50-76	D/C Ratio	0.48	0.09	0.77	0.24	0.40	0.78	32
	Element	781	781	786	786	999	786	
CRB;4;C-B;76-100	D/C Ratio	0.22	0.03	0.29	0.08	0.16	0.35	32
	Element	2524	2076	2221	2221	2372	2528	
CRB;4;C-B;100-120	D/C Ratio	0.18	0.04	0.13	0.03	0.17	0.20	23
	Element	3324	3324	3032	3032	3173	3038	
CRB;4;D-C;50-76	D/C Ratio	0.33	0.06	0.43	0.15	0.36	0.65	8
	Element	779	778	778	778	778	779	
CRB;4;D-C;76-100	D/C Ratio	0.20	0.03	0.17	0.09	0.25	0.19	8
	Element	2218	2068	2067	2067	2218	2523	
CRB;4;D-C;100-120	D/C Ratio	0.12	0.02	0.14	0.04	0.18	0.34	5
	Element	3172	3172	3031	3031	3315	3031	
CRB;4;E-D;50-76	D/C Ratio	0.58	0.09	0.53	0.22	0.49	0.59	28
	Element	777	777	775	775	1341	774	
CRB;4;E-D;76-100	D/C Ratio	0.30	0.06	0.24	0.12	0.46	0.27	28
	Element	2211	2060	2367	2060	2060	2064	
CRB;4;E-D;100-120	D/C Ratio	0.25	0.05	0.23	0.09	0.43	0.28	20
	Element	3310	3309	3025	3025	3165	3030	

Table 3B-31: Summary of D/C Ratios for Control Building Wall at Grid Line 4 After Averaging Affected Elements (Continued)

Demand/Capacity Ratios								
Section		Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
CRB;4;E-D;120-140	D/C Ratio	0.26	0.06	0.18	0.06	0.25	0.14	8
	Element	3740	3928	3740	3739	3928	3740	

Note:

The highlighted values of the D/C ratios for the corresponding element shown in this table are based on the averaged demand values. It should be noted that the D/C ratios of the other elements shown in this table will be proportionally reduced if the same averaging methodology is used.

Table 3B-32: Summary of D/C Ratios for Control Building Wall at Grid Line A

Section		Demand/Capacity Ratios: Horizontal Reinf.	Horiz. Comp. Stress	Vertical Reinf.	Vert. Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
CRB;A;1-2;50-63	D/C Ratio	0.90	0.11	0.89	0.22	0.67	0.95	16
	Element	643	635	639	647	635	639	
CRB;A;2-2.8;50-63	D/C Ratio	0.52	0.09	0.39	0.16	0.46	0.43	6
	Element	692	692	692	903	698	692	
CRB;A;2.8-4;50-63	D/C Ratio	0.54	0.09	0.47	0.21	0.54	0.84	12
	Element	770	770	770	770	982	770	
CRB;A;1-2;63-76	D/C Ratio	0.56	0.07	0.56	0.16	0.54	0.62	16
	Element	1220	1200	1212	1200	1200	1416	
CRB;A;2-2.8;63-76	D/C Ratio	0.43	0.06	0.32	0.15	0.50	0.25	6
	Element	1258	1241	1251	1258	1461	1444	
CRB;A;2.8-4;63-76	D/C Ratio	0.34	0.05	0.24	0.15	0.76	0.12	12
	Element	1469	1340	1296	1266	1469	1521	
CRB;A;1-2;76-100	D/C Ratio	0.41	0.05	0.39	0.13	0.40	0.51	32
	Element	2122	1990	1990	1978	2273	1987	
CRB;A;2-2.8;76-100	D/C Ratio	0.37	0.04	0.21	0.11	0.48	0.29	12
	Element	2306	2002	2005	2002	2011	2002	
CRB;A;2.8-4;76-100	D/C Ratio	0.28	0.05	0.20	0.13	0.71	0.16	24
	Element	2049	2018	2514	2059	2018	2502	
CRB;A;1-2;100-120	D/C Ratio	0.23	0.02	0.16	0.05	0.18	0.19	24
	Element	3230	2955	2937	2937	3233	3230	
CRB;A;2-2.8;100-120	D/C Ratio	0.33	0.04	0.31	0.06	0.36	0.15	9
	Element	3251	3251	3251	3251	2975	2961	
CRB;A;2.8-4;100-120	D/C Ratio	0.20	0.04	0.25	0.08	0.78	0.41	18
	Element	2982	3283	3024	3024	2982	3014	
CRB;A;2.8-4;120-140	D/C Ratio	0.26	0.06	0.23	0.08	0.46	0.28	24
	Element	3906	3711	3711	3711	3906	3711	

Table 3B-33: Element Averaging of IP Shear Exceedance of Control Building Wall at Grid Line A

Element		Length (in)	Thickness (in)	Shell Sxy (kip/in)	IP Shear Demand (kip)	$f_c^{'}$ (psi)	IP Shear Capacity $\phi_v 8 A_{cv} \sqrt{f_c^{'}}$ (kip)
Shell	635	64.33	36	12.83	825.1	5000	982.5
Shell	639	64.33	36	14.59	938.4	5000	982.5
Shell	643	64.33	36	15.69	1009.6	5000	982.5
Shell	647	58.33	36	15.35	895.6	5000	890.9
Shell	651	58.33	36	15.81	922.1	5000	890.9
Shell	655	58.33	36	12.46	726.6	5000	890.9
				Sum =	5317.4	<	5620.3

Table 3B-34: Moment and Shear Capacity: 5 Foot Thick Control Building Basemat Foundation (Type 1)

Description	Parameters	Value
Information	-	5′-0″ Basemat; 3 Layers EWEF (#11 @ 12″ c/c); 2-Leg Stirrups (#6 @ 12″ c/c)
Section thickness	h (in)	60
Concrete cover dimension	c (in)	3
Rebar diameter	d_t (in)	1.41
Stirrup diameter	d_s(in)	0.75
Rebar area	$A_{st(t)}$ (in^2)	1.560
Stirrup area	$A_{st(s)}$ (in^2)	0.44
Effective depth	d (in)	51.32
Lever arm	jd (in)	48.57
Out-of-Plane Moment Capacity $\phi M_N = \phi_M M_N$	ϕM_N (kip-ft/ft)	1,023
Shear Capacity provided by Concrete $\phi V_c = \phi_v 2bdv(fc')$	$\phi_v V_c$ (kip/ft)	65
Shear Capacity provided by Stirrups $\phi V_s = \phi_v((A_{st(s)} f_y d)/s_s)$	$\phi_v V_s$ (kip/ft)	169
In-Plane Shear Capacity by Concrete $\phi V_{conc}=\phi A_{cv}(\alpha_c \sqrt{(f_c')})$	$\phi_v V_{conc}$(kip/ft)	76
In-Plane Shear Capacity $\phi V_{in\text{-}plane}$=Minimum of $\phi A_{cv}(\alpha_c \sqrt{(f_c')}+\rho_t f_y)$ or $\phi_v 8Acv\sqrt{(f_c')}$	$\phi_v V_{in\text{-}plane}$ (kip/ft)	305

Table 3B-35: Moment and Shear Capacity: 5 Foot Thick Control Building Basemat Foundation (Type 2)

Description	Parameters	Value
Information	-	5′-0″ Basemat; 4 Layers EWEF (#11 @ 12″ c/c); 2-Leg Stirrups (#6 @ 12″ c/c)
Section thickness	h (in)	60
Concrete cover dimension	c (in)	3
Rebar diameter	d_t (in)	1.41
Stirrup diameter	d_s(in)	0.75
Rebar area	$A_{st(t)}$ (in^2)	1.560
Stirrup area	$A_{st(s)}$ (in^2)	0.44
Effective depth	d (in)	49.91
Lever arm	jd (in)	46.24
Out-of-Plane Moment Capacity $\phi M_N = \phi_M M_N$	ϕM_N (kip-ft/ft)	1298
Shear Capacity provided by Concrete $\phi V_c = \phi_v 2bdv(fc')$	$\phi_v V_c$ (kip/ft)	64
Shear Capacity provided by Stirrups $\phi V_s = \phi_v((A_{st(s)} f_y d)/s_s)$	$\phi_v V_s$ (kip/ft)	165
In-Plane Shear Capacity by Concrete $\phi V_{conc}=\phi A_{cv}(\alpha_c \sqrt{(f_c')})$	$\phi v V_{conc}$(kip/ft)	76
In-Plane Shear Capacity $\phi V_{in\text{-}plane}$=Minimum of $\phi A_{cv}(\alpha_c \sqrt{(f_c')}+\rho_t f_y)$ or $\phi_v 8Acv\sqrt{(f_c')}$	$\phi_v V_{in\text{-}plane}$ (kip/ft)	305

Table 3B-36: Magnitudes of Bounding Demand Forces and Moments for Perimeter of Main Control Building Basemat Slab

	FX(S_{xx})	FY(S_{yy})	S_{xy}	V_{xz}	V_{yz}	MX(M_{yy})	MY(M_{xx})
	k/ft	k/ft	k/ft	k/ft	k/ft	k-ft/ft	k-ft/ft
Maximum	312	291	216	143	125	406	593
Elm. No.	386	375	373	373	345	69	386

Note:
The shear forces and bending moments are obtained by the absolute sum of the static and seismic results

Table 3B-37: Magnitudes of Bounding Demand Forces and Moments for Interior of Main Control Building Basemat Slab

	FX(Sxx)	FY(Syy)	Sxy	Vxz	Vyz	MX(Myy)	MY(Mxx)
	k/ft	k/ft	k/ft	k/ft	k/ft	k-ft/ft	k-ft/ft
Maximum	309	228	135	114	83	302	326
Elm. No.	45	347	25	45	45	99	45

Note:
The shear forces and bending moments are obtained by the absolute sum of the static and seismic results.

Table 3B-38: Magnitudes of Bounding Demand Forces and Moments for Control Building Basemat of Control Building Tunnel

	FX(Sxx)†	FY(Syy)†	Sxy	Vxz	Vyz	MX(Myy)	MY(Mxx)
	k/ft	k/ft	k/ft	k/ft	k/ft	k-ft/ft	k-ft/ft
Maximum	-	-	230	196	212	732	793
Elm. No.	-	-	547	516	485	488	486

† Forces are not calculated since the west end of the tunnel is separated from the RXB by a nominal 6 inch gap

Table 3B-39: Design Check Control Building Basemat Foundation of Perimeter of the Main Slab

Basemat Foundation for CRB Perimeter: Design Check					
East-West Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	East-West Reinf. D/C Ratio
5.772	3.107	2.848	11.727	12.480	0.940
North-South Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	North-South Reinf. D/C Ratio
5.393	3.107	1.952	10.452	12.480	0.838
Shear Friction			**Code Check**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
6.708	25,154.2	OK	OK	173.2	0.826
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
7.087	26,577.8	OK		176.8	0.704

Table 3B-40: Design Check Control Building Basemat Foundation of Interior of the Main Slab

Basemat Foundation for CRB Interior: Design Check					
East-West Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	East-West Reinf. D/C Ratio
5.713	1.292	1.491	8.496	9.360	0.908
North-South Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	North-South Reinf. D/C Ratio
4.215	1.292	1.382	6.889	9.360	0.736
Shear Friction			**Code Check**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	Sxy < $\phi_v V_{nx}$?	Sxy < $\phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
3.647	13,676.4	OK	OK	178.7	0.637
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	Sxy < $\phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
5.145	19,294.4	OK		193.4	0.431

Table 3B-41: Design Check for Control Building Basemat Foundation for the Control Building Tunnel

Basemat Foundation for CRB Tunnel: Design Check					
East-West Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	East-West Reinf. D/C Ratio
0.000	3.410	3.629	7.039	9.360	0.752
North-South Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	North-South Reinf. D/C Ratio
0.000	3.410	3.347	6.756	9.360	0.722
Shear Friction			**Code Check**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
9.360	35,100.0	OK	OK	234.7	0.835
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
9.360	35,100.0	OK		234.7	0.905

Table 3B-42: Summary of D/C Ratios for Control Building Slab at EL. 100'-0"

Section		Demand/Capacity Ratios						
		East-West Reinf.	**E-W Comp. Stress**	**North-South Reinf.**	**N-S Comp. Stress**	**XZ-Plane Shear**	**YZ-Plane Shear**	**# Elems Checked**
CRB;100;7-1;D-E	D/C Ratio	0.82	0.19	0.84	0.14	0.51	1.13	10
	Element	2543	2539	2538	2538	2539	2538	
CRB;100;1-2;D-E	D/C Ratio	0.96	0.17	0.38	0.03	0.80	0.50	55
	Element	2562	2562	2561	2718	2562	2649	
CRB;100;2-3;D-E	D/C Ratio	0.33	0.05	0.27	0.06	0.51	0.38	22
	Element	2742	2764	2764	2764	2764	2747	
CRB;100;3-4;D-E	D/C Ratio	0.17	0.03	0.09	0.02	0.53	0.30	25
	Element	2895	2824	2893	2827	2897	2827	
CRB;100;7-1;C-D	D/C Ratio	0.84	0.21	0.62	0.10	0.56	0.95	10
	Element	2540	2557	2541	2541	2540	2541	
CRB;100;1-2;C-D	D/C Ratio	1.00	0.16	0.30	0.03	1.01	0.48	16
	Element	2565	2565	2610	2564	2565	2679	
CRB;100;2-3;C-D	D/C Ratio	0.20	0.03	0.30	0.03	0.37	0.39	8
	Element	2749	2749	2748	2748	2789	2809	
CRB;100;3-4;C-D	D/C Ratio	0.15	0.04	0.12	0.02	0.52	0.44	10
	Element	2829	2899	2899	2899	2898	2899	
CRB;100;1-2;B-C	D/C Ratio	1.09	0.13	0.53	0.04	0.84	0.32	64
	Element	2566	2566	2566	2567	2573	2566	
CRB;100;2-3;B-C	D/C Ratio	0.25	0.03	0.19	0.03	0.66	0.35	32
	Element	2812	2750	2817	2816	2817	2816	
CRB;100;3-4;B-C	D/C Ratio	0.26	0.06	0.15	0.03	0.50	0.44	40
	Element	2837	2907	2900	2834	2835	2900	
CRB;100;1-2;A-B	D/C Ratio	0.47	0.03	0.38	0.03	0.83	0.47	48
	Element	2574	2574	2671	2740	2574	2694	
CRB;100;2-3;A-B	D/C Ratio	0.40	0.03	0.35	0.06	0.60	0.48	20
	Element	2822	2822	2763	2802	2822	2763	
CRB;100;3-4;A-B	D/C Ratio	0.28	0.06	0.18	0.03	0.58	0.35	14
	Element	2838	2908	2891	2890	2839	2838	

Table 3B-43: Element Averaging of East-West Reinforcement Exceedance - Control Building Slab at EL. 100'-0"

Average of Shell Elements 2566/2567: Design Check					
East-West Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	East-West Reinf. D/C Ratio
1.337	0.645	0.636	2.618	3.120	0.839
			E-W Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.21	2.42	0.087
North-South Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	North-South Reinf. D/C Ratio
0.602	0.645	0.302	1.549	3.120	0.496
			N-S Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.09	2.42	0.036
Shear Friction			**Code Check**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
1.783	6,686.1	OK	OK	28.1	0.540
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
2.518	9,442.8	OK		35.8	0.277

Table 3B-44: Element Averaging of XZ Plane Shear Exceedance - Control Building Slab at EL. 100'-0"

Average of Shell Elements 2565/2564: Design Check					
East-West Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	East-West Reinf. D/C Ratio
2.392	0.058	0.300	2.750	3.120	0.881
			E-W Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.35	2.42	0.145
North-South Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	North-South Reinf. D/C Ratio
0.446	0.058	0.227	0.731	3.120	0.234
			N-S Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.07	2.42	0.030
Shear Friction			**Code Check**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
0.728	2,730.2	FAIL†	OK	17.0	0.727
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
2.674	10,028.2	OK		37.5	0.248

Note:
† See text in Section 3B.3.3.2 and Table 3B-47.

Table 3B-45: Element Averaging of YZ Plane Shear Exceedance - Control Building Slab at EL. 100'-0"

Average of Shell Elements 2538/2542: Design Check					
East-West Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	East-West Reinf. D/C Ratio
2.148	1.538	0.865	4.551	6.240	0.729
			E-W Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.31	2.63	0.117
North-South Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	North-South Reinf. D/C Ratio
1.275	1.538	1.313	4.126	6.240	0.661
			N-S Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.21	2.63	0.081
Shear Friction			**Code Check**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
4.092	15,343.3	OK	OK	66.6	0.187
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
4.965	18,618.4	OK		74.8	0.601

Table 3B-46: Summary of D/C Ratios for Control Building Slab at EL. 100'-0" After Averaging Affected Elements

		Demand/Capacity Ratios						
Section		East-West Reinf.	E-W Comp. Stress	North-South Reinf.	N-S Comp. Stress	XZ-Plane Shear	YZ-Plane Shear	# Elems Checked
CRB;100;7-1;D-E	D/C Ratio	0.82	0.19	0.84	0.14	0.51	0.60	10
	Element	2543	2539	2538	2538	2539	2538	
CRB;100;1-2;D-E	D/C Ratio	0.96	0.17	0.38	0.03	0.80	0.50	55
	Element	2562	2562	2561	2718	2562	2649	
CRB;100;2-3;D-E	D/C Ratio	0.33	0.05	0.27	0.06	0.51	0.38	22
	Element	2742	2764	2764	2764	2764	2747	
CRB;100;3-4;D-E	D/C Ratio	0.17	0.03	0.09	0.02	0.53	0.30	25
	Element	2895	2824	2893	2827	2897	2827	
CRB;100;7-1;C-D	D/C Ratio	0.84	0.21	0.62	0.10	0.56	0.95	10
	Element	2540	2557	2541	2541	2540	2541	
CRB;100;1-2;C-D	D/C Ratio	0.84	0.16	0.30	0.03	0.73	0.48	16
	Element	2565	2565	2610	2564	2565	2679	
CRB;100;2-3;C-D	D/C Ratio	0.20	0.03	0.30	0.03	0.37	0.39	8
	Element	2749	2749	2748	2748	2789	2809	
CRB;100;3-4;C-D	D/C Ratio	0.15	0.04	0.12	0.02	0.52	0.44	10
	Element	2829	2899	2899	2899	2898	2899	
CRB;100;1-2;B-C	D/C Ratio	0.84	0.13	0.53	0.04	0.84	0.32	64
	Element	2566	2566	2566	2567	2573	2566	
CRB;100;2-3;B-C	D/C Ratio	0.25	0.03	0.19	0.03	0.66	0.35	32
	Element	2812	2750	2817	2816	2817	2816	
CRB;100;3-4;B-C	D/C Ratio	0.26	0.06	0.15	0.03	0.50	0.44	40
	Element	2837	2907	2900	2834	2835	2900	
CRB;100;1-2;A-B	D/C Ratio	0.47	0.03	0.38	0.03	0.83	0.47	48
	Element	2574	2574	2671	2740	2574	2694	
CRB;100;2-3;A-B	D/C Ratio	0.40	0.03	0.35	0.06	0.60	0.48	20
	Element	2822	2822	2763	2802	2822	2763	
CRB;100;3-4;A-B	D/C Ratio	0.28	0.06	0.18	0.03	0.58	0.35	14
	Element	2838	2908	2891	2890	2839	2838	

Note: The highlighted values of the D-C ratios for the corresponding element shown in this Table is based on the averaged demand values using methodology shown in Section 3B.1.1.1. It should be noted that the D-C ratios of all other elements shown in this Table will be proportionally reduced if the same averaging methodology is used.

Table 3B-47: Element Averaging of Shear Friction Exceedance for Control Building Slab at EL. 100′-0″

Average of Shell Elements 2566/2567: Design Check					
East-West Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	East-West Reinf. D/C Ratio
1.337	0.645	0.636	2.618	3.120	0.839
			E-W Membrane Comp. Stress f_{xx} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.21	2.42	0.087
North-South Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total A_s (in^2)	A_s Provided (in^2)	North-South Reinf. D/C Ratio
0.602	0.645	0.302	1.549	3.120	0.496
			N-S Membrane Comp. Stress f_{yy} (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			0.09	2.42	0.036
Shear Friction			**Code Check**	**OOP Shear**	
XZ-Plane Shear-Friction A_{vfx} (in^2)	$\phi_v V_{nx} = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
1.783	6,686.1	OK	OK	28.1	0.540
YZ-Plane Shear-Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
2.518	9,442.8	OK		35.8	0.277

Table 3B-48: Summary of D/C Ratios for Control Building Pilasters on Grid Line 1 Wall

Section		Demand/Capacity Ratios				
		Moment Axis 3	Shear Axis 2	Compression	Tension	# Elems Checked
CRB;PI;1C;50-63	D/C Ratio	0.50	0.33	0.06	0.06	3
	Element	245	2	245	646	
CRB;PI;1B;50-76	D/C Ratio	0.62	0.95	0.06	0.04	5
	Element	647	667	246	667	
CRB;PI;1C;63-76	D/C Ratio	0.15	0.12	0.02	0.07	2
	Element	666	666	656	666	
CRB;PI;1C;76-100	D/C Ratio	0.41	0.24	0.02	0.09	4
	Element	696	706	706	696	
CRB;PI;1B;76-100	D/C Ratio	0.52	0.84	0.03	0.04	4
	Element	697	677	677	677	
CRB;PI;1C;100-120	D/C Ratio	0.51	0.32	0.03	0.08	3
	Element	821	801	801	801	
CRB;PI;1B;100-120	D/C Ratio	0.67	0.39	0.02	0.02	3
	Element	822	812	822	802	

Table 3B-49: Summary of D/C Ratios for Control Building T-Beams on EL. 120'-0" Slab

Demand/Capacity Ratios						
Section		**Moment Axis 3**	**Shear Axis 2**	**Compression**	**Tension**	**# Elems Checked**
CRB;TB;120;D-E;1-2(1)	D/C Ratio	0.32	0.17	0.00	0.02	7
	Element	850	854	852	853	
CRB;TB;120;D-E;1-2(2)	D/C Ratio	0.27	0.16	0.00	0.01	7
	Element	879	879	874	874	
CRB;TB;120;1-3;C-C	D/C Ratio	0.45	0.19	0.00	0.01	12
	Element	830	830	886	904	
CRB;TB;120;1-3;B-C(2)	D/C Ratio	0.59	0.21	0.00	0.01	12
	Element	868	837	843	831	
CRB;TB;120;1-3;B-C(1)	D/C Ratio	0.77	0.25	0.00	0.01	12
	Element	869	838	844	832	
CRB;TB;120;1-3;B-B	D/C Ratio	0.75	0.45	0.01	0.01	12
	Element	833	833	833	833	
CRB;TB;120;1-3;A-B(2)	D/C Ratio	0.58	0.21	0.01	0.05	12
	Element	871	914	914	914	
CRB;TB;120;1-3;A-B(1)	D/C Ratio	0.30	0.25	0.02	0.11	11
	Element	872	909	909	909	

Table 3B-50: Element Averaging of IP Shear Exceedance of Reactor Building Wall at Grid Line 3

Element		Length (in)	Thickness (in)	Shell Sxy (kip/in)	IP Shear Demand (kip)	f_c' (psi)	IP Shear Capacity $\phi_v 8A_{cv}\sqrt{f_c'}$ (kip)
Shell	4942	46.5	60	81.53	3791.2	5000	1183.7
Shell	4943	46.5	60	20.73	964.2	5000	1183.7
Shell	4944	53	60	9.86	522.8	5000	1349.2
Shell	4945	37	60	7.16	264.9	5000	941.9
Shell	4946	37	60	6.07	224.6	5000	941.9
Shell	4947	37	60	5.77	213.5	5000	941.9
Shell	4948	55	60	6.37	350.5	5000	1400.1
Shell	4949	52.5	60	10.17	533.9	5000	1336.4
Shell	4950	44.25	60	25.91	1146.4	5000	1126.4
Shell	4951	44.25	60	69.39	3070.5	5000	1126.4
				Sum =	11082.6	<	11531.5

Table 3B-51: Element Averaging of Shear Friction Exceedance of Reactor Building Wall at Grid Line 3

Average of Shell Elements 4951/4431/4421: Design Check					
Horizontal Reinforcement (Local X)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total As (in^2)	As Provided (in^2)	Horizontal Reinf. D/C Ratio
11.416	7.563	1.938	20.917	28.080	0.745
			Horiz. Membrane Comp. Stress fxx (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			1.39	3.34	0.416
Vertical Reinforcement (Local Y)					
Membrane Tension A_{s1} (in^2)	In-Plane Shear A_{s2} (in^2)	OOP Moment A_{s3} (in^2)	Total As (in^2)	As Provided (in^2)	Vertical Reinf. D/C Ratio
9.867	7.563	0.821	18.251	28.080	0.650
			Vertical Membrane Comp. Stress fyy (ksi)	Membrane Compression Strength (ksi)	Membrane Compression Stress D/C Ratio
			1.15	3.34	0.345
Shear Friction			**IP Shear**	**OOP Shear**	
XZ-Plane Shear- Friction Avfx (in2)	$\mu vVnx = \phi_v A_{vfx} f_y \mu$ (lb)	$Sxy < \phi_v V_{nx}$?	$Sxy < \phi_v V_{in\text{-}plane}$?	XZ-Plane Shear Capacity (kip)	XZ-Plane D/C Ratio
16.664	36,000.0	OK	OK	129.8	0.374
YZ-Plane Shear- Friction A_{vfy} (in^2)	$\phi_v V_{ny} = \phi_v A_{vfy} f_y \mu$ (lb)	$Sxy < \phi_v V_{ny}$?		YZ-Plane Shear Capacity (kip)	YZ-Plane D/C Ratio
18.213	36,000.0	OK		129.8	0.162

Table 3B-52: Analysis Cases for NuScale Power Modules

Run Case ID	Ground Motion Seed	Soil Type	NPM Module	Concrete Section	NPM Module Stiffness
1	Capitola	7	1	Cracked	Nominal
2	Capitola	7	1	Uncracked	Nominal
3	Capitola	7	6	Cracked	Nominal
4	Capitola	7	6	Uncracked	Nominal
5	Capitola	7	1	Cracked	Reduced (Scaled to 77%)
6	Capitola	7	6	Cracked	Reduced (Scaled to 77%)

Table 3B-53: Strength Reduction Factors for Reinforced Concrete Design

Strength Reduction Factor	Value
Tension controlled	ϕ_m=0.9
Compression controlled (without spiral)	ϕ_c=0.65
Shear and torsion	ϕ_v=0.75

Table 3B-54: RXB Critical Sections

Structure Type	Location	Figure Reference	Critical Dimension*
Walls			
	Wall at grid line 1 - West outer perimeter wall at foundation level	3B-8, 3B-9	5'-0"
	Wall at grid line 3 - Interior weir wall	3B-11, 3B-12	5'-0"
	Wall at grid line 3 - Interior upper stiffener	3B-11, 3B-13	4'-0"
	Wall at grid line 4 - Interior wall of RXB	3B-15, 3B-16	5'-0"
	Wall at grid line 4 - Interior wall of RXB	3B-15, 3B-17	4'-0"
	Wall at grid line 6 - Upper stiffener wall	3B-19, 3B-20	4'-0"
	Wall at grid line 6 - Pool wall	3B-19, 3B-21	5'-0"
	Wall at grid line 6 - Pool wall	3B-19, 3B-21	7'-6"
	Wall at grid line E - South exterior wall extending upward from foundation level	3B-23, 3B-24	5'-0"
Slabs			
	Slab at EL. 100'-0" - Slab at grade	3B-29, 3B-27	3'-0"
	Slab at EL. 181'-0" - Slab at roof	3B-29, 3B-30	4'-0"
Pilasters			
	Pilasters at grid line A	3B-32, 3B-33, 3B-34, 3B-35, 3B-36	5'-0"
Beams			
	Beam at EL. 75'-0"	3B-38, 3B-39	2'-0"
Buttresses			
	Buttress at EL. 126'-0"	3B-41	5'-0"
NPM Bay			
	West wing wall	3B-43, 3B-44	5'-0"
	Pool wall	3B-46, 3B-47	5'-0"

*Dimensions shall be acceptable if found within the tolerances specified in ACI 117-06

Table 3B-55: CRB Critical Sections

Structure Type	Location	Figure Reference	Critical Dimension*
Walls			
	Wall at grid line 3 - Interior structural wall	3B-66, 3B-67	2'-0"
	Wall at grid line 4 - East exterior structural wall	3B-69, 3B-70	3'-0"
	Wall at grid line A - North exterior structural wall	3B-72, 3B-73	3'-0"
Slabs			
	Basemat foundation	3B-75, 3B-76	5'-0"
	Slab at EL. 100'-0" - Slab at grade	3B-78, 3B-79	3'-0"
	Slab at EL. 100'-0" - Slab at grade	3B-78, 3B-79	2'-0"
Pilasters			
	Pilasters at grid line 1	3B-81, 3B-82	3'-0"
T-Beams			
	T-Beam at EL. 120'-0"	3B-84, 3B-85	3'-0"
	T-Beam at EL. 120'-0"	3B-84, 3B-85	2'-0"

*Dimensions shall be acceptable if found within the tolerances specified in ACI 117-06

Figure 3B-1: Whitney Rectangular Stress Block

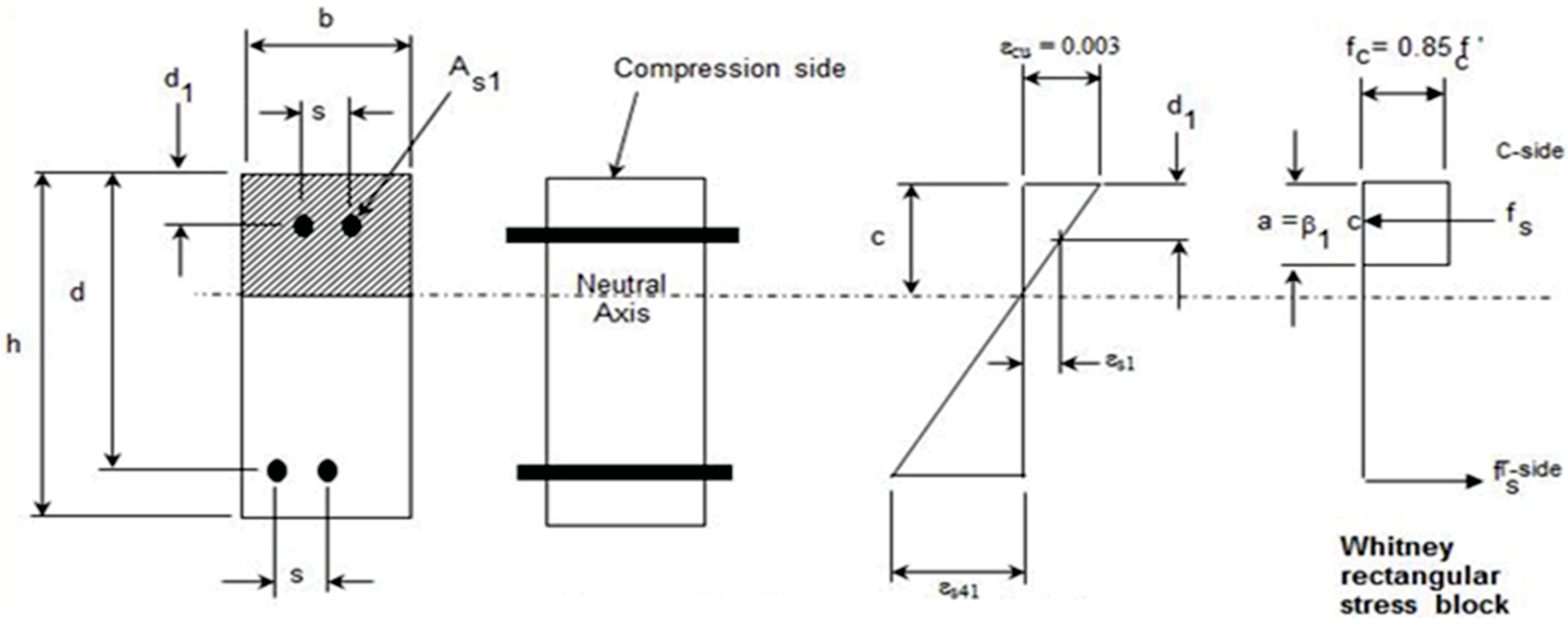


Figure 3B-2: SAP2000 Membrane and Sheer Force Definition

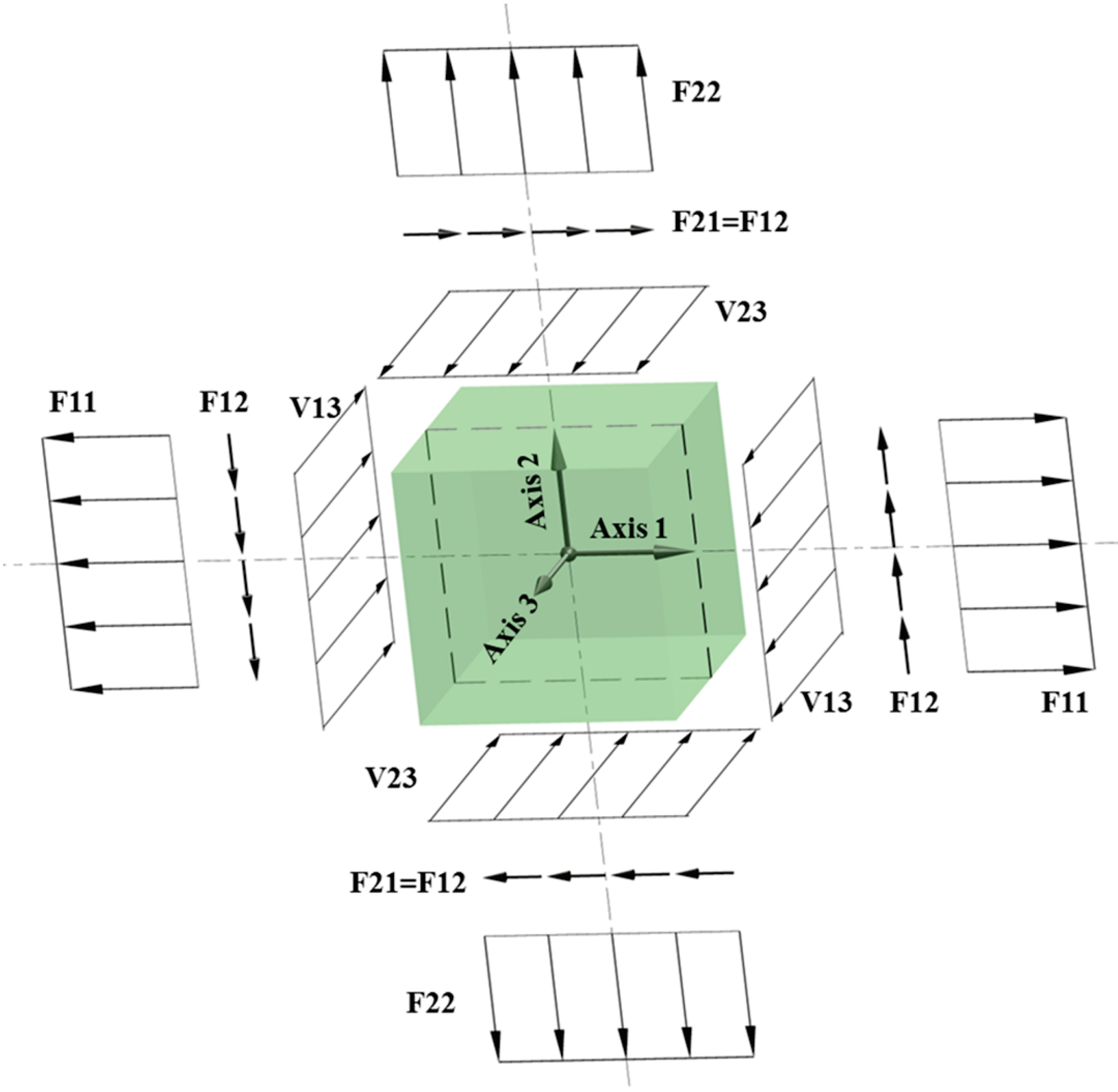


Figure 3B-3: SAP2000 Bending Moment Definition

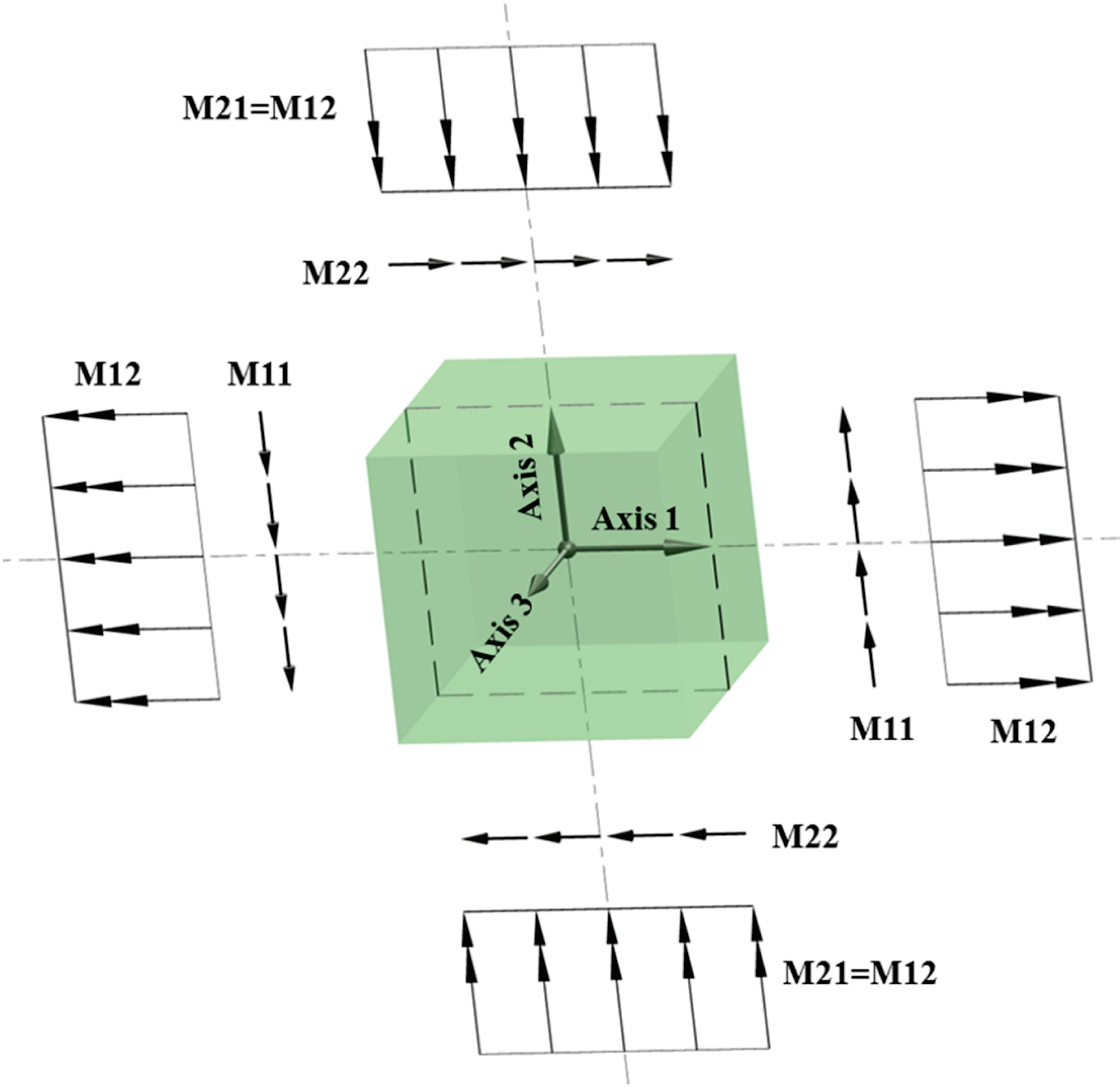


Figure 3B-4: SASSI2010 Membrane, Shear Force, and Bending Moment Definitions

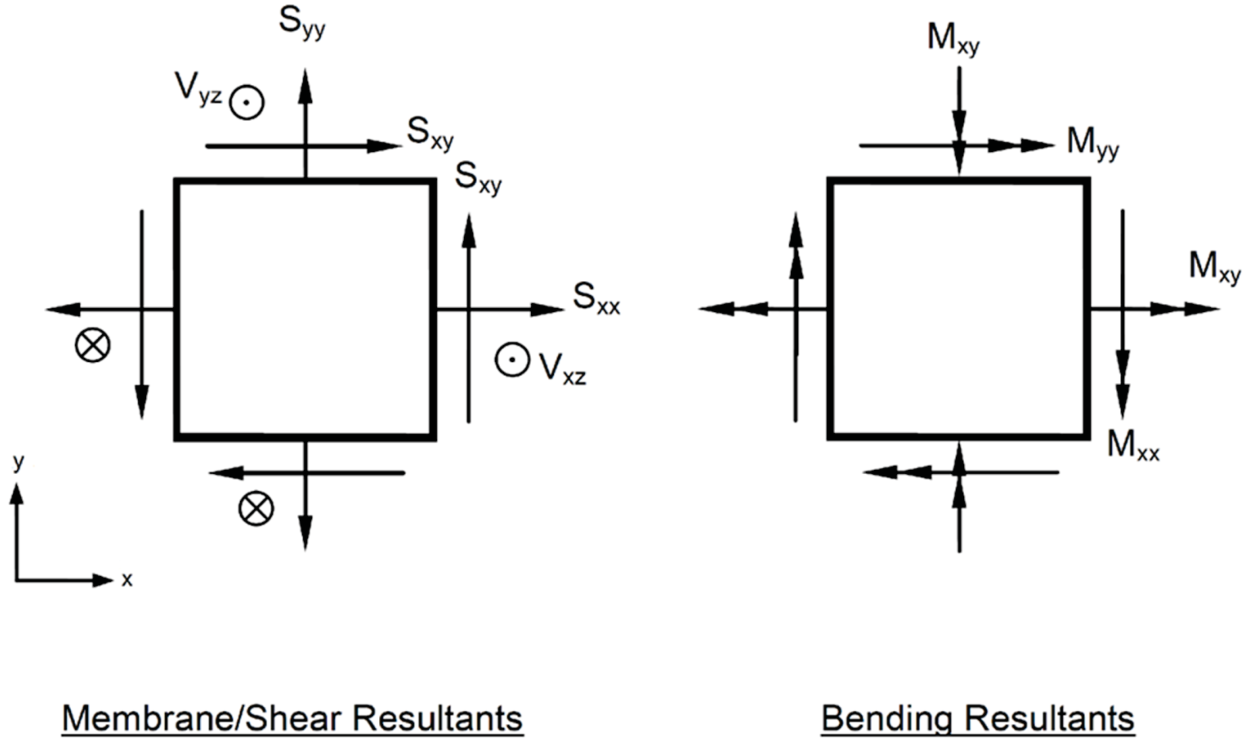
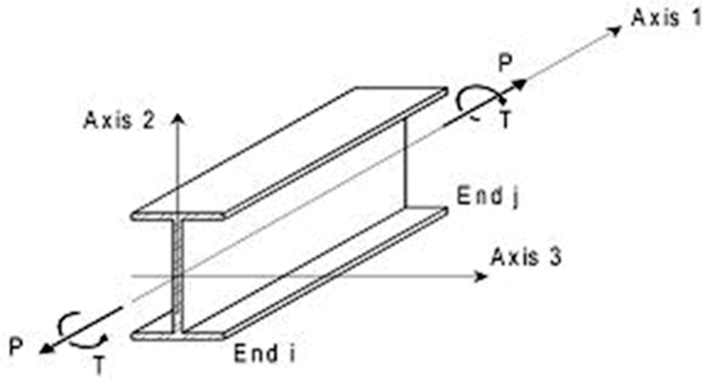
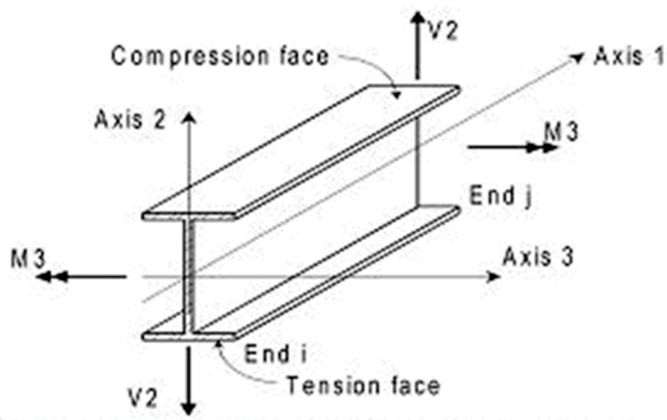


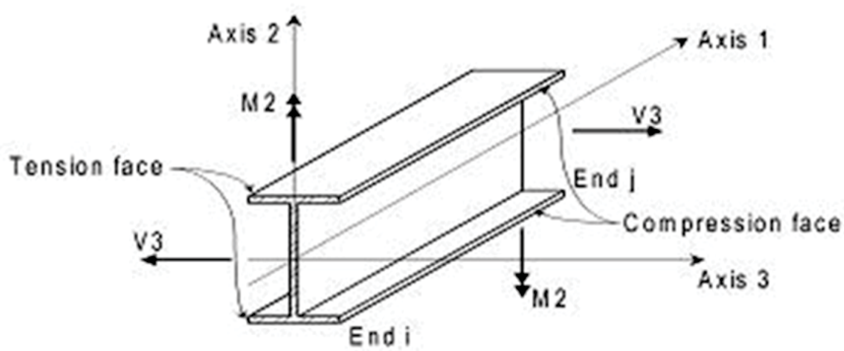
Figure 3B-5: SAP2000 Frame Element Results Definition



a. Positive Axial Force and Torque



b. Positive Moment and Shear in the 1-2 Plane



c. Positive Moment and Shear in the 1-3 Plane

Figure 3B-6: SASSI2010 Frame Element Results Definition

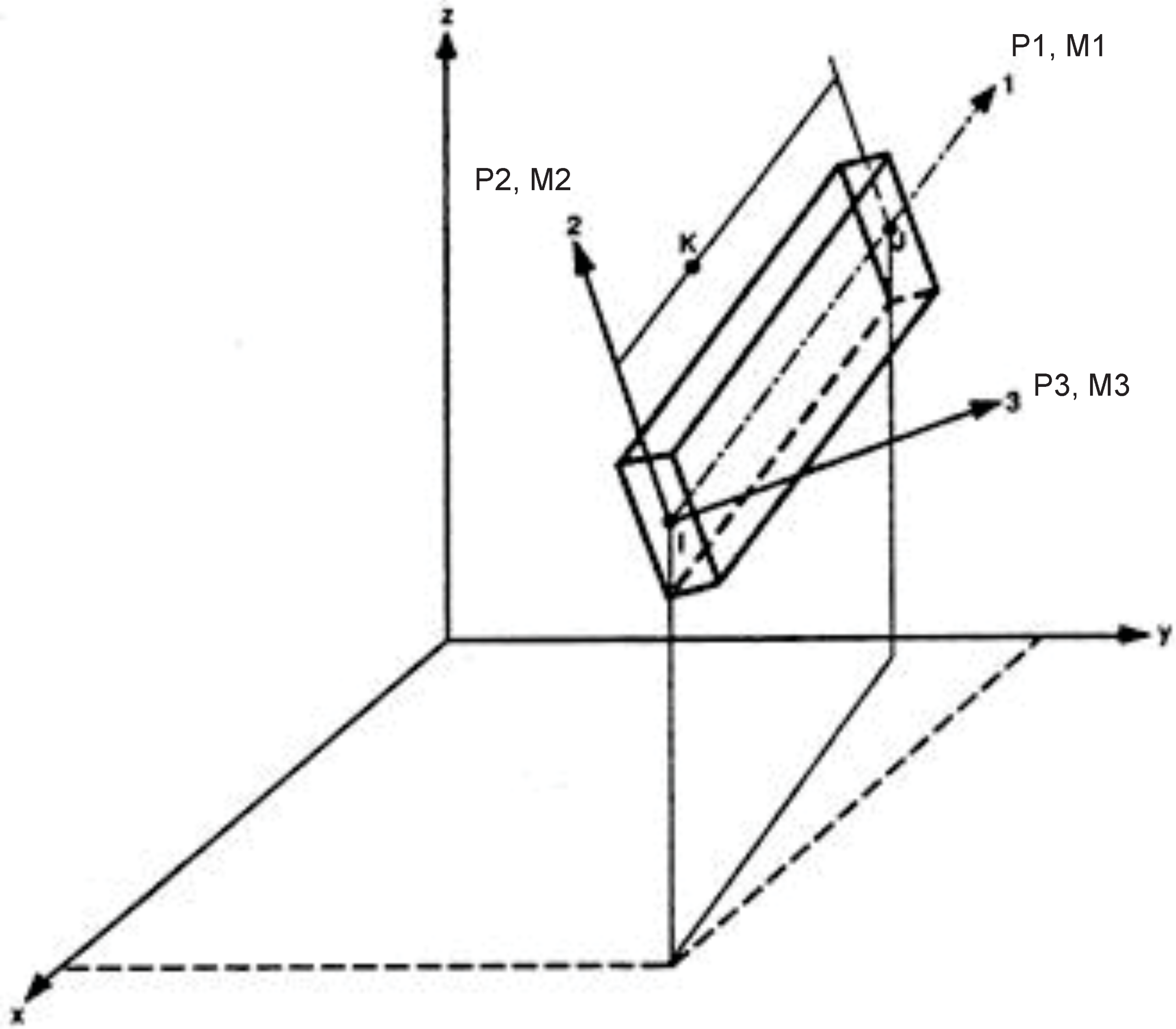


Figure 3B-7: SAP2000 Elevation View and Shell Element Numbers at RXB Grid Line 1 (Looking West)

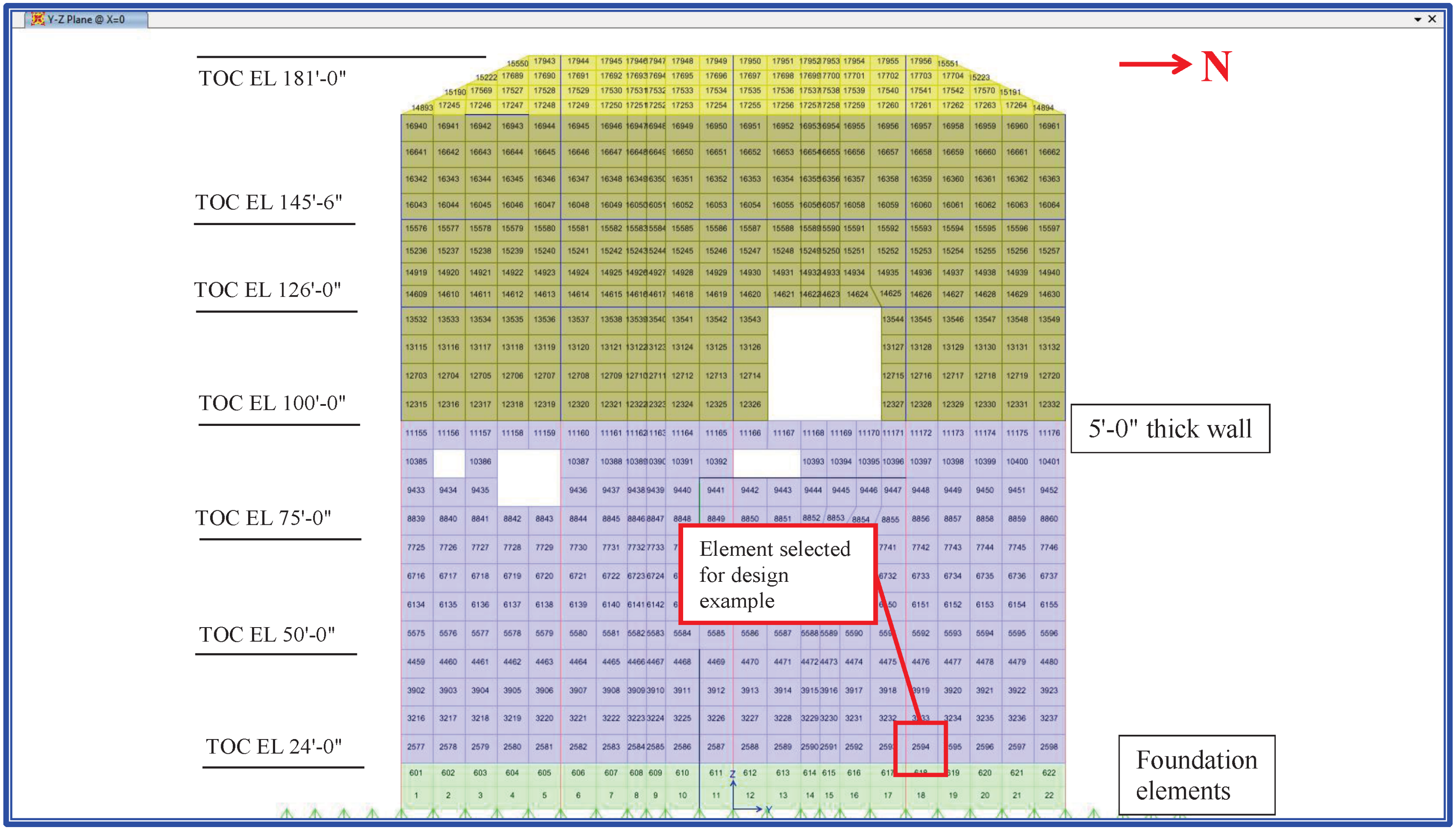


Figure 3B-8: RXB Reinforcement Elevation at Grid Line 1 Wall

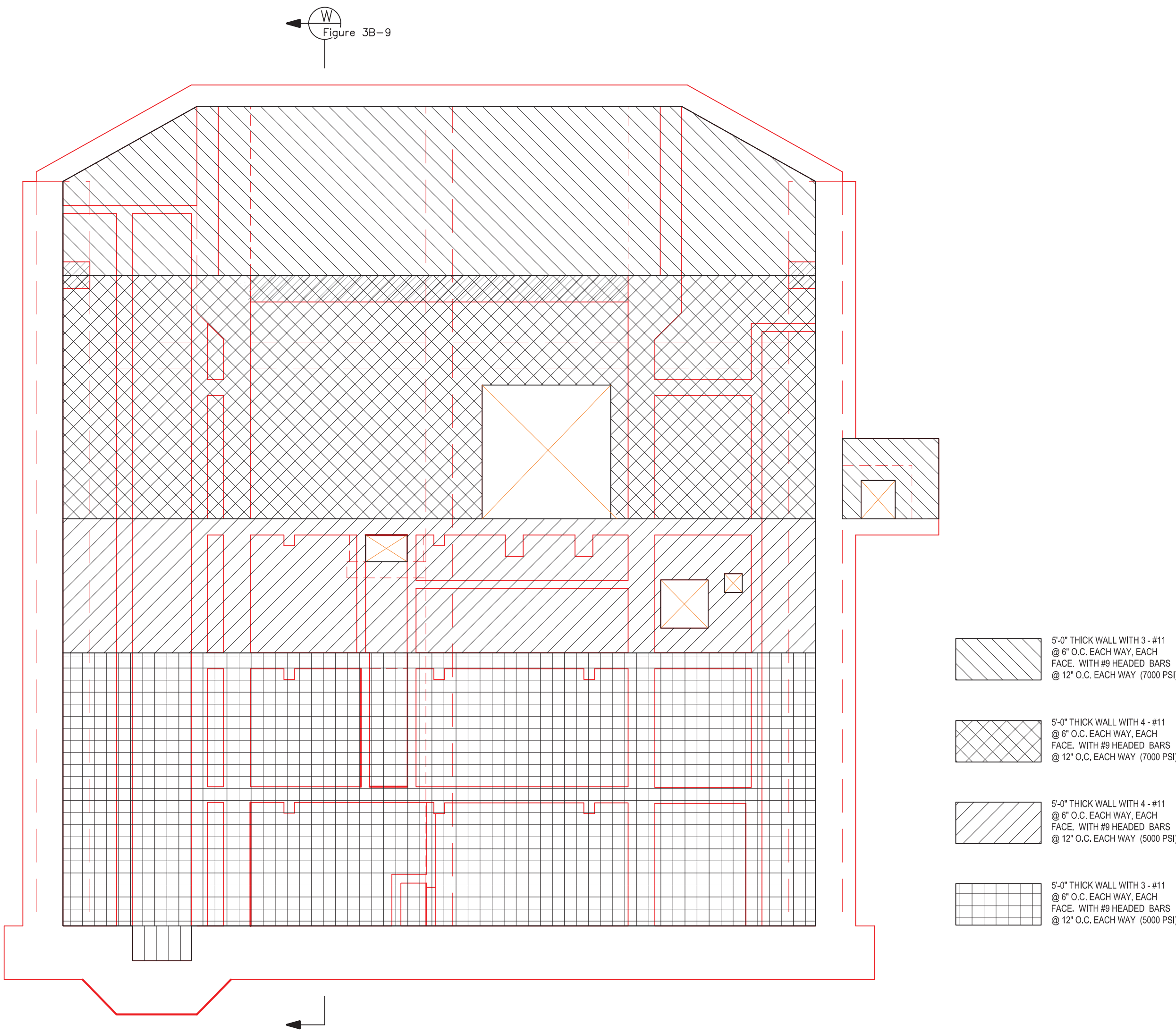


Figure 3B-9: RXB Reinforcement Section View of Wall on Grid Line 1

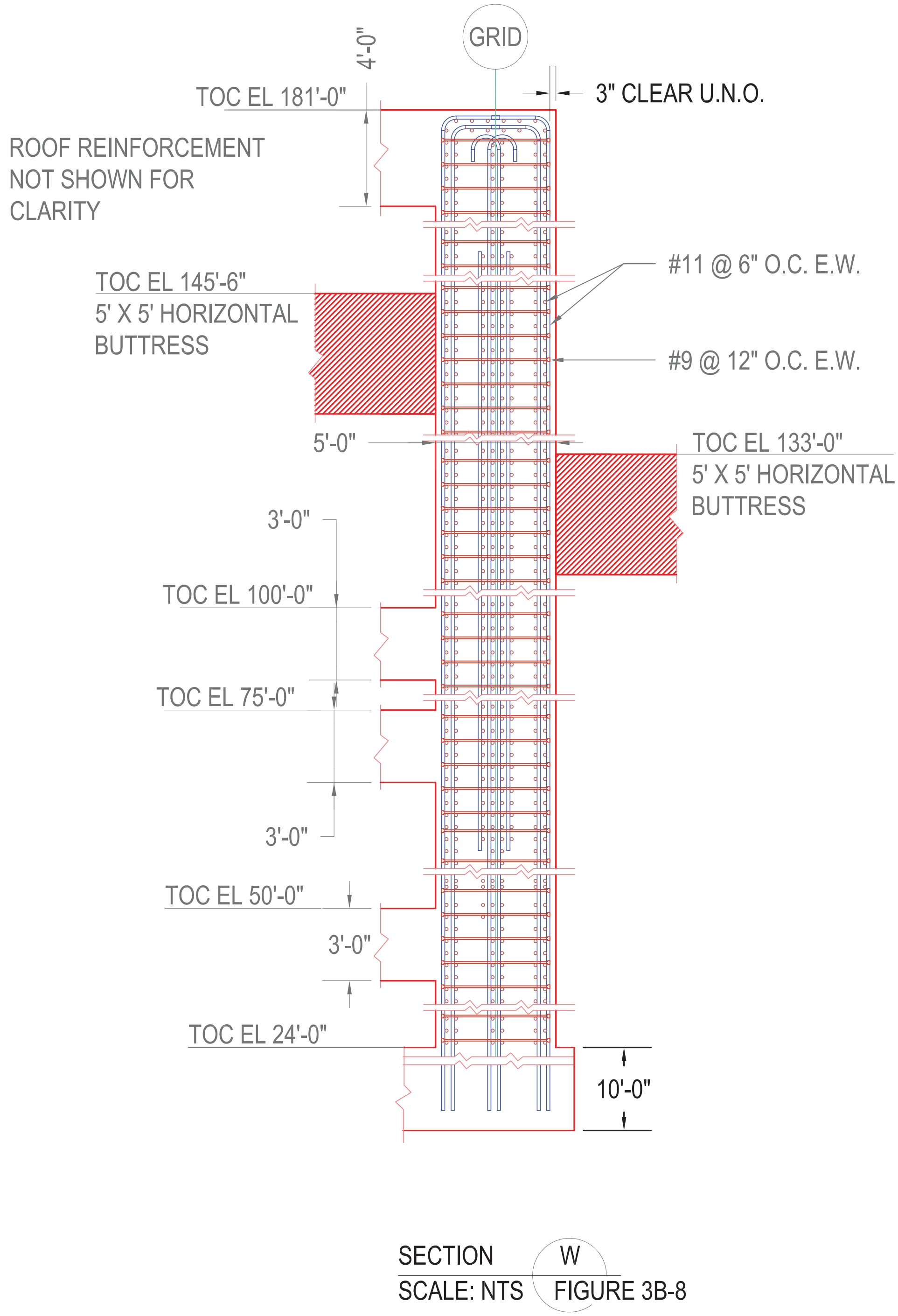


Figure 3B-10: SAP2000 Elevation View and Shell Element Numbers at RXB Grid Line 3 (Looking West)

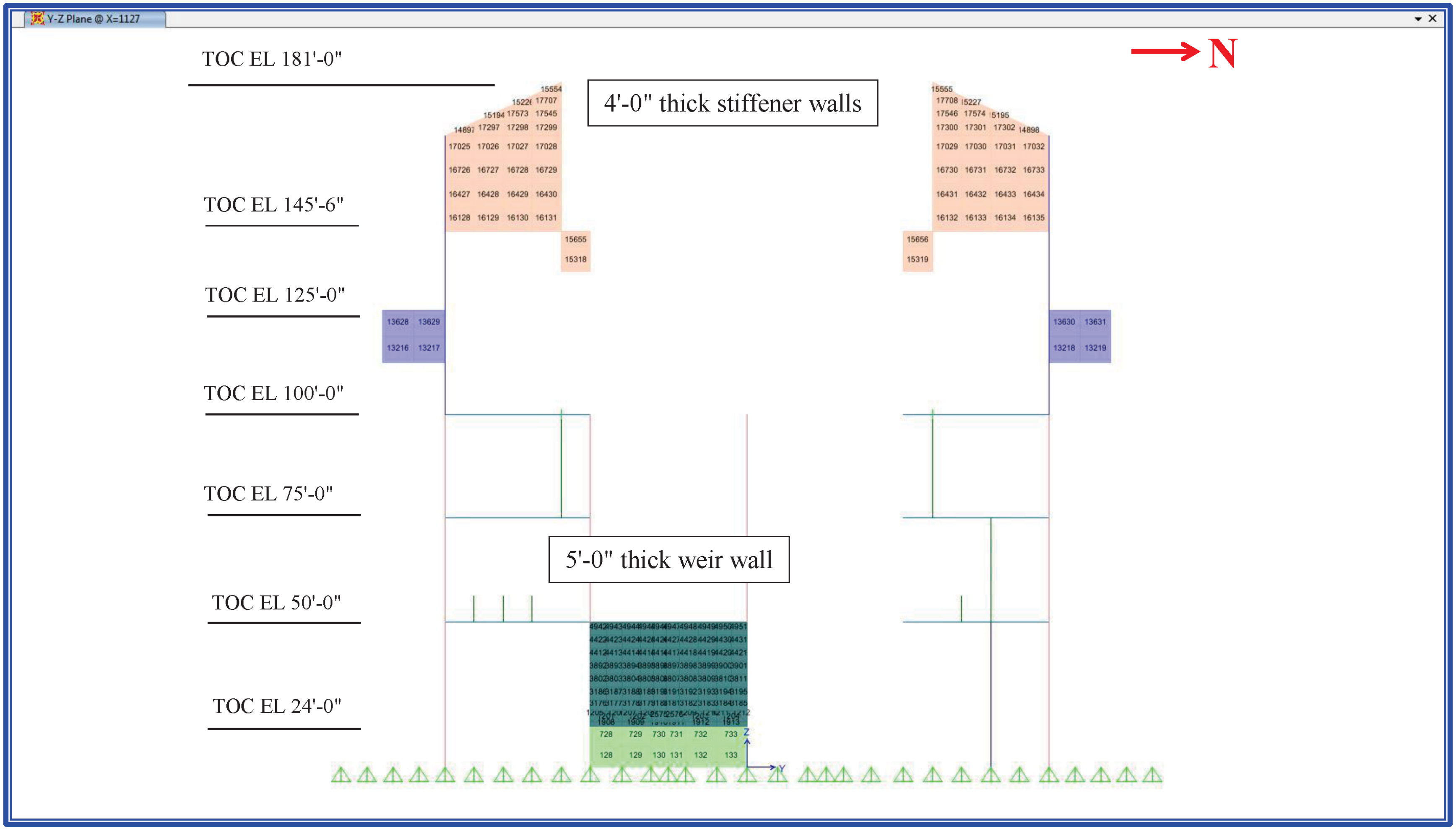


Figure 3B-11: RXB Reinforcement Elevation at Grid Line 3 Wall

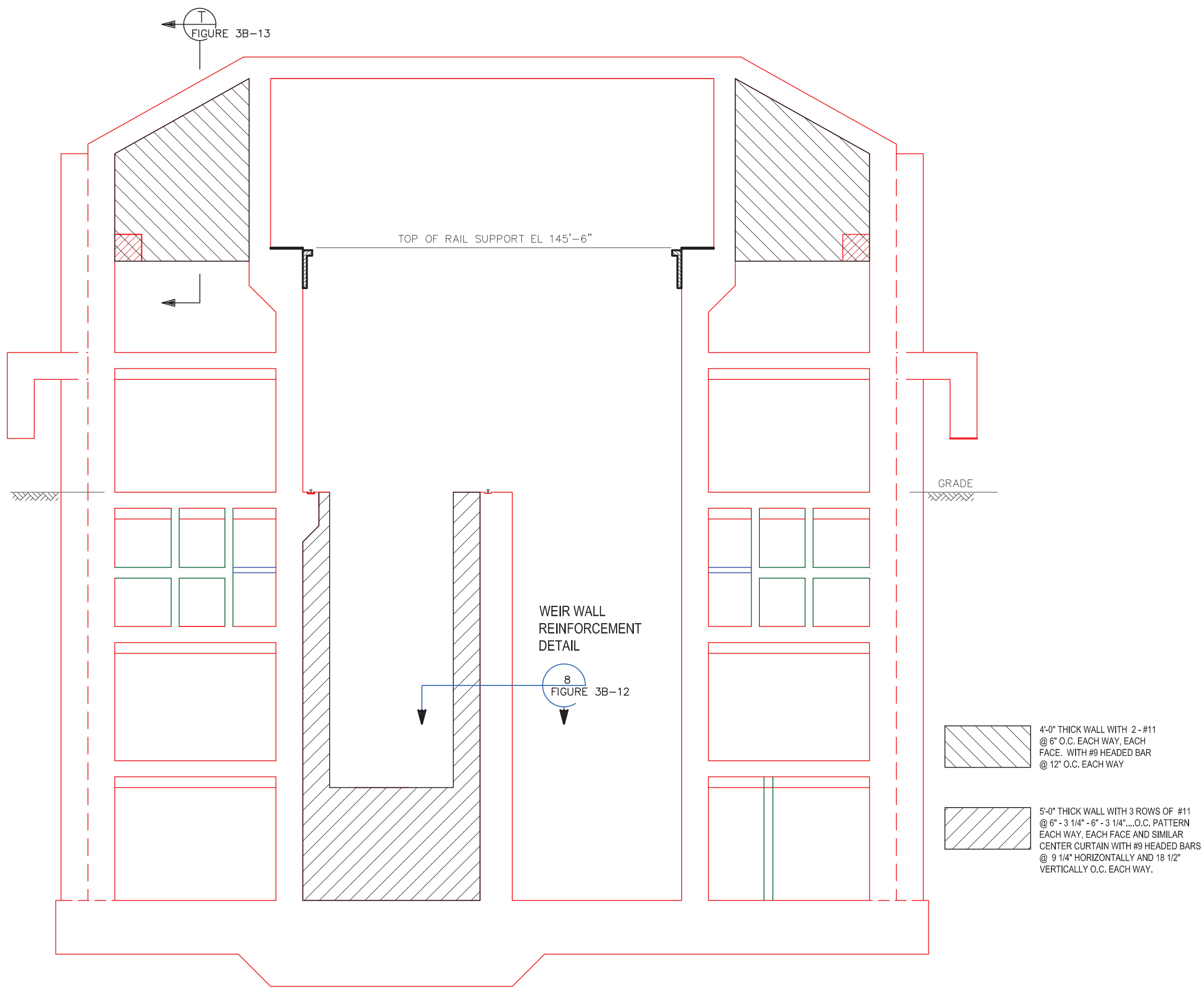


Figure 3B-12: RXB Reinforcement Section View of Pool Weir Wall on Grid Line 3

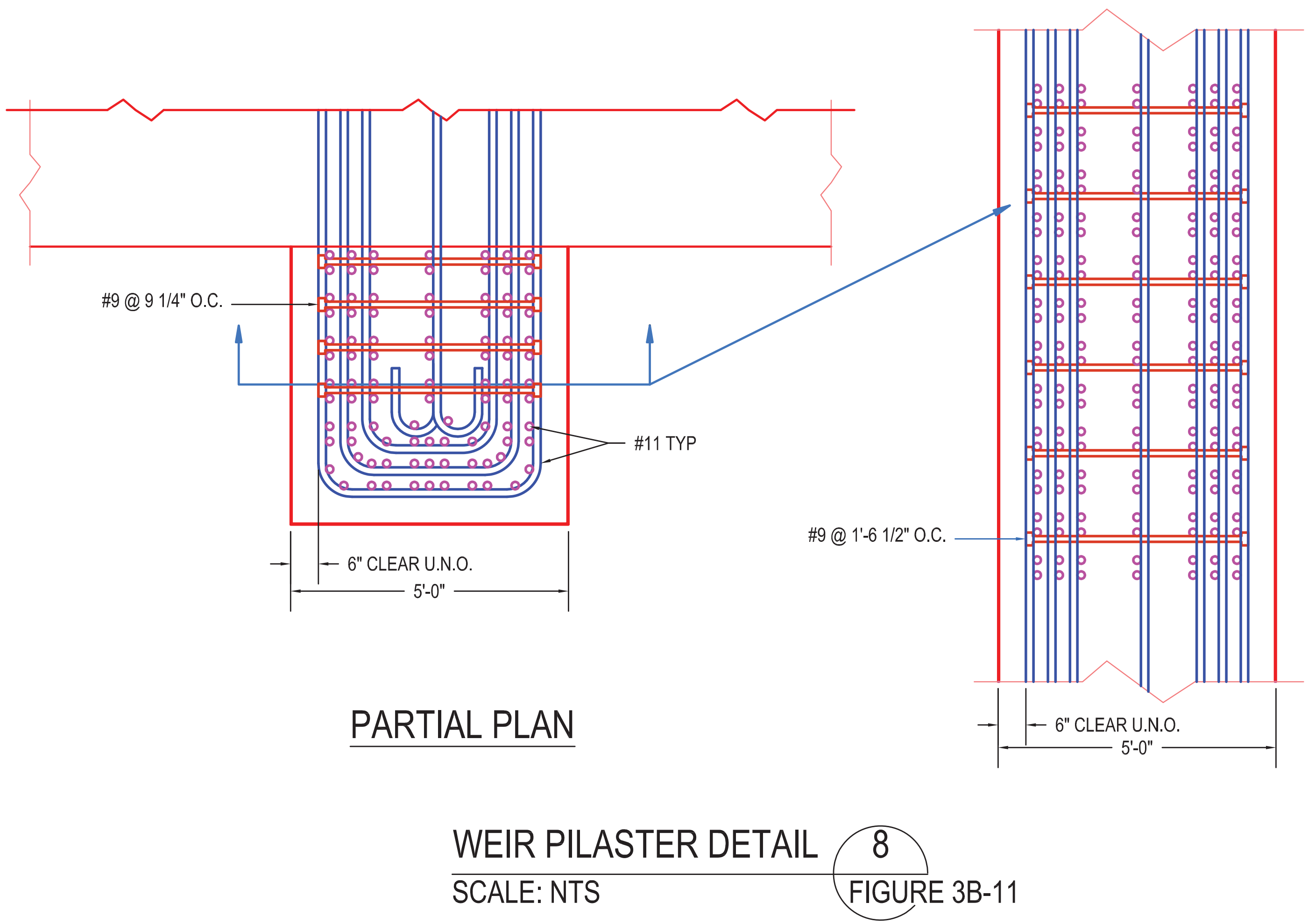


Figure 3B-13: RXB Reinforcement Section View of Stiffener Wall on Grid Line 3

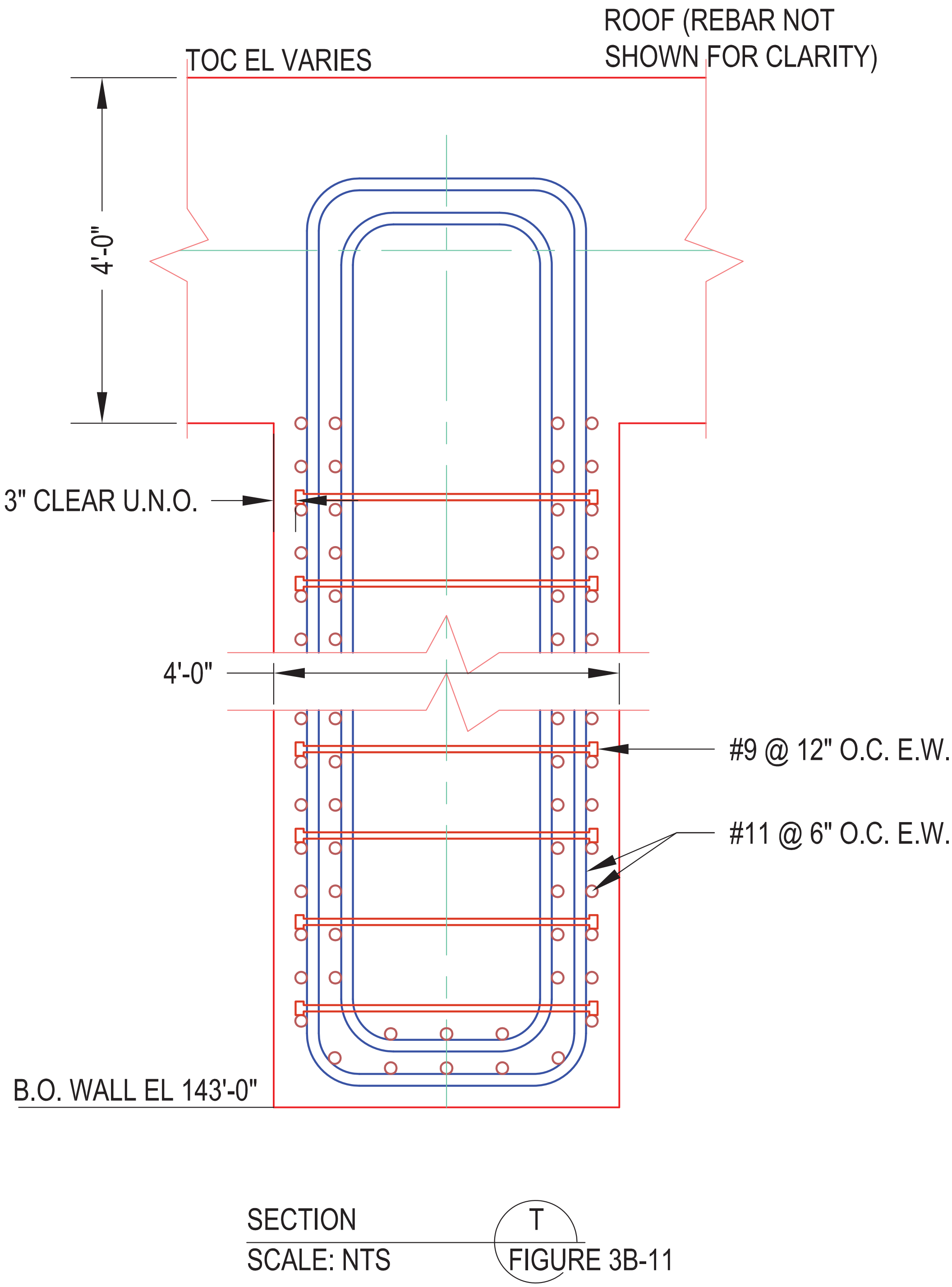


Figure 3B-14: SAP2000 Elevation View and Shell Element Numbers at RXB Grid Line 4 (Looking West)

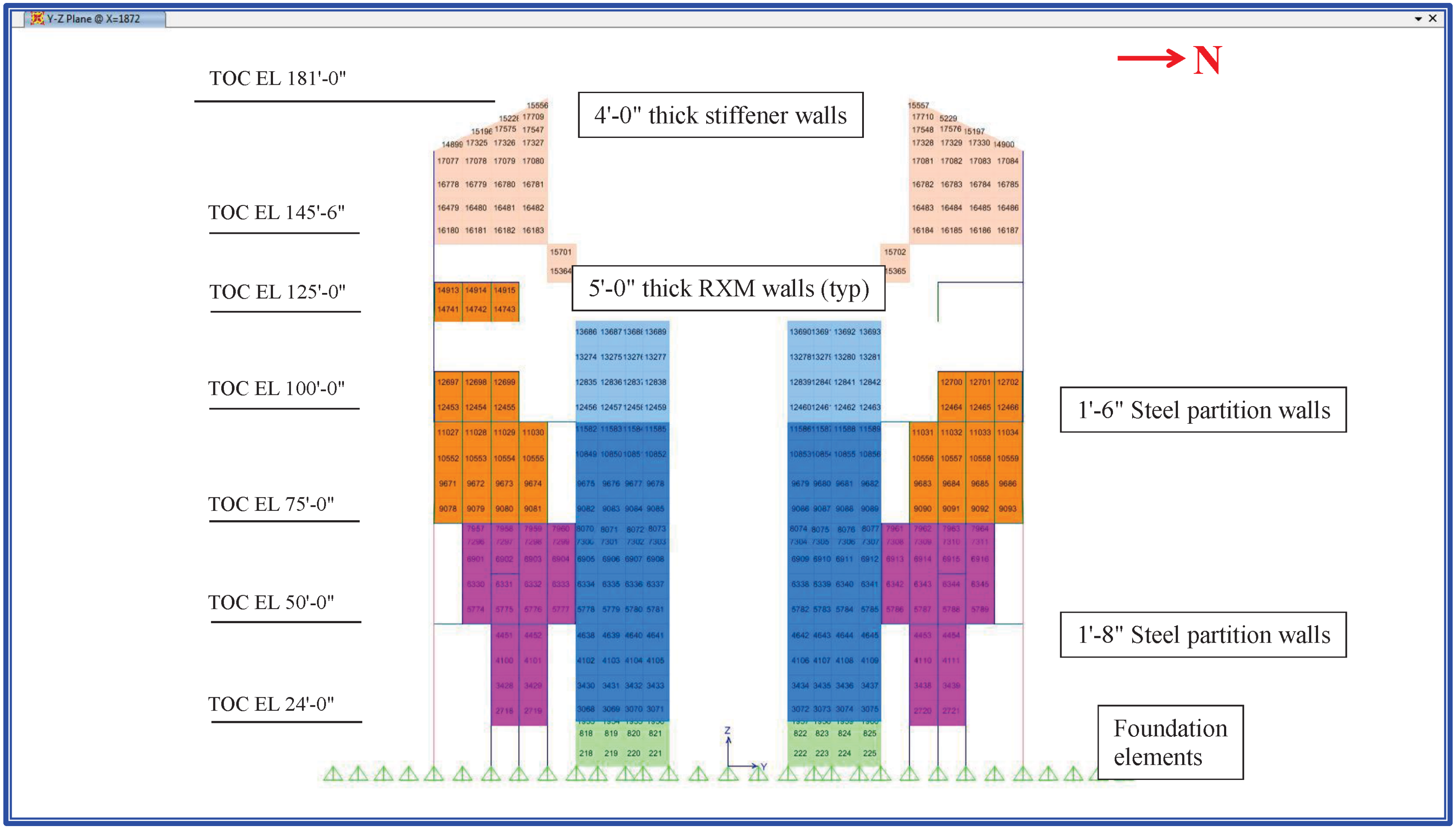


Figure 3B-15: RXB Reinforcement Elevation at Grid Line 4 Wall

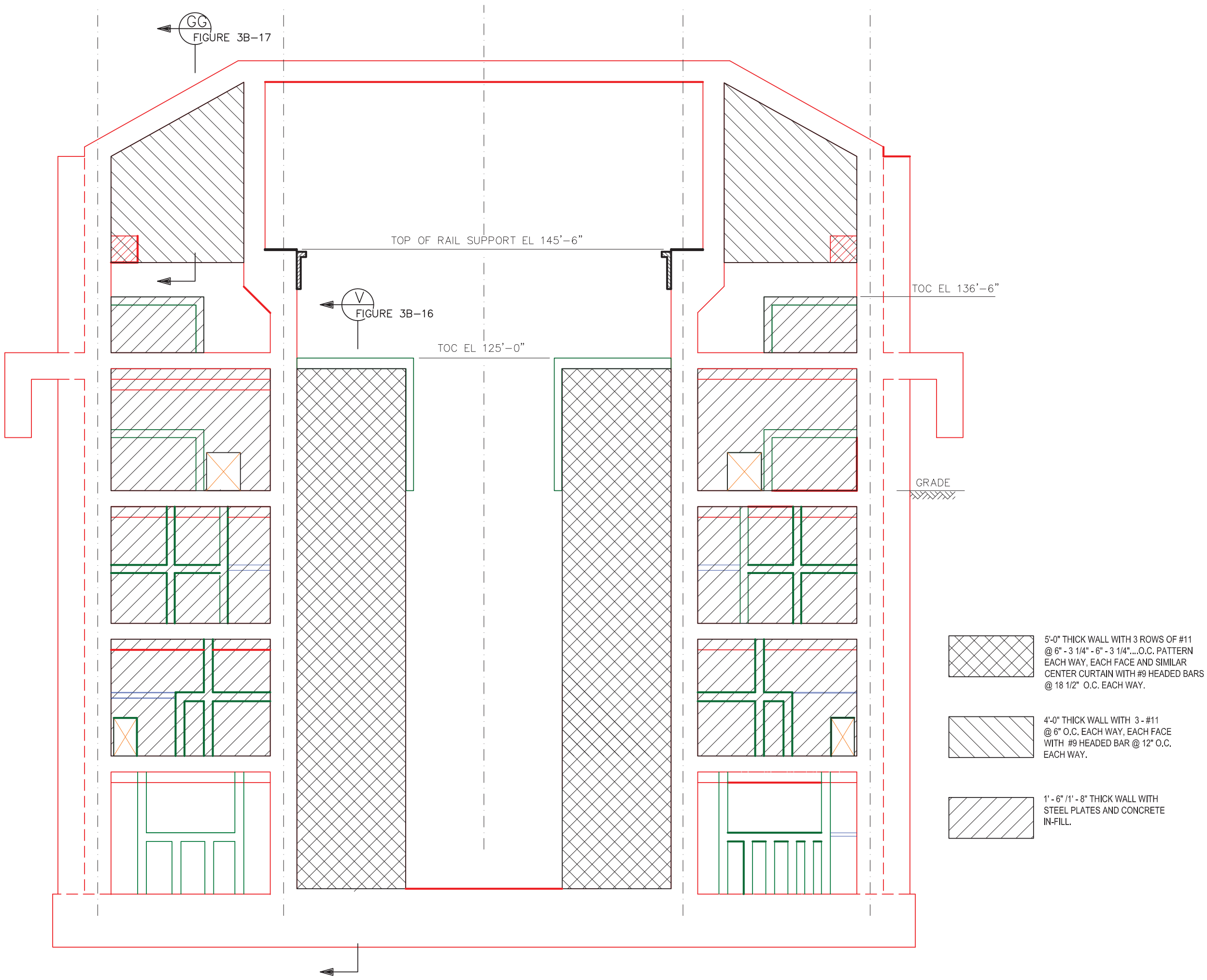


Figure 3B-16: RXB Reinforcement Section View of 5 ft Thick Wall on Grid Line 4

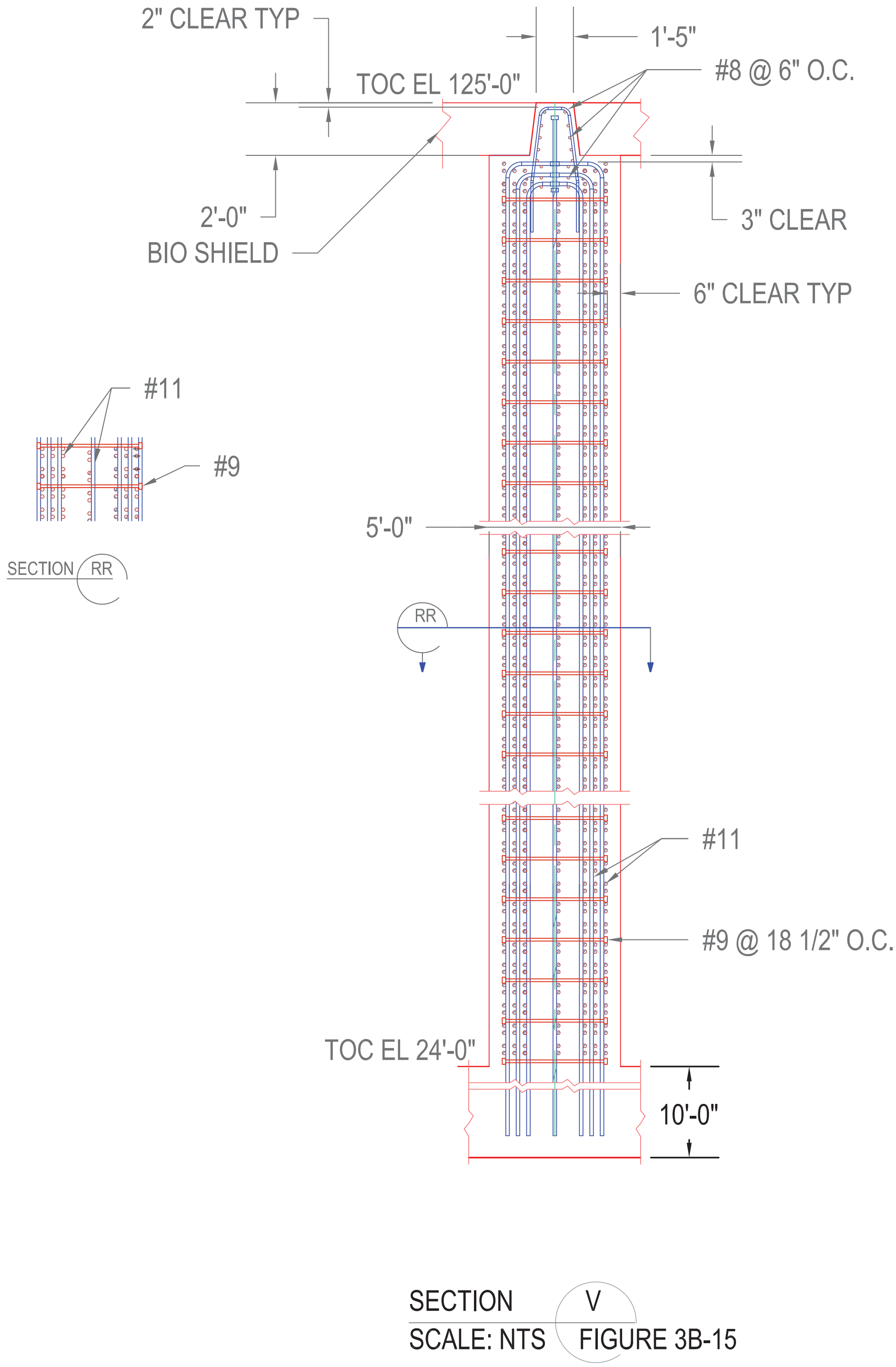


Figure 3B-17: RXB Reinforcement Section View of 4 ft Thick Wall on Grid Line 4

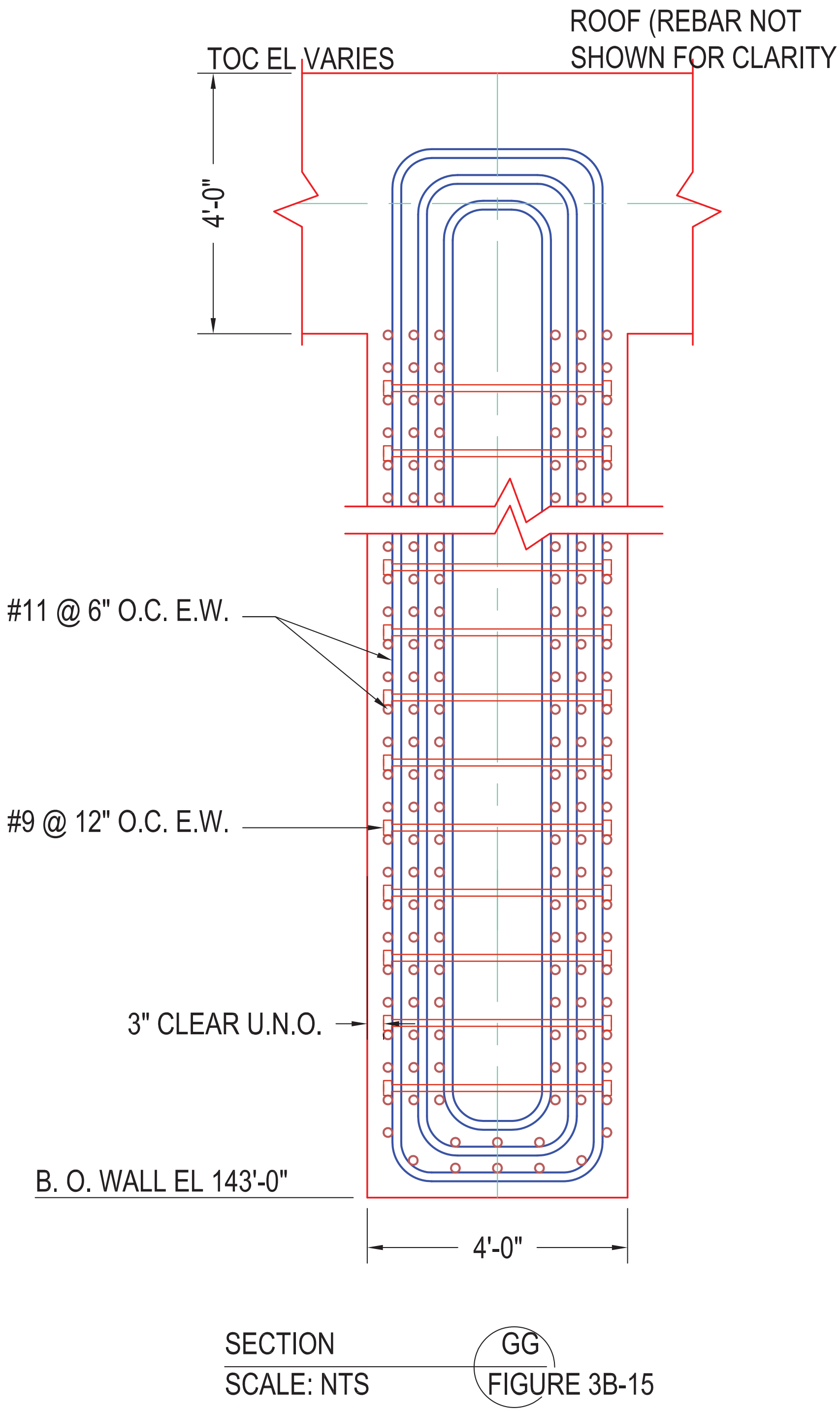


Figure 3B-18: SAP2000 Elevation View and Shell Element Numbers at RXB Grid Line 6 (Looking West)

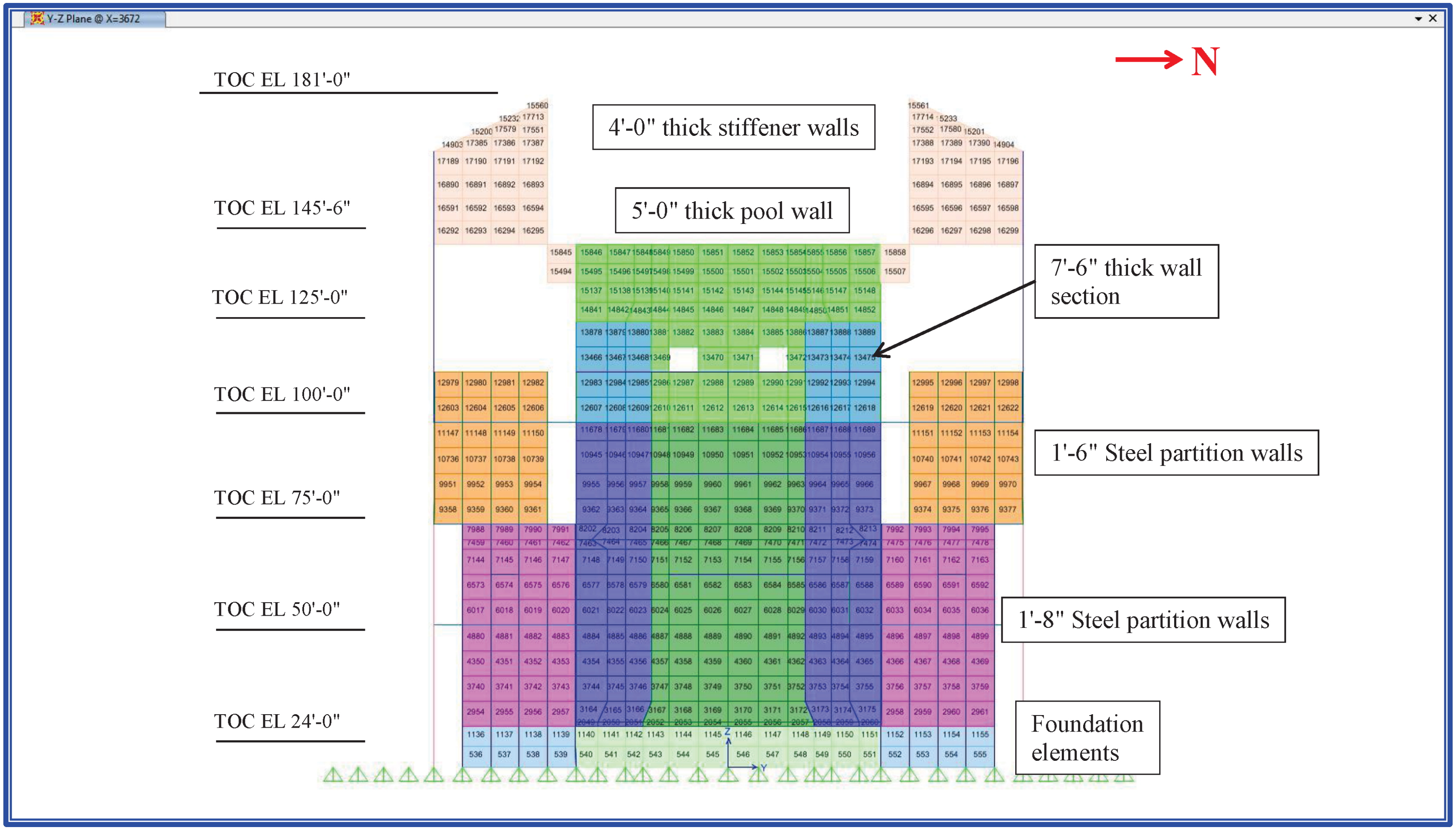


Figure 3B-19: RXB Reinforcement Elevation at Grid Line 6 Wall

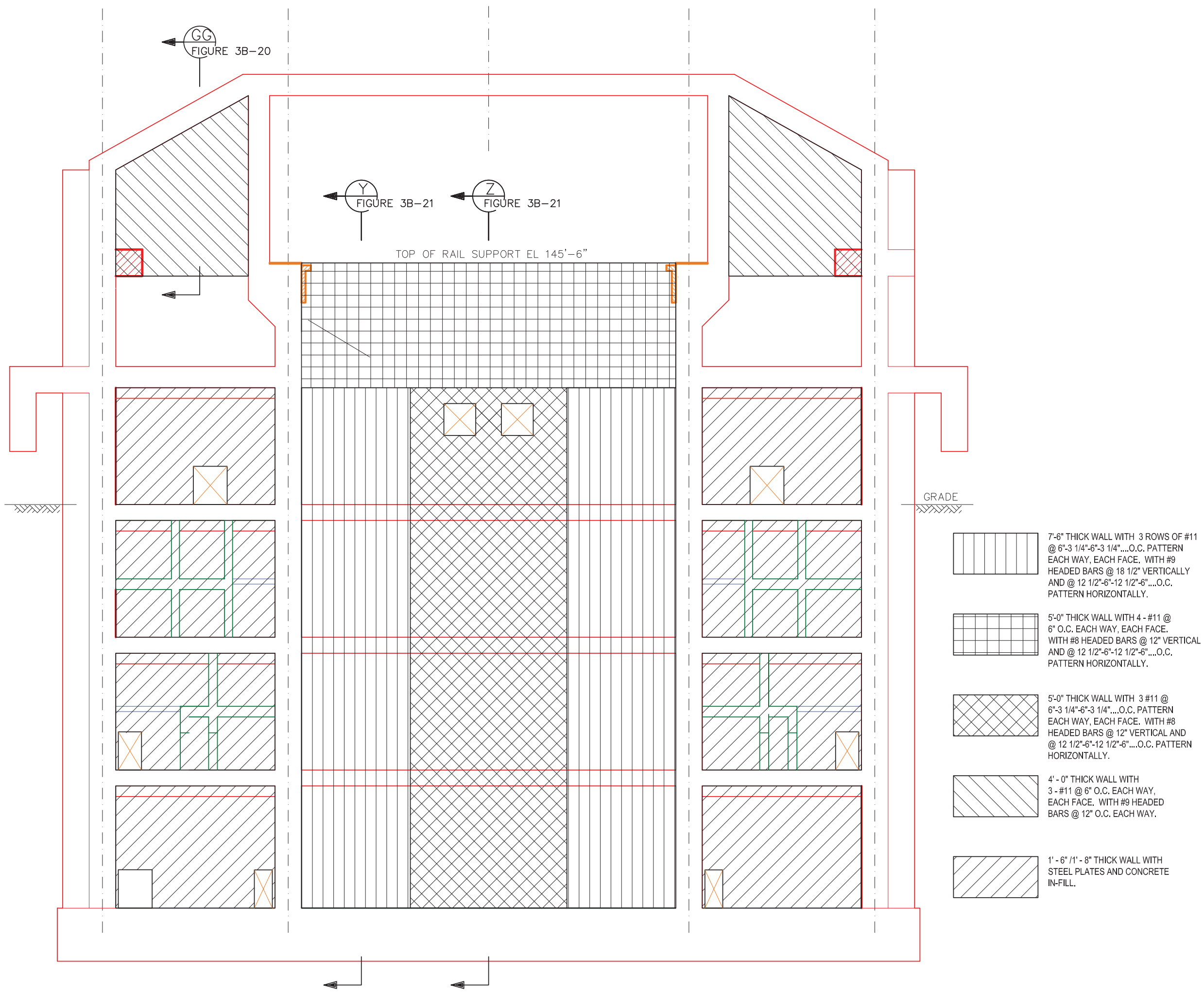


Figure 3B-20: RXB Reinforcement Section View of Upper Stiffener Wall on Grid Line 6

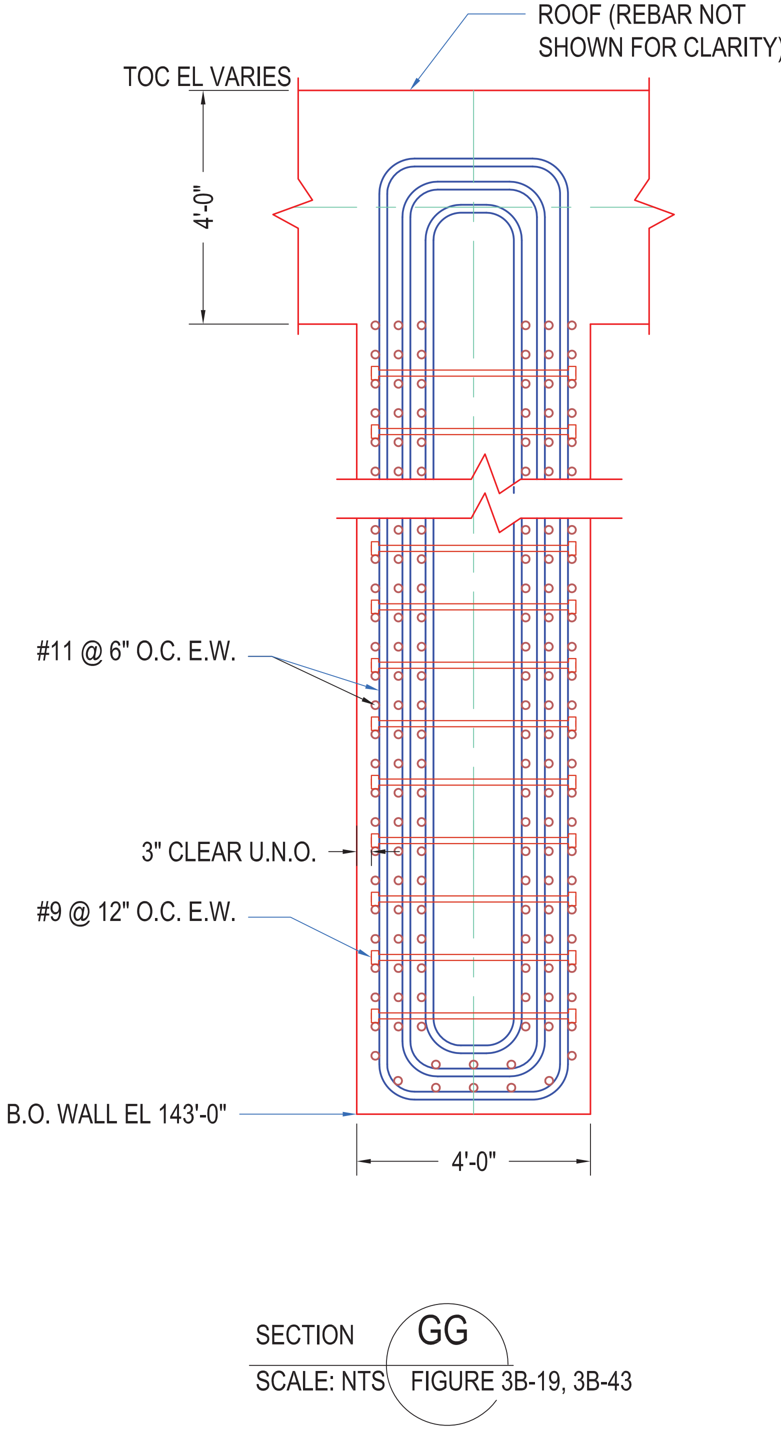


Figure 3B-21: RXB Reinforcement Section Views of Pool Wall on Grid Line 6

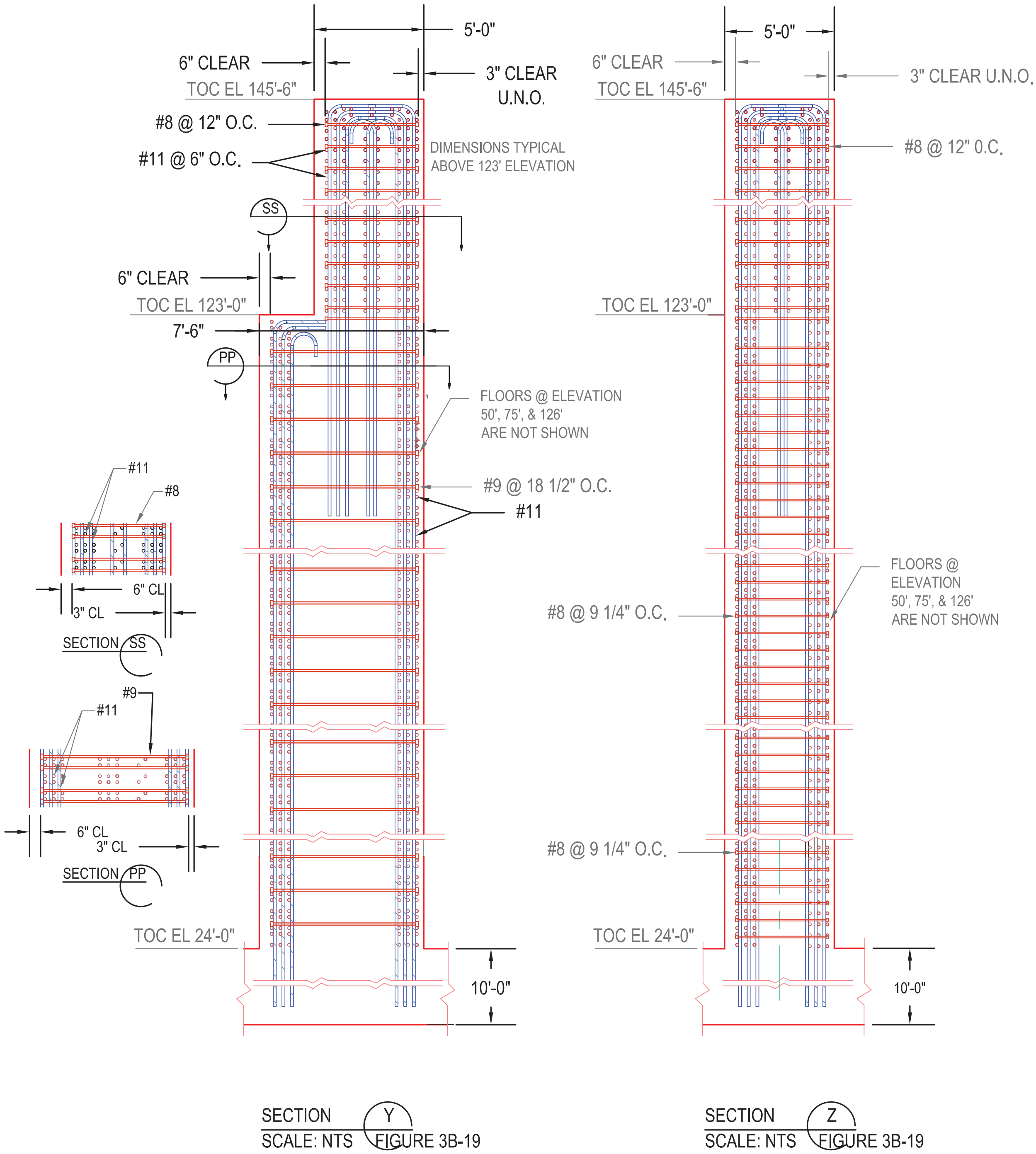


Figure 3B-22: SAP2000 Elevation View and Shell Element Numbers at RXB Grid Line E (Looking North)

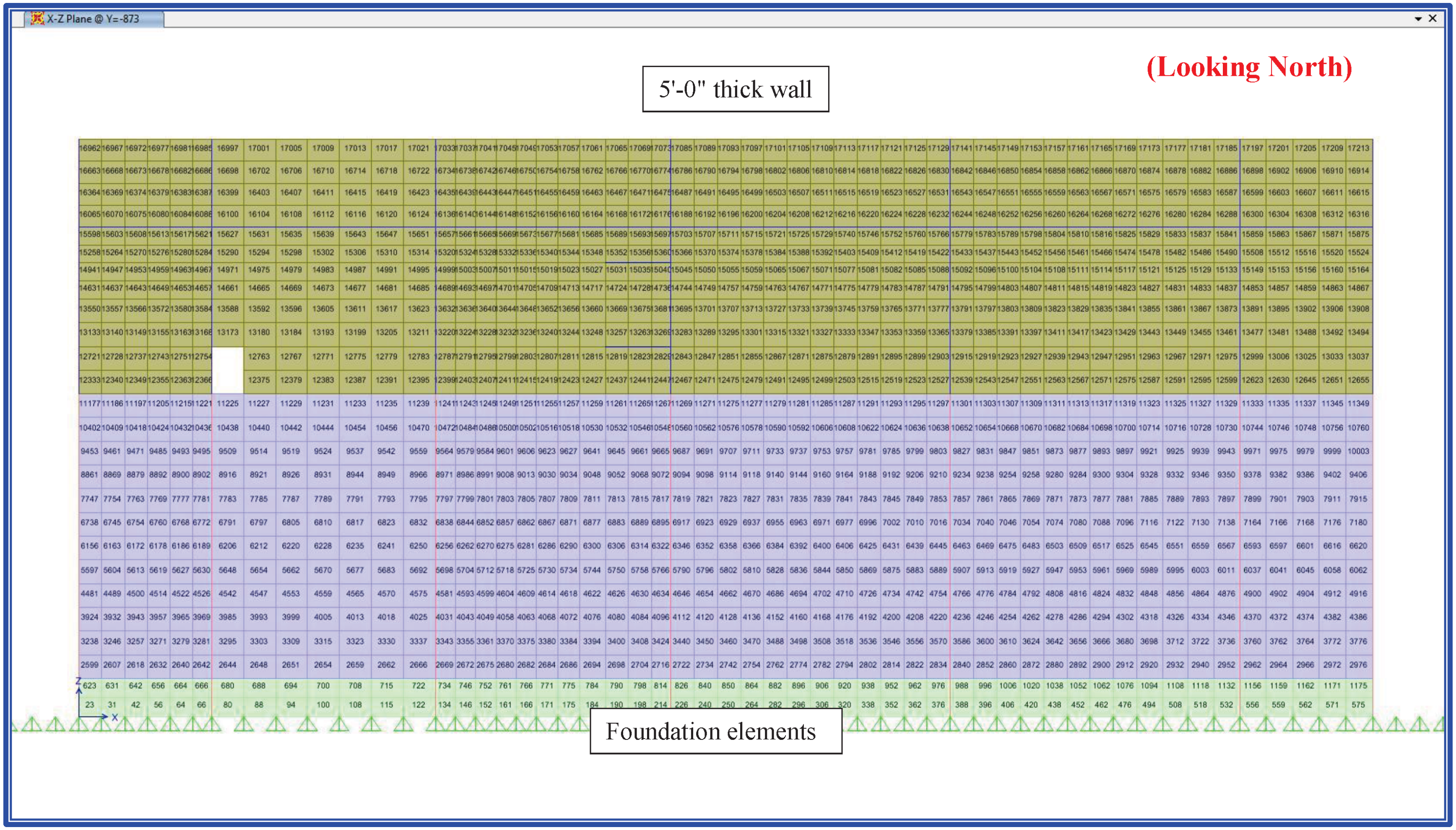


Figure 3B-23: RXB Reinforcement Elevation at Grid Line E Wall

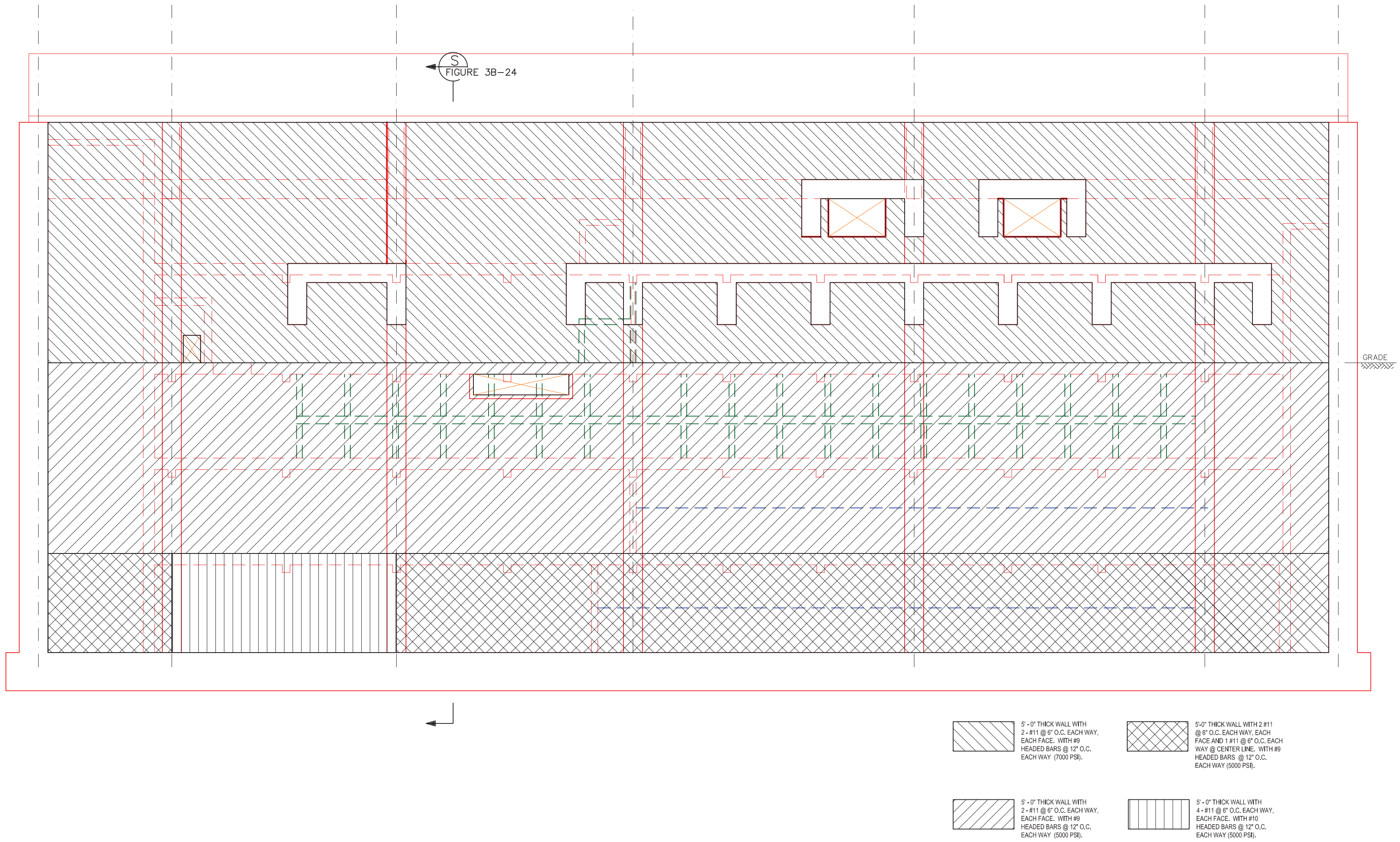


Figure 3B-24: RXB Reinforcement Section View of Wall on Grid Line E

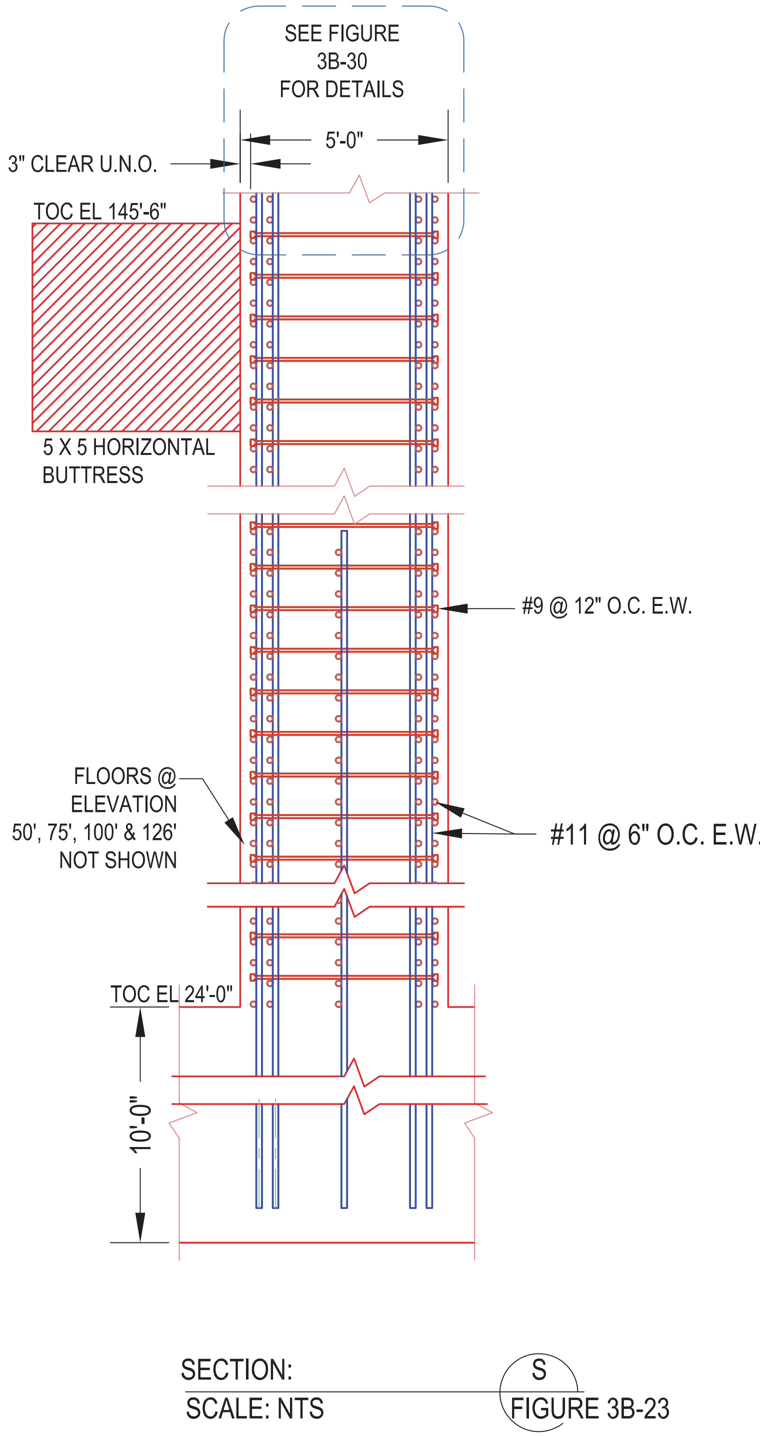


Figure 3B-25: SAP2000 Plan View and Shell Element Numbers on Slab at RXB EL 100'-0"

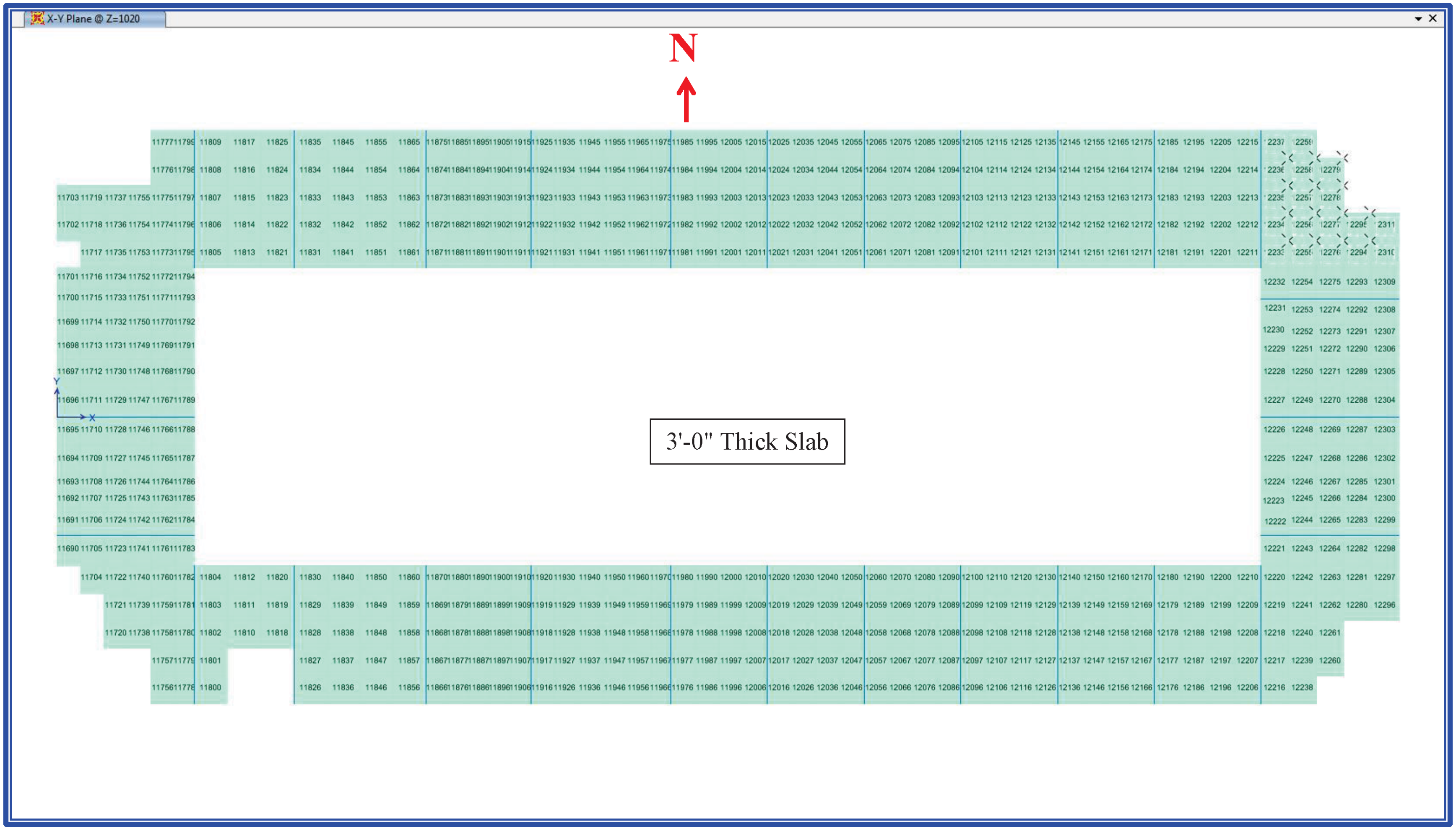


Figure 3B-26: RXB Reinforcement Plan at EL 100'-0"

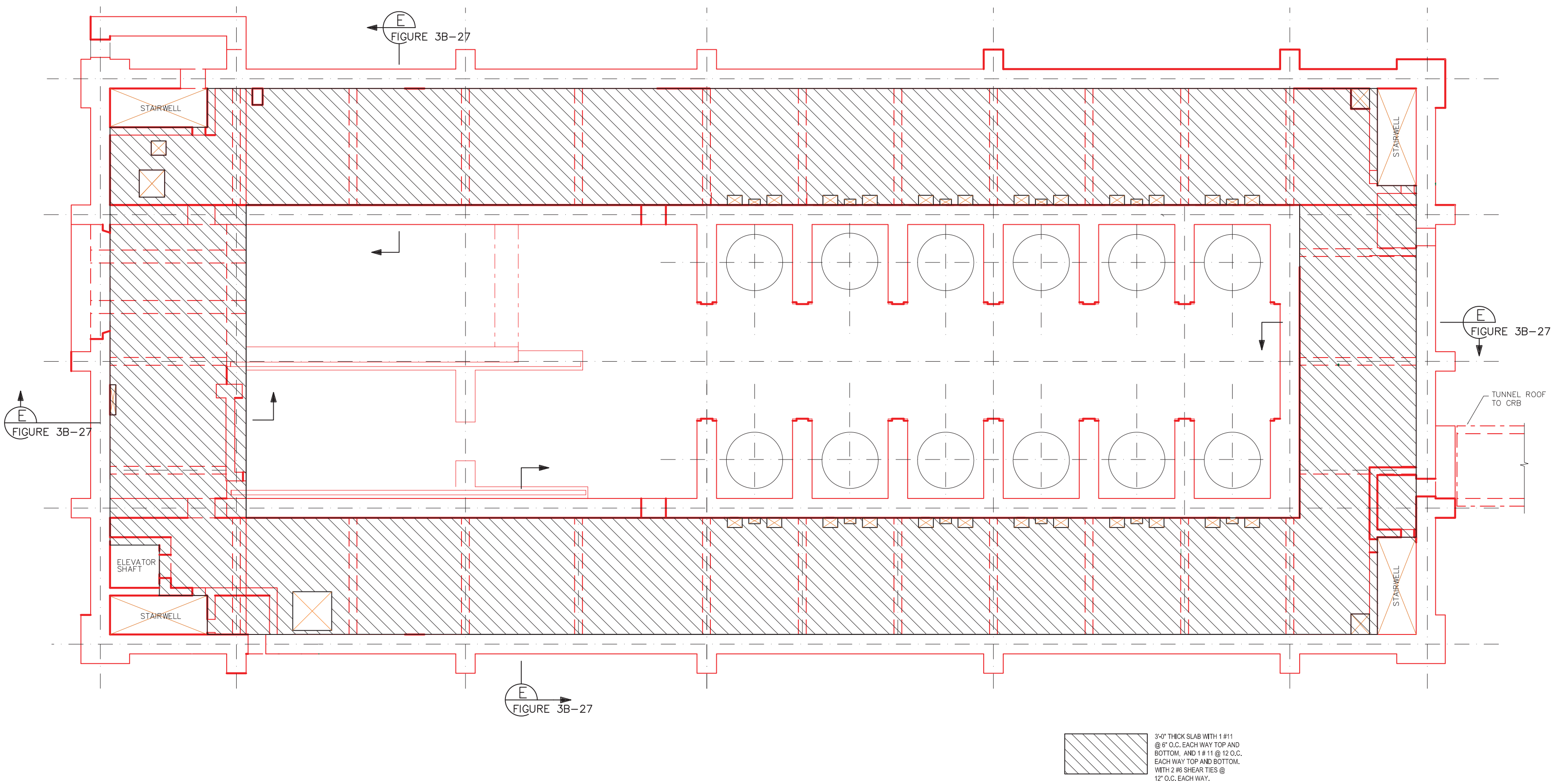


Figure 3B-27: RXB Reinforcement Section View of Slab at EL 100'-0"

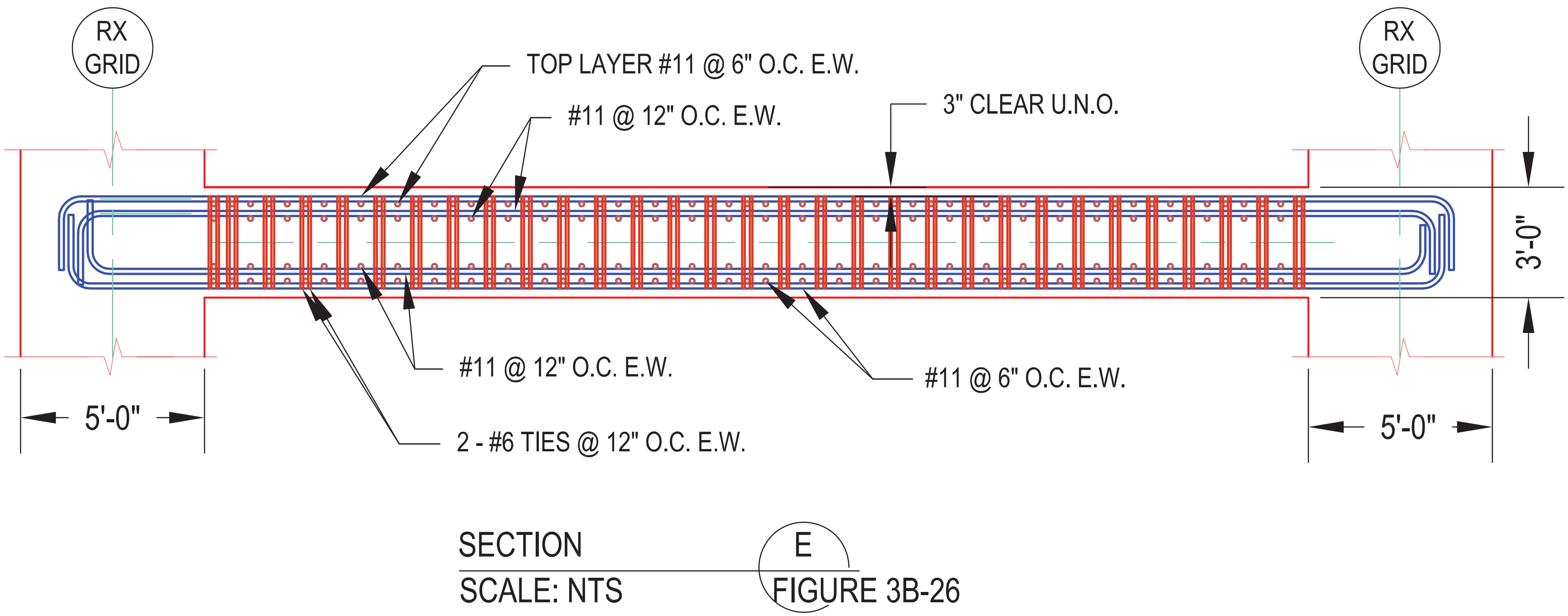


Figure 3B-28: SAP2000 Plan View and Shell Element Numbers on RXB Roof Slab

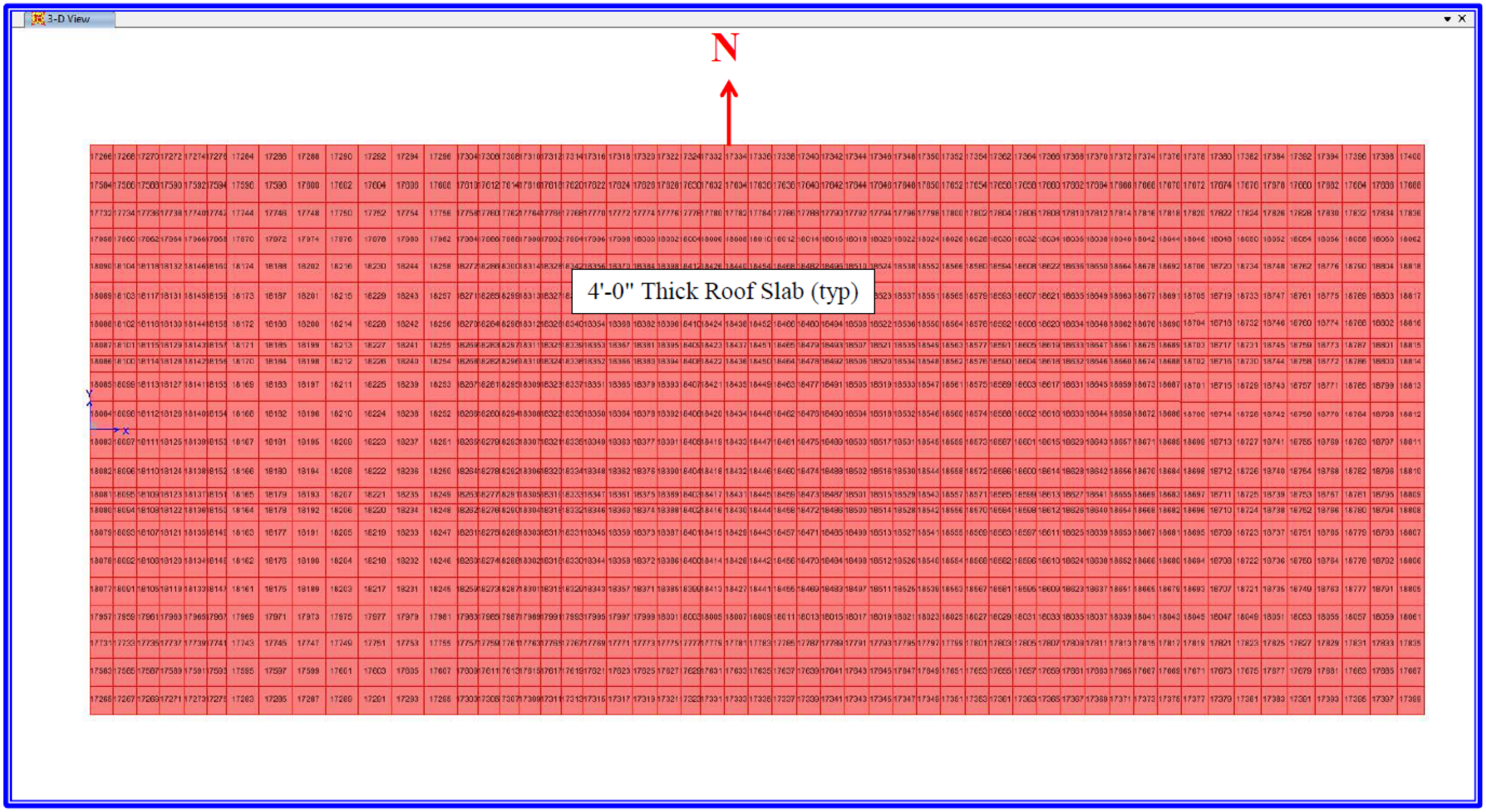


Figure 3B-29: RXB Reinforcement Plan for Roof Slab

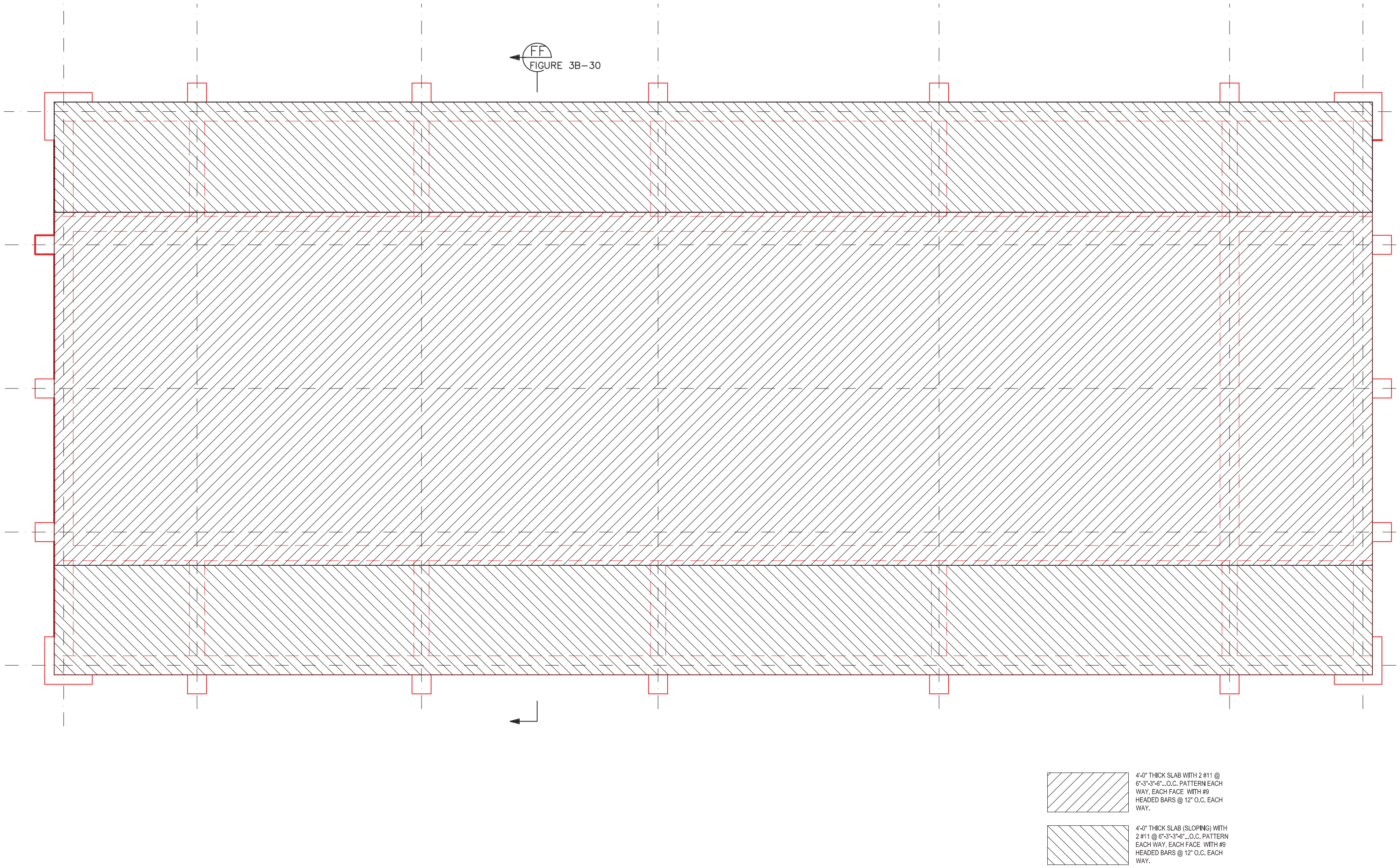


Figure 3B-30: RXB Reinforcement Section View of Roof Slab

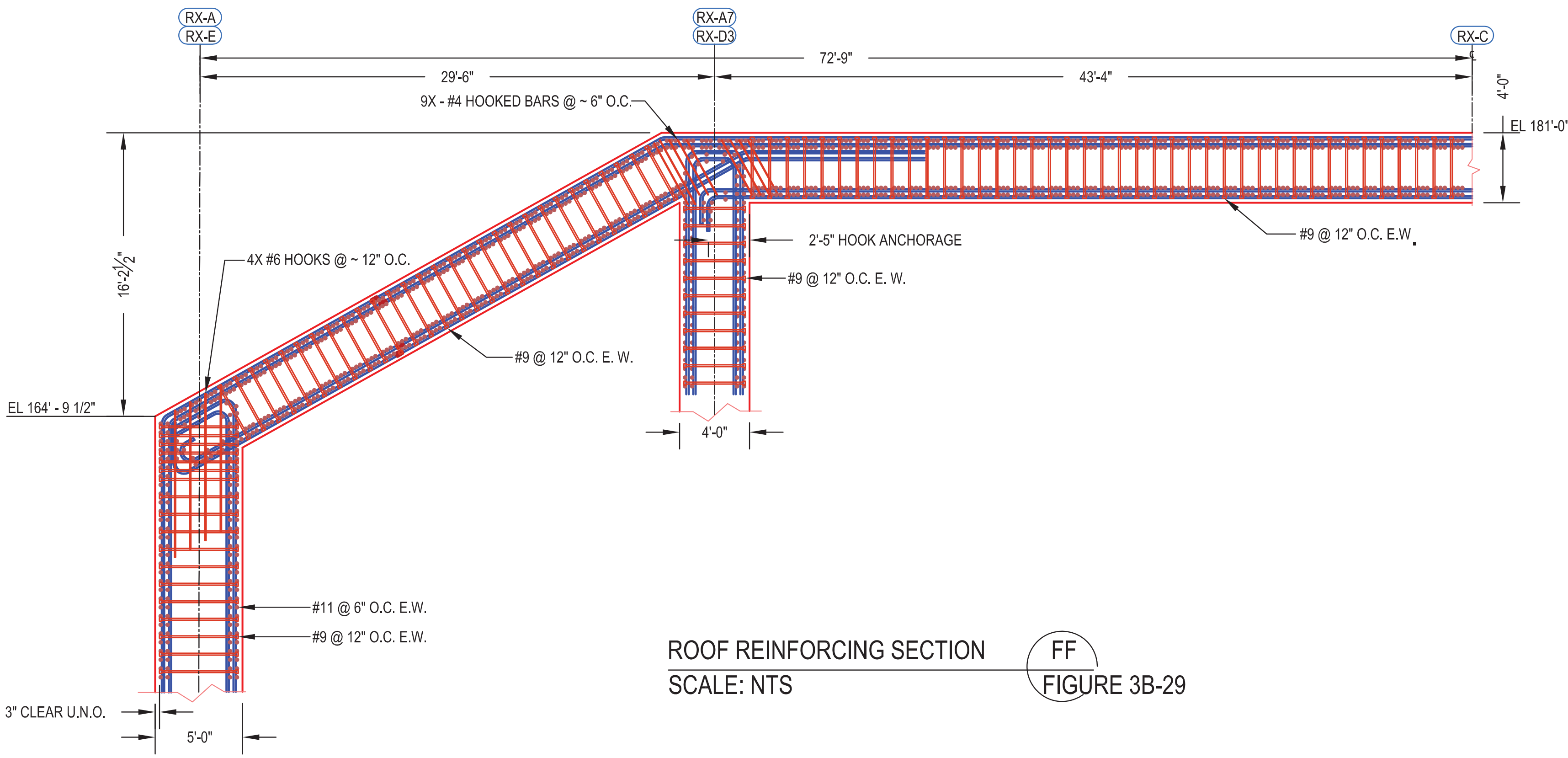


Figure 3B-31: SAP2000 View and Frame Element Numbers of Pilasters on RXB Grid Line A Wall

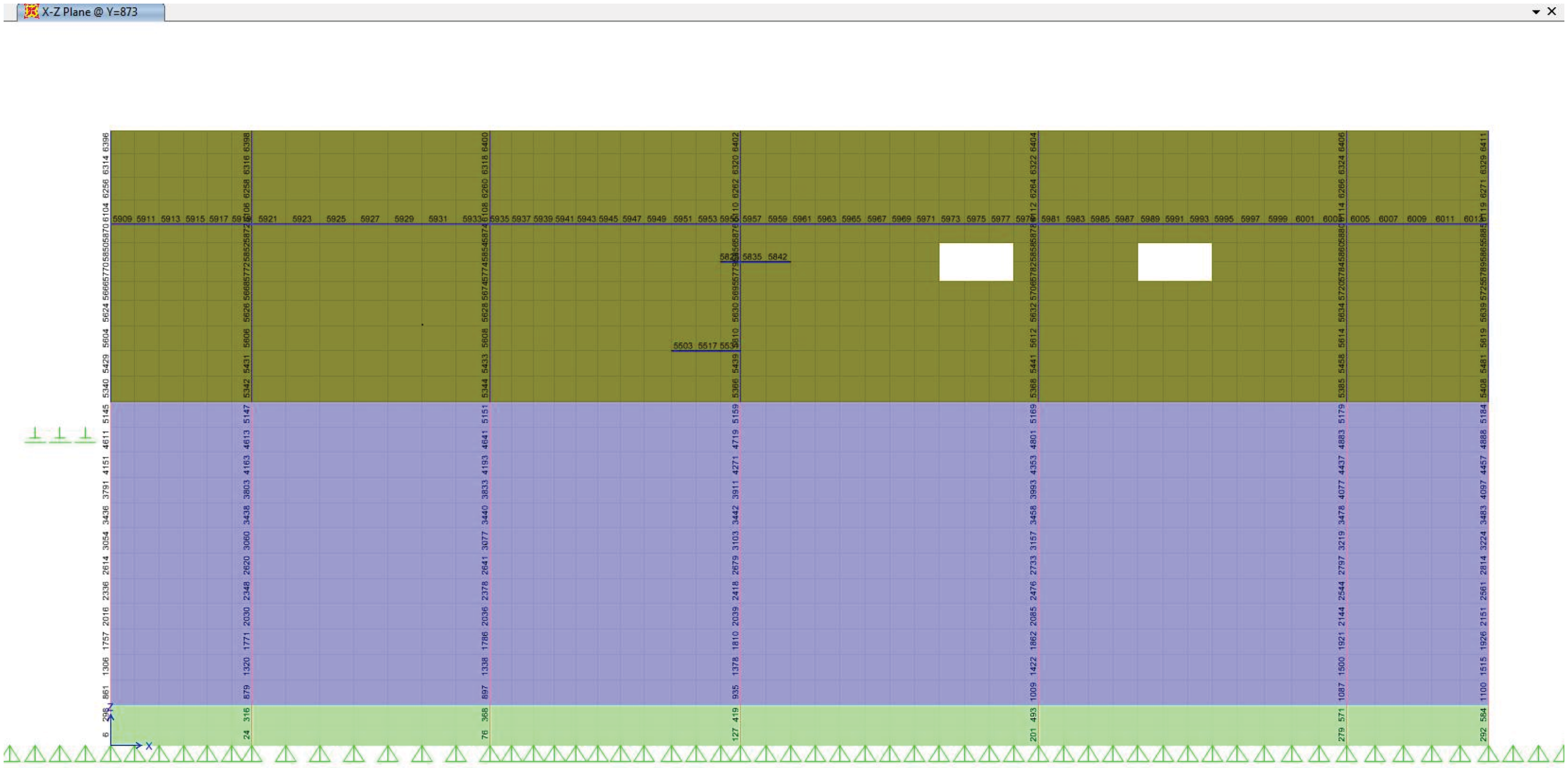


Figure 3B-32: RXB Reinforcement Detail for Pilaster Type 1

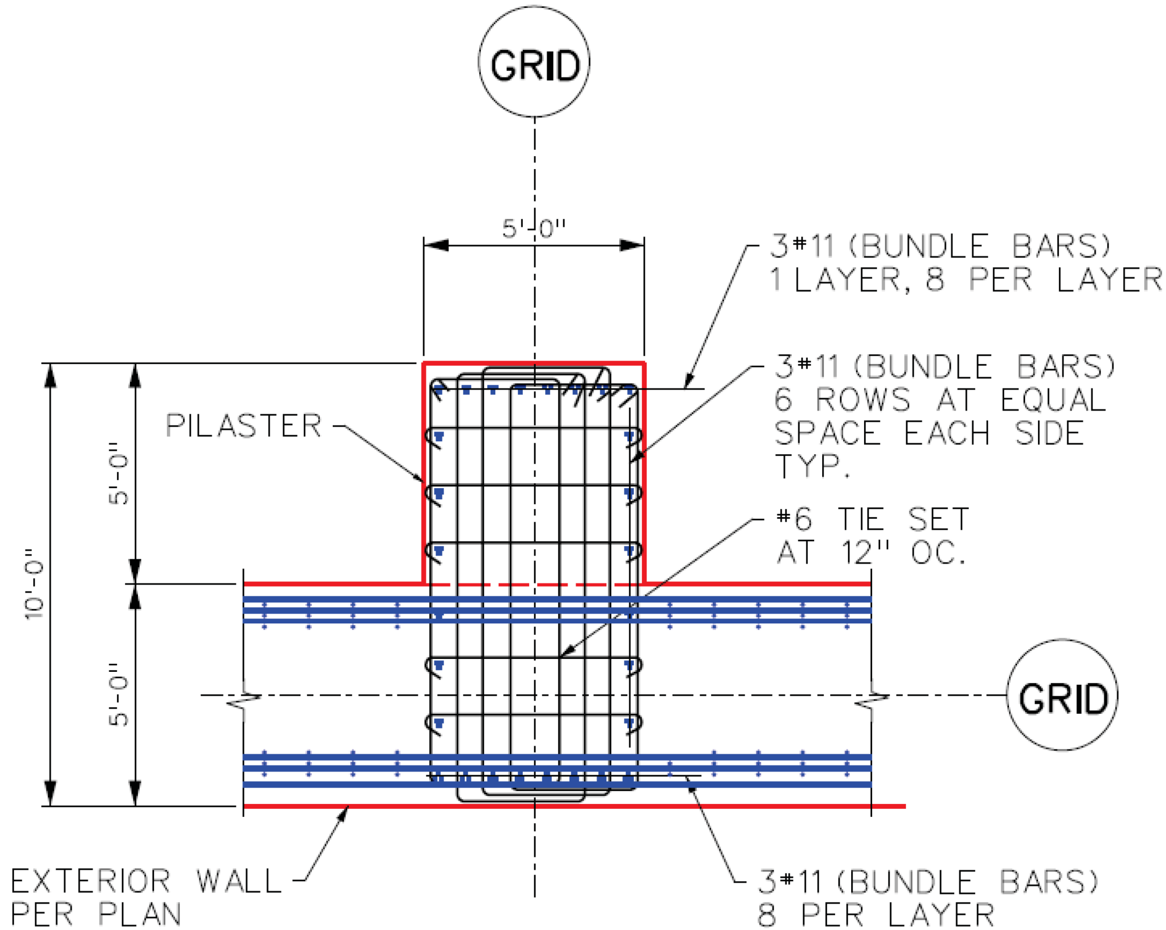


Figure 3B-33: RXB Reinforcement Detail for Pilaster Type 2

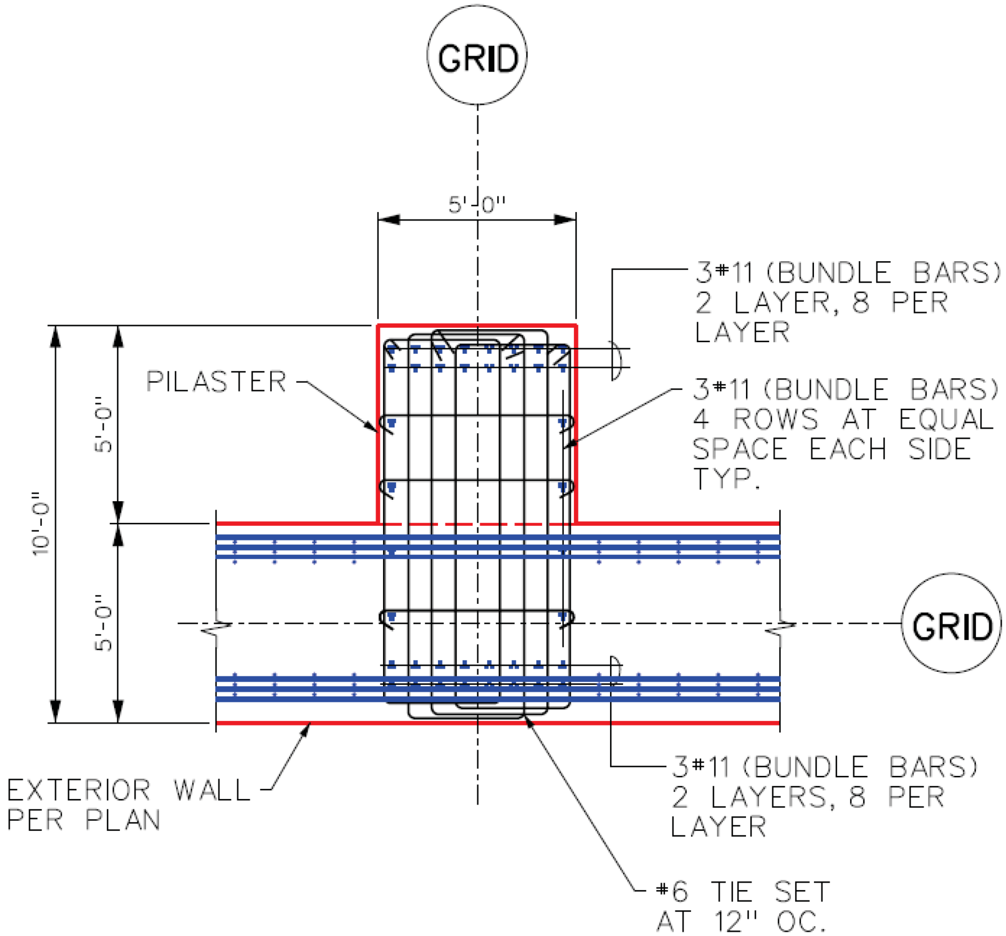


Figure 3B-34: RXB Reinforcement Detail for Pilaster Type 3

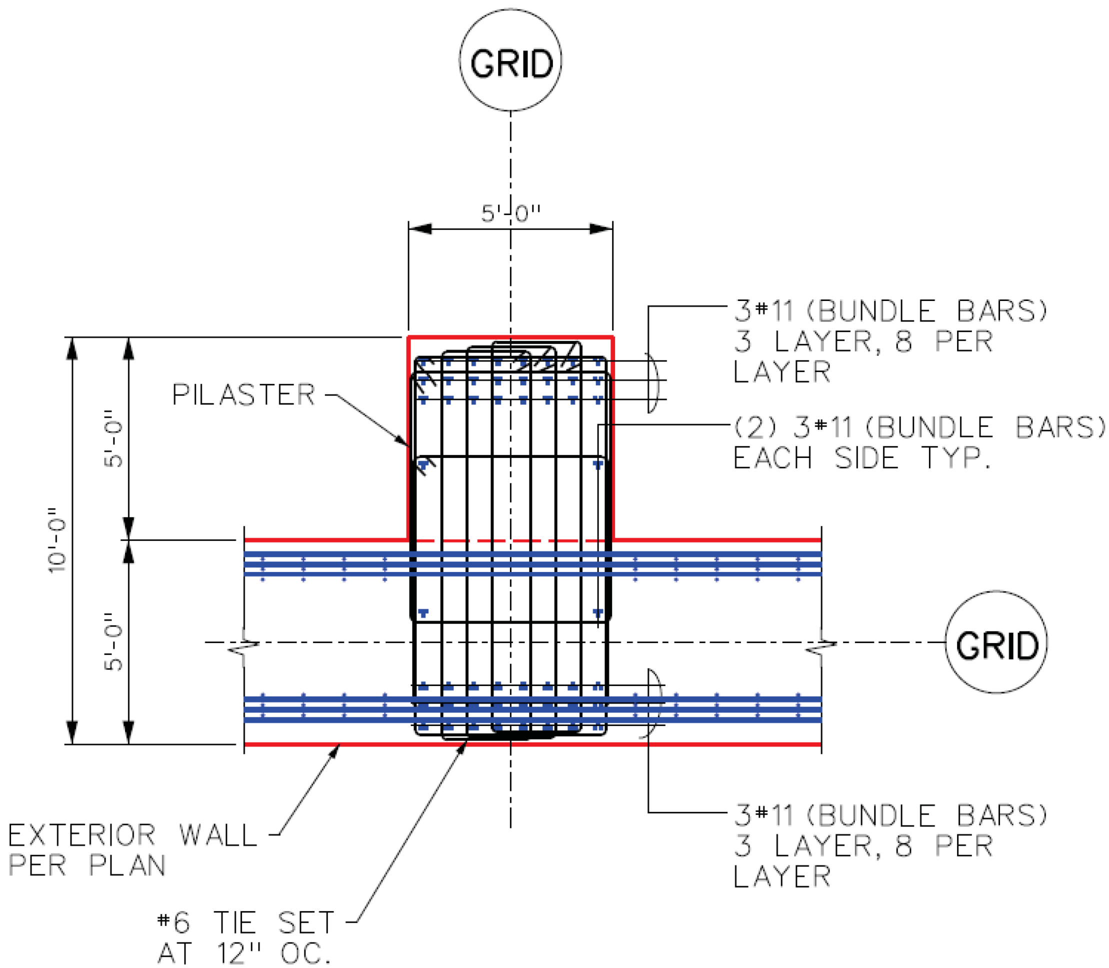


Figure 3B-35: RXB Reinforcement Detail for Pilaster Type 4

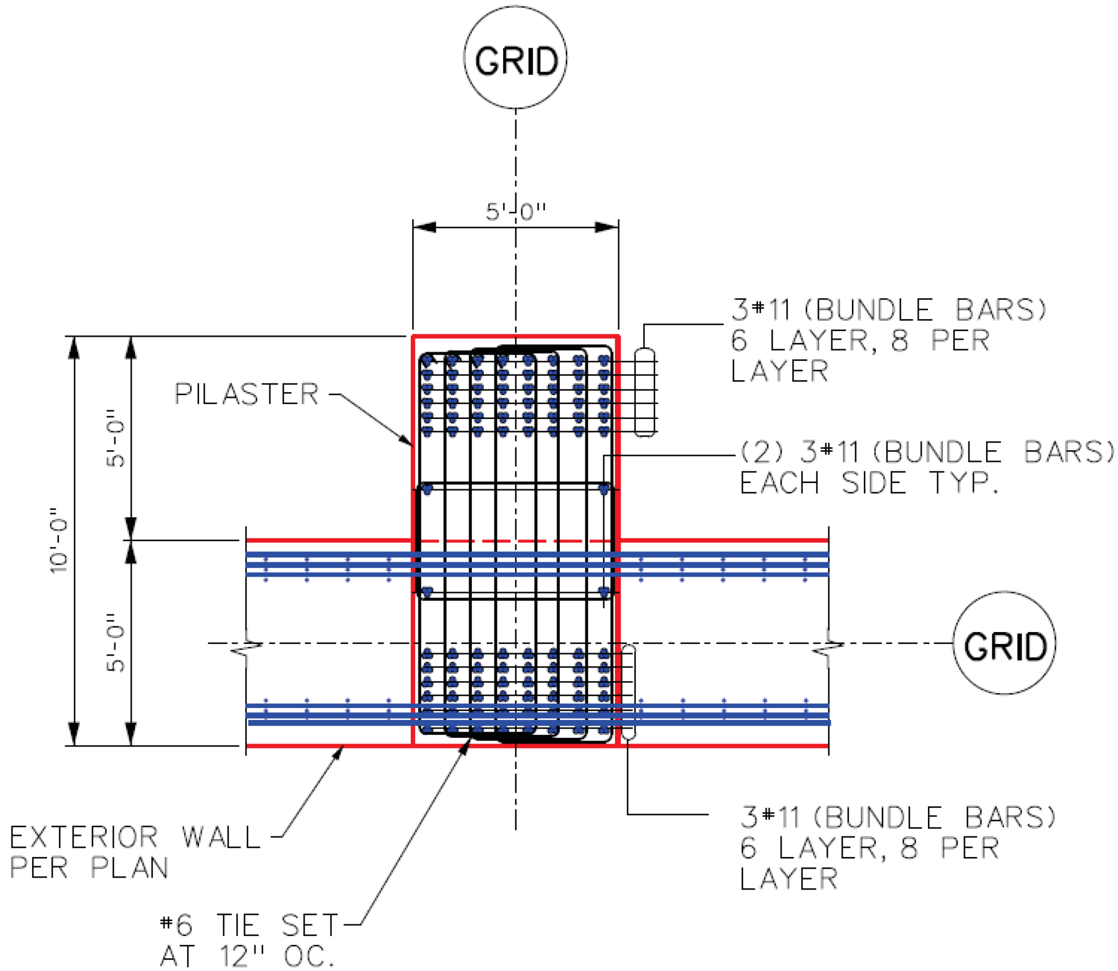


Figure 3B-36: RXB Reinforcement Detail for Pilaster Type 5

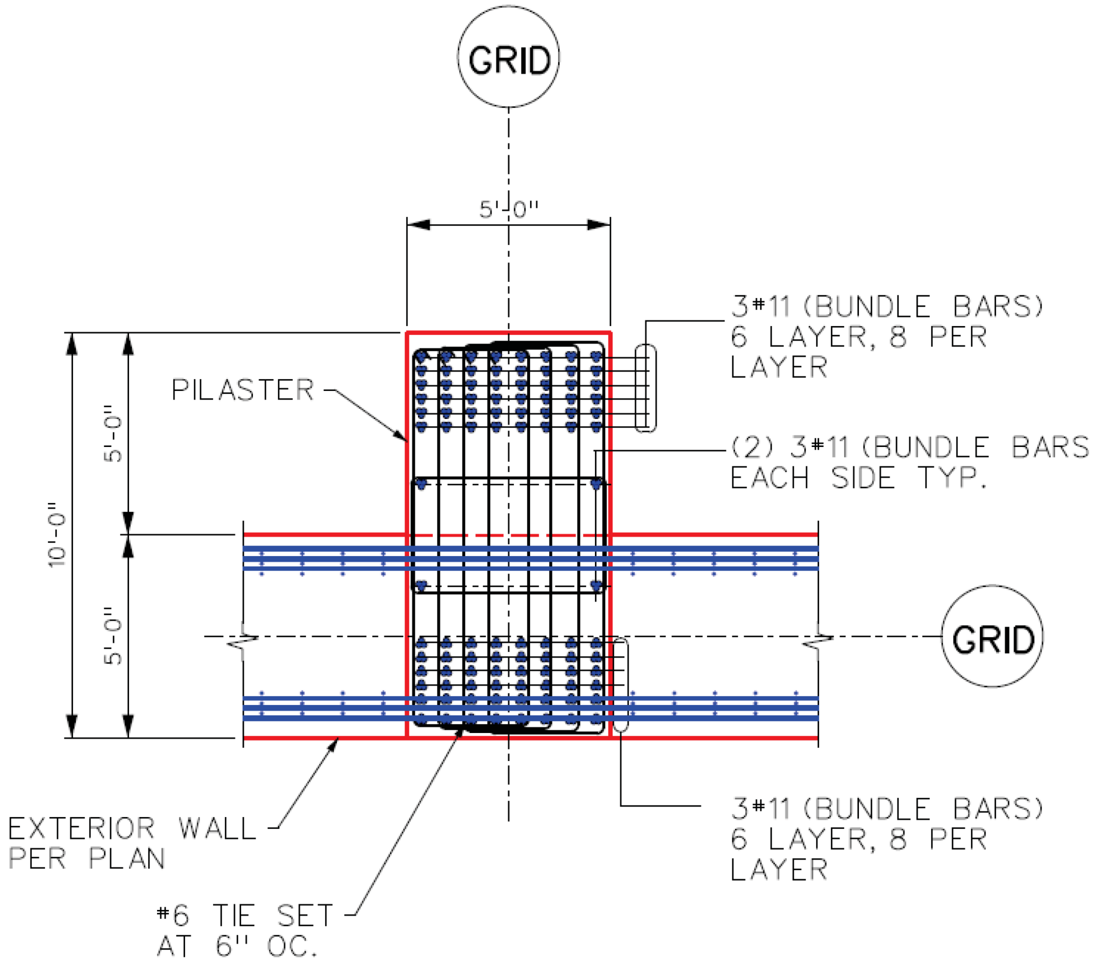


Figure 3B-37: SAP2000 View and Frame Element Numbers of Beams on RXB EL 75'-0" Slab

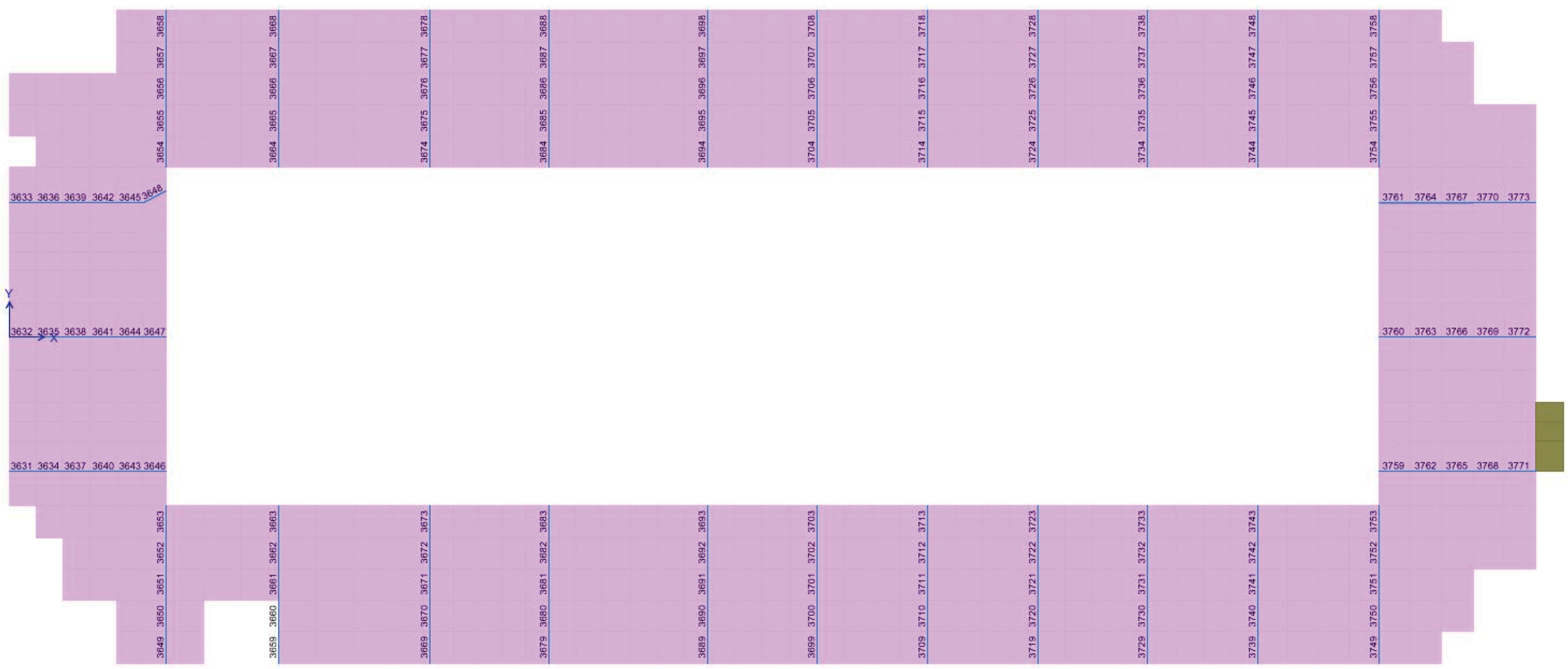
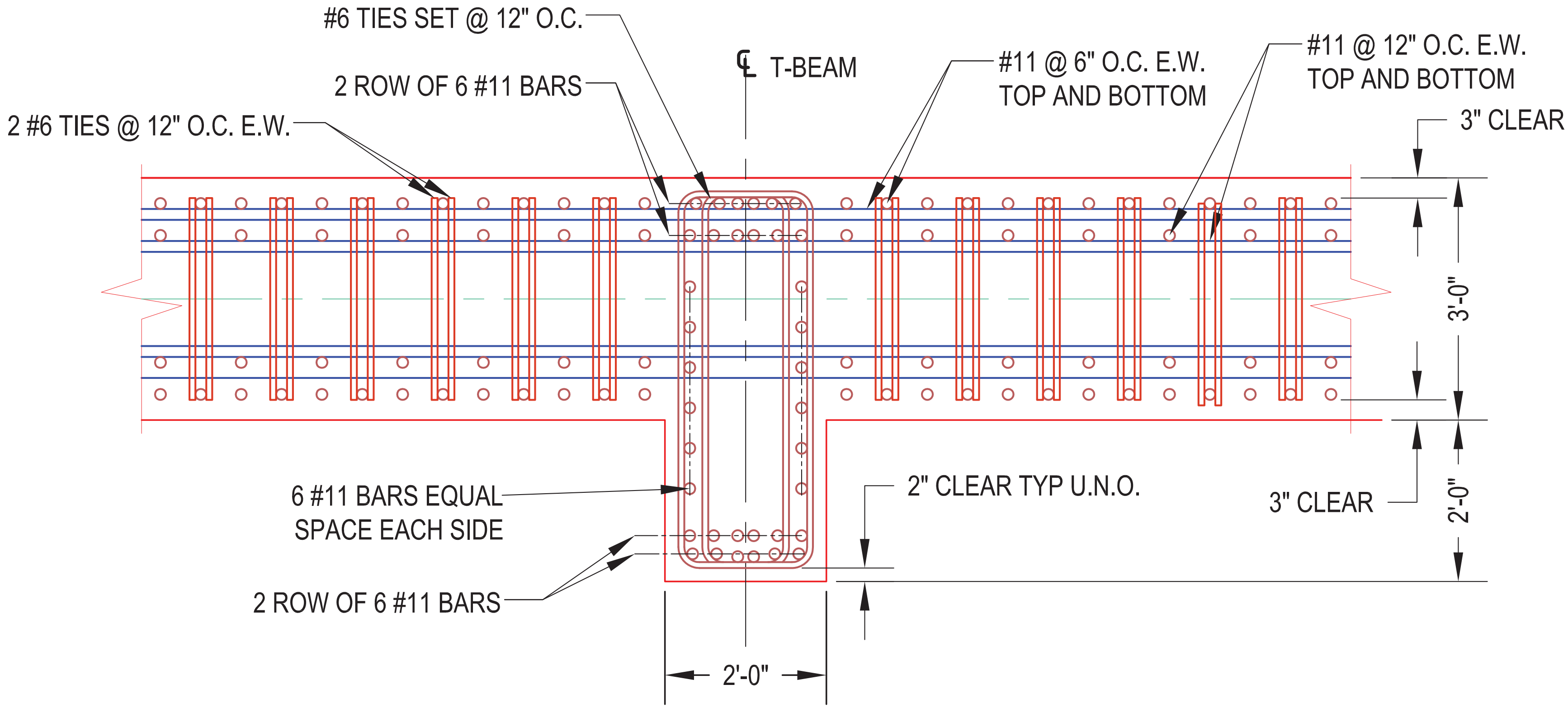
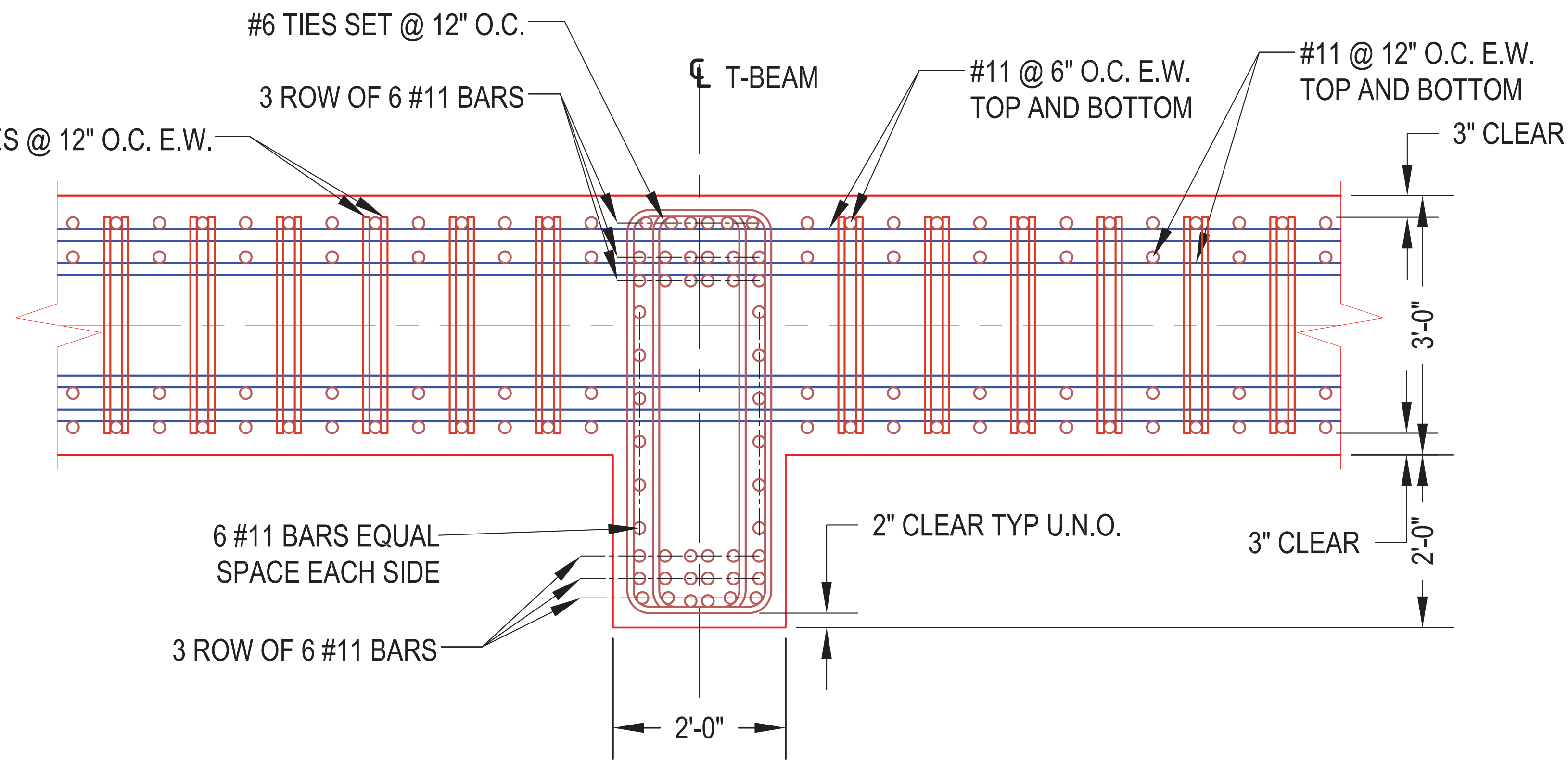


Figure 3B-38: RXB Reinforcement Detail for Type 1 T-Beams at EL 75'-0"



TYPICAL DETAILS OF REINFORCING STEEL IN THE T-BEAM AND SLAB

Figure 3B-39: RXB Reinforcement Detail for Type 2 T-Beams at EL 75'-0"



TYPICAL DETAILS OF REINFORCING STEEL IN THE T-BEAM AND SLAB

Figure 3B-40: SAP2000 View and Frame Element Numbers of Buttresses at Grid Line 1 on RXB EL. 126'-0"

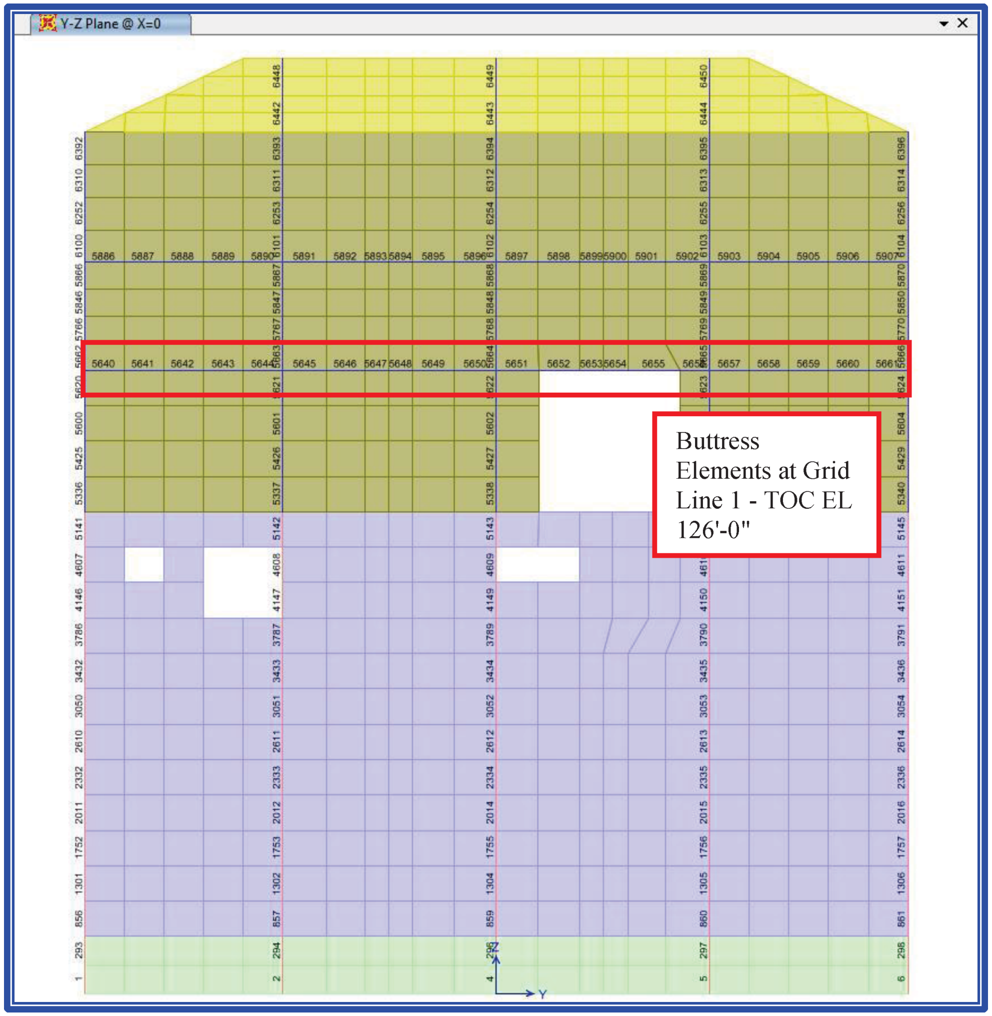


Figure 3B-41: RXB Reinforcement Detail for Buttress Type 1

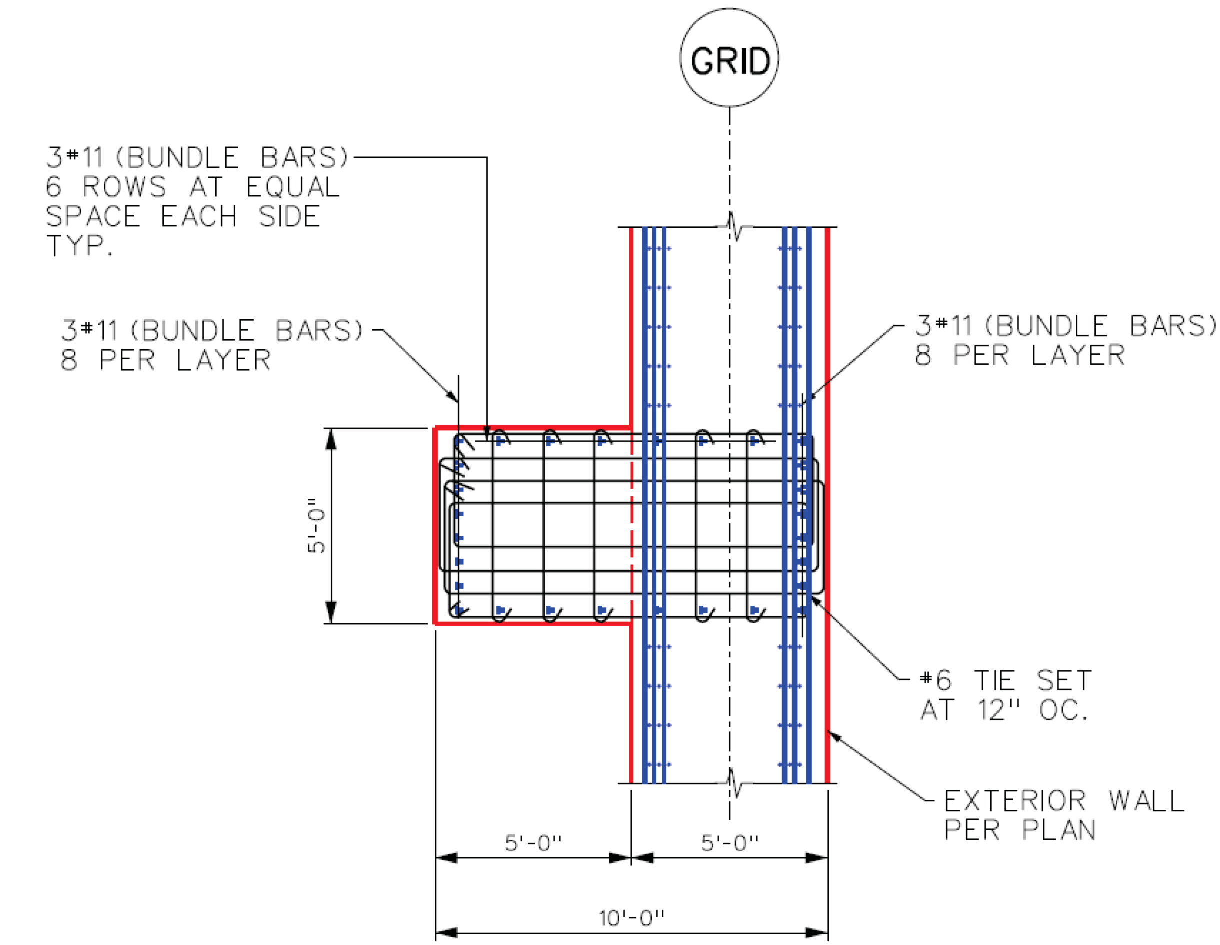


Figure 3B-42: SAP2000 Elevation View and Shell Element Numbers for West Wing Wall at Grid Line 4

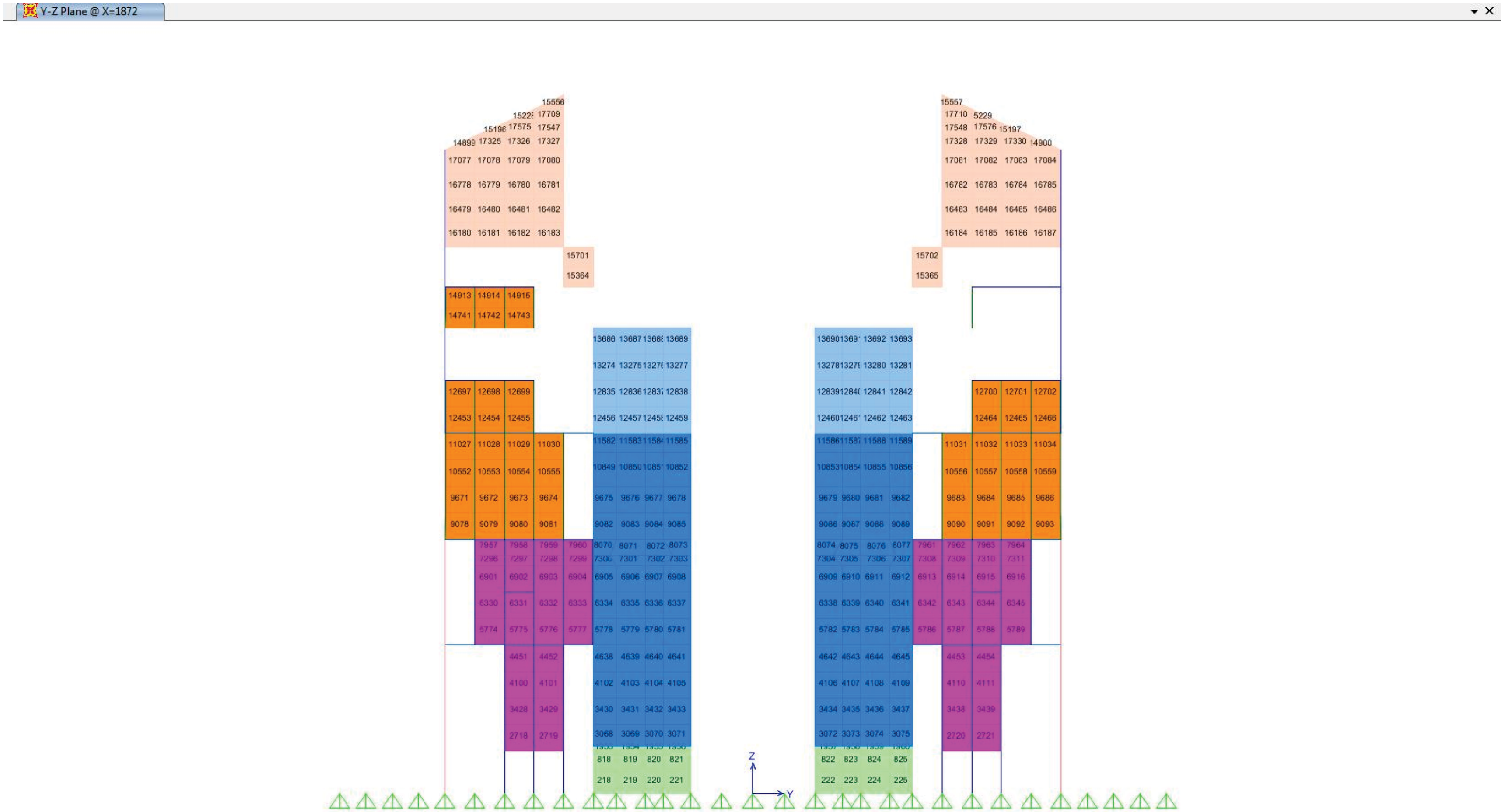


Figure 3B-43: RXB Reinforcement Elevation at RXB Grid Line 4 Wall

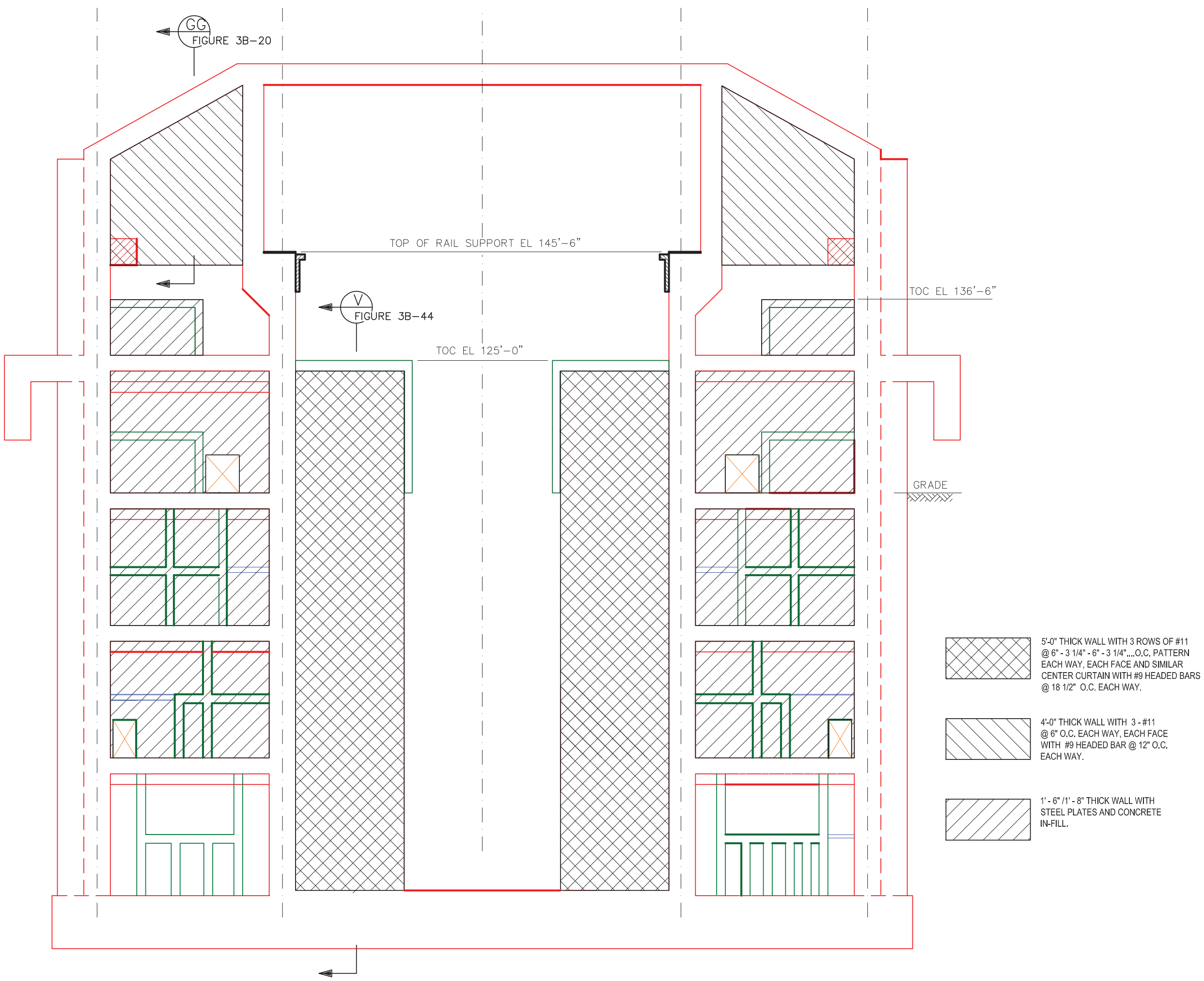


Figure 3B-44: RXB Reinforcement Section View of 5 Foot Thick Wall on RXB Grid Line 4

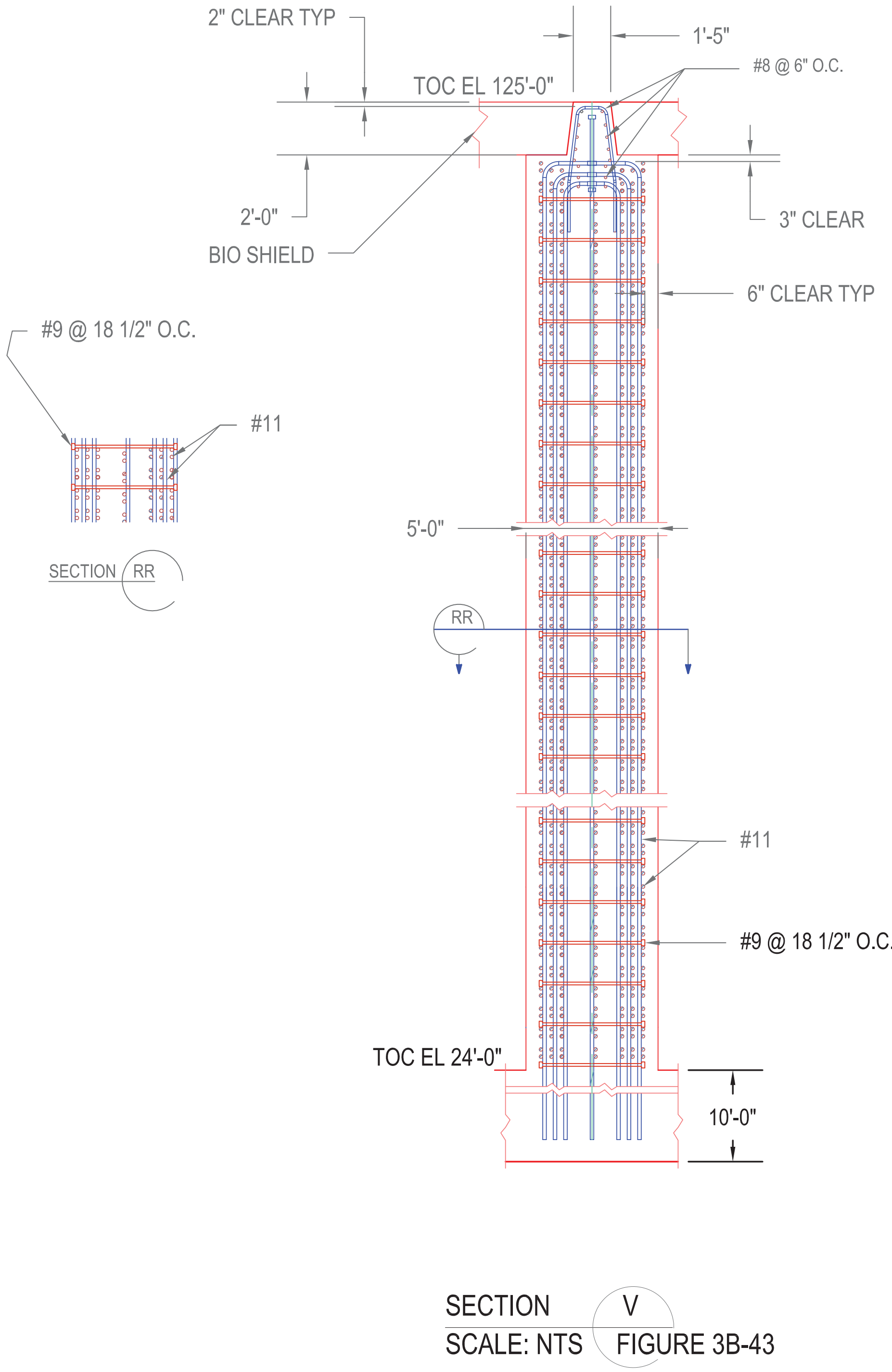


Figure 3B-45: SAP2000 Elevation View and Shell Element Numbers at RXB Wall at Grid Line B (Looking North)

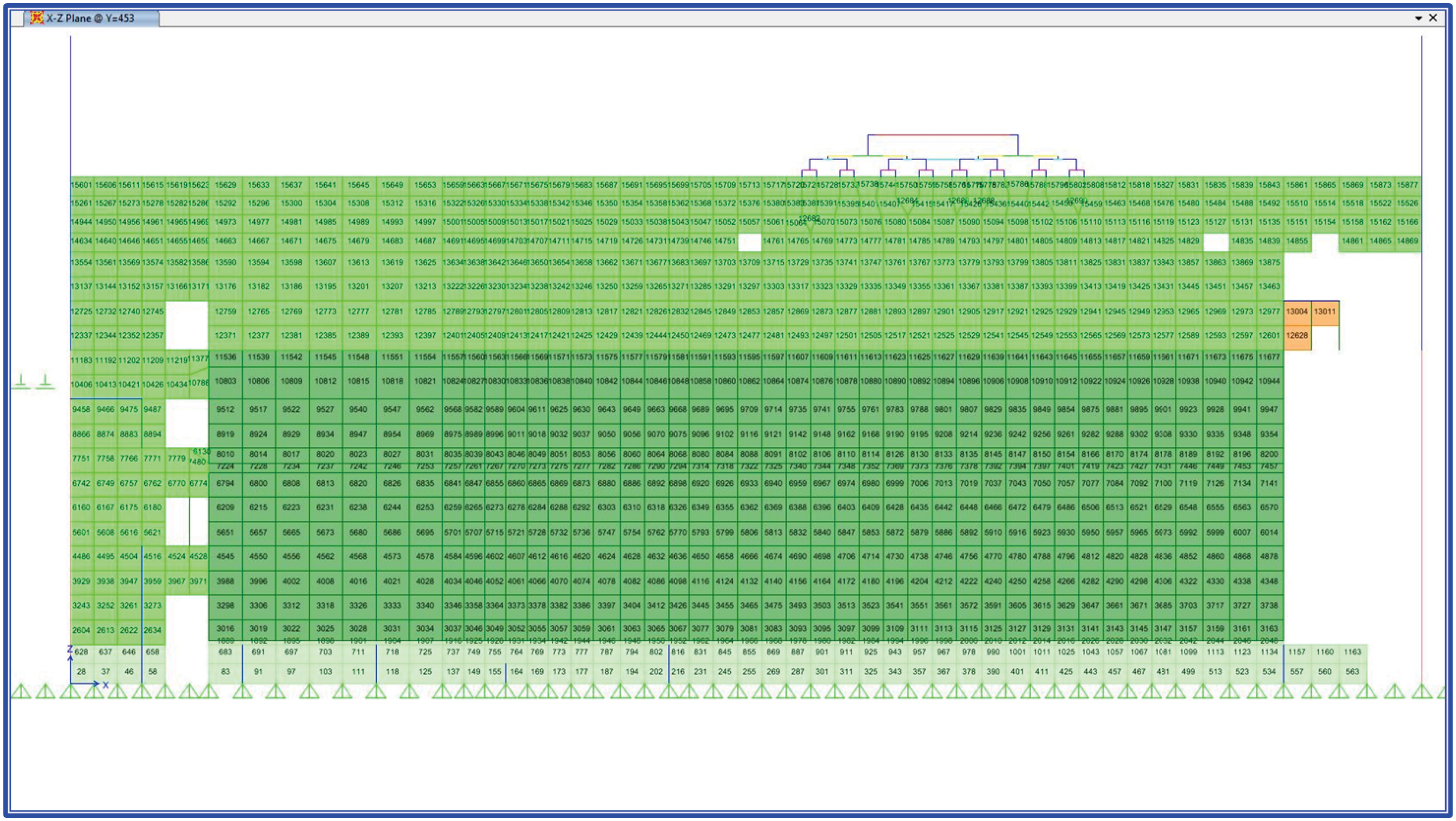


Figure 3B-46: RXB Reinforcement Elevation at RXB Wall at Grid Line B

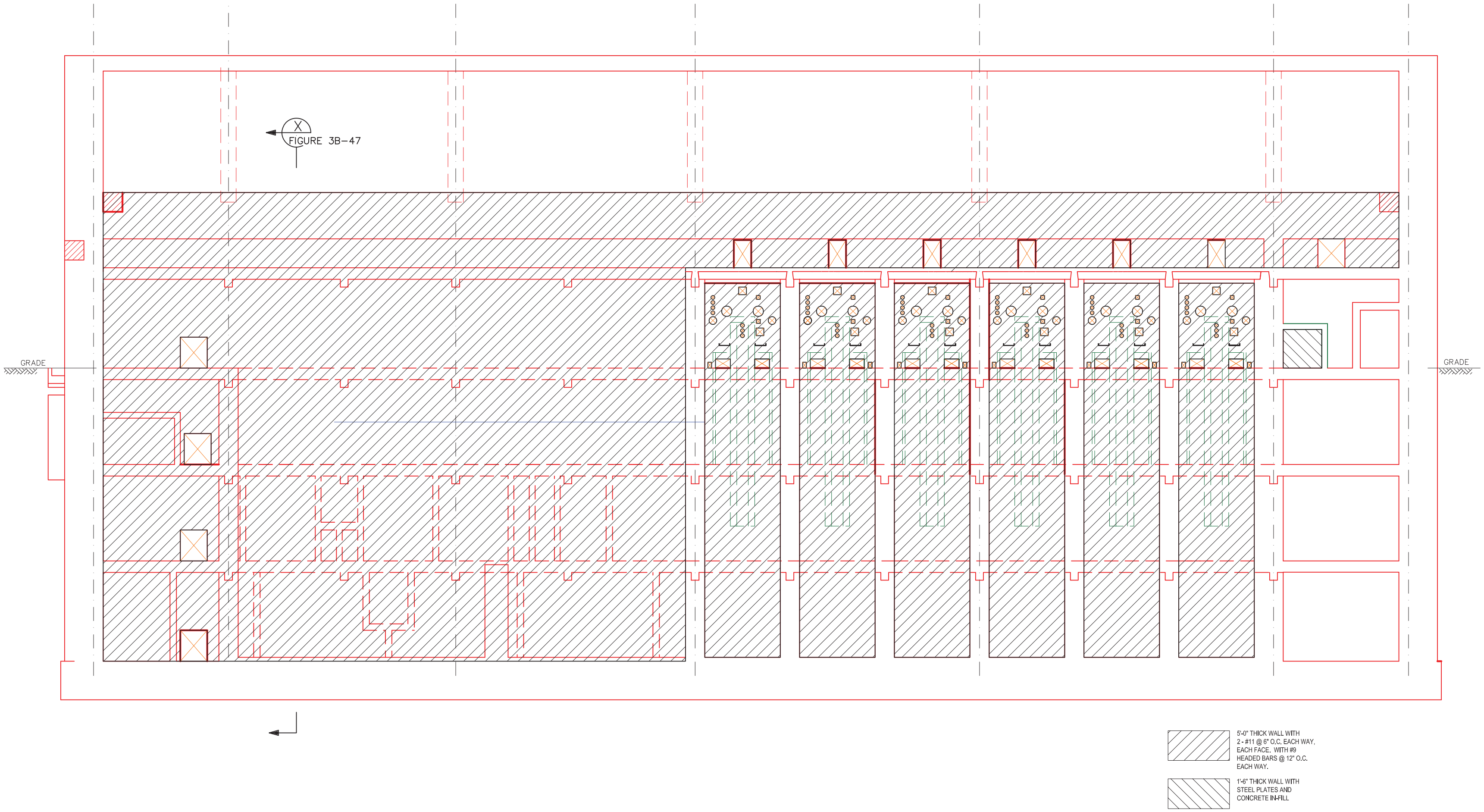


Figure 3B-47: RXB Reinforcement Section View of RXB Wall at Grid Line B

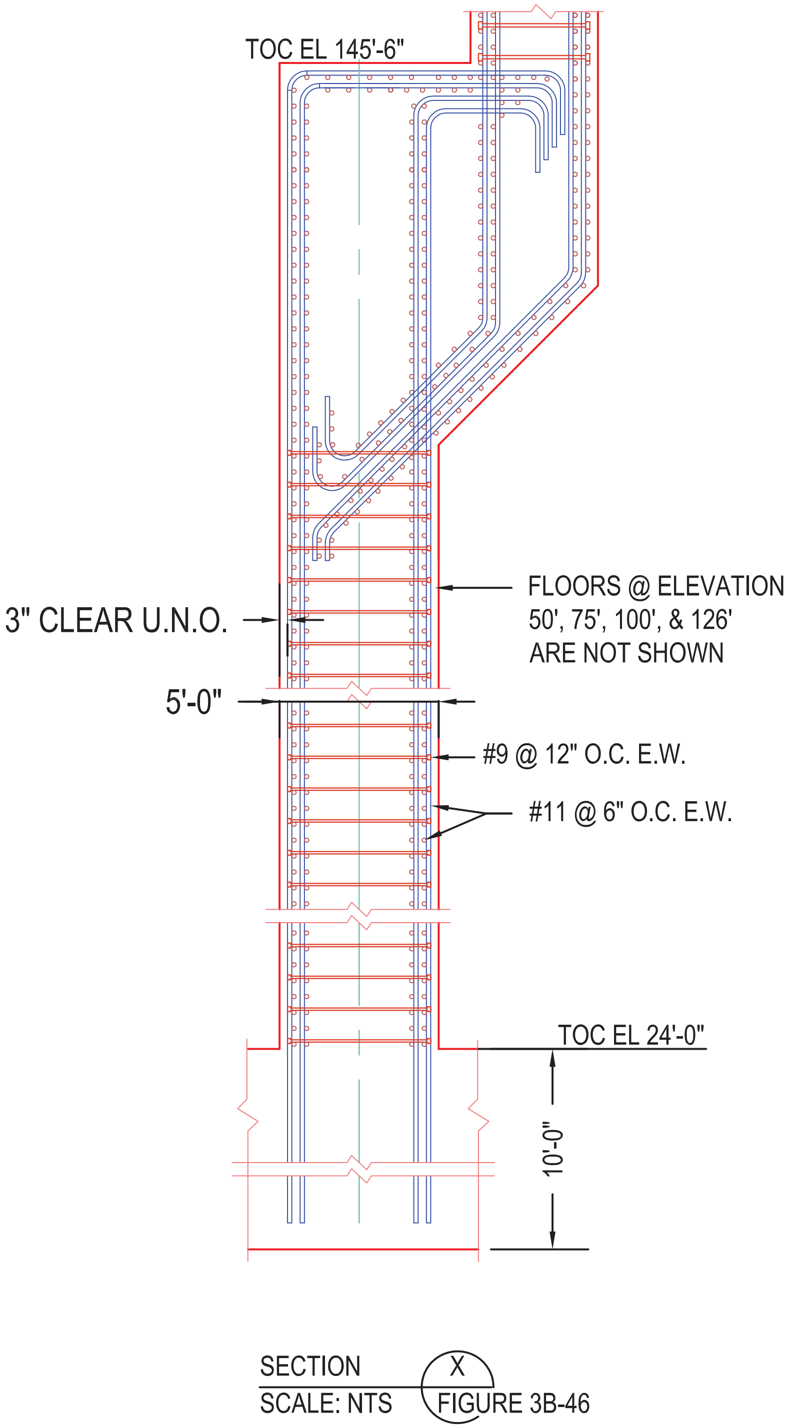


Figure 3B-48: Elevation View of the NPM Base Support at RXB Pool Floor

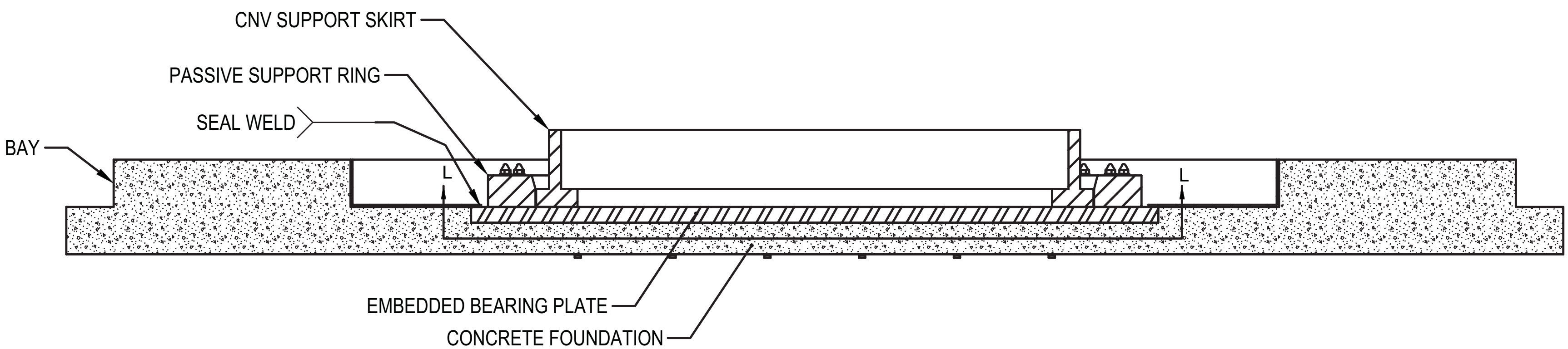


Figure 3B-49: Plan View of NPM Base Support Passive Support Ring

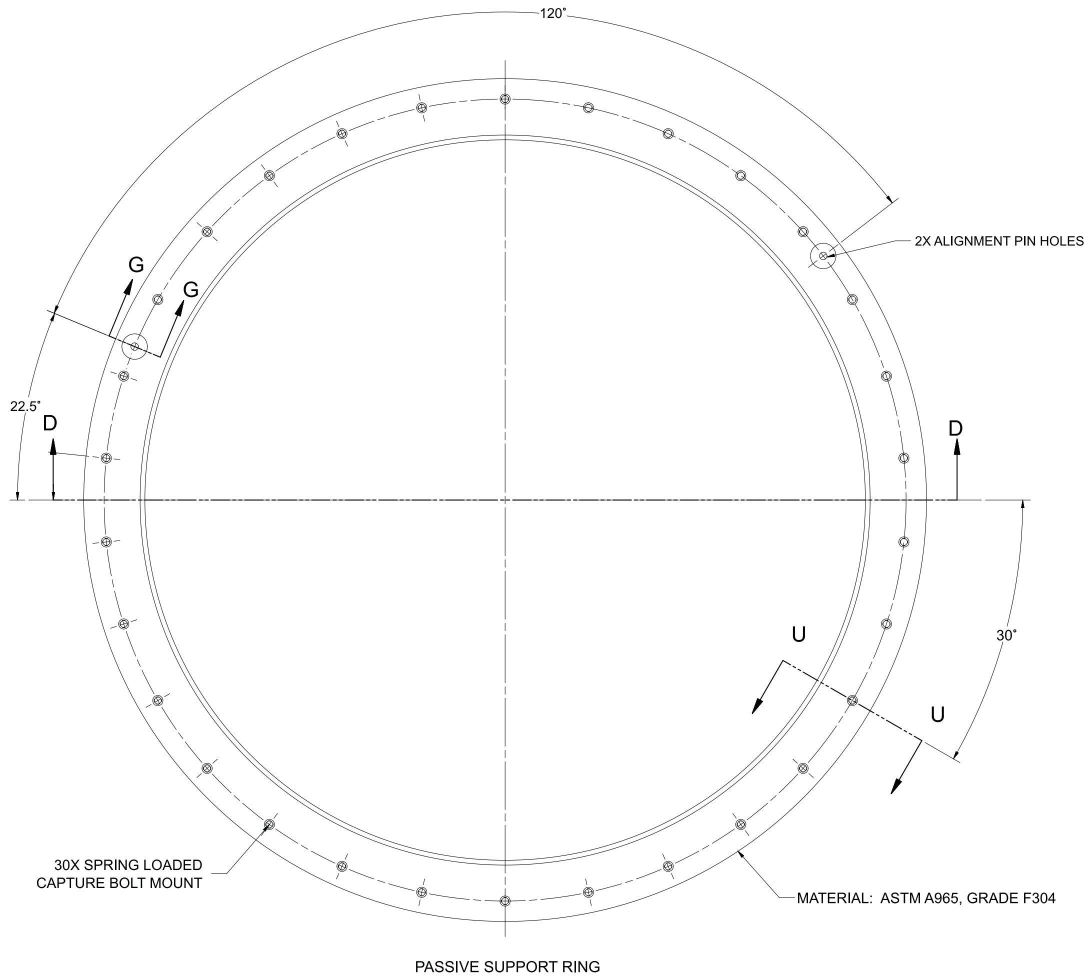


Figure 3B-50: Plan View of NPM Base Support Bearing Plate

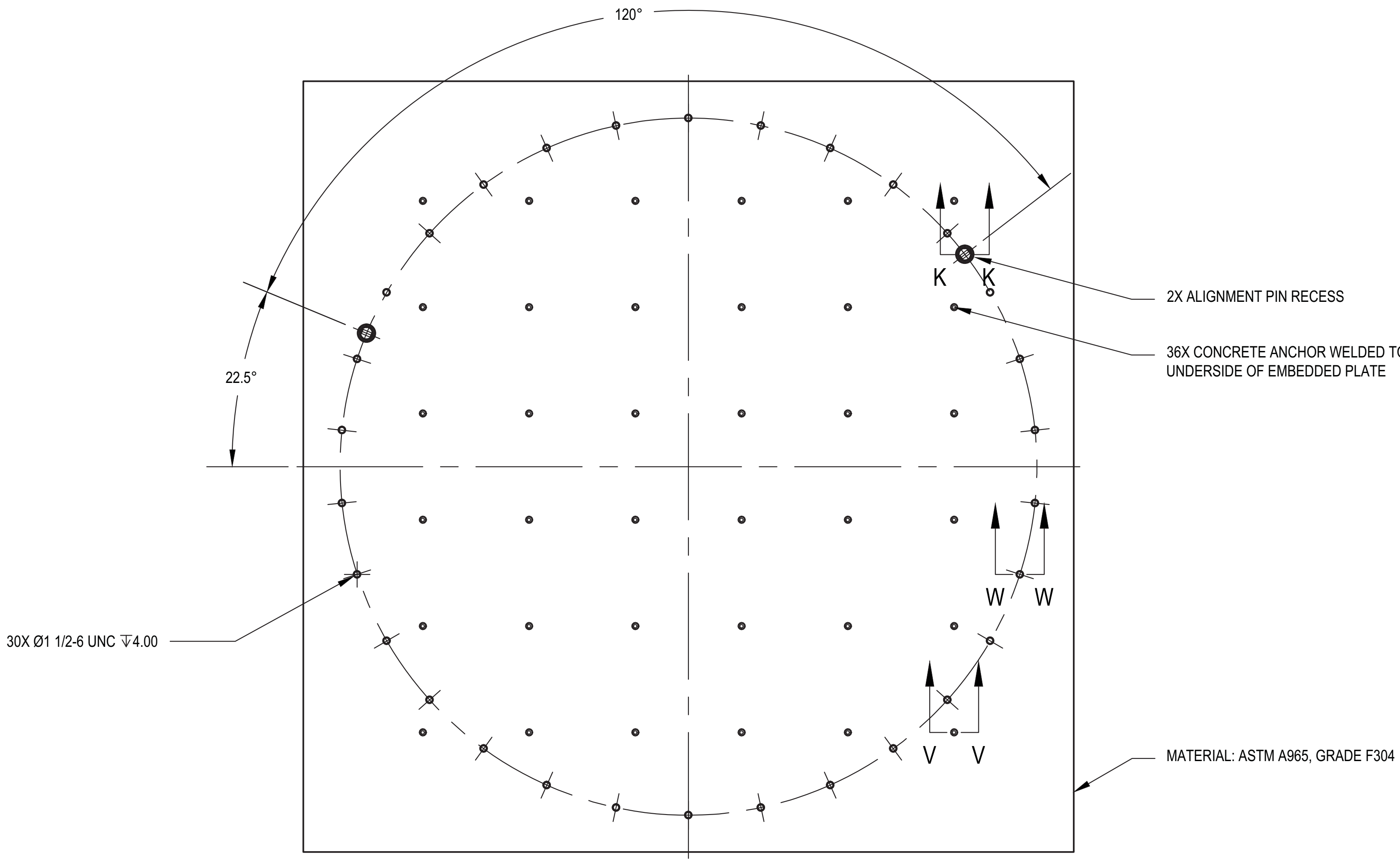
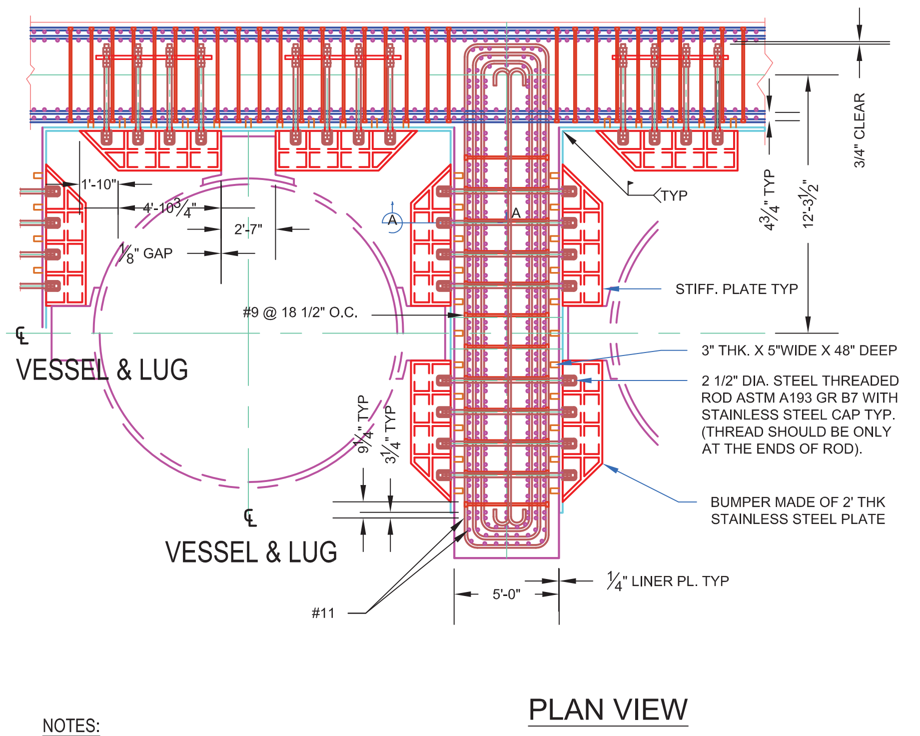
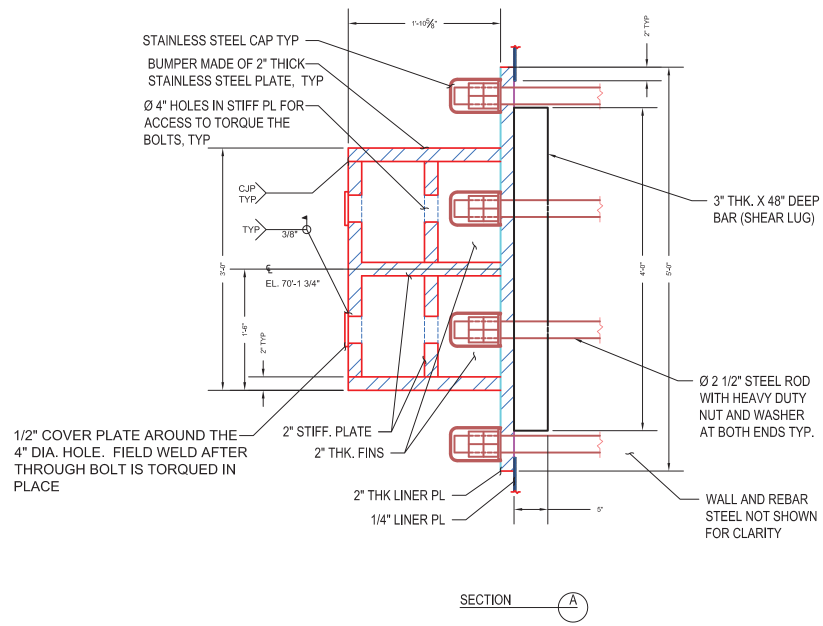


Figure 3B-51: NPM Lug Support Plan View and Details





NOTES:

1. THE FINAL LOCATION OF THE STEEL THREADED RODS WILL BE IN BETWEEN THE #11 REBAR SPACING. THE FINAL POSITION OF THE SHEAR LUGS WILL BE ADJUSTED ACCORDINGLY.
2. CONSTRUCTION: NOTE THE RXM LUG SUPPORTS NEED TO BE SHOP ASSEMBLED REBAR/LINER/RXM . LUG SUPPORTS WILL NEED TO BE MODELED TO BE CONSTRUCTIBLE.
3. THE SHEAR TIES WILL EXTEND THOROUGH THE 66" X 66" ANCHOR PLATE AND THE FINAL LOCATIN WILL BE BETWEEN THE #11 REBAR SPACING.

Figure 3B-52: NPM Lug Location

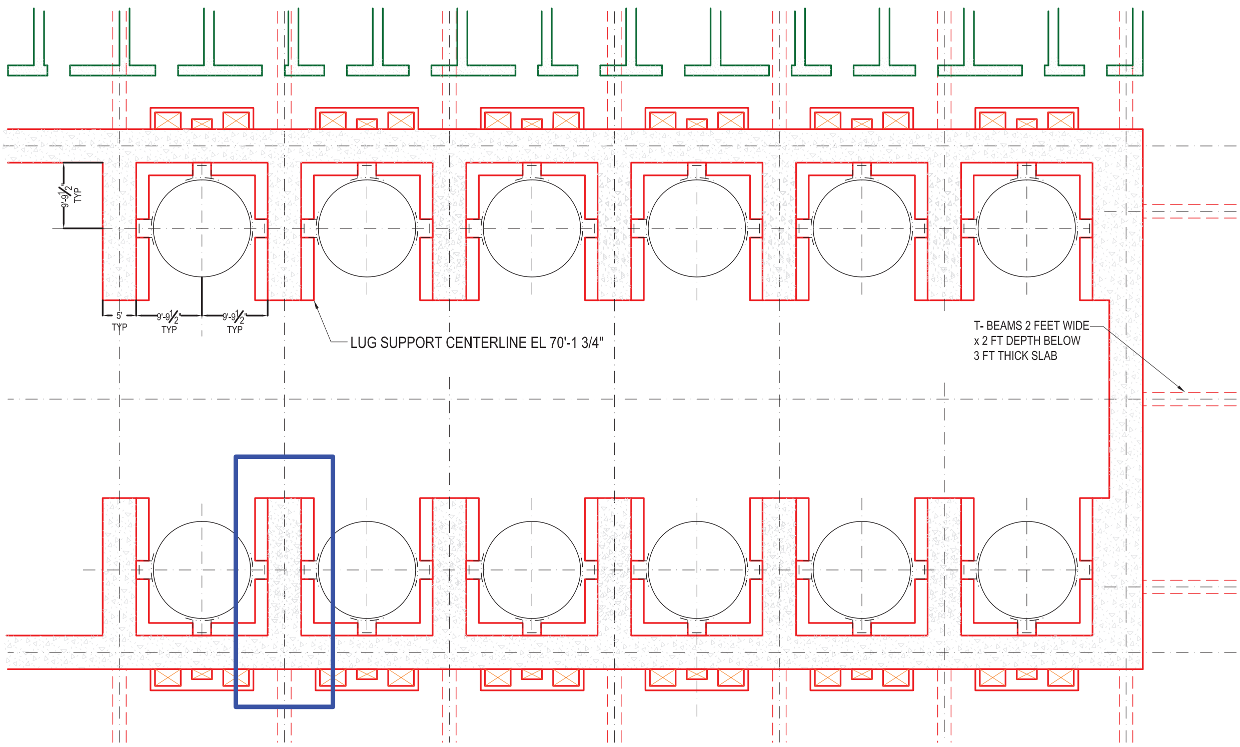


Figure 3B-53: NPM Lug Support SAP2000 Model

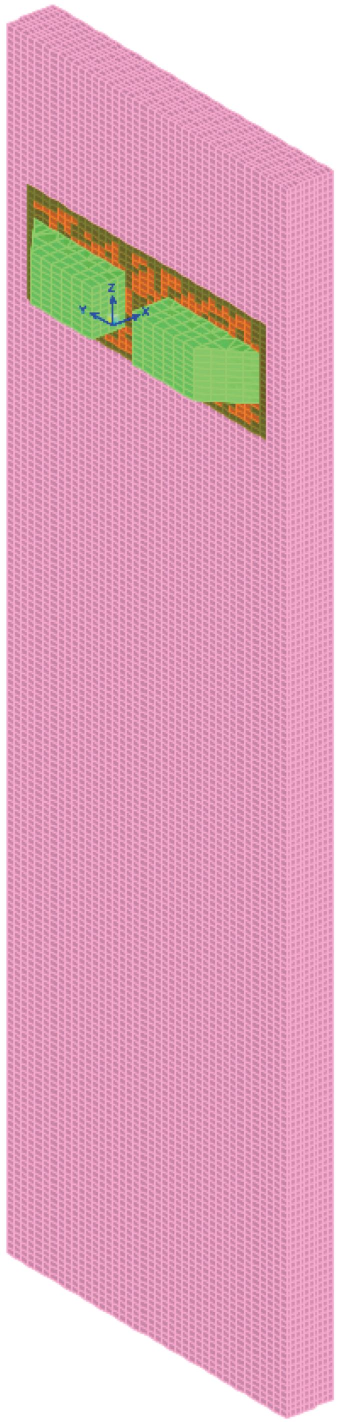


Figure 3B-54: NPM Lug Support SAP2000 Model Close-Up

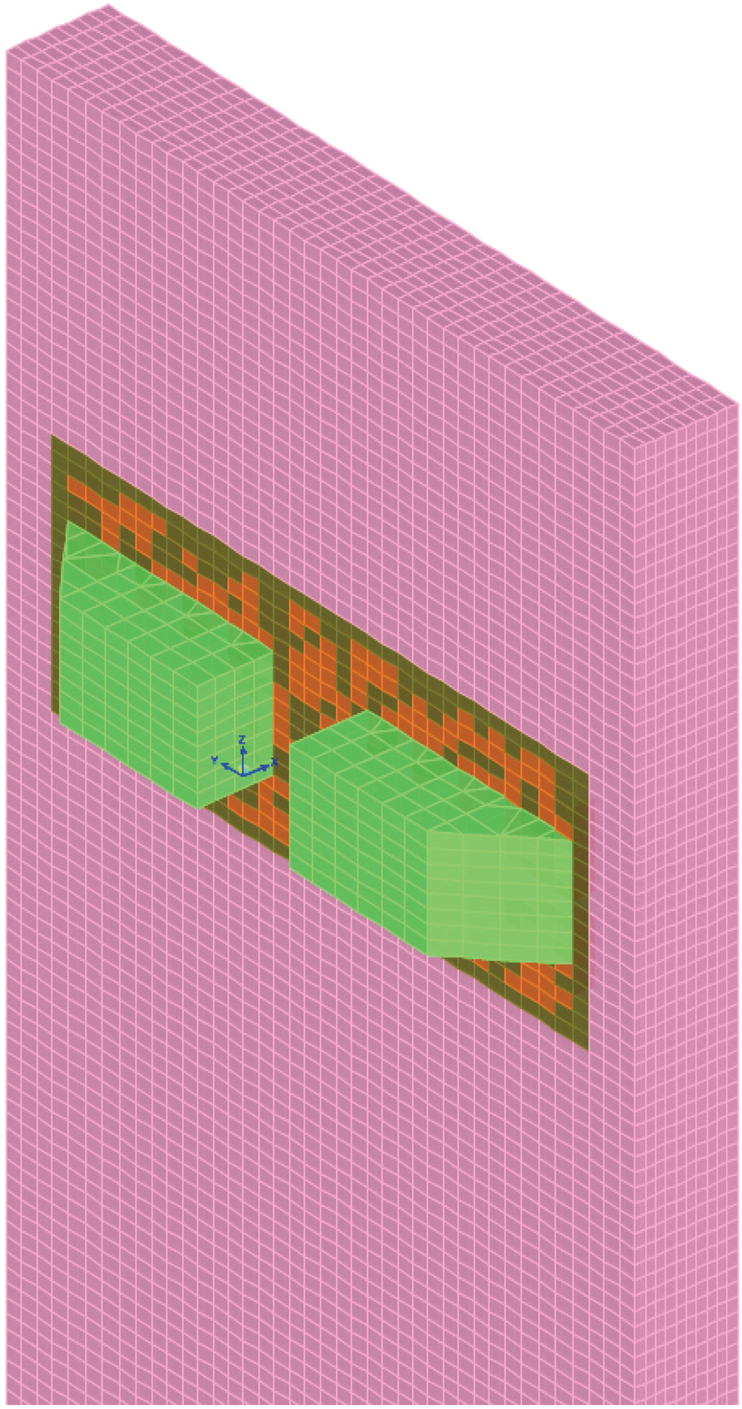


Figure 3B-55: NPM Lug Support Liner Plate Section

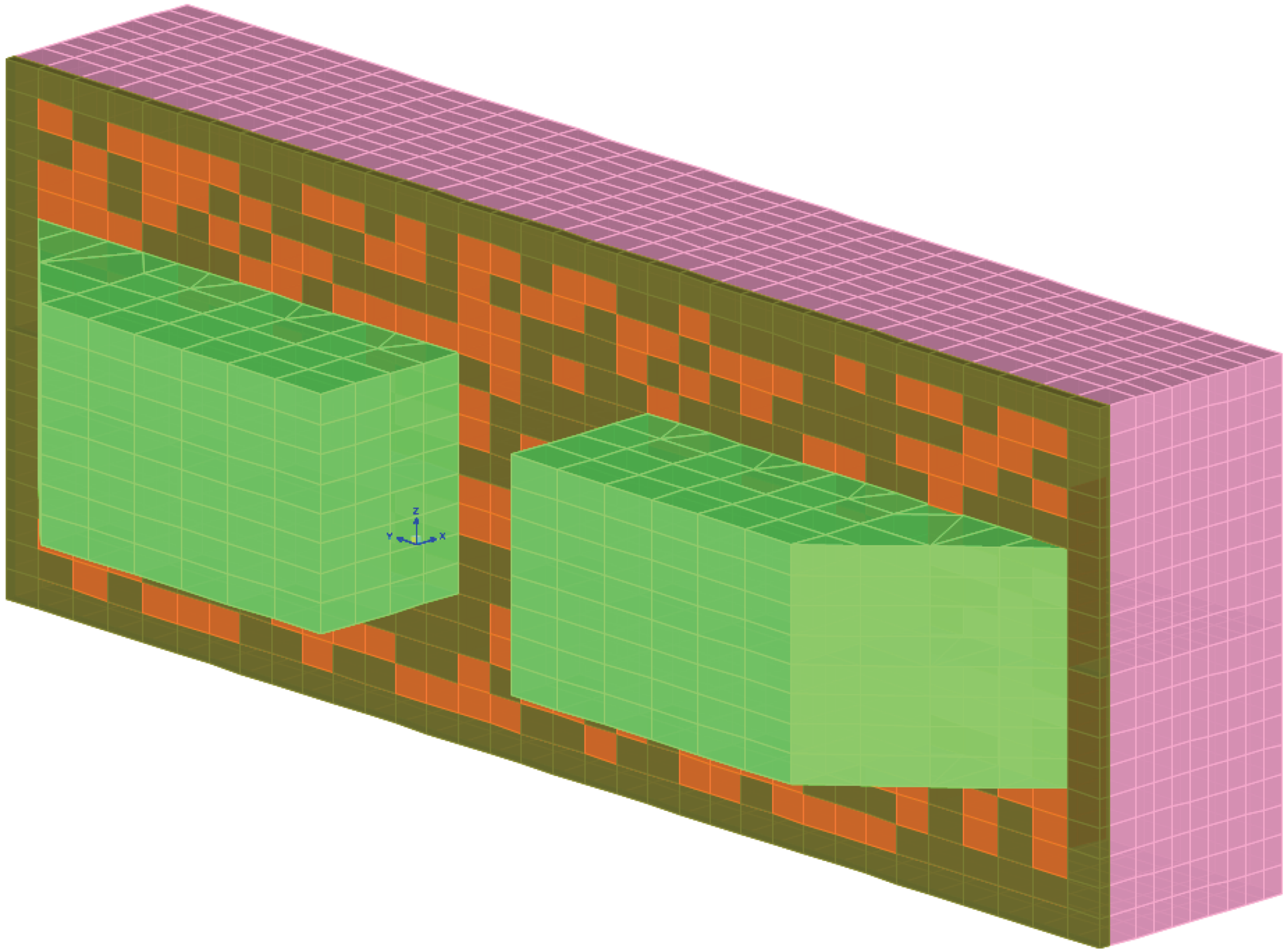


Figure 3B-56: NPM Lug Support Liner Plate and Shear Lugs (Shown in Red)

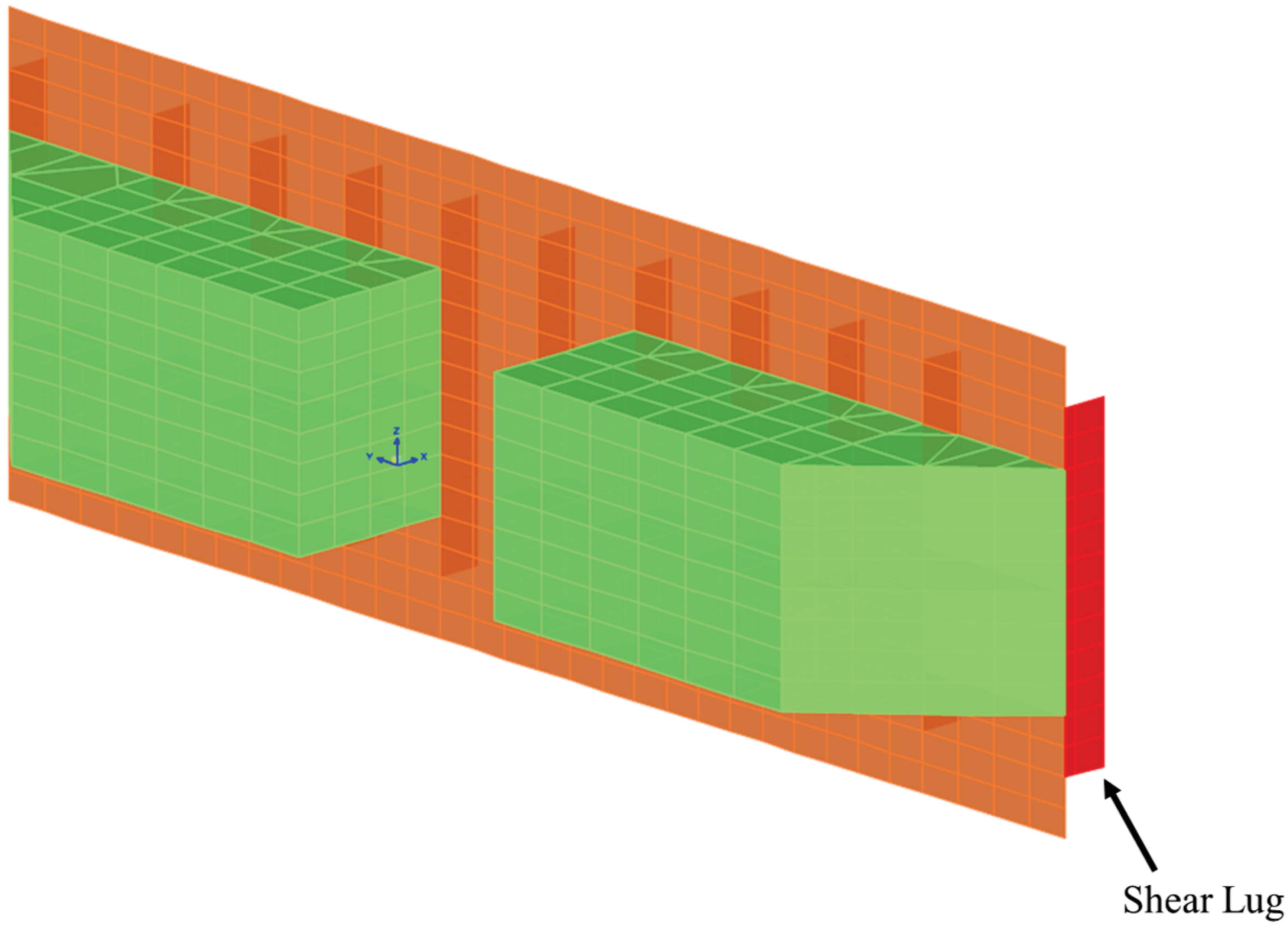


Figure 3B-57: NPM Lug Support Model showing internal Stiffener Plates

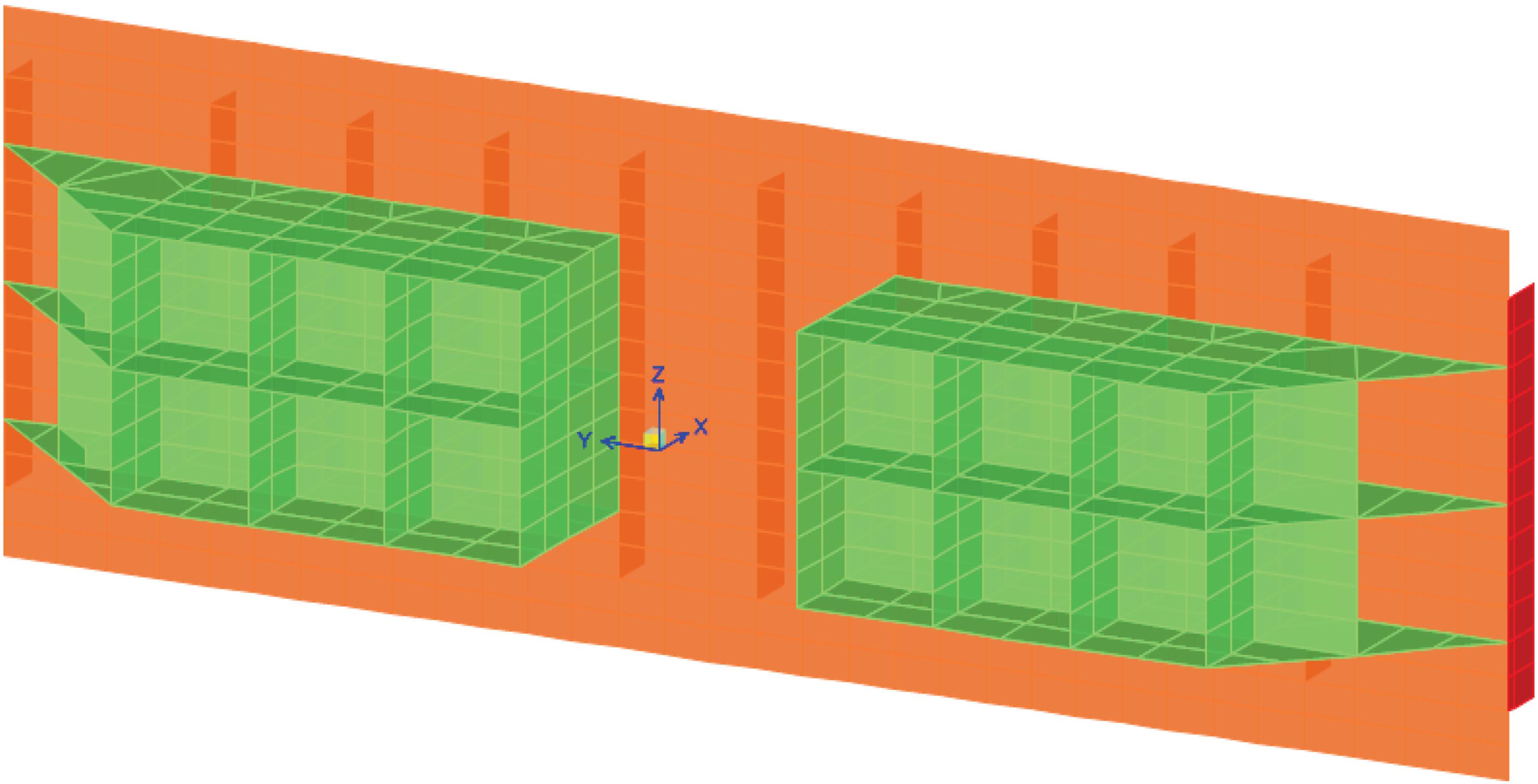


Figure 3B-58: NPM Lug Support Loading (W-Lug-PY+)

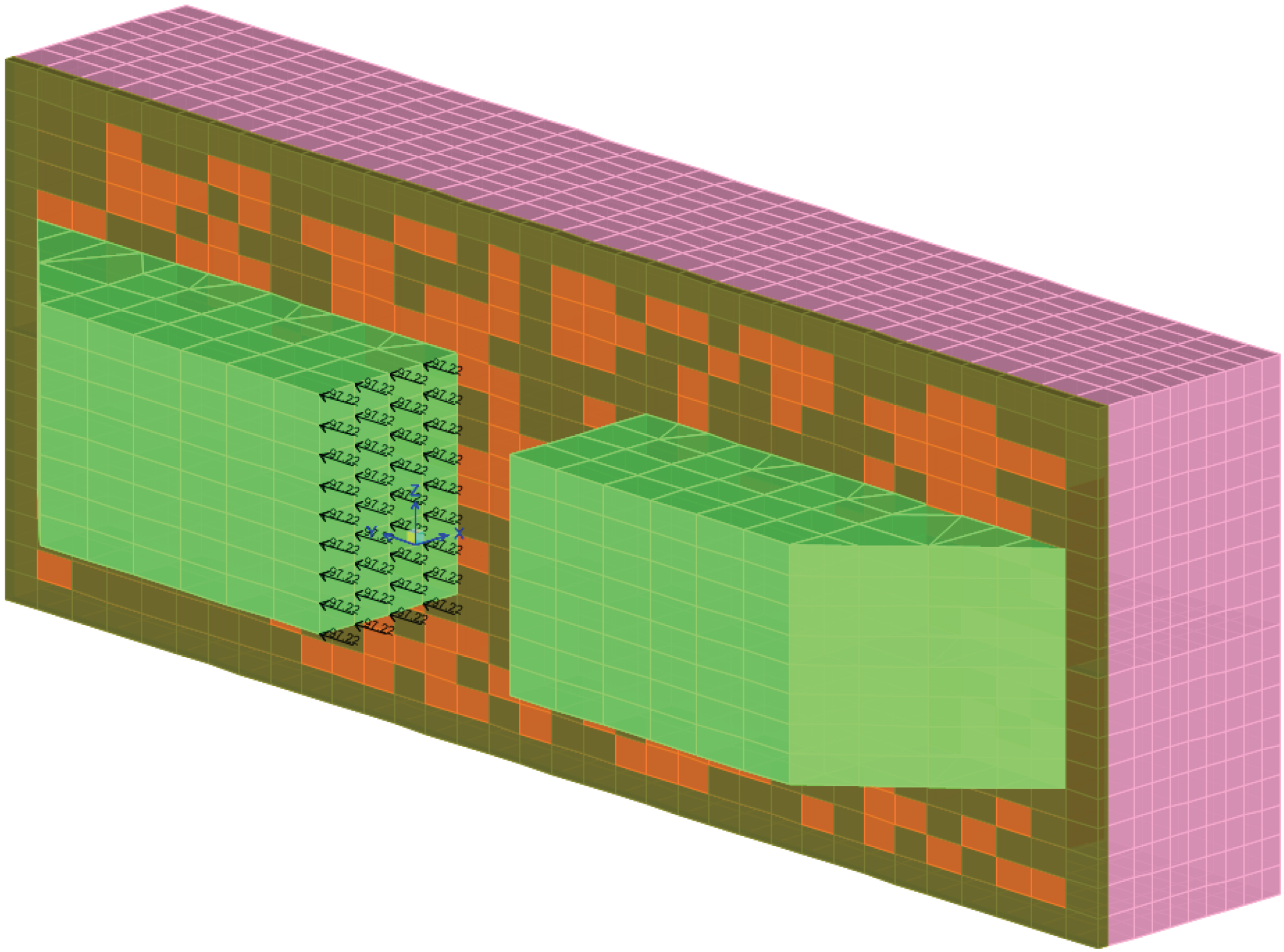


Figure 3B-59: NPM Lug Support Loading (W-Lug-PY-)

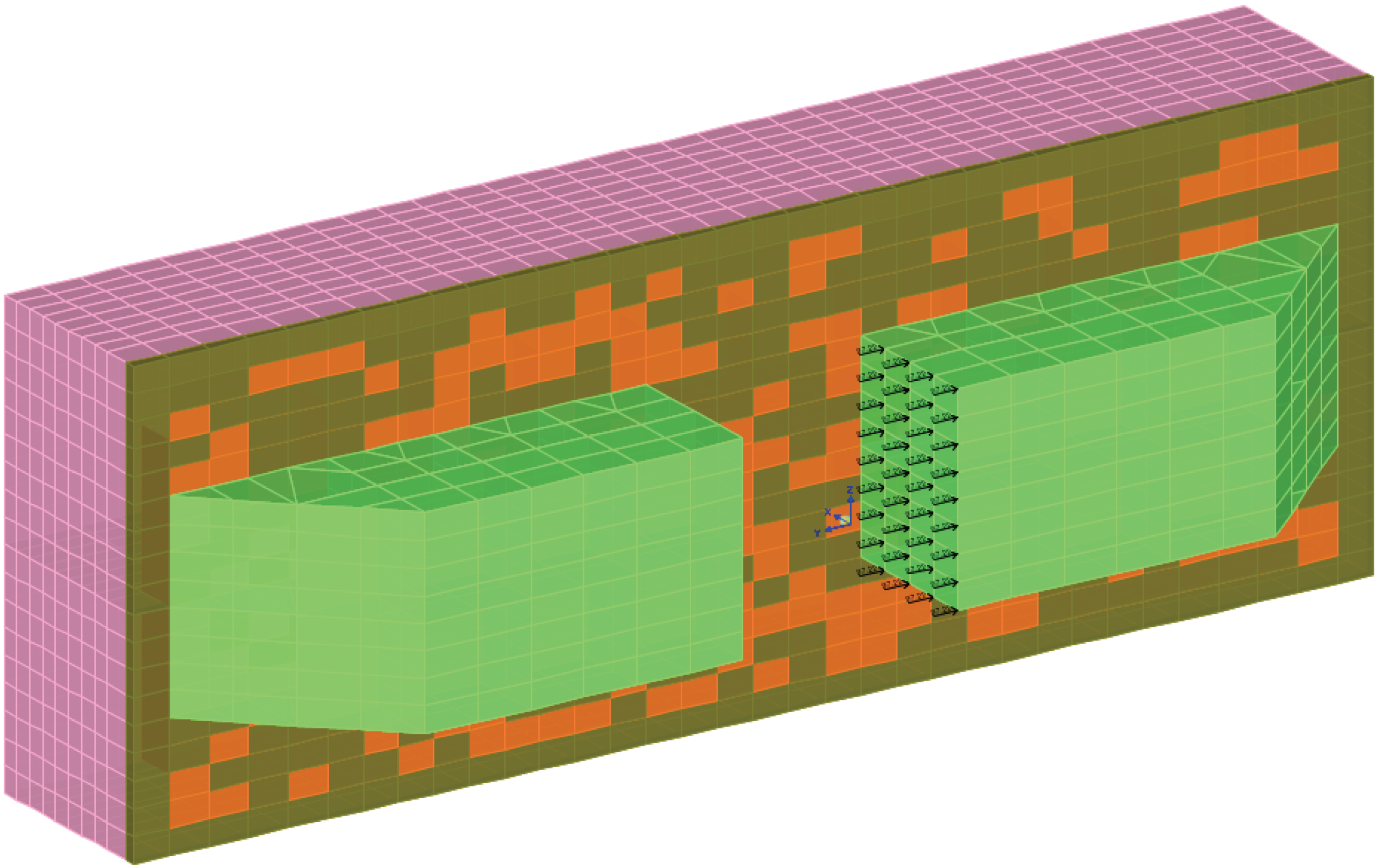


Figure 3B-60: NPM Lug Support SAP2000 Model Restraints

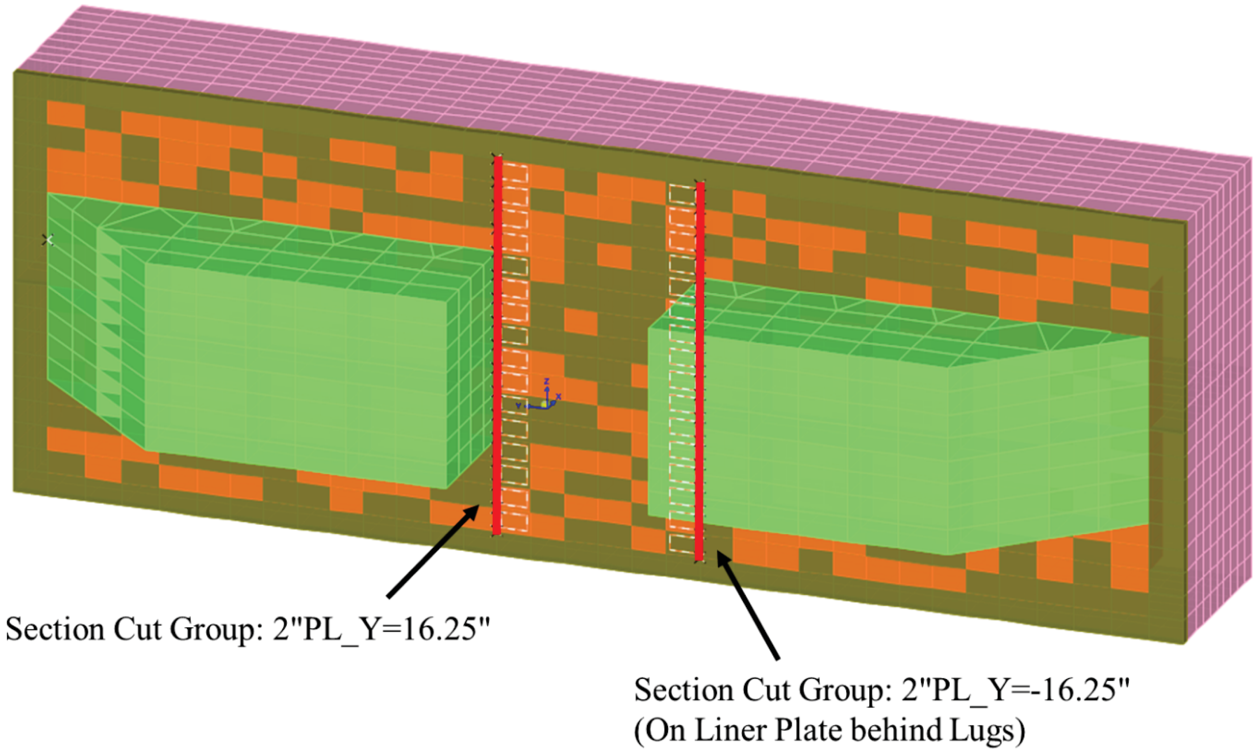


Figure 3B-61: Stiffener Plate Section Cut Groups (Fins)

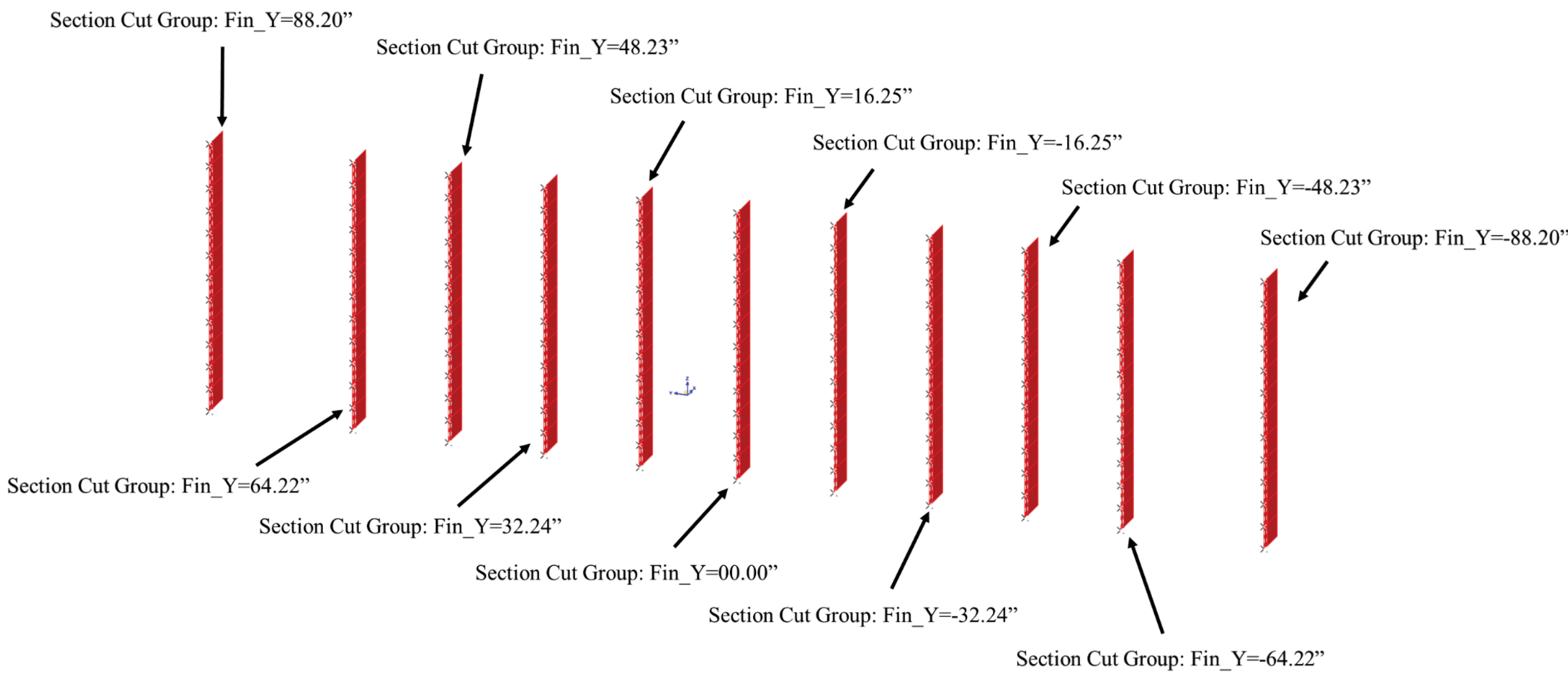


Figure 3B-62: S11 Stress plotted on the Deflected Shape due to Load Combination W-Lug-PY+ (psi)

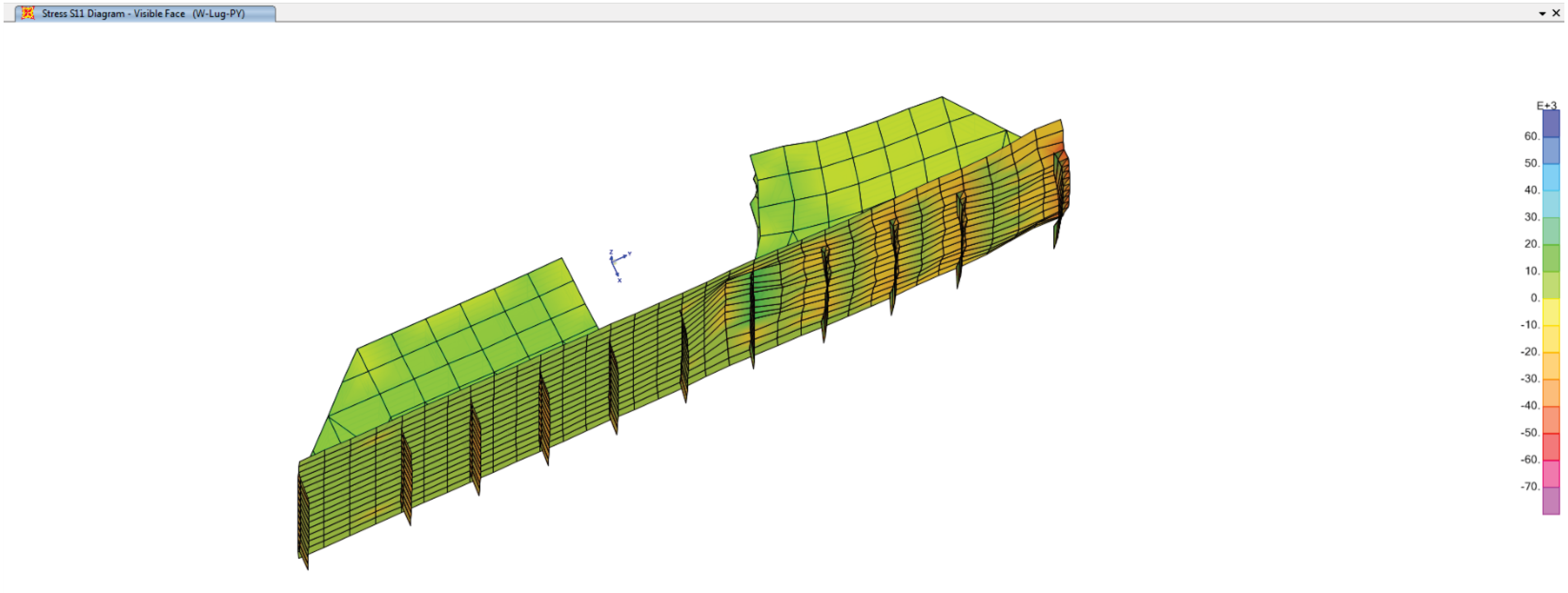


Figure 3B-63: Not Used

Figure 3B-64: Not Used

Figure 3B-65: SAP2000 Elevation View and Shell Element Numbers at CRB Grid Line 3 (Looking North)

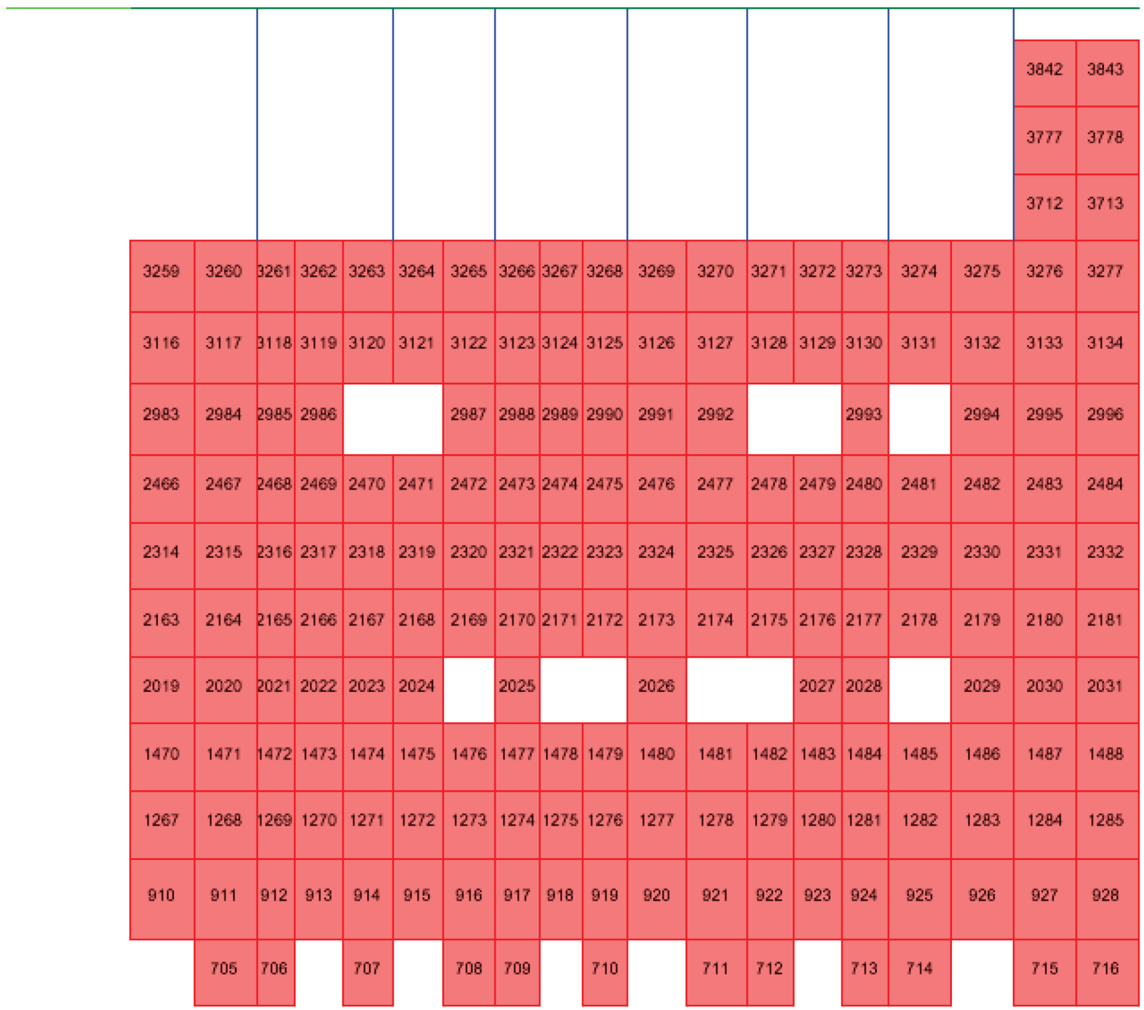


Figure 3B-66: CRB Reinforcement Elevation at Grid Line 3 Wall

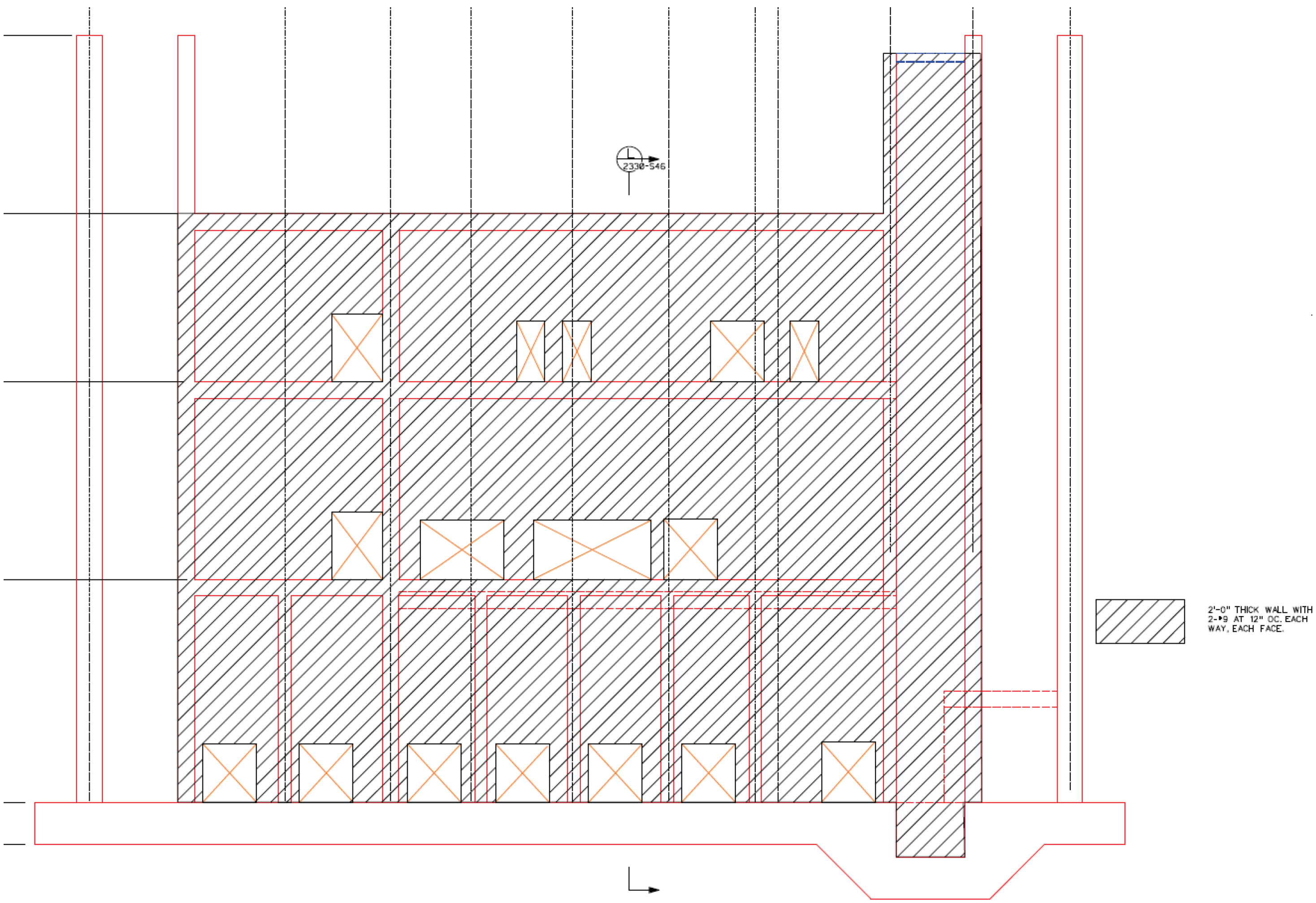


Figure 3B-67: CRB Reinforcement Section View of Wall on Grid Line 3

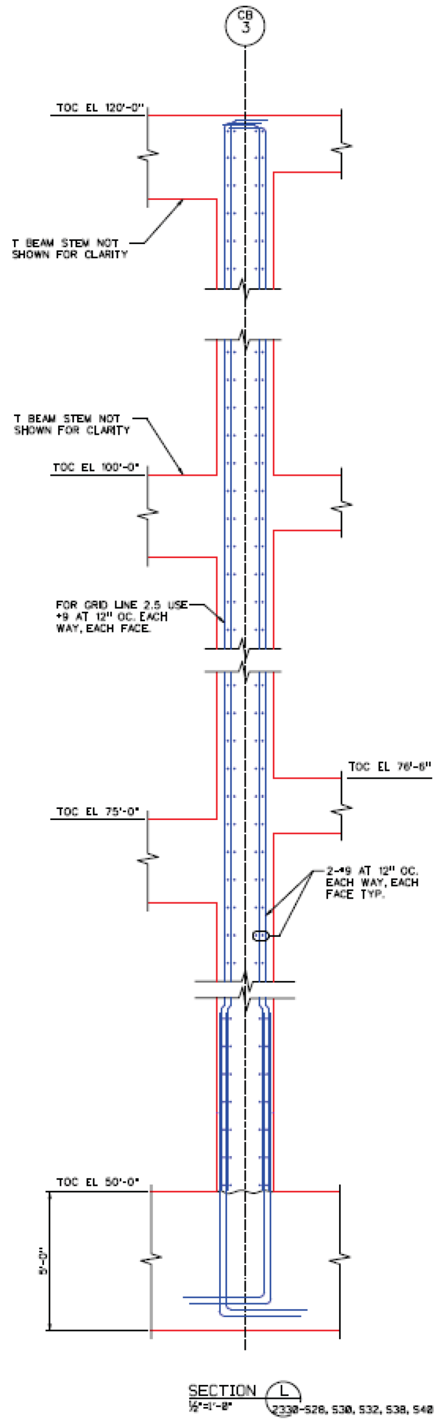


Figure 3B-68: SAP2000 Elevation View and Shell Element Numbers at CRB Grid Line 4 (Looking West)

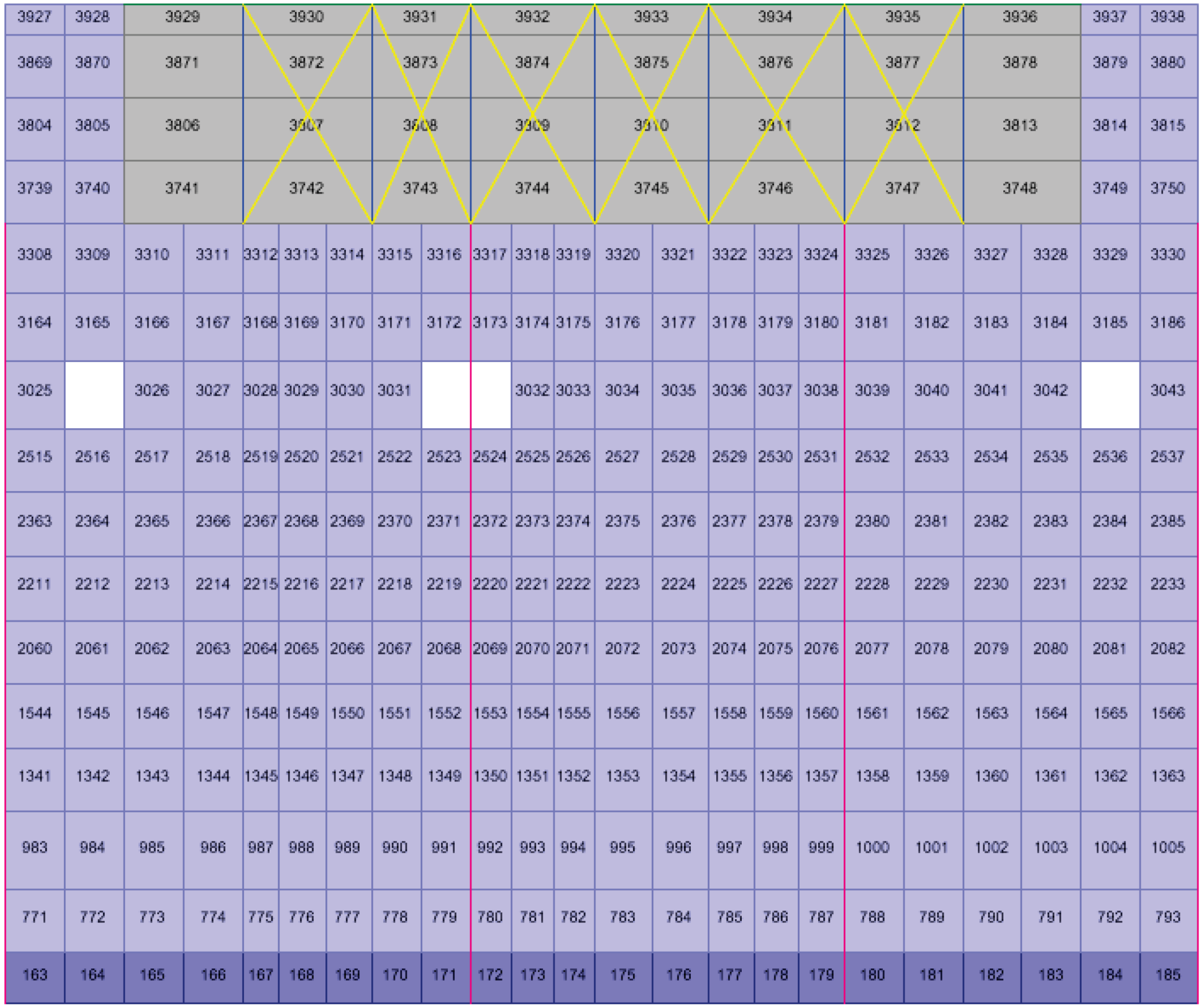


Figure 3B-69: CRB Reinforcement Elevation at Grid Line 4 Wall

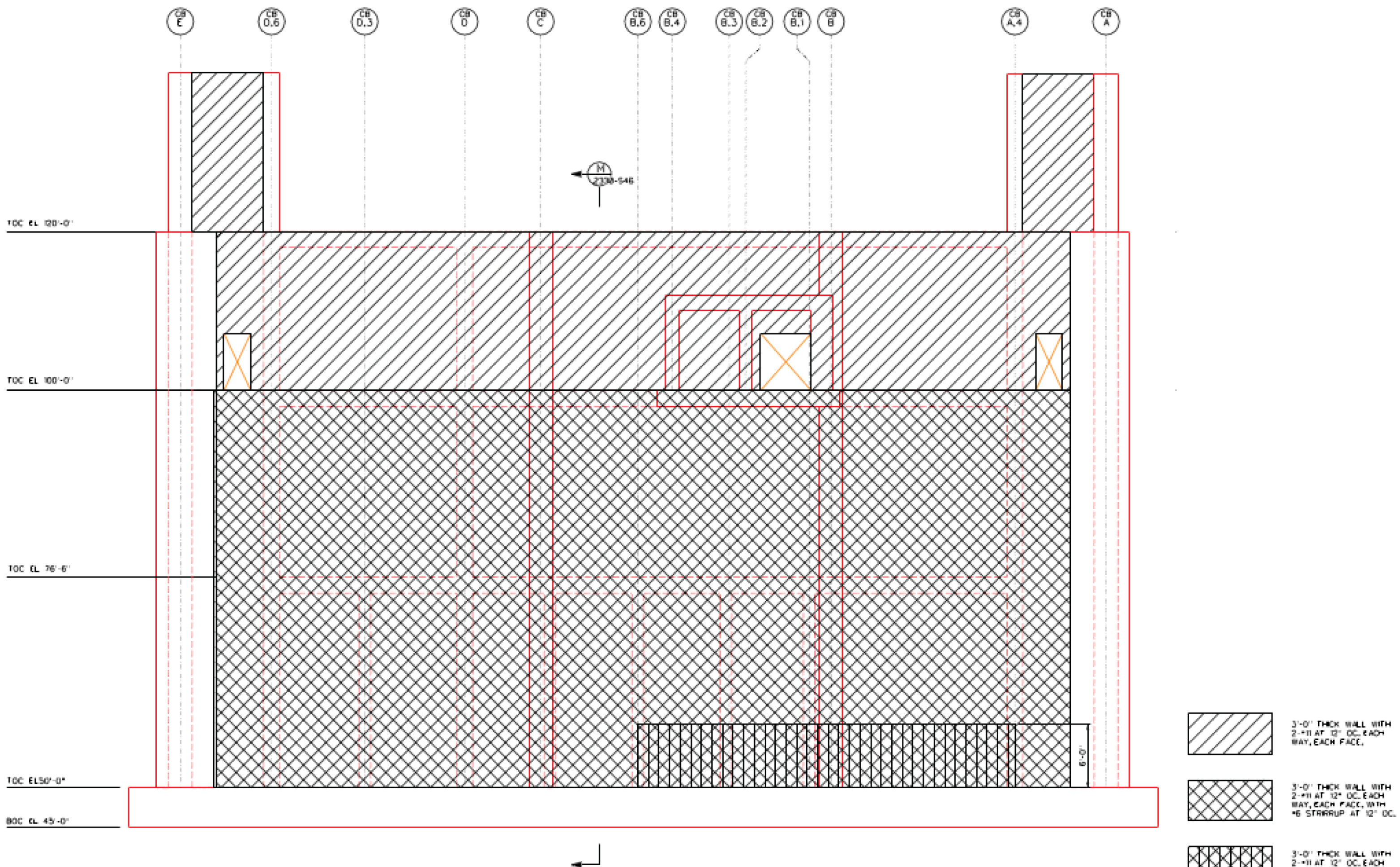


Figure 3B-70: CRB Reinforcement Section View of Wall on Grid Line 4

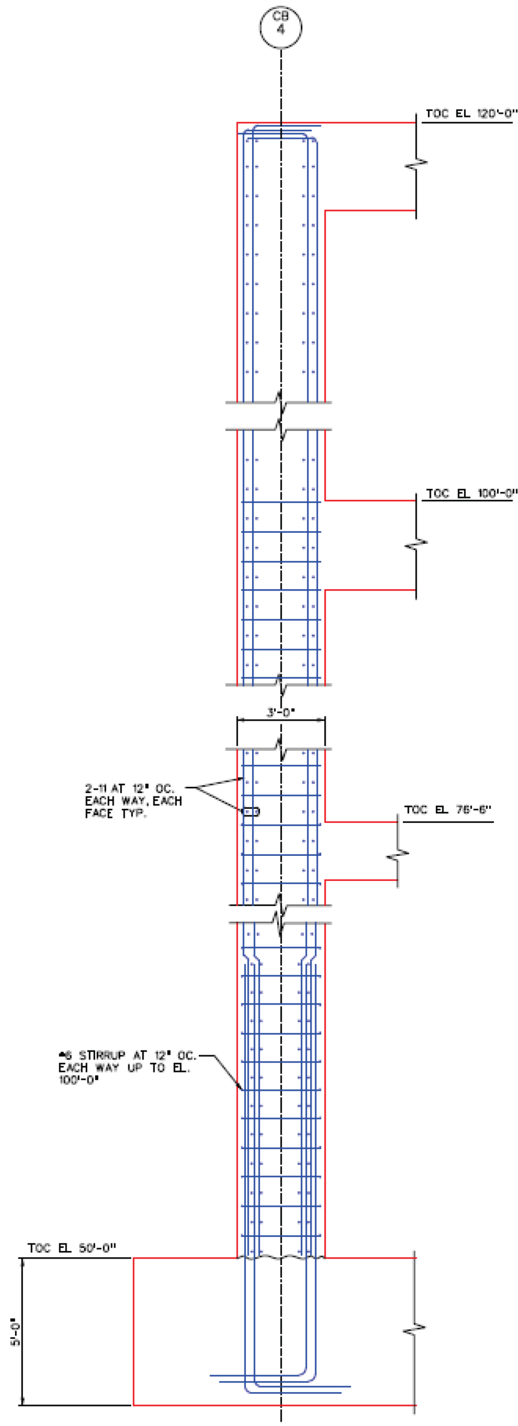


Figure 3B-71: SAP2000 Elevation View and Shell Element Numbers at Grid Line A (Looking West)

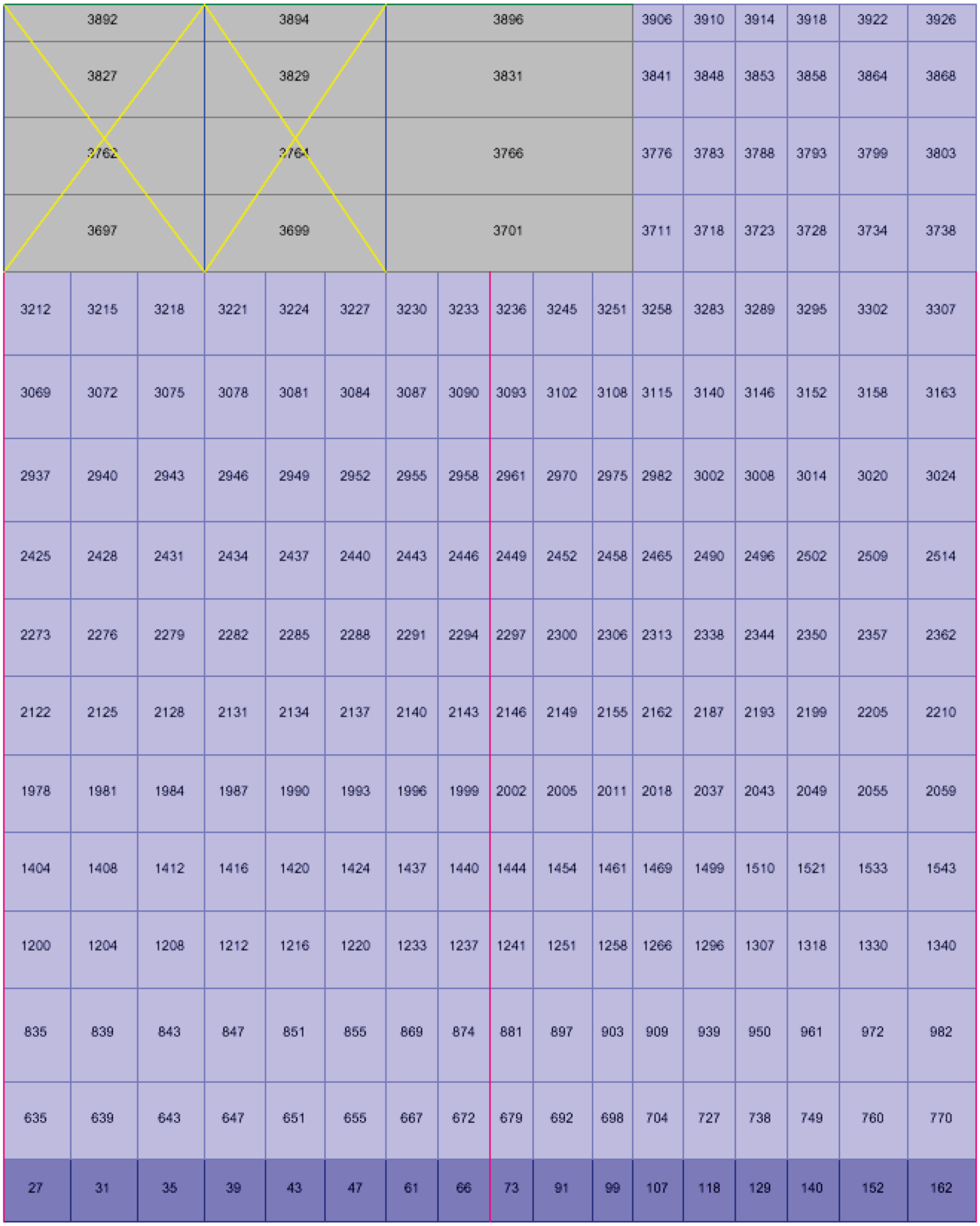


Figure 3B-72: CRB Reinforcement Elevation at Grid Line A Wall

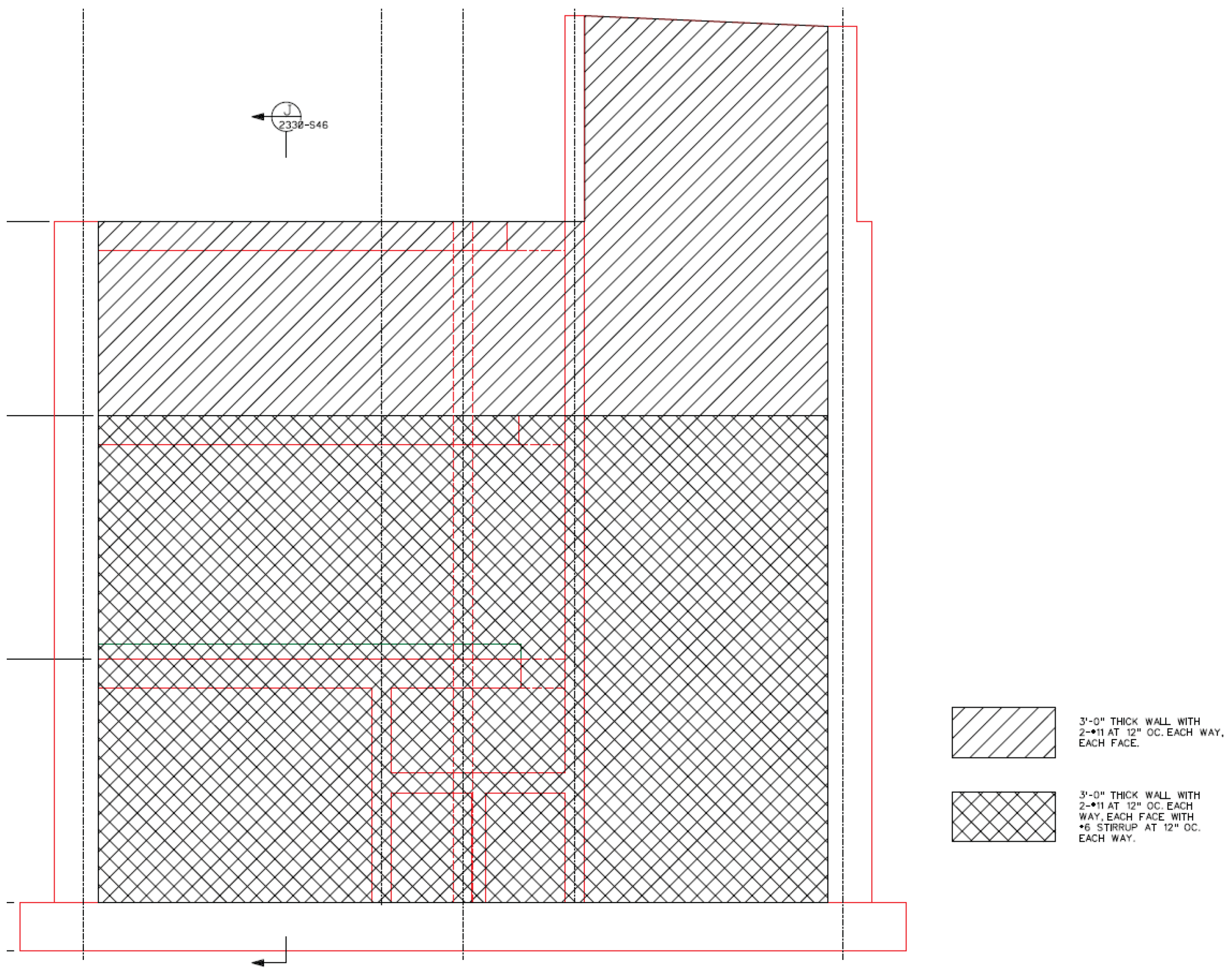


Figure 3B-73: CRB Reinforcement Section View of Wall on Grid Line A

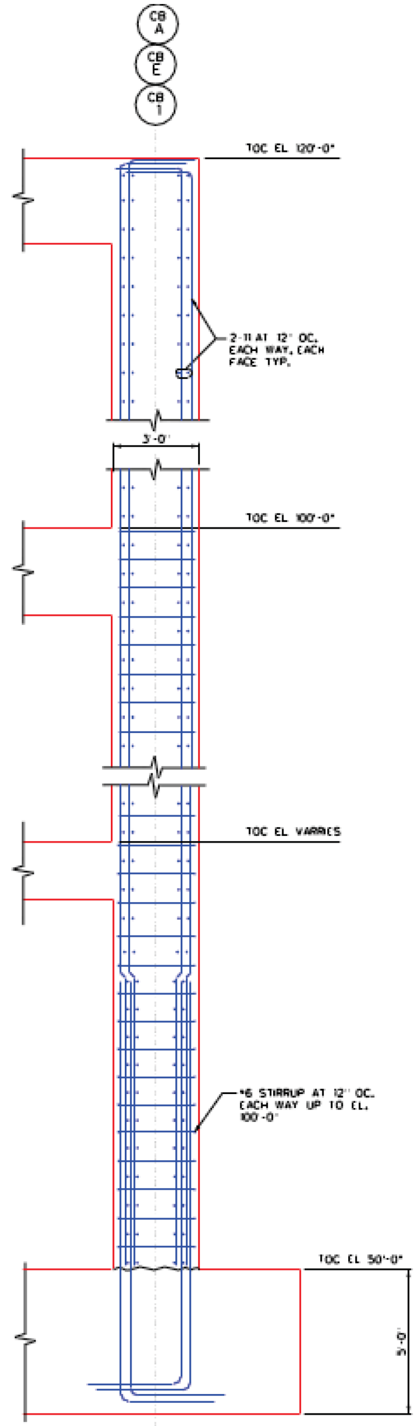


Figure 3B-74: CRB Basemat View of Finite Element Model

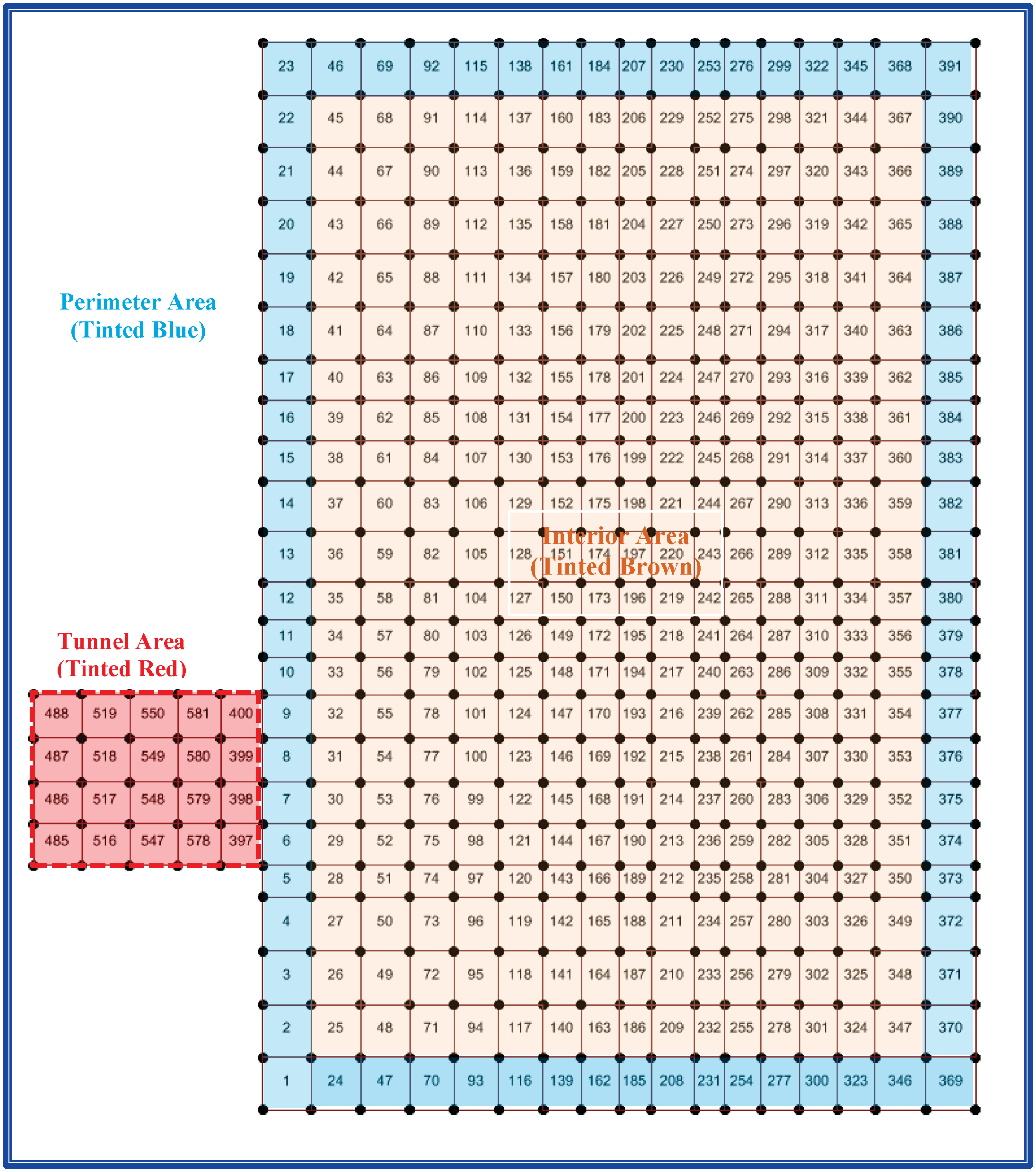


Figure 3B-75: CRB Reinforcement Plan of Basemat Foundation

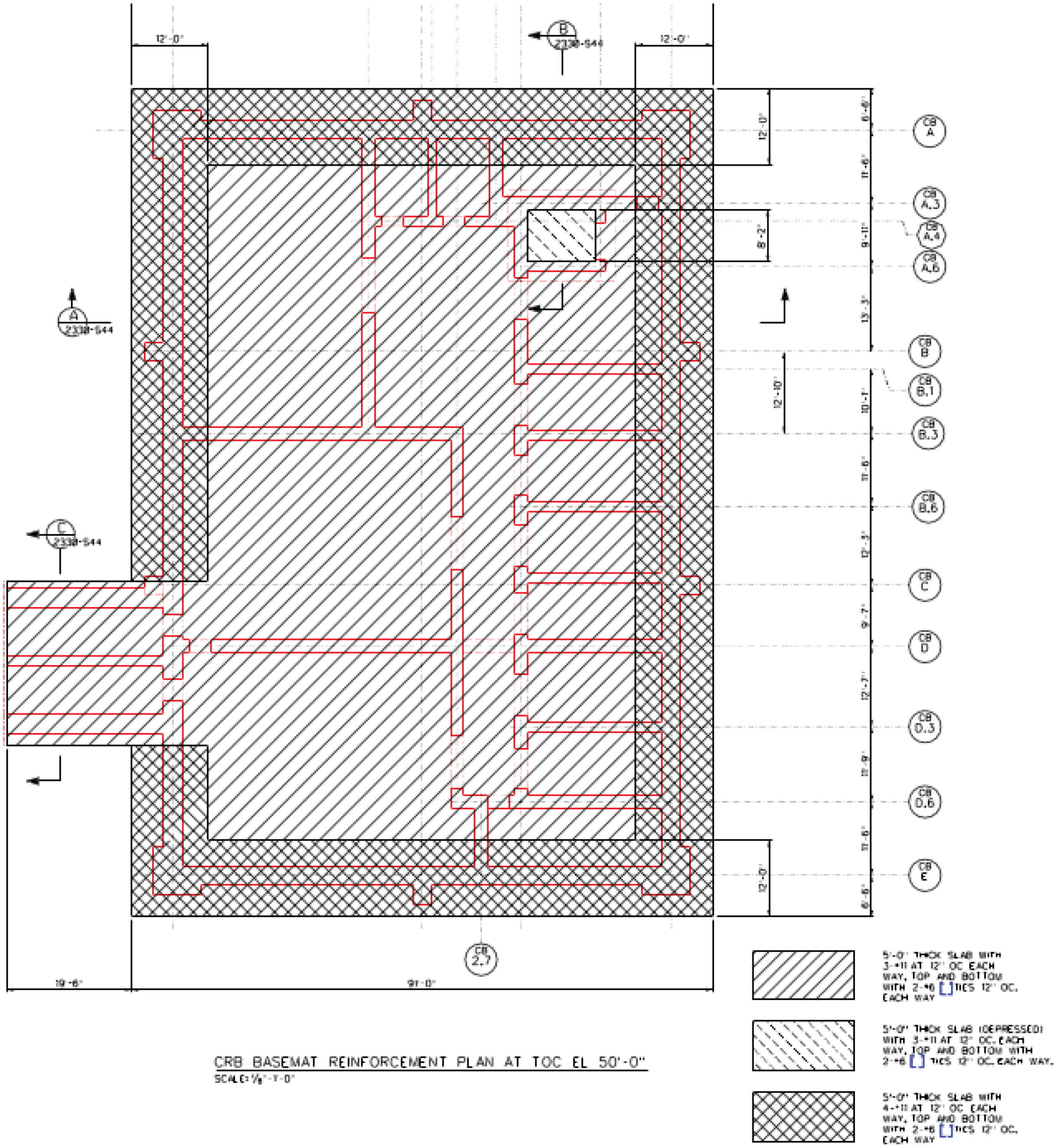


Figure 3B-76: Cross Section of CRB Basemat Showing Reinforcing Steel

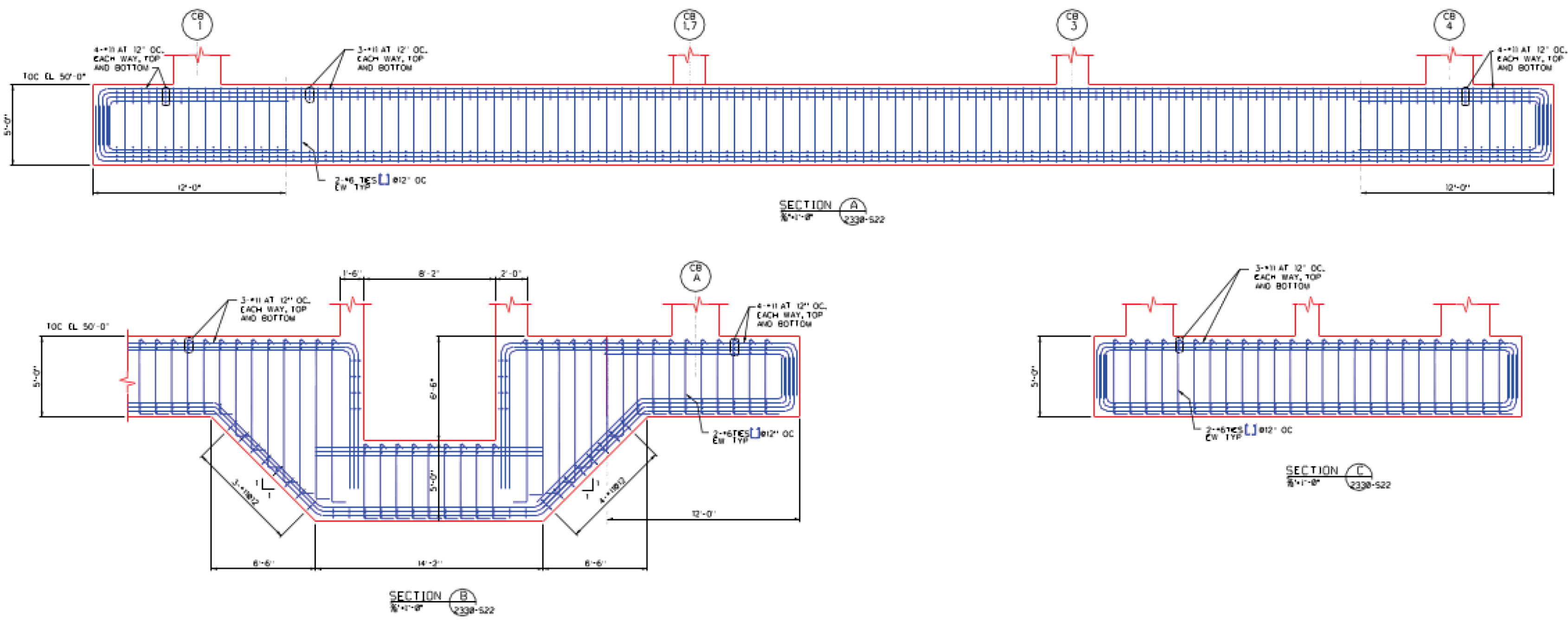


Figure 3B-77: SAP2000 Plan View and Shell Element Numbers on CRB Slab at EL. 100'-0"

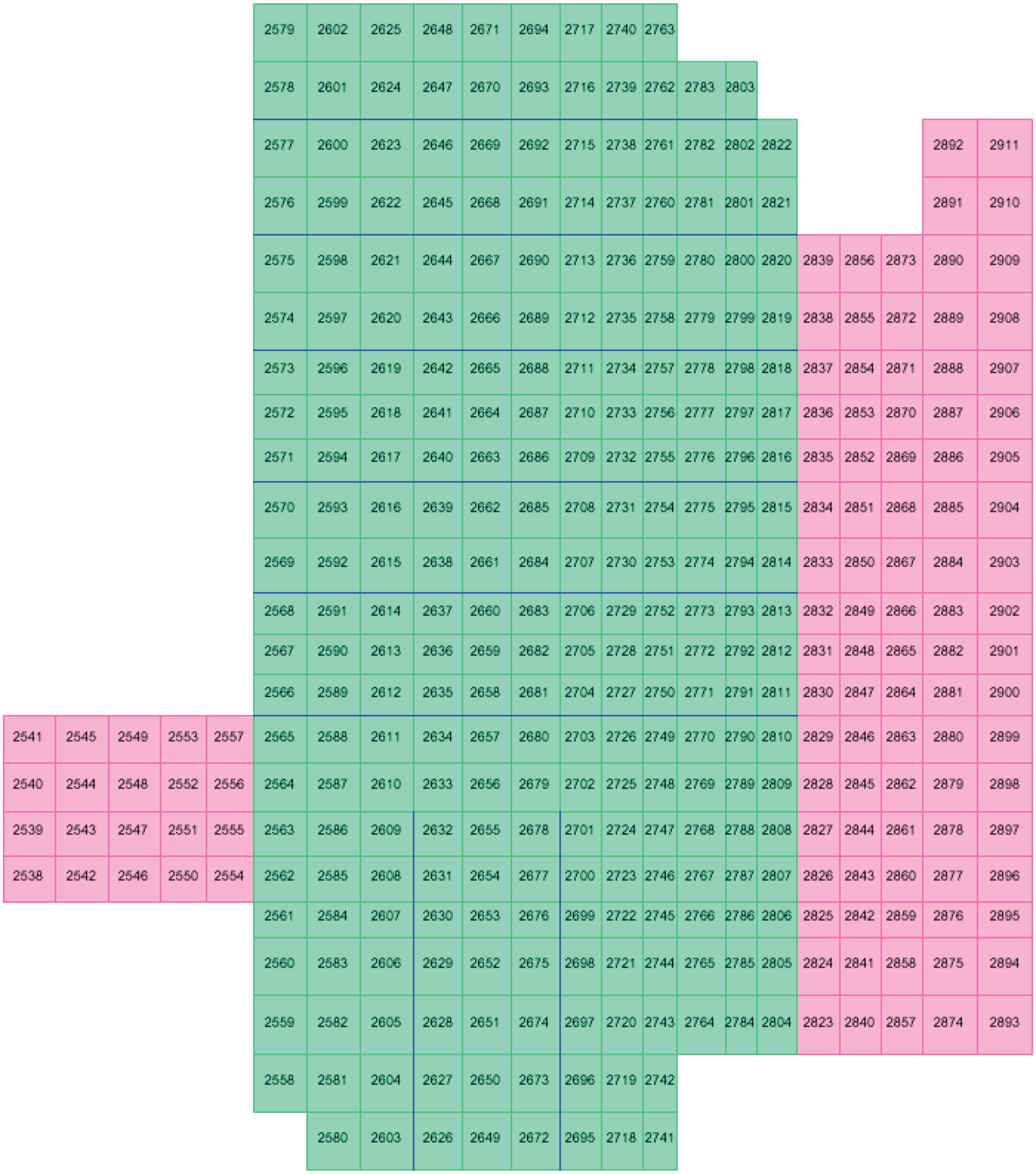


Figure 3B-78: CRB Reinforcement Plan at EL. 100'-0"

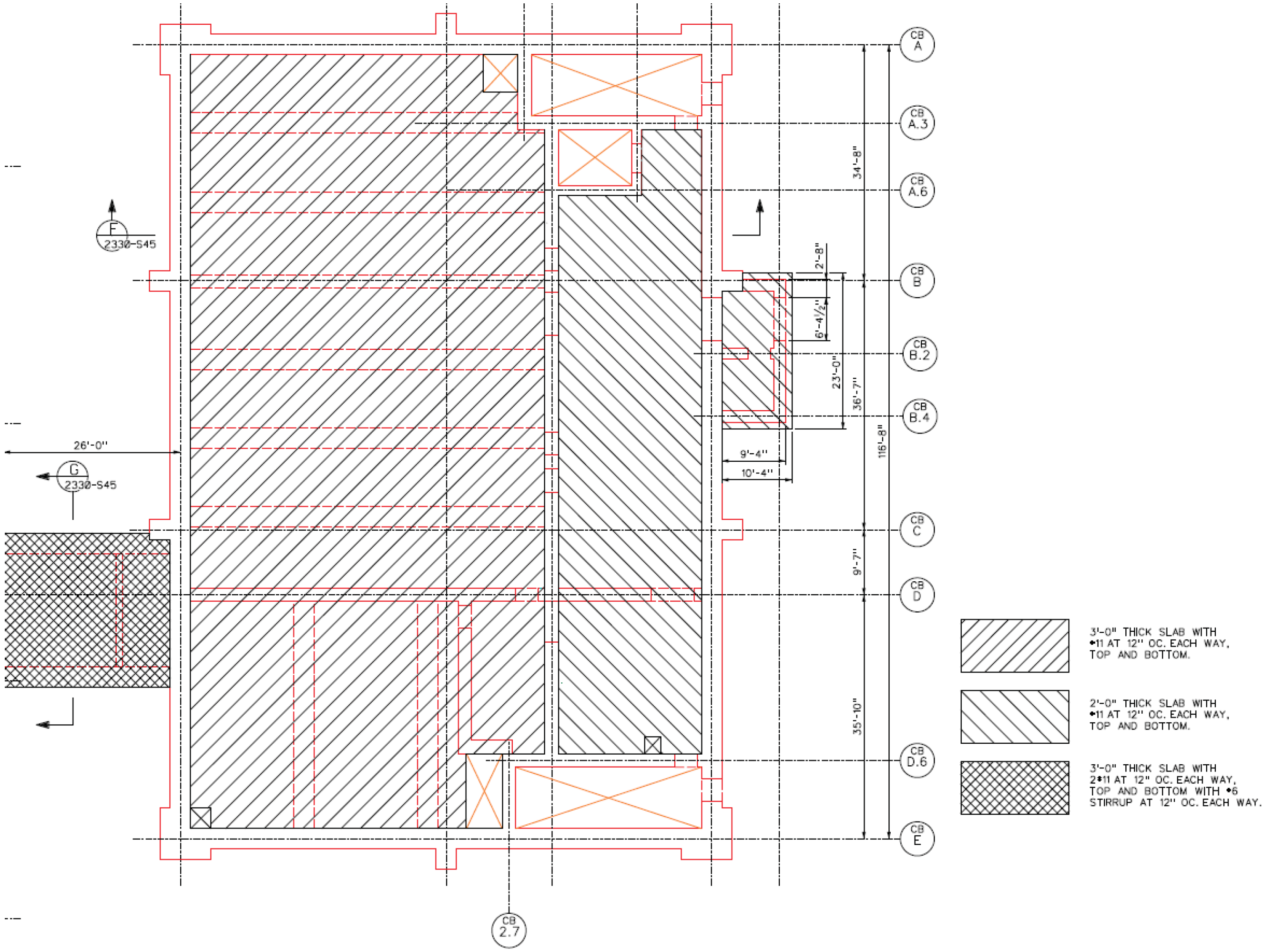


Figure 3B-79: CRB Reinforcement Section Views of Slab at EL. 100'-0"

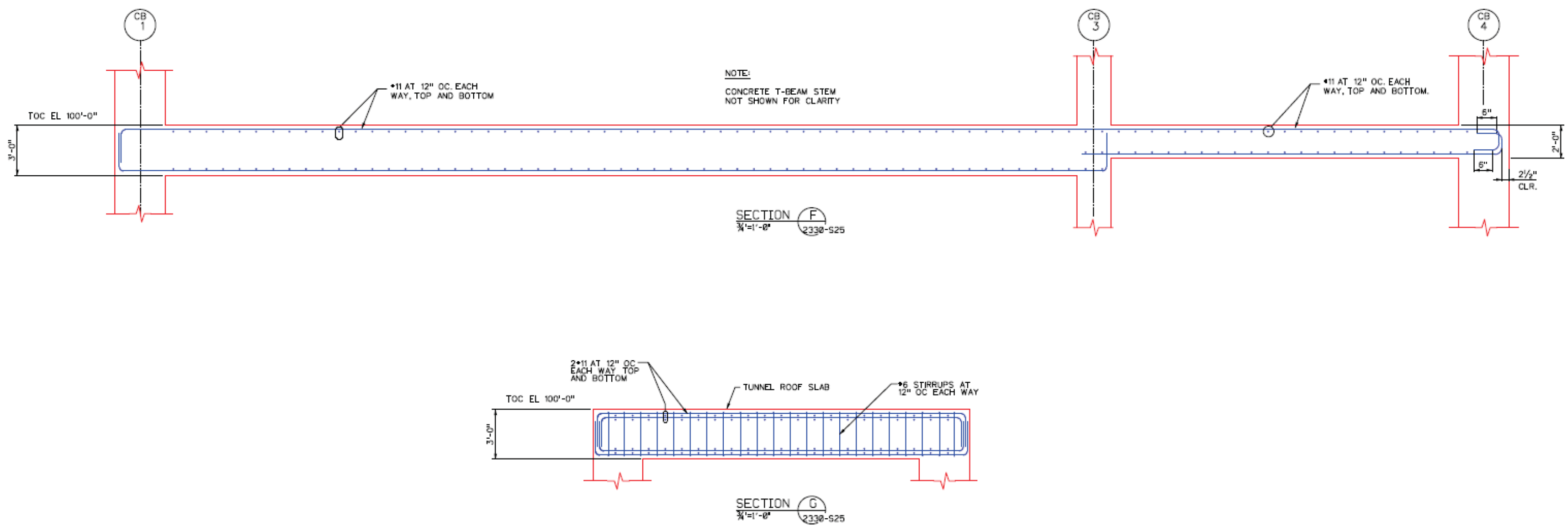


Figure 3B-80: SAP2000 View and Frame Element Numbers of Pilasters on CRB Grid Line 1 Wall

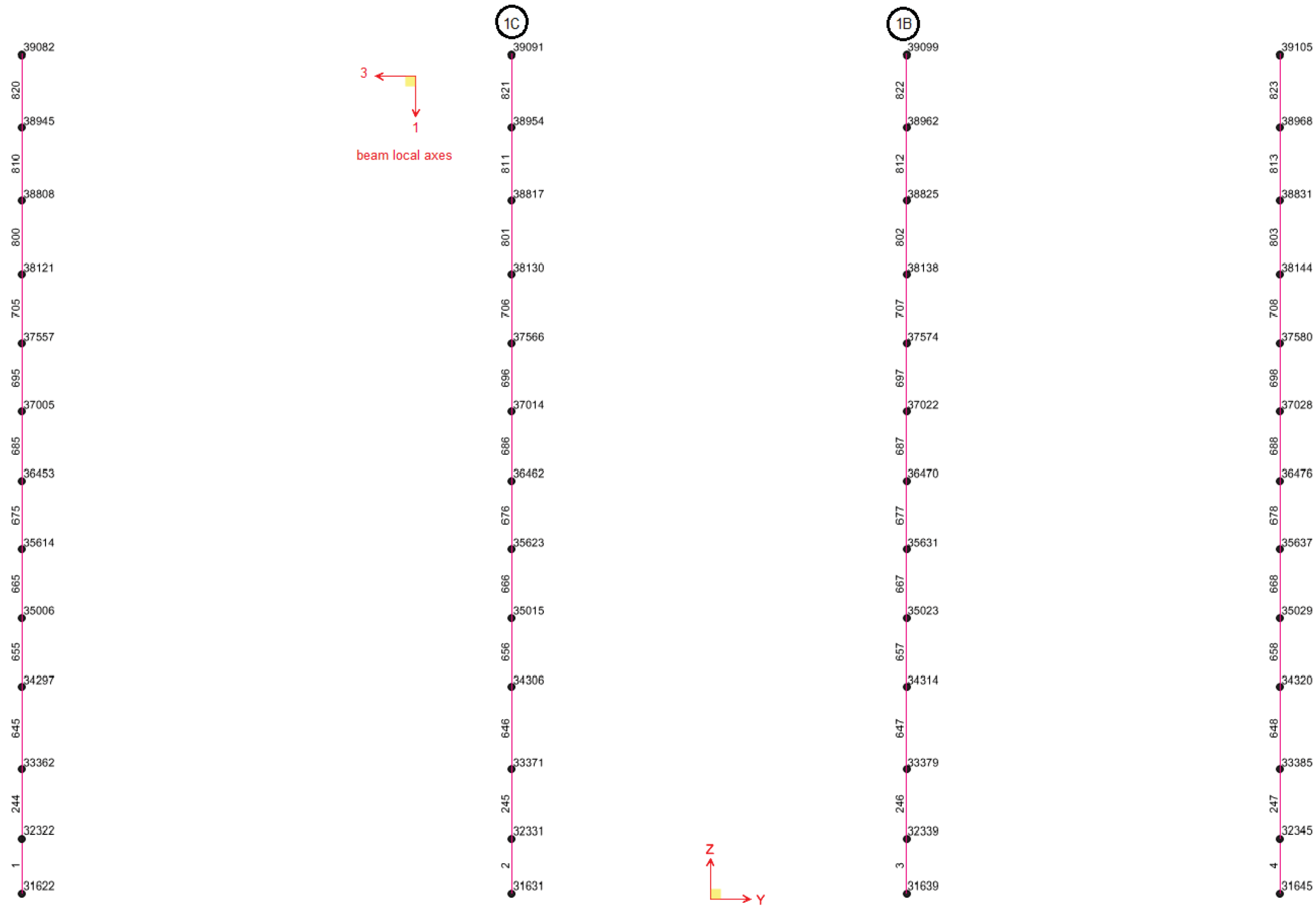


Figure 3B-81: CRB Reinforcement Detail for Pilaster Type 1

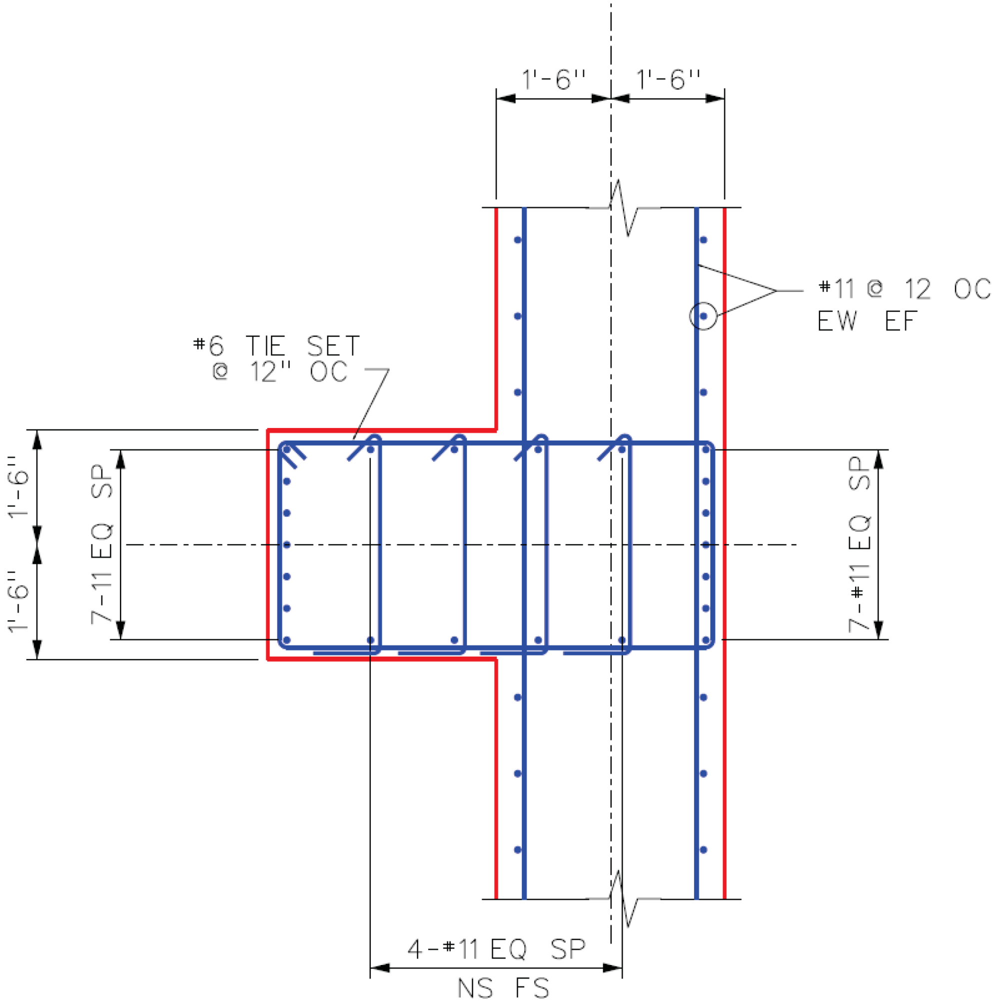


Figure 3B-82: CRB Reinforcement Detail for Pilaster Type 2

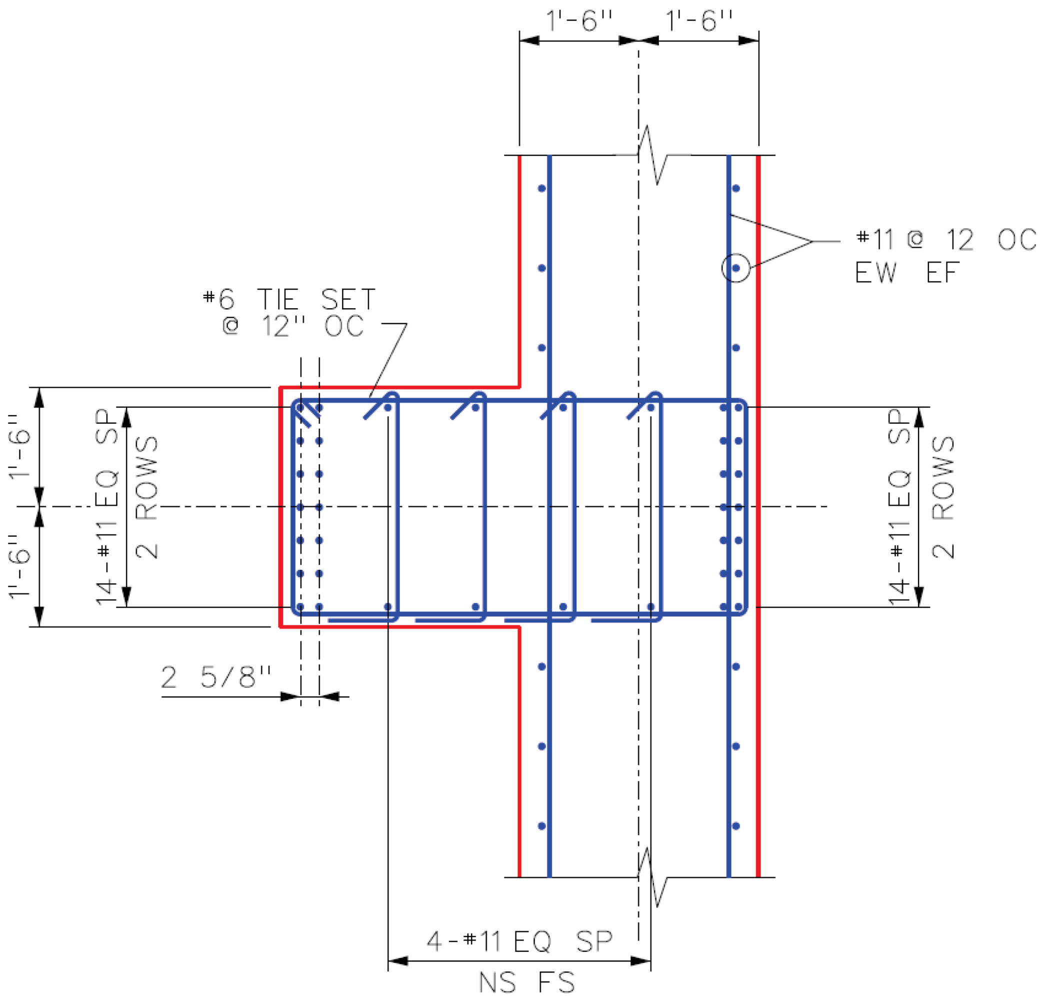


Figure 3B-83: SAP2000 View and Frame Element Numbers of T-Beams on CRB EL. 120'-0" Slab

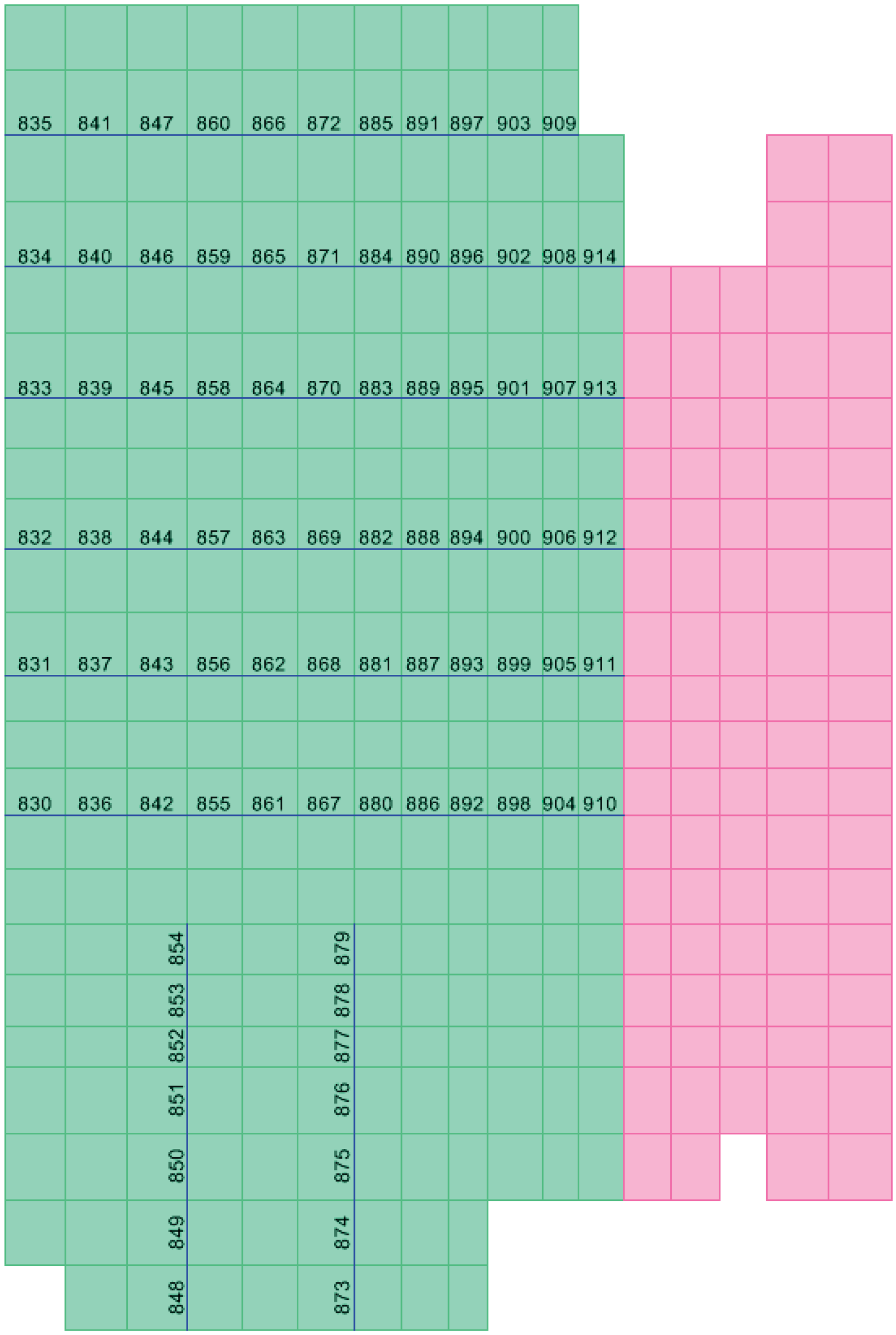


Figure 3B-84: CRB Reinforcement Detail for T-Beam (Type 1) at EL. 120'-0"

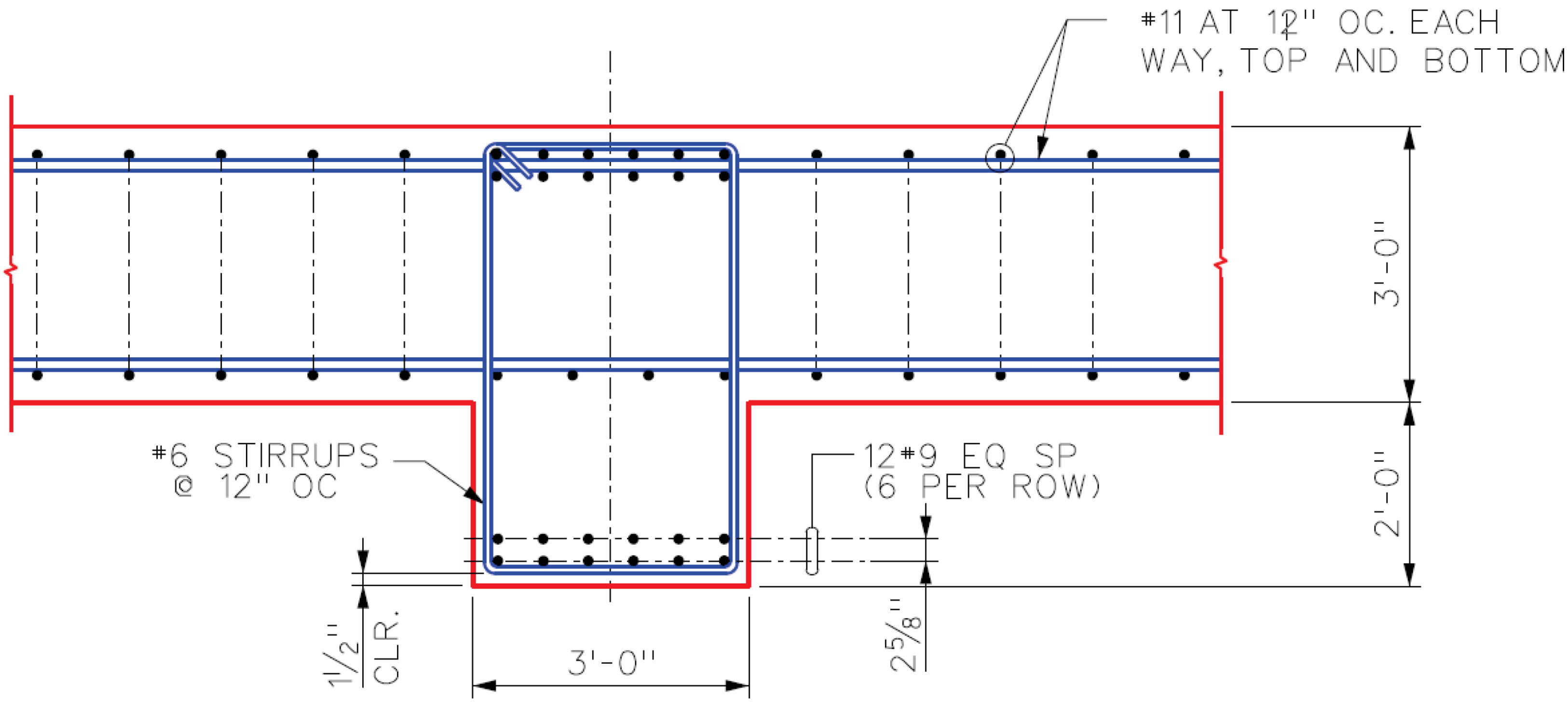
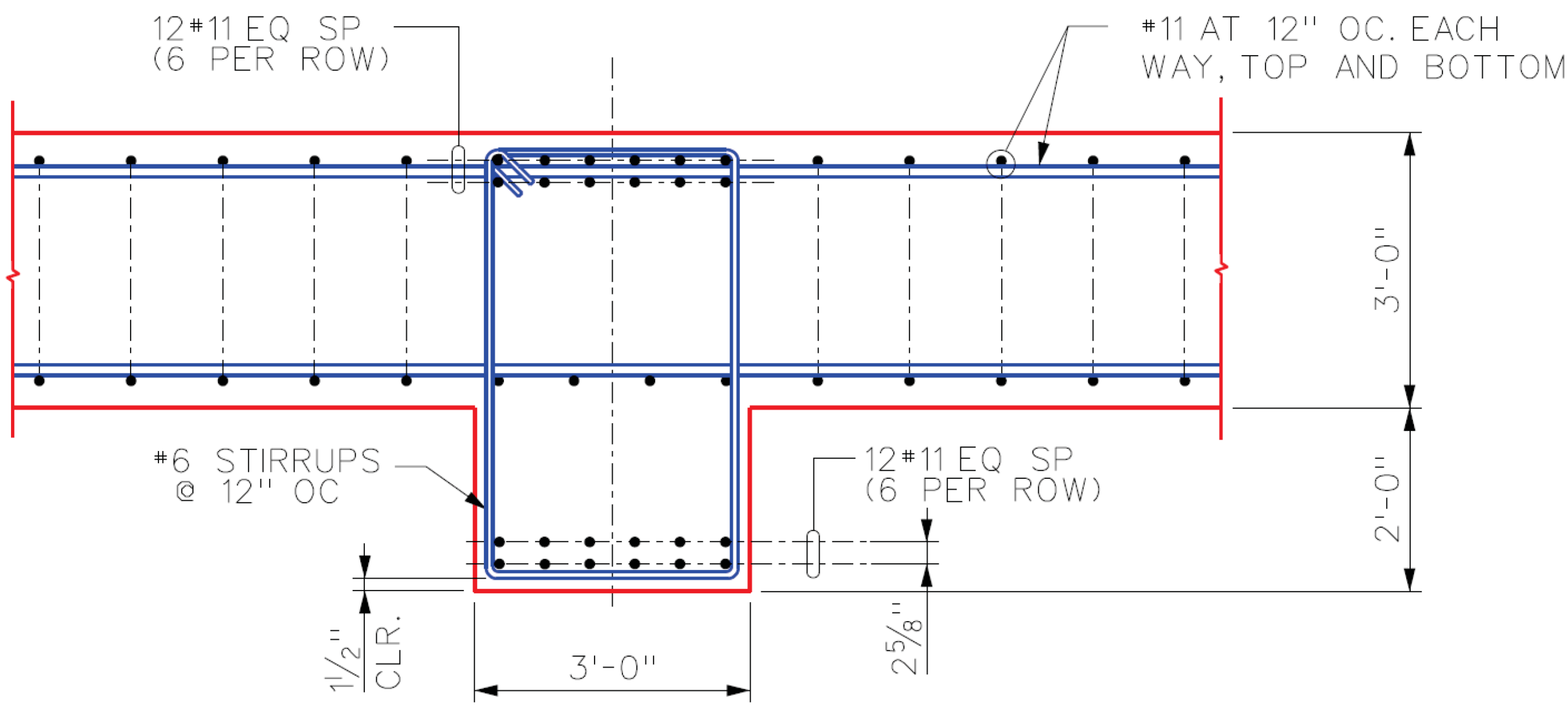


Figure 3B-85: CRB Reinforcement Detail for T-Beam (Type 2) at EL. 120'-0"



Appendix 3C Methodology for Environmental Qualification of Electrical and Mechanical Equipment

3C.1 Purpose

This appendix describes the Environmental Qualification (EQ) program methodology for qualifying electrical equipment and mechanical equipment in accordance with the applicable requirements. The environmental qualification and seismic and dynamic qualification of electrical and mechanical equipment is addressed in Sections 3.11 and 3.10, respectively.

This appendix defines the qualification methods employed to ensure the functionality of mechanical and electrical equipment (including instrumentation and controls) required to perform a design function related to safety during the full range of normal and accident loadings (including seismic), and under all normal environmental conditions, anticipated operational occurrences, and accident and post-accident environmental conditions.

3C.2 Scope

This appendix presents the methods and procedures for qualifying electrical and mechanical equipment to a range of environments to which the equipment could be exposed during normal and abnormal conditions or design basis events (DBE).

These methods and procedures are applicable to mechanical and electrical equipment associated with systems that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal or are otherwise essential in preventing significant release of radioactive material to the environment.

3C.3 Introduction

This appendix specifies the plant environmental conditions to which equipment that performs a design function related to safety, listed in Section 3.11, is designed and qualified. The environmental conditions are defined for plant conditions, including normal and abnormal operating conditions, and accident conditions including post-accident operations. The accident conditions considered are assumed events that are not reasonably expected to occur over the course of plant life and that could potentially result in creating adverse environmental conditions for qualified equipment that performs a design function related to safety. The accident conditions that are postulated are based on conservative assumptions.

Pressure, temperature, relative humidity, radiation, chemical conditions, spray/wetting, and submergence are the primary environmental parameters addressed in this appendix. In accordance with 10 CFR 50.49, the environmental conditions that equipment required to perform design functions related to safety are designed and qualified to are the result of the most limiting design basis accident (DBA). The design and qualification parameters for the equipment meet the EQ program acceptance criteria. The equipment qualification parameters do not include any margins that may be required to satisfy environmental qualification requirements in other applicable code and standards. The radiation parameters in this appendix provide a conservative basis for equipment qualification and are not applicable to personnel access requirements.

The following plant areas contain equipment that performs a design function related to safety for equipment qualification:

- Reactor Building (RXB)
- Control Building (CRB)

The CRB and the electrical equipment rooms on RXB elevations 75'-0" and 86'-0" are, by design, considered mild environments.

This section provides background for the EQ program and presents a summary of the program objectives, a program outline, and definitions for terms used in this document. Section 3C.4 identifies qualification criteria. Section 3C.5 presents design specifications. Section 3C.6 presents the equipment qualification methods, which includes: type-testing, analyses, operating experience, a combination of methods, and supplemental methods to aid qualification. Section 3C.7 and Section 3C.8 describe the documentation, including data packages, test reports, and maintenance records needed to support the equipment qualification program.

3C.4 Qualification Criteria

General Design Criteria (GDC) 1, 2, 4, and 23 of 10 CFR 50, Appendix A; Quality Assurance Criteria III, XI, and XVII of 10 CFR 50, Appendix B; and 10 CFR 50.49 establish the regulatory requirements for this program.

Electrical and active mechanical equipment required to perform design functions related to safety, including instrumentation, must be qualified to operate in environments associated with design basis conditions. GDC 4 requires that structures, systems, and components that perform design functions related to safety be designed to accommodate the environmental effects associated with normal operation, maintenance, testing, and postulated accidents, such as a loss-of-coolant accident (LOCA). The primary objective of environmental qualification is to demonstrate with reasonable assurance that equipment for which a qualified life or condition has been established can perform its design function related to safety without experiencing common-cause failures before, during, and after applicable design basis events. The environmental design requirements apply to equipment required to perform their design function related to safety, including both mild and harsh environments. The environmental qualification procedures described in this appendix define the conditions for which equipment required to perform a design function related to safety must be qualified. Electrical equipment required to perform a design function related to safety located in a harsh environment is qualified in accordance with the requirements of 10 CFR 50.49. Active mechanical equipment required to perform a design function related to safety located in a harsh environment is qualified to comply with the requirements of GDC 4 by incorporating the design-basis environmental conditions into the design process. Mechanical equipment that performs an active design function related to safety during or following exposure to harsh environmental conditions is qualified in accordance with ASME QME-1, Appendix QR-B (Reference 3C-4).

Mechanical and electrical equipment required to perform a design function related to safety located in mild environments is qualified in accordance with the provisions of GDC 4. For each piece of equipment selected for environmental qualification, the environmental parameters and the qualification process is listed in the associated equipment qualification record file (EQRF).

3C.4.1 Environmental Conditions

The environmental conditions considered in the qualification process are pressure, temperature, humidity, radiation, flooding, chemistry effects, aging and synergistic effects. The appropriate margins to be included during qualification are addressed in the description of the qualification program. The applied margin considers the most severe effects identified through industry operational experience or those identified by analysis. The plant environmental conditions are characterized as either harsh or mild.

Harsh Environment

The environmental conditions existing before, during and after a design basis event constitute a harsh environment. The consequences of a design basis event include severe or elevated effects of pressure, temperature, humidity, radiation, chemistry, and submergence. Equipment qualified to operate in a harsh environment must operate without a loss of capability to perform their design function related to safety. The equipment requiring qualification for a harsh environment, as identified in Section 3.11, includes the following:

- equipment within the containment and outside the containment under the bioshield
- equipment required to detect, mitigate, monitor the event or those related to achieving and maintaining safe shutdown
- equipment connected to, supporting, or in the vicinity of equipment in either of the two preceding categories
- equipment subject to the environmental effects of a rod ejection accident (environmental conditions are bounded by inadvertent opening of one reactor vent valve)
- equipment subject to environmental conditions that are more severe for other parameters (e.g., temperature, pressure, humidity, flood level, spray/wetting, radiation) such as those resulting from a fuel handling accident or moderate-energy line break

Instruments and devices requiring qualification include the associated sensors, and supporting loop components. The supporting components of a sensor, such as cables, connectors, terminals, junction boxes, preamplifiers, or other signal processing equipment, is qualified for the environmental conditions at the component's location. Electrical equipment in a harsh environment is qualified according to the requirements of IEEE Std. 323-1974 (Reference 3C-2).

Mechanical equipment located in harsh environmental zones is designed to perform under appropriate environmental conditions. The primary focus for mechanical equipment concerns materials that are sensitive to environmental effects (e.g., seals, gaskets, lubricants, fluids for hydraulic systems, and diaphragms).

The harsh environmental zones within the RXB are listed in Table 3C-1.

Mild Environment

A mild environment is never more severe than the normal plant environment, including during anticipated operational occurrences. To qualify equipment operating in a mild environment, the environmental conditions are described quantitatively in the equipment specification that is provided to the vendor or supplier. Certification from the vendor or supplier that the equipment will operate in the environment described in the specification is sufficient to qualify the equipment. Additional analysis or testing may be required for seismic and aging qualification.

IEEE Std. 323-2003 (Reference 3C-1), as endorsed by Regulatory Guide 1.209, "Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants," addresses qualification of computer-based I&C systems to mild environments that may affect their performance. Parameters that can affect computer-based I&C systems are ionizing doses in a mild environment and smoke. Qualification of computer-based I&C components for the mild environment that can exist during a DBE is necessary to assure that computer-based I&C systems can perform their design functions related to safety.

Other equipment located in a mild environment with no significant aging mechanisms does not require environmental qualification. For equipment requiring seismic qualification, pre-aging prior to the seismic testing is necessary only when there is a known correlation where aging adversely affects seismic performance. (Note that EPRI NP-3326 (Reference 3C-7) indicates for most equipment there is no aging seismic correlation).

3C.4.2 Aging

Equipment is qualified for aging by testing and analysis. The qualification process considers natural aging effects that are present during the installed service life of the equipment. The objective of the qualification program is to place the test specimen(s) in an end of life condition prior to exposure to simulated accident conditions. All significant types of degradation that can affect the ability of the equipment to perform its design function related to safety during or following exposure to harsh environmental conditions must be considered in the qualification process. Typical aging mechanisms that are addressed as part of a qualification test program includes:

- Thermal aging or thermal degradation
- Radiation aging
- Cyclic aging or wear related degradation

Periodic inspection, testing, and calibration can monitor equipment for aging effects which are otherwise difficult to quantify or are not able to be fully simulated by the accelerated aging applied during a qualification test program.

The concept of condition based qualification may be used to supplement the concept of qualified life. As the qualified life of the equipment approaches the end of its theoretical qualified life, periodic condition monitoring may be implemented to determine if actual aging is occurring at a slower rate such that further qualified service is possible based on the condition monitoring results. The use of condition monitoring is tied to the ability to monitor one or more condition indicators to determine whether equipment remains in a qualified condition. The trend of the condition indicator is determined during the performance of age conditioning of the test specimen during the qualification testing. The condition indicator must be measurable, linked to functional degradation of the qualified equipment, and have a consistent trend from unaged through the limit of the qualified pre-accident condition.

Thermal Aging

As stated in NUREG-0588 (Reference 3C-16), the Arrhenius methodology is considered an acceptable method of addressing accelerated thermal aging. The development of the accelerated thermal aging parameters and activation energies shall consider or be based on the applicable guidance in IEEE Std. 1 (Reference 3C-9), IEEE Std. 98 (Reference 3C-10), IEEE Std. 99 (Reference 3C-11), IEEE Std. 101 (Reference 3C-12), and IEEE Std. 1205 (Reference 3C-13). The selection of activation energies shall be based on material properties that are representative of the design function related to safety of the item. Justification shall be provided for any use of Thermogrametric Analysis to establish an activation energy that demonstrates that the resulting qualified life is conservative or representative of actual degradation under normal service conditions.

The minimum acceptable accelerated aging time shall be greater than 150 hours. Thermal aging of materials where diffusion limited oxidation effects have the potential to not fully simulate actual thermal aging degradation effects, the thermal acceleration rates are adjusted to minimize or otherwise account for these effects.

Radiation Aging

Radiation aging may be performed separately from the accident radiation exposure or the accident radiation exposure may be performed as part of the radiation aging. Radiation aging shall be performed using either a Cobalt-60 or Cesium-137 source. The maximum acceptable dose rate is 1.0 MRad/hr (10 k Gr/hr). For radiation aging of materials where diffusion limited oxidation effects have the potential to not fully simulate actual aging degradation effects from irradiation, the dose rates should be adjusted to minimize or otherwise account for these effects.

Cyclic Wear Aging

Cyclic wear aging is used to simulate electrical or mechanical degradation of the equipment due to normal operation of the equipment. This aging is intended to simulate wear related degradation as well as fatigue effects. The definition of the required number of cycles to be simulated during the qualification test program shall consider expected service conditions and be based on a conservative estimation of equipment cycles during power operation, module startup, module shutdown, outages, maintenance activities, surveillance activities, transients, anticipated operational occurrences, and accident conditions.

Qualified Life Objective

The qualified life objective shall be based on a specified set of harsh environment service conditions. Pre-service conditions shall be considered if significant aging occurs before equipment is placed into service. Qualified life can be demonstrated by age conditioning a test sample to simulate effects of significant aging mechanisms during a time equal to the qualified life objective. An adjunct to establishing a qualified life objective is to establish an end-condition objective of equipment condition indicators that correlate to the ability of equipment to perform its design function related to safety. In this case, the end condition is the basis of qualification, and the time to reach that end condition in service may be more or less than the qualified life established by age conditioning. The fundamental objective of qualified life of equipment ensures that the equipment possesses the capability to perform its required design function(s) related to safety at the end of the qualified life with demonstrated margin to failure.

Design Life

Equipment in mild environment locations is expected to perform satisfactorily during the design life (Reference 3C-1) for the specified set of mild environmental service conditions. The design life of equipment is obtained from manufacturer's literature. Surveillance or trending programs also assist in verifying the design life or the need for re-evaluation.

Shelf Life

The equipment and material controlled storage program complies with the requirements of 10 CFR 50, Appendix B. This program verifies that equipment is handled and stored in accordance with the manufacturer's or vendor's recommendations, the engineering requirements, or general industry practices. In addition, the shelf life of non-metallic materials is considered and used in specifying the maximum allowable time a component or material can be stored. Materials are removed and replaced when they reach their established shelf life.

Qualified Life

Equipment in harsh environment locations is expected to perform satisfactorily during the qualified life (Reference 3C-16) for the specified set of harsh environmental service conditions for the required operating time with margin to failure. The margin included ensures that the accident function can be performed if the accident occurred just prior the item's replacement at the end of the qualified life.

3C.4.3 Synergistic Effects

Environmental qualification in accordance 10 CFR 50.49 requires that synergistic effects be considered. Regulatory Guide 1.89, Revision 1, Section C.5.a provides further guidance for addressing synergisms.

The synergistic relationship between multiple stresses usually cannot be deduced from physical principles; rather, an experimental approach must be employed. Synergistic stresses usually require extensive testing to reveal their magnitudes, since most interaction effects are minute by comparison to the primary effects, and thus require significantly more experimental evidence to identify. Current research, as referenced below, indicates that synergistic effects can typically be categorized under two main headings:

- Test sequence effects - The sequence in which radiation and thermal aging exposures occur is an important consideration. Radiation combined with elevated temperatures or radiation followed by elevated temperatures may produce more material degradation than when thermal aging precedes radiation exposure (NUREG/CR-3629 (Reference 3C-14)).
- Radiation dose rate effects - For many materials, it has been observed that lower dose rates produce more degradation than a higher dose rate for the same total applied dose (NUREG/CR-2157 (Reference 3C-15)).

Test Sequence Effects

An important aging consideration is the possible existence of synergistic effects when multiple stress environments such as radiation and elevated temperatures, are applied simultaneously. Currently, sequential exposure is the only commercially available means of testing; no commercial facility offers simultaneous steam and radiation exposure. Although sequential and simultaneous tests can produce variances in degradation, the differences tend to be minor compared to total degradation. The possibility that significant synergistic effects may exist is addressed by the using the "worst-case" aging sequence, conservative accelerated aging parameters and conservative, DBE test levels to provide confidence that any synergistic effects are enveloped.

Radiation Dose Effects

The need for qualification due to radiation exposure is evaluated for each piece of equipment. The radiation environment is based on the type of radiation, the total dose expected during normal operation over the installed life of the equipment, and the radiation environment associated with the most severe design basis accident during or following which the equipment is required to remain functional.

In general, dose rate effects occur over long periods and, therefore, need only be addressed during the radiation conditions that occur during normal plant operation.

3C.4.4 Operating Time

Equipment required to be environmentally qualified has one or more of the following design functions related to safety: reactivity control, decay heat removal, post-accident monitoring, containment isolation, maintenance of RCS pressure boundary integrity, control room habitability, event severity mitigation or system support functions. For each function, a period of operability is assigned that ranges from less than 1 hour to a maximum of 2400 hours. The assignment of these post accident operating times is separated into the five different time frames that are related to plant status or system functional requirements. These operating time designations and durations are summarized in Table 3C-4.

Equipment that performs its design function related to safety prior to significant changes in its environment may be qualified for shorter durations. In accordance with Regulatory Guide 1.89, justification for shorter duration includes:

- the consideration of a spectrum of pipe break sizes
- the potential need for the equipment later in an event or during recovery operations
- Subsequent failure of the equipment is shown to not be detrimental to plant safety or to mislead the operator

Post-accident operating times for equipment to be qualified shall be specified in the EQ Master List and as shown in Table 3.11-1.

3C.4.5 Performance Criterion

The qualification test program demonstrates the capability of the equipment to meet the design function related to safety performance requirements defined in the EQRF (Section 3C.8). As stated previously, the primary objective of qualification is to demonstrate that equipment, for which a qualified life or condition has been established, can perform its design functions related to safety without experiencing common-cause failures before, during, and after applicable DBEs. The continued capability for this equipment and its interfaces (Reference 3C-16) to meet or exceed its specification requirements is provided through an operational program that includes, but is not limited to, design control, quality control, qualification, installation, maintenance, periodic testing, and surveillance.

3C.4.6 Margin

The purpose of using margin in the qualification program is to account for commercial production variability, errors in establishing satisfactory performance, and errors in experimental measurements, thereby providing greater assurance that the equipment can perform under the specified service conditions. Table 3C-5 presents the margins for various environmental parameters. The margins shown in the table are those recommended in IEEE Std. 323 (Reference 3C-1).

3C.4.7 Treatment of Failures

Any failure to meet the acceptance criteria is analyzed to determine the cause. Equipment modifications, equipment retesting, or equipment use limitations are imposed as necessary to address the failure.

3C.5 Design Specifications

The equipment design specification identifies the applicable codes and standards, required operating times, performance requirements, design functions related to safety, operational service conditions, environmental service conditions, accepted methods of qualification, and acceptance criteria. The design specification also provides the basis for establishing the EQ of the specific equipment or the family of equipment.

Environmental Qualification of Electrical Equipment

The environmental conditions for which equipment is qualified are the most severe conditions resulting from the DBE for which the equipment is required to perform its design function related to safety. The equipment qualification life of electrical and mechanical equipment is established as a conservative 60 years unless otherwise noted on the equipment's specification. Periodic inspection and testing shall be used during the life of the equipment to verify its ongoing qualification.

The amount of time, after a design basis event, for which some equipment must remain functional, may be a few minutes or several hours depending on its design function related to safety.

Environmental Qualification of Mechanical Equipment

Both passive and active mechanical equipment (Reference 3C-3) is qualified according to the criteria and methodology described in this document. Non-metallic components like O-rings, seals, gaskets, and lubricants for mechanical equipment with a design function related to safety are also qualified in accordance with these criteria. Equipment that only has the design function related to safety of maintaining its structural integrity, for support or to protect the integrity of a pressure boundary, is qualified in accordance with the requirements specified in Section 3.11. The design specification will also identify if qualification to ASME QME-1 is required for active mechanical equipment.

3C.5.1 Normal Operating Conditions

Normal operating conditions are summarized in Table 3C-6. For qualification under normal operating conditions, the equipment is mounted, connected, interfaced, and operated in a manner that simulates its normal inservice conditions, and the equipment's design functions related to safety are demonstrated during exposure to normal service conditions. Data are recorded for later reference as required by Section 3C.8.

Normal Radiation Dose

The normal radiation integrated doses for equipment are based on the maximum normal reactor coolant system (RCS) radionuclide activities and system parameters to determine bounding normal cumulative doses both inside and outside of the containment, as shown in Table 3C-6. These values were determined based on 60 years (bounding environmental qualification life) of continuous operation and steady-state operating conditions, and take into account radiation exposure because of recirculatory fluid for equipment outside the containment.

The integrated doses shown in Table 3C-6 represent the direct dose to equipment and bound any additional airborne doses.

3C.5.2 Seismic

The methods, including applicable seismic loads, used for the seismic qualification of mechanical, electrical, and I&C equipment are addressed in Sections 3.7 and 3.10.

3C.5.3 Containment Test Environment

The design pressure of containment is 1000 psia, though it is hydrostatically tested at the manufacturing facility at a hydrostatic pressure of 1250 psia (1.25 times design pressure). Subsequent testing will be conducted as described in Section 6.2.6.

3C.5.4 Design Basis Event Conditions

Design Basis Events (DBE)

Design basis events are defined as normal operation, including anticipated operational occurrences, and design basis accidents as analyzed within the scope of Section 3.6 and Chapter 15.

Design-Basis Accidents (DBAs)

The design basis accidents were reviewed and evaluated to determine which DBAs are addressed in FSAR Chapter 15. Based on this review, the following DBAs are evaluated to determine the mechanical and electrical equipment that requires environmental qualification.

FSAR Section 15.1.5 - steam system piping failure inside and outside of containment. This covers main steam line breaks (MSLB) inside and outside of containment. For the purpose of environmental qualification, main steam line breaks are considered inside the CNV even though the main steam piping is classified as leak before break (LBB).

FSAR Section 15.2.8 - feedwater system pipe break inside and outside of containment. This covers feedwater line breaks (FWLB) inside and outside of containment. For the purpose of environmental qualification, feedwater line breaks are considered inside the CNV even though the FW piping is classified as leak before break (LBB).

FSAR Section 15.4.8 - rod ejection accident (REA) reflects a potential break in the RCS pressure boundary. The equipment relied upon to mitigate this accident is the same as that used for the spectrum of small break loss of coolant accidents addressed by FSAR Section 15.6.5. The REA is analyzed as a reactivity event.

FSAR Section 15.6.5 - loss of coolant accidents (LOCA) from spectrum of postulated pipe breaks within the RCS pressure boundary inside and outside of containment. There are no large break LOCA events for the NuScale design. The small break LOCAs are the result of CVCS pipe rupture events that are postulated inside or outside of containment.

FSAR Section 15.7.4 - radiological consequences of fuel handling accidents. This covers the FHAs within the RXB pool area.

Infrequent Events (IE)

FSAR Section 15.6.2 - radiological consequences of failure of small lines carrying primary coolant outside of containment. Similar to FSAR Section 15.6.5, this covers chemical and volume control systems (CVCS) pipe rupture events that are postulated inside or outside of containment.

Other Design Basis Events

FSAR Section 3.6 - high energy line breaks (HELB) outside containment. This covers HELB outside of containment that are not already addressed by FSAR Sections 15.1.5, 15.2.8, or 15.6.5, such as the postulated rupture of the module heatup system (MHS) piping in the gallery areas of the RXB.

FSAR Section 3.6 - moderate energy line breaks (MELB) outside containment.

Normal and Bounding Conditions

Containment vessel and reactor building pressure and humidity experienced during the indicated DBE are shown in Table 3C-7. Equipment that is required to perform a design function related to safety, and could potentially be subjected to the design basis environments, is qualified to these conditions for the required operating time.

RPV and containment vessel metal temperatures in the lower (liquid) space with corresponding liquid temperatures for the bounding DBAs are shown on Figure 3C-1. RPV and containment vessel metal temperatures in the upper (vapor) space with corresponding vapor temperatures for the bounding DBAs are shown on Figure 3C-2. The average vapor temperatures at the top of module for the bounding DBAs, and assuming a vented bioshield, are shown on Figure 3C-3. The maximum vapor temperatures for elevation 145' in the RXB from the same bounding DBAs are shown on Figure 3C-4.

Design Basis Event Radiation Doses

The accident integrated doses are based on the guidance provided in Regulatory Guide 1.183 for equipment following design basis events (as provided in TR-0915-17565-P (Reference 3C-5)). The doses resulting from this DBA source term bound those from all other design basis accidents.

The accident conditions integrated doses within the reactor building were determined using the maximum normal core radionuclide inventory. The maximum normal core inventory bounds the equilibrium cycle burnup for the NuScale Power Module reactor and is representative of operating cycle characteristics for environmental qualification purposes. The required dose used for environmental qualification considers the total integrated dose consisting of the normal dose plus the accident dose corresponding to the required post-accident operating time. The normal dose considers gamma and neutron effects, while the accident dose considers the gamma and beta dose that is expected at the equipment location.

Based on the above, the integrated doses following a design basis event are shown in Table 3C-8.

For discussion on gamma and beta radiation effects, refer to Section 3.11.5.

3C.6 Qualification Methods

A qualification program plan defines tests, inspections, performance evaluation, acceptance criteria, and required analysis to demonstrate that, when called upon, the qualified equipment can perform its specified design function(s) related to safety for the required post-accident operating time with margin to failure.

This section describes the methodologies used to qualify equipment. Alternative approaches are available; however, the equipment vendor selects the methods best applied to the equipment. The result is an auditable record demonstrating that the equipment can perform its design function related to safety, under the specified service conditions, if an accident occurred at anytime during its Qualified Life.

IEEE Std. 323-2003 (as endorsed by RG 1.209 for computer-based digital I&C equipment in a mild environment) and IEEE Std. 323-1974 allow various qualification methods (e.g., testing, analysis, operating experience, or a combination of methods) as applicable to the equipment scope. Although type testing is the preferred method of qualification, a qualification program usually involves some combination of these methods. The qualification methods used depend on factors such as the:

- materials used in construction of the equipment
- applicable normal, abnormal, and DBE service conditions
- operational requirements during and after accidents
- nature of the required design function(s) related to safety
- size of the equipment
- dynamic characteristics of the expected failure modes (e.g., structural or functional)

In general, analysis may be used to supplement test data.

3C.6.1 Type Testing

The type test shall demonstrate that equipment performance meets or exceeds the design function related to safety requirements. Type test conditions shall meet or exceed specified service conditions. Appropriate margin shall be added to design basis event parameters if not otherwise included in the specified service conditions.

The type test program is designed to demonstrate that the equipment can perform its design functions related to safety within the accuracy and response time requirements applicable for normal, abnormal, and DBE service conditions. The type test consists of a demonstration of design functions related to safety under a planned sequence of environmental tests both before and after age conditioning (Reference 3C-1). Regulatory Guide 1.180 specifies electromagnetic compatibility design requirements for electromagnetic and radio-frequency interference and power surges for equipment and is independent of the EQ Program.

A test plan is prepared at the beginning of the test program, which includes the qualification methodology, its intent and purpose, and a description of the tests in sufficient detail to demonstrate compatibility with specified requirements. As a minimum, the plan includes:

- applicable codes and standards
- equipment description
- number of test specimens
- acceptance criteria
- failure definition
- service conditions (environmental and operational)
- testing sequence
- aging technique with justification
- test levels that envelope or equal the service conditions
- parameters to be monitored
- test equipment to be used
- mounting and connection methods
- qualified life goal and design life
- documentation to be maintained

Similarity

Analysis may be employed to demonstrate that the test results obtained for one piece of equipment are applicable to a similar piece of equipment. Documentation of this analysis conforms with the guidelines in IEEE Std. 323-1974, IEEE Std. 323-2003 and IEEE Std. 627-1980 (Reference 3C-8).

3C.6.2 Analysis

Analytical techniques are used in qualification in a variety of ways, including evaluating aging effects, demonstrating qualification for particular DBE conditions, and evaluating differences between installed and tested equipment. Qualification by analysis requires a logical assessment or a valid mathematical model of the equipment to be qualified. When quantitative analysis is used for qualification, it needs to be supported by test data, operating experience, or physical laws of nature to demonstrate that the equipment can perform its design function(s) related to safety under specified conditions.

3C.6.3 Operating Experience

Operating experience can serve as a basis for determining or modifying the Qualified Life of equipment, including systems, elements, components, modules, and other constituent parts.

Auditable data are maintained for environmental qualification of equipment qualified on the basis of operating experience that addresses the following criteria:

- the equipment cited for operating experience is identical or justifiably similar to the equipment to be qualified
- the equipment cited for operating experience has operated under service conditions that equal, or exceed in severity, service conditions for which the equipment is to be qualified, and has performed its design function related to safety under these conditions
- the normal and abnormal service condition requirements were satisfied prior to the occurrence of the DBE conditions
- margin has been considered in determining the accident service conditions for the equipment to be qualified

Operating experience has been used to address the qualification of mechanical equipment principally because of the severe process conditions experienced by mechanical equipment during normal service applications.

Operating experience has been used on an infrequent basis to qualify electrical equipment to harsh environments, principally because LOCA-type pipe break accidents rarely occur. Therefore, qualification of electrical components can be qualified using operating experience as a basis when used with a combination of other methods per Section 3C.6.4.

When the above criteria are met the equipment may be qualified.

3C.6.4 Combination of Methods

Equipment may be qualified by test, analysis, previous operating experience, or any combination of these three methods. Using a combination of methods may be appropriate under a variety of circumstances, such as:

- equipment is too complex for analysis alone or too large for testing alone
- test data are available on samples of similar design and materials that are of different sizes, so extrapolation may be possible
- verification of a mathematical model using partial type test to determine mode shapes and resonant frequencies
- operating experience provides the basis for developing simulated aging techniques
- analysis of an assembly to determine the environment to which components are to be tested
- two subassemblies that have been tested and qualified separately are combined into a complete assembly, and analysis of certain parameters (e.g., individual subassemblies' error rates and response times) demonstrates that the combination is also qualified

The combined qualification demonstrates that the equipment can perform its design function related to safety under normal, abnormal, and DBE service conditions throughout its Qualified Life. Combined qualification provides auditable data by which the various primary qualification methods may be brought together to satisfy the qualification program requirements.

3C.7 Equipment Qualification Maintenance Requirements

The equipment qualification maintenance requirements consider condition monitoring and preventive maintenance activities to ensure effective aging management.

These maintenance requirements documents typically consist of the following sections:

1) Equipment Description

   Tag numbers, equipment numbers, description of function, location, manufacturer, and model number; general information for completing maintenance orders.

2) Technical References

   Reference information useful for preparing for or conducting maintenance.

3) Installation and Maintenance Requirements

   a) Installation Requirements

      Tasks essential to achieving installations that conform to EQ requirements; derived from vendor technical manuals and equipment EQ test reports.

   b) Electrical Connection Interface and Data Requirements

      The requirements for environmentally qualified connections; the information represents the current physical configuration.

   c) Maintenance Requirements

      Tasks and their frequencies necessary to maintaining the equipment's EQ; derived from vendor technical manuals and equipment EQ test reports; to be incorporated into the plant surveillance test procedures or preventive maintenance program, as applicable.

   d) Post-Maintenance Test Requirements

      Testing to be performed after EQ maintenance is completed.

   e) Condition Monitoring Requirements

      Monitoring required to detect and assess degradation of materials or performance; derived from review of qualification documentation, evaluation of degrading mechanisms, and engineering judgment.

4) Replacement Parts

   The description, manufacturer, and model number of parts needed to maintain EQ equipment; includes items routinely used in the maintenance activity.

3C.7.1 On-going Qualification

The equipment qualification program may employ on-going qualification, though this method is not acceptable as a sole means for qualifying equipment for DBE conditions. Its use is generally limited to areas subjected to mild environment conditions or as a method in which to modify the Qualified Life that was established using another qualification method. Supplemental test, analysis, or experience data to address equipment qualification and performance during and after a seismic DBE is also required.

3C.8 Documentation

The equipment qualification program documentation consists of equipment qualification data packages, equipment qualification test reports, and qualification maintenance requirements.

Equipment Qualification Record File

The EQRF for each equipment item contains the documentation that demonstrates that the equipment or system is environmentally qualified for its application, and can accomplish its specified design functions related to safety. An equipment item refers to equipment categorized by manufacturer and model, which is representative of identical or similar equipment in plant areas potentially exposed to the same bounding environmental conditions during and after a design basis event. Documentation that supports EQ for the equipment is compiled in the EQRF or referenced therein. The elements of the EQRF include: equipment identification, interfaces, qualified life, design functions related to safety, service conditions (e.g., normal, abnormal, DBE), qualification program plan, and qualification program implementation following the guidance of IEEE Std. 323-1974 (Reference 3C-2) for harsh environment applications and IEEE Std. 323-2003 (Reference 3C-1) for mild environment applications.

Equipment Qualification Test Reports

The equipment qualification test report is prepared by the equipment vendor or an independent testing laboratory. This report documents the tests that demonstrate the capability to meet specified functional requirements under specified environmental conditions and operational parameters. These tests subject one or more equipment samples to conditions designed to simulate normal, abnormal, containment test, DBE, and post-DBE conditions, as applicable.

3C.9 References

3C-1 IEEE Std. 323-2003, "Qualifying Class 1E Equipment for Nuclear Generating Stations," Institute of Electrical and Electronics Engineers.

3C-2 IEEE Std. 323-1974. "IEEE Standard for Qualifying Class IE Equipment for Nuclear Power Generating Stations,"Institute of Electrical and Electronics Engineers.

3C-3 IEEE Std. 344-2004, "IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

3C-4 ASME QME-1-2007, "Qualification of Active Mechanical Equipment Used in Nuclear Power Plants," American Society of Mechanical Engineers.

3C-5 NuScale Power, LLC, "Accident Source Term Methodology," TR-0915-17565-P, Revision 2.

3C-6 IEEE Std. 497-2002, "IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Generating Stations," Institute of Electrical and Electronic Engineers.

3C-7 EPRI NP-3326, "Correlation Between Aging and Seismic Qualification for Nuclear Plant Electrical Components," Electric Power Research Institute, December 1983.

3C-8 IEEE Std. 627-1980, "IEEE Standard for Design Qualification of Safety Systems Equipment Used in Nuclear Power Generating Stations," Institute of Electrical and Electronics Engineers.

3C-9 IEEE Std. 1-2000, "General Principles for Temperature Limits in the Rating of Electrical Equipment and for the Evaluation of Electrical Insulation," Reaffirmed 2005, Institute of Electrical and Electronics Engineers.

3C-10 IEEE Std. 98-2016, "The Preparation of Test Procedures for the Thermal Evaluation of Solid Electric Insulating Materials," Institute of Electrical and Electronics Engineers.

3C-11 IEEE Std. 99-2007, "Recommended Practice for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electric Equipment," Institute of Electrical and Electronics Engineers.

3C-12 IEEE Std. 101-2004, "IEEE Guide for the Statistical Analysis of Thermal Life Test Data," Reaffirmed 2010, Institute of Electrical and Electronics Engineers.

3C-13 IEEE Std 1205-2014, "Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment Used in Nuclear Power Generating Stations and Other Nuclear Facilities," Institute of Electrical and Electronics Engineers.

3C-14 NUREG/CR-3629, "The Effect of Thermal and Irradiation Aging Simulation Procedures on Polymer Properties," Sandia National Laboratories, April 1984.

3C-15 NUREG/CR-2157, "Occurrence and Implications of Radiation Dose-Rate Effects for Material Aging Studies," Sandia National Laboratories, June 1981.

3C-16 NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety Related Electrical Equipment," Revision 1, July 1981.

Table 3C-1: Environmental Qualification Zones - Reactor Building

EQ Zone(1)	Description	Environment
A	Room 010-022, Containment Vessel - bottom of containment (6") to bottom of upper core plate (142")	Harsh
B	Room 010-022, Containment Vessel - bottom of upper core plate (142") to bottom of riser transition (236")	Harsh
C	Room 010-022, Containment Vessel - bottom of riser transition (236") to bottom of baffle plate (587")	Harsh
D	Room 010-022, Containment Vessel - bottom of baffle plate (587”) to top of pressurizer (697”)	Harsh
E	Room 010-022, Containment Vessel - top of pressurizer (697") to bottom of torispherical head (841")	Harsh
F	Room 010-022, Containment Vessel - bottom of torispherical head (841") to top of containment (904")	Harsh
G	Room 010-022, Module pool bay vapor space - outside containment and under the BioShield (Top of Module) (Figure 1.2-19: Reactor Building East and West Section View)	Harsh
H	Rooms 010-022, 010-422, and 010-423 above pool level to ceiling (RXB Pool Room Vapor Space) (Figure 1.2-16: Reactor Building 100'-0"' Elevation thru Figure 1.2-18: Reactor Building 145'-6" Elevation)	Harsh
I	Room 010-022, 010-023 and 010-024 up to top of pool level (RXB Pool Room liquid space) (Figure 1.2-10: Reactor Building 24'-0" Elevation)	Harsh
J	Rooms 010-101, 010-102, 010-103, 010-104, 010-005, 010-106, 010-107, 010-112, 010-114, 010-115, 010-116, 010-117, 010-118, 010-119, 010-120, 010-121, 010-122, 010-123, 010-125, 010-126, 010-127, 010-128, 010-129, 010-130, 010-131, 010-133, 010-134 (Figure 1.2-12: Reactor Building 50'-0" Elevation)	Harsh
K	Rooms 010-201, 010-202, 010-203, 010-204, 010-005, 010-206, 010-207, 010-208, 010-242, 010-275 (Figure 1.2-14: Reactor Building 75'-0" Elevation)	Harsh
L	Rooms 010-201, 010-202, 010-203, 010-204, 010-005 (Figure 1.2-15: Reactor Building 86'-0" Elevation)	Harsh
M	Rooms 010-005, 010-401, 010-402, 010-403, 010-404, 010-405, 010-406, 010-407, 010-408, 010-409, 010-410, 010-411, 010-412, 010-414, 010-415, 010-416, 010-417, 010-418, 010-419, 010-420 (Figure 1.2-16: Reactor Building 100'-0" Elevation)	Harsh
N	Rooms 010-005, 010-501, 010-502, 010-503, 010-504, 010-506, 010-507, 010-508, 010-509, 010-510 (Figure 1.2-17: Reactor Building 126'-0" Elevation)	Harsh

Note:

1) EQ Zones listed are those areas within the Reactor Building that are harsh environments and contain equipment that requires environmental qualification.

Table 3C-2: Designated Harsh Environment Areas

Area	Basis	Comment/Remarks
EQ Zones A, B, C, D, E and F	Harsh environment as a result of primary and secondary HELBs potential to occur in this area Total integrated dose (60 yrs + accident) > 1.0E4 Rads	Inaccessible post-accident and during normal operation.
EQ Zone G	Harsh environment as a result of primary and secondary HELBs potential to occur in this area Total integrated dose (60 yrs + accident) > 1.0E4 Rads	Inaccessible post-accident
EQ Zone H	Harsh environment as a result of primary and secondary HELBs potential to occur in the Top of Module (TOM) ≥ 120F and > 18F increase above normal operating conditions with RH ≥85%	Harsh due to HELBs potential to occur under the bioshield
EQ Zone I	Harsh environment as a result of primary and secondary HELBs potential to occur in the TOM Total integrated dose (60 yrs + accident) > 1.0E4 Rads	
EQ Zones J, K, L, M, and N	These areas will contain high and moderate energy piping.	Harsh by preliminary design

Table 3C-3: Designated Mild Environment Areas

Area	Basis	Comments/Remarks
CRB	No harsh environment DBA or IE are postulated to occur in the control building. Total integrated dose (60 years + accident ≤ 1.0E3 Rads) Control building does not contain any high energy piping systems (>200F or > 275 psig) and flooding analysis demonstrates that no equipment designed to perform a function related to safety is submerged. Max temp is < 120F with humidity < 85%	Satisfies MILD environment criteria
EDS equipment rooms on RXB elev. 75' Gallery areas, specifically: EDSS battery rooms MPS rooms EDSS SWGR rooms	No harsh environment DBA or IE are postulated to occur in these rooms. Total integrated dose (60 years + accident ≤ 1.0E3 Rads) Max temp is < 120F with humidity < 85%	Satisfies MILD environment criteria
Diesel Generator Building	No harsh environment DBA or IE occur in this building. Total integrated dose (60 years + accident ≤ 1.0E3 Rads) Diesel Generator Building Ventilation maintains DGB temperatures within design specification for backup diesel generator (BDG).	Satisfies MILD environment criteria Supports PAM function beyond 72 hours

Table 3C-4: Equipment Post-Accident Operating Times

Description	Time Frame (hours)	Actions Accomplished	Basis
Short Term (ST)	≤1	• Event Detection • Initiation of Trip and ESF actuation • Achievement of Hot Shutdown	Note 1
Intermediate Term (IT)	ST ≤ IT ≤ 36	• Achievement of Safe Shutdown • RCS Depressurization and Cooldown • Maintain Fission Product Barrier Integrity	Note 2
Long Term (LT)	IT ≤ LT ≤ 72	• Maintaining Safe Shutdown • Maintain Fission Product Barrier Integrity	Note 3
Extended	LT ≤ Extended ≤ 720	• Maintaining Safe Shutdown • Maintain Fission Product Barrier Integrity	Note 4
Extended PAM	LT ≤ Extended ≤ 2400	• Monitoring of Fission Product Barrier Integrity	Note 5

Notes:

1. The Short Term post-accident operating time (PAOT) is assigned to components associated with event detection, reactor trip initiation, or Engineered Safety Features (ESF) actuation that occur very early in the accident sequence. This includes the Module Protection System (MPS) initiation of:
   - Reactor Trip,
   - Containment Isolation,
   - Decay Heat Removal System (DHRS) actuation,
   - Emergency Core Cooling System (ECCS) actuation,
   - De-energizing the Pressurizer Heaters, and
   - Isolation of demineralized water

   Short Term actions are also associated with the achievement of Hot Shutdown.

2. Intermediate Term actions are associated with the achievement of Safe Shutdown using DHRS. The Intermediate Term time frame extends to 36 hours and is used to qualify equipment that is relied upon to support the ECCS hold for up to 24 hours.
   Examples of equipment assigned an Intermediate Term PAOT includes:
   - Reactor Vent Valves
   - Reactor Recirculation Valves

3. The Long Term time frame extends to 72 hours. This category is considered the maximum post-accident operating time for HELB and MELB events outside containment in areas that are readily accessible after break termination or isolation. Examples of equipment assigned to this category includes the following:
   - Equipment that is relied upon to mitigate a HELB or MELB outside containment, that are located outside of the top of module area (outside containment and under BioShield).
   - Highly Reliable DC Power System (EDS) Batteries for separation groups B and C which are sized to support an extended loss of AC power for up to 72 hours.

4. The Extended time frame of 720 hours represents the maximum post-accident operating time used to qualify equipment that is relied upon to maintain a safe shutdown condition. Equipment assigned to this post-accident operating time category are typically located inside the CNV or in an inaccessible area outside of containment, such as under the BioShield.

   This duration is selected to align with 10 CFR 50 Appendix J, 10 CFR 50 Appendix K, as well as control room habitability analysis timeframes. This duration is considered appropriate for an advanced light water reactor design that employs passive means to maintain a safe shutdown condition.

This duration is also applicable to equipment assigned to support the following, including equipment located in the top of module area (outside containment and under BioShield) or in the Reactor Pool / Pool Bays:

- Containment Integrity
- RCS pressure boundary integrity
- Decay Heat Removal/Emergency Core Cooling (DHRS/ECCS)
- Mitigation of Fuel Handling Accidents
- Supporting Control Room Habitability
- PAM Type B and D variables

5. Extended PAM category specifically applies to RG 1.97 Type C variables and is consistent with Reference 3C-6.

Table 3C-5: EQ Program Margin Requirements

Parameter	Required Margin[1]	Notes
Peak Temperature	+15°F	For accident profile.
Peak Pressure	+ 10% of gauge, but not more than 10 psig	
Radiation	+10%	On accident dose only.
Power Supply Voltage	±10%	Of rated value, not to exceed equipment design limits.
Equipment Operating Time	+10%	For the period of time the equipment is required to operate following the start of a DBE. See also Section 3C.4.5 and Table 3C-4.
Seismic Vibration	+10%	Margin added to acceleration requirements at the mounting point of equipment.
Line Frequency	N/A	Line frequency margin is N/A because the relied upon electrical power is from EDSS (DC power).
Time	+10%	In addition to the period of time the equipment is required to be operational following the DBE.
Environmental Transients	2 or more	The initial transient and the dwell at peak temperature shall be applied at least twice

Notes:

1. The margins apply unless it can be shown that the derivation of environmental conditions contain conservatisms that can be quantified to show that appropriate margin exists.

Table 3C-6: Normal Operating Environmental Conditions

Zone[2]	Temperature (°F)	Pressure (psig) (Nominal)	Maximum Relative Humidity (%) [1]	60 Years Integrated N Dose (Rads)		60 Years Integrated γ Dose (Rads) (Includes fission γ, N-γ, coolant)		Water Level (ft. above RXB pool floor)
A	487 (lower RPV wall)	<(-14.6)[3]	0	2.42E8		9.01E10		47' (inside CNV for refueling)
B	491 (RPV wall) 295 (CNV wall)	<(-14.6)[3]	0	6.71E8		4.51E10		(inside CNV for refueling)
C	551 (RPV wall)	<(-14.6)[3]	0	1.10E9		4.11E7		47' (inside CNV for refueling)
D	618 (outside top of PZR) 295 (CNV wall)	<(-14.6)[3]	0	6.00E7		3.01E6		47' (inside CNV for refueling)
E	581 (surface of MS piping)	<(-14.6)[3]	0	4.77E7		2.26E6		47' (inside CNV for refueling)
F	295 (upper CNV volume)	<(-14.6)[3]	0	3.55E7		1.51E6		-
G	140	0	<100	1.85E6		4.35E4		-
H	100	0	<100	above bioshield	2.65E1	above bioshield	1.60E3	-
				EL 145	5.50E0	EL 145	3.90E2	
I	140	0 plus submergence head	N/A	pool center	0	pool center (coolant only)	4.65E3	69' (normal operating level outside CNV)
				next to operating module	8.70E7	next to operating module	1.53E10	

Notes:

1. Normal service relative humidity outside of the containment vessel is shown as <100%; the relative humidity inside the containment vessel is 0% because the environment is normally maintained in a vacuum.
2. DCA EQ Zones J, K, L, M, and N are isolated from the RXB Pool and bioshield areas but are preliminarily designated as harsh environments in the RXB because these areas contain high or moderate energy piping.
3. The pressure inside the CNV is maintained less than the saturation pressure corresponding to the reactor pool pressure; this results in a vacuum.
4. The boron concentration in the pool areas will be nominally 1800 ppm. EPRI primary water chemistry guidelines show the pH of a pool with 1800 ppm boron concentration to be 4.75.

Table 3C-7: Design Basis Event Environmental Conditions

Zone[3]	DBE	Temperature (F)	DBE	Pressure (psig)[2]	DBE	Relative Humidity (%)	Water Level (ft. above RXB pool floor)	Water Spray (pipe rupture)
A	HELB	See Figure 3C-1	HELB	958.4	All Events	100	24 (inside CNV to support ECCS operation)	-
B	HELB	See Figure 3C-1	HELB	958.4	All Events	100	24 (inside CNV to support ECCS operation)	-
C	HELB	See Figure 3C-2	HELB	958.4	All Events	100	-	Yes
D	HELB	See Figure 3C-2	HELB	958.4	All Events	100	-	Yes
E	HELB	See Figure 3C-2	HELB	958.4	All Events	100	-	Yes
F	HELB	See Figure 3C-2	HELB	958.4	All Events	100	-	Yes
G	HELB	See Figure 3C-3	HELB	2.5	All Events	100	-	Yes
H	Conditions resulting from HELB and fuel handling accident (FHA) in the pool area/top of module (TOM)	See Figure 3C-4	Conditions resulting from HELB and FHA in the pool area/ TOM	2.75	Conditions resulting from HELB and FHA in the pool area/ TOM	100	-	-
I	Conditions resulting from HELB and FHA in the pool area/ TOM	212[1]	Conditions resulting from HELB and FHA in the pool area/ TOM	2.75 (Equipment located below water level will be affected by hydrostatic pressure plus atmospheric overpressure)	Conditions resulting from HELB and FHA in the pool area/ TOM	N/A	75 (top of pool, not DBA condition)	-

Notes:

1. The long term pool temperature will remain at 212°F due to all modules being on DHRS from a loss of power. Equipment exposed to this environment will need to be qualified at 212°F for as long as the equipment is required as specified in Table 3.11-1.
2. Refer to Table 6.2-4a for the CNV pressure for the spectrum analyses of primary and secondary mass and energy releases.
3. DCA EQ Zones J, K, L, M, and N are isolated from the RXB Pool and bioshield areas but are preliminarily designated as harsh environments in the RXB because these areas contain high or moderate energy piping.
4. The CNV post-accident pH for any postulated accident that results in core damage is 6.9 at 1000 ppm boron concentration and 8.3 at 200 ppm boron concentration. These values remain essentially unchanged between 25C and 200C.

Table 3C-8: Accident EQ Radiation Dose

		Accident Integrated Dose (rads)				
Zone(1)	Dose	1 hour	36 hours	72 hours	720 hours	2400 hours
A	Integrated β	0	2.11E6	3.56E6	1.44E7	3.15E7
	Integrated γ	0	6.05E6	1.06E7	6.07E7	1.52E8
B	Integrated β	0	2.11E6	3.56E6	1.44E7	3.15E7
	Integrated γ	0	6.05E6	1.06E7	6.07E7	1.52E8
C	Integrated β	0	1.39E9	2.40E9	8.63E9	1.57E10
	Integrated γ	0	2.54E9	4.39E9	2.35E10	5.73E10
D	Integrated β	0	1.39E9	2.40E9	8.63E9	1.57E10
	Integrated γ	0	2.54E9	4.39E9	2.35E10	5.73E10
E	Integrated β	0	1.39E9	2.40E9	8.63E9	1.57E10
	Integrated γ	0	2.54E9	4.39E9	2.35E10	5.73E10
F	Integrated β	0	1.39E9	2.40E9	8.63E9	1.57E10
	Integrated γ	0	2.54E9	4.39E9	2.35E10	5.73E10
G	Integrated β	0	4.94E5	1.45E6	2.06E7	6.84E7
	Integrated γ	0	2.82E5	7.51E5	1.54E7	8.98E7
H	Integrated β	0	2.11E3	6.24E3	8.83E4	2.93E5
	Integrated γ	0	1.21E3	3.22E3	6.60E4	3.85E5
I	Integrated β+ γ	25.6	5.83E2	1.12E3	8.3E3	2.5E4

Notes:

1. DCA EQ Zones J, K, L, M, and N are isolated from the RXB Pool and bioshield areas but are preliminarliy designated as harsh environments in the RXB because these areas contain high or moderate energy piping.

Figure 3C-1: Containment Liquid Space Metal and Liquid Temperatures with Bounding Curve (Zones A and B)

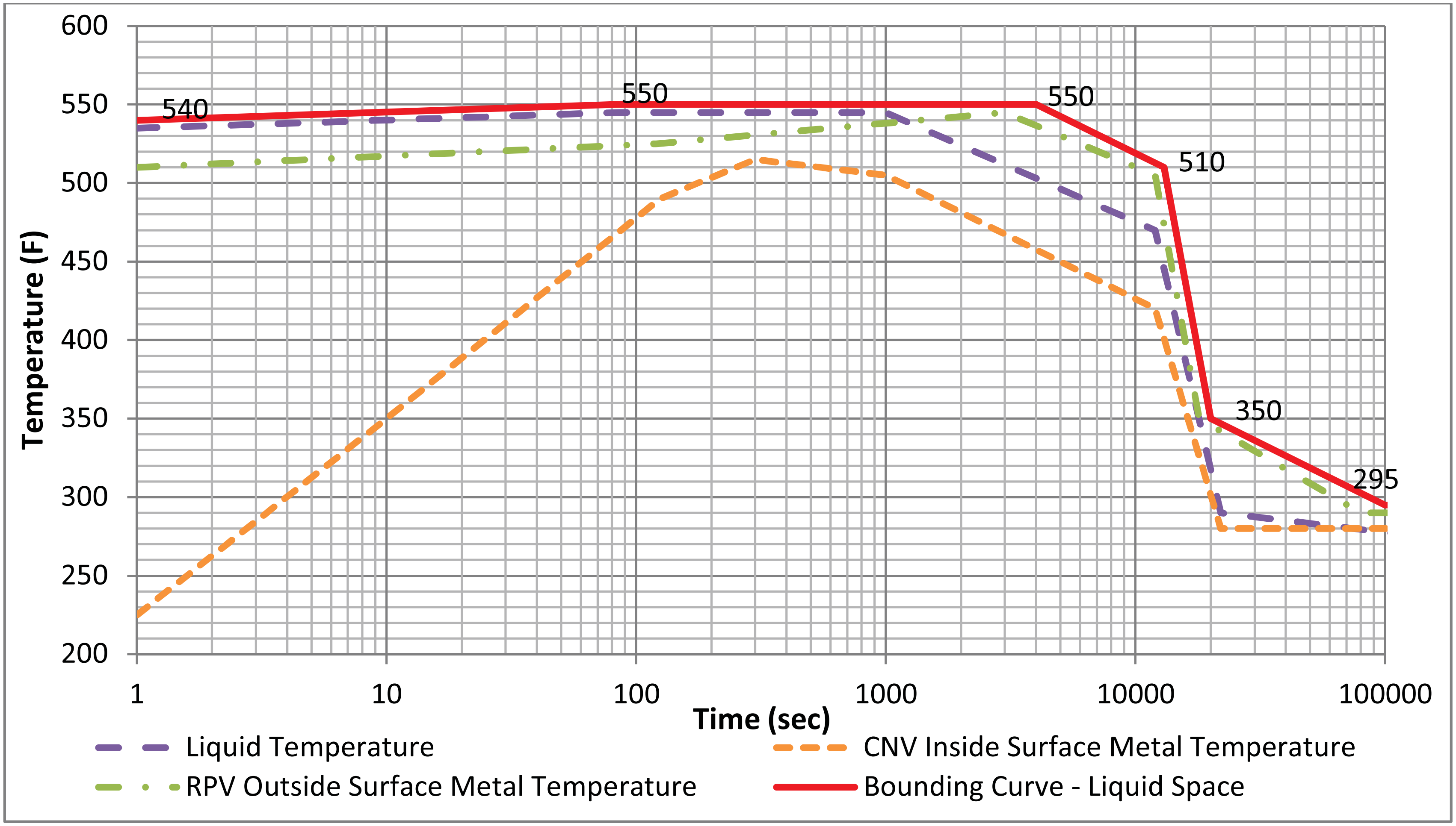


Figure 3C-2: Containment Vapor Space Metal and Gas Temperatures with Bounding Curve (Zones C, D, E, and F)

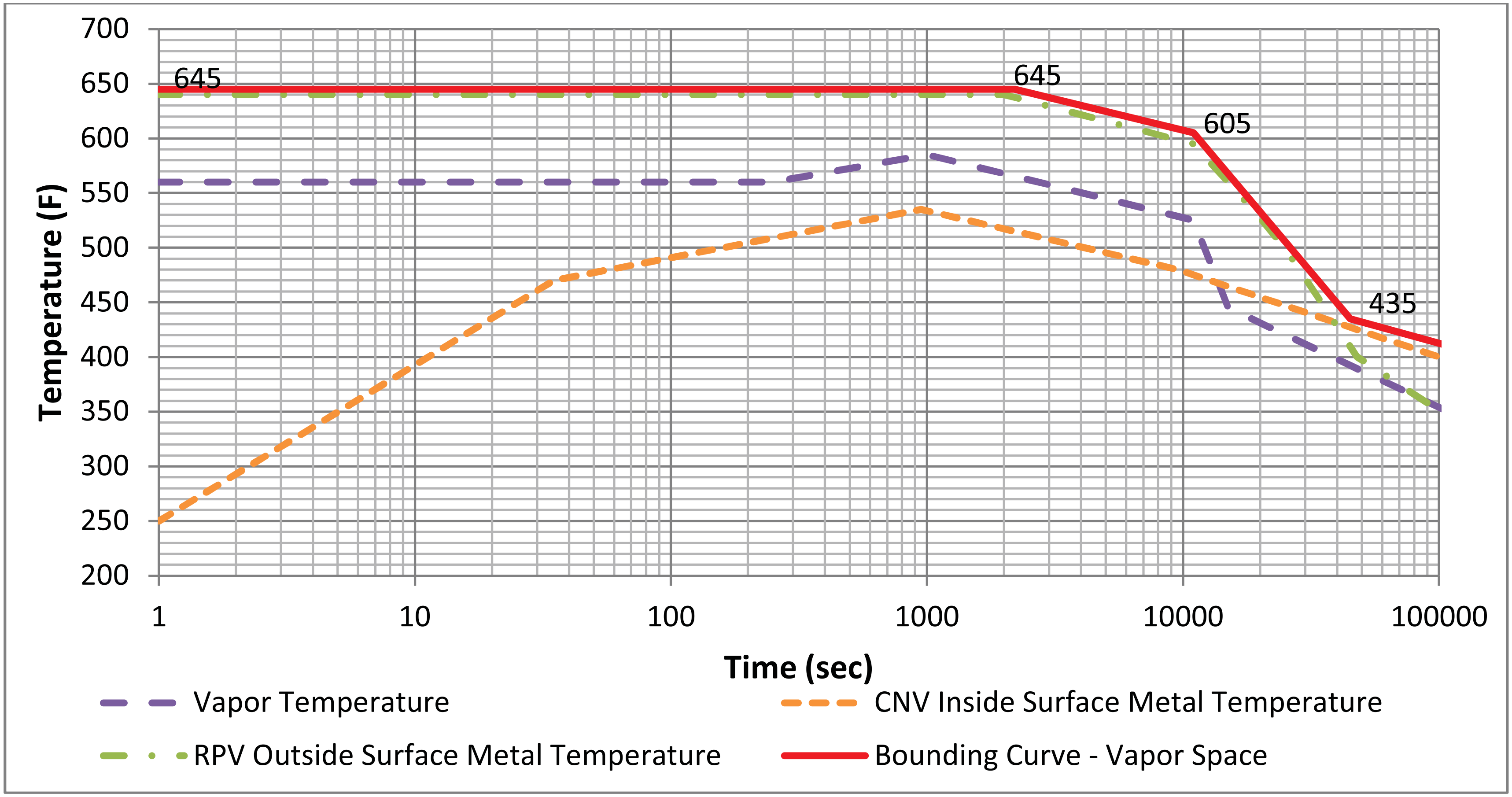


Figure 3C-3: Bounding Envelope for Average Vapor Temperature at Top of Module (Zone G)

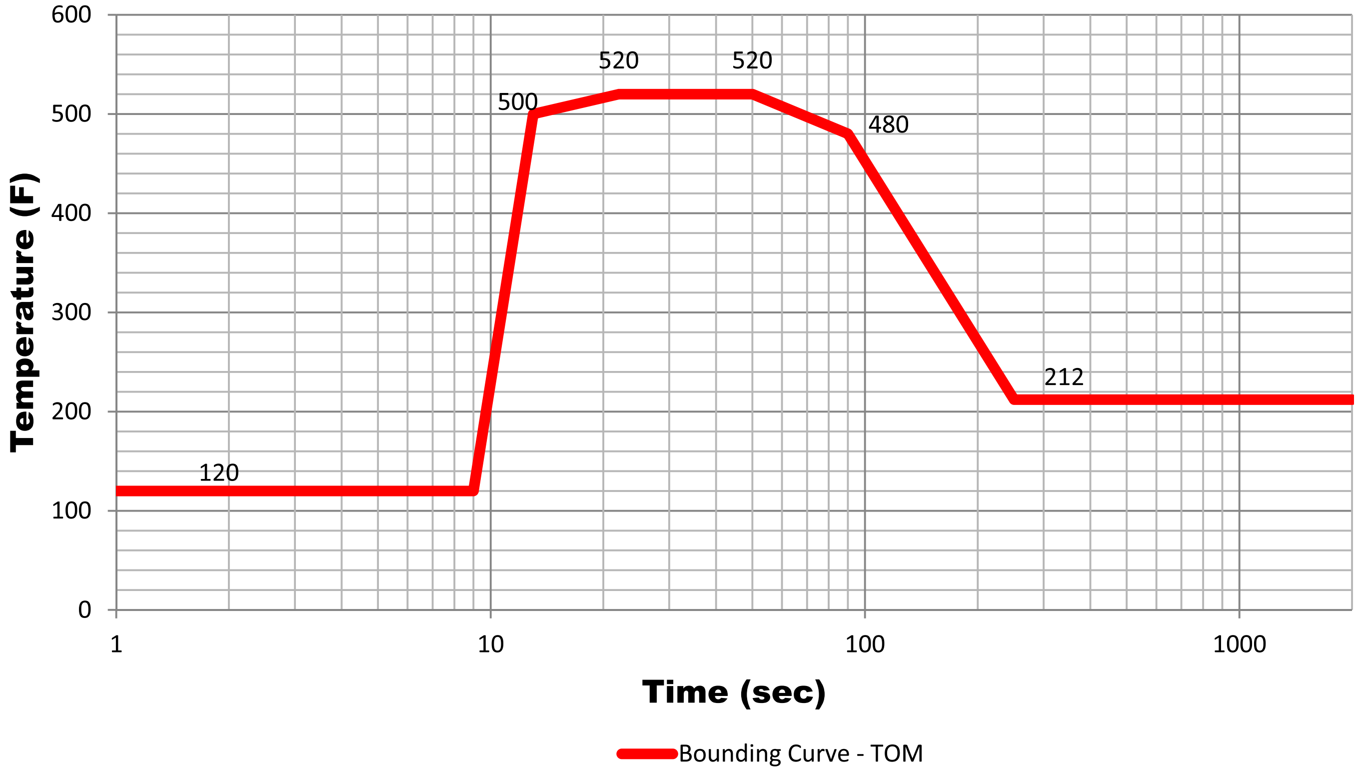


Figure 3C-4: Bounding Envelope for Maximum Vapor Temperatures at Reactor Building El 145'-0 (Zone H)