pressure-retaining but not backed by concrete, have been discussed previously in Section 3.8.1.

3.8.3 Concrete and Steel Internal Structures of Concrete Containment

Concrete and steel structures internal to the PCCV, but not part of the containment pressure boundary, provide support of the RCS components and related piping systems and equipment. The containment internal structure is the primary support structure that provides compartmentalization and radiation shielding within the PCCV. The major structures internal to containment include:

- Reactor support system
- SG support system
- RCP support system
- Pressurizer support system
- Primary shield wall as part of containment internal structure
- Secondary shield walls as part of containment internal structure
- Reactor cavity and refueling cavity as part of containment internal structure
- Other structures internal to containment include additional supports, RWSP, the operating floor, intermediate floors and platforms, and polar crane supporting elements

These structures internal to containment are capable of resisting the design loads and load combinations to which they may be subjected. The containment internal structure mitigates the consequences of an accident by protecting the containment and other engineered safety features from the effects induced by an accident, such as jet impingement forces and whipping pipes.

3.8.3.1 Description of the Structures Internal to Containment

3.8.3.1.1 Reactor Vessel Support System

The RV support system consists of eight steel support pads which are integrated with the inlet and outlet nozzle forgings. The support pads are placed on support brackets, which are supported by an embedded steel structure on the primary shield wall elevation 35 ft, 10.87 in. The support system is designed for operating and accident load cases caused by seismic and postulated pipe rupture, including LOCAs. The supports are formed by sliding surfaces between the shim plates and support pads to allow radial thermal growth of the RCS and RV. The vessel position is maintained unchanged by controlling the horizontal load through the support brackets and the base plate. Figure 3.8.3-1 provides the detail of the RV supports and relationship with the primary shield wall.

3.8.3.1.2 Steam Generator Support System

The SG support system consists of an upper shell support structure at centerline elevation 96 ft, 7 in., an intermediate shell support structure at centerline elevation 75 ft, 5 in., and a lower shell support structure at centerline elevation 45 ft, 7.64 in.

The upper and intermediate shell supports are lateral restraints utilizing snubbers attached to structural steel brackets, while the lower support structure is constructed entirely of structural steel and provides both vertical and lateral support. All support systems are designed considering thermal expansion of piping. The support system also restrains horizontal movement of the SG in the event of earthquake or other DBAs.

Four columns transfer the vertical loads of the SG to the reinforced concrete slab at elevation 25 ft, 3 in. The upper and lower ends of the columns are pin-jointed to permit movement of the SGs caused by thermal expansion of piping. Figure 3.8.3-2 depicts the SG support system.

3.8.3.1.3 Reactor Coolant Pump Support System

Each RCP support system consists of a lateral support structure, and three support columns.

The lateral support structure at centerline elevation 42 ft, 7.3 in. is constructed entirely of structural steel. Both support structures are designed considering thermal expansion of piping. The support structure also restrains horizontal movement of the RCPs in the event of an earthquake or other DBAs.

The three support columns carry the vertical loads of the RCP from the reinforced concrete slab at elevation 25 ft, 3 in. The upper and lower ends of the supports are pin-jointed to permit movement of the pumps caused by thermal expansion of piping. Figure 3.8.3-3 depicts the RCP support system.

3.8.3.1.4 Pressurizer Support System

The pressurizer is supported by an upper support structure and a lower support skirt. The upper support structure constructed of four structural steel struts at centerline elevation 110 ft, 9 in. does not restrain movement by thermal expansion, but restrains horizontal movements in the event of design-basis earthquakes or accidents. The lower support structure supports the vertical load through a continuous structural steel skirt welded to the bottom of the pressurizer supported at elevation 59 ft, 1 in. Figure 3.8.3-4 depicts the pressurizer support system.

3.8.3.1.5 Primary Shield Wall

The RV is located at the center of the PCCV. Primary shield walls form the perimeter around the RV, which also serve to support the RV at elevation 35 ft, 10.87 in. The top of primary shield wall elevation is 46 ft, 11in. The general arrangement drawings in Chapter 1 show the location and configuration. Isometrics of the primary shield walls are shown in Figure 3.8.3-5.

The primary shield wall and other walls inside containment are fabricated as steel-concrete (SC) module walls. The modules are formed using permanently placed carbon steel faceplates and web~~-~~ plates with a ~~nominal~~ typical thickness of 1/2 in. The faceplates, connected by ~~tie bars, fabricated from carbon steel plate, or by carbon steel web-plates~~carbon steel tie bars and web plates, also function as formwork for concrete placed in the interior. The primary purpose of the tie bars and web~~-~~ plates is to stiffen and hold together the faceplates during handling, erection, and concrete placement, and to provide out-of-plane shear strength. The nominal pitch of the tie bars is 24 in. for the SC module walls. The ~~primary functions of the~~ web~~-~~ plates ~~are~~ also function to mitigate faceplate stress concentration, maintain the SC module configuration, and stiffen corners of faceplates. Shear studs are welded to the steel faceplates and web plates to provide shear transfer between the steel plates and the concrete. Where SC modules intersect, web~~-~~ plates are installed in-line with faceplates to maintain continuity across the point of intersection. The nominal pitch of studs is 8 in. to 12 in. in both directions. Faceplates are welded to adjacent plates with full penetration welds so that the weld is at least as strong as the plate. The SC module walls are welded at the base to a continuous embedded plate in the basemat. After erection, concrete is placed between the faceplates.

MIC-04-03-0001

MIC-04-03-0001

MIC-04-03-0001

MIC-04-03-0001

3.8.3.1.6 Secondary Shield Walls

The secondary shield walls surround the primary loops from the SG compartments. SC modules also form supports for intermediate floors and operating floors. The secondary shield walls are a series of walls that enclose the SGs and the pressurizer. Each of the four secondary shield wall compartments provides supports and houses a SG and RCL piping. The GA drawings in Chapter 1 show the location and configuration. Isometrics of secondary shield walls are shown in Figure 3.8.3-5.

3.8.3.1.7 Refueling Cavity

The cavity space directly above the RV and between SC module walls to the north is referred to as the refueling cavity. The refueling cavity connects to the fuel transfer tubes that penetrate the north end of PCCV. The floor of the refueling cavity varies in elevation from 19 ft, 4 in. to 46 ft, 11 in. The top of the refueling cavity is at elevation 76 ft, 5 in. Additionally, containment racks are installed in the refueling cavity to temporarily store new or irradiated fuel assemblies. A more detailed description of the containment racks is provided in Section 9.1.

MIC-04-03-0001

The walls of the refueling cavity are formed by SC modules, which are lined with 1/8 in. stainless steel ~~over~~ that is bonded to the 1/2~~-~~ in. thick carbon steel plates by the hot roll bonding process, referred to as “clad steel.” The ~~ceiling and~~ floor slabs are also lined with clad steel.

MIC-04-03-0001

3.8.3.1.8 RWSP

The RWSP is located at the lowest part of the PCCV. The walls of the RWSP ~~is~~ are formed by ~~wall of~~ SC modules using clad steel. A floor at elevation 3 ft, 7 in. is formed of clad steel in a layer of concrete that covers the containment liner and basemat. The ceiling is similarly lined with stainless steel. Subsection 6.2.1.1 provides a description of the RWSP layout and design features.

MIC-04-03-0001

3.8.3.1.9 Interior Compartments

The containment internal structure includes several subcompartments designed to provide containment, radiation shielding, and protection of safety-related components. These compartments, except for the heat exchanger rooms, are formed by the secondary shield walls surrounding the primary loops from the SGs. Heat exchanger rooms are formed by the secondary shield wall on one side and the other sides are formed by reinforced concrete structures. They also protect the containment from postulated pipe ruptures inside the containment. These SC wall modules also form supports for intermediate floors and the operating deck at elevation 76 ft, 5 in. The walls are designed for load cases including earthquake and DBAs. MIC-04-03-0001

Subcompartments and/or rooms comprising the containment internal structure are summarized as follows:

- reactor cavity EL. -9 ft, 2 in.
- containment drain sump room EL. 9 ft, 6 in.
- letdown heat exchanger room EL. 25 ft, 3 in.
- regenerative heat exchanger room EL. 50 ft, 2 in.
- excess letdown heat exchanger room EL. 50 ft, 2 in.

Labyrinths are provided beside the shield wall openings at several elevations for radiation protection, which consist of SC modules and reinforced concrete walls, floors, and ceilings.

Reinforced concrete slabs are used for the floor above the RWSP at elevation 25 ft, 3 in., the intermediate floor at elevation 50 ft, 2 in., and the operating floor at elevation 76 ft, 5 in. The floors are shown on the GA drawings in Chapter 1. The floor at elevation 25 ft, 3 in. is supported by the primary shield wall, the secondary shield wall, and the RWSP. The floors at elevations 50 ft, 2 in. and 76 ft, 5 in. are supported by the secondary shield wall and the structural steel framing (beams and columns) arranged between the secondary shield wall and the PCCV. The floors consist of reinforced concrete slabs, placed on steel beams and deck plate.

3.8.3.1.10 SC Modules

Figure 3.8.3-5 provides isometric views of the SC modules.

The module framework, consisting of the steel faceplates prior to concrete placement, is positioned on the supporting reinforced concrete basemat. The SC modules are anchored to the basemat using a steel baseplate that also serves as the containment liner. The baseplate is anchored to the basemat with~~through~~ reinforcement doweled with the slab. MIC-04-03-0001 Seaming of adjacent plates is accomplished using full penetration welding that maintains full design strength of the plate units. The interior of the modular unit is filled with concrete to complete the installation process. Figure 3.8.3-6 depicts the containment internal structure compartment wall layout and configuration. Figure 3.8.3-7 provides typical details for the SC module construction including connection details and anchorage connection details to the reinforced concrete basemat.

3.8.3.1.11 Polar Crane Supports

An internal polar crane is supported by the PCCV. A continuous crane girder transfers the polar crane loads to the PCCV wall. Refer to Subsection 3.8.4.3 for loads applicable to the polar crane supports. Figure 3.8.3-8 depicts the polar crane supports layout and construction.

3.8.3.1.12 Structural Steel Framing

Structural steel framing within the interior of PCCV is primarily for support of floor slab, equipment, distribution systems such as piping, valves, and cable trays, and access platforms. Service platforms and secondary intermediate floors consist of steel grating or checkered plate supported by structural steel framing. All structural steel members are capable of resisting the loads and load combinations to which they may be subjected.

3.8.3.2 Applicable Codes, Standards, and Specifications

Refer to Subsection 3.8.4.2 for industry standards applicable to the design and construction of seismic category I structures inside containment. Other codes, standards and specifications applicable to materials, testing and inspections are identified in Subsections 3.8.4.6 and 3.8.4.7.

3.8.3.3 Loads and Load Combinations

Typical loads and load combinations are detailed in Subsection 3.8.4.3. Load combinations to be utilized for the design of the containment internal structure include hydrostatic, pressure, and thermal loads as summarized below. Hydrostatic loads reflect the water inventory and its location during various plant conditions.

Seismic category I concrete structures are designed for impulsive and impactive loads in accordance with the ACI 349-06 Code (Reference 3.8-8), with exceptions given in RG 1.142 (Reference 3.8-19). Impactive and impulsive loads must be considered concurrent with seismic and other loads (i.e., dead and live load) in determining the required load resistance of structural elements.

Subcompartment pressure loads are the result of postulated high-energy pipe ruptures. In determining an appropriate equivalent static load for Y_r, Y_j, and Y_m, elasto-plastic behavior is acceptable with appropriate ductility ratios, provided excessive deflections do not result in loss of function of any safety-related system.

3.8.3.3.1 Floor Loads Inside Containment

The following are the minimum values for live loads used in load combinations involving non-seismic loads. Live loads for the seismic analysis are defined in Subsection 3.8.4.3.

Containment operating deck	950 lb/ft^2 (during maintenance and refueling outages) 200 lb/ft^2 (during normal operation)
Maintenance and service platforms	The load is calculated for individual locations based on the functional requirements and service equipment
All other floors (ground floor and elevated floors, including stairs and walkways)	200 lb/ft^2 (For non-seismic load combinations and for global seismic analysis, this load may be reduced if the equivalent live load on the floor is more than 50 lb/ft^2. The sum of the live load and equivalent live load need not exceed 250 lb/ft^2)

In design reconciliation analysis, if actual loads are determined to be lower than the above loads, the actual loads may be used for reconciliation. Floor live loads for design are not reduced below 100 lb/ft^2.

3.8.3.3.2 Liquid Loads (F)

The vertical and lateral pressures of liquids inside containment are treated as dead loads. Structures supporting fluid loads during normal operation and accident conditions are designed for the hydrostatic as well as hydrodynamic loads.

Hydrostatic loads are based on the tank or flooded volume. The water inventory is considered to be in any one of the following locations with other areas being dry.

RWSP	Water in the RWSP. Normal water level is elevation 20 ft, 2 in.
Refueling Cavity	Water in the refueling cavity during refueling operations. Normal water level during refueling is elevation 75 ft, 3 in.

The overall seismic analyses and ISRS considers the water to be in the RWSP, which is its normal location. Water inventory at any one of these locations is also considered as a normal operating liquid load. In the event of a SSE, the containment internal structure is designed with the water inventory in any one of the above locations.

The RWSP design also considers the hydrodynamic response of the refueling water under seismic excitation. The manner in which the impulsive and convective response components are considered is discussed in Subsection 3.8.3.4.2.

3.8.3.3.3 Accident Pressure Load (P_a)

Accident pressure loads within or across a compartment and/or building are considered in the design. Differential pressure is generated by postulated pipe rupture and includes the dynamic effects due to pressure time-history. The containment internal structure subcompartments are designed to the pressures shown in Table 3.8.3-2 and identified on Figure 3.8.3-9. These pressures are combined by SRSS with SSE loads, including sloshing loads, or by using more conservative combinations. The water inventory is assumed to be in the RWSP. Steel floors with grating need not be designed for differential pressure.

3.8.3.3.4 Operating Thermal Loads (T_o)

The normal operating environment inside and outside the PCCV is specified in Table 3.8.1-3. Under the normal operating condition, the primary shield wall, and the secondary shield wall (in the proximity of the main steam and feedwater pipes) experience temperature rises, including temperature distribution through the wall thicknesses. The loads resulting from these thermal gradients provided in Table 3.8.1-3 are combined with other loads for the containment internal structure as specified in the load combinations in Table 3.8.4-3.

3.8.3.3.5 Accident Thermal Load (T_a)

Thermal loads due to temperature gradients caused by the postulated pipe breaks are considered in the design. The temperature gradients are calculated using the temperatures corresponding to LOCA and main steam line break (MSLB) and are presented in Table 3.8.1-3. Local areas are designed for the elevated temperature effects and the loads resulting from the postulated accidents.

Temperatures of the SC modules during an accident do not exceed ~~450~~365°F at the ~~surface~~ exposed steel surface, and the concrete temperatures do not exceed 350°F. However, local areas are allowed to reach 650°F from steam or water jets in the event of a pipe failure in accordance with Section E.4.2 of ACI 349-06 Appendix E. ~~Although the 450°F accident temperatures exceed the 350°F surface temperature limit of ACI 349-06 Section E.4.2, the accident temperatures do not reduce the design strengths of the CIS SC modules. This assessment is described in Section 9.0 of Technical Report MUAP-11019 and Appendix B, Section 10 of MUAP-11013.~~ For the reinforced concrete slabs in the CIS, temperatures during an accident do not exceed 350°F at the surface. MIC-04-03-0001 MIC-04-03-0001

3.8.3.3.6 Accident Thermal Pipe Reaction (R_a)

Pipe and equipment reactions under thermal conditions are generated by the postulated pipe break and includes Ro (see Subsection 3.8.4.3).

3.8.3.3.7 Reaction Due to Pipe Ruptures (Y_r)

The load on a structure generated by the reaction of a ruptured high-energy pipe during the postulated event includes an appropriate dynamic load factor. The time dependent nature of the load and the ability of the structure to deform beyond yield are considered in establishing the structural capacity necessary to resist the effects of Y_r.

3.8.3.3.8 Jet Impingement (Y_j)

The load on a structure generated by the jet impingement from a ruptured high-energy pipe during a postulated event includes an appropriate dynamic load factor. The time-dependent nature of the load and the ability of the structure to deform beyond yield are considered in establishing the structural capacity necessary to resist the effects of Y_j.

The dynamic load factor is calculated using a long duration step function for the load. The target resistance is idealized as bilinear elasto-perfectly plastic.

3.8.3.3.9 Impact of Ruptured Pipe (Y_m)

The load on a structure or a pipe restraint resulting from the impact of a ruptured high-energy pipe during the postulated event includes an appropriate dynamic load factor. The type of impact (i.e., plastic, elastic), together with the ability of the structure to deform beyond yield are considered in establishing the structural capacity necessary to resist the impact.

3.8.3.4 Design and Analysis Procedures

The CIS is a complex structure that includes several different structure categories. As discussed in previous sections, a significant portion of the CIS consists of SC walls, including the primary shield walls, the secondary shield walls, the walls of the refueling cavity, and the walls of the RWSP.

As presented in Technical Report MUAP-11005 (Reference 3.8-63), experimental investigations have been conducted in the past to evaluate the behavior of the SC walls with geometries representative of those in the US-APWR CIS, as follows:

- 1/10th scale cyclic pushover test of a complete CIS
- 1/6th scale cyclic pushover test of the primary shield structure
- Component in-plane shear tests of SC walls with flanges
- Component tests of SC wall panels without flanges subjected to combined axial compression and cyclic in-plane shear
- Component out-of-plane shear tests of SC beams
- Component axial compression test of SC stub columns
- Component tests on the effects of thermal gradients on cracking and mechanical behavior of SC walls

Technical Report MUAP-11005 Appendices A, B, C, and D explain the correlation of the SC wall geometries considered in these tests to the SC walls in the US-APWR CIS. In addition, the technical report describes the key results of these tests that demonstrates the performance of SC walls under the design loading conditions for the CIS, including seismic and thermal loading.

The experimental results presented in Technical Report MUAP-11005 (Reference 3.8-63) also demonstrate the similarity of SC wall behavior to that of standard reinforced concrete walls. SC walls are similar to reinforced concrete walls, as they both consist of thick concrete sections that are reinforced by steel. In SC walls, the concrete section is reinforced with steel faceplates that are anchored to the concrete using shear studs and connected to each other using tie bars. In reinforced concrete walls, the concrete section is reinforced with orthogonal grids of steel rebars that are embedded within the concrete.

In several aspects of structural behavior, such as axial tension, compression, flexure, and out-of-plane shear, the behavior of SC walls is very similar to that of reinforced concrete walls. In other aspects (e.g., in-plane shear and thermal effects), the general behavior is similar to that of reinforced concrete, but there are some differences that must be addressed in the design of the SC walls.

The design of the CIS SC walls is based on ACI 349-06 (Reference 3.8-8) code provisions. The overall approach for confirming the applicability of the ACI 349-06 (Reference 3.8-8) code equations, evaluating the results of the small-scale (1/10th and 1/6th scale) tests, and developing SC wall section details that prevent SC-specific limit states not specifically addressed in the ACI 349-06 code ~~were evaluated as~~are described in Technical Report MUAP-11013 (Reference 3.8-68). MIC-04-03-0001

The results of the 1/6th scale and 1/10th scale test results have been evaluated and analyzed to confirm the performance of containment internal structures constructed with SC modules under seismic loading up to SSE and beyond SSE loading levels.

Additionally, the component-level tests were also evaluated using benchmarked nonlinear analysis methods to confirm that the behavior of SC walls is appropriately addressed using ACI 349-06 provisions. The benchmarked nonlinear analysis of these test results confirm the behavior of the SC modules, but is not a basis of design. The analysis is summarized in MUAP-11013 Appendix A.

To further confirm the applicability of the ACI 349-06 design provisions for the US-APWR specific SC module design details, a series of confirmatory physical tests were conducted, as summarized in Table 3.8.3-7. The results of these tests demonstrate behavior of the SC walls and confirm the conservatism of the ACI 349-06 design strength equations. The US-APWR confirmatory testing program is further summarized in Technical Report MUAP-11013 Appendix B.

The analysis and design procedures for the CIS are organized into three sets of criteria, as follows:

Stiffness and Damping: The stiffness and damping terms used for analysis of the CIS are defined for six structure categories and two basic loading conditions, as described in Table 3.8.3-4 and following in this section. This is also summarized in detail in Technical Report MUAP-11018 (Reference 3.8-70).

SC Wall Design Criteria: The design criteria for the US-APWR SC walls address the SC specific design issues and limit states observed in the experimental database, and present the detailing approaches required to prevent these limit states from governing the design. The design criteria also addresses the applicability of the ACI 349-06 code provisions for each loading condition, including axial tension, axial compression, out-of-plane flexure, out-of-plane shear, in-plane shear, design for combined forces, and accident thermal considerations. Based upon observation of behavior in the experimental research, conservative forms of the ACI 349-06 (Reference 3.8-8) code provisions are identified as required. The key aspects of these design procedures are summarized in Subsection 3.8.3.4.5, and in greater detail in Technical Report MUAP-11019 (Reference 3.8-71).

SC Wall Connection Design and Detailing: The design criteria for SC wall connection design and detailing addresses design procedures for all anchorages and connections in the CIS involving SC walls. The criteria includes two connection design philosophies that are intended to ensure sufficient strength and ductility of the SC wall connections. These include the full-strength design philosophy, which designs the connection to develop the expected strength of the weaker of the connected parts, and the overstrength design philosophy, which provides significant overstrength (e.g., 200%) with respect to the design demands on the connection. The full-strength design philosophy is intended to be used for all SC wall connections in the US-APWR CIS. The overstrength design philosophy is to be utilized only in limited circumstances where a full strength connection cannot be provided. The design criteria are in accordance with ACI 349-06 provisions for anchorages and connections. In addition, the criteria require that the SC wall anchorage connection to the basemat (e.g., welding faceplates and studs to baseplate and couplers to baseplate) be designed per the provisions of both ACI 349-06 and ASME Section III Division 2 because this connection is at a jurisdictional boundary with the containment pressure boundary. ~~Three~~ Seven connections are designed as representative using the full strength design approach, as summarized in Subsection 3.8.3.5.2, Table 3.8.3-5, and Appendix 3L. The SC wall connection design and detailing criteria are summarized in further detail in Technical Report MUAP-11020 (Reference 3.8-72). MIC-04-03-0001

Summary of Stiffness and Damping for Analysis:

The containment internal structure is unique among the R/B complex structures in that it is comprised of a number of different structural types. The structural types include composite SC walls of varying thickness, massive reinforced concrete sections, and reinforced concrete slabs. These structures experience varying levels of stress and resultant concrete cracking under the seismic and accident thermal loading applied to the containment internal structure. Each structural type exhibits unique stiffness and damping characteristics before and after cracking. Thus, it is not appropriate to apply a uniform stiffness reduction to the entire containment internal structure for the SSI analyses of the R/B complex. Each structural component is assigned stiffness and damping values appropriate for its structural type and estimated cracking levels. This assignment is simplified by grouping structural components into six structural categories with common behavior. Stiffness and damping values are then defined for each category under two basic loading conditions that encompass the full range of stresses and resultant cracking anticipated for the containment internal structure seismic response.

The six structural categories defined for stiffness and damping characterization are described below and summarized in Table 3.8.3-4. As discussed in Technical Report MUAP-11018 (Reference 3.8-70), the values are derived from supporting experimental data for the SC modules and from industry standards for reinforced concrete structures. Plan and elevation views illustrating the use of each of the six structural categories are presented in Figures 3.8.3-12 through 3.8.3-18.

Overall thicknesses of the single-celled SC walls vary from 36” to 67”, while the multi-celled primary shielding SC walls have overall thickness in excess of 9’-11”. The range of experimental data establishing the composite stiffness characteristics of SC walls is applicable to sections with overall thickness less than or equal to 56” and steel plate reinforcement ratio (ρ) greater than 1.5%, as defined below. MIC-04-03-0001

$$\rho = 2 \cdot t_p / T > 0.015$$

Where

t_p = faceplate thickness,

T = overall wall thickness

The SC walls are separated into three categories, as follows:

CIS Category 1: SC Walls with thickness less than or equal to 56 in. These SC walls have material and geometric parameters that are within the range of the experimental database. This category includes the majority of the secondary shielding walls in the containment internal structure. The most common SC wall is 48 in. thick with 0.5 in. thick steel faceplates.

CIS Category 2: SC Walls with thickness greater than 56 in. This category includes a relatively small portion of the containment internal structure SC walls with a thickness~~es ranging from 58.5 in. to~~ of 67 in. MIC-04-03-0001

CIS Category 3: Primary Shield Walls. The primary shield walls below elevation 35'-11” range in thickness from 9'-11” to 15'-4”. They have a multi-cellular arrangement comprised of two steel faceplates, a mid-thickness steel plate, and numerous transverse web plates. The primary shield walls between Elevations 35'-11" and 46'-11" also have a multicellular arrangement consisting of inner and outer faceplates and multiple transverse web plates. MIC-04-03-0001

Non-SC structural components of the CIS are separated into three additional categories, as follows:

CIS Category 4: Reinforced concrete slabs. Standard reinforced concrete floor slabs are used at various elevations throughout the containment internal structure.

CIS Category 5: Massive reinforced concrete. This category includes the thick reinforced concrete blocks at the base of the containment internal structure that support the steam generators and reactor coolant pumps. These blocks are nominally 8 to 32 feet deep and are anchored to the basemat of the reactor building complex with steel reinforcement.

CIS Category 6: ~~Steel structures with nonstructural concrete infill.~~ These structures consist of steel plates or steel shape grillages with ~~nonstructural~~ composite concrete infill ~~provided for shielding purposes~~. MIC-04-03-0001

Discussion of Basic Loading Conditions for Consideration of Concrete Cracking:

The design loading conditions for the CIS are condensed to two basic loading conditions that are evaluated to assess the range of concrete cracking. This is discussed in further detail in MUAP-11018 Section 3.1 (Reference 3.8-70). These two basic loading conditions consider the load cases with the most significant potential to cause cracking, (i.e., safe-shutdown earthquake and accident thermal loads).

Condition A: Seismic + Operating Thermal. The normal operating thermal loading involves ambient temperatures of 105°F to 120°F, which are not anticipated to cause

cracking that would significantly reduce the stiffness of the SC modules or any of the reinforced concrete structures. The operating temperature of the reactor cavity is 150°F, such that a linear temperature distribution is postulated through the nominally 10-ft thickness of the primary shielding walls, varying from 150°F at the interior face to 105-120°F at the exterior face. As discussed in Technical Report MUAP-11018, Appendix F (Reference 3.8-70), this shallow linear gradient is not anticipated to cause significant cracking of the primary shielding walls. Thus, the stiffness for Condition A is estimated by evaluating stresses resulting from the seismic loading condition only.

Condition B: Seismic + Accident Thermal. The accident thermal conditions postulated involve ~~initial~~ peak steel surface temperatures of ~~450~~ 249 to ~~550~~365°F as shown in Table 3.8.1-3~~Figure 3.8.1-12 and Figure 3.8.3-13 in the pipe-rupture side, with an immediate increase of temperature 270 to 300°F in Containment Vessel and RWSP as shown in Figure 3.8.1-11~~. The more detail of compartments for accident thermal conditions are summarized in Technical Report MUAP-11018 (Reference 3.8-70). Within approximately 10,000 seconds (2.8 hours), the temperatures on each face ~~equilibrate to~~ are below 300°F, which sets up parabolic (U-shaped) temperature distributions through the thickness of the SC walls. MIC-04-03-0001 MIC-04-03-0001

This distribution will cause through-thickness cracks in the SC walls. These cracks will reduce the in-plane shear stiffness, cause overall thermal deformations and out-of-plane flexural cracking at restraints.

Estimated Stiffness for Each Category and Loading Condition:

The following is a summary of the estimated stiffness for each CIS structural category and loading condition. The stiffness terms summarized below are utilized in the two SSI analysis models involving upper and lower bound stiffness terms (as discussed in Section 3.7.2,) and in the two more detailed CIS structural design models with stiffnesses corresponding to Conditions A and B. Further discussion of the structural design analysis models is given in Section 3.8.3.4.1. Further detail on the basis for the CIS Condition A and B stiffness terms is provided in Technical Report MUAP-11018 (Reference 3.8-70).

Category 1, Condition A: An assessment of the maximum seismic in-plane shear demands in each SC wall of the containment internal structures indicated that these demands were generally lower than the cracking threshold for in-plane shear. Thus, the best estimate in-plane shear stiffness for Condition A is that of the uncracked composite section (i.e., $G_cA_c + G_sA_s$).

where

G_c = shear modulus of concrete

A_c = area of concrete per unit length

G_s = shear modulus of steel

A_s = area of steel per unit length

Note that the cracking threshold for SC walls was assumed at a concrete stress of $2\sqrt{f'c}$. Typically the cracking threshold for concrete is related to concrete stress of $4\sqrt{f'c}$, but the limit for SC walls is reduced to account for shrinkage and other effects, as described in Technical Report MUAP-11018, Section 4.1.2 (Reference 3.8-70). In addition, the uncracked stiffness estimated for this condition takes into account the recommendation to increase calculated secant stiffness values by a factor of 1.25 to obtain effective in-plane shear stiffness values appropriate for use in an equivalent linear elastic model as described in Technical Report MUAP-11018, Section 4.1.4 (Reference 3.8-70). Note that the effective stiffness values resulting from calculation of 1.25 times the secant stiffness are not to exceed the initial uncracked stiffness.

As discussed in Technical Report MUAP-11018 Appendix E, (Reference 3.8-70), experimental data indicates there is little to no uncracked out-of-plane flexural stiffness manifest in SC walls. This is due to effects of shrinkage cracking and partial composite action resulting from the discrete nature of the shear connectors (studs) between the face plates and the concrete core. Instead, the stiffness ($EcIct$) associated with the cracked transformed section is exhibited very early during the application of out-of-plane moments to SC walls.

where

E_c = modulus of elasticity of concrete

I_{ct} = cracked-transformed moment of inertia of concrete

Category 1, Condition B: The through-thickness temperature gradient resulting from the accident thermal loading can cause significant cracking that reduces the in-plane shear stiffness of the SC walls. An empirical relationship providing a best-estimate of secant in plane shear stiffness of cracked SC walls is as follows, and as described in Technical

Report MUAP-11018, Appendix C (Reference 3.8-70):

$$K_{cr} = 0.5\left(\overline{\rho}^{-0.42}\right)G_s A_s$$

where

$$\overline{\rho} = \frac{A_s F_y}{\sqrt{f'_c}\; A_c}$$

G_s = shear modulus of steel

A_s = area of steel per unit length

F_y = yield strength of steel plates

f'_c = specified compressive strength of concrete

A_c = area of concrete core per unit length

Category 2, Condition A: Stress evaluation indicates these thick walls remain uncracked for Condition A. Thus, uncracked stiffness values of the concrete section shall be used; i.e., G_cA_c for in-plane shear and E_cI_c for out-of-plane flexure.

where

G_c = shear modulus of concrete

A_c = area of concrete per unit length

E_c = modulus of elasticity of concrete

I_c = moment of inertia of concrete

Category 2, Condition B: Stiffness of these walls shall account for cracking due to accidental thermal loading. Stiffness values of $0.5G_cA_c$ and $0.5E_cI_c$ are assigned per the recommendations for cracked concrete walls as shown in ASCE 43-05 (Reference 3.8-60).

Category 3, Condition A: The linear temperature gradient through the primary shield walls for normal operating conditions is not anticipated to cause significant cracking, and seismic demands on these walls are relatively limited in comparison to wall strength capabilities. Thus the primary shield wall stiffness shall be modeled as that of uncracked concrete (G_cA_c and E_cI_c). No credit is taken for the stiffness of the steel plates.

Category 3, Condition B: The accident thermal loading conditions are anticipated to cause only localized cracking in the thick primary shielding walls, which are largely enclosed by the mass concrete (Category 5) at the base of the containment internal structures. Thus, the stiffness for this condition is the same as that assigned for Condition A (uncracked).

Category 4, Condition A: In-plane shear stiffness of the reinforced concrete slabs shall be that of the gross concrete section (G_cA_c, in accordance with ASCE 43-05 (Reference 3.8-60)). Out-of-plane flexural stiffness is equal to that of the gross concrete section (E_cI_c), as seismic-induced moments in the slabs are shown generally to be less than cracking moments (M_{cr}):

$$M_{cr} = f_r \cdot S$$

where

S = gross section modulus

f_r = modulus of rupture of concrete

Category 4, Condition B: In-plane shear stiffness of the reinforced concrete slabs for this condition shall also be that of the gross concrete section (G_cA_c). Out-of-plane flexural stiffness is taken as 0.5 E_cI_c, as described by ASCE 43-05 (Reference 3.8-60).

Category 5 (both conditions): No significant cracking is anticipated in the massive reinforced concrete at the base of the structure as a result of either seismic or accident thermal loading. Thus, the stiffness is taken to be equal to that of uncracked concrete for both the A and B loading conditions.

Category 6 (both conditions): ~~The stiffness of in-fill concrete provided for shielding purposes is not modeled for the A and B loading conditions; only the mass of these sections is included. For the pressurizer support platform, which is comprised of a grillage of steel shapes with in-fill concrete, only the stiffness of the steel members is modeled.~~ This category includes structural elements that are part of the primary load resisting system, as well as other miscellaneous elements. The stiffness of the primary load resisting elements considers the stiffness of the steel elements and the composite action of infill concrete provided for shielding purposes. The miscellaneous elements that are not part of the primary load resisting elements are modeled considering concrete mass only with no stiffness. The stiffness of these elements is modeled as follows: RAI 03.08.03-94

- Lower Pressurizer Support: Full composite steel + cracked concrete
- Refueling Cavity to SG Compartment: Full composite steel + cracked concrete
- Other Category 6 Elements: Mass only, no stiffness

Damping values are assigned to each structural category based on the estimated level of Cracking (See Table 3.8.3-4). A damping value of 4% is assigned to composite SC walls with uncracked conditions (Condition A), and 5% when significant cracking is anticipated (Condition B). This is based on the results of the 1/10th scale test discussed in Technical Report MUAP-10002 (Reference 3.8-80). For walls and slabs modeled as reinforced concrete structures, 4% damping is specified in RG 1.61 (Reference 3.8-64) for the limited levels of cracking associated with the OBE, while 7% damping is specified for cracked response exhibited during SSE loading. The massive concrete in the containment internal structures (Category 5) is not expected to exhibit significant cracking, such that 4% damping is considered appropriate in all cases. It is noted that the structural steel members within the CIS are very limited in scope relative to the mass and stiffness of the SC and RC members in the CIS. ~~Recognizing that the amplified seismic response of the containment internal structure is dominated by the response of the SC walls, constant damping ratios of 4% for Condition A and 5% for Condition B are conservatively used for the seismic response analyses (See Table 3.8.3-4).~~ RAI 03.08.03-94 RAI 03.08.03-94

3.8.3.4.1 SC Module Stress Analyses

As discussed in Technical Report MUAP-11013 Section 3.2 (Reference 3.8-68), the design forces and moments for each member of the containment internal structure are calculated using two detailed 3-D FE models with stiffness and damping corresponding to loading Conditions A and B. Table 3.8.3-3 summarizes the analysis methods and objectives for the FE analyses performed for structural design. The geometry and element mesh of the detailed FE models are shown in Figure 3.8.3-10. Table 3.8.3-3 summarizes the objectives, analysis methods, and boundary conditions for the FE analyses performed with the detailed 3-D models.

As shown in Figure 3.8.3-10, the Category 1 and 2 SC modules are simulated within the detailed FE model using ~~three-dimensional~~3-D shell elements. The Category 3 (primary shield) SC modules are modeled using ~~three-dimensional~~3-D solid elements. Equivalent elastic stiffness constants are computed for each of the SC walls, as well as the RC slabs, to achieve the stiffness terms identified for Conditions A and B summarized above in Subsection 3.8.3.4 and in Technical Report MUAP-11018 (Reference 3.8-70). The method of calculating the equivalent elastic constants is explained in Section 8.0 of Technical Report MUAP-11018. MIC-04-03-0001

To generate the SSE load cases for structural design, response spectrum analysis is performed on each of the two detailed FE models (Condition A and Condition B). The inputs to both of these response spectrum analyses are the broadened, enveloped ARS generated at the base of the CIS by the SSI analyses. Likewise, each of the other design load cases (such as dead load, live load, and fluid load) are also run on each of the two detailed FE models, and combined with the corresponding SSE load case according to the applicable design loading combinations summarized in Table 3.8.4-3. This results in two sets of design loading combinations for the CIS; one set generated with the Condition A stiffness and a second set generated with the Condition B stiffness. The complete set of load combination results is then considered in the verification of the structure for the applied loads. RAI 03.08.03-96

Seismic Analysis of the CIS for Structural Design

Due to the irregularity of mass and stiffness in the CIS, response spectrum analysis using the Lindley-Yow Method described in NRC RG 1.92 (Reference 3.8-75) is selected for the seismic analysis in lieu of equivalent static procedures. The Lindley-Yow method divides the total seismic response into two components: the “periodic” response that is out-of-phase with the ground motion and the “rigid” response that is in-phase with the ground motion.

The input spectra for the response spectrum analyses are defined using in-structure response spectra (ISRS) calculated at the base of the CIS from the soil structure interaction (SSI) analyses.

ISRS are calculated at five different nodes, including four nodes on the CIS perimeter at the base of the RWSP outer wall and one near the center of the CIS on the face of the refueling cavity. The input spectra envelopes the ISRS generated at each of these nodes from SSI analyses that considered each of six soil cases and both cracked and uncracked conditions. In addition, 15% peak broadening is applied to the input spectra. Finally, story shear forces are computed from the RSA results at several elevations over the height of the structure and compared with SSI analysis results at each level. The RSA results used for structural design are then factored as required for the RSA story shear forces to envelope the SSI results at all levels in the structure. For a more detailed explanation of the SSI analyses, refer to Section 3.7 of the DCD.

Recognizing that the amplified seismic response of the containment internal structure is dominated by the response of the SC walls, constant damping ratios of 4% and 5% are considered for the Condition A and Condition B response spectrum analyses respectively, as described in MUAP-11018 (Reference 3.8-70). This is implemented by using the base input spectra generated for 4% and 5% damping and applying constant modal damping ratios of 4% and 5% in the respective analyses.

The specific response spectrum analysis procedures are performed in accordance with RG 1.92 (Reference 3.8-75). First, the input spectra are modified by the Lindley-Yow method in RG 1.92 RAI 03.08.03-96

Position C.1.3.2 to separate the rigid and periodic response components. The periodic response in each direction is then obtained from the response spectrum analysis, which uses the Complete Quadratic Combination method to combine the individual modal responses. In accordance with RG 1.92 Position C.1.4.2, the rigid response in each direction is obtained by the Static ZPA Method, involving a separate static analysis of the total structure mass times the ZPA. The total seismic response in each direction is then calculated as the SRSS of the periodic and rigid responses, per RG 1.92 Position C.1.5.2. Finally, the three directional responses are combined by SRSS to obtain the total seismic response, in accordance with RG 1.92 Position C.2.1.

3.8.3.4.2 Hydrodynamic Analyses

The vertical and lateral pressures of liquids inside containment are treated as dead loads. Structures supporting fluid loads during normal operation and accident conditions are designed for the hydrostatic as well as hydrodynamic loads as discussed in Subsection 3.7.3.9. The hydrodynamic analyses take into account the flexibility of walls in considering fluid-structure interaction. Sloshing height, however, is calculated using a conservative simplified assumption of a rigid tank shell in accordance with guidance provided in ASCE 4-98 (Reference 3.8-34), Subsection 3.5.4.3.

3.8.3.4.3 Thermal Analyses

The RWSP water and containment operating atmosphere temperatures are considered stable during normal operations. ~~The operating thermal load for each concrete member is calculated as the average and gradient based on this condition.~~ The stress analysis for normal operating thermal loading is carried out by inputting steady-state structural temperatures ~~these loads~~ into a 3-D FE model of the containment internal structures and the R/B basemat. The portion of the R/B basemat to which the CIS is connected is included in the 3-D FE model to obtain realistic restraint of the structure walls at the basemat connection. The SC walls and reinforced concrete structures in the CIS are assigned stiffness values identified for Condition "A" in Technical Report MUAP-11018 (Reference 3.8-70) and in Subsection 3.8.3.4 above.~~For thermal effects on dynamic response, see the discussion of stiffness reductions due to thermal loading in Subsection 3.8.3.4.~~ MIC-04-03-0001

The RWSP water and containment atmosphere are subject to temperature transients in the event of a LOCA as described in Subsection 3.8.3.3. The temperature distribution in the CIS following postulated pipe breaks in the reactor coolant loop is determined by thermal analysis using GOTHIC computer code. The thermal analysis takes into consideration heat transfer to the exposed surfaces of the CIS through a combination of condensation and forced/natural convection, conduction within the CIS and additional heat generation due to gamma heating. The peak surface temperatures of the CIS structure are summarized in Table 3.8.1-3. ~~The accident temperature transients result in a nonlinear temperature distribution within the members. Temperatures within the concrete members are calculated in a unidimensional heat flow analysis. The accident thermal load (average and equivalent linear gradients) is calculated from this analysis, at selected times during the transient.~~ MIC-04-03-0001

The stress analysis for accident thermal loading is carried out by inputting the accident thermal peak surface temperatures~~load~~ into a ~~three dimensional~~ 3-D FE model of the CIS and the portion of the R/B basemat to which the CIS is connected. Inclusion of the basemat in the model is necessary to obtain realistic restraint of the structure walls at the basemat connection. The SC walls and reinforced concrete slabs in the containment internal structures are assigned the reduced stiffness values resulting from thermally induced cracking, as identified for Condition "B" in Technical Report MUAP-11018 (Reference 3.8-70) and in Subsection 3.8.3.4 above. MIC-04-03-0001

In SC modules that are relatively free to expand, the significant thermal gradient that develops through the section thickness following a LOCA places the concrete core in tension and causes an orthogonal grid of through-thickness concrete cracks to develop. After cracking, the steel plate expansion due to exposure to the compartment surface temperatures governs the expansion of the SC walls. Therefore, the peak SC module surface temperatures are applied to the FE model to yield appropriate moments and forces at the interfaces of the walls in the portions of the CIS that are not restrained. For areas of significant restraint, such as portions of the structure that directly connect to the basemat or to the massive concrete sections at the base of the CIS, applying the surface temperatures can tend to generate overly conservative demands because the thermally induced moments and forces in these areas are governed by the through thickness temperature gradients. For these areas, a restraint adjustment factor is computed with consideration of the SC section geometry, stiffness, and through thickness temperature gradients as a function of time. MIC-04-03-0001

For modules with different peak surface temperatures on opposing faceplates, an average of the two temperatures is applied to the FE model. This approach does not capture the moment caused by differential heating and resulting thermal gradients. Therefore, the moments due to thermal gradients are calculated separately for each module and added to the moments obtained from the FE analysis.

The moments and force~~s~~ demands induced by the operating and accident thermal conditions ~~in the modeled structure~~ are then included in the ACI 349-06 (Reference 3.8-8) design load combinations that involve ~~accident~~ thermal loading.

Thermal transients for the DBAs are described in Section 6.3. For thermal effects on dynamic response of the CIS, see the discussion of stiffness reductions due to thermal loading in Subsection 3.8.3.4.

3.8.3.4.4 Design Procedures

The reinforced concrete members of the containment internal structure are designed by the strength method, as specified in the ACI 349-06 (Reference 3.8-8).

The primary and secondary shield walls, RWSP, refueling cavity, and other structural walls are designed using SC modules. SC modules are designed using the methodology of reinforced concrete structures in accordance with ACI 349-06 (Reference 3.8-8), as supplemented in Technical Reports MUAP-11019 (Reference 3.8-71) and MUAP-11020 (Reference 3.8-72).

The concrete floor slabs and massive concrete sections near the base of the CIS are designed as reinforced concrete structures in accordance with ACI 349-06 (Reference

3.8-8). The floor slabs at elevation 76 ft, 5 in. (Operating floor) and elevation 50 ft, 2 in. are supported by structural steel framing.

Methods of analysis used are based on accepted principles of structural mechanics and are consistent with the geometry and boundary conditions of the structures. The safe shutdown earthquake loads are determined from the results of seismic response analysis described in Section 3.7.

The determination of pressure and temperature loads due to pipe breaks is described in Subsections 3.6.1 and 6.2.1.2. Subcompartments inside containment containing high energy piping are designed for pressurization loads of 2 to 39 psi.

Determination of RCL support loads is described in Subsection 3.9.3. Design of the RCL supports is in accordance with ASME Code, Section III, Division 1, Subsection NF (Reference 3.8-2) as described in Subsections 3.9.3.

Computer codes used are general purpose codes. The code development, verification, validation, configuration control, and error reporting and resolution are according to the Quality Assurance requirements of Chapter 17.

3.8.3.4.5 SC Modules Design and Analysis

The SC modules are designed for dead, live, operating and accident thermal, accident pressure, and safe shutdown earthquake loads. The RWSP walls are also designed for the hydrostatic head due to the water in the pit and the hydrodynamic pressure effects of the water due to the safe shutdown earthquake loads. The walls of the refueling cavity are also designed for the hydrostatic head due to the water in the refueling cavity during refueling operations.

~~Figure 3.8.3-7~~Appendix 3L shows the typical design details of the SC modules, typical anchorages of the SC modules to the reinforced concrete basemat, connections between adjacent walls, and connections between reinforced concrete slabs and SC walls. SC modules are designed using the methodology of reinforced concrete structures in accordance with ACI 349-06 (Reference 3.8-8), as supplemented in Technical Reports MUAP-11019 (Reference 3.8-71) and MUAP-11020 (Reference 3.8-72). The faceplates are considered as the reinforcing steel, bonded to the concrete by headed studs. MIC-04-03 -0001

The procedures of Technical Report MUAP-11019, Section 1.0 through 9.0 (Reference 3.8-71) are used to design the SC walls for the design loading conditions. The primary shield wall described in Subsection 3.8.3.1.5 is not a standard SC wall section and is designed per the procedures of Technical Report MUAP-11019, Appendix 2 (Reference 3.8-71). Essentially, the primary shield wall is a thick, multicellular SC structure with a cylindrical arrangement and a very low aspect ratio. Physical testing and confirmatory analysis as described in MUAP-11013, Appendix A, Section A-8 (Reference 3.8-68) have demonstrated that the primary shield wall is shear-controlled and responds to lateral loading as a squat shear wall. Therefore the structure is evaluated for the design lateral loads using the provisions of ACI 349-06 Chapter 21 Section 21.7.4 for low aspect ratio shear walls, with strength contributions of the steel faceplates and web plates calculated as discussed in MUAP-11019, Appendix 2(Reference 3.8-71). MIC-04-03 -0001

The procedures of Technical Report MUAP-11020 (Reference 3.8-72) are used to design connections involving SC walls, such as SC wall-to-wall connections, reinforced concrete slab-to-SC wall connections, and SC wall basemat anchorage connections. The SC wall anchorage connection to the basemat is evaluated in accordance with the applicable requirements of both ACI 349-06 and ASME Section III, Division 2, since the connection crosses a code jurisdictional boundary ~~as shown in Figure 3.8.3-7 sheet 5~~. The application of both codes is required because the steel baseplate and rebar anchors in this connection serve both as part of the force transfer mechanism between the SC faceplates and the reinforced concrete basemat, and as part of the containment pressure boundary liner and liner anchorage. The applicable code requirements are detailed in Technical Report MUAP-11020 Section 7.1. It is further noted that the applicable ACI or ASME load combinations are used to evaluate the corresponding requirements from each code. The application of these loading combinations to the basemat anchorage calculation is detailed in the CIS basic design calculations. MIC-04-03-0001

3.8.3.4.5.1 Design for Axial ~~Loads and Bending~~Tension, Axial Compression, and Out-of-Plane Flexural Strength

MIC-04-03-0001

Design for axial loads (tension and compression) and out-of-plane bending is in accordance with the methodology of ACI 349-06 (Reference 3.8-8) Chapters 10 and 14, as supplemented by Sections 3, 4, and 5 of Technical Report MUAP-11019 (Reference 3.8-71). The design of the SC module faceplate reinforcement for combined axial loading, out-of-plane bending, and in-plane shear is performed as described in Technical Report MUAP-11019, Chapter 8.0, (Reference 3.8-71).

The design approach is based on SC module experimental research, in which the behavior of SC walls subjected to axial compression and out-of-plane flexural loading is similar to that of reinforced concrete walls subjected to these loads, provided that SC-specific limit states such as faceplate local buckling and interfacial shear failure are prevented. The observations and results of experimental research on SC wall out-of-plane flexure and axial compression behavior are summarized in Technical Report MUAP-11005, Appendices B and D, respectively (Reference 3.8-63). The manner in which the SC walls are detailed to prevent SC-specific limit states is presented in Technical Report MUAP-11019, Chapter 2 (Reference 3.8-71).

3.8.3.4.5.2 Design for In-Plane Shear

Design for in-plane shear is in accordance with the methodology of ACI 349-06 (Reference 3.8-8) Chapters 11 and 21, as supplemented by Section 7 of Technical Report MUAP-11019 (Reference 3.8-71). The steel faceplates are treated as reinforcement for the concrete which satisfy the provisions of Section 21.7 of ACI 349-06 (Reference 3.8-8).

The design approach is based on SC module experimental research in which the in-plane shear behavior of the infill concrete and longitudinal (faceplate) reinforcement was observed to be similar to that of reinforced concrete shear walls. The observations and results of experimental research on SC wall in-plane shear behavior are summarized in Technical Report MUAP-11005, Appendix C (Reference 3.8-63). The steel plate acts as shear reinforcement in each of two orthogonal directions, similar to the grids of longitudinal reinforcement provided in standard reinforced concrete shear walls.

However, as discussed in Technical Report MUAP-11019, Section 7 (Reference 3.8-71), the ACI 349-06 (Reference 3.8-8) code design strength for in-plane shear is conservatively modified by neglecting the initial concrete contribution before cracking. The concrete contribution to in-plane shear strength after cracking is included directly in the $A_s f_y$ term of MUAP-11019 Equation 7.3-1 (Reference 3.8-71). MIC-04-03 -0001

3.8.3.4.5.3 Design for Out-of-Plane Shear

Design for out-of-plane shear is in accordance with the methodology of ACI 349-06 (Reference 3.8-8) Chapter 11, as supplemented by Section 6 of Technical Report MUAP-11019 (Reference 3.8-71).

The design approach is based on SC module experimental research in which the out-of-plane shear behavior of the infill concrete and transverse (tie bar) reinforcement was observed to be similar to that of reinforced concrete members. The observations and results of experimental research on SC wall out-of-plane shear behavior are summarized in Technical Report MUAP-11005, Appendix B (Reference 3.8-63). As discussed in Section 6 of Technical Report MUAP-11019, (Reference 3.8-71) the concrete contribution to out-of-plane shear strength is reduced to account for size effects. In addition, the concrete contribution to out-of-plane shear strength is ~~ignored~~ reduced for load cases in accordance with ACI 349-06 Section 11.3.2.3 (Reference 3.8-8) and MUAP-11019 Equation 6.2-3 (Reference 3.8-71)~~which result in axial tensioninvolving seismic loading~~. MIC-04-03 -0002

3.8.3.4.5.4 Evaluation for Thermal Loads

The forces and moments induced in the SC walls due to ~~restraint of thermal growth~~operating and accident thermal loading are included in the design load combinations in accordance with ACI 349-06 (Reference 3.8-8). As discussed in Section 9 of Technical Report MUAP-11019 (Reference 3.8-71), empirical data derived from experiments demonstrates that design basis accident thermal conditions cause no significant reduction in SC wall design strength. Thus, SC walls are evaluated and designed to resist combined design basis accident mechanical and thermal loads consistent with provisions of ACI 349-06 (Reference 3.8-8), as supplemented by Technical Report MUAP-11019 (Reference 3.8-71). MIC-04-03 -0001

The analysis considering the accident thermal condition indicates that the flexural demands at the base of the RWSP wall are in excess of the SC wall capacities calculated in accordance with MUAP-11019. These demands are the result of large out-of-plane moments acting in the vertical direction, primarily due to restraint of growth caused by accident thermal temperatures. The RWSP wall does not constitute a primary lateral load path for the CIS and localized yielding at the base of the RWSP wall would act to partially relieve the restraint of thermal demands. Therefore local yielding of the SC faceplates at the base of the RWSP wall is acceptable if the demands are less than those which would cause a full plastic hinge to develop at the base of the wall. This is demonstrated by: MIC-04-03 -0002

- Calculations showing that the maximum out-of-plane flexural demand/capacity ratio at the expected extent of plastic hinging does not exceed 0.9.
- Calculations showing that the maximum combined faceplate demand/capacity ratio at the expected extent of plastic hinging does not exceed 0.9.

As observed in Test Series 5.2, described in MUAP-11013 Appendix B, Section B-13 (Reference 3.8-68), a plastic hinge is expected to form over a height of wall approximately equal to total section thickness *T* above the basemat. This is also the plastic hinge length quantified in ASCE 43-05 (Reference 3.8-60). Therefore, since both the maximum out-of-plane moment and the combined Y-direction demand at *T* above the basemat are less than 90% of the calculated capacity (including ϕ factors), it is shown that while some yielding will occur at the bottom of the SC wall due to flexural tension induced by accident thermal loading, the wall will not exceed its full plastic moment capacity and will retain lateral load carrying capacity. This is considered to meet the intent of ACI 349-06 Section R21.2.1 (Reference 3.8-8), which is that essentially elastic behavior with no significant damage (i.e., limited yielding only) must be demonstrated for all design loading conditions including the extreme condition involving simultaneous peak demands from SSE seismic and accident thermal loading. MIC-04-03 -0002

3.8.3.4.5.5 Design of Tie Bars

During SC module transportation and erection, the tie bars welded between the steel faceplates maintain the module configuration and separation between the faceplates, and act as "form ties" between the faceplates when concrete is being placed. The tie bars are fabricated from steel plates as shown in Technical Report MUAP-11019, Section 2.8 (Reference 3.8-71) and assembled in the manner discussed in Technical Report MUAP-12006 Section 3.0 (Reference 3.8-79). Welding between the tie bars and the faceplates is in accordance with American Welding Society (AWS D1.1) requirements. After the concrete has cured, the tie bars provide out-of-plane shear reinforcement similar to the transverse stirrups or ties provided in reinforced concrete members. The tie bars are designed as out-of-plane shear reinforcement according to the requirements of ACI 349-06, Section 11.5 (Reference 3.8-8), as supplemented by Sections 2.6 and 6.0 of Technical Report MUAP-11019 (Reference 3.8-71). The tie bar spacing is selected to meet the shear reinforcement spacing limits of ACI 349-06, Section 11.5.5 (Reference 3.8-8). The tie bar size is selected to ensure the development of ductile flexural yielding in

the SC wall connection regions prior to concrete shear failure under out-of-plane loading, as discussed in Technical Report MUAP-11020, Sections 3.1 and 3.2, (Reference 3.8-72). The tie bar size and spacing selected for the connection regions is then used conservatively throughout the expanse of the SC walls for fabrication simplicity. Finally, the selected tie bar size and spacing is confirmed to maintain structural integrity of the SC walls by preventing section delamination or splitting failure, as discussed in Technical Report MUAP-11019, Section 2.7 (Reference 3.8-71).

3.8.3.4.5.6 Design of Shear Studs

The SC modules are designed as reinforced concrete elements, with the faceplates serving as reinforcing steel. Since the faceplates do not have deformation patterns typical of reinforcing steel, shear studs are provided to transfer the forces between the concrete and the steel faceplates. The shear studs are designed according to Appendix D of ACI 349-06 (Reference 3.8-8), as supplemented by Sections 2.1 through 2.5 of Technical Report MUAP-11019 (Reference 3.8-71). As discussed in Technical Report MUAP-11019, Section 2.2 (Reference 3.8-71), the shear stud spacing is selected so that the shear stud spacing to faceplate thickness ratio, or faceplate slenderness ratio, is less than or equal to 20. This is to prevent faceplate local buckling under applied compression, based on the behavior observed in experimental research. This research is summarized in Technical Report MUAP-11005, Appendix C (Reference 3.8-63). As discussed in Technical Report MUAP-11019, Section 2.3, the design shear strength of the studs is determined in accordance with ACI 349-06 Appendix D Section D.4.5 (Reference 3.8-8). Using these provisions, the shear studs are sized to prevent interfacial shear failure of the cross section under out-of-plane loading, as discussed in Technical Report MUAP-11019, Section 2.5. Finally, as discussed in Technical Report MUAP-11019, Section 2.4, the shear studs are confirmed to provide faceplate development lengths comparable to those of standard reinforcing bars typically used in reinforced concrete nuclear structures.

3.8.3.4.6 Floor Slabs

The reinforced concrete floor slabs are analyzed and designed according to ACI 349-06 (Reference 3.8-8) considering the same design loading conditions as for the SC modules. The floor design does not rely on composite action with supporting structural steel beams.

3.8.3.4.7 Structural Steel Design and Analysis

Structural steel framing within the interior of the PCCV is primarily for support of floor slabs, equipment, distribution systems, and access platforms. Design and analysis procedures, including assumptions on boundary conditions and expected behavior under loads, are in accordance with the allowable stress design (ASD) method in AISC N690 (Reference 3.8-9). Analysis methods are generally simple calculations using seismic loads obtained from Section 3.7 methodologies in load combinations. Frame connections are detailed for simply-supported beams unless otherwise analyzed and detailed.

3.8.3.4.8 RCL Supports

The RCL piping and support system is analyzed for the dynamic effects of a SSE. A coupled model of the containment internal structure and the RCS is dynamically

evaluated using a time-history integration method of analysis. Appendix 3C provides additional information regarding the qualification of RCL supports.

3.8.3.5 Structural Acceptance Criteria

Structural acceptance criteria is reflected in Table 3.8.4-3 for concrete structures and Table 3.8.4-4 for steel structures, and are in accordance with ACI 349-06 (Reference 3.8-8) and AISC N690 (Reference 3.8-9), except as provided in the table notes.

3.8.3.5.1 Design Report

A Design Report of the containment internal structure is provided separately from the DCD. The Design Report has sufficient detail to show that the applicable stress limitations are satisfied when components are subjected to the design loading conditions. Deviations from the design due to as-procured or as-built conditions are acceptable based on an evaluation consistent with the methods and procedures of Section 3.7 and 3.8 provided the following acceptance criteria are met.

- The structural design meets the acceptance criteria specified in Section 3.8.

- The ISRS meet the acceptance criteria specified in Subsection 3.7.2.5.

Depending on the extent of the deviations, the evaluation may range from documentation of an engineering judgment to performance of a revised analysis and design. The results of the evaluation are documented in an as-built summary report.

3.8.3.5.2 Design Summary of ~~Representative Elements~~Critical Sections

RAI 03.08.03-112

This subsection summarizes the design of the following ~~representative elements~~critical sections:

- ~~Wall 1 - North-east wall of refueling cavity (4 ft, 8 in. thick)~~
- ~~Wall 2 - North-west wall of secondary shield (4 ft, 0 in. thick)~~
- ~~Wall 3 - North-east wall of RWSP (3 ft, 3 in. thick)~~
- ~~Connection 1 - SC Wall Basemat Anchorage~~
- ~~Connection 2 - SC Wall to SC Wall T Connection~~
- ~~Connection 3 - Reinforced Concrete Slab to SC Wall Connection~~
- NE Wall of Refueling Cavity (56 in.)
- NW Wall of SSW (48 in.)
- NE Wall of RWSP (39 in.)
- SC Wall to Basemat Anchorage
- SC Wall to SC Wall (T) Connection
- RC Slab (both sides) to SC Wall
- Duct Penetration on SC Wall
- Primary Shield Wall
- Mass Concrete to SC Wall
- RC Slab (one side only) to SC Wall
- Pressurizer Bottom Support (Category 6) to SC Wall
- Refueling Cavity Wall to SG Wall Connection (Category 6)

Representative elements are selected to illustrate SC wall and connection designs for the CIS. ~~The details and locations~~A summary of the ~~six~~ 12 representative elements are defined in Table 3.8.3-5. Locations, ~~are shown in Figure 3.8.3-7 Sheet 2 for connections and Figure 3.8.3- 11 for walls. The~~ structural configuration, and typical details are shown Appendix 3L~~in Figures 3.8.3-5, 3.8.3-6, 3.8.3-7, and 3.8.3-10~~. The structural analyses described in Subsection 3.8.3.4 are summarized in Table 3.8.3-4. The design procedures are described in Subsection 3.8.3.4.

RAI 03.08.03-112

3.8.3.6 Materials, Quality Control, and Special Construction Techniques

Subsection 3.8.4.6 contains information pertaining to the materials, quality control programs, and any special construction techniques utilized in the construction of seismic category I structures for the US-APWR.

3.8.3.6.1 Special Construction Techniques

Special module construction techniques, in addition to the methodology described in Subsection 3.8.3.1, is provided as necessary in Technical Report MUAP-12006, “Steel Concrete (SC) Wall Fabrication, Construction and Inspection" (Reference 3.8-79). The COL Applicant is to provide detailed construction and inspection plans and documents in accordance with MUAP-12006.

3.8.3.7 Testing and Inservice Inspection Requirements

Monitoring of seismic category I structures is performed in accordance with the requirements of NUMARC 93-01 (Reference 3.8-28) and 10 CFR 50.65 (Reference 3.8-29) as detailed in RG 1.160 (Reference 3.8-30), specifically Section 1.5 of RG 1.160. Subsection 3.8.4.7 describes the applicable testing and ISI requirements.

3.8.3.7.1 Construction Inspection

Inspection relating to the construction of seismic category I SSCs is in accordance with the codes applicable to the construction activities and/or materials. In addition, weld acceptance is performed in accordance with the National Construction Issues Group (NCIG), Visual Weld Acceptance Criteria for Structural Welding at Nuclear Power Plants, NCIG-01 (Reference 3.8-31).

3.8.4 Other Seismic Category I Structures

Table 3.8.1-3 Thermal Conditions of the R/B and PCCV (Sheet 2 of 2)

Area **(See Figure 3.8.1-9 for Identification of Location)**	**Normal Operation, T_o (°F)**		**Accident Condition T_a (°F)**	
	Winter	**Summer**	**Pipe Break in Reactor Cavity (Winter, Summer)**	**Pipe Break in SG Compartment (Winter, Summer)**
19 PCCV atmosphere	105	120	Figure 3.8.1-10 (PCCV) 284(8)	
20 SG compartment atmosphere	~~150~~105	120	306(8)	
21 [Deleted]				
22 Reactor cavity atmosphere (upper)(2)	150		365(8)	
23 Reactor cavity atmosphere (lower)(3)	105	120	- (See No.26)	- (See No.26)
24 PCCV Sump Pool Water (except except SG Compartment Sump, Reactor Cavity Sump and RWSP)	-		306(4),(8)	
25 SG compartment sump water(7)	-		306(8)	
26 Reactor cavity sump water	-		365(8)	
27 RWSP water(6)	105	120	249(8)	
28 CV Sump Pump Area	105	120	- (See No.24)	- (See No.24)
29 Outdoor Air Temperature	-40	115	equal to temperature during normal operation	equal to temperature during normal operation
30 Basemat Side Temperature	Calculated by the linear interpolation between earth temperature and outdoor air temperature			
31 Earth Temperature	35	80	equal to temperature during normal operation	equal to temperature during normal operation
32 Essential service water pipe chase	-4	140	equal to temperature during normal operation	equal to temperature during normal operation

MIC-04-03 -0001

MIC-04-03 -0001

MIC-04-03 -0001

1: Deleted
2: EL. 7'-3" to 46'-11" (atmosphere around RV)
3: Below EL -7'-3" (atmosphere under RV)
4: Below EL. 21'-3": The temperature of "26 Reactor cavity sump water" shall be applied. (EL. 21'-3" is the maximum water level in a LOCA.)
5: Deleted
6: The water level of the RWSP is EL. 20'-2" in a normal operation mode and EL. 7'-7" in a recirculation mode.
7: The temperature conditions of "25 SG compartment sump water" shall be applied from EL 25'-3" to EL 25'-9" in SG compartment from EL 15'-10" to EL 21'-3" in header compartment.
8: Peak CIS steel surface temperatures for each compartment, based on multiple break cases, are considered for CIS structural design analysis.

MIC-04-03 -0001

Table 3.8.3-3 Summary of CIS Models and Analysis Methods

Computer Program and Model	Analysis Method	Purpose	Concrete Stiffness(1)
Three Dimensional ANSYS FE of CIS fixed at ~~elevation 3 ft, 7 in.~~ the top of basemat under CIS	- Static Analysis for Mechanical Loads - Dynamic Analysis (Response Spectrum Analysis) for Seismic Loads	To obtain member forces for seismic and mechanical loads	Condition A (Operating) Condition B (Accident)
Three Dimensional ANSYS FE of CIS and R/B basemat	Static Analysis	To obtain member forces for thermal loads	Condition A (Operating) Condition B (Accident)

MIC-04-03-0001

MIC-04-03-0002

Table 3.8.3-4 Summary of CIS Stiffness and Damping Values for Seismic Analysis

RAI 03.08.03-94

Structural Category	Description	Loading Condition A (*Ess + To*)			Loading Condition B (*Ess + Ta*)		
		Shear ~~-~~Stiffness	Flexural ~~-~~Stiffness	Damping	Shear ~~-~~Stiffness	Flexural ~~-~~Stiffness	Damping
1	SC Walls, T ≤ 56"	Uncracked $G_cA_c + G_sA_s$	Cracked-Transformed E_cI_{ct}	4%	Fully Cracked $0.5\left(\bar{\rho}^{-0.42}\right)G_sA_s$	Cracked-Transformed E_cI_{ct}	5%
2	SC Walls with T > 56"	Uncracked G_cA_c	Uncracked E_cI_c	4%	Cracked $0.5G_cA_c$	Cracked $0.5E_cI_c$	7%
3	Primary Shielding	Uncracked G_cA_c	Uncracked E_cI_c	4%	Uncracked G_cA_c	Uncracked E_cI_c	4%
4	Reinforced Concrete Slabs	Uncracked G_cA_c	Uncracked E_cI_c	4%	Uncracked G_cA_c	Cracked $0.5E_cI_c$	7%
5	Massive Reinforced Concrete Sections	Uncracked G_cA_c	Uncracked E_cI_c	4%	Uncracked G_cA_c	Uncracked E_cI_c	4%
6	Steel structure with ~~non-structural~~ concrete infill	~~No Concrete Stiffness or Damping Applied~~					
	Lower Pressurizer Support	$0.5G_cA_c + G_sA_s$	$0.5E_cI_c + E_sI_s$	4%	$0.5G_cA_c + G_sA_s$	$0.5 E_cI_c + E_sI_s$	4%
	Refueling Cavity to SG Compartment	$0.5G_cA_c + G_sA_s$	$0.5E_cI_c + E_sI_s$	4%	$0.5G_cA_c + G_sA_s$	$0.5 E_cI_c + E_sI_s$	4%
	Other Category 6 Elements (Mass Only)	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

Note: The damping values provided in this table are ~~those~~ considered for SSI and SSSI analysis. Constant damping values are considered for seismic design analysis as described in Subsection 3.8.3.4.1.

MIC-04-03-00001

Table 3.8.3-5 Definition of Critical Section and Thicknesses for Containment Internal Structure[1] (Sheet 1 of 2)

RAI 03.08.03-112

~~Wall~~ Identifier	Applicable Wall Location	Applicable Elevation Range	Member Thickness[2]	Thickness of Face Plates Provided
~~Wall 1~~ID1	Northeast wall of Refueling Cavity	Elevation 46'-11" to 76'-5"	4'-8" SC Wall with 0.5~~-~~ in. thick steel plate on inside and outside of wall	0.5 in.
~~Wall 2~~ID2	Northwest Wall of Secondary Shield	Elevation 50'-2" to 76'-5"	4'-0" SC Wall with 0.5~~-~~ in. thick steel plate on inside and outside of wall	0.5 in.
~~Wall 3~~ID3	Northeast Wall of RWSP	Elevation 1'-11" to 25'-3"	3'-3" SC Wall with 0.5~~-~~ in. thick steel plate on inside and outside of wall	0.5 in.
ID7	Duct penetration on SC Wall	Elevation 62'-4" to 69'-1"	4'-0" SC Wall with 0.5 in. thick steel plate on inside and outside of wall	0.5 in.
ID8	Primary Shield Wall	Elevation 15'-10" to 46'-11"	Variable thickness multicellular wall with inner, center, and, outer plate	0.5 in. to 1.25 in.

RAI 03.08.03-112

Table 3.8.3-5 Definition of Critical Section and Thicknesses for Containment Internal Structure(1) (Sheet 2 of 2)

RAI 03.08.03-112

~~Connection~~ Identifier	Applicable Connection Location	First Connected Member	Second Connected Member	Connection Design Methodology(3)
~~Connection 1~~ ID4	SC Wall Basemat Anchorage	3'-3" SC Wall at Outside Face of RWSP	Basemat	Full Strength
~~Connection 2~~ ID5	SC Wall to SC Wall T Connection	4'-0" SC Wall between SG	4'-0" SC Wall at Outside Face of SG Compartments	Full Strength
~~Connection 3~~ ID6	Reinforced Concrete Slab to SC Wall Connection	Compartments 3'-4" Reinforced Concrete Slab at Top-of-Concrete Elevation 25'-3"	4'-0" SC Wall at Outside Face of SG Compartments	Full Strength
ID9	Mass concrete to SC Wall	4'-0" SC Wall Elevation 1'-11" to 15'-10"	Mass Concrete	Full Strength
ID10	RC Slab (one side only) to SC Wall	RC slab at Elevation 50'-2"	4'-0" SC Wall at Outside Face of SG Compartments	Full Strength
ID11	Pressurizer Bottom Support (Category 6) to SC Wall	Pressurizer Bottom Support at Elevation 58'-5"	4'-0" SC Wall at Inside Face of Pressurizer Compartment	Full Strength
ID12	Refueling Cavity Wall to SG Wall Connection (Category 6)	Category 6 structure at Elevation 68'-3" to 76'-5"	4'-10" SC Wall at Refueling Cavity and 4'-0" SC Wall at SG	Full Strength

NOTES:

1. The applicable locations of each section are identified in ~~Figure 3.8.3-7 (Sht 2) and Figure 3.8.3-11~~Appendix 3L.
2. The member thickness includes the steel face plates.
3. Connection Design Methodology refers to the Full Strength and Overstrength design approaches defined in Technical Report MUAP-11020 (Reference 3.8-72).

RAI 03.08.03-112

Figure 3.8.1-11 Deleted~~Transient Conditions of Temperature of General Sump Pool Water in the PCCV and RWSP~~ MIC-04-03 -0001

Figure 3.8.1-12 Deleted~~Transient Conditions of Temperature of the SG Compartment Atmosphere and Sump Pool Water (Pipe Break in the SG Compartment)~~

MIC-04-03-0001

Figure 3.8.1-13 Deleted~~Transient Conditions of Temperature of the Reactor Cavity Atmosphere and Sump Pool Water (Pipe Break in the Reactor Cavity)~~ MIC-04-03-0001

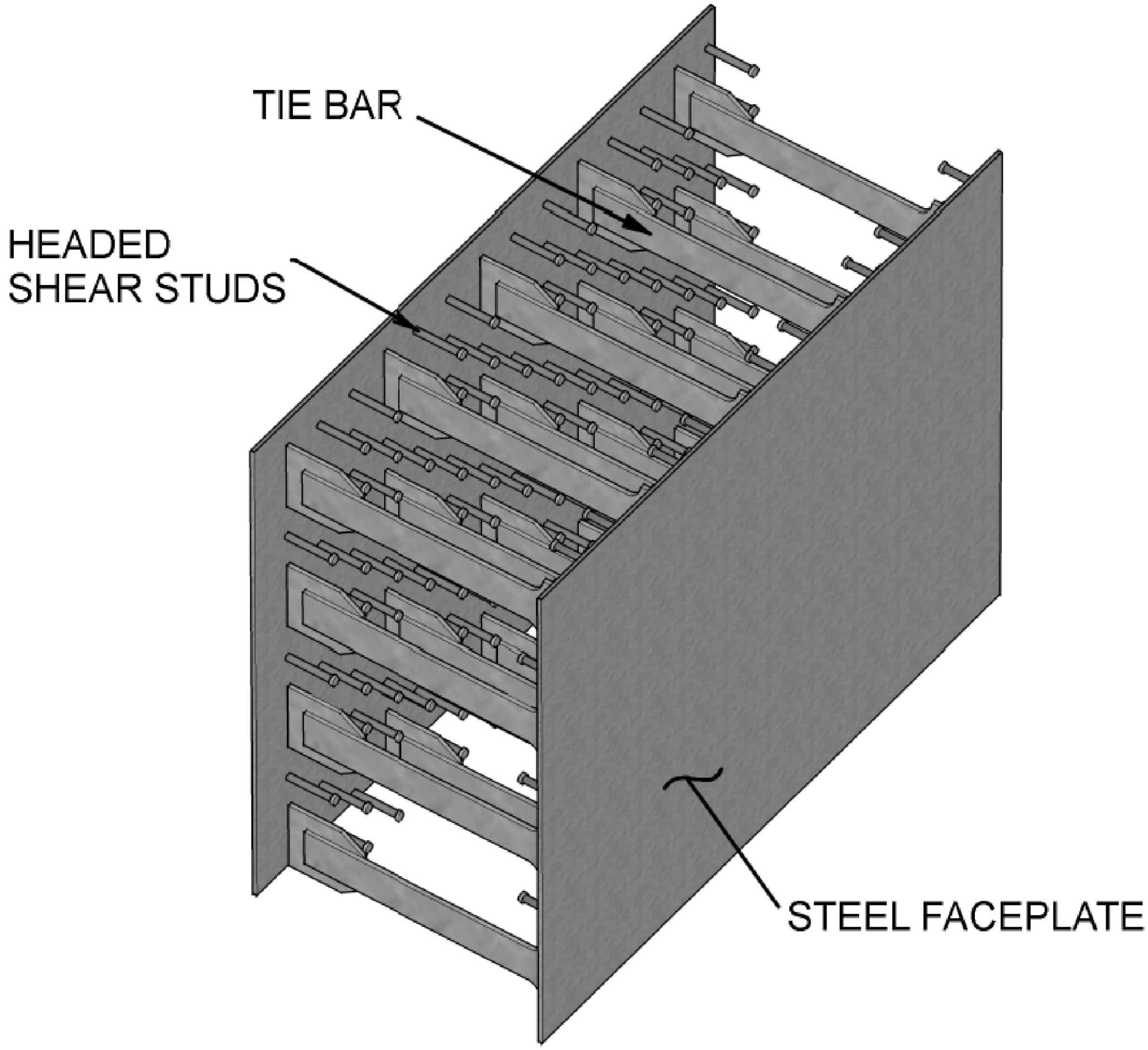


Figure 3.8.3-7 Typical Details of SC Modules ~~(Sheet 1 of 5)~~ MIC-04-03-0001

~~**Figure 3.8.3-7 Typical Details of SC Modules (Sheet 2 of 5)**~~ MIC-04-03-0001

~~**Figure 3.8.3-7 Typical Details of SC Modules (Sheet 3 of 5)**~~ MIC-04-03-0001

~~Figure 3.8.3-7 Typical Details of SC Modules (Sheet 4 of 5)~~ MIC-04-03-0001

~~Figure 3.8.3-7 Typical Details of SC Modules (Sheet 5 of 5)~~

RAI 03.08.03-111

MIC-04-03
-0001

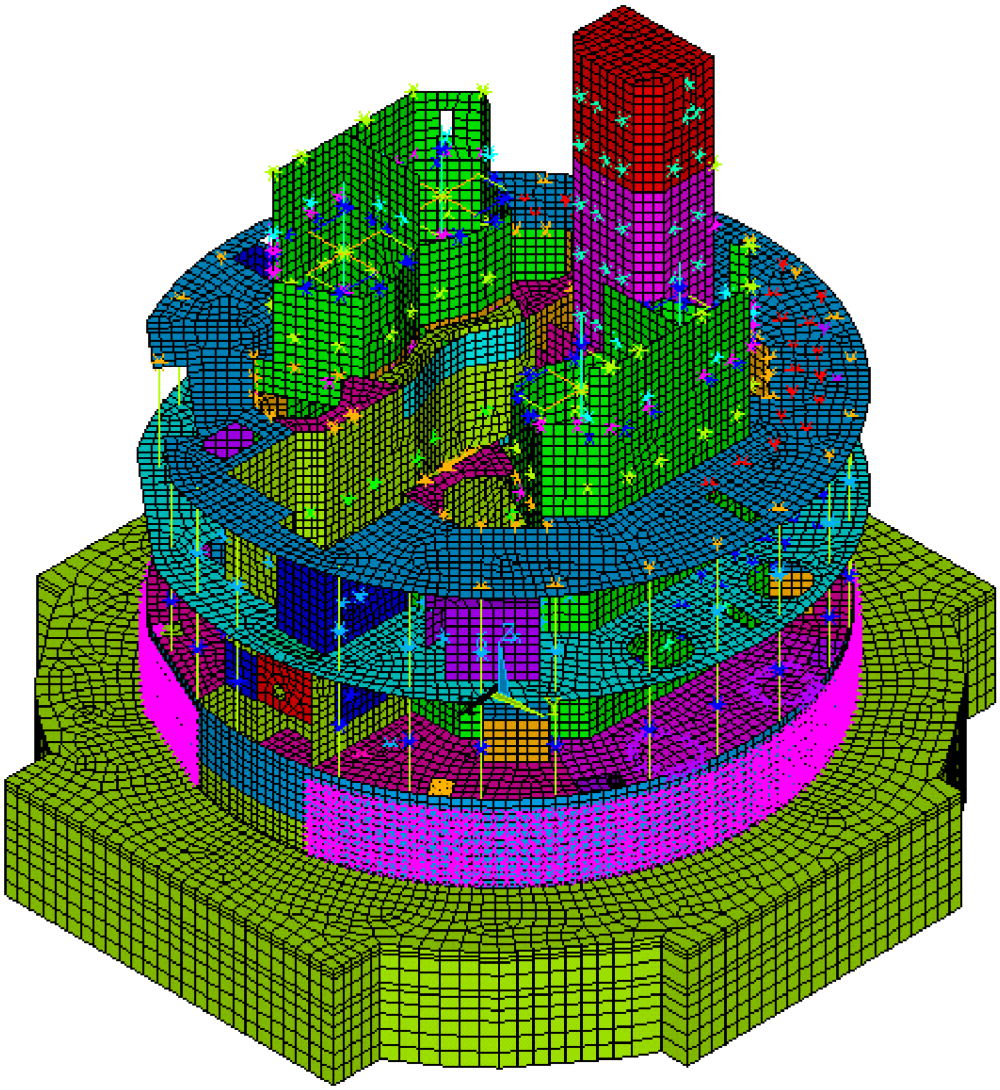
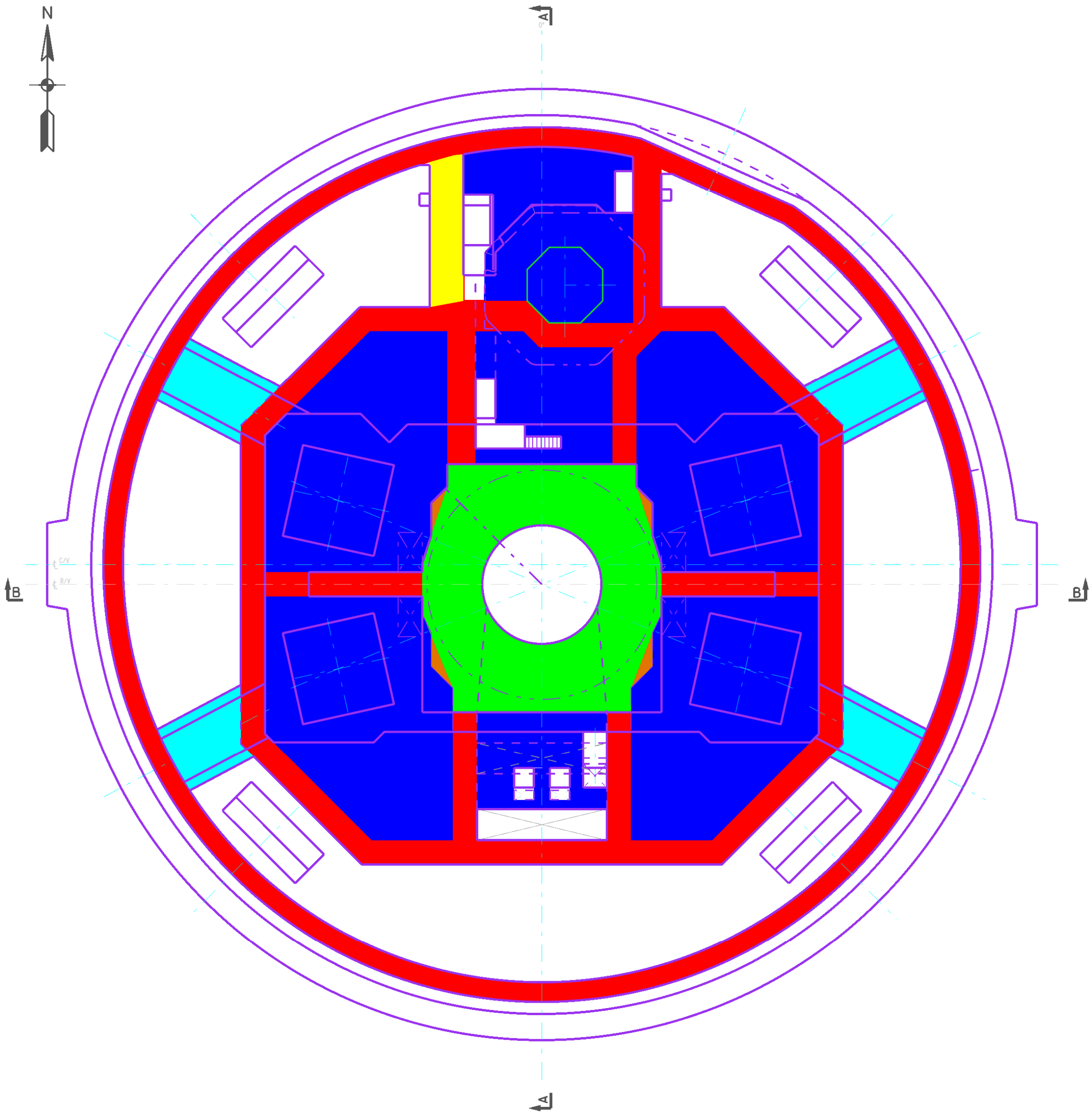


Figure 3.8.3-10 CIS FE Model

Figure 3.8.3-11 Deleted~~Critical Sections of SC Modules~~ MIC-04-03-0001

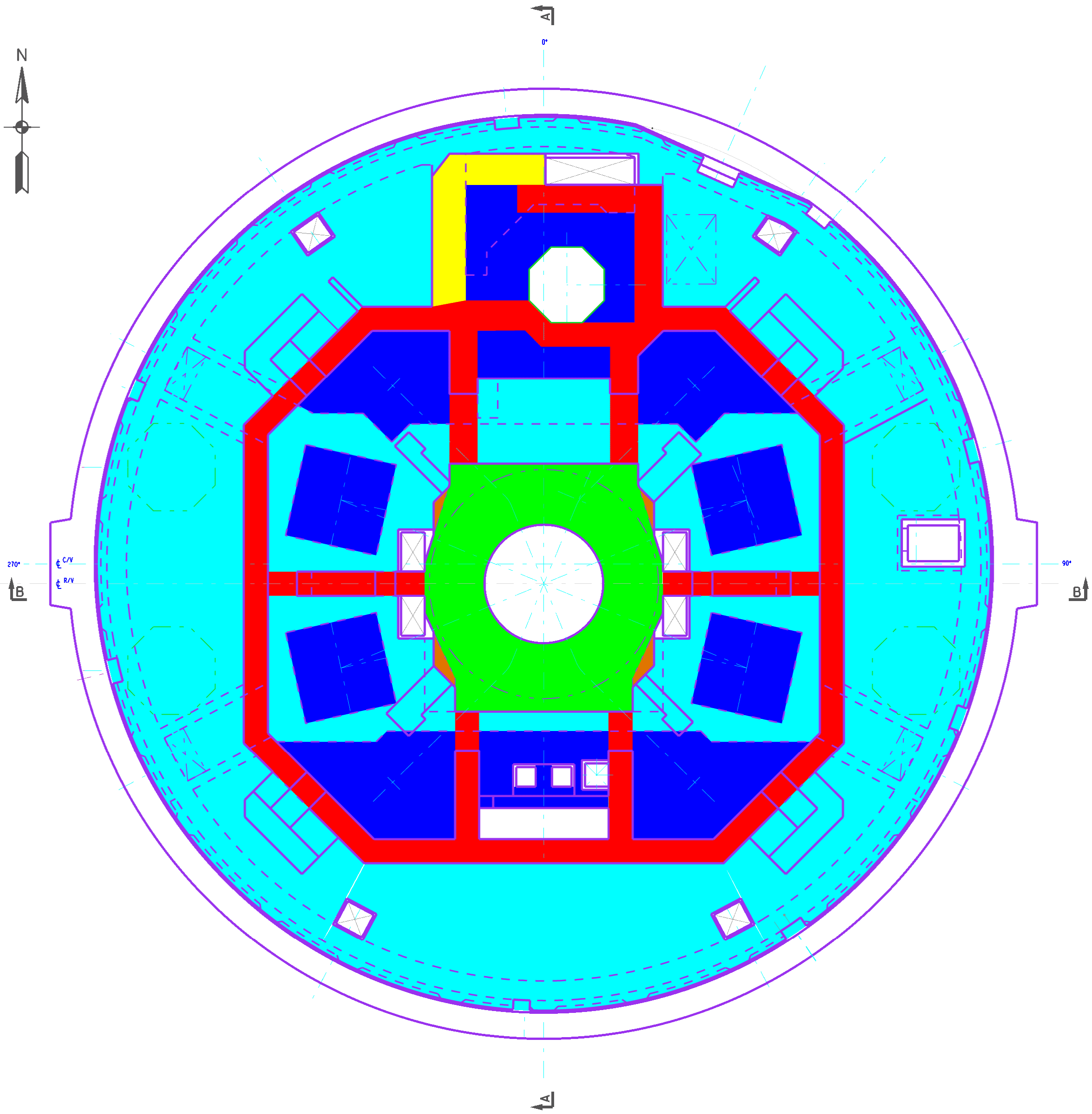
RAI 03.08.03-94



	STRUCTURAL CATEGORY	DESCRIPTION
	1	SC WALLS, T ≤ 56”
	2	WALLS WITH T > 56”
	3	PRIMARY SHIELDING WALLS
	4	RC SLABS
	5	MASSIVE RC SECTIONS
	6	STEEL STRUCTURE WITH CONCRETE INFILL

Figure 3.8.3-12 Structural Categories Between Elevations 3’-7” and 21’-0”

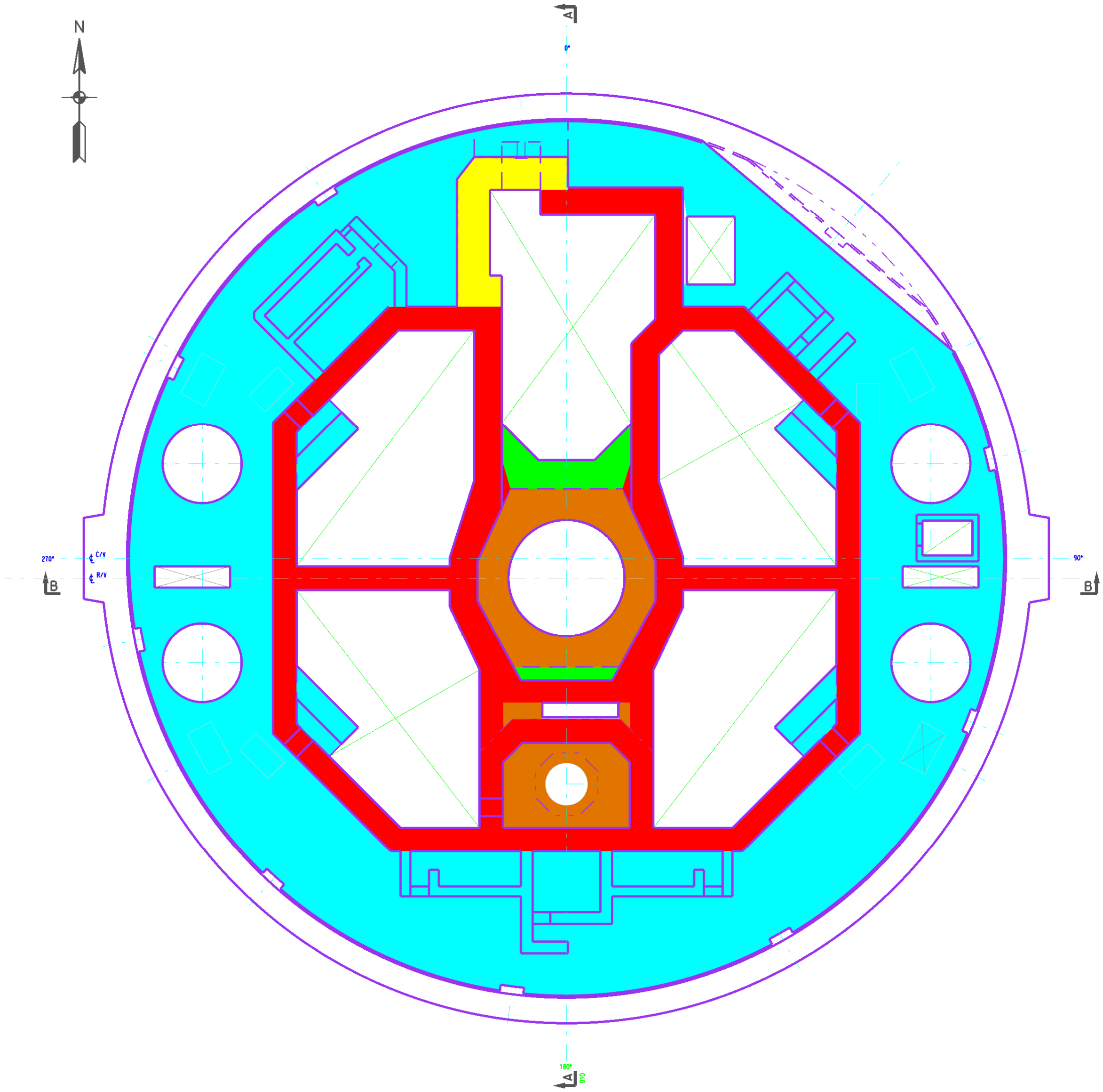
RAI 03.08.03-94



	STRUCTURAL CATEGORY	DESCRIPTION
	1	SC WALLS, T ≤ 56"
	2	WALLS WITH T > 56"
	3	PRIMARY SHIELDING WALLS
	4	RC SLABS
	5	MASSIVE RC SECTIONS
	6	STEEL STRUCTURE WITH CONCRETE INFILL

Figure 3.8.3-13 Structural Categories Between Elevations 21'-0" and 35'-11"

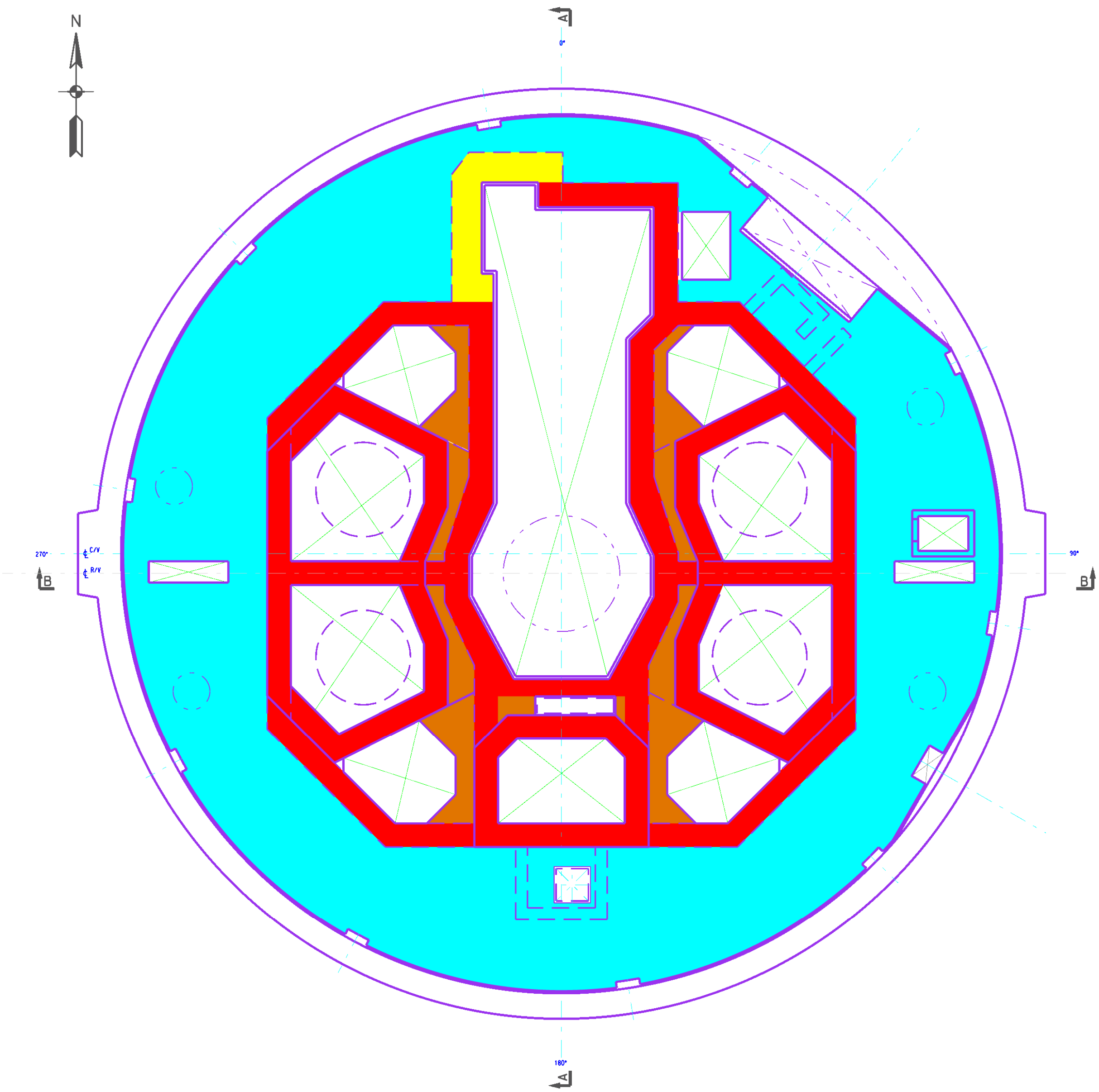
RAI 03.08.03-94



	STRUCTURAL CATEGORY	DESCRIPTION
(red)	1	SC WALLS, T ≤ 56″
(yellow)	2	WALLS WITH T > 56″
(green)	3	PRIMARY SHIELDING WALLS
(cyan)	4	RC SLABS
(blue)	5	MASSIVE RC SECTIONS
(orange)	6	STEEL STRUCTURE WITH CONCRETE INFILL

Figure 3.8.3-14 Structural Categories Between Elevations 37’-9” and 62’-4”

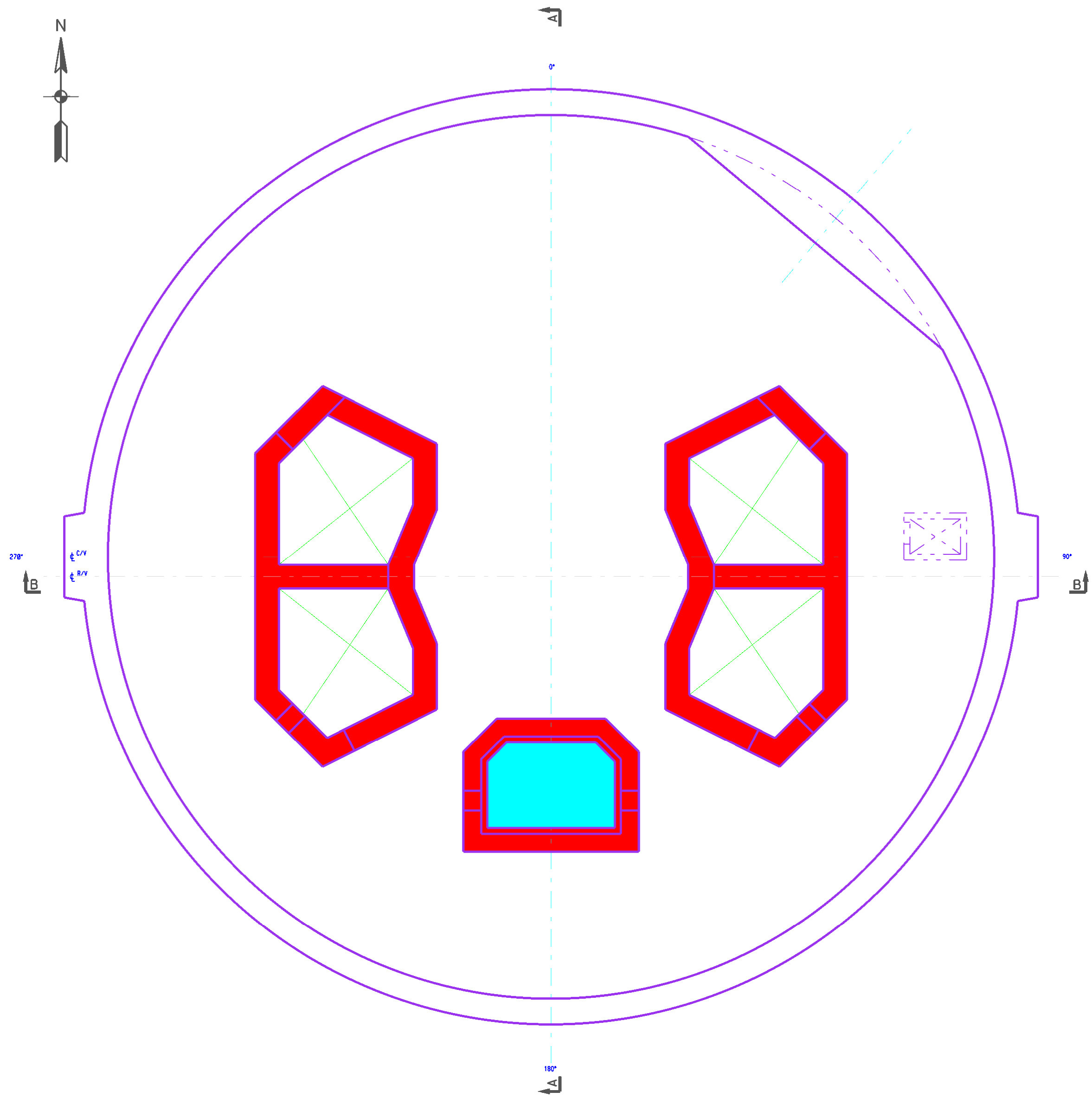
RAI 03.08.03-94



	STRUCTURAL CATEGORY	DESCRIPTION
	1	SC WALLS, T ≤ 56"
	2	WALLS WITH T > 56"
	3	PRIMARY SHIELDING WALLS
	4	RC SLABS
	5	MASSIVE RC SECTIONS
	6	STEEL STRUCTURE WITH CONCRETE INFILL

Figure 3.8.3-15 Structural Categories Between Elevations 62'-4" and 76'-5"

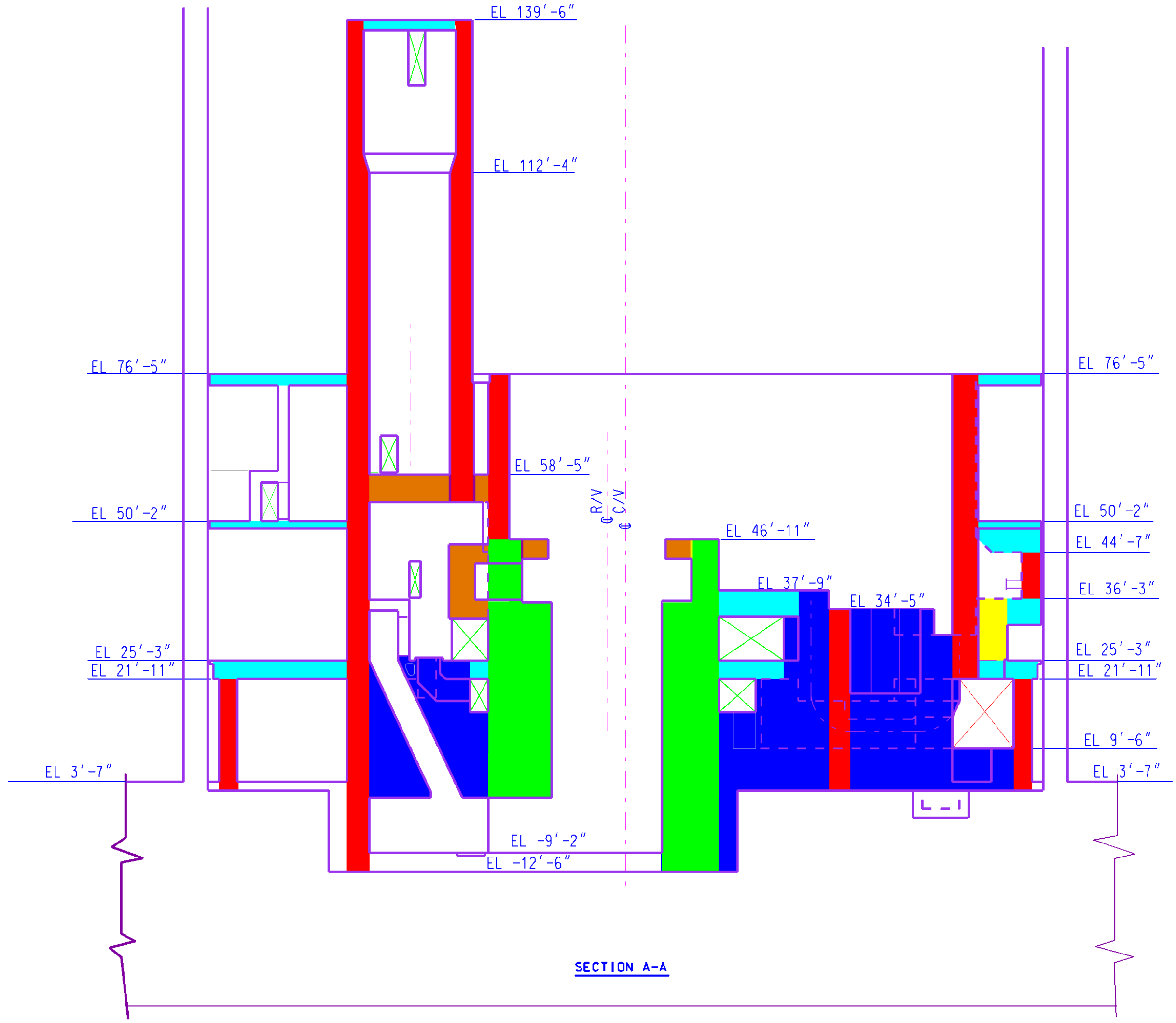
RAI 03.08.03-94



	STRUCTURAL CATEGORY	DESCRIPTION
	1	SC WALLS, T ≤ 56″
	2	WALLS WITH T > 56″
	3	PRIMARY SHIELDING WALLS
	4	RC SLABS
	5	MASSIVE RC SECTIONS
	6	STEEL STRUCTURE WITH CONCRETE INFILL

Figure 3.8.3-16 Structural Categories Between Elevations 76’-5” and 139’-6”

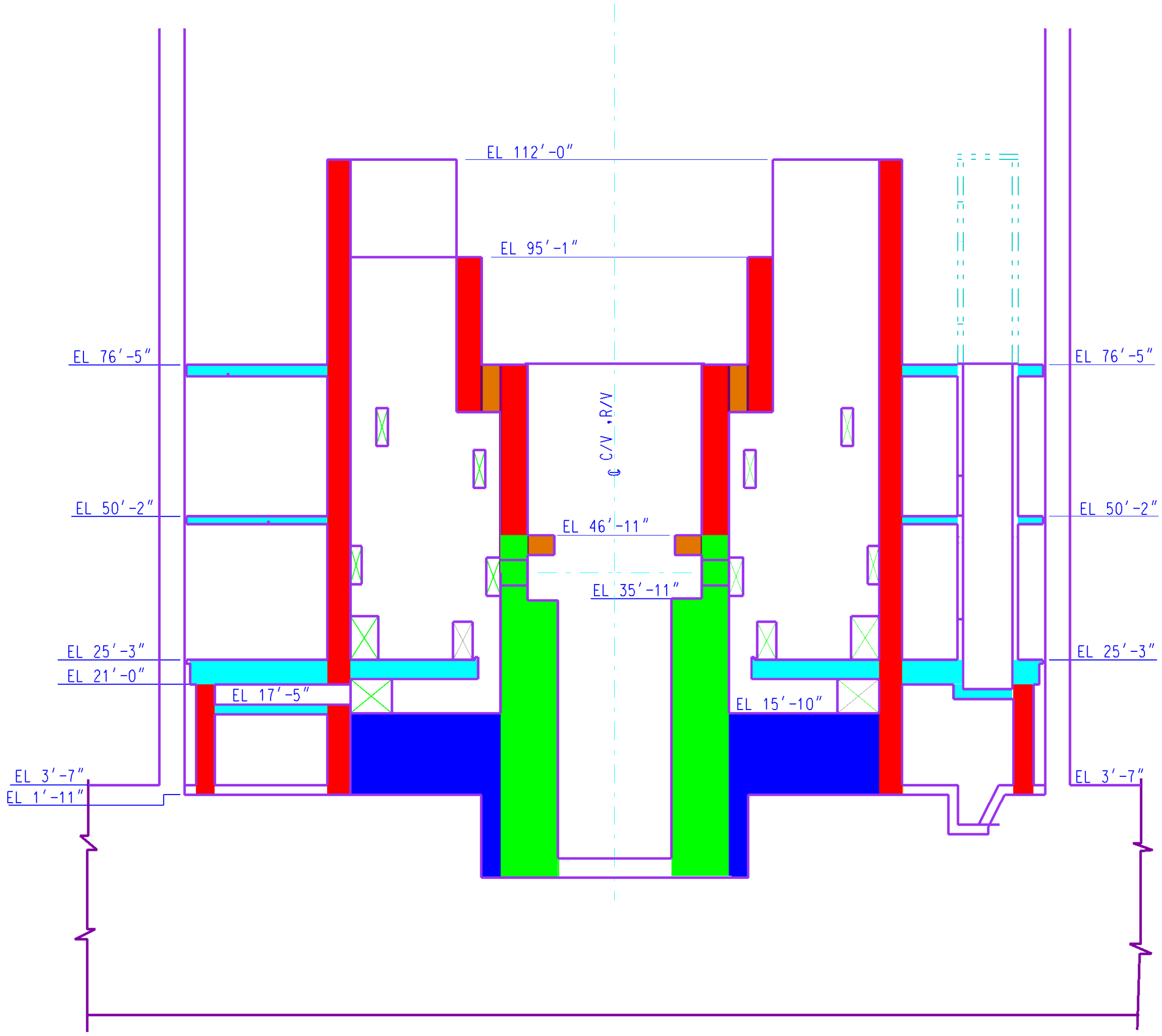
RAI 03.08.03-94



	STRUCTURAL CATEGORY	DESCRIPTION
	1	SC WALLS, T ≤ 56"
	2	WALLS WITH T > 56"
	3	PRIMARY SHIELDING WALLS
	4	RC SLABS
	5	MASSIVE RC SECTIONS
	6	STEEL STRUCTURE WITH CONCRETE INFILL

Figure 3.8.3-17 Structural Categories, Section A-A (Looking West)

RAI 03.08.03-94



	STRUCTURAL CATEGORY	DESCRIPTION
	1	SC WALLS, T ≤ 56"
	2	WALLS WITH T > 56"
	3	PRIMARY SHIELDING WALLS
	4	RC SLABS
	5	MASSIVE RC SECTIONS
	6	STEEL STRUCTURE WITH CONCRETE INFILL

Figure 3.8.3-18 Structural Categories, Section B-B (Looking North)