INTERIM STORAGE
PARTNERS

December 9, 2019
E-55622

Director, Division of Fuel Management
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Subject: Submission of ISP Draft Responses for RAIs and Associated Document Markups from Part 2 CHB Cat B Design DRAFT Docket 72-1050 CAC/EPID 001028/L-2017-NEW-0002

Reference: 1. Letter from John-Chau Nguyen (NRC) to Jeffery D. Isakson, "Interim Storage Partners LLC's License Application To Construct And Operate The Waste Control Specialists Consolidated Interim Storage Facility, Andrews County, Texas, Docket No. 72-1050 – First Request For Additional Information, Part 2," dated March 6, 2019

Interim Storage Partners LLC hereby submits draft responses to two additional RAIs from First Request for Additional Information; Part 2 issued March 6, 2019 (Reference [1]) related to the Cask Handing Building (CHB) to support the continued review of the Licensing Application. Enclosure 1 (Public) contains the draft responses to the RAIs RAIs NP-7-1 and NP-7-12 along with the associated marked up pages for the Safety Analysis Report (SAR).

Should you have any questions regarding this submission, please contact Mr. Jack Boshoven, of my staff, by telephone at (410) 910-6955, or by email at jack.boshoven@orano.group.

Sincerely,

Jeffery D. Isakson
Chief Executive Officer/President
Interim Storage Partners LLC

NMSS20
NMSS26

cc: John-Chau Nguyen, Senior Project Manager, U.S. NRC
Jack Boshoven, ISP LLC
Elicia Sanchez, ISP LLC

Enclosures:
1. Draft RAI Responses with associated application change pages (Public)

Add theSAR Chapter 7, "Installation Design and Structural Evaluation"

RAI NP-7-1:

Specify how the cask handling building (CHB) overhead crane design combines seismic loadings with normal loadings (e.g., CMAA #70, "Specifications for Top Running Bridge & Gantry Type Multiple Girder Electric Overhead Travelling Cranes," with discussion of how seismic loading is incorporated or an appropriate alternative standard such as the design criteria for a Type II crane as defined in ASME NOG-1), and justify the "not-important-to-safety" (NITS) classification of the crane structure exclusive of the seismic clips and runway beams.

The design measures necessary to ensure the crane structure itself can withstand design seismic loading must be specified to verify the crane structure would not fall and damage important-to-safety (ITS) equipment per 10 CFR 72.122(b). WCS CISF SAR Section 7.5.3.1 states the following regarding seismic design of the overhead bridge cranes:

> The overhead bridge cranes are classified as [NITS] and are designed in accordance with ANSI B30.2, "Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist)." The overhead bridge cranes rails are attached to the CHB structure in a manner that provides adequate assurance that the rails will remain attached to the CHB structure during the above-described seismic event. Seismic clips are provided on the overhead crane bridge trucks and trolley to limit uplift during a seismic event, thereby eliminating the potential for the bridge or trolley to fall onto loaded casks inside the CHB.

Also, WCS CISF SAR Section 3.4.1 states:

> The 130-ton overhead crane and associated NUHOMS® MP197HB and MP187 Casks Lift Beam Assembly are NITS because the NUHOMS® cask and canister are not lifted above the Technical Specifications [3-1] height limits. The building structure (structural steel and column foundations) is classified as ITS, Category C to meet the requirements of 10 CFR 72.122(b)(2)(ii) [3-23] and to prevent massive building collapse onto cask systems and related ITS SSCs. The overhead crane bridge trucks and trolley seismic clips are ITS.

WCS CISF SAR Section 7.5.3.7, "Structural Analysis and Design," describes how the loadings on the crane runway beams were established, but not the loadings on the crane structure itself.

This information is needed to determine compliance with 10 CFR 72.122(b)(2)(ii).

Response to RAI NP-7-1:

This RAI makes the following requests related to CHB overhead crane design:

1. Justify the NITS classification of the CHB overhead cranes exclusive of the seismic clips and runway beams.
2. Specify the design measures that ensure the crane structure itself can withstand design seismic loading and will not fall and damage ITS equipment.

3. Specify how the overhead crane design combines seismic loadings with normal loadings, with discussion of how seismic loading is incorporated.

These requests are addressed by the following:

1. The CHB overhead cranes are equipped with important-to-safety (ITS) Category B seismic clips on the trolley and bridge to prevent separation of the trolley from the bridge girder and separation of the end trucks from the runway beam. The runway beams and their supporting structures are also ITS Category B to prevent failure or deformation. ITS classification of these components, which serve the safety function of preventing collapse of crane structures onto canisters, provide reasonable assurance that collapse and resulting potential for loss or reduction of packaging effectiveness will not occur. The integral crane structure consisting of the bridge rails, bridge girders, and trucks, as well as the trolley structure and the various drive components, are NITS because they do not have the potential for structural collapse onto canisters as long as the ITS Category B seismic clips and runway support structure retain their safety function. For lifting, operational protocols limit overhead crane lifts to a height not exceeding the drop height that could cause loss or reduction of packaging effectiveness for the NUHOMS® casks. Additionally, for insurance reasons and to provide defense in depth, the overhead cranes are analyzed and designed as Type 1, single failure-proof (SFP) cranes in accordance with American Society of Mechanical Engineers (ASME) NOG-1-2015, even though this does not form the licensing basis for these components.

2. The crane structures (bridge rails, bridge girders, trucks, etc.) do not have the potential for collapse onto canisters e.g. during seismic loading as long as the ITS Category B seismic clips and runway support structure retain their safety function. The cranes are, however, analyzed and designed as Type 1, SFP cranes in accordance with ASME NOG-1-2015, providing defense in depth as discussed above. In accordance with ASME NOG-1-2015, Section 4150, seismic demands on the overhead cranes are determined from modal response spectrum analysis of a three-dimensional mathematical model meeting all requirements of Section 4153, including requirements for model geometry, boundary conditions, and trolley and hook positions. WCS CISF Safety Analysis Report (SAR) Sections 7.5.3.2.4 and 7.5.3.6 have been added to reflect this discussion.

3. New WCS CISF SAR Sections 7.5.3.2.4 and 7.5.3.6 have been added to provide clarification that seismic demands on the CHB overhead cranes are analyzed in accordance with ASME NOG-1-2015 and ASCE 4-16 and to provide more details on incorporation of seismic loading.

SAR Sections 3.2.3.10.9, 3.2.8.4, 3.2.8.6, 3.4.1, 4.7.2, and 7.5.3.1.3, and Table 3-5, have further been revised to reflect the SFP design of the overhead crane in accordance with NOG-1-2015 and clarify the classification of the overhead crane bridge truck and trolley seismic clips and crane runway support beams as ITS Category B SSCs.

Impact:

SAR Sections 3.2.3.10.9, 3.2.8.4, 3.2.8.6, 3.4.1, 3.8, 4.7.2, and 7.5.3.1.3, and Table 3-5, have been revised as described in the response. SAR Sections 7.5.3.2.4, and 7.5.3.6 have been added as described in the response.

RAI NP-7-12:

Provide a report for the design of the CHB that, at a minimum, includes the following: (1) the dimensions of all sections that have a structural role including locations, sizes, configuration, and spacing, (2) structural materials with defining standards or specifications, (3) location and specifications for assembly, and (4) fabrication codes and standards.

WCS CISF SAR Section 7.5.3.7, "Structural Analysis and Design," states that the CHB will be designed using static analysis methods for the determination of forces and moments on structural steel members from service loading conditions and dynamic methods for loading conditions involving seismic loads. The application, however, provides no additional information that would allow the staff to review the design of the CHB consistent with the guidance in Section 5.5.4 of NUREG-1567.

The report provided should include descriptions of the design method used, computer models used, and information on the application of the structural analysis methods used to determine the capacity of the CHB for service and natural phenomena loads. In addition, clarify if the modal response spectrum analysis will be the dynamic method used for the evaluation of seismic loads of the CHB.

This information is needed to determine compliance with 10 CFR 72.122(b)(2)(ii).

Response to RAI NP-7-12:

1. The dimensions (sizes, configuration, and spacing) of all sections with a structural role are provided in new Table 7-41 and new Figures 7-54 through 7-63 in the WCS CISF Safety Analysis Report (SAR), with a corresponding discussion added in Section 7.5.3.1.1.

1. Structural materials with defining standards and specifications are provided in new SAR Table 15-1.

2. Locations and specifications for assembly and connections are provided in new SAR Section 7.5.3.4.2.

3. Fabrication codes and standards are provided in New SAR Section 15.2.4.

Discussion of the design and analysis of the CHB is provided in SAR Section 7.5.3 and all subsections, which have been significantly expanded and restructured, and material and construction specifications and properties have been provided in new sections in SAR Chapter 15. ISP calculations providing the detailed analysis methodology and results will be enclosed with the final response for NRC information. SAR Sections 1.2.3, 7.4, and 7.5 and SAR Figures 1-7 and 1-8 have been revised in accordance with the expanded discussion in Section 7.5.3.

Impact:

SAR Sections 1.2.3, 7.4, 7.5, and 7.5.3 (including all subsections) have been revised, SAR Sections 15.1.5, 15.2.4, and 15.3.4, Tables 7-41, 7-42, 15-1, and 15-2, and Figures 1-7, 1-8, and 7-54 through 7-63 have been added as described in the response.

1.2.2 Principal Design Criteria

The WCS CISF principal design criteria are based on the site characteristics, the design criteria associated with the cask systems listed in Table 1-1 that have been previously approved by the NRC, and specific criteria required for the WCS CISF design.

The cask systems listed in Table 1-1 meet the WCS CISF design criteria. Table 1-2 provides a summary of the WCS CISF principal design criteria.

1.2.3 Facility Descriptions

The major facilities at the WCS CISF are the Cask Handling Building and the storage area. The Cask Handling Building is approximately *175* feet long by *193* feet wide by *72* feet high. The building is a two-bay steel structure designed to support two commercial overhead cranes used to move transportation casks from the rail car to the transport vehicle. One bay of the building will house the Canister Transfer System described in Section 1.3.1.2 and the other bay will be available for direct transfer of transportation casks from the rail car to the transport vehicle. A 2,400 square foot area of the building is set aside for cask storage. The building plan view is shown in Figure 1-7. Figure 1-8 is a section through the building showing the overhead crane location. Air monitors and dosimeters are located in the building for monitoring purposes. The building is not designed or intended to provide confinement or shielding for SNF or GTCC materials. The building is classified as ITS - Category *B*. The purpose of the Cask Handling Building is to receive and prepare for storage shipments of dual-purpose canister systems. It will also receive GTCC waste canisters for storage at the site. It is also designed to process canisters stored at the site for off-site shipment. The Cask Handling Building is designed to handle canisterized material and does not have the capability to handle bare fuel.

RAI NP-7-12

As Low As Reasonably Achievable (ALARA) principles are incorporated, to the maximum extent practical, throughout the facility design to reduce radiation exposure to facility personnel. Cranes/lifting devices for transferring the NUHOMS® transportation/transfer casks from the transportation skid to the transfer trailer/skid are designed to minimize the need for facility personnel to be near the loaded cask. This equipment is NITS as the lift heights of the loaded casks are maintained below 80 inches at all times after removal of the impact limiters. The analysis of bounding drop scenarios shows that a NUHOMS® transportation/transfer cask will maintain structural integrity of the DSC confinement boundary and maintain basket geometry from an 80 inch (from the bottom of the cask to the "ground") drop. The ITS canister transfer system for the vertical transfer of canisters is remotely operated and the transfer equipment used to make the transfer to the storage overpacks is substantially identical to that used to transfer the canister into dry storage at the reactor facilities where the material was initially stored.

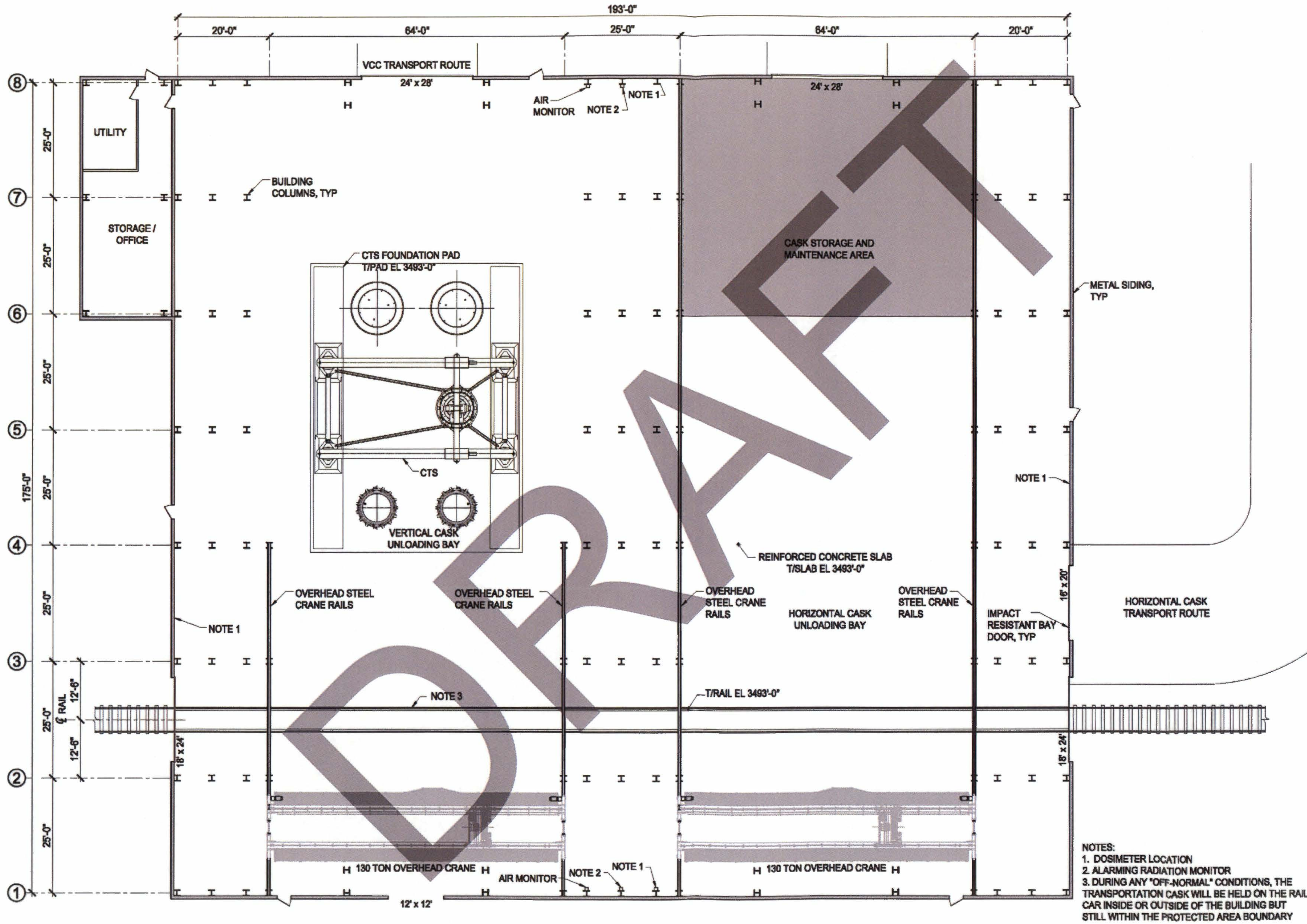

Figure 1-7
Cask Handling Building Plan

All Indicated Changes are in response to RAI NP-7-12

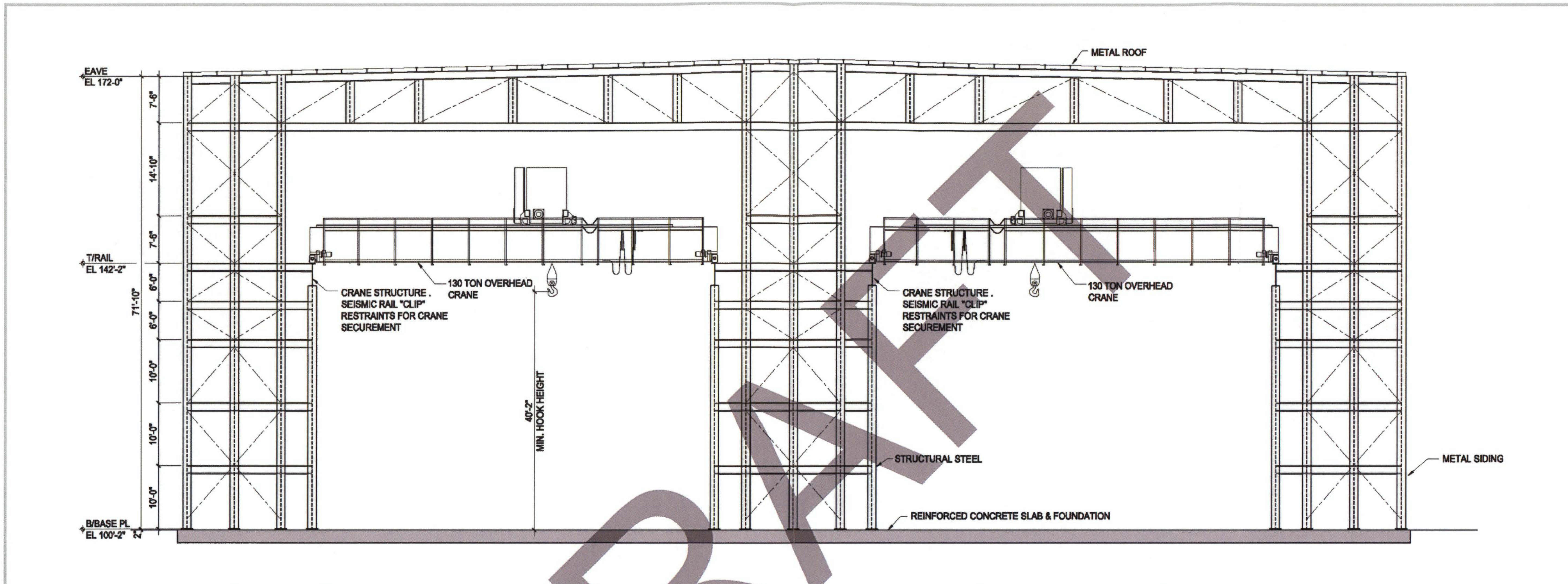

Figure 1-8
Cask Handling Building Section View

All Indicated Changes are in response to RAI NP-7-12

3.2.3.10.3 Procedure Used to Lump Masses

The mass of a system is distributed throughout the actual structure. Lumping mass is an idealized method that concentrates the mass of a system at the nodes of the structure model. The lumped masses at the nodes of a structure are the sums of the actual system mass that can be reasonably attributed to that specific node point represented in the analysis model.

3.2.3.10.4 Methods Used to Couple Soil with Seismic-System Structures

The soil can be represented by discrete springs or a finite element model to represent the soil subgrade.

3.2.3.10.5 Methods Used to Account for Torsional Effects

The storage pads and the CHB are modeled to consider torsional effects due to the eccentricities of the masses.

3.2.3.10.6 Methods for Seismic Analysis of Dams

There are no dams onsite or in the immediate area.

3.2.3.10.7 Methods to Determine Overturning Moments

Stability of the storage overpacks on the storage pads is evaluated to ensure stability. Overturning moments are developed using site-specific seismic design parameters.

3.2.3.10.8 Analysis Procedure for Damping

Critical damping values are developed in accordance with Regulatory Guide 1.61 [3-27].

3.2.3.10.9 Seismic Analysis of Overhead Cranes

The CTS is analyzed for seismic effects in accordance with the requirements of NUREG-0554 [3-29] for single-failure-proof cranes.

The overhead cranes in the CHB are analyzed for the seismic effects in accordance with the requirements in *NOG-1-2015 [3-36] for Type 1, single-failure-proof cranes*. Seismic clips are provided on the overhead crane bridge trucks and trolley to limit uplift during a seismic event, thereby eliminating the potential for the bridge or trolley to fall onto loaded SNF casks inside the CHB.

3.2.3.10.10 Seismic Analysis of Specific Safety Features

SSCs classified as ITS meet the requirements of 10 CFR 72.122(b)(2) [3-23], which requires SSCs be designed such that design basis ground motion will not impair the capability to perform their safety functions.

All Indicated Changes are in response to RAI NP-7-1

3.2.8.1 NUHOMS® and Vertical Cask Systems

The NUHOMS® storage systems and the Vertical storage systems are designed to provide long-term storage of SNF. The canister materials are selected to protect against degradation during the storage period, including the application of system specific aging management programs.

3.2.8.2 Cask Storage Pad Load Combinations

The storage pads for the Vertical system storage modules are ITS. Load combinations are provided in Section 7.6.1.4.

3.2.8.3 Canister Transfer System

The CTS is ITS. Load combinations are in accordance with ASME NOG-1 [3-34].

3.2.8.4 Cask Handling Building Load Combinations

The CHB is a structural steel building with metal siding. The building will support two overhead cranes *(themselves evaluated in accordance with NOG-1-2015 [3-36])* and consider their effects on loading combinations. The design of the structure is in accordance with *nuclear facility codes.* The design will consider load combinations as required by *these codes*. Section 7.5.3 provides additional information on the CHB design criteria.

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3.2.8.5 Cask Handling Building Foundation

The foundation for the CHB is a conventional mat foundation of reinforced concrete construction. *Loads, load combinations, load factors,* and allowable stresses used in the design *are* in accordance with *ACI 349-13, refer to Section 7.5.3.2.3*.

3.2.8.6 Cask Handling Building Cranes

The overhead bridge cranes are classified as Not-Important-to-Safety (NITS), *with the exception of seismic clips and runway beams and supports, but are* designed *as Single Failure Proof (SFP)* in accordance with *ASME NOG-1-2015, "Rules for Construction of Overhead Gantry Cranes (Top Running Bridge, Multiple Girder)" [3-36] for defense in depth*. The overhead bridge cranes rails are attached to the CHB structure in a manner that provides adequate assurance that the rails will remain attached to the CHB structure. The cranes are procured and designed to follow the loading conditions and combinations established in *NOG-1-2015*.

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Criteria utilized for criticality safety of the canister/cask systems are not based on site-specific criticality safety criteria, therefore no additional criticality evaluations are required specific to this application. Chapter 10 addresses the criticality criteria for each of the canisters authorized for storage at the WCS CISF identified in Table 1-1.

Table 3-5 describes the Quality Assurance classifications for major SSCs as utilized at the WCS CISF per NUREG/CR-6407 [3-31]. Quality Assurance Classifications for each of the Storage Systems SSCs are addressed in Table 3-4. The canisters are classified as Category A because a failure could lead in loss of primary containment. The Storage Overpacks, CTS, VCT, *and CHB* have been classified as Category B because the failure of these components would require the failure of an additional component to result in an unsafe condition. The Storage Pads for the Vertical Storage System *have* been classified as Category C because the failure of these components would not likely result in an unsafe situation.

All other components are NITS because their failure would not result in an unsafe condition.

The classification of the components that make up the cask systems authorized for storage at the WCS CISF, including canister, transfer casks, storage overpacks, transfer equipment and storage pads are provided in Appendices A.3, B.3, C.3, D.3, E.3, F.3 and G.3, depending on the canister/cask system. Section 2.1 of the Technical Specifications [3-1] lists the SNF canisters authorized for storage at the WCS CISF. Table 3-1 provides the cross reference to the applicable appendix and section for each canister/storage overpack where the classifications of the components of that system are identified.

3.4.1 Cask Handling Building Quality Classification

The purpose of the CHB and associated lifting equipment is to receive, inspect and prepare for storage, shipments of canisterized SNF and GTCC waste canisters and to provide for cask and rail car light maintenance. The CTS and associated lifting hardware used for stack up and transfer operations for the NAC canisters is located inside the building. The 130-ton overhead crane and associated NUHOMS® MP197HB and MP187 Casks Lift Beam Assembly are NITS because the NUHOMS® cask and canister are not lifted above the Technical Specifications [3-1] height limits *and seismic clips provide reasonable assurance against crane structural collapse onto canisters, but the crane is designed to NOG-1-2015 [3-36] Type 1, Single Failure Proof specifications to provide defense in depth*. The building structure (structural steel and column foundations) is classified as ITS, Category *B* to meet the requirements of 10 CFR 72.122(b)(2)(ii) [3-23] and to prevent massive building collapse onto cask systems and related ITS SSCs. The overhead crane bridge trucks and trolley seismic clips are ITS. The balance of the facility is also NITS as the fuel remains sealed from the environment inside the confinement boundary provided by the canister for all operations and the overpacks provide protection from natural phenomena and postulated off-normal and accident events.

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3-22 Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation."

3-23 Title 10, Code of Federal Regulations, Part 72, "License Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater than Class C Waste."

3-24 ASCE-7 (formerly ANSI A58.1), Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers, 1995.

3-25 McGuire, R.K., Silva, W.J. and Constantino, C.J., 2001, Technical basis for revision of regulatory guidance on design ground motions: Hazard- and risk-consistent ground motion spectra guidelines, U.S. Nuclear Regulatory Commission NUREG/CR-6728.

3-26 *Not Used.*

3-27 Regulatory Guide 1.61, Damping Values For Seismic Design of Nuclear Power Plants, U.S. Nuclear Regulatory Commission, October 1973.

3-28 *Not Used.*

3-29 NUREG-0554, Single-Failure-Proof Cranes for Nuclear Power Plants, U.S. Nuclear Regulatory Commission, 1979.

3-30 ASME B30.2-2005 Overhead and Gantry Cranes.

3-31 NUREG/CR-6407, (INEL-95/0551), Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety, 1996.

3-32 Electric Power Research Institute (EPRI), 2013, Ground motion model (GMM) review project, Final Report.

3-33 Geoservices, LLC, Project No. 31-151247, "Report of Geotechnical Exploration: Consolidated Interim Storage Facility (CISF) Andrews, Texas," August 20, 2015.

3-34 ASME NOG-1-2010, "Rules for Construction of Overhead Gantry Cranes (Top Running Bridge, Multiple Girder)," The American Society of Mechanical Engineers, 2010.

3-35 ASCE 7-16, "Minimum Design Loads for Buildings and Other Structures."

3-36 ASME NOG-1-2015, "Rules for Construction of Overhead Gantry Cranes (Top Running Bridge, Multiple Girder)," The American Society of Mechanical Engineers, 2015.

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RAI NP-7-1

Table 3-5
Quality Assurance Classification of Structures, Systems, and Components as Utilized at the WCS CISF(1)

Important-To-Safety	**Not Important-To-Safety**
Classification Category A	Facility Infrastructure
SNF Canister	Security and Administration Building
	Storage Pads (NUHOMS® Storage Overpacks)
Classification Category B	Overhead Building Cranes
Storage Overpacks	Overhead Building Crane Lifting Devices
Canister Transfer System *(See Note 3)*	Electrical Power
Vertical Cask Transporter	
Cask Handling Building	
(Crane Runway Beams and Support Structures)	
Overhead Crane Bridge Truck Seismic Clips and Trolley Seismic Clips	
Classification Category C	Facility Lighting
Storage Pads (Vertical Concrete Storage overpacks)	NUHOMS® Cask Transfer Trailer
	Radiation Monitors
	Temperature Monitoring System
Treated as Category C	Communication System
Derailer (See Note 2)	Fire Protection System
CAS (See Note 2)	Potable Water System
Security Lighting (See Note 2)	Sanitary Waste/Septic Systems
Security Cameras (See Note 2)	Facility Roads
Security Alarm Systems (See Note 2)	Railroad Line Components
Backup Electric Power (Generators) (See Note 2)	Associated Support Equipment

RAI NP-7-1

Notes:

(1) Quality Assurance Classifications for each of the Storage Systems SSCs are addressed in Table 3-4.

(2) Treated as ITS Category C with the exception 10 CFR Part 21 does not apply.

(3) The Canister Transfer System includes transfer casks for the NAC MAGNASTOR, UMS, and MPC systems.

4.7.1.3 Confinement Features

The CHB is not counted on to provide confinement for SNF or GTCC waste.

4.7.1.4 Function

The CHB facilitates cask handling operations at the WCS CISF. Those operations are described in more detail in Chapter 5. The functions of the CHB include: loading and unloading transportation casks from rail cars; general weather protection for the handling operations; a location for the CTS; support structure for overhead cranes; staging area for storage overpacks; and storage and staging for other transfer and shipping equipment. The CHB is not counted on to provide shielding or confinement.

4.7.1.5 Components

The major components that comprise the CHB are two 130 ton overhead bridge cranes. Minor components include a compressed air supply system for tools as discussed in Section 4.3.3 and the CHB will have a standard commercial HVAC system in the Utility and Storage room area of the building. The larger building will not be heated or cooled. Ventilation will be commercial grade equipment and materials.

In addition to components that are part of the CHB, all or parts of the transfer systems will operate within the building. Six storage systems were evaluated for storage in the WCS CISF Storage Area. These storage systems use various cask transfer systems. These transfer systems are described in Sections 4.7.3 and 4.7.4. Table 4-1 provides a cross-reference to the applicable appendix and section for each canister/storage overpack where the individual cask transfer systems are discussed.

4.7.1.6 Design Bases and Safety Assurance

The CHB is classified as being ITS *Category B*. The design bases for the CHB are described in Section 7.5.3.

4.7.2 Overhead Bridge Cranes

The CHB houses two 130 ton overhead bridge cranes. These cranes are classified as NITS*, with the exception of seismic clips and runway beams and support structures, but are designed as Type 1, Single Failure Proof cranes in accordance with NOG-1-2015 to provide defense in depth*. The cranes are provided for the purpose of loading and unloading NUHOMS® transportation casks off or on the rail car and to or from the Transfer Trailer. The cranes *shall include limit switches that shall be procedurally verified to be pre-set, limiting the travel (lifting height)* so that they do not lift the NUHOMS® casks above their analyzed drop height. Section 7.5.3.1 provides additional information on the overhead bridge cranes. The NUHOMS® casks will be lifted by the crane utilizing the WCS Lift Beam Assembly, which is referenced in Section 4.10.

RAI NP-7-1

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7.4 Reinforced Concrete Structures – Important To Safety

The NUHOMS® Horizontal Storage Modules (HSMs), NAC VCCs, storage pads for the vertical systems, *and the CHB foundation and floor slab* comprise the only WCS CISF reinforced concrete structures that are ITS. The individual Appendices describing each of the proposed system components provide the structural descriptions and evaluations for each of the selected cask systems. Table 7-2 provides the cross reference to the applicable appendix and section for each canister/storage overpack where the structural evaluation is discussed.

Reinforced structures associated with the CHB are discussed in Sections 7.5.3.2.3 and 7.5.3.5.

7.5 Cask Handling Building

The Cask Handling Building (CHB) is a two-bay ITS - Category *B* steel structure. The CHB is *175* feet by *193* feet and approximately *72* feet tall with rail access to facilitate cask unloading operations, canister transfer operations, and miscellaneous maintenance activities. Figures 1-7 and 1-8 show the general building layout and building cross section. CHB Structural Design is discussed in Section 7.5.3.

To facilitate rail car unloading activities for NUHOMS® systems, the CHB design incorporates two overhead bridge cranes rated at 130 tons each for lifting loaded transportation casks from the rail car, removal of impact limiters, and shielding, etc.

All transfer operations to move the NUHOMS® System MP187 and MP197HB transportation casks are accomplished with the transportation casks in a horizontal orientation utilizing a NITS bridge crane as all lifts are limited to a maximum height of 80 inches. The vertical systems will utilize the overhead bridge cranes to remove impact limiters and personnel barriers, and the Vertical Cask Transporter (VCT) is used to move the NAC transportation casks from the rail car to the Cask Transfer System (CTS).

The CHB also houses operations involving both a CTS and a VCT in support of unloading transportation casks and transferring canisters from the NAC transportation casks into the storage casks. Both systems are considered ITS, although the VCT transport of a storage cask to the pad has been evaluated for limited lift height drops.

The CTS and VCT are independently designed and analyzed to meet the intent of NUREG-0612 [7-3], "Control of Heavy Loads at Nuclear Power Plants,"

> "To provide adequate measures to minimize the occurrence of the principal causes of load handling accidents and to provide an adequate level of defense-in-depth for handling heavy loads near spent fuel and safe shutdown systems".

Understanding the WCS CISF will not have safe shutdown equipment or spent fuel pools, it is recognized that the canisters loaded with fuel must be safely and securely handled thereby protecting the fuel from damage and protecting the site and surrounding areas from any potential radiological impacts. Even though the potential for a radiological release is very low, the WCS CISF objective is to prevent the occurrence of load handling accidents. Therefore, the licensing basis is to provide handling systems that are robust to failure which makes the likelihood of a load drop event extremely small.

All Indicated Changes are in response to RAI NP-7-12

The VCT is not an overhead hoisting system as defined by any ASME Standard, rather it is a mobile hydraulic gantry crane and adheres to applicable ASME B30.1 requirements. The lift links, lifting pins and header beam are designed, load tested and inspected in accordance with the requirements as specified in ANSI N14.6.

7.5.3 Cask Handling Building Structural Design

This section presents the structural description and design criteria, *and analysis* for the WCS CISF Cask Handling Building (CHB). The CHB *structures are designed to meet the applicable requirements for ITS structures in 10 CFR 72.122 as outlined in NUREG-1567 Section 5.4.4*. The CHB is a two bay commercially designed and fabricated steel frame structure with metal siding *and roofing designed to provide a weather-protective enclosure for cask handling operations and* to support two commercial overhead cranes used to move transportation casks from the rail car to the transfer vehicle. The CHB *and its foundations are* ITS - Category *B*. The overhead cranes will also be used to remove or install personnel barriers, impact limiters from the transportation casks. All operations to move the NUHOMS® System MP187 and MP197HB transportation casks are accomplished with the transportation casks in a horizontal orientation.

7.5.3.1 *Descriptions of Systems, Structures, and Components*

Three separate structural systems are included within the CHB structural design, including the steel-framed building itself, the reinforced concrete foundations for the steel building, and the two overhead bridge cranes. Arrangement of the CHB structures and description of each system are provided in the following subsections. Material specifications utilized for the primary structural components of all CHB structures are summarized in Table 15-1.

All Indicated Changes are in response to RAI NP-7-12

7.5.3.1.1 Description of CHB Steel Building

As shown in Figures 7-54 through 7-61, the CHB steel building is a braced frame structure with column centerline grid plan dimensions of 175'-0" (north-south) by 193'-0" (east-west) and an eave height 72'-0" above the top of the concrete foundation (Elevation 100'-0" in the figures). The roof is gabled with 1/4-inch per foot slope on each side and peak ridge elevation of 174'-0 1/8". The north-south plan dimension of the building comprises seven equal bays of 25'-0" spacing, with vertically braced interior bays similar to those shown in Figure 7-56 on column lines A, C, F, H, K, and M. The east-west plan dimension comprises two crane bays with 64'-0" spacing between independent crane support columns that are laterally supported by three separate vertically braced frames at column lines A-C, F-H, and K-M (see Figures 7-55 and 7-56). All seven east-west column lines support a primary lateral roof truss system that is tied together with a secondary north-south bridging roof truss system and horizontal roof bracing at the top and bottom truss chord levels. The primary roof trusses vary in depth from 7'-6" at the eave to 9'-6 1/8" at the ridge. The vertical bracing and primary roof truss arrangement is shown in Figure 7-56, with the secondary bridging roof trusses and horizontal roof truss chord bracing shown in Figures 7-60 and 7-61, respectively.

The framing arrangement shown in Figure 7-56 and utilized on all seven east-west column lines provides lateral system redundancy, distributed lateral stiffness with limited torsional irregularity, and sufficient lateral stiffness to meet drift limitations for bridge crane supporting structures. These design objectives are further achieved via the arrangement of the roof bracing system (i.e., diaphragm); see Figures 7-54, 7-60, and 7-61. As shown, the primary east-west roof trusses are laterally supported by the secondary bridging trusses framed along the full north-south length of the building at the two wind column lines in each crane bay (Column lines D.1, D.2, I.1, and I.2; a typical section at line I.2 is shown in Figure 7-60). Horizontal diagonal roof bracing in the planes of the top and bottom chords is then provided between the primary and secondary trusses to create a continuous roof diaphragm that assures system redundancy by distributing lateral loads among the north-south and east-west braced column lines. The continuous roof diaphragm also limits relative drift of individual vertical frames subjected to localized lateral forces imparted by the cranes.

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The bridge crane support system consists of simply-supported runway girders spanning 25 feet between the aforementioned independent crane support columns. As illustrated in Figure 1-7, the crane runways provide crane access to the complete length of the building in the east crane bay, while in the west crane bay the runways span only the four southernmost east-west column lines (from Line 1 to Line 4). Similar to the main building column lines, vertical bracing is provided in two bays of each crane column line (Lines D, E, I, and J); see the typical section shown in Figure 7-59. The runway girders are built-up steel sections with overall depth of 5'-6". At the top girder flange and at Elevation 136'-2", crane runway tie-back elements are provided to transfer lateral loads from the runway girders to the supporting vertically braced frames. The tie-back elements and their connections are detailed to accommodate flexural displacements of the runway without experiencing fatigue. The crane rail supported by the runway girders is 175 lb-per yard, ASTM A759 crane rail with rail clips sized and spaced to ensure both the rails and rail clips can withstand lateral crane operating loads as well as seismic loads.

Ordinary Concentrically Braced Frames (OCBFs) are selected as the seismic lateral force resisting system for the CHB in both the north-south and east-west directions, in accordance with ASCE 43-05 Table 4-1. Although ASCE 7-16 is not a governing code for CHB design (see Section 15.2.4), OCBFs are permitted by ASCE 7-16 Table 12.2-1 for buildings of any height in Seismic Design Category C and lower. For the seismic site coefficients given in the project geotechnical report (SAR Attachment E), Seismic Design Category C would apply to the CHB per ASCE 7-16 Section 11.6.

All vertical braces in the CHB are ASTM A1085 round HSS sections, which are the most efficient sections meeting the seismic ductility and slenderness requirements of AISC 341-16. Vertical braces are arranged in multi-story X configurations in both the north-south and east-west directions, to balance braces in tension and compression under lateral loads and to limit unbalanced forces on intersecting columns and struts. For the east-west braced frames, the three-column arrangement for each of the braced frames illustrated in Figure 7-56 is selected to provide vertical and lateral load path redundancy in the event of column damage due to tornado missile impact. Similarly, redundancy is achieved in the north-south braced frames by providing two bays of multi-story X braces (four vertical brace members per level) in each of the north-south braced frames and redundant longitudinal struts between columns (see Figure 7-58). For this configuration, the loss of an individual brace, or connection thereto, would only reduce the contribution of the given braced frame to the strength of the associated building story by 25%. This will result in no loss in overall structural integrity.

Figures 7-55 through 7-60 illustrate typical member size groups utilized for CHB primary framing. Member size classes utilized for each primary framing member category are also summarized in Table 7-41. Further discussion of the CHB structural steel analysis and design is given in Sections 7.5.3.3 and 7.5.3.4.

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7.5.3.1.2 Description of CHB Foundation

The principal safety function of the foundation system for the CHB is to transfer design-basis normal operating and extreme environmental loading demands from the building columns and crane support columns to the supporting soils, while providing sufficient resistance to sliding and overturning. These functions are achieved with a foundation consisting of cast-in-place, reinforced concrete footings and pedestals supporting the CHB column base plates. The use of shallow spread-footing type foundations is in accordance with recommendations in the project geotechnical report (see SAR Attachment E). The general foundation arrangement consists of three continuous strip mat footings running north-south, each supporting one of three column line groups shown in Figure 7-55: Lines A-D, Lines E-I, and Lines J-M. Separate footings are provided for the wind column vertical trusses at the north and south ends of the building. All footings are founded at a nominal depth of 9 feet below grade. This depth is selected to provide sufficient pedestal depth for development of the reinforcement and anchor rods required for resistance of tornado-induced uplift demands on the CHB columns. Excavation to the bearing stratum depth of nominally 9 feet below grade also ensures the foundations will bear on competent material below the maximum 6.5-foot depth of loose overburden material encountered in boring activities documented in the project geotechnical report. See Section 7.5.3.3.3 for evaluation of soil-structure interaction effects. Further discussion of CHB foundation analysis and design is given in Section 7.5.3.5.

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The working floor of the CHB is provided by a reinforced concrete slab on grade that is structurally isolated from the CHB foundations and the CTS foundation. The slab is founded on compacted structural fill placed to a sufficient depth to remove loose in-situ materials, in accordance with the project geotechnical report. Thickened reinforced concrete sections are provided for support of the rails and railcars at the south end of the building (see Figure 1-7).

7.5.3.1.3 Description of CHB Overhead Cranes

RAI NP-7-1

To facilitate rail car unloading activities for NUHOMS® systems, the CHB design incorporates two overhead bridge cranes rated at 130 tons each for lifting loaded transportation casks from the rail car, removal of impact limiters, and shielding, etc. The vertical systems will utilize the overhead bridge cranes to remove impact limiters and personnel barriers, and the VCT is used to move the NAC transportation casks from the rail car to the CTS.

The two cranes are identical in terms of geometry and configuration, which generally consists of two box-beam bridge girders supporting a top-running trolley. As shown conceptually in Figures 1-8 and 7-56, the bridge girders span 64'-0" between crane runway rails, and a minimum height of 40'-2" is provided from hook to finished floor. Bridge and trolley travel are limited by structural steel end stops installed on the crane runway girders and bridge girders, respectively. The end stops engage bumpers installed on the crane and trolley that are sized and configured to limit impact forces applied to the supporting structure. A minimum of 3 inches of clearance is provided in all directions between crane components and surrounding obstructions in the building, in accordance with ASME NOG-1 and CMAA-70.

RAI NP-7-1

The overhead bridge cranes are classified as Not-Important-to-Safety, *with the exception of seismic clips and runway beams and supporting structures, but are* designed in accordance with *NOG-1-2015 [7-70] "Rules for Construction of Overhead Gantry Cranes (Top Running Bridge, Multiple Girder)" for defense in depth.* The overhead bridge cranes rails are attached to the CHB structure in a manner that provides adequate assurance that the rails will remain attached to the CHB structure during the above-described seismic event. Seismic clips are provided on the overhead crane bridge trucks and trolley to limit uplift during a seismic event, thereby eliminating the potential for the bridge or trolley to fall onto loaded casks inside the CHB.

Lifts performed by the overhead bridge crane are governed by the guidance of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants: Resolution of Generic Technical Activity A-36," to minimize the potential for release of radioactive material from a spent fuel cask. NUHOMS® transportation/transfer cask lifts are performed using the overhead bridge crane and the lift height is administratively controlled to ensure that the 80-inch design basis drop accidents previously approved by the NRC remain bounding (Reference WCS CISF SAR Tables A.3-1, B.3-1, C.3-1, and D.3-1). The overhead cranes may be used for miscellaneous lifts that do not involve lifting of loads over loaded transportation or storage casks inside the CHB.

7.5.3.2 Design Criteria

Analysis and design of the CHB structures are governed by nuclear facility codes and standards. NUREG-1567 Section 5.4.4, "Other SSCs Important to Safety," references ANSI/ANS 57.9 and the codes and standards cited therein as the basic references for ISFSI structures important to safety. Although ANSI/ANS 57.9 is no longer maintained as an American National Standard, the principal references it cites for analysis and design of ITS steel and concrete structures are consistent with current codes and standards applicable to safety-related nuclear facilities. As also summarized in Section 15.2.4, the following codes and standards are utilized for the given purposes:

RAI NP-7-12

- *ANSI/AISC N690-18, Specification for Safety-Related Steel Structures for Nuclear Facilities. Applicable to definition of steel design load combinations and steel member and connection design requirements. ANSI/AISC 360-16, Specification for Structural Steel Buildings, is the baseline document modified in part by ANSI/AISC N690-18 for application to nuclear facilities.*
- *ANSI/AISC 341-16, Seismic Provisions for Structural Steel Buildings. Applicable to definition of seismic design and detailing requirements for the CHB structural steel seismic lateral force resisting system.*
- *ACI 349-13, Code Requirements for Nuclear Safety-Related Concrete Structures. Applicable to definition of concrete design load combinations and design of reinforced concrete structures and anchorages.*
- *ASCE 43-05, Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities. Applicable to evaluation of seismic demand and capacity of the CHB structures.*
- *ASCE/SEI 4-16, Seismic Analysis of Safety-Related Nuclear Structures. Applicable to seismic analysis procedures for the Cask Handling Building and its foundations.*
- *ASCE/SEI 7-16, Minimum Design Loads and Associated Criteria for Buildings and Other Structures. Applicable to development of normal operating wind loads, snow and rain loads, and overhead crane operating loads.*
- *ASCE/SEI 7-05, Minimum Design Loads for Buildings and Other Structures. Applicable to transforming tornado wind speed into pressures applicable to the CHB, in accordance with NUREG-0800 Section 3.3.2, Tornado Loads.*
- *ASME NOG-1-2015, Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder). Applicable to analysis and design of the two 130-ton overhead cranes supported by the CHB.*
- *CMAA-70 2015, Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes. Applicable to design of the CHB crane runway system.*

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7.5.3.2.1 Load Definitions

The CHB structure is designed to withstand snow and rain in accordance with the International Building Code. In addition, it is designed to resist failure of structural members under concurrent loading by design-basis tornado winds, atmospheric pressure change (APC), and tornado missiles.

Administrative Controls will be used to mitigate certain impacts of design-basis tornado loading. The transportation cask will not be moved into the building to begin the railcar unloading process unless current and forecasted weather for the approaching eight (8) hours indicate safe weather conditions. Eight hours is the estimated time to move any of the casks from the railcar to a stable configuration within the CHB in which the crane is no longer overhead or adjacent. For the NUHOMS® systems, eight hours bounds the approximate time (6.4 hours for MP187 casks, 4.3 hours for MP197HB casks) from entry of the cask railcar into the CHB, to the point where the cask has been placed on the transfer skid and the overhead crane can be relocated to the south end of the CHB. For the NAC systems, eight hours bounds the approximate time (5.5 hours for NAC-STC casks, 6.5 hours for NAC-UTC casks, and 8 hours for NAC-MAGNATRAN casks) from entry of the cask railcar into the CHB, to placement of the canister on the Canister Transfer Facility pad, at which point the overhead crane will no longer be overhead or adjacent to the cask on the railcar. Estimated time to perform cask receipt and transfer activities are provided as occupancy times in the occupational collective dose tables in each cask model's respective Appendix, refer to Tables A.9-2, B.9-2, C.9-2, D.9-2, E.9-1, F.9-1, and G.9-1. Administrative controls will restrict the movement of the overhead crane such that it will remain in the south-most bay of the CHB once railcar unloading has been completed. Administrative controls will prohibit additional non-empty casks on railcars inside the CHB, and thus adjacent to the crane, until the previous cask has been removed from the CHB and the next unloading evolution can proceed, weather conditions permitting. Similarly, for railcar loading operations following retrieval of a loaded canister, the loading process will not be permitted to proceed unless current and forecasted weather for the approaching eight hours indicate safe weather conditions. These actions eliminate the potential for collapse of overhead cranes onto canisters during receipt, transfer, and retrieval operations (with storage operations occurring outside the CHB).

A safe condition and forecast is considered to be the absence of: Tornado and Severe Thunderstorm Watches, Tornado and Severe Thunderstorm Warnings, and predicted wind speeds that would qualify for a Severe Thunderstorm Watch (58 mph or greater). Weather forecasts will be accessed from the NOAA Weather Forecast Office prior to each railcar loading/unloading. The nearest NOAA Weather Forecast Office to the CISF is the Midland/Odessa Office. Administrative controls triggered by the presence of Tornado and Severe Thunderstorm Watches, Tornado and Severe Thunderstorm Warnings, and predicted wind speeds that would qualify for a Severe Thunderstorm Watch ensure avoidance of atmospheric conditions which are favorable for the development of severe thunderstorms capable of producing tornados within the following eight hours.

This section describes loads, loading combinations and analysis methods to be met for design of the WCS CISF reinforced concrete and structural steel structures.

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Loads

Loads used in analysis and design of CHB structure include the following:

- D Dead load
- L Live load
- *C – Crane operating and lifted (hoist) loads*
- *S – Snow load*
- H lateral soil pressure load
- T_o Thermal load
- W Wind load
- *W_t Tornado load*
- F' Flood load
- E' Design Basis Earthquake seismic load

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Load Definitions

- **Dead Load** ***(D)*** **–** Defined as any load, including related internal moments and forces, that is constant in magnitude, orientation, and point of application. Dead loads include the mass of the structure, and any permanent equipment loads *including the overhead crane bridge and trolley weights*. *A* minimum uniform load allowance of 20 lb/ft^2 is applied to roof *and elevated platform* areas to account for miscellaneous electrical conduits, handrails and ladders for which the actual dead load contribution is not precisely known at the time the analysis or design is performed.
- **Live Load** ***(L)*** – Defined as any normal load, including related internal moments and forces that may vary with intensity, orientation and/or location of application. Movable equipment loads, *other than crane loads,* loads due to vibration and any support movement effects and operating load are types of live loads. The following descriptions provide design requirements for various types of live loads.

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  - **Transportation Vehicle Loads and Heavy Floor Loads** – Loads due to vehicular truck and rail traffic in designated building areas are in accordance with standard loadings defined by the American Association of State Highway and Transportation Officials (AASHTO) and by the American Railway Engineers Association. Special heavy loading conditions resulting from transport of SNF and storage casks on truck and rail transporters/carriages are considered. Design basis cask weights bound the worst-case condition of all vendor designs handled at the WCS CISF. Floor loadings from transportation, transfer and storage mode casks are also considered, along with sufficient allowance for any impact resulting from placing the moving loads on the floor or other areas of the structure. Within the building, the floor under the

Canister Transfer System will be designed to handle the specific loads produced by the hydraulic gantry system.

- **Floor Live Loads** – A floor live load of 300 lb/ft^2 is applied in areas of heavy *equipment* operation in the CHB. *Live load for stairs, walkways, and platforms is 100 lb/ft^2.*

- ***Crane and Hoist Loads (C)*** *– Design loads for the CHB permanently installed cranes and hoists envelop the full rated capacity of the cranes, including allowances for impact loads and test load requirements. The rated capacity of each of the two overhead bridge cranes in the CHB is 130 tons. Crane test loads are considered in the design at 125% of the rated capacity of the cranes, increased by an additional 5% in accordance with ASME NOG-1-2015 Section 7423. Forces induced by crane movement are calculated in accordance with ASCE 7-16, as follows:*
  - *Vertical impact: 25% of maximum wheel loads (including lifted load and crane self-weight).*
  - *Lateral side thrust: 20% of the sum of the rated hoist capacity, plus the weight of the crane trolley and hoist.*
  - *Longitudinal traction: 10% of maximum wheel loads (including lifted load and crane self-weight).*

- ***Snow Load (S)*** *– As described in Chapter 3, the design live load due to rain, snow, and ice is 10 lb/ft^2, which is the ground snow load. Determination of roof snow and ice loads is in accordance with the requirements of ASCE 7-16.*

- **Hydrostatic Fluid Pressure Loads** – Are due to fluids held in internal building compartments, such as tanks. There are no reinforced concrete tanks in the [redacted]. All tanks located in the *CHB* are designed in accordance with mechanical equipment design criteria.

- **Soil Load (H)** – Based on the density of the soil and includes the effects of groundwater, see attachment E of the WCS CISF SAR Chapter 2. Since the WCS CISF site is a dry, relatively flat site and the CHB is a slab-on-grade structure, no groundwater or soil pressure loads are exerted on building structures. Therefore, determination of lateral soil pressure loads is not necessary for structural analysis or design.

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- ***Thermal Load (T_o)*** – *Consists of thermally induced forces and moments resulting from operation and environmental conditions affecting the CHB. The design temperature changes (ΔT) used for structural analysis and design of the CHB are the differences between expected construction temperatures and winter or summer operating temperatures, assuming the building is unheated and without air conditioning. The temperatures considered for these ΔT calculations are based on data for Midland, Texas in Technical Report No. 65, Expansion Joints in Buildings, which include a 66°F mean temperature during construction, a summer operating temperature of 100°F (exceeded, on average, only 1% of the time between June and September), and a winter operating temperature of 19°F (exceeded, on average, 99% of the time between December and February). This results in a positive ΔT of 34°F and a negative ΔT of 47°F for consideration in the CHB analysis. In accordance with NUREG-1536 and ANSI/ANS 57.9, thermal loads are not combined with tornado or seismic loads given that the CHB thermal loading is self-limiting and will be relieved during response of the structure to these extreme loading conditions.*

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- ***Wind Loads (W)*** – *Are those pressure loads generated by the design (or "normal") wind. The basic wind speed used to determine design wind loads on the CHB walls and roof is 116 miles per hour. Design wind loads are determined in accordance with the requirements of ASCE 7-16 [7-69], which consider ultimate strength level (limit state) wind speeds rather than service level wind speeds. The resulting pressures are intended for use with unity (1.0) LRFD wind load factors in the steel and concrete design load combinations. Wind loading conditions applicable to the CHB Main Wind Force Resisting System are determined in accordance with the Directional Procedure given in ASCE 7-16, Chapter 27 Part 1. Internal pressure coefficients are based upon an enclosed structure, given use of rated doors and operational protocols to shut all CHB doors during inclement weather. Design velocity pressures (q_z) are determined using ASCE 7-16 Equation 26.10-1:*

$$q_z = 0.00256 K_z K_{zt} K_d K_e V^2$$

where:

K_z = velocity pressure exposure coefficient, equal to 1.18 for Exposure Category C and eave height of 73 feet above ground

K_{zt} = topographic factor, taken as 1.0

K_d = wind directionality factor, equal to 0.85 for Building Main Wind Force Resisting System

K_e = ground elevation factor, taken as 0.9 for site elevation of approximately 3500 feet

V = basic wind speed, equal to 116 mph for the WCS CISF site.

Assessment of the site soil properties and the CHB dynamic response indicates that Soil-Structure Interaction (SSI) effects are minimal, such that the criteria of ASCE 4-16, Section 5.1.1 can be applied to justify fixed-base analysis in lieu of detailed SSI analysis. Section 5.1.1(a) permits seismic response analysis without consideration of soil-structure interaction (i.e., fixed-base analysis) if the frequencies of a rigid structure supported on soil springs representing site-specific soil properties are more than twice the dominant frequencies of the actual structure. This condition is present for the CHB, given the stiff soils at the WCS CISF site and the relatively low dominant structural frequencies of the updated CHB design. Soil spring frequencies calculated for the soils are larger than twice the primary lateral response frequencies of the CHB, as determined from analysis of the CHB framing arrangement and structure mass. Therefore, fixed-base analysis is performed, utilizing the surface Design Response Spectra (DRS) developed in the Probabilistic Seismic Hazard Analysis for the WCS CISF (discussed in SAR Chapter 2).

Fixed-base analysis neglecting SSI effects is further justified by the separation between the frequency range of the amplified portion of the DRS (approximately 6-20 Hz) and the dominant structural frequencies (less than 4 Hz). ASCE 4-16, Sections 5.1(b) and C5.1.1 indicate that this assessment is a prerequisite for considering a fixed-base analysis in accordance with Section 5.1.1. Regarding the additional fixed-base analysis criteria in ASCE 4-16, Section 5.1.1(b) related to embedment effects, the CHB will be founded on shallow mat foundations in accordance with the geotechnical report recommendations (SAR Attachment E), such that embedment effects will not be significant. Finally, the criterion in ASCE 4-16, Section 5.1.1(c), which requires SSI analysis in all cases where wave incoherency effects are to be considered, is not applicable to the CHB analysis. In accordance with the provisions in ASCE 4-16, Section 5.1.10, ground motion incoherency is conservatively neglected for WCS CISF structures.

For further discussion of CHB seismic load development, see Sections 7.5.3.3.3 (steel building) and 7.5.3.6 (overhead cranes).

7.5.3.2.2 Structural Steel Load Combinations

Structural steel load combinations applicable to the CHB are based on the LRFD load combinations given in ANSI/AISC N690-18, with the following three basic assumptions:

1. *The design-basis seismic load case discussed above (E) is utilized where the safe-shutdown earthquake load (SSE) appears in the ANSI/AISC N690-18 load combinations. Load combinations with operating-basis earthquake loads applicable to nuclear power plant SSCs are not applicable to CHB design.* RAI NP-7-12

2. *As previously stated, self-limiting operating thermal loads are not combined with tornado or seismic loads, in accordance with ANSI/ANS 57.9.*

3. *Since wind loads are developed per ASCE 7-16 using ultimate wind speeds, use of a 1.0 load factor on the wind load case (W) is appropriate in the severe environmental load combinations.*

4. *Crane load (C) is included with normal wind load (W) and seismic load, but is neglected with tornado loads (W_t) given the aforementioned crane administrative controls for tornado warnings. This is in accordance with ANSI/AISC N690-18 Equations NB2-4 and NB2-7.*

5. *For uplift load combinations, 90% of dead load is considered in conjunction with 100% of operating crane loads with a destabilizing effect (i.e., crane vertical impact, side thrust, and longitudinal traction loads). This is in accordance with ANSI/AISC N690-18 Section NB2.5d(4).*

The following are structural steel design load combinations that result from these assumptions, when reduced to contain only the load cases previously defined as applicable to the CHB:

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1. $1.4D + C + T_o$
2. $1.2D + 1.6L + 1.4C + 0.5S + 1.2T_o$
3. $1.2D + 0.8L + 1.4C + 1.6S + 1.2T_o$
4. $1.2D + W + 0.8L + C + 0.5S + T_o$
5. $D + 0.8L + C + E$
6. $D + 0.8L + W_t$
7. $0.9D + C + W$
8. $0.9D + C + E$
9. $0.9D + W_t$

7.5.3.2.3 *Reinforced Concrete Load Combinations*

Reinforced concrete load combinations applicable to the CHB foundations and floor slab are based on the load combinations given in ACI 349-13 [7-68], with similar assumptions to those applied to the structural steel load combinations:

1. *The design-basis seismic load case discussed above (E) is utilized where the safe-shutdown earthquake (SSE) load appears in the ANSI/ACI 349-13 load combinations. Load combinations with operating-basis earthquake loads are not applicable.*

2. *As previously stated, self-limiting operating thermal loads are not combined with tornado or seismic loads, in accordance with ANSI/ANS 57.9.*

3. *Since wind loads are developed per ASCE 7-16 [7-69] using ultimate wind speeds, use of a 1.0 load factor on the wind load case is appropriate in the concrete load combinations.*

4. *For consistency with the CHB steel design load combinations, crane load (C) is included with normal wind load (W) and seismic load but is neglected with tornado loads (W_t) given the aforementioned crane administrative controls for tornado warnings.*

5. *For uplift load combinations, 90% of dead load is considered in conjunction with 100% of operating crane loads with a destabilizing effect (i.e., crane vertical impact, side thrust, and longitudinal traction loads).*

The following are concrete design load combinations that result from these assumptions, when reduced to contain only the load cases previously defined as applicable to CHB concrete structures:

1. $1.4D + T_o$
2. $1.2D + 1.6L + 1.4C + 0.5S + 1.2T_o$
3. $1.2D + 0.8L + 1.4C + 1.6S$
4. $1.2D + 1.6L + W + C$
5. $D + 0.8L + C + E$
6. $0.9D + C + W$
7. $0.9D + C + E$
8. $0.9D + W_t$

7.5.3.2.4 Overhead Crane Load Combinations

Crane Load combinations applicable to the design of the overhead bridge cranes are developed in accordance with ASME NOG-1 Section 4140. The design-basis seismic load (E) discussed above is considered in the safe-shutdown earthquake (SSE) load case in the ASME NOG-1 extreme environmental load combinations.

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7.5.3.3 CHB Steel Building Structural Analysis

To evaluate the performance of the CHB steel framing shown in Figures 7-54 through 7-61, the building is modeled in a detailed three-dimensional structural analysis model and subjected to all of the applicable design load cases and load combinations defined above in Sections 7.5.3.2.1 and 7.5.3.2.2. The assumption of linear elastic response for static, seismic, and tornado wind loads permits separate analysis of each loading condition and superposition of applicable load case member forces and moments to determine total load combination demands for evaluation vs. code defined member capacities.

In accordance with ANSI/AISC 360-16 Chapter C (as referenced by ANSI/AISC N690-18 Chapter NC), the First-Order Analysis Method is used to address stability analysis requirements. The CHB meets AISC limitations for use of this method, since the lateral system consists of a highly redundant braced frame with minimal second-order deformations (P-Δ). This method is also considered the most appropriate approach for dynamic analysis of the CHB. The member stiffness reductions required by other stability methods, such as the Direct Analysis Method, would result in unrealistic modal responses for the CHB braced frames, as the columns and struts are expected to remain elastic under design basis seismic loading. In addition, the Direct Analysis Method requires second-order, nonlinear analysis, which is not compatible with the modal response superposition performed in both the CHB seismic and tornado missile analyses.

7.5.3.3.1 CHB Steel Building Structural Analysis Model

Figure 7-62 shows an isometric view of the three-dimensional finite element analysis model generated in program STAAD.Pro (STAAD). The STAAD version utilized is the CONNECT Edition, Version 22.01.00.38, which is verified and validated under an ASME NQA-1 compliant quality program.

The global coordinate system for the CHB STAAD model is defined with positive X eastward, positive Y upward, and positive Z southward. The global boundary conditions modeled in all static and dynamic loading cases in STAAD consist of pinned supports at the base of each column. Each pinned base restrains the global UX, UY, and UZ translations, as well as ROTY rotations for analysis stability. The pinned base nodes are modeled at the bottom of column base plate elevation. Local boundary conditions applicable to individual members typically involve pinned member end releases (local ROTY and ROTZ) for all beams, vertical braces, and horizontal braces, as well as at the top of columns where they connect to the continuous roof truss chords.

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The model includes approximately 3100 nodes and 5800 beam elements, with the intent of sufficient refinement to provide an accurate assessment of structure response to static and dynamic loading. The STAAD beam elements are formulated with six degrees of freedom per node (three translations and three rotations) and with shear deformation effects included in the member stiffness matrix. STAAD utilizes a diagonal, lumped mass matrix approach, with mass terms at all active degrees of freedom. Since dynamic analysis is performed to evaluate the CHB for seismic and tornado missile loading, members with significant transverse loading between points of support (e.g., beams and girders) are subdivided into multiple beam elements to capture dynamic flexural responses while utilizing the STAAD lumped mass formulation. At a minimum, three intermediate nodes (four elements) are used for all beams and girders.

Member stiffness properties for all rolled shapes are assigned using built-in AISC section property tables provided in STAAD, while properties for built-up sections such as the crane runway girders are manually calculated and inputted. Bridge crane and trolley members are not modeled in the CHB STAAD model; rather, the mass of the bridge is proportionally distributed to the runway girders while the trolley and lifted load mass is distributed to the runways according to trolley position along the bridge. Other entities modeled only as applied mass include secondary framing members and elements, such as girts, purlins, siding, roofing, and floor deck.

Linear elastic, isotropic material properties are assigned for all steel members in the CHB analysis model, including elastic modulus (E), Poisson's ratio (ν), unit weight (γ), and coefficient of thermal expansion (α). See Table 15-2 for the material property values utilized.

7.5.3.3.2 Static Analysis

Static analyses are performed to determine member forces, column reactions, and structure deflections due to gravity loads, crane operating loads, and wind/tornado pressures. The overall dead (D), crane (C), wind (W), and tornado wind (W_t) load cases defined in Section 7.5.3.2 are subdivided into several separate static load cases as needed to develop design load combinations that include enveloping directional permutations. Separate static load cases are modeled and analyzed for structure dead load, live load, crane dead load, crane lifted load, and crane impact loads in each direction (vertical, lateral, and longitudinal). With regard to wind load (W), separate static load cases are modeled for each primary direction of wind loading (i.e., +X, -X, +Z, and –Z), each containing the associated windward, leeward, sidewall, and roof pressures. Internal pressures are also addressed in a separate static load case. These are then combined in accordance with the ASCE7-16 Directional Procedure, as discussed in Section 7.5.3.2. A similar approach is used for tornado wind pressures, with a separate static load case for each primary direction of wind pressure loads (W_w) and for atmospheric pressure change (W_p).

Static analysis is also performed for the operating thermal (T_o) load case to evaluate forces induced in the CHB due to restraint of building temperature changes between ambient construction and winter or summer operating temperatures, as discussed in Section 7.5.3.2.1. Two load cases are developed to apply uniform temperature changes (ΔT) to all CHB framing equal to +34°F and -47□F, as previously defined. In accordance with ANSI/ANS 57.9, the resulting forces and moments are combined with gravity load cases within normal operating load combinations, but are not applied for extreme environmental conditions.

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7.5.3.3.3 Seismic Analysis

The seismic response of the CHB is evaluated using modal response spectrum analysis, in accordance with ASCE 43-05 and ASCE 4-16. The input response spectra for the analysis are developed from the site-specific response spectra generated by the PSHA for the WCS CISF site (discussed in SAR Chapter 2).

Evaluation of Soil Structure Interaction Effects

Per ASCE 43-05 Section 3.1 and ASCE 4-16 Section 5.1(a), soil-structure interaction (SSI) effects must be considered. To evaluate the significance of SSI effects for the CHB, an assessment of site soil properties and dominant structural frequencies is performed in accordance with ASCE 4-16 Section 5.1.1. This evaluation entails calculation of soil frequencies based on a single degree-of-freedom system consisting of the lateral, vertical, torsional, or rocking soil spring and the relevant mass or mass moment of inertia for the overall CHB. The mass of the embedded CHB foundation is neglected in this calculation. Equivalent soil spring stiffness terms are calculated in accordance with ASCE 4-16 Table 5-2, using strain-compatible shear modulus determined from the site PSHA at the elevation of foundation bearing (9 feet below grade). A minimum strain-compatible shear wave velocity at the depth of foundation bearing equal to 1,500 ft/second is assumed. Equivalent rectangular foundation dimensions are calculated on the basis of the combined contact areas of the three primary strip mat foundations as preliminarily sized. As shown in Table 7-42, all soil/structure frequency ratios exceed 2, in which case the CHB seismic analysis is permitted by ASCE 4-16 to be performed assuming fixed-base supports. The minimum ratio shown in Table 7-42 (2.1) pertains to the vertical response. The response frequency considered for this ratio is not associated with a dominant mode involving overall structural response. The mode involves the response of the loaded crane runway girder and has a small overall mass participation of approximately 10% in the vertical direction. There are also other modes involving vertical response of the crane system with similar frequencies and mass participation ratios.

7.5.3.3.4 Tornado Missile Impact Analysis

Refer to the discussion of Tornado Loads in Section 7.5.3.2.1 for an introduction to the Tornado Missile Impact Analysis.

The transient dynamic analysis performed in STAAD utilizes the mode superposition method of calculating structural response at each time step. Similar to the seismic response spectrum analysis, the Load-Dependent Ritz eigensolver is utilized, as it is more effective in capturing high frequency modes important to tornado missile response. A sufficient number of modes are extracted to capture more than 90% mass participation. A time step of 0.0001 seconds is considered for the transient analysis, which is well less than 1/20th of the shortest structural response period of interest, in accordance with industry practice. A constant modal damping ratio of 5% is assumed. The impulsive missile loading for the given impact location is applied as a nodal load with a rectangular load vs. time function that has a magnitude equal to that of the calculated impulsive force and a duration of 0.05 seconds. This duration is in accordance with guidance on automobile tornado missile impacts in UCRL-ID-115234, Title I Wind/Tornado Design Guidelines for New Production Reactors," Lawrence Livermore National Laboratory, September 1993. As maximum member forces are shown to occur within the first second of dynamic response, the total duration of the transient analysis is two seconds.

For each impact location of interest, a separate STAAD model is executed to perform static analyses for all other tornado wind, APC, and gravity load cases in the tornado load combinations, along with the mode superposition transient analysis for the single automobile impact case under consideration. Member demands are calculated in accordance with the design load combinations for each tornado missile impact model for all primary framing members in the STAAD model, and the envelope of all load combination demands from all models are considered in the member design checks.

7.5.3.4 CHB Steel Building Design

Design of the CHB steel framing is performed in accordance with the requirements of ANSI/AISC N690-18, which overlays additional requirements on the provisions of ANSI/AISC 360-16. This is in general accordance with the NUREG-1567 reference to ANSI/ANS 57.9, which in turn references ANSI/AISC N690-1984 for steel structure load combinations and design limits. ANSI/AISC N690 is considered for CHB design because it provides specific requirements for safety-related nuclear structures, including load combinations containing tornado loading. The 2018 version is utilized for compatibility with current national consensus codes and standards providing requirements for building structures (e.g., IBC 2016 and ASCE 7-16).

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With regard to seismic design, the CHB lateral force resisting system is evaluated in accordance with the design requirements and acceptance criteria given in ASCE 43-05. ASCE 43-05 identifies OCBFs as acceptable structural systems for use in nuclear facilities, and permits design of steel structures in accordance with LRFD requirements given in AISC specifications (AISC 360 or AISC N690), as modified by the AISC Seismic Provisions (see ASCE 43-05 Section 4.2.4.) Thus, the CHB OCBFs are designed to meet the system, member, and connection requirements given in ANSI/AISC 341-16, Section F1.

Both ASCE 43-05 and ANSI/AISC 341-16 ensure acceptable seismic performance of OCBF systems by requiring design of critical members and connections for larger seismic demands than those considered for vertical brace member design. In the design of the CHB OCBFs in accordance with ASCE 43-05, the full seismic force developed from the elastic analysis is considered for design of all members and connections except vertical brace members. The design seismic force for the vertical braces is taken as the elastic seismic demand divided by the specified System Inelastic Energy Absorption Factor ($F\mu s$; see ASCE 43-05 Section 5.1.2). For design of the CHB to Limit State C, the $F\mu s$ factor applicable to OCBF vertical bracing members is 1.5 (see ASCE 43-05 Table 5-1). The CHB has no weak or soft stories and its fundamental frequencies are less than the amplified acceleration region of the design response spectrum; therefore $F\mu s = F\mu$. Thus, design of the CHB per ASCE 43-05 ensures that inelastic response under seismic loading will first occur in the vertical braces, while the columns and beams are designed not to buckle under the design-basis seismic loads (i.e., those calculated in the elastic analysis with $F\mu = 1.0$).

7.5.3.4.1 <u>Member Design</u>

Design of the CHB structural steel framing confirms that no applicable strength or serviceability limit state is exceeded when the structure is subjected to the design load combinations. In terms of strength limit states, the design compares all individual and combined loading member demands calculated from the design load combinations evaluated in the STAAD analysis model with the corresponding LRFD design strengths. In accordance with ANSI/AISC N690-18, member design strengths are calculated per ANSI/AISC 360-16 Chapters D through H, without modification. In general, the design for each member and each applicable strength limit state confirms:

$$R_u \leq \phi R_n$$

where R_u is the required strength (load combination demand), R_n is the nominal strength, and ϕ is the applicable resistance factor defined in ANSI/AISC 360-16.

All Indicated Changes are in response to RAI NP-7-12

With regard to serviceability, seismic story drifts are confirmed to meet the drift ratio limit specified in ASCE 43-05 for concentrically braced frames designed to Limit State C, which is 0.005. Additionally, the crane runway girders are confirmed to have lateral and vertical deflections less than the serviceability limits specified in CMAA-70 (L/400 for lateral deflection and L/600 for vertical deflection) under service level loading conditions.

STAAD Code Checking

Member strength design checking is performed in accordance with ANSI/AISC 360-16 LRFD provisions using the code checking capabilities provided in STAAD. Code checks are executed for all analyzed members and all design load combination demands calculated in each STAAD analysis model. This includes the primary model executed to determine gravity, normal wind, and seismic load combination demands, and separate models executed to determine load combination demands due to the combined effects of tornado wind, APC, and tornado missile impacts at each of the locations considered. Within the primary model used for seismic analysis and design, additional load combinations applicable only to vertical brace member design are defined with seismic load case demands divided by $F_{\mu\sigma} = 1.5$.

Execution of ANSI/AISC 360-16 code checks within STAAD requires user entry of all applicable member design parameters required for calculation of member design strengths. This includes the specified minimum yield strength of the modeled members, equal to 50 ksi for all CHB members, and various parameters defining the unbraced lengths for each member. Unbraced length parameter inputs include the following:

- *K: Effective length factor, taken as 1.0 for all members in accordance with the First-Order Analysis Method (see AISC 360-10 Appendix 7.3).*
- *LX: Member unbraced length for torsional and flexural torsional buckling.*
- *LY / LZ: Member unbraced lengths for compression buckling about the member Y and Z axes.*
- *UNT / UNB: Unsupported lengths of member top and bottom flanges in flexural compression, for evaluation of lateral torsional buckling.*

STAAD performs member strength checks for the demands calculated at each end of every member, as well as at 11 equally-spaced points along the member length (1/12th points). The maximum Demand/Capacity Ratio (DCR) for any of these points is presented for each member in the STAAD postprocessor, along with the governing load combination and the governing ANSI/AISC 360-16 strength equation. The governing DCR for each CHB member is taken as the maximum DCR calculated in all STAAD CHB models.

All Indicated Changes are in response to RAI NP-7-12

It is noted that STAAD AISC code checking considers the limiting width-to-thickness (member slenderness) ratios defined for members subjected to axial compression and flexure in ANSI/AISC 360-16 Chapter B. However, the seismic ductility and slenderness limits specified in ANSI/AISC 341-16 are not evaluated in STAAD. In accordance with ANSI/AISC 341-16 Section F1.5, all OCBF vertical braces are confirmed in separate calculations to be moderately ductile and to have member slenderness ratios (L/r) less than $4\sqrt{(E/F_y)}$.

7.5.3.4.2 Connection Design

CHB structural steel framing connections utilize shop-welded and field-bolted detailing, to minimize field welding and field weld inspection. Design of CHB framing connections is performed in accordance with ANSI/AISC 360-16 Chapter J, as modified by ANSI/AISC N690 Chapter NJ, and AWS D1.1 and AWS D1.8 where required. The required strengths of connections are determined from all applicable design load combinations, including seismic and tornado load combinations. In addition to meeting the general requirements of ANSI/AISC 360-16, all primary lateral force resisting system connections are designed and detailed in accordance with the provisions applicable to OCBFs in ANSI/AISC 341-16. The following is a summary of applicable requirements implemented in the CHB design:

- *All bolts are high strength bolts installed with full pretension.*
- *Bolts and welds do not share the same force component in any connection.*
- *Bolts are installed in standard holes or in short slots perpendicular to the applied load.*
- *The available shear strength of bolted joints is calculated as that for bearing-type joints in accordance with ANSI/AISC 360-16 Chapter J.*
- *Faying surfaces are prepared to satisfy slip-critical connection requirements in ANSI/AISC 360-16 and are prepared to have a Class A slip coefficient or higher.*
- *The required strength of OCBF vertical brace connections is determined using the overstrength seismic loads, in accordance with AISC 341-16 Section F1.6a. This requirement is met by designing for $F_\mu = 1.0$ seismic demands, in accordance with ASCE 43-05.*
- *All OCBF welded connections are detailed and installed in accordance with the applicable requirements of AWS D1.1 and D1.8 as required.*
- *Column base connections and splices are designed for the required axial, shear, and flexural forces defined in ANSI/AISC 341-16 Sections D2.5 and D2.6.*
- *The available strengths of concrete and reinforcing steel utilized in column base anchorage to the foundation are determined in accordance with ACI 349-13.*

7.5.3.5 Reinforced Concrete Structural Analysis and Design

Analysis and design of the CHB reinforced concrete foundations is performed in accordance with the requirements of ACI 349-13, considering all design load combinations defined in Section 7.5.3.2.3. This is in general accordance with the NUREG-1567 reference to ANSI/ANS 57.9, which in turn references ACI 349-85 for concrete load combinations and design limits. Design of CHB column baseplate anchorage is in accordance with the requirements of ACI 349-13 Appendix D.

Material properties considered in foundation analysis and design, including specified strengths for structural concrete, reinforcing steel, anchor rods, and steel plate (utilized for baseplate shear lugs) are summarized in Table 15-2. Soil properties considered in foundation design are those specified in the project geotechnical report (SAR Attachment E). This includes an allowable bearing pressure of 3000 lb/ft^2 and a subgrade modulus of 150 lb/in^3. As stated in the geotechnical report, the allowable bearing pressure is permitted to be increased to 4000 lb/ft^2 (33% increase) for load combinations that include transient loads (such as wind, seismic, and tornado loads). The unit weight of structural fill considered in foundation stability calculations is assumed to be 110 lb/ft^3.

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Foundation stability is evaluated for the west strip mat foundation, which is considered representative of all three strip mats. The east and west strip mats have a narrower plan dimension in the east-west direction than the center strip mat, while the west strip mat has somewhat less applied dead load with fewer crane columns than the east strip mat. A minimum factor of safety of 1.5 is required for sliding and overturning when evaluated for the stability load combination containing normal wind and crane operating loads in Section 7.5.3.2.3 (load combination #6). For the seismic and tornado uplift load combinations (#7 and #8 in Section 7.5.3.2.3), the minimum factor of safety for sliding and overturning is 1.1. This is in accordance with ASCE 43-05 Section 7.2 for seismic stability.

7.5.3.6 Overhead Crane Analysis and Design

To ensure the CHB overhead cranes can withstand design-basis seismic loading and will not fall and damage ITS equipment, the cranes are analyzed and designed as Type 1, single-failure-proof cranes in accordance with ASME NOG-1. NUREG-0800 Section 9.1.5, Subsection I.4.C, states that an acceptable approach for ensuring overhead crane safety is to comply with NUREG-0554, and that design in accordance with NOG-1 criteria for Type 1 cranes is an acceptable method of compliance with NUREG-0554. Type 1 criteria require the cranes to be designed to ensure that any credible failure involving a single component does not result in loss of capability to stop and hold the critical load. In the case of the CHB overhead cranes, the critical load is conservatively considered as the rated crane capacity (130 tons).

RAI NP-7-1

In accordance with ASME NOG-1-2015 Section 4150 [7-70], seismic demands on the cranes are determined from modal response spectrum analysis of a three-dimensional finite element model meeting all requirements of Section 4153, including requirements for model geometry, boundary conditions, and trolley and hook positions. Input to the response spectrum analysis consists of broadened in-structure response spectra (ISRS) computed in each of three directions at the crane support level of the CHB. The crane-level ISRS are developed from coupled analysis of the building and crane, in accordance with the requirements of ASCE 4-16 [7-71], Section 3.7. For response spectrum analysis of the crane in the vertical direction, the crane model includes the mass of the credible critical load, defined by NOG-1 as the lifted load with a probability of occurrence in conjunction with the Design Basis Earthquake (DBE) greater than or equal to 10-7. For analysis of CHB ITS structures, the DBE return period is 10,000 years (1x10-4 annual probability) and the expected number of rated load lifts per year, per crane is approximately 200, with an assumed duration of two hours per lift. As the combined probabilities of both cranes lifting a rated load in conjunction with the DBE exceeds 10-7, the rated load is considered as the credible critical load for seismic analysis of the cranes. For response spectrum analysis in the horizontal directions, response of the lifted load mass is addressed in accordance with NOG-1 Section 4153.3 criteria for separation between the frequency of pendulum motion and the fundamental horizontal frequencies of the crane. All operational hook positions are considered when calculating the pendulum frequency of the lifted load.

Normal operating crane loads, including dead loads of trolley and bridge, lifted loads, and crane impact/inertial forces, are developed in accordance with NOG-1 Section 4130. Combinations of normal operating loads and seismic loads are developed in accordance with NOG-1 Section 4140, with the DBE seismic loads discussed above considered in the Safe-Shutdown Earthquake (SSE) load case in the extreme environmental load combinations. As discussed above, the credible critical load for seismic load combinations is the rated load.

RAI NP-7-1

7.5.3.7 *Not Used.*

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7.5.3.8 On-Site Accidents

WCS CISF-initiated explosions are not considered credible since insufficient explosive materials are present to initiate an event that would result in the destruction of the building. During operations, the amount of flammable liquids that are in the CHB will be administratively controlled to ensure the amount of flammable liquids is maintained below the fire load limits for the respective systems (e.g., 300 gallons of diesel fuel *equivalent* for NUHOMS® *and 50 gallons of diesel fuel equivalent for the NAC-MPC, NAC-UMS, and MAGNASTOR Systems*). In combination with fuel limitations and a fire suppression system, the fire hazard for the building is adequately mitigated (see WCS CISF SAR Section 3.3.6).

7.5.3.9 Off-Site Accidents

Off-site accidents are addressed in WCS CISF SAR Section 12.2.2.

7-58 Nuclear Energy Institute (NEI), "Consistent Site-Response/Soil-Structure Interaction Analysis and Evaluation," June 2009.

7-59 Deleted.

7-60 Deleted.

7-61 ANSI/AISC N690-06, "Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures in Nuclear Facilities."

7-62 ANSI/AISC 360-05, "Specification for Structural Steel Buildings."

7-63 APA Consulting Computer Code SASSI, Version 1.0.

7-64 ASCE 7-10, "Minimum Design Loads for Buildings and Other Structures."

7-65 ANSYS Computer Code and User's Manual, Version 16.0.

7-66 Calculation AREVATN001-CALC-002, Rev. 0 "Soil Structure Interaction Analysis of TN Independent Spent Fuel Storage Installation (ISFSI) Concrete Pad at Andrews, TX."

7-67 Calculation AREVATN001-CALC-001, Rev. 1 "ISFSI Pad Design for WCS at Andrews, Texas."

7-68 ACI 349-13, "Code Requirements for Nuclear Safety-Related Concrete Structures and 731Commentary."

7-69 ASCE 7-16, "Minimum Design Loads for Buildings and Other Structures."

7-70 ASME NOG-1-2015, "Rules for Construction of Overhead Gantry Cranes (Top Running Bridge, Multiple Girder)," The American Society of Mechanical Engineers, 2015.

7-71 ASCE/SEI 4-16, "Seismic Analysis of Safety-Related Nuclear Structures," American Society of Civil Engineers, 2016.

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Table 7-41
Cask Handling Building Primary Framing Member Sizes

Structural Element	*Member Size Class*
Main Building Columns	*W14*
Crane Columns	*W14*
Wind Columns	*W14*
Wind Column Vertical Truss Web Members	*2L8x8*
North-South Struts	*W14, W18*
East-West Struts	*W12, W16*
East-West Vertical Braces	*HSS8.625 (round)*
North-South Vertical Braces	*HSS9.625, HSS5.5 (round)*
Intermediate Level Horizontal Braces	*WT*
Primary Roof Truss Chords	*W14*
Secondary Roof Truss Chords	*W14*
Primary Roof Truss Web Diagonal Members	*2L5x5*
Secondary Roof Truss Web Diagonal Members	*2L8x6*
Interior Roof Truss Web Vertical Members	*2L3.5x3.5*
Exterior Roof Truss Web Vertical Members	*W8*
Primary Roof Horizontal Braces	*HSS7x7 (square)*
Secondary Roof Horizontal Braces	*WT*

All Indicated Changes are in response to RAI NP-7-12

Table 7-42
Cask Handling Building Evaluation of Soil and Structural Dominant Frequencies

Mode	*Soil Frequency, f_{soil} (Hz)*	*CHB Fixed-Base Dominant Frequency, f_{CHB} (Hz)*	*Ratio f_{soil}/f_{CHB}*
Horizontal, E-W (X)	*18.7*	*3.5*	*5.3*
Horizontal, N-S (Z)	*18.1*	*4.0*	*4.5*
Vertical (Y)	*20.8*	*10.1*	*2.1*
Rocking in E-W direction (about Z)	*14.7*	*4.6*	*3.2*
[redacted]	*24.4*	*4.0*	*6.1*
Torsion	*25.2*	*5.0*	*5.0*

All Indicated Changes are in response to RAI NP-7-12

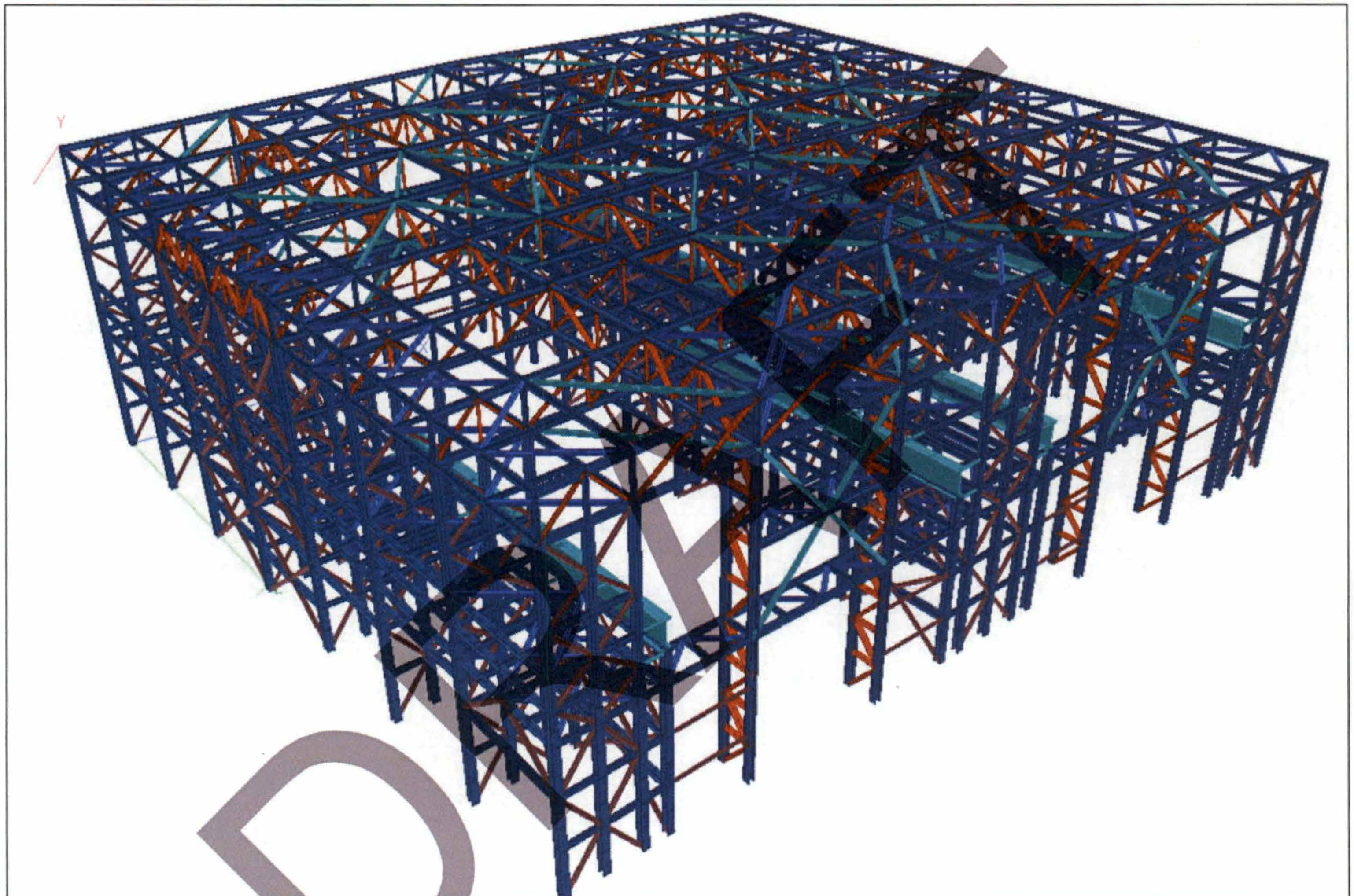

Figure 7-54
Isometric View of Cask Handling Building Structural Steel Framing

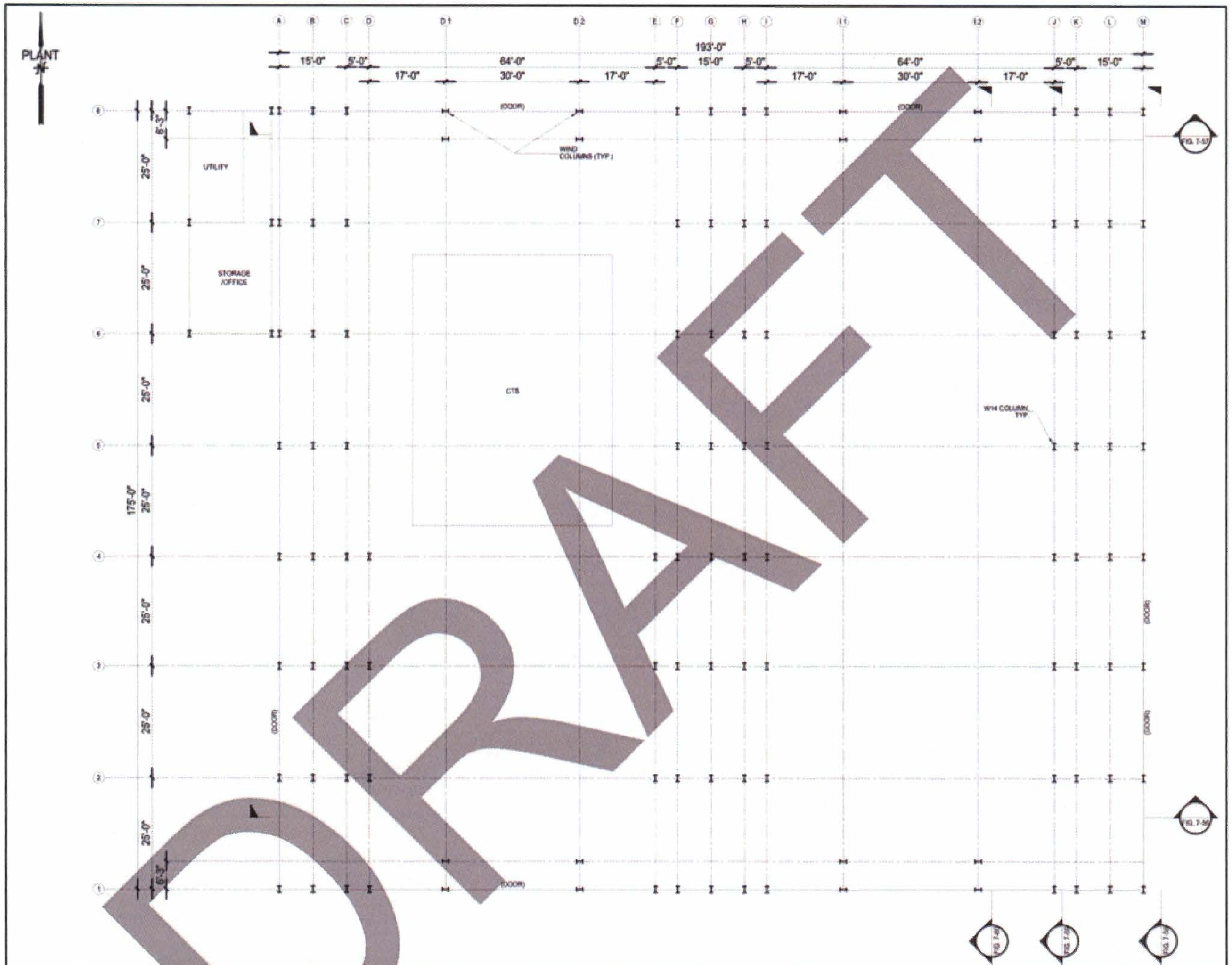

Figure 7-55
Plan View of Cask Handling Building Structural Steel Framing Arrangement, at Grade Level (Elevation 100'-0")

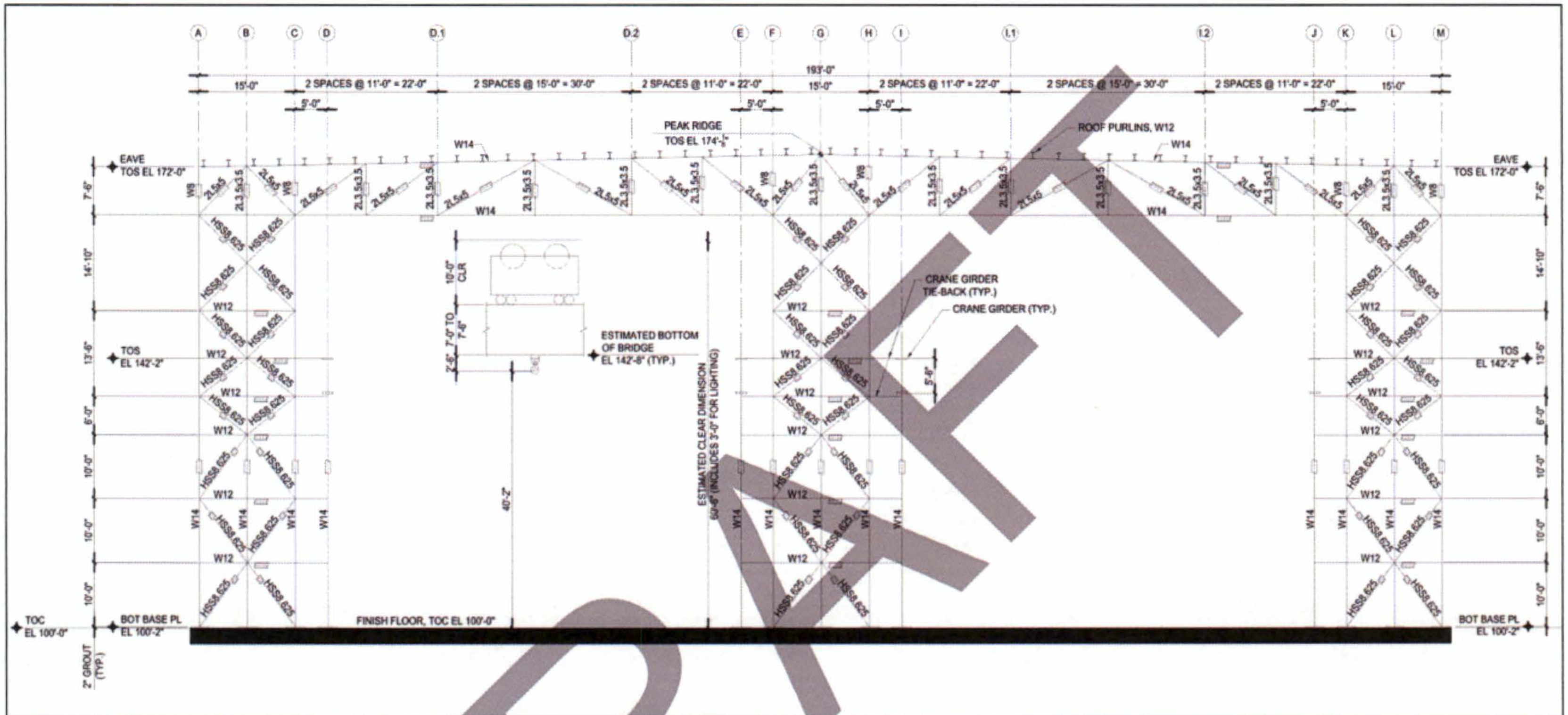

Figure 7-56
Cask Handling Building Structural Steel Framing Arrangement, Typical Interior Section (Looking North)

All Indicated Changes are in response to RAI NP-7-12

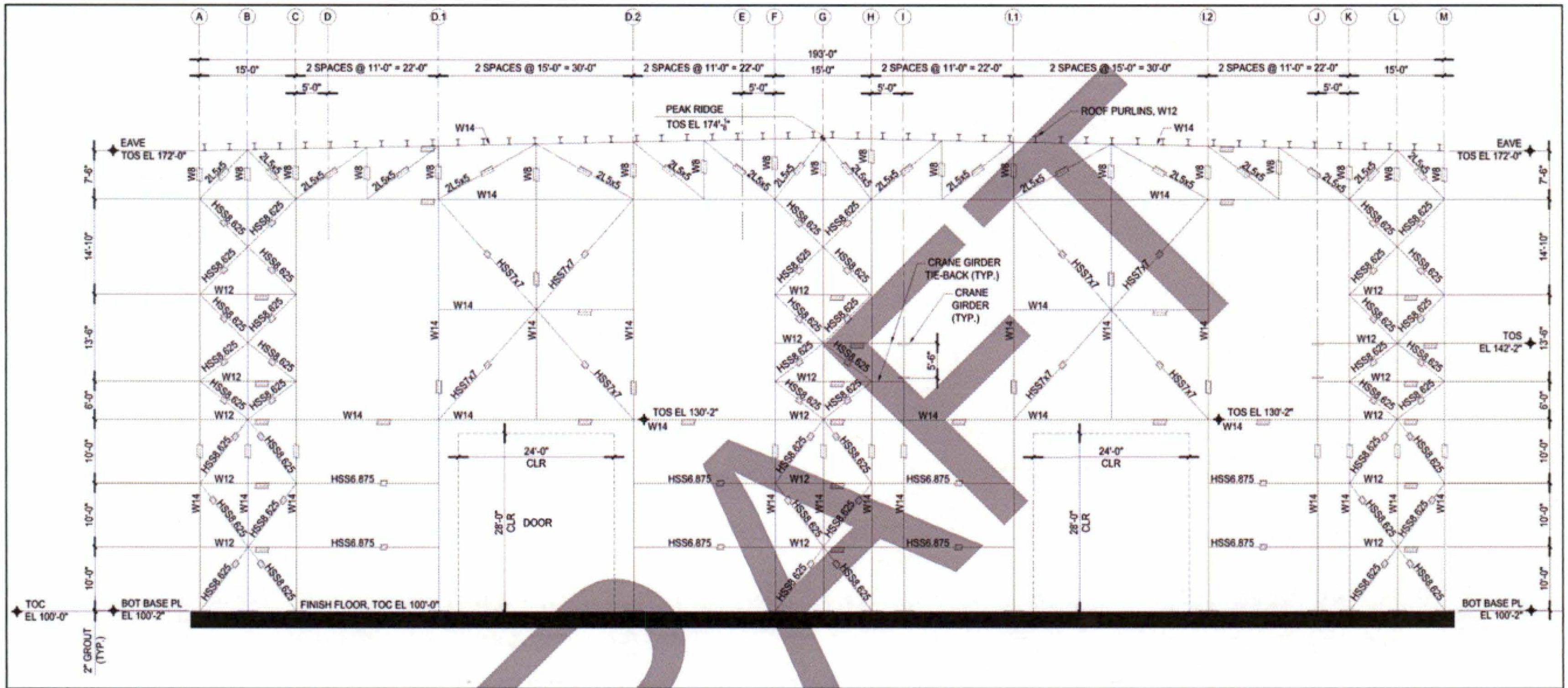

Figure 7-57

Cask Handling Building Structural Steel Framing Arrangement, Section at North Exterior Frame (Looking North)

All Indicated Changes are in response to RAI NP-7-12

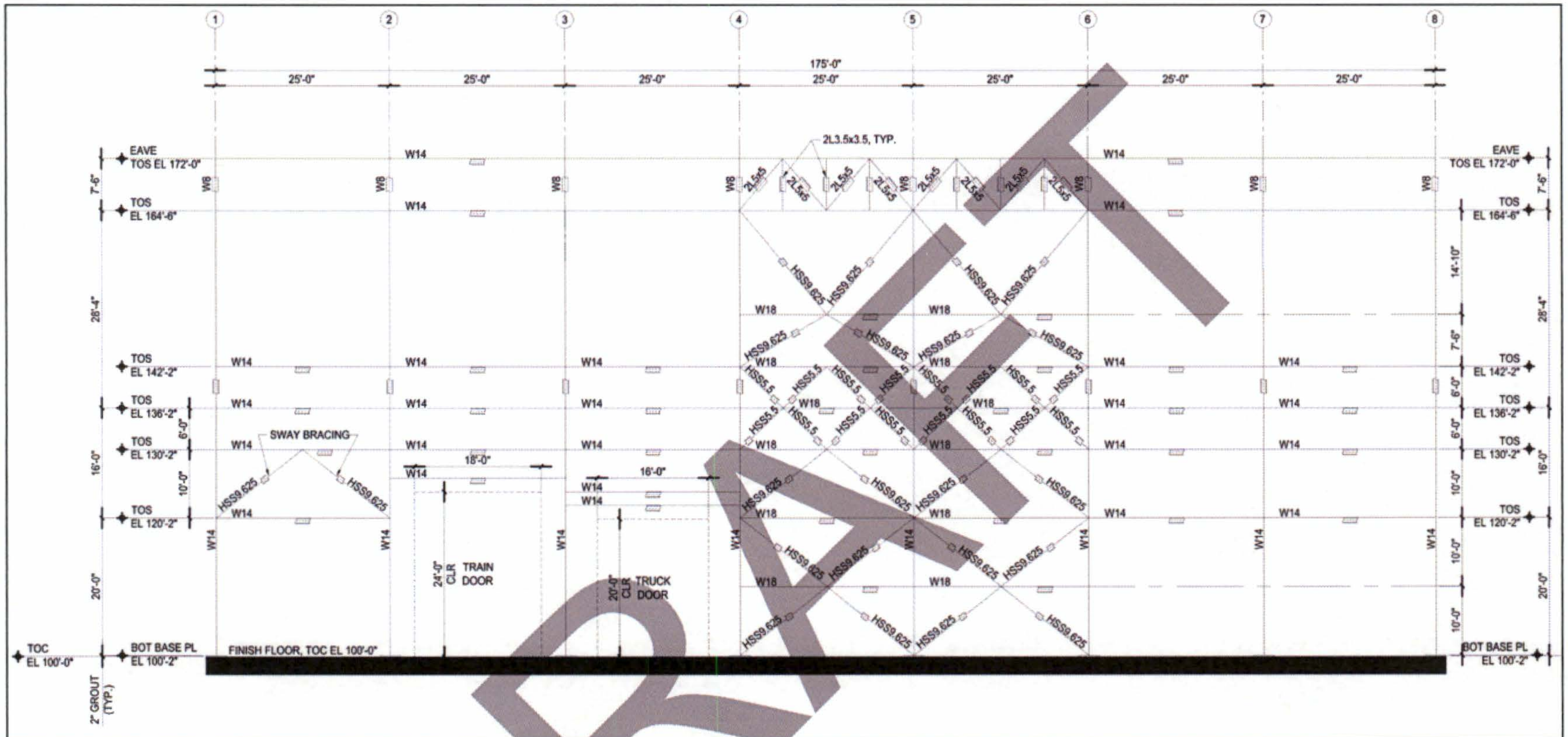

Figure 7-58

Cask Handling Building Structural Steel Framing Arrangement, Typical Section at Main Building Column Line (Looking West)

All Indicated Changes are in response to RAI NP-7-12

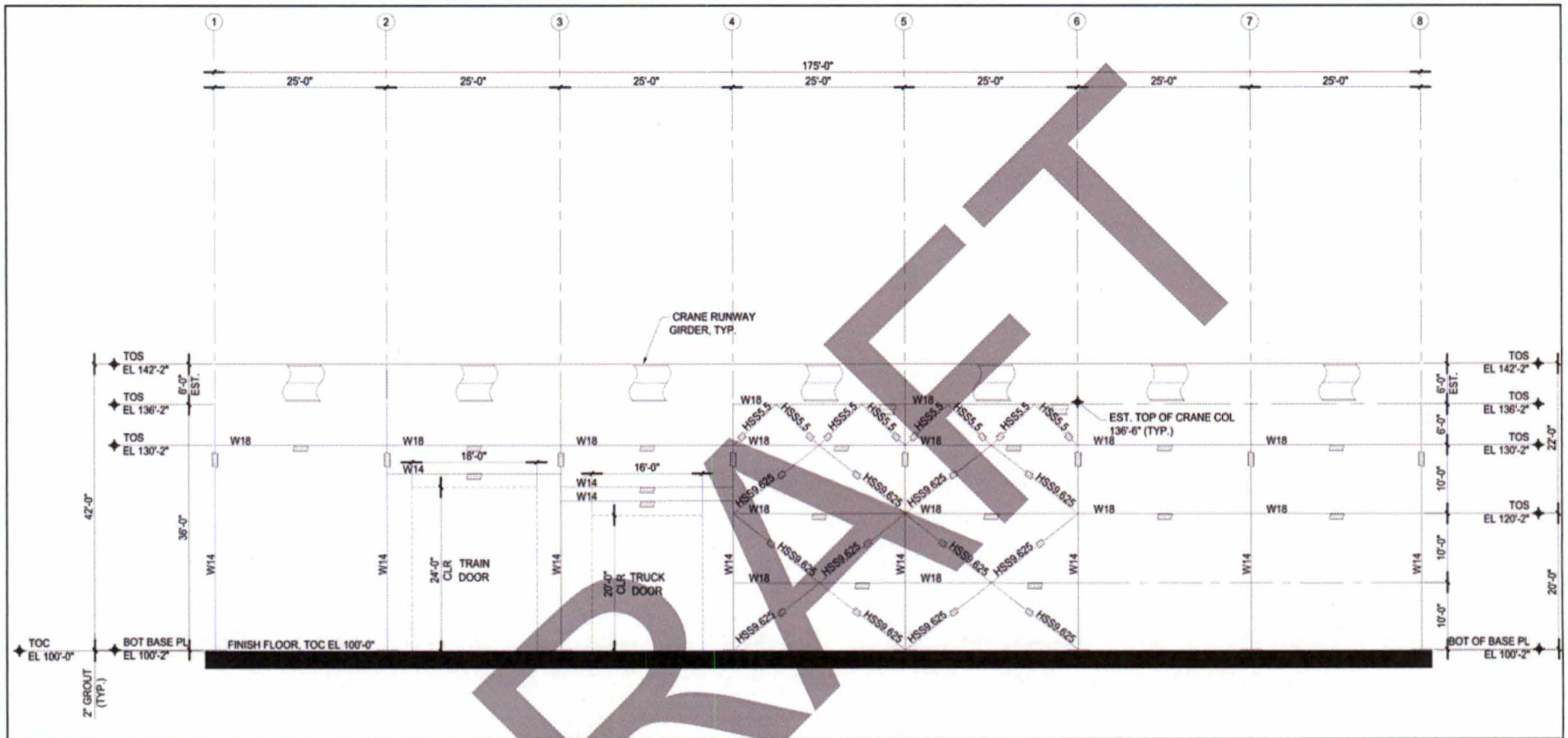

Figure 7-59
Cask Handling Building Structural Steel Framing Arrangement, Typical Section at Crane Column Line (Looking West)

All Indicated Changes are in response to RAI NP-7-12

Figure 7-60
Cask Handling Building Structural Steel Framing Arrangement, Typical Section at Wind Column Line (Looking West)

All Indicated Changes are in response to RAI NP-7-12

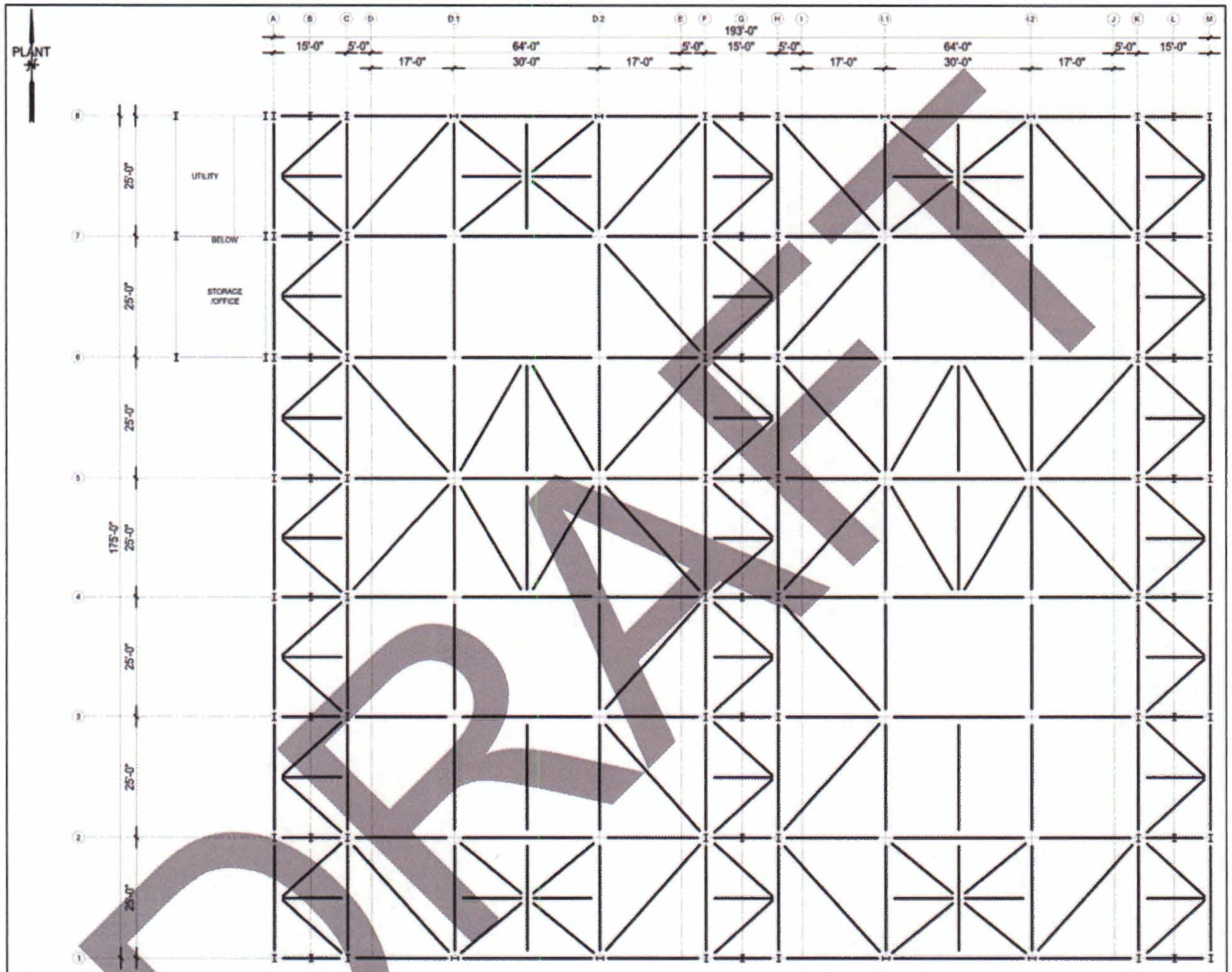

Figure 7-61
Cask Handling Building Structural Steel Framing Arrangement, Plan View at Roof Top Chord (Bottom Chord Similar)

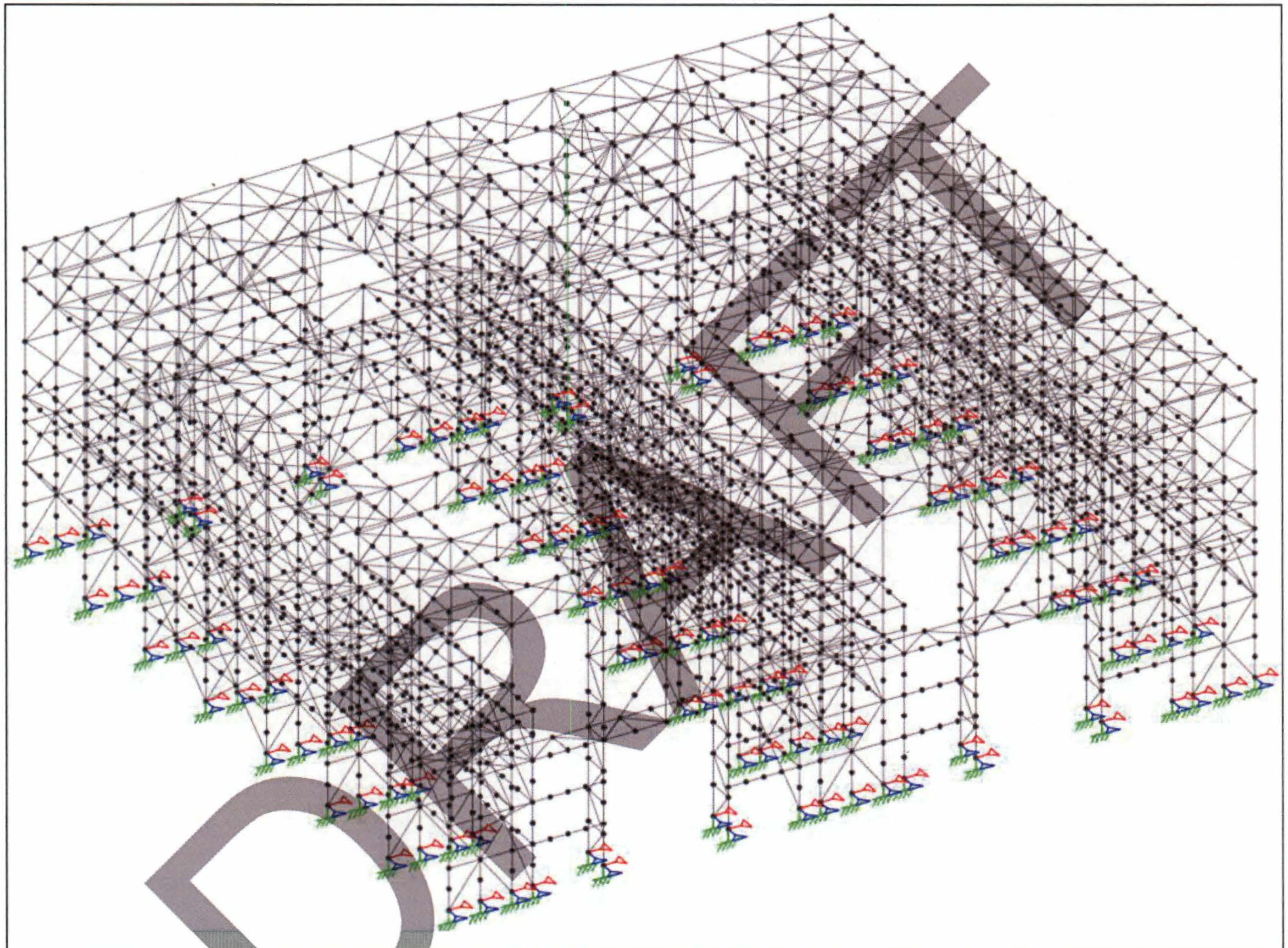

Figure 7-62
Cask Handling Building 3D STAAD.Pro Finite Element Model

All Indicated Changes are in response to RAI NP-7-12

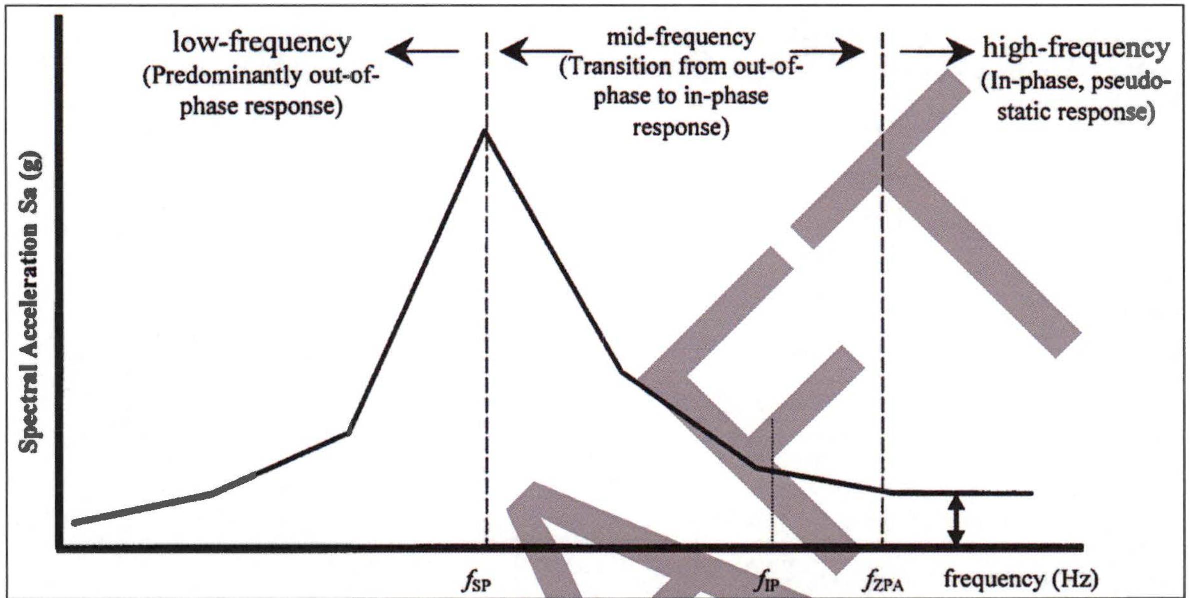

Figure 7-63
Generalized Acceleration Response Spectrum

All Indicated Changes are in response to RAI NP-7-12

Because only previously loaded canisters will be accepted at the WCS CISF the following topics identified in ISG-15 are remain unchanged from what has been previously reviewed and approved by the US NRC in the applications incorporated by reference listed in Section 1.6.

- Material Properties
- Weld Design and Inspection
- Galvanic and Corrosive Reactions
- Bolt Applications
- Protective Coatings and Surface Treatments
- Neutron Shielding Materials
- Materials for Criticality Control
- Seals
- Low Temperature Ductility of Ferritic Steels
- Fuel Cladding, including burnup and cladding temperature limits
- Prevention of Oxidation Damage During Loading of Fuel
- Flammable Gas Generation
- Canister Closure Weld testing and Inspection

15.1.5 Cask Handling Building

The materials used in the construction of the Cask Handling Building are given in Table 15-1.

15.2.2.2 AHSM

The reinforced concrete AHSM is designed to meet the requirements of ACI 349-97. Load combinations specified in ANSI 57.9-1984, Section 6.17.3.1 are used for combining normal operating, off-normal, and accident loads for the AHSM.

15.2.2.3 HSM Model 102

The HSM Model 102 reinforced concrete is designed to meet the requirements of ACI 349-85 and ACI 349-97 Editions, respectively. Load combinations specified in ANSI 57.9-1984, Section 6.17.3.1 are used for combining normal operating, off-normal, and accident loads for the HSM.

15.2.2.4 NAC-MPC VCC

The American Concrete Institute Specifications ACI 349 (1985) and ACI 318 (1995) govern the NAC-MPC system VCC design and construction, respectively.

15.2.2.5 NAC-UMS VCC

The American Concrete Institute Specifications ACI 349 (1985) and ACI 318 (1995) govern the NAC-UMS system VCC design and construction, respectively.

15.2.2.6 MAGNASTOR VCC

The American Concrete Institute Specifications ACI-349 (1985) and ACI-318 (1995) govern the MAGNASTOR system VCC design and construction, respectively.

15.2.3 Transfer Casks for Vertical Systems

The ANSI N14.6 (1993) and NUREG-0612 govern the NAC-MPC, NAC-UMS and MAGNASTOR system transfer cask designs, operations, fabrication, testing, inspection, and maintenance.

15.2.4 Cask Handling Building

Materials for Cask Handling Building steel structures will be constructed to ANSI/AISC 360-16. Materials for the Cask Building Overhead Cranes will adhere to NOG-1-2015 fracture toughness requirements. The reinforced concrete structures in the Cask Handling Building are designed to ACI 349-13 and constructed to ACI 318-08.

All Indicated Changes are in response to RAI NP-7-12

Coefficient of Thermal Expansion, α (x 10^{-6} in/in/°F)	5.9
Density (lbm/in^3)	0.29

15.3.4 Cask Handling Building

The Cask Handling Building is built with the use of reinforced concrete for foundation and slab, and structural steel members for above-ground structure.

The specifications and details that apply to these materials are given in Table 15-2.

All Indicated Changes are in response to RAI NP-7-12

Table 15-1
Material Specifications for Cask Handling Building Structures

Structural Element	*Applicable Material Specification*
Wide Flange Beams and Columns	*ASTM A992 Grade 50*
Channels	*ASTM A572 Grade 50*
Angles	*ASTM A572 Grade 50*
Plate	*ASTM A572 Grade 50*
Hollow Structural Shapes	*ASTM A1085*
Bolts for primary framing connections	*ASTM F3125 Grade A325*
Crane Rail	*ASTM A759*
Anchor Rods	*ASTM A193 Grade B7*
Concrete Reinforcing Steel	*ASTM A706 Grade 60*

Table 15-2
Material Properties for Cask Handling Building Structural Analysis and Design

Structural Element	Property	Value
Structural Steel Members and Plates	Elastic Modulus, E	29,000 ksi
	Poisson's Ratio, μ	0.30
	Coefficient of Thermal Expansion, α	6.5 x 10-6 in/(in°F)
	Unit Weight, γ	0.490 kip/ft^3
	Specified Yield Strength, F_y	50 ksi
Concrete Foundation and Slab	Specified Compressive Strength, f'_c	4500 psi
	Elastic Modulus, E	3820 ksi
	Poisson's Ratio, μ	0.17
	Coefficient of Thermal Expansion, α	5.5 x 10-6 in/(in°F)
	Unit Weight, γ	0.150 kip/ft^3
Concrete Reinforcing Steel	Specified Yield Strength, F_y	60 ksi
Anchor Rods	Specified Yield Strength, F_y	105 ksi
	Specified Tensile Strength, F_u	125 ksi
Structural Fill	Unit Weight, γ	0.110 kip/ft^3