DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Washington, DC 20004-2901

September 6, 2012

The Honorable Thomas P. D'Agostino
Administrator
National Nuclear Security Administration
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0701

Dear Mr. D'Agostino:

The Defense Nuclear Facilities Safety Board (Board) is engaged in a safety review of the design of the Uranium Processing Facility (UPF) at the Y-12 National Security Complex. In January 2012, the Board's staff reviewed the structural analysis and design for the UPF main building, and determined that, the overall structural design is adequate to resist anticipated natural and man-made hazards based on the information reviewed to date. This conclusion was supported by the Board's letter to the National Nuclear Security Administration (NNSA) concerning the UPF project dated April 2, 2012. However, as detailed design has progressed it has become clear that a number of specific modeling assumptions were used in the UPF structural analyses and design that require technical validation. These assumptions may conceal localized issues with the structural design such as the inability of the structure to support safety-related controls. The ability of safety-related controls to function after a seismic event is necessary to maintain worker safety. The Board believes that justification of these assumptions is necessary to understand adequately the UPF structure's behavior in the event of an earthquake and ensure that the potential to damage safety-related controls is not overlooked or incorrectly represented.

Since the Board's January review, the UPF project personnel have worked to develop a path forward to provide additional justification for unverified technical assumptions. The project team documented this path forward in their plan, *Plan for Definition of Modeling/Design Techniques in Calculations for Safety Related Structures*. However, this plan does not describe the technical approach to be used to resolve the types of issues identified by the Board or the technical basis to justify the modeling and design techniques used. The enclosed report describes a representative set of structural design issues that illustrate the Board's concerns.

Pursuant to 42 U.S.C. § 2286b(d), the Board requests a report within 60 days of receipt of this letter describing NNSA's approach to validate the modeling assumptions in the analysis and design of the UPF main building. This report should take into account the types of issues described in the enclosed report.

Sincerely,

Peter S. Winokur, Ph.D.
Chairman

Enclosure

c: Mr. Steven C. Erhart
Mr. Robert B. Raines
Mr. John R. Eschenberg
Mrs. Mari-Jo Campagnone

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

July 2, 2012

MEMORANDUM FOR: T. J. Dwyer, Technical Director

COPIES: Board Members

FROM: Z. McCabe

SUBJECT: Structural Analysis and Design, Main Building, Uranium Processing Facility, Y-12 National Security Complex

This report documents a review by the staff of the Defense Nuclear Facilities Safety Board (Board) of the structural analysis and design for the main building of the Uranium Processing Facility (UPF) at the Y-12 National Security Complex (Y-12). This review was conducted January 25–26, 2012, by staff members J. Blackman, D. Grover, Z. McCabe, and outside expert J. Stevenson. The UPF project team was represented by personnel from the Y-12 Site Office, Babcock and Wilcox Y-12 (B&W), CH2M HILL, and Degenkolb and Associates (Degenkolb). Since the January review, the Board's staff has worked with project personnel to develop a path forward to resolve design issues through bi-weekly teleconferences and an additional onsite visit on March 29, 2012. The project team documented their path forward in a draft plan to address these design issues titled, *Plan for Definition of Modeling/Design Techniques in Calculations for Safety Related Structures* received by the Board's staff on May 3, 2012. The plan does not describe the technical approach to be used to resolve the types of issues identified by the Board or the technical basis to justify the modeling assumptions and design techniques used.

Background. The UPF main building is a two-story, reinforced concrete structure extending from the foundation at grade to an elevation of 69 ft. The building is subdivided into individual modules by interior shear walls forming a 4 x 3 grid. The first story (process level) rests on the foundation. The second story (utility level) floor consists of reinforced concrete slab supported by a steel framing system. These components are designed to act compositely (i.e., the concrete slab is cast around steel studs welded to the top flange of the steel). Several of the modules contain a mezzanine level between the first and second stories. The shear walls are attached to a 5 ft. thick reinforced concrete base mat. The mat is founded on concrete fill overlying weathered and unweathered shale.

B&W is responsible for the overall UPF engineering effort. CH2M HILL is preparing the structural analysis and design for the entire facility, supported by Degenkolb.

Issues Related to the Structural Analysis and Design for the Main Building. Carl J. Costantino and Associates performed soil-structure interaction analysis of the structure and foundation of the main building to determine the building's overall seismic response. Based on these results, the project team determined that very little seismic interaction exists between the building walls and the supporting base mat. The analysis revealed that the building's structure and base mat can be treated as two separate structures. Based on its review of the building structural analysis to date, the Board's staff concludes that the UPF global structural analyses demonstrate that the main building structure meets design requirements. However, some assumptions in the analyses are not explicitly described.

The UPF project utilizes two types of assumptions: (1) unverified assumptions—information that is not currently available and must be verified at a later date, such as equipment loads; and (2) modeling assumptions—idealizations of actual structural behavior, such as omitting wall openings. The project lists all unverified assumptions explicitly in its calculations for later disposition. However, modeling assumptions are not generally noted and justified. As a result, modeling errors may be overlooked. For example, insight into the potential damage of safety-related controls could be overlooked or incorrectly represented without an adequate understanding of local structural behavior. This is not possible unless each modeling assumption or idealized structural behavior is adequately evaluated. Additionally, validation of modeling assumptions as early as practicable and preferably prior to the completion of the main facility final design, minimizes the potential for costly impacts to the UPF project if design revisions are required.

The following examples are a subset of the modeling assumptions used by the UPF project in their structural analysis and design that have the potential to impact safety-related controls in the event of an earthquake.

Simplification of Local Areas—The structural analysis for the main building utilizes a large finite element model containing approximately 29,000 joints, 34,500 elements, and 144,000 dynamic degrees of freedom. For models of this size, the common practice is to simplify local areas of the model to reduce the number of joints and elements to reduce computer run time. It is the staff's understanding that the local simplifications used by Degenkolb in the analysis do not affect the overall stiffness and the global building response based on information reviewed to date. However, as a result of the degree of simplification used throughout the model, the predicted loads in local areas are not representative of the actual local load distribution and may not be suitable for design purposes.

Modeling of Wall Openings in Analysis for Main Building—The finite element analysis model for the main building does not include individual wall openings less than 30 ft^2. Degenkolb personnel indicated that this modeling decision was based on engineering judgment. It is the staff's opinion that load amplification effects and variations in the load due to wall openings may be significant and should receive further consideration. For example, if the area around the opening is uniformly loaded, it may be acceptable to neglect the opening in the finite element model. However, if the loading around the opening varies non-uniformly, it may be necessary to model the opening, since the opening itself influences load distribution. The

Board's staff understands that Degenkolb intends to prepare a study validating the assumption that modeling single openings smaller than 30 ft^2 will not affect the local response of the building, and thus the finite element model for the main building does not need to include such openings.

Modeling of Wall Element Ties—There are a number of areas in the main building where parallel walls are closely spaced and structurally tied. The ties consist of 6-inch diameter pipes welded to embedded wall plates. When these walls are loaded, axial, moment, and shear loads develop in the pipe and embedded plates. However, the wall element ties are modeled as truss elements in the finite element model for the building. Models for truss elements neglect the moment resistance provided by the embedded plates. As a result, the ability of the pipe welds and embedded plates to resist the moment loads is not evaluated. If the pipe welds and/or embedded plates were to fail, the adjoining walls would also fail due to the local imposed loads, since there are no redundant building elements to resist the lateral loads on the walls. To correct this issue, the moment resistance provided by the pipe welds and embedded plates should be included in the analysis, or truss type members should actually be used in the design process to be consistent with the current structural modeling.

Section Cuts in Foundation Design—In addition to the local modeling assumptions, the building foundation design is based on section cut results from the soil-structure interaction analysis for the main building. The purpose of this analysis is to determine the overall earthquake response of the main building by utilizing a coarse finite element representation of the foundation. While this representation is suitable for soil-structure interaction analysis of the facility to determine in-structure response spectra (accelerations), it is not necessarily representative of local behavior, including moments and shears. This coarse degree of refinement has yet to be justified or validated for purposes of developing section cut information for foundation design. It is necessary to demonstrate that the element refinement used is adequate for final design of the foundation. The Board's staff understands that the project team plans to prepare a justification addressing this issue.

Structural Summary Report. The project team indicated that they intend to develop a structural summary report for the UPF facility. The structural analysis and design of the facility are based on safety requirements, design acceptance limits, and numerous analysis and design calculations including DAC-ES-801768-A005, A006, A012, A018, A024, A026, A027, A034, A043, A046, A050, A054, A060 through A066, and A069. These documents are voluminous and complex, and thus difficult to understand holistically. A structural summary report would provide an integrated explanation of the overall facility design process and a summary of all analysis and design results. The Board's staff notes that preparation of such a report would facilitate analyses supporting any future work involving the UPF facility and allows for a better understanding of the basic design strategy.

Conclusion. The Board's staff determined that the current global design for the structure of the UPF main building is adequate based on the information reviewed to date. However, several modeling assumptions, while not affecting the global building response, may not properly model behavior that can affect safety-related controls. To be consistent with the expectations outlined in Department of Energy (DOE) Standard 1189-2008, *Integration of Safety into the Design Process*, at this stage of the design process, the project team should verify the adequacy of safety structures, systems, and components, ensuring that each will maintain its integrity during design basis events and fulfill its safety function. In this case, all modeling assumptions, including the examples discussed above, should be technically justified before the final design is completed. Doing this now will also minimize any potential impact on the project should design changes be required if an existing assumption proves to be unjustified.