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DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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June 4, 1996

Mr. Mark B. Whitaker, Jr.
Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0119

Dear Mr. Whitaker:

Enclosed for your information and distribution are three Defense Nuclear Facilities Safety Board staff reports. The reports have been placed in our Public Reading Room.

Sincerely,

George W. Cunningham
Technical Director

Enclosures (3)

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

May 5, 1994

MEMORANDUM FOR: G. W. Cunningham, Technical Director

COPIES: Board Members

FROM: A. H. Hadjian
C. H. Keilers

SUBJECT: Y-12 Plant - Structural, Seismic, and Ground Motion Review

1. **Purpose:** This trip report documents a Defense Nuclear Facilities Safety Board (Board) technical staff review of structural, seismic, and ground motion analyses at Y-12 Plant. This review was performed by staff members A. Hadjian and C. Keilers and by outside experts W. Hall, P. Rizzo, and J. Stevenson on March 28-30, 1994. The purpose of this trip was to determine how results from on-going hollow clay tile wall research and ground motion studies are being used to assess the seismic adequacy of Y-12 structures. The review then focused in on one high-priority hazardous facility on the site (Building 9212).

2. **Summary:** Many Y-12 production facilities are housed in buildings that rely on unreinforced hollow clay tile masonry walls for their earthquake resistance. Also, design seismic loads in the region have increased in the last twenty years. The Y-12 Management and Operations (M&O) contractor, Martin Marietta Energy Systems (MMES), has initiated efforts, including testing, to better understand the seismic resistance of these structures. These efforts have resulted in analytical refinements of the site-specific ground motion and of the strength and stiffness of the hollow clay tile walls. The Board's staff is concerned that the combined uncertainties of these "increasingly realistic" refinements do not appear to be well understood and may actually exceed the overall seismic margin available in these structures.

3. **Background:** Many Y-12 production facilities are located in buildings dating from the mid 1940s. These buildings are typically steel or reinforced concrete frame structures with unreinforced hollow clay tile masonry blocks built in between the framing. Seismic zoning changes in the early 1970s increased design seismic loads and more sophisticated evaluations of extreme loading events are now required by Department of Energy (DOE) Orders. The Y-12 Management and Operations contractor, Martin Marietta Energy Systems (MMES), has initiated efforts to better define both hollow clay tile wall seismic resistance and site-specific seismic ground motion.

4. **Discussion:** DOE and MMES briefed the Board's staff and outside experts on the site's hazardous facilities, the seismic evaluation process, and the status of the hollow clay tile wall research program and ground motion studies. MMES, DOE, and the Board's staff next discussed in detail seismic evaluations for the enriched uranium processing in Building 9212 and toured part of this facility. The review focused on Building 9212 since it contains some of the major hazards on the site. It is typical of most Y-12 facilities using hollow clay tile walls and has a high-priority in the safety analysis report upgrade program.

Based on recent ground motion studies, MMES is using a site-specific seismic ground response spectrum, approved by DOE, with most of its power shifted to higher frequencies (i.e., from a 1 to 8 Hz band to a 10 to 30 Hz band). In parallel, MMES structural analyses now predict lower fundamental natural frequencies for buildings with hollow clay tile walls (typically around 1 Hz). These two effects result in a large reduction in the predicted building response during the site-specific earthquake. As an example, preliminary analyses of Building 9212, E1 Wing, predict less than 1 inch displacement at the roof. Even with these reductions, some hollow clay tile wall bracing and other modifications are anticipated in order to accommodate extreme loading events.

The staff has the following concerns:

a. Neither the presentations nor the documentation that was provided clearly explain the bases for the site-specific seismic ground motion, especially at low frequencies at which the buildings are most sensitive (i.e., below 10 Hz). Furthermore, it is not clear that the uncertainty in low frequency accelerations has been quantified and accounted for when assessing the seismic resistance of these buildings.

b. Seismic evaluations of the hollow clay tile walls appear to rely heavily on the residual strength and stiffness in the walls after mortar cracking develops. However, tests have shown that wall damage propagates in a complicated, non-linear fashion, starting with the mortar cracking, followed by these cracks extending between sets of blocks, and leading ultimately to individual block failures. It is not clear how much dynamic load carrying capacity really remains after the mortar cracks initiate. The building integrity relies on the performance of the hollow clay tile walls.

c. Several tests show the hollow clay tile blocks ultimately fail at locations different than expected based on the MMES model. Specifically, failures occurred at the top center instead of at top corners during shaketable testing. This is unexpected based on the "equivalent strut" MMES model, which assumes that the load path is between opposing corners of the wall. Relying on this model before understanding the observed progressive failure mechanisms witnessed in the tests is unacceptable.

d. The equivalent strut model is assumed to analytically sustain tension loads, which is unrealistic for masonry structures. As a result, even though the model maintains the total wall stiffness, compressive loading on the columns is halved. Doubling the seismic induced compression in the columns could well cause their failure, leading to catastrophic collapse of the building.

e. The combined effect of the MMES refinements on the overall seismic safety margin of the buildings is not apparent. Furthermore, MMES is using standard DOE methodology to perform their seismic evaluations (UCRL-15910). This methodology was developed using judgement on how much seismic margin in terms of system ductility exists in generic DOE structures. This judgement may not apply to the Y-12 hollow clay tile wall buildings since these structures are fairly unique within the DOE complex. It may be that the combined uncertainties in the MMES analyses exceed the seismic margin available.

f. The MMES process for formally reviewing seismic analyses and proposed seismic upgrades needs improvement. In particular, MMES has proposed several building upgrades based on dynamic structural analyses that have not yet been formally reviewed. These analyses may also have been intended for use in seismically verifying safety systems and components. Furthermore, some of these analyses indicate unexpected participation by high frequency modes that could not be explained. This type of unusual behavior should be spotted and corrected or confirmed when a formal design review is done.

g. Given the uniqueness of Y-12 structures and the above uncertainties, data on the first few structural modes, gained from a building low level nondestructive test, appear to be highly desirable. This test would increase confidence in the hollow clay tile wall stiffness predictions made using the equivalent strut model.