DEFENSE NUCLEAR FACILITIES SAFETY BOARD

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August 16, 2006

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

Dear Mr. D'Agostino:

On March 18, 2005, the Defense Nuclear Facilities Safety Board (Board) requested that National Nuclear Security Administration (NNSA) evaluate building leaks and structural cracks in the Device Assembly Facility (DAF) at the Nevada Test Site. In response, NNSA has identified and documented the existing leak locations and cracks. A leak repair plan has also been developed to stop water infiltration. In a letter dated March 13, 2006, NNSA concluded that the observed concrete cracking does not affect the structure's operability and that further evaluation of the integrity of the structure is not necessary. Based on its review, the Board agrees that the observed concrete cracking does not, of itself, affect the structure's operability. However, the Board remains concerned in three areas.

First, although the cracks themselves may not affect the structure's operability, the cause of the cracks could. The unprecedented level of cracking in the DAF structure may have been caused or exacerbated by low in situ concrete strength, which could adversely affect the structural capacity of the facility during a seismic event. The Board believes the in situ strength of the concrete should be verified (using a nondestructive test) prior to the planned structural analysis of the facility.

Second, the extensive cracking, combined with water leakage, provides the potential for long-term corrosion of the steel reinforcement. This potential should be eliminated to prevent long-term degradation of structural capacity.

Third, although the ultimate capacities of the walls and slabs are not expected to be significantly compromised as a result of the cracking, the extensive cracking will impact the elastic stiffness of structural elements and should be addressed during the planned structural analysis.

Enclosed is a report detailing observations of members of the Board's staff concerning the existing cracks in the facility. The DAF structure is a safety-class control relied upon to reduce the likelihood of and mitigate high explosive violent reactions, fires, accidental releases of radiological material, and criticality accidents. This safety classification requires performance under design-basis loads with high reliability. Therefore, the Board requests a response within two months that describes how NNSA intends to address the three concerns discussed above.

Sincerely,

A. J. Eggenberger
Chairman

c: Dr. Jay H. Norman
Mr. Mark B. Whitaker, Jr.

Enclosure

DEFENSE NUCLEAR FACILITIES SAFETY BOARD

Staff Issue Report

June 23, 2006

MEMORANDUM FOR: J. K. Fortenberry, Technical Director

COPIES: Board Members

FROM: B. Jones
A. Hadjian

SUBJECT: Existing Structural Cracks, Device Assembly Facility

This report documents a series of meetings, discussions, and reviews regarding the existing structural cracks in the Device Assembly Facility (DAF) at the Nevada Test Site (NTS).

Background. DAF was designed in the late 1980s; construction of the facility began in April 1988, with a majority of the reinforced concrete construction taking place from June 1988 to July 1989. Cracking in the floor slabs and walls was first documented in 1996, but it is not clear when the cracks actually occurred. A crack monitoring program was initiated in 1999. The wall cracks tend to be oriented vertically, and the cracks in the floor slab tend to be oriented perpendicular to the walls. In general, these cracks line up with each other. Most wall cracks are continuous through three lifts of concrete placement. A majority of the ceilings are covered by tiles, but where visible, the crack pattern is similar to that of the floor slabs.

DAF was designed as a nuclear explosive facility, including both bays and cells. While portions of the facility are currently being readied for the relocation of criticality experiments previously conducted at Technical Area 18, Los Alamos National Laboratory (LANL), DAF is expected to be ready to perform nuclear explosive operations when required.

In a letter dated March 18, 2005, the Defense Nuclear Facilities Safety Board (Board) requested an evaluation of DAF's structural cracks and water leaks. In response, National Nuclear Security Administration (NNSA) identified and documented the existing cracks and leak locations. On March 13, 2006, NNSA provided to the Board an assessment of the cracks and a water leak repair plan. Based on the results of the survey and assessment, NNSA concluded that the observed concrete cracking does not affect the structure's operability and that furthur evaluation of the integrity of the structure is not necessary

LANL's Crack Inspection Report. A task team of licensed professional engineers was formed by the Department of Energy (DOE) to investigate the observed cracking in DAF. The primary goal was to ascertain the likely cause of the observed cracking and determine whether it compromises the structural or functional integrity of the facility.

The team members toured DAF on May 20, 2003; their findings are documented in a memorandum dated July 1, 2003. The task team reached the following conclusions:

- The observed cracks are due to "normal" drying shrinkage and thermal stresses caused by temperature differentials resulting from different cooling rates.
- The cracks are not increasing in size, providing further evidence that they are the result of self-relieving loads (e.g., shrinkage).
- The construction specifications did not include special provisions to control the rate of cooling, which would have limited the formation of shrinkage cracks.
- Tapping the surface of the concrete with a hammer revealed no laminar cracking near the surface. (This activity was not performed by licensed inspectors.)
- The crack pattern is not consistent with overstress conditions due to normal service loads.
- The cracks have not degraded the strength or serviceability of the structure.

As a result of these conclusions, the task team stated that no further condition assessment (e.g., ultrasonic testing, radiography, concrete cores) is necessary.

Bechtel's Crack Assessment Report. Experts from Bechtel National, Incorporated conducted a visual inspection of DAF, reviewed various documents, and discussed the design and construction history of the facility. Their conclusions are documented in a report, *Review of Concrete Cracked Condition at Device Assembly Facility; Nevada Test Site (NTS)*, dated September 29, 2005. The report states the primary cause of the observed cracking is concrete shrinkage as a result of moisture loss. The authors believe the cracking will not effect the initial stiffness or capacity of the structure. However, these conclusions rely solely on expert judgement and lack a technical analysis or in situ testing.

Observation of the Board's Staff. Members of Board's staff, along with outside expert J. Jirsa, participated in a series of meetings, discussions, and reviews regarding the cracking issue. This effort included a walk-through of the facility; discussions with DOE and its contractors; and a review of construction documentation, including photographs, specifications, and concrete test data. The staff's observations are summarized below.

Extent of Cracking—The cracks at DAF are easily observed from a distance and are closely spaced. The Board's staff is not aware of any other nuclear facility in the DOE complex with cracking of the extent and size observed in DAF (about 700 cracks greater than or equal to 0.015 inches in width). The staff does not consider these cracks to be normal for a nuclear facility.

Concrete Strength—All concrete shrinks as it hardens. The presence of steel reinforcement restrains the concrete from shrinking, causing hairline cracks that relieve the internal forces. Several precautions are typically taken during construction to minimize or limit the extent and size of shrinkage cracks. Adverse curing conditions (high temperatures and low humidity) and insufficient efforts to control shrinkage can lead to extensive cracking such as that observed at DAF. Adverse curing conditions can also adversely affect the concrete strength.

The extensive cracking at DAF cannot conclusively be attributed to simple shrinkage cracking. The data needed to ascertain the cause of the cracking conclusively is typically not recorded during construction. The staff does not believe it necessary to identify the cause of the cracking; however, the factors that cause cracking can also impact the quality and the strength of concrete. Therefore, it would be prudent to determine whether low in situ concrete strength contributed to the extensive cracking.

Although testing of concrete cylinders in a laboratory indicated that the design compressive strength was achieved, the field construction practices employed could have adversely affected the quality of the concrete. A quantitative assessment of the concrete's actual in situ strength using nondestructive test methods (e.g., SCHMIDT® concrete test hammers) would increase confidence with respect to the quality of the concrete and its long-term strength and serviceability. The test program ought to include, at a minimum, both highly cracked regions and areas with no cracking so that a determination can be made as to whether low concrete strength may have exacerbated the cracking. This comparison ought to be performed for both bay and cell structures.

Structural Analysis—The size of the cracks is not expected to prevent aggregate interlock along their length. Nor are the ultimate capacities of the walls and slabs expected to be significantly compromised as a result of the cracking. However, the existing cracking will impact the elastic stiffness of the elements, and any analysis ought to quantify this impact. This issue ought to be addressed during the planned analysis of DAF's response to earthquake motions.

Potential for Rebar Corrosion—The potential for long-term corrosion of the steel reinforcement due to the presence of moisture needs to be addressed. DOE has prepared a leak repair plan to stop the flow of rainwater into the facility from identified leaks by September 2009. Surface repairs of cracks (i.e., not complete through-wall repairs) could allow water to accumulate behind the repair, which would exacerbate the corrosion process. This situation needs to be prevented.

Summary. In summary, the staff believes that the compressive strength of the concrete in situ ought to be verified using nondestructive techniques to ensure that the concrete continues to meet design requirements. Additionally, an evaluation of the impact of the cracks on structural response and an assessment of the potential for long-term corrosion of structural rebar ought to be performed.