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Department of Energy
National Nuclear Security Administration
Washington, DC 20585

March 13, 2006

The Honorable A. J. Eggenberger
Chairman
Defense Nuclear Facilities Safety Board
625 Indiana Avenue, N.W., Suite 700
Washington, DC 20004-2901

Dear Mr. Chairman:

Ambassador Brooks has requested that I provide you additional information in response to your March 18, 2005 letter. In two previous letters, dated May 16, 2005, and June 15, 2005, Ambassador Brooks provided you results of our survey of leaks and crack locations within the Device Assembly Facility (DAF). In his May 16, 2005, letter, Ambassador Brooks committed to providing you a copy of our plan to repair the DAF water leaks. A copy of this Water Leak Repair Plan is enclosed (Enclosure 1). In addition, an assessment of the severity and significance of the observed cracks on the DAF was conducted by experts from the Bechtel National, Incorporated. A copy of the report containing results of this assessment is also enclosed (Enclosure 2).

The Bechtel National, Incorporated experts concluded that the primary cause of the observed concrete cracking is shrinkage, and the observed shrinkage cracking is expected to have a negligible effect on the capacity of the structure. In addition, these experts concluded that the observed concrete cracking does not affect the operability of the structure. The Bechtel National, Incorporated report recommended an enhanced monitoring program to be implemented to further investigate any anomalous conditions observed in the future. I am committed to implementing the report-recommended enhanced monitoring program. This program is included as part of the Water Leak Repair Plan.

In the Ambassador's June 15, 2005, letter to you, he described our plan for a phased approach to analyze the structural adequacy of the Device Assembly Facility safety systems' slabs and walls with cracks 0.04 inch or wider. In light of the results of our survey of leaks and crack locations within the DAF, and in consideration of detailed analysis provided by Bechtel concrete experts, we have concluded that further evaluation of the integrity of DAF structures will not be necessary. I understand that the Board retained an independent concrete expert to assess the structural adequacy of the DAF. If the results of the Board's assessment are substantially different from the Bechtel report provided in Enclosure 2, I would appreciate a copy of the report.

As discussed in the Water Leak Repair Plan, a review of concrete test records and concrete curing conditions will be completed to ensure that the concrete used had attained the specified design strength, and is in compliance with required specifications. If this review identifies anomalous conditions, additional actions will be identified.

We have initiated actions to execute the Seismic Analysis and Evaluation Plan that was mentioned in the Ambassador's May 16, 2005, letter. Currently, geotechnical site investigations are underway in support of efforts to update our understanding of seismic hazards.

I am committed to ensuring all operations within the Device Assembly Facility are conducted safely. Our plan is to start the leak repair program in the current fiscal year, starting with repairing the roofs in the Device Assembly Facility buildings where the criticality assembly machines will be installed. This schedule is consistent with the future programmatic needs for criticality experiments.

If you have any questions, please contact me or have your staff call Ms. Deborah D. Monette of the Nevada Site Office at (702) 295-2588.

Sincerely,

Thomas P. D'Agostino
Deputy Administrator
for Defense Programs

Enclosures

cc:
L. Brooks, NA-1, w/enclosures
K. Carlson, NSO, w/o enclosures
M. Whitaker, DR-1, w/enclosures

SEPARATION

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Enclosure 1

Enclosure to DNFSB Letter Transmitting Device Assembly Facility Water Leak Repair Plan and Bechtel National, Inc. Independent Assessment of the Device Assembly Facility

Device Assembly Facility (DAF)

Water Leak Repair and Crack Monitoring/Evaluation Program

Prepared by

Lawrence Livermore National Laboratory (LLNL)
&
Bechtel, Nevada

February 2006

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1.0 Introduction and Background

In early 2005, during the rainy season, water leaks through cracks, construction joints, and penetrations were observed in walls and roof slabs in various locations of the Device Assembly Facility (DAF) located on the Nevada Test Site (NTS). Additionally, the facility was observed to have many visible cracks in the concrete structure. During that period, at the request of the Defense Nuclear Facilities Safety Board (DNFSB) (Reference 1), two surveys were conducted to locate water leaks and also cracks wider than 0.015 inches. The National Nuclear Security Administration (NNSA) transmitted the leak and crack survey data to the DNFSB via letters dated May 16 and June 15, 2005, respectively (References 2 and 3).

In the May 16 transmittal letter, NNSA committed to submit a plan to repair the leaks, and in the June 15 letter, it presented a plan for a three-phase structural evaluation of the DAF. The first two phases of the structural evaluation encompass a determination of the adverse impact of the cracks, if any, on the structural integrity of the DAF building walls. The third phase includes update of the Probabilistic Seismic Hazard Analysis (PSHA) and seismic evaluation of DAF structures and safety-related equipment. Updating of the PSHA is currently underway. As it progresses, major milestones and results will be presented to and discussed with DNFSB staff periodically so that potential issues concerning methodology, assumptions, etc., can be resolved in a timely manner.

This document, prepared for the DNFSB, discusses:

- Evaluation of potential adverse effects of observed water infiltration and concrete cracks on the safety basis of the facility
- Determination of the necessity of a structural integrity evaluation
- Enhancement of the crack monitoring program
- A plan for water leak repairs

2.0 Evaluation of the Potential Adverse Effects of Leaks and Cracks

The DAF is a large facility that consists of many interconnected buildings constructed primarily of reinforced concrete walls, floor and roof slabs, and round rooms (gravel gerties). Even though some cracking in large concrete structures is normal, to ensure that the cracks observed in DAF walls and floor slabs do not progress to a stage that may be detrimental to the structural integrity and safety function of the structures, a crack monitoring program was put into place in 1997 (see Reference 4). A sample of forty two wall cracks was included in this program. The cracks were mapped and measured to establish a crack baseline in 1999 (see Reference 5).

In 2003, a team of structural engineers from Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and Department of Energy Headquarters (DOE/HQ) inspected the cracks and various construction records to assess the cause of the cracks and their impact on structural integrity (see Reference 6). The team also re-measured the widths of the original forty two instrumented cracks and concluded that the cracks were stable. The team further concluded that the primary cause of the cracks is shrinkage and thermal constraint related, and that the potential adverse impact of the cracks on the structural integrity was insignificant.

The 42 monitored cracks included in the original 1999 baseline effort were also re-mapped in February 2005 (Reference 7) and compared against the baseline. Results showed no appreciable propagation or change in crack size and width.

The 2005 crack survey detected about 700 cracks wider than 0.015 inches of which about 90 were wider than 0.040 inches (see DAF Crack Mapping Data Table in Reference 3). All 42 cracks that have been monitored since 1999 were observed to be stable, with no change in crack width, shape, or growth. Other observations made in the facility, e.g., in-service inspections, did not reveal evidence of settling, sagging, or deterioration in the DAF structure. This is indicative of the fact that the cracks are stable.

Hence, following the guidelines provided in ACI 349.3R-02 (Reference 8), the effect of cracks on the structural integrity needs to be evaluated only for those 90 cracks that are wider than 0.040 in. This was presented as Phase 1 and Phase 2 structural integrity evaluation in a letter (Reference 3) from NNSA to the DNFSB. However, based on the results of two other subsequent evaluations, it was concluded that the two-phase structural integrity evaluation of the effects of cracks may not be necessary. These results are summarized as follows:

1. A systematic safety evaluation of the cracks and leaks was performed by LLNL to determine if these have any potential adverse effects on the safety functions of DAF structures, systems, and components (SSCs). Cracks and leaks were evaluated, among others, for their potential impact on leak path factors assumed in the Documented Safety Analysis (DSA) and on the criticality safety. The conclusion from this evaluation was that the cracks and leaks have an insignificant impact on the DAF SSCs that are important to safety.

2. An assessment of the severity and significance of the observed cracks on the DAF was conducted by two subject matter experts from Bechtel National, Inc. (Reference 10). Conclusions from their assessment are summarized below:

    - Observed concrete cracks were caused mostly by concrete shrinkage. This conclusion is primarily based on the extent, location, spacing, size, and pattern of the cracks. Cracking does not correlate to other potential causes evaluated. Evidence indicates that the cracks are independent of load and are attributable to the inherent properties of concrete and construction practices employed.

    - Crack monitoring has shown that cracks are stable, and there is no evidence suggesting that this status will change.

    - Water leaks are the likely result of torn water stops at expansion joints, local damage to the exterior waterproofing, and a roofing membrane that has exceeded its reliable service life.

- Concrete cracks are not expected to have an effect on the lateral or vertical load-carrying capacity of the structure.

- Cracks in the concrete are expected to have a negligible effect on the initial stiffness of structure when subjected to the postulated earthquake loads.

- Concrete cracks have a negligible structural impact on the functionality and operability. Nonstructural functions, such as confinement, were not evaluated.

- Water leaks that have occurred are not jeopardizing the durability of the structure because the leaks were found to be harmless to the concrete and no evidence of steel corrosion has been observed. The coloration of stains where leakage has taken place across cracks indicates that corrosion is not an issue affecting the DAF at this time. The potential for future corrosion, if necessary, could be either monitored or prevented by sealing the cracks.

- No repairs or modifications are necessary at this time. However, a monitoring program should be in place, and any anomalous conditions identified in the future should be investigated.

Even though the above two evaluations, as well as the evaluation performed in 2003 by LANL, LLNL, and DOE-HQ engineers, concluded that the cracks would have insignificant effects on the structural integrity of DAF, as an added measure of safety, the following activities are planned:

1. Develop a plan to repair the leaks. Prioritization is to be based on potential for adverse radiological or explosive-related safety consequences (see Section 4.4, below).
2. Review concrete test records to ensure that the concrete used had attained the specified design strength by September 2006.
3. Review available documents providing data or information on concrete curing conditions to ensure that these are in compliance with the specification or acceptable practice by September 2006.
4. Enhance the existing crack monitoring program by increasing the number of sample cracks to ensure that (a) cracks are stable, and (b) the steel reinforcing bars do not show any sign of corrosion (see Section 3.0 below).

3.0 Enhancement of Existing Crack Monitoring Program

The fact that all of the 42 cracks monitored since 1999 were observed to be stable provides a high level of confidence that all of the 700 identified cracks are stable. However, since a large number of cracks (about 90) were found to be wider than 0.04 in., for added safety assurance, it was decided to include several more cracks in the existing crack monitoring program. The selection and number of additional cracks to be included will be based on the following considerations:

- Width of the crack

- Crack location, length, and orientation
- Minimum number of sample cracks that should be monitored to statistically provide a high level of confidence
- Possibility that some of the large number of cracks, less than 0.015 in. wide, may not be stable in the long run

Crack selection will be made in FY 2006. These cracks will be mapped and monitors will be installed as described in Reference 7. A baseline of the initial configuration of the additional monitored cracks will be documented and issued in FY 2006 as a revision to Reference 7.

4.0 The Leak Repair Plan

4.1 Observations Made During the Leak Survey

The water leak survey identified forty-one water leaks in DAF walls, roof slabs, and gravel gerties (Reference 2). These leaks were carefully inspected, photographed, and catalogued for size, probable leak path, location, and reference drawings. Leak paths were assessed to be through:

- Expansion joints (EJ)
- Ceiling Tiles (CT)
- Construction joints (CJ)
- Structural Cracks (SC)
- Roof penetration for piping or other equipment (P)
- Crack or cracks in the water protection system on gravel overburden above the round rooms (GR)

Many of the leaks were determined to be through expansion joints (EJ) in concrete walls and roofs. In fact, inspection of expansion joint materials in both the exterior and interior of the DAF shows that these joints have badly deteriorated over the years and are in need of replacement.

Leak paths for several leaks (CT) could not be ascertained with certainty because they are hidden behind ceiling or roof tiles or other equipment. A few of these leaks were suspected to be through expansion joints. These are identified here as EJ/CT.

Leaks through two types of construction joints were observed and designated as follows:

1) Those at the interface between the wall and the floor or roof slab (hereafter called Type A construction joints). Details of these are shown on the as-built drawings.

2) Those not explicitly shown on the drawings but which were identified as potential construction/cold joints by the presence of nearly straight cracks in the walls (hereafter called Type B construction joints).

There is only one leak that is through a structural crack (SC). This leak is through a vertical crack in the wall near the intersection of the wall and the floor.

4.2 Potential for Corrosion of Steel Reinforcing Bars (Rebar)

Of the 41 observed leaks listed in Reference 2, four leaks have been identified as through cracks in the walls, i.e., Leak Numbers 1-8, 1-13, 1-18, and 2-8. Water could reach the rebar through these cracks creating a potential for rebar corrosion.

Leaks other than the above are through Type A construction joints. Structural reinforcing bars may cross some of these Type A construction joints, and so these leaks may also create a potential for rebar corrosion. Other identified leak paths are such that rebar is not directly exposed to water. Rebar corrosion is a long-term effect and depends on many factors such as:

- Crack width
- Chemical/mineral content of the water
- Length and frequency of exposure
- Aridity/humidity and general climatic condition
- Level of sustained stress to the rebar

In the leaks listed in Reference 2, the water did not show any sign of corrosion in the rebar. As such, it is concluded that, at the present time, the likelihood of rebar corrosion to a level that may affect the structural integrity is insignificant. A similar conclusion was reached by two independent experts who inspected the cracks and water marks/stains in Device Assembly Facility walls resulting from the past water leaks.

However, leaking cracks identified above will be included for inspection in the routine facility maintenance and surveillance program (see Section 3 above).

4.3 Repair Method by Leak Type

A conceptual repair method has been developed for each of the six types of leaks (based on leak paths) listed in Section 4.1 above and is briefly described in Table 1 below.

Table 1 - Repair Method by Leak Type

Leak Type	Repair Method---Description
Expansion Joint (EJ)	Cleanout existing elastomeric sealant and backer rods which are deteriorated, and replace these with similar or better material on front wall, parapet wall, and roof; replace concrete waterproof membrane in the vicinity of EJ if accessible and considered necessary.
Type A Construction Joint (CJA)	These construction joints are in the walls that support soil backfill behind the walls. As such, repairing these leaks will require finding the leak paths through the backfill. This may not be practical to implement. Instead, repairing or replacing the waterproofing system on the DAF roof may be the most pragmatic and cost-effective approach to preventing these leaks.
Type B Construction Joint (CJB)	Seal locally by epoxy injection or other cost effective state-of-the-art method.
Structural Crack (SC)	Seal locally by epoxy injection or other cost effective state-of-the-art method.
Roof Penetration (Pipes, Ducts) (P)	Replace flashing, counter-flashing, and caulking/sealant on pipes and ducts; replace concrete water-proof membrane on the DAF roof in vicinity of penetration, as necessary; re-grade the DAF roof covering materials to eliminate local low spots in area around penetrations.
Round Room Ceilings (GR)	Repair existing roofing tiles locally above round rooms by sealing cracks, taping joints, and replacing damaged tiles; repair/unclog drains and drain piping, as necessary.
DAF Roof Repair or Replacement	Remove roofing tile and overburden; repair/replace water-proof membrane on concrete roof; repair new or lingering leaking joints and penetrations; install select soil material and provide final grading for positive drainage; emplace state-of-the art roofing membrane on roof surface; cover with gravel.

Considering the difficulty in establishing the complete leak paths with certainty for CT, CJA, SC, and P types of leaks, repairing these leaks individually in a localized manner may not be the most cost-effective method. Rather, an overall repair or replacement of the waterproofing system on the DAF roof is more likely to prevent water infiltration and is therefore most preferable. A conceptual method of repairing or replacing this waterproofing system is briefly described in the table. Alternately, a significant cost saving may be achieved by undertaking repairs of several leaks of either the same type or those that will require similar construction techniques and equipment. For example, the repair of all expansion joint leaks should be performed together, and repairing the CJB and SC types of leaks by epoxy injection method can be performed concurrently to reduce installation costs.

4.4 Schedule and Funding for Leak Repairs

A schedule of leak repairs and evaluation has been established based on the following considerations:

- Potential effects of leaks on the facility hazards assessment and safety basis
- Potential adverse impact (e.g. impact on schedule) of the water leak on major programmatic activities (e.g., CEF and TA-18 Early Move) and project operations;
- Current near term (2 year) and future funding requests; and
- Schedule of major programmatic activities (e.g., CEF).

The emphasis of this schedule is to address water leaks affecting nuclear safety and programmatic priorities followed by leak repairs of lesser significance using a logical approach that groups repairs by repair type (Section 4.3) and sequences repairs from the roof down to interior level concerns (e.g., structural crack). Nuclear safety considerations are directly related to programmatic priorities since nuclear safety is of the utmost importance in operational buildings where nuclear materials are present.

The targeted Leak Repair Schedule is presented in Table 2. In it, the repair of cell (i.e., Round Room Ceiling) leaks has been given the greatest repair priority because of their programmatic importance and extent of leakage in these buildings. The extent of observed leakage is relatively significant in non-Criticality Experiment Facility (CEF) cells, but it does exist in CEF cells. Construction of a CEF capability is scheduled to be initiated at DAF in October 2006 with operations commencing in FY 2009. Thus, the repair of cell roofs will have the highest priority. This repair will also include the repair of cell ceilings inside the facility once the outer roof is repaired. This prioritization is supported by the relative safety and programmatic significance of cell leaks compared to other DAF operational buildings. The approach for cell repair is to develop a comprehensive cell repair plan in FY 2006 that will define the strategy and sequence of repairing cell roofs. The comprehensive cell repair plan will be followed by the necessary engineering and work planning/execution documentation to support an immediate start of this work in FY 2007 when expected funding is received.

The second priority will be to generally address water leakage through facility Expansion Joints. This type of leak is present throughout the facility, and the relative safety and programmatic significance of these leaks is high. Thus, a focused repair of these types of leaks would yield relatively high benefit. Also, these repairs may eliminate other types of leaks, e.g., through Type A and Type B Construction Joints or Structural Cracks, in lower levels of the facility.

The third repair priority focuses on leaks through Roof Penetrations (e.g., pipes and ducts) that need to be better sealed by flashing or other methods such as caulking/sealant.

Finally, leak repairs through Type A and Type B Construction Joints and Structural Cracks will receive the next priority. It is anticipated that some of the executed roof repairs may negate the need for some of these repairs by preventing the intrusion of water into these lower areas of the DAF. Thus, it is beneficial and cost effective to accumulate additional experience of leakage to determine ongoing repair needs.

As an ongoing assurance of safety, in-service inspections (ISI) of DAF buildings are performed in accordance with Technical Safety Requirements to ensure each building used for hazard category 2 nuclear operations fulfills its designated safety functions. A completed ISI that identifies a leak path that challenges the continued fulfillment of these safety functions will receive immediate priority and attention as part of the ISI program. Thus, a leak of a duct or pipe into a DAF building that is needed to enable or support nuclear operations would receive immediate attention regardless of the relative priorities provided in this Section.

Table 2 – Targeted Leak Repair Schedule

Fiscal Year 2006		
Task	**Completion Date**	**Remarks**
Develop comprehensive cell repair plan	March 2006	Defines sequence and strategy for repairing cell roofs
Develop Project Data Sheets and refined cost estimates for cell roof repair and other repair types	April 2006	Supports normal budget formulation process in April
Complete design engineering documentation for cell roof repairs	July 2006	
Develop engineering and work planning/execution documentation for expansion joints	July 2006	Enables initiation of repairs in FY 2006
Initiate expansion joint repairs	August 2006	
Develop work planning/ execution documentation	September 2006	Completed documentation enables actual repair/restoration.
In-Service Inspection Summary Report	September 2006	Summary report of completed ISIs, identified nonconformances, and engineering disposition (as necessary)

Fiscal Year 2007		
Task	Completion Date	Remarks
Initiate Cell Roof Repairs	November 2006	Initiation of field work
Re-initiation of building expansion joint repairs	November 2006	Assumes some delay in starting work in FY because of delays in funding receipt
Complete design engineering documentation and work planning/control documentation for other repair types (e.g., penetrations, joints)	June 2006	Enables immediate start of out-year work.
Complete Cell Roof Repairs	September 2007	
Complete Expansion Joint Repairs	September 2007	
In-Service Inspection Summary Report	September 2007	Summary report of completed ISIs, identified nonconformances, and engineering disposition (as necessary)

Fiscal Year 2008 & 2009		
Task	**Completion Date**	**Remarks**
Initiate Penetration Repairs	November 2007	Initiation of field work
Complete Penetration Repairs	February 2008	
Complete budget estimation for any new or ongoing leaks	March 2008	Supports budget formulation in April
Initiate construction joint and structural crack repairs	March 2008	
Complete construction joint and structural crack repairs	September 2008	
In-Service Inspection Summary Report	September 2008	Summary report of completed ISIs, identified nonconformances, and engineering disposition (as necessary)
Initiate leak repairs for new leaks (if any) identified by living leak plan	November 2008	
Complete budget estimation for any new or ongoing leaks	March 2009	Supports budget formulation in April
Complete necessary leak repairs	September 2009	
In-Service Inspection Summary Report	September 2009	Summary report of completed ISIs, identified nonconformances, and engineering disposition (as necessary)

4.5 Immediate Hazard Mitigation and Evaluation of the Effects of Future Leaks

Once a water leak is noticed during or after a rainstorm, steps are undertaken by DAF personnel to mitigate immediate hazards. Measures include:

- Covering electrical equipment
- Collecting/diverting water
- Timely maintenance to eliminate slipping hazards
- Posting of warning signs

If a leak is detected during or after any future storm, it is assessed as a new leak by comparing its location and leak path with those listed in Reference 2. If it is determined to be a new leak, it will be added to the table contained in Reference 2, subjected to an effects evaluation process, and then ranked as in Table 2 in Section 4.4. The tables will be continually updated and will be part of the facility maintenance record.

5.0 References

1. Letter from John T. Conway (DNFSB) to Linton Brooks (NNSA), transmitting Staff Issue Report on DAF Seismic Structural Review, dated March 18, 2005
2. Letter from Linton F. Brooks to A. J. Eggenberger (DNFSB), transmitting Condition Assessment Mapping of Building Leaks at DAF, dated May 16, 2005
3. Letter from Linton F. Brooks to A. J. Eggenberger, transmitting Condition Assessment Mapping of Cracks at DAF, dated June 15, 2005
4. *Structure – Surveillance*, Device Assembly Facility, DAF Procedure No. DAF-MNT-018, Bechtel Nevada, October 28, 1997
5. *Device Assembly Facility (DAF) Concrete Crack Inspection Initial (First Time) Report*, Rev. 0, Bechtel Nevada, September 30, 1999
6. *Concrete Inspection Device Assembly Facility,* by Michael Salmon (LANL), Robert. Murray (LLNL), and Tom Nelson (LLNL), LANL Document FWO-DECS: 03-066, June 4, 2003
7. *DAF Concrete Crack Inspection Current (Second) Report*, Document No. 0062, Rev. 0, Bechtel Nevada, dated July 2005
8. *Evaluation of Existing Nuclear Safety-Related Concrete Structures,* American Concrete Institute, ACI 349.3R-02, 2002
9. *Project Plan for Upgrading Seismic Analyses and Evaluation of the Device Assembly Facility*, Letter from Dennis Kelly (LLNL) to Angela Colarusso (DOE/NSO), September 14, 2005
10. *Review of Concrete Cracked Condition at Device Assembly Facility, Nevada Test Site (NTS),* by Pepe Vallenas and John Grubber, Bechtel National, Inc., September 29, 2005.

SEPARATION

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Enclosure to DNFSB Letter Transmitting Device Assembly Facility Water Leak Repair Plan and Bechtel National, Incorporated Independent Assessment of the Device Assembly Facility

Enclosure 2

Bechtel National, Incorporated Report

September 29, 2005

Bechtel Nevada Engineering Dept.
P.O. Box 98521, M/S CF085
Las Vegas, NV 89193-8521

Attention: Mr. James P. Dockery

Subject: Review of Concrete Cracked Condition at Device Assembly Facility; Nevada Test Site

Dear Mr. Dockery,

Transmitted herewith, please find our report:

"Review of Concrete Cracked Condition at Device Assembly Facility; Nevada Test Site"

The report documents the evaluation performed by Pepe Vallenas and John Gruber of Bechtel National, Inc. Resumes for the above are included in this transmittal.

Should you have any questions regarding the attached report, please feel free to contact me at (415) 768-247, or John Grubber at (301)228-7616.

Very truly yours,

Pepe Vallenas

Jose (Pepe) Vallenas

Principal Engineer
Bechtel National, Inc.

Enclosures

**REVIEW OF
CONCRETE CRACKED CONDITION
AT
DEVICE ASSEMBLY FACILITY
NEVADA TEST SITE (NTS)**

Prepared for:
Bechtel Nevada

Prepared by:
Bechtel National, Inc.

Pepe Vallenas

Pepe Vallenas
Principal Engineer

John Gruber
Principal Engineer

September 29, 2005

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REVIEW OF CONCRETE CRACKED CONDITION AT DEVICE ASSEMBLY FACILITY
NEVADA TEST SITE (NTS)
By:

Pepe Vallenas and John Gruber
Bechtel National Inc.
September 29, 2005

1 Executive Summary

Bechtel National Inc. (BNI) was asked to assess concrete cracking observed at the Device Assembly Facility (DAF) Building, located in Area 6 of the Nevada Test Site. The scope of this assessment was limited to evaluating the severity and significance of the observed cracks. The scope does not include evaluation of the structure for current of future missions or evaluation of potential addition of equipment and modifications to the exiting facility

BNI representatives performed the following information gathering activities:

1. A site visit and visual inspection of DAF structure was performed on August 3, 2005.
2. A document review was performed of design documents, reports and other available information relevant to the design, construction, loading history and performance of DAF as it may have impacted the observed cracking.
3. Cognizant personnel familiar with the design and construction history of DAF were interviewed.

The BNI evaluation of the concrete cracking considered its severity and potential root causes, such as settlement, seismic accelerations, nuclear testing induced accelerations, construction procedures, loading history, shrinkage, temperature effects, etc. This report provides the results of the evaluation.

The BNI conclusions, based on the gathered information, are as follows:

<u>Cause of the Concrete Cracking:</u>
The primary cause of the observed concrete cracking is shrinkage. This conclusion is primarily based on the extent, size, spacing, location, and pattern of cracking. The observed cracking does not correlate with any of the other potential causes evaluated.

<u>Potential Impact of Cracking:</u>
The observed shrinkage cracking is expected to have a negligible effect on the lateral or vertical load capacity of the structure. Additionally, the cracking is expected to have a negligible effect on the initial stiffness characteristics of the structure when subjected to postulated natural phenomena hazard (NPH) loads.

Operability:
The observed concrete cracking does not affect the operability of the structure. Nonstructural functions, such as confinement, are outside the scope of this assessment.

Recommendations:
Based on the information gathered for this assessment, no repairs or modifications are recommended at this time. However, it is recommended that monitoring be performed, and that any anomalous conditions identified in the future be investigated.

2 Introduction

This report summarizes the independent assessment of cracking observed in the concrete elements at the Device Assembly Facility (DAF) Building at the Nevada Test Site (NTS). Bechtel National Inc. (BNI) was asked to review the structure and provide an opinion regarding the probable cause and the potential consequences of the cracking.

3 Scope

The scope of this assessment is limited to evaluating the severity and significance of the observed cracks with respect to its as-designed structural capacity. The scope does not include evaluation of the structure for current or future missions or evaluation of potential additions of equipment and modifications to the exiting facility.

4 Information Gathering

A site visit to DAF was performed by Pepe Vallenas and John Gruber on August 3, 2005. The site visit was complemented by review of available information relevant to the design, construction and loading history of DAF as it may have impacted the observed cracking. Information reviewed included:

1. Aggregate Study for Proposed Device Assembly Facility, Converse Consultants, November 30. 1984
2. Geotechnical Investigation for Proposed Device Assembly Facility, Nevada Test Site, Converse Consultants, November 30, 1984.
3. Supplemental Design Recommendations, Converse Consultants, 1985
4. Loading Criteria, Bernard Johnson Incorporated, October 20, 1986
5. Concrete Specifications, August 12, 1987
6. Memorandum, K. J. Coppersmith (Geomatrix) to Dorothy Ng (LLNL) Simplified Seismic Analysis for Device Assembly Facility (DAF), March 13,1995
7. DAF Seismic Retrofit, Bechtel Nevada, January 6, 1997
8. Structural Evaluation for the Device Assembly Facility, UCRL-ID-126251, LLNL, 1999.
9. Device Assembly Facility (DAF) Concrete Crack Inspection Report, 2170D-99-280, dated September 30, 1999.
10. Inspection Procedure for Monitoring Cracks, Bechtel Nevada, March 24, 2000.
11. Crack Inspection Reports dated May 8 and 20, 2003

12. Memorandum, M. W. Salmon (LANL) to W.H. Hamilton (LLNL), Concrete Inspection Device Assembly Facility, July 1, 2003

13. Letter, Dennis Kelly (LLNL) to John Leppert (DOE), Device Assembly Facility (DAF) Water Infiltration, March 11, 2005

14. Letter, Dennis Kelly (LLNL) to John Leppert (DOE), Device Assembly Facility (DAF) Crack Information, May 9, 2005

15. Crack Mapping Data Table, May 17, 2005.

16. DAF Concrete Crack Current (Second) Inspection Report, Bechtel Nevada, July, 2005.

17. Evaluation of Existing Nuclear Safety-Related Concrete Structures; ACI 349.3R-02

18. Construction photographs

In addition, BNI representatives also met with persons familiar with the construction and history of DAF, among them: Vinod K. Sahni, Jim Pedalino, Dave Mc Donald, Jerry La Roy, John Blanco and Roy White from Bechtel Nevada, and Quazi Hossain from LLNL.

5 Background

Significant milestones in the history of DAF are as follows:

1984-1987 The DAF building was originally designed for a "maximum credible earthquake," with accelerations of 0.67 g horizontal and 1.0 g vertical. Manual calculation methods were used in design. There were no explicit criteria regarding building seismic performance or safety category.

1988-1989 Most of the concrete placements for building foundation, walls, roofs, etc., were done in this time period. It is of note to indicate that there was a period of over two years between completion of concrete pours and installation of doors. Also of note is that underground explosive tests were conducted at NTS at this time and beyond.

1992 End of underground explosive testing at NTS.

1995 Re-evaluation effort initiated to establish a safety basis for the building in accordance with DOE Order 6430.1A and the related standard DOE-STD-1020. For this purpose, a simplified probabilistic seismic analysis was performed and site-specific ground design spectra were developed. Consistent with DOE-STD-1020, the return period for the design basis earthquake was set at 2000 years. These spectra were anchored at peak ground acceleration of 0.30 g horizontal and 0.27 g vertical. The peak spectral accelerations at 10% damping were 0.57 g horizontal at around 5 Hz and 0.49 g vertical at around 13 Hz. The building seismic analysis was performed using a fixed-base finite element model and designating the building as a seismic PC-3 structure. During this effort, cracks were noticed. However per recollection of personnel at the site, cracking had been present before that time.

1999 Crack monitoring program initiated.

2003 A team of LLNL and LANL structural engineers performed an inspection and a second set of crack readings taken. Results indicate that cracks are stable (Reference 12)

2005 A third set of crack readings taken. Results indicate that cracks are stable (Reference 16).

6 Concrete Cracking

The crack monitoring program has provided a detailed record of concrete cracks including their location, widths and lengths. The initial readings were taken in 1999; significant cracks were mapped. A second set of records in May 2003 showed that there were no significant changes from the readings taken in 1999. Details of the cracking are documented in References 9 to 16.

The cracks are thin as documented in references 11 and 16. In walls, the cracks can for the most part be described as vertical and uniformly spaced. Some wall cracks are located at what appears to be construction joint locations in that they are straight and of uniform width. There are some diagonal cracks, and not all cracks are continuous at non-construction joint locations.

The cracks in the slabs are similar in that they are tight and generally extend across the width of the room or hall.

In almost all cases, the concrete on each side of a crack is in the same plane. That is, there has been no differential movement between the concrete on either side of the cracks.

Water has leaked into the building through several cracks in the roof. DAF has a 5 - 6 foot soil overburden on top of waterproofing applied on the external concrete surfaces except for the round rooms which have approximately 23 feet of gravel overburden with tile roofing applied on the surface. Visual inspection of the roof performed by BNI representatives found the roofing membrane on top of the fill severely cracked. There are also "ponding" areas in the roof because of discontinuous slopes. The details call for a "waterproofing" membrane on the wall exterior but no other information on the system is available.

The exterior walls have vertical expansion joints and water has been identified as leaking through them. The building details show "dumbbell" type water stops at the expansion joints that are not equipped with hollow-center bulbs to allow movement.

Calcium carbonate deposits (a white powder) were observed at several cracks as would be expected where water has leaked though the concrete.

7 Causes of Cracking

Concrete is a brittle material that has comparatively low tensile strength. It "cracks" whenever the induced tensile stress exceeds the maximum allowable. Cracking is an inherent property of the material and to a large degree cannot be avoided. This Section examines the possible causes of cracking observed.

Cracks in concrete that occur independent of load (often termed "temperature and shrinkage") are very common. They result from the basic properties of the material. Several mechanisms cause concrete to lose volume after it is in place and hardened. If a concrete member is restrained from movement when this volumetric reduction occurs, tensile stresses are induced.

The orientation and pattern for the cracks observed at DAF, generally vertical in walls and across slabs, is consistent with what is expected when cracks occur independent of load. Most of the cracks independent of load result from either moisture loss or thermal expansion. For example, when constructed, walls are doweled into mats and footings. Construction joints between the base of wall and slabs/mats/strip footings are prepared to maximize bond. These provisions assure a rigid attachment that fully restrains the wall from movement when volumetric changes occur. Vertical "shrinkage" cracks are endemic at the base of walls unless provisions for minimizing the length of wall pours are made (the rule of thumb being that the maximum pour length is not to exceed one to three times the wall height depending on the height of the wall). Such cracks can extend the full height of the wall while others extend only a few feet above the slab and then stop.

Some limited diagonal cracking was observed in the walls. Diagonal shrinkage cracks occur depending on the restraint provided at the wall boundaries. For example, if a wall is placed such that it is integral with an intersecting, perpendicular wall, restraint is provided at its base and along its edge, thus making for a more complex distribution of tensile stresses in the wall with diagonal cracks resulting. These shrinkage cracks tend to be near the corner of the wall intersections and are different from cracks caused by in-plane shear which tend to initiate along the main diagonal direction of the wall panel.

As noted previously, in most cases the concrete on each side of a crack is in the same plane indicating that the applied stress was uniform across the section (as is the case when shrinkage is restrained) and not the result of fracture attributable to external load. For the few cases where a slight difference between the surfaces can be felt on each side of a crack (rubbing one's hand across the crack is the easiest way to check), it is very likely that this situation results from a situation similar to that described for diagonal cracking. That is, if wall is placed and tied to an intersecting wall, the stiffness of the existing wall will affect the deflection of the new wall as it shrinks. Slight out of plane movement can be experienced and the relative position of the concrete on each side of a crack.

Slabs behave in a similar manner except that the restraint is provided by friction with the sub grade and the reinforcing itself.

Shrinkage

Moisture loss is a common cause of cracking and is likely the mechanism most responsible for the cracks observed at DAF. When fresh concrete is placed, conventional concrete mixtures (as was used for this building's construction) contain more water than the minimum required for assuring hydration of the portland cement. Prior to hardening, the "solids" in the concrete mixture settle as the concrete is placed and consolidated. As the solids settle, capillaries are formed within the concrete as conduits for the excess water that seeps to the surface of the element (termed "bleed water") prior to hardening. After placement, the concrete is "cured" by assuring that the surface is maintained in a saturated condition (either by applying water or sealing the surface with a membrane-forming compound). Thus, except for the bleed water, the remainder of the excess mix water remains in the concrete until after it has achieved its specified strength. After curing is terminated, water begins to evaporate from capillaries. This loss of moisture reduces the capillary pressure. This reduction in pressure causes the overall concrete mass to shrink. If the concrete mass is restrained from movement (as occurs because of friction between a grade slab and the ground, or at the base of a wall that is doweled into a footing), tension stresses are induced that cause the concrete to crack.

As the concrete ages, it continues to gain strength and better resist the applied tensile stress. Further, the stronger the concrete is when moisture loss occurs, the amount of cracking attributable to moisture loss will reduce. Given the arid NTS environment, moisture loss would begin and progress rapidly after the curing period ended. Thus, moisture loss is likely the mechanism most responsible since it is very likely that the concrete dried rapidly after curing was terminated.

The cracking observed at DAF (regular spacing, generally vertical at walls and across slabs and cracks at restraint points) is clearly consistent with concrete shrinkage. Environmental conditions at the site are also consistent with this conclusion.

Thermal Effects

Another cause of cracking in concrete is thermal contraction. The hydration of portland cement is an exothermic process that causes the temperature of the concrete mass to increase. Like most other materials, concrete expands as temperatures rise and contracts as temperatures fall. During the heating cycle (during the initial phases of hydration), the concrete mass expands usually without detrimental effect. After the hydration peaks (approximately one week after placement), the temperature of the element decreases and contracts thermally, thus inducing tensile stresses in the same manner as previously described. The thickness of the walls at DAF is a contributor to this effect.

Cracks also initiate because of thermal gradients within the concrete mass after placement. Unless special provisions are taken for cooling the interior or insulating, the interior of a concrete element will have a significantly higher temperature than the exterior. Depending on factors specific to each concrete pour, such as geometry, thickness, ambient temperature fluctuation, etc., the temperature difference can be quite large. Cracking results in the tension zone caused by the gradient. Once such cracks initiate soon after the concrete is placed, cracks caused by other mechanisms will often be attracted to these comparatively weak planes in the concrete mass. Thick structural elements, such as those at DAF, are susceptible to this effect.

Autogenous Shrinkage

Autogenous shrinkage also occurs caused by the reduction in volume inherent to the hydration of the portland cement. The volume of hydrated portland cement is less than the original volume of the water and the portland cement. This is comparatively minor component of the total volumetric contraction that the concrete experiences after placement, but remains a tensile inducing mechanism in structural elements that are restrained against movement and is a minor factor at DAF

Other Shrinkage Mechanisms

Other mechanisms that cause concrete to shrink include the amount of paste (i.e., the quantity of cement) and the shrinkage characteristics of the aggregates. Like autogenous shrinkage, these are generally minor components of the total amount of shrinkage experienced at DAF.

Chemical Causes

No pattern cracking that would be indicative of internal disruption of the concrete attributable to such causes as sulfate attack, alkali reactivity, or other deficiencies in the concrete's ingredients was found. Further, there is no evidence of cracking attributable to poor concrete placement practices such as plastic shrinkage or plastic settlement.

Lateral Loads

Lateral loads can be introduced in a structure because of seismic events, and in the case of DAF because of ground accelerations induced by underground testing.

Lateral loads tend to introduce diagonal crack patterns in two directions (X patterns) in the in-plane shear walls. No such crack pattern is found at DAF. Lateral also tend to introduce flexural horizontal cracks at the base of walls and at wall boundaries. Again, no such crack pattern is found at DAF.

Furthermore, no significant seismic activity has been recorded at DAF during the life of the facility. Cracks observed at DAF can not be attributed to seismic loads

Also, while underground testing has taken place at NTS in the past, actual acceleration records obtained at DAF during underground testing as provided in Reference 8 show accelerations of at most 0.0016g. An informal calculation (Reference: E-mail from Larry Sanford [LLNL] to Quazi Hossain [LLNL], dated August 18, 2005) showed that, for the tests conducted during and after DAF construction, the maximum peak ground acceleration at the DAF site is less than 0.05g, and the peak of the response spectrum for 5% damping is less than 0.1g. The informal calculation uses LLNL-developed software. The software was developed using actual recorded data. These acceleration levels are much smaller than the 0.67g lateral acceleration used in the design of the facility. Cracks observed at DAF can not be attributed to underground testing.

Settlement

Settlement cracks tend to show distinct localized diagonal patterns (V or Λ patterns) indicating tension fields at specific locations of the structure. That is not a crack pattern found at DAF. Settlement cracks also tend to increase with time. This has not been observed at DAF, as demonstrated by the crack monitoring program which has shown that cracks at DAF are stable. Cracks observed at DAF can not be attributed to differential settlement.

8 Effect of Cracking at DAF

Structural Safety

Cracking observed does not in any way compromise the load carrying capacity of slabs, walls or concrete connections in the structure. The cracks are not in areas where high tensile stresses are expected during response to seismic ground motions. The shrinkage cracks observed are not expected to have an effect on the lateral or vertical load capacity of the structure.

The observed cracking is expected to have a negligible effect on the stiffness characteristics of the structure when subjected to postulated natural phenomena hazard (NPH) loads.

Operability

As noted above, the observed cracking will not impair the functionality of the DAF Structure. Therefore, there are no structural operability concerns associated with the cracking.

Per review of the DAF Documented Safety Analysis (DSA), portions of DAF are required to perform an additional function as secondary containment barrier. This barrier function is in support of the HVAC System and the review of such function is not within the scope of this assessment. However, the following observations are provided for information only.

Water leakage has been evident through some of the cracks. Consequently, air or vapor leakage may be expected. The DSA for the facility notes that an acceptable leakage rate has been calculated to support the HVAC System in order to maintain a negative pressure in some areas of DAF. Testing and balancing of the HVAC system to maintain the specified negative pressures has been performed in the past and this issue does not appear to be a problem. Therefore, the effect of cracking on the functionality of secondary containment barrier walls and slabs is assumed to be negligible, but this determination is outside the scope of this assessment.

<u>Water Leakage</u>

Most of the observed leaks originate from the roof slab. The drawings show that the roof was covered with a waterproofing membrane, but no data as to the type of membrane is available. The details do not indicate that any material was required to be placed on the membrane to protect it from damage when the roof was covered with earth fill. It is possible that the membrane was damaged when the earth fill was placed. Regardless, the roof membrane is approximately 18 years old which places it at about the end of its functional life. Leaks in 18 year old roofs are not unusual. Visual inspection of the roof performed by BNI representatives found the roofing membrane above the fill severely cracked. There are also "ponding" areas in the roof because of discontinuous slopes.

Leaks were also identified at exterior expansion joints. The details show that the exterior of the building was to be encapsulated in a waterproofing membrane but no description of the membrane is available. Like the roof, no requirement for a protection course is specified to keep the membrane from being damaged. It is not clear if the waterproofing membrane was intended to cover the expansion joints. Unlike the construction joints between the walls and mats, a water stop is shown in the expansion joint details. Unfortunately, the type of waterstop shown, a simple 6-inch wide dumbbell type (material not identified), does not contain a hollow center bulb to allow the joint to move. While it may be that such a water stop was actually provided, movement of these walls would tear a waterstop that does not have a hollow ball. Similarly, many waterproofing membranes adhere or are otherwise attached directly to the concrete wall. Again, they will tear if the joint moves. Thus, while the available details are not clearly definitive, there is a high likelihood that if the concrete moved relative to the joint as designed, this movement damaged the waterproofing (if any) or the waterstop.

Other leaks were identified as simple cracks in the exterior wall. Not every crack showed evidence of water. There were also leaks noted at some slab/wall intersections. Obviously, only a damaged or failed waterproofing membrane, if installed, could allow water to pass though these cracks.

Water leakage at DAF is a maintenance issue and not a structural safety issue.

Autogenous Healing

Hairline cracks in concrete will heal themselves as water is available provided that the cracks are static, the water has a pH of 7 or greater, and water is unable to flow through the joint. This process is termed "autogenous" healing and is the result of calcium hydroxide being leeched from the hydrated portland cement paste and then precipitating out of solution in the form of insoluble calcium carbonate when carbon dioxide or monoxide is available. In many cases, the crack will "choke-off" as the calcium carbonate accumulates on the "dry" side of the section allowing the crack to fill and heal.

There is evidence of calcium carbonate deposits at many of the cracks. Unfortunately, rain is uncommon in the site region and the building is far above the ground water table. Thus, while it is possible that some cracks have healed and will no longer leak when it again rains and saturates the fill surrounding the building, it is likely that there has been insufficient exposure to water for many of the cracks to heal completely.

Corrosion

A concern associated with leakage of water through a reinforced concrete section is the possibility of corrosion of the reinforcing bars. This corrosion can result in reduced structural capacity of the section. However, no evidence of corrosion was observed.

Reinforcing steel embedded in concrete is protected from corrosion by a thin, passivating oxide film caused by the alkaline nature of the concrete. Additionally, oxygen is very slow to diffuse through saturated portland cement mortars.

As noted, water passing though cracks leeches calcium hydroxide from the hydrated paste which significantly increases the pH of the water. Thus, the water that comes into contact with the embedded reinforcing steel is highly alkaline in a saturated environment that is relatively free of oxygen. Unless the water contains a high chloride content (and there is no indication of high amounts of chloride in the site environment), the corrosion rate of the bar in these circumstances would be very low or non-existent.

No rust staining or other evidence of corrosion was observed at any of the cracks. Unless the bar is in a high chloride environment where corrosion can occur without staining (which is not the case at this site), any corrosion is taking place resulting from water passing through cracks in the concrete would stain the inside surface of the structure to some degree. Without any evidence of rust stains, it is not likely that corrosion has occurred at DAF.

9 Conclusions

Reason for Cracking

1. The cracking observed was caused mostly by concrete shrinkage. This conclusion is primarily based on the extent, size, spacing, location, and pattern of cracking observed. The cracking observed does not correlate with any of the other potential causes evaluated. All evidence indicates that the cracks occurred independent of load and are attributable to the inherent properties of concrete and the construction practices employed

2. Approximately 6 years of crack width and growth monitoring (42 cracks were monitored for propagation, widening, and differential movement) has shown without exception that there is no significant movement or changes in the crack widths and propagation lengths. There is no evidence suggesting that this status will change.

3. Leaks are the likely result of torn water stops at expansion joints, local failures or damage to the exterior waterproofing, and a roofing membrane that has exceeded its reliable service life.

Potential Impact of Cracking

1. Structural Safety: The shrinkage cracks observed are not expected to have an effect on the lateral or vertical load capacity of the structure. Additionally, the cracking observed is expected to have a negligible effect on the initial stiffness characteristics of the structure when subjected to future postulated natural phenomena hazard (NPH) loads;

2. Operability: The observed concrete cracking has a negligible impact on the functionality of the structure and therefore, does not affect the operability of the structure. Nonstructural functions, such as confinement, are outside the scope of this assessment.

3. Corrosion: The leaks that have occurred are not jeopardizing the durability of the structure since the leaks are harmless to the concrete and no evidence of reinforcing steel corrosion has been observed. The coloration of stains where leakage has taken place across cracks indicates that corrosion is not an issue affecting DAF at this time. The potential for future corrosion could, if necessary, be monitored or prevented by sealing the cracks.

10 Recommendations

Based on the information gathered for this assessment, no repairs or modifications are recommended at this time. However, it is recommended that monitoring be performed, and that any anomalous conditions identified in the future be investigated.

Although not recommended at this time, the following actions are recommended should there be a change in the conditions observed to date:

1. An annual walk-though to visually inspect the areas where leaks have occurred for evidence of corrosion should be sufficient to provide timely situation assessment and remediation by a trained corrosion engineer. If at any time visual evidence that corrosion is not occurring is deemed insufficient, half-cell potential tests can be performed in selected locations to determine the corrosion rate of the reinforcing steel. Such measurements are performed by attaching electrodes to a bar and measuring the current in the steel. The current measurement is used to estimate the corrosion rate and provide an estimate of the amount of loss the bar will experience over time. Generally, a core drill sample through one of the tested bars is then obtained to correlate the estimated corrosion rate to the actual amount of corrosion experienced. Once installed, these electrodes can be accessed repeatedly in the future whenever it is deemed necessary to update the corrosion estimate. It should only be necessary to monitor several bars in the entire facility with the areas adjacent to the major leaks given top priority.

2. If crack repair is deemed necessary for non-structural reasons, then epoxy injection of interior, non-leaking cracks, and low or non-absorbent urethane injection of exterior cracks is preferred. Epoxy injection is a common crack repair material when moisture resistance is not required and there is no reason to expect the joint to move in the future. Urethanes that are low or non-absorptive effectively seal cracks from water flow. Alternate grout materials can be used if fire resistance is an issue. Note that sealing a concrete structure from water leakage by injection is a difficult task, especially at a site like this one where exterior water is only occasionally available. It has been repeatedly observed at other locations that once a specific crack where water leakage has occurred has been successfully sealed, an adjacent, formerly dry crack often begins to leak. Water will find the easiest path though these labyrinths and when one is blocked, the pressure builds enough to open a new path. With exterior water only available on an occasional basis, it could take many visits (and many years) by a specialty subcontractor to successfully complete sealing the structure.

JOSE M. (PEPE) VALLENAS

EDUCATION:

- o Ph.D., Structural Mechanics, University of California, Berkeley, CA.
- o M.S., Structural Engineering, University of Southern California, Los Angeles, CA.
- o Graduate Business Studies, ESAN, Graduate Business School for Latin America, Lima, Peru.
- o B.S., Civil Engineering, National Engineering University, Lima, Peru.

PROFESSIONAL REGISTRATION:

Registered Civil Engineer, California.

CERTIFICATES

Certified Project Management Professional (PMP ID #03292)
OSHA 29 CFR 1910.120 (e)

SECURITY CLEARANCE

Department of Defense, Secret Clearance (not active)
Department of Energy, L Clearance (active)

PROFESSIONAL EXPERIENCE:

Dr. Vallenas has over 27 years of experience in seismic/structural engineering for a variety of commercial, industrial, residential, and nuclear projects.

As member of the Bechtel National Inc. Chief Civil Structural Architectural Staff he provides technical support and oversight for BNI and BSII projects including the New Doha Airport, Seattle Monorail, Tacoma Narrows Replacement Bridge, WTP at Hanford, Yucca Mountain Project, Pantex, Y-12, Pueblo, Aberdeen, Blue Grass and GMD.

His project experience includes:

o Responsible for the criteria development, seismic analysis, and design of the cylindrical 48 story, 101 California high-rise in San Francisco.

o Responsible for the structural design and analysis of the High Level Waste Tank Farm Replacement (HLWTFR) Project for the Idaho National Electric Laboratory (INEL). His responsibilities included development of criteria, tank analysis and design, seismic soil structure interaction analysis using the SASSI program, analysis of systems and equipment, retrofit of existing facilities, and presentations to Department of Energy's (DOE) reviewing entities. As part of this project Dr. Vallenas developed a base isolation design for the above ground portion of the HLWTFR facility. The design received favorable reviews from DOE. The project was not carried to Title III status because of DOE shift in priorities.

JOSE M. (PEPE) VALLENAS

o Dr. Vallenas has represented INEEL in meetings with DOE's Tank Seismic Experts Panel. He has provided input for the development of the criteria document: "Seismic Design and Evaluation Guidelines for the Department of Energy High-Level Waste Storage Tanks and Appurtenances".

o Responsibility for the design of a new 26-mile long 24-in diameter Gas line for SMUD from Sacramento to Rancho Seco. The project included Aerial Photography, Surveying, Routing, design of trench-less crossings for highways and environmental sensitive areas, design of valve stations, consideration of cultural and historical sites, permitting, specification writing and bid packaging.

o Vulnerability study for the Kinder Morgan Energy Partners fuel storage facility near the San Francisco International Airport. The design of solar panel arrays for the U.S. Postal Service facility in Marina del Rey. and several retrofit studies for FEMA following the Nisqually Earthquake.

o Responsible design and construction of PG&E's L-21 turnkey Project, a new 24-inch diameter main supply gas line for the San Francisco Bay Area. The line was designed to withstand seismic accelerations of over 10g. The line crosses over the ¾ mile wide Carquinez Strait in Northern California. Some of the challenges faced by the project include hazardous heights, traffic, weather, hazardous materials contamination, union labor issues, coordination with Caltrans, PG&E, Union Pacific Rail Road, State and Federal agencies.

o Project responsibility for a 5 year seismic retrofit effort at Savannah River, and a similar 3 year project at Idaho.

o Lead peer reviewer for the W236 storage tank Project at the DOE Hanford Site. The W236 project includes the design of 6 high-level waste storage tanks and associated systems.

o Modification and seismic upgrade of existing storage and administration buildings to provide Nuclear Material Storage Facility at the Los Alamos National Laboratory. This is a dry storage facility with an innovative natural convection passive cooling system.

o Seismic vulnerability assessment and upgrade of Plutonium Facility as part of the PF-4 Maintenance and Improvements Project also at Los Alamos.

o Dr. Vallenas has also provided ongoing consulting services to the Nuclear Engineering Department at Pacific Gas & Electric Company (PG&E). He developed the Design Criteria for Class I Structures, and provided independent review for PG&E's Long Term Seismic Program. In this program, state of the art re-analysis of the Diablo Canyon Nuclear Power Plant was performed.

o Provided Independent review function for Texas Utilities Electric Company

o Responsible the Systematic Evaluation Program (SEP) for Yankee Rowe Nuclear Power Plant. This project required the development of design criteria, use of advanced analysis techniques, and design of retrofits for the major structures, systems and components, including the Containment Structure, the Turbine Building and the Fuel Pool. The project involved extensive presentations to, and discussions with, the Nuclear Regulatory Commission.

- o Developed the Final Safety Analysis Report (FSAR) for the San Onofre Nuclear Generating Station (SONGS 1). Evaluation and hardening of the San Onofre Nuclear Power Plant for wind and tornado effects: pressurization, depressurization and missile impact loads.

- o Qualification of mechanical equipment using experimental methods on the WPPSS-2 nuclear plant.

- o Cooper Nuclear Station (CNS) Restart. Dr. Vallenas developed the operability and function criteria for CNS systems. He also provided the justification for continued operation.

- o Performed Probabilistic Risk Assessment of the Yankee Rowe Nuclear Power Station.

- o Seismic rehabilitation design of the 240,000 square foot 6 story Tolman Hall at the University of California in Berkeley. The design was performed as a pilot study using the non-linear procedures per NEHRP 273 and verified using the 1997 UBC.

- o Dr. Vallenas has also been working with the State of California in the evaluation and seismic retrofit of state owned facilities.

- o Design and analysis of San Francisco Bay Area Rapid Transit System (BART) Colma Station and adjoining parking structure over maintenance yard.

- o Conceptual design of the Cali-Buenaventura oleo duct for ECOPETROL in Colombia. Dr. Vallenas evaluated the seismic risk for different alternatives for the purpose of optimizing the design concept.

- o Dr. Vallenas has managed due diligence seismic structural investigations in support of real estate purchases by JMB Properties throughout California. Among the buildings he investigated are landmarks such as the Shell Building, the Alcoa Building, the Fourth and Market building in San Francisco, and Park Center Plaza in San Jose.

- o Responsible for the structural evaluation and design of upgrades for Seattle Water Department structures, piping and equipment facilities. Design and installation of seismic isolation for retrofit of two million gallon water storage tanks.

- o Seismic safety review of equipment and systems on two major offshore platforms for Chevron Oil. These platforms, Grace and Edith, are located off the California coast on over 400 feet deep water.

JOSE M. (PEPE) VALLENAS

- o Seismic Vulnerability Studies for over 200, U.S. Navy, buildings in Tennessee and South Carolina

Dr. Vallenas has been involved in the development of innovative structural steel solutions such as ductile braced frames and the Friction Pendulum energy absorption/base isolation system for which he shares patent ownership.

Dr. Vallenas is also very active in the area of post-earthquake damage assessment. As a member on call of several scientific organizations has traveled and investigated earthquake damage in New Zealand, Chile, Mexico, Peru, Coalinga, Los Angeles, San Fernando, Whittier, and of course San Francisco. The Electrical Power Research Institute, the National Academy of Sciences and the Earthquake Engineering Research Institute have financed these studies.

JOSE M. (PEPE) VALLENAS
REPRESENTATIVE PUBLICATIONS:

"Development of in-situ Dynamic Soil Properties for Very High Soil Strains", with Vince Drnevich and Paul Grant, Fifth Department of Energy Natural Phenomena Hazards Mitigation Conference, Denver CO, October 1995.

"Optimization of Mathematical Models for Soil-Structure Interaction", with C. Wong and D. Wong, Fourth Department of Energy Natural Phenomena Hazards Mitigation Conference, Atlanta GA, October 1993.

"Use of Base Isolation Techniques for the Design of High Level Waste Storage Facility Enclosure at INEL. Fourth Department of Energy Natural Phenomena Hazards Mitigation Conference, Atlanta GA, October 1993.

"The New Zealand Earthquake of March 2, 1987." Electrical Power Research Institute (EPRI) Report No. NP-5970, August 1988.

"The Chile Earthquake of March 3, 1985," J. Vallenas et al. Earthquake Spectra, The Professional Journal of the Earthquake Engineering Research Institute, February 1986.

"Seismic Qualification Using Dynamic Analyzer Data to By-Pass Analysis Steps," with B. Atalay and B. Horstman. 8th International Conference on Structural Mechanics and Reactors Technology, Brussels, Belgium, August 1985.

"A Methodology for the Determination of Seismic Resistant Design Criteria," with B. Kacyra, presented at the Second U.S.

National Conference on Earthquake Engineering, Stanford, California, August 1979.

"Hysteretic Behavior of Reinforced Concrete Walls," with V. V. Bertero and E. P. Popov, Report No. UCB/EERC-79/20, Earthquake Engineering Research Center, University of California, Berkeley, California, August 1979.

"Concrete Confined by Rectangular Hoops and Subjected to Axial Loads," with V. V. Bertero and E. P. Popov, Report No. UCB/EERC-77/13, Earthquake Engineering Research Center, University of California, Berkeley, California, August 1977.

"Confined Concrete: Research and Development Needs," with V. V. Bertero, ERCBC Seminar, Berkeley, California, July 1977.

"Seismic Design Implications of Hysteretic Behavior of Reinforced Concrete Walls," with V. V. Bertero, E. P. Popov, and T. Y Wang, Sixth World Conference on Earthquake Engineering, New Delhi, India, January 1977.

RESUME

NAME: **John V. Gruber** **DATE:** August, 2005

EMPLOYEE NUMBER: 803960

BECHTEL APPROVED CLASSIFICATION: Principal Engineer

WORKING TITLE: Civil Staff Specialist

ORGANIZATION & DEPT: Bechtel Power Corporation

LOCATION: Frederick, Maryland

BIRTHDATE: August 20, 1952 **CITIZENSHIP:** U. S. A.

ORIGINAL BECHTEL EMPLOYMENT DATE: June 10, 1974 to March 1985

RE-EMPLOYMENT DATE(S): May 6, 1991

SPOUSE'S NAME: Kerry

PROFESSIONAL LICENSES AND SOCIETIES

Registered Professional Engineer — Virginia, Maryland
American Society of Civil Engineers (ACSE) — Member
American Concrete Institute (ACI) — Member
Chi Epsilon — Member

EDUCATION AND PERSONNEL DEVELOPMENT PROGRAMS

DEGREE, CERTIFICATE, ETC.	SCHOOL	MAJOR (OR SUBJECT)	DATE
B. S.	The Pennsylvania State University	Civil Engineering	June 1, 1974

OTHER SIGNIFICANT INFORMATION:

Voting Member — ACI Committee 237 — Self-Consolidating Concrete
Voting Member — ACI Committee 304 — Measuring, Mixing, Transporting, and Placing Concrete
Voting Member — ACI Committee 311 — Inspection of Concrete
Associate Member — ACI Committee 211 — Mixture Proportioning

SKILLS/EXPERIENCE (KEYWORD LIST):

Concrete Materials Technology   Concrete and Underground Construction

WORK HISTORY

DATES From	To	COMPANY OR DEPARTMENT LOCATION AND SUPERVISOR	POSITION HELD, SUMMARY OF RESPONSIBILITIES AND SIGNIFICANT ACCOMPLISHMENTS
May, 1991	Present	Bechtel Power Corporation Gaithersburg/Frederick, Maryland J. Whitcraft/ E. Thomas/ W. Brittle/ A. Gillespie/ M. Reifschneider	Principal Engineer responsible for concrete materials engineering and specification preparation. Duties include mix design review, ingredient specification and selection, investigation of deficient concrete, and preparation of repair procedures. Perform concrete batching plant, pre-cast manufacturing, on-site concrete operations, and ingredients evaluations for projects throughout the United States and in India, Syria, Egypt, Chile, the Philippines, China, Colombia, Kazakhstan, the United Kingdom, Saudi Arabia, the United Arab Emirates, Brazil, Taiwan, the Netherlands, Bahrain, Croatia, Ecuador, Iceland, Libya, Qatar, and Mexico.
August, 1988	May, 1991	Guy F. Atkinson Construction Company College Park, Maryland N. Rackstraw	Quality Control Manager for tunnel construction project. Established and maintained QC program for soft ground tunnel project featuring twin, 5200-foot conventional shield driven tunnels with temporary pre-cast concrete and cast-in-place final liner.
November, 1987	August, 1988	Sverdrup Corporation Rossilyn, Virginia R. Ford	Structural Construction Specialist in the embassy task group under contract with the U.S. Department of State, Foreign Building Office. Responsible for performing constructability reviews of embassy compounds in Cyprus, Jordan, Yemen, Chile, Peru, Thailand, and Burma. Coordinated design details between A/E's and the State Department.
March, 1985	November, 1987	Harrison Western Corporation Washington, D. C. A. Fournier	Quality Control Manager for tunnel construction project. Established and maintained QC program for subaqueous soft ground tunnel project, including shaft construction by deep slurry wall method and once-through pre-cast tunnel liner system.
March, 1984	March, 1985	Bechtel Power Corporation Gaithersburg, Maryland J. Ivany	Senior Engineer performing structural design and analysis on SNUPPS project. Designs included masonry buildings and tornado missile shields.

DATES From	DATES To	COMPANY OR DEPARTMENT LOCATION AND SUPERVISOR	POSITION HELD, SUMMARY OF RESPONSIBILITIES AND SIGNIFICANT ACCOMPLISHMENTS
March, 1983	March, 1984	Bechtel Power Corporation Homestead, Florida G. Nutwell	Civil Group Supervisor for Steam Generator Replacement Project at Turkey Point Unit 4. Additional duties included repair and modifications to block walls per IEB 80-11, plant auxiliary power upgrade program, and evaluation of Cat. I raceways.
June, 1981	March, 1983	Bechtel Power Corporation Gaithersburg, Maryland J. Ivany	Deputy Civil Group Supervisor for SGR at Turkey Point Unit 3. Responsible for design of various facilities in support of steam generator repair outage.
September, 1980	June, 1981	Bechtel Power Corporation Gaithersburg, Maryland C. Andrews	Design engineer assigned to Turkey Point Project. Responsible for design of various plant modifications including radiation-shielding structures.
March, 1980	September, 1980	Bechtel Northern Corporation Middletown, Pennsylvania F. McDougall	Site Liaison Engineer at Three Mile Island Unit II Recovery Project. Coordinated design information between engineering and construction. Responsible for preparation of initial containment decontamination functional criteria.
September, 1979	March, 1980	Bechtel Power Corporation Clemson, South Carolina W. Brittle	Shift Supervisor at Oconee Nuclear Station responsible for supervision of walkdown teams obtaining "as-built" piping, IEB 79-14 data in Unit 1, 2, and 3 containment buildings.
September, 1978	September, 1979	Bechtel Power Corporation Dothan, Alabama D. Armstrong	Resident Engineer for Farley Nuclear II construction. Coordinated designs between engineering and construction. Developed expansion anchor inspection for Farley I IEB 79-02 program.
March, 1977	September, 1978	Bechtel Power Corporation Gaithersburg, Maryland W. Miller	Engineer assigned to SNUPPS project. Duties included design of various Category I site unique structures at Callaway and Wolf Creek Nuclear Stations.
June, 1974	March, 1977	Bechtel Power Corporation Gaithersburg, Maryland C. Wang	Engineer assigned to Hatch Nuclear project. Prepared initial report for Mark I Torus Plant Unique Analysis, designed miscellaneous yard foundations, and cooling tower flumes. Checked structural steel and reinforcing steel shop drawings.