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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD '01 JUN 27 A11 :57

OFFICE OF SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

In the Matter of:	)	Docket No. 72-22-ISFSI
PRIVATE FUEL STORAGE, LLC (Independent Spent Fuel Storage Installation)	)	ASLBP No. 97-732-02-ISFSI
	)	June 19, 2001

STATE OF UTAH'S REQUEST TO MODIFY THE BASES OF LATE-FILED CONTENTION UTAH QQ IN RESPONSE TO FURTHER REVISED CALCULATIONS FROM THE APPLICANT

On May 16, 2001, pursuant to 10 CFR § 2.714 and the Board's April 26, 2001 Order, the State sought admission of late-filed Contention Utah QQ, Seismic Stability[1], based on a number of revised calculations submitted to the NRC accompanying PFS License Application Amendment No. 22 ("Amendment 22). The State received calculations relating to Amendment 22 upon which Utah QQ is based, on various dated between April 6 and 16, 2001. PFS has revised, yet again, calculations relating to Amendment 22.

In particular, and in response to a request by NRC Staff, PFS has revised two critical calculations relating to the seismic stability analysis of the storage pads and Canister Transfer Building ("CTB"). In its May 31, 2001 submittal to NRC, Enclosure 1 at 57, PFS states:

> Calculation No. 05996.02-G(B)-04, Revision 8, entitled "Stability Analysis of Storage Pads" and Calculation No. 05996.02-G(B)-13, Revision 5, entitled "Stability Analysis of the Canister Transfer Building Supported on a Mat Foundation" are attached. These calculations have been revised to clarify the critical failure modes, failure surfaces, and the required material strengths.....

[1] The State recognizes that Utah QQ has not been admitted and in this Modification Request, the use of the term "Utah QQ" is for convenience only.

Template=SECY-041

SECY-02

The State received the two revised calculations referred to above on June 1, 2001.

Utah QQ, in general, challenges the application of PFS's newly revised design basis ground motions to the Canister Transfer Building, the storage pads, and their foundations; PFS's intended use and redesign of soil cement around the CTB and under and around the storage pads; and the foundation design of the CTB, storage pads, and their underlying soils, and the stability of the storage casks, to safely withstand the newly revised design basis ground motions. The State now finds it necessary to add to the bases of Utah QQ because Calculation No. 05996.02-G(B)-04, Revision 8, "Stability Analysis of Storage Pads" ("Cal. G(B)-04, Rev. 8") and Calculation No. 05996.02-G(B)-13, Revision 5, "Stability Analysis of the Canister Transfer Building" ("Cal. G(B)-13, Rev. 5") inaccurately conclude there are adequate factors of safety against sliding. PFS has failed to demonstrate that the shallow foundation system of the pads and CTB will support the inertial loads for the design basis ground motions at the ISFSI site. Thus, PFS's application does not support a finding that the ISFSI will satisfy the design bases with an adequate margin for safety. 10 CFR § 72.24(c)(3); *see also* 10 CFR §§ 72.102, 72.122(b)(2).

Modification of Utah QQ is supported by the Declaration of Dr. Steven Bartlett. The State meets the late-filed factors and, for the reasons stated below, requests the Board to admit Utah QQ as modified by this request.

DISCUSSION

A. Seismic Stability Analysis of the Storage Pads

This Modification Request addresses four significant concerns with respect to the factors of safety against sliding in the PFS's storage pad analyses, Cal. G(B)-04, Rev. 8: PFS's inaccurate analysis of the inertial forces acting on the pads; PFS's inconsistent design approach with respect to the buttressing effect of cement-treated soil; PFS's continued failure to address impacts that affect the adhesive strengths at various foundation interfaces; and PFS's inadequate longitudinal analysis of the storage pads.

As described in Utah QQ, PFS intends to use cement-treated soil under and around the storage pads. Utah QQ at 4-5. The objective of Revision 7 to Cal. G(B)-04,[2] was to "[d]etermine the minimum required strength of the soil cement along the sides of the pads and below the pads to provide a factor of safety against sliding of the cask storage pads of 1.1." Cal. G(B)-04, Rev. 7 at 12. With respect to Revision 7, the NRC advised that before NRC could begin to review PFS's recent license application amendment, it would need, *inter alia*, the following:

> Revised analyses of the stability of the storage pads to include a clear identification of the potential failure modes and failure surfaces, and the material strengths required to satisfy the regulatory requirement, considering the critical failure modes and failure surfaces.

Attachment, page 1, to letter from E. William Brach, NRC, to John D. Parkyn, PFS, dated May 7, 2001 and attached as Exhibit 5 to Utah QQ. In Revision 8 to Cal. G(B)-04, PFS attempts but fails to address the NRC's request.

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[2] Utah QQ is, in part, based on Revision 7.

In Revision 7, PFS primarily relied upon the buttressing effect or passive resistance of the cement-treated soil around the pads to demonstrate that the storage pads could maintain a factor of safety against sliding of 1.1. As the State pointed out in Utah QQ, PFS's attempt to use this buttressing effect against sliding is not defensible. *See* Utah QQ at 10-11. In Revision 8, PFS presents a confusing and conflicting analysis, at times ignoring the buttressing effect of soil cement on the factor of safety against sliding, and at other times adding the buttressing effect back into its analysis.

In Revision 8 to Cal. G(B)-04, PFS claims that it can still maintain a factor of safety against sliding of 1.1 by ignoring horizontal resistance to sliding due to passive pressures acting on the sides of the pad (*i.e.* the buttressing effect of cement-treated soil around the pads) provided the shear strength is at least 1.85 ksf at the base of the storage pad. Cal. G(B)-04, Rev. 8 at 23. The minimum shear strength required to resist dynamic forces with a factor of safety of 1.1 is a function of the magnitude of the dynamic forces. Bartlett Dec. ¶ 8. In Revision 8, PFS has underestimated the minimum shear strength required to resist dynamic forces by making erroneous and unconservative assumptions about the dynamic loads transferred to the native soil from the pad-cask system. Id.

PFS's analysis of the case in which it ignores the buttressing effect contains a fundamental and fatal flaw. PFS assumes that the cement pad and the cement-treated soil will act as an integral block and transfer all inertial forces to the top of the native soil (*i.e.* the silty clay / clayey silt), but PFS has failed to use as an input into its analysis the total combined mass of pad and the underlying cement-treated soil. Bartlett Dec. ¶ 9. This fundamental flaw in the calculation means that PFS has significantly and erroneously over-estimated computation of the factor of safety against sliding. Id. Moreover, PFS still has not addressed several dynamic loading issues raised in Utah QQ. Id. With such an ineffectual analysis PFS cannot maintain that it can meet the required 1.1 the factor of safety against sliding and cannot claim to meet 10 CFR § 72.24(c)(3); *see also* 10 CFR §§ 72.102, 72.122(b)(2).

PFS may argue that the State is too late in raising this objection because the State should have raised this issue in response to Revision 7. This argument has no merit. Revision 7 contains a hypothetical case of "Sliding Stability of the Pads Constructed Directly on Silty Clay/Clayey Silt." Cal. G(B)-04, Rev. 7 at 16. This case is hypothetical because at the PFS site the bottom of the cement storage pads will not be in contact with the native soils; there will be a layer of cement-treated soil in between the pads and the underlying native soils. There is no discussion whatsoever in Revision 7 of why this case is representative of the conditions at PFS. *See also* Attachment to NRC's May 7, 2001 letter to PFS, discussed *supra* at 3. In contrast, PFS in Revision 8 attempts to explain how PFS will use the cement-treated soil as an "engineering mechanism" to bond the storage pad to the underlying clayey soils. Cal. G(B)-04, Rev. 8 at 14, 16, 23-26; Bartlett Dec. ¶ 9. Therefore, not until Revision 8 was this issue apparent in its application to the PFS site. As described above, if PFS attempts to support its "engineering mechanism" concept by assuming the pad and cement-treated soil will act as an integral block, it has fatally erred in not including the full inertial force that will act on the underlying soils. Bartlett Dec. ¶ 9.

In Revision 8 PFS presents a confusing and inconsistent design approach in considering whether or not the passive resistance provided by cement-treated soil will have a "beneficial effect" on the factor of safety against sliding. Bartlett Dec. ¶ 10. In the same paragraph of the section titled "Soil Cement Above the Base of the Pad," PFS claims that "soil cement is NOT required to resist sliding of the pads" and "soil cement surrounding the pad may also help to spread the seismic load into the clayey soil outside the pad area to engage additional resistance against sliding of the pad." Cal. G(B) 04, Rev. 8 at 27 (*emphasis in original*). Here PFS is trying to have it both ways. PFS should either include the passive resistance scenario and address all the attendant shortcomings with the use of cement-treated soil or eliminate that concept from its analyses. Bartlett Dec. ¶ 10.

PFS cannot claim any "beneficial effect" from cement-treated soil unless and until it addresses several possible failure mechanisms regarding cement-treated soil's ability to withstand dynamic bending, torsional, and beam shear stresses; its long-term durability without cracking or without significant shear strength degradation; and its interaction with soil chemistry. Bartlett Dec. ¶ 10. Furthermore, during deposition testimony in Utah L, one of PFS's experts, admitted that he could not preclude the possibility that tensile stresses would occur in the soil cement mat, and he committed to consider tensile strength in the future. Trudeau Tr. at 148 (*see* Exh. A to attached Bartlett Dec.). Revision 8 still persists in using the same "beneficial effect" without any analysis whatsoever of the tensile strength of the cement-treated soil. Bartlett Dec. ¶ 10. Accordingly, PFS cannot claim that it meets or exceeds the 1.1 factor of safety against sliding.

PFS has added a section in Revision 8 at 23-25 entitled "Adhesion Between the Base of Pad and Underlying Clayey Soils." Here, PFS assumes it can attain a minimum factor of safety against sliding when the static undrained strength of clayey soils is "fully engaged." Id.

at 25. What Revision 8 still does not address is the impact of increased water content, disturbance and remolding to the strength of the partly saturated silty clay/ clayey silt soils beneath the cement-treated soil, and, thus, PFS cannot take credit in its analysis for the static undrained strength of the clayey soils being "fully engaged." Bartlett Dec. ¶ 11. This is yet another indication of how PFS has underestimated the factor of safety against sliding.

The Applicant's computation of the factor of safety against sliding of individual pads in the longitudinal (north - south) direction is also incorrect. Cal. G(B)-04, Rev. 8 at 28; Bartlett Dec. ¶ 12. In this case analysis, the passive resistance provided by cement-treated soil is ignored. Id. The analysis relating to the factor of safety against sliding is wrong in two essential respects. First, as described above, PFS has applied the incorrect inertial forces acting on the clayey soils because in its analysis it has ignored the mass of the cement-treated soils. The resultant effect is that the factor of safety against sliding will be significantly reduced from that reported in Revision 8. Id.

The second error in PFS's longitudinal pad analysis is that PFS has used an incorrect peak undrained strength to represent the soil's shear resistance for the high levels of inertial forces introduced by the new design basis ground motions. Bartlett Dec. ¶ 12. PFS has failed to analyze the change in soil behavior under the pads where the soil may be subjected to a high intensity of ground shaking and is being impacted by large, cyclic inertial loadings resulting from the masses of the storage casks, concrete pad and cement-treated soil. Changes in the soil behavior from such high intensity cyclic loading will decrease the peak undrained strength used in PFS's analysis and have a significant and detrimental effect on safety. Id. This issue is a long-standing dispute between PFS and the State in Utah L and it still persists in Revision 8. The effects of a thirty five percent increase in the design basis ground motion, however, makes the issue of critical importance to safety.

In sum, PFS has significantly underestimated the factor of safety against sliding by failing to compute the total dynamic forces acting on the native soils in the case where PFS ignores the buttressing effect of cement-treated soils around the pads; PFS has taken credit in estimating the factor of safety against sliding for the beneficial effect of cement-treated soils around the pads without addressing all the attendant shortcoming that cement-treated soil presents; PFS has erroneously assumed that the static undrained native soils will be fully engaged without analyzing the effects of an increase in water content, or a disturbance and remolding of those soils; and in the longitudinal analyses of the sliding of individual pads, PFS has used the wrong inertial forces acting on the native soils and has used the wrong peak undrained strength of those soils to represent shear resistance to design basis ground motions. Taken alone or together, these inaccuracies and unsupported assumptions negate PFS's claim in Cal. G(B)-04, Rev. 8, that it can meet or exceed the 1.1 factor of safety against sliding for the storage pads. PFS does not meet 10 CFR §§ 72.24(c)(3), 72.102, or 72.122(b)(2), and the State requests that the Board allow these significant safety issues to be added to the bases of Utah QQ.

B. Seismic Stability Analysis of the CTB

PFS still persists in assuming that the passive resistance of cement-treated soil around the CTB is available to resist sliding. PFS's analysis was unconservative and inaccurate in Revision 4 of Cal. G(B)-13, and it remains so in Revision 5 too.

In Cal. G(B)-13, Rev. 4, the seismic stability analysis of the CTB upon which Utah

QQ is partly based, PFS "assume[s] that only one-half of the passive pressures are available [to] resist sliding and no credit is taken for the fact that the strength of cohesive soils increases as the rate of loading increases...." Cal. G(B)13, Rev. 4 at 35. Based on that analysis, PFS computes the factor of safety against sliding of the CTB to be 1.13. Id. In Rev. 5 of Cal G(B)-13, PFS has included additional sliding stability analyses based on the full passive resistance of the soil cement and a twenty percent reduction in the residual strength of the clayey soils under the CTB. Cal. G(B)-13, Rev. 5 at 5 and 17; *see also* Bartlett Dec. ¶ 12. Under this additional analyses, PFS computes the factor of safety against sliding of the CTB to be 1.26 and concludes that "[a]ll these factors of safety are greater than 1.1, the minimum required value." Cal. G(B)-13, Rev. 5 at 17.

The new analyses in Revision 5 do not overcome the concerns raised in Utah QQ because the Applicant still inappropriately relies on the passive pressure from cement-treated soil to resist seismic loading. Bartlett Dec. ¶¶ 10 and 13, Utah QQ at 8-9 and Ostadan Dec. ¶ 13. PFS has next to no acceptable margin for safety in its computed CTB stability analysis; it has used non-conservative and unrealistic assumptions; and it has not shown that adding a large quantity of cement-treated soil around the CTB will be effective in resisting the dynamic forces acting on the CTB foundation during seismic excitation. Utah QQ at 9.

In sum, PFS has not demonstrated that the ability of the cement-treated soil around this critically important safety structure will resist the strong ground motions at the ISFSI site. PFS's attempt to buttress its sliding analysis with another additional sliding stability case analysis adds support to the concerns that the State raised about the CTB analysis in Utah QQ. The State requests the Board admit Utah QQ as modified by this Request.

LATE FILED FACTORS:

The State meets the 10 CFR § 2.714(a) late-filed factors for Contention Utah QQ.

Good Cause: The State has good cause for late filing its request to modify Contention Utah QQ. First, the modification request is timely because it is being filed in less than 20 days of receipt of the two revised seismic stability analyses calculations for the pads and CTB.[3] Second, the revised calculations raise new safety concerns that were not evident in the revisions upon which Utah QQ is based.[4] Third, the revised calculations attempt to address some issues raised in Utah QQ but fail to do so; these failed attempts are discussed in this Modification Request and supporting declaration. Fourth, the safety issues raised in both Utah QQ and this Modification Request are significant and compelling. Accordingly, the State has good cause for late-filing this Request.

Availability of Other Means for Protecting the State's Interests: The State has no means, other than this proceeding, of protecting its interests. PFS's notion that the State is challenging commitments that PFS will implement post license and that the State may protect its interest by resort to 10 CFR § 2.206 is without merit. PFS Response to Utah QQ

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[3] The State received the latest revised calculations on June 1, 2001. The State received the prior revisions to these calculations on April 16, 2001. *See* State of Utah's Request for Permission to File Late Filed Geotechnical Contentions Within Thirty Days of Receipt of Calculations Supporting License Amendment (April 23, 2001) at Exhibit 1. A thirty-day rule-of-thumb for timely filing late filed contentions has often been applied in this proceeding. *See* id. at 2.

[4] Pages 2-6 *supra* discusses the distinctions between Revision 7 and Revision 8 of the storage pad analyses with respect to PFS's inaccurate analysis of the case where the buttressing effect of cement-treated soil is ignored. That discussion is incorporated herewith.

at 17. To obtain a Part 72 license, the burden is on PFS to demonstrate that the design of its structures, systems, and components important to safety can withstand the effects of earthquakes without impairing their ability to perform properly. 10 CFR § 72.122. PFS has offered no proof of concept that its novel use of cement-treated soil will provide the required stability to the CTB, storage pads or casks. Section 2.206 is a procedure for requesting the Staff to take enforcement action against an existing licensee and it offers no means of protecting the State's interest in challenging PFS's flawed seismic stability analyses.

Development of a Sound Record: Utah QQ and this Modification Request are not merely legal arguments by counsel but are based on technical support by the State's experts. *See* LBP-01-03, 53 NRC 84, slip op at 13. By conducting critical and substantive reviews of the continual revisions to PFS's calculations to support the design basis ground motion for the ISFSI site, the State demonstrates that it will assist in the development of a sound record in this proceeding. The State's experts and proposed witnesses, Drs. Steven Bartlett, Farhang Ostadan and James Mitchell, amongst themselves have expertise in the disciplines needed to challenge the seismic stability analyses of the pads and CTB, such as soil structure interaction, dynamic analyses, soil strengths and properties, and soil cement and cement-treated soil. Dr. Bartlett's Declaration in support of this Request contains a high degree of technical detail, with specific citation to PFS's calculation packages where, in his expert opinion, PFS's analyses contain omission, errors or inaccurate premises. Dr. Bartlett will testify consist with his declaration. Bartlett Dec. ¶ 3.

Based on past testimony filed in this proceeding,[5] the State has shown that its experts have considerable sophistication on the issues involved with Utah QQ. *See* Cleveland Electric Illumination Co. (Perry Nuclear Power Plant, Units 1 & 2), LBP-83-80, 18 NRC 1404, 1408 (1983). Moreover, because the Staff is likely to support the Applicant, only by having the State's experts participate in this proceeding will the Board be exposed to all sides of the issue. Id. In addition, factor three should not be considered a shorthand notation that the petitioner must submit a summary of its pre-filed testimony where the record already establishes the State's contribution to related seismic issues (Utah L) that overlap in part with Utah QQ and modification thereto. *See* Board Order dated April 26, 2001, at 3 (requesting that the parties brief the Board on the impact, if any, of admission of Utah QQ on PFS's Motion for Summary Disposition of Utah L); State's Request to Admit Utah QQ at 19-20; *see e.g.*, Arizona Public Service Co. (Palo Verde Nuclear Generating Station, Units 1, 2 and 3), LBP-82-117B, 16 NRC 2024, 2029-2030 (1982). Moreover, the difficulty with summarizing pre-filed testimony here is that the State anticipates PFS will again revise the seismic stability analyses for the pads and CTB now that the State has pointed out further shortcomings with PFS's analyses.[6]

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[5] *See e.g.*, Declarations filed on January 30, 2001 in Response to PFS's Motion for Summary Disposition, Utah L.

[6] PFS's response to Utah QQ is reminiscent of PFS's response to Utah E, *i.e.*, the State submits its criticism of PFS's latest concept (*e.g.*, the first draft of the Model Service Agreement) only to find that PFS makes changes in an attempt to deflect the State's criticism. Again, the State finds that PFS has created a moving target because, even at this late stage in the licensing proceeding, PFS's concepts are still evolving on how it can maintain a shallow foundation system through the use of soil cement, notwithstanding a significant increase in design basis ground motions. Therefore, given this moving target, as

The State's demonstration of its grasp of the highly technical issues involved with Utah QQ will assist the Board in evaluating whether adding some cement-treated soil under and around the pads and around the CTB, while still retaining the same basic design in the face of a thirty five percent increase in design basis ground motions, will meet NRC seismic standards. This is a significant safety concern that favors admission of this modification request.

Representation by Another Party: The State is the only party to this proceeding who has challenged the Applicant's seismic analysis of the Skull Valley site, and thus, the State's interests in this matter are not and will not be represented by any other party.

Broadening of Issues or Delay of the Proceeding: Litigation of this issue may somewhat broaden the proceeding but that is through no fault of the State. PFS has created a moving target whereby PFS continues to alter its critical analyses as it attempts to maintain that a shallow foundation system can support the size of the inertial loads for the revised design basis ground motion. The State should not be freighted with this factor being weighed against it because it is the Applicant's continued revisions to its supporting calculations and design concepts that may cause the issues to be broadened or the proceeding delayed. Moreover, a thorough scrutiny of critical safety concerns with the

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well as the sheer volume to material to be reviewed, it is unreasonable to expect the State to summarize its experts' testimony. That said, the State's experts have committed to testify consistent with their detailed declarations in support of Utah QQ and this Modification Request.

foundation systems PFS intends to employ to overcome a thirty five percent increase on ground motions should not be trumped by this procedural consideration.

DATED this 19th day of June, 2001.

Respectfully submitted,

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CERTIFICATE OF SERVICE

I hereby certify that a copy of STATE OF UTAH'S REQUEST TO MODIFY THE BASES OF LATE-FILED CONTENTION UTAH QQ IN RESPONSE TO FURTHER REVISED CALCULATIONS FROM THE APPLICANT was served on the persons listed below by electronic mail (unless otherwise noted) with conforming copies by United States mail first class, this 19th day of June, 2001:

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DECLARATION OF DR. STEVEN F. BARTLETT

JUNE 19, 2001

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of:	)	Docket No. 72-22-ISFSI
	)	
PRIVATE FUEL STORAGE, LLC	)	ASLBP No. 97-732-02-ISFSI
(Independent Spent Fuel	)	
Storage Installation)	)	June 19, 2001

DECLARATION OF DR. STEVEN F. BARTLETT

I, Dr. Steven F. Bartlett, hereby declare under penalty of perjury and pursuant to 28 U.S.C. § 1746, that:

1. I am an Assistant Professor in the Civil and Environmental Engineering Department of the University of Utah, where I teach undergraduate and graduate courses in geotechnical engineering and conduct research. I hold a B.S. degree in Geology from Brigham Young University and a Ph.D. in Civil Engineering from Brigham Young University. I am a licensed professional engineer in the State of Utah.

2. My Declaration in support of State of Utah's Request for Admission of Late-filed Contention Utah QQ (Seismic Stability) (May 16, 2001) was filed on May 16, 2001. I also prepared a declaration in support of State of Utah's Response to Applicant's Motion for Summary Disposition of Utah Contention L, filed on January 30, 2001. Information about my qualifications can be found in both of these declarations.

3. I provide this declaration in support of the State of Utah's Request to Modify the Bases of Late-filed Contention Utah QQ in Response to Further Revised Calculations from the Applicant and, if admitted, I am prepared to offer testimony consistent with this declaration.

4. I am familiar with the Applicant's seismic analysis, and specific to Contention Utah QQ, have reviewed the relevant sections of PFS's License Amendment No. 22 and documents relating to License Amendment No. 22, including the calculation packages and technical reports listed in my May 16, 2001 Declaration ¶ 8.

5. Specific to Utah's Request to Modify the Bases of Contention Utah QQ, I have also reviewed the Applicant's recently revised calculations, Stone & Webster Calculation No. 05996.02-G(B)-04, Rev. 8, *Stability Analyses of Cask Storage Pads* (May 31, 2001), and Stone & Webster Calculation No. 05996.02-G(B)-13, Rev. 5, *Stability Analyses of Canister Transfer Building* (May 31, 2001).

6. The following items have changed from Revision 7 to Revision 8 of Calculation No. 05996.02-G(B)-04, *Stability Analyses of Cask Storage Pads* ("calculation G(B)-04, Rev. 8"):

   a. Calculation G(B)-04, Rev. 8 includes definitions of potential failure modes and failure surfaces and the material strengths to satisfy regulatory requirements.

   b. Calculation G(B)-04, Rev. 8 adds an assessment of the edge effect of the last pad in the column of pads on the stability of the storage pads under the new seismic loads.

   c. In calculation G(B)-04, Rev. 8 (dynamic bearing capacity calculations), the horizontal cask earthquake forces were reduced. If the maximum horizontal inertial force (calculated as pga_h * (weight of the pad + cask dead load) * load case factor (*i.e.*, 0.4 or 1.0) exceeded 0.8 * normal force, then the latter was used as the inertial force. This assumes that cask sliding will occur at this level of horizontal inertial force. This is similar to what has been done previously for the dynamic sliding calculations.

   d. Calculation G(B)-04, Rev. 8 reduces the undrained shear strength of clayey soils beneath the pads to 95% of peak shear strength measured in direct shear tests in analyses that included both shear resistance along the base of the sliding mass and passive resistance. This 5% reduction of peak strength to residual strength was the maximum value measured in three direct shear tests that were performed on these clayey soils for specimens confined at 2 ksf, which corresponds to the approximate final effect stress at the base of the pads.

7. I am familiar with Utah QQ and its bases and assisted in drafting and supporting the State's request for admission of that contention. I have reviewed calculation G(B)-04, Rev. 8 and, as described below, believe that there are further shortcomings in the Applicant's analyses that result from Revision 8.

8. Calculation G(B)-04, Rev. 8 at 14, No. 1, states: "Ignoring horizontal resistance to

sliding due to passive pressures acting on the sides of the pad (i.e., Line AB or DC in Figure 8), the shear strength must be at least 1.85 ksf (12.84 psi) at the base of the cask storage pad line (Line BC) to obtain the required minimum factor of safety against sliding of 1.1."

I disagree with the above statement. The minimum shear strength required to resist dynamic forces with a factor of safety of 1.1 is a function of the magnitude of the dynamic forces. Thus, if the dynamic forces have been underestimated, the minimum required shear strength will be higher than that proposed by the Applicant. Listed below, as well as in the original Contention Utah QQ, are several errors and unconservative assumptions that the Applicant has made regarding the dynamic load transferred to the native soil from the pad/cask system.

9. Inertial Forces Resulting from the Cement-Treated Soil and Other Inertial Forces Resulting from the Pads and Casks.

The Applicant has made a significant error in calculating the dynamic forces acting upon the native soil by the pad-cask system. In evaluating the dynamic force applied to the silty clay / clayey silt at the interface between the top of the foundation soil and the bottom of the cement-treated soil, the Applicant has failed to include the inertial force resulting from the mass of the cement-treated soil. Calculation G(B)-04, Rev. 8 at 17-22 discusses several sliding stability cases for this interface. The analyzed system and potential failure mode are described as follows:

> Material under and around the pad will be soil cement. In this analysis, however, the presence of the soil cement is ignored, both below the pad and adjacent to the sides of the pads, to demonstrate that there is an acceptable factor of safety against sliding of the pads <u>if they were founded directly on the silty clay / clayey silt.</u>

G(B)-04, Rev. 8 at 17 (*emphasis added*).

However, the presence of the approximate 2-foot thick layer of soil cement cannot be ignored in calculating the inertial forces acting upon the native soil. The Applicant's proposed design is based on the assumption that the pad and cement-treated soil will act as an integral block, thus transferring all inertial forces to the top of the clayey soil.

> The soil-cement layer beneath the pads provides an "engineered mechanism" to ensure that the full, static, undrained strength of the

> clayey soils is engaged in resisting sliding forces. It also demonstrates that the bond between this soil-cement layer and the base of the concrete pad will be stronger than the static, undrained strength of the in situ clayey soils, and thus, the interface between the in situ soils and the bottom of the soil-cement layer is the weakest link in the system.

G(B)-04, Rev. 8 at 16.

Thus, inherent in these statements is the assumption that all inertial loads resulting from the casks, pad, and the cement-treated soil must be resisted at the top of the clayey soils. The Applicant has incorrectly calculated the inertial force resulting from the cement-treated soil. The inclusion of this force in the sliding calculation will significantly reduce the factor of safety against sliding. Therefore, the assertion made by the Applicant that the minimum factor of safety against sliding is 1.25 (G(B)-04, Rev. 8 at 25) is incorrect and an adequate factor of safety has not been demonstrated.

Further, the Applicant still has not addressed several dynamic loading issues raised in Utah QQ. These include: (1) the effects of inclined waves striking the pads, (2) pad flexibility and the natural frequency of vibration of the pad/cement treated soil system and the corresponding dynamic loading for that natural frequency of vibration, (3) potential for out-of-phase motion and pad-to-pad interaction, (4) applicable range of phasing in time histories and waves striking the pads, and (5) realistic evaluation of the motion of the casks atop the pads and their interaction with the pads.

I disagree with the Applicant's conclusions that there are adequate factors of safety against sliding for the storage pads. Because of the shortcomings described above, the "true" dynamic loadings acting upon the foundation system remain unknown, and thus the Applicant has not demonstrated adequate factors of safety against sliding.

10. The Applicant's Inconsistent Design Approach Regarding the Use of Cement-Treated Soil to Provide Passive Earth Pressure Resistance to Sliding.

In calculation G(B)-04, Rev. 8 the Applicant proposes an analysis that ignores the "buttress effect" of the cement-treated soil adjacent to the pads and subsequently calculates factors of safety of sliding:

> Material under and around the pad will be soil cement. In this analysis,

> however, the presence of the soil cement is ignored, both below the pad and adjacent to the sides of the pads, to demonstrate that there is an acceptable factor of safety against sliding of the pads if they were founded directly on the silty clay / clayey silt.

G(B)-04, Rev. 8 at 17.

However, later in the same calculation, the Applicant calculates the factor of safety against sliding assuming the soil cement is available to resist sliding:

> The beneficial effect of this soil cement on the factor of safety against sliding can be estimated by considering that the passive resistance provided by this soil cement is available to resist sliding before a sliding failure has occurred.

G(B)-04, Rev. 8 at 27.

The design approach is confusing and contradictory. The Applicant should clearly state its position regarding the use of passive earth pressure from the cement treated soil to resist sliding in its design calculations (*i.e.*, whether it should be included or not). In my opinion, if the Applicant chooses to include its "beneficial effect," then that effect needs to be demonstrated by addressing the cracking and durability issues raised in Utah QQ; otherwise the Applicant should not include the "beneficial effect" in its calculations.

Left unaddressed in G(B)-04, Rev. 8, are the cement-treated soil's ability to withstand dynamic bending, torsional, and beam shear stresses; its long-term durability without cracking or without significant shear strength degradation; and its interaction with soil chemistry. *See* Utah QQ, Bartlett Dec. ¶¶ 13, 15, and 17; Mitchell Dec. ¶ 13. Further, one of the Applicant's experts testified that the Applicant would consider bending and torsional stresses in its design of the cement-treated soil and would provide information regarding the tensile strength of the cement-treated soil. *See* Trudeau Tr. at 146-148, attached hereto as Exhibit A. To date, no such analyses and testing have been forthcoming from the Applicant.

It is my opinion that the Applicant has used inconsistent approaches in G(B)-04, Rev. 8, first in ignoring the passive resistance of cement-treated soil in one set of calculations, then using the "beneficial effects" of cement-treated soil in other calculations. Thus, there is no consistency and reliability in the Applicant's computation of the factor of safety against sliding in G(B)-04, Rev. 8.

11. Adhesion in Calculation G(B)-04, Rev. 8.

Adhesion is the bonding shear strength between two materials. In its most recent revision of the sliding calculations for the storage pads, the Applicant has included a section entitled: "Adhesion Between the Base of Pad and Underlying Clayey Soils." Calculation G(B)-04, Rev. 8 at 23-25. The Applicant claims:

> The shear strength available at each of the interfaces applicable to resisting sliding of the cask storage pads will exceed the undrained strength of the underlying clayey soils. The soil cement beneath the pads is used as an "engineered mechanism" to ensure that the full static undrained shear strength of the underlying clayey soils is engaged to resist sliding and ... the minimum factor of safety against sliding of the pads is 1.25 when the static undrained strength of the clayey soils is fully engaged.

Calculation G(B)-04, Rev. 8 at 25.

In my opinion there are significant shortcomings in the adhesive strength the Applicant assumes at various foundation element interfaces (*e.g.*, bottom of cement-treated soil and top of native soil). The Applicant has still not addressed the significant concerns expressed by State and its experts during written discovery and depositions in Utah L and, most recently, in Dr. James Mitchell's May 16, 2001 Declaration ¶ 14, supporting Utah QQ. Not in calculation G(B)-04, Rev. 8 or elsewhere, has the Applicant addressed the impact of increased water content to the adhesion of the partly saturated silty clay, clayey silt soils beneath the cement-treated soil. Changes in water content in this layer could impact the settlement, strength, and the adhesion between the soil and the soil-cement. *See* Utah QQ, Mitchell Dec. ¶ 14. In my opinion, until these issues are addressed, the Applicant cannot support its claim for an adequate factor of safety against sliding.

Also, the Applicant has not explained, in calculation G(B)-04, Rev. 8 or elsewhere, what construction methods and procedures it will use to ensure that significant disturbance or remolding of the top of the silty clay, clayey silt subbase does not occur.

Accordingly, the Applicant has not demonstrated and cannot maintain that the peak undrained shear strength of the soil will be "fully engaged." *See* calculation G(B)-04, Rev. 8 at 25. Thus, the factor of safety against sliding calculated for the case of sliding atop the native clay will be lower than that calculated by the Applicant.

12. The Applicant's Analysis of the Factor of Safety Against Dynamic Sliding for the Case Where the Passive Resistance Due to the Soil Cement Has Been Ignored.

In calculation G(B)-04, Rev. 8 at 28, the Applicant calculates the factor of safety against sliding for a case where the passive resistance provided by the cement-treated soil is ignored and the dynamic forces act in the north - south direction. The reported factor of safety is incorrect for two primary reasons.

First, the inertial forces used by the Applicant are incorrect. *See* ¶ 8 and 9 above and Contention Utah QQ, Basis 2. The design inertial forces acting on the clayey soil will be greater than those used in calculation G(B)-04, Rev. 8.

Second, the use of peak undrained strength determined from a monotonic test (*i.e.*, one cycle of loading in a direct shear test) to represent the soil's shear resistance for the high levels of cyclic inertial forces introduced by the new design basis ground motion is also incorrect. For analyses where the soil is subjected to several cycles of strong ground motion and is being subjected to large inertial loadings resulting from the interaction of the masses of the storage casks, concrete pad and cement-treated soil, such high intensity cyclic loadings may change the soil behavior from elastic behavior (pre-yield) to plastic (post-yield) behavior. Thus, in my opinion, without the results of cyclic testing performed at the appropriate strain levels for the PFS soils, a conservative reduction in peak undrained shear strength should be used in design. Based on experimental data, Makidisi and Seed (1978)[1] report that the cyclic yield strength is about 80 percent or more of the peak strength determined from static undrained analyses (p. 853). Thus, in my opinion, it is appropriate to consider a 20 percent reduction in peak undrained shear strength as a conservative design value in the sliding calculations. This suggested strength reduction factor of 20 percent is the same value as that used by the Applicant in the sliding calculations for the Canister Transfer Building, Stone & Webster Calculation No. 05996.02-G(B)-13, Rev. 5, *Stability Analyses of Canister Transfer Building* (May 31, 2001), at 17.

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[1] Makdisi, F. I., and Seed, H. B. (1978), "Simplified Procedure for Estimating Dam and Embankment Earthquake Induced Deformation," American Society of Engineers Journal of Geotechnical Engineering Division, pp. 849 - 867, July 1978.

13. Changes to the Sliding Calculations of the Canister Transfer Building.

The Applicant has included additional sliding stability analyses in G(B)-13, Rev. 5 at 37 to attempt to demonstrate "that there is additional margin available to resist sliding of the building due to earthquake loads." This analysis assumes that full passive resistance of the soil cement (*i.e.*, full buttress effect) is available to resist sliding and that the underlying clayey soil has reached residual strength due to the large strain required to mobilize the passive resistance.

In my opinion it is improper to use any passive resistance from the soil cement in any sliding calculations for the reasons discussed in Utah QQ and ¶ 10 of this declaration.

Executed this 19th day of June, 2001.

Steven Bartlett

By: ______________________________
Steven F. Bartlett, Ph.D., P.E.

EXHIBIT A

TO

DECLARATION OF DR. STEVEN F. BARTLETT

JUNE 19, 2001

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of:	)	Docket No. 72-22-ISFSI
	)	ASLBP No. 97-732-02-ISFSI
	)	
PRIVATE FUEL STORAGE, LLC	)	Deposition of:
	)	
(Independent Spent Fuel	)	PAUL TRUDEAU and
Storage Installation)	)	
	)	THOMAS Y. CHANG
	)	

Wednesday, November 15, 2000 - 9:14 a.m.

Location: Utah Attorney General's Office
160 E. 300 S.
Salt Lake City, Utah

Reporter: Vicky McDaniel, CMR
Notary Public in and for the State of Utah

. . .

Q. Do you know what the tensile strength is of the soil cement?
A. (Mr. Trudeau) Not yet. Hasn't been designed yet.
Q. When will it be designed?
A. (Mr. Trudeau) We're -- well, we've -- we're in the process of preparing the ESSOW for the lab testing required for that right now, Engineering

Services Scope of Work.

Q. In designing the soil cement mat, were the effects of surface waves and non-horizontally propagated waves considered?

A. (Mr. Trudeau) We looked only at the strength required to resist the dynamic forces.

Q. In which direction?

A. (Mr. Trudeau) Horizontal direction.

Q. But you didn't consider the vertical direction?

A. (Dr. Chang) The vertical direction is not -- you have up and down, you're not going to slide.

Q. Were the bending and torsional stresses imposed by the surface waves calculated over the four quadrants of the pad area?

A. (Mr. Trudeau) No.

Q. Would bending stresses place the pad mat in contention?

A. (Mr. Trudeau) I don't know.

Q. You stated that -- is the design complete for the cement pad?

A. (Mr. Trudeau) For the --

Q. For the cement --

A. (Mr. Trudeau) For the concrete pad?

Q. Concrete pad mat -- I mean, soil cement mat.

A. (Mr. Trudeau) No.
Q. Is it still in a conceptual stage?
A. (Mr. Trudeau) That's correct.
Q. When do you expect to reduce it from a conceptual stage to a design stage?
A. (Mr. Trudeau) As I said, we're working on getting the lab program to test the soils to see what percentages cement are required to get the unconfined compressive strengths and the durability requirements done now.
Q. Do you plan to measure tensile strength?
A. (Mr. Trudeau) I had not planned to.
Q. Can you preclude that there won't be any tensile stresses in the mat?
A. (Mr. Trudeau) No.
Q. Are you likely to change your mind about whether you're going to consider tensile strength?
A. (Mr. Trudeau) We will look at that. Thank you very much.