

June 7, 2002

**UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION**

Before the Atomic Safety and Licensing Board

| | | |
|---------------------------------|---|---------------------------|
| In the Matter of |) | |
| |) | |
| PRIVATE FUEL STORAGE L.L.C. |) | Docket No. 72-22 |
| |) | |
| (Private Fuel Storage Facility) |) | ASLBP No. 97-732-02-ISFSI |

**REBUTTAL TESTIMONY OF WEN S. TSENG
ON SECTION D OF UNIFIED CONTENTION UTAH L/QQ**

**I. REBUTTAL TO TESTIMONY OF STATE OF UTAH WITNESS DR.
FARHANG OSTADAN**

Q1. In his answer to questions 25, 26 and 31 in the "State of Utah Testimony of Dr. Steven F. Bartlett and Dr. Farhang Ostadan on Unified Contention Utah L/QQ (Dynamic Analyses)" ("Bartlett/Ostadan Direct Testimony"), and in his oral testimony at the May 8, 2002 hearing (Tr. 7455-7472), Dr. Ostadan raises the concern that PFS incorrectly assumes that the reinforced concrete pads upon which the storage casks rest behave rigidly under earthquake loadings. Dr. Ostadan disputes the validity of this assumption, claiming that there is evidence that the pads exhibit significant flexibility under seismic loadings. What is your response to Dr. Ostadan's claim?

A1. PFS has demonstrated using the methodology in a recognized industry technical paper by Iguchi and Luco that the effect of flexibility on the foundation stiffness and damping properties of the pad is insignificant in the frequency range of importance to the cask response. The calculation that demonstrates this result is included in the record as PFS Exhibit MM. In addition, as discussed in my testimony, an analysis of the maximum dynamic displacement of the pad in the vertical direction as computed by ICEC at various nodes on the pad (these are reported in Table D-1(d) at page 234 of the ICEC Calculation G(PO17)-2, Rev. 3) shows that the maximum local deformation of the pad for the nine cases shown on Table D-1(d) is on the order of 0.01 ft, or approximately 1/8 of an inch. Such a small local displacement would produce only secondary effects on the global dynamic response of the system.

Q2. In his oral testimony at the May 8 and May 9, 2002 hearings, Dr. Ostadan disagreed with your conclusion that a maximum pad deformation of 1/8 of an inch establishes pad rigidity for global dynamic response purposes. Dr. Ostadan testified (Tr. 7464-7470) that what is significant is not so much the amplitude of the displacement but the relative motion of various points on a pad with respect to each other, so that if you effectively have a rippling effect of the pad, this will tend to decrease the radiation damping available from the pad. Do you agree with Dr. Ostadan's position?

A2. No. The results of ICEC calculation G (PO17)-2, Rev. 3, which include the effect of pad flexibility, indicate that there is generally only one-half of a wave length, or ripple, in the pad's vertical deflection over the length of the pad. Therefore, there are not multiple "ripples" in the pad vertical displacement. Furthermore, as explained in the response to the previous question, the PFS assessment using the published results of Iguchi and Luco (PFS Exhibit MM) demonstrates that pad flexibility has a relatively insignificant effects on the pad foundation stiffness and radiation damping for the frequency range important to the cask response.

Q3. What is the basis for your conclusion that, contrary to Dr. Ostadan's contention, there will be no deformation ripples" in the pad that will cause it to behave as a flexible, rather than a rigid body?

A3. PFS Exhibit 227 demonstrates that Dr. Ostadan's contention is incorrect. The exhibit is an electronic message from PFS counsel to counsel for the State dated April 28, 2002 and a three-page attachment prepared under my supervision. As described in the e-mail, the attachment consists of a Figure 1, which is a model of a cask storage pad showing node points and the two sections selected for plotting pad displacements; a Figure 2, which shows a plot of dynamic vertical response displacements at 5.285 seconds of the pad along the longitudinal section; and a Figure 3, which shows a plot of dynamic vertical response displacements of the pad at 5.285 seconds along the transverse section. These two plots show the maximum local deformation observed for the pad for the asymmetrical loading of two casks.

Figure 2 of the Exhibit plots vertical displacements on the vertical axis against location at various points on the pad in the long direction of the pad, identified in feet and by node number, with the "Node 7" on the left corresponding to the middle lower edge of the pad and "Node 293" corresponding to the upper middle edge. This plot shows that the maximum pad displacement is about minus 0.01 foot, or about 1/8th of an inch, and it occurs at about 52 feet from the lower edge

of the pad, or 18 feet from the upper edge. This location is between nodes 253 and 255 on the grid, and as expected is the location where the dynamic loadings act on the two casks.

The plot shows that, at time 5.285 seconds, the displacement along the pad is virtually zero for roughly the left half of the pad and then there is one slowly changing set of displacements starting at about 35 feet off the lower edge of the pad, achieving a maximum at 52 feet or so, and then returning to almost zero at the other edge of the pad.

Q4. What is the significance of these results?

A4. These results show that there is a small displacement of the pad at the point of application of the seismic loadings, which then slowly decreases as you move away from the point of application of the force. There are no multiple "ripples" of the type postulated by Dr. Ostadan. In fact, this plot shows that only one-half of a ripple (wave-length) is present in the dynamic vertical displacement due to pad flexibility.

Q5. Would you turn to Figure 3 of Exhibit 227 and indicate what it means?

A5. That figure represents the vertical displacements against location in the pad along the centerline of the casks in the short direction of the pad, going from Node 248 at the edge of the cask on top of the page to node 260. The vertical downward displacements on the pad shown in this plot increase linearly from 0 on Node 248 to a little less than minus (downward) 0.02 feet on Node 260. Such a smooth and near linear increase in vertical displacement demonstrate near rigid vertical motion of the pad in the short direction of the pad.

Q6. In answer 28 of the Bartlett/Ostadan Direct Testimony, Dr. Ostadan testifies that a critical shortcoming in the ICEC pad design calculation is that ICEC obtained the dynamic forces acting on the pad from the Holtec Report HI-2012640. At the May 8, 2002 hearing (Tr. 7532), Dr. Ostadan further testified that ICEC analysis does not include the inertial seismic loading on the pad, which should have been provided by Holtec. As a result, Dr. Ostadan asserts, ICEC used .7g times the weight of the pad to compute that loading, a procedure that probably underestimated the pad accelerations. Are these criticisms valid?

A6. No. For purposes of structural design of the pad, the earthquake inertial loading on the pad itself is insignificant. For a pad of constant thickness, such as the PFSF pads, the earthquake inertial loading is uniformly distributed and produces

no in-plane stresses and very insignificant out-of-plane bending stresses in the pad. Therefore, for the pad's structural design purpose, the earthquake inertial loading on the pad itself has very little influence on the pad design and, thus, is not a significant loading parameter. The earthquake inertial load on the pad does increase the soil shearing and bearing stresses but this inertial loading has been explicitly included when checking the pad's sliding and overturning stability.

Q7. In answer 31 of the Bartlett/Ostadan Direct Testimony, Dr. Ostadan testifies that "The horizontal reaction forces are reported in the ICEC calculation. By dividing the reaction forces by the weight of the casks and the pad, one can clearly observe the effective acceleration experienced by the cask and the pad system. This acceleration is less than 0.60 g. This is for the case where 8 casks are placed on a pad with a coefficient of friction of 0.8. The effective acceleration is less than the peak ground acceleration and is clearly much less than the design motion at the natural frequency of the system. This simple calculation shows that the dynamic loads given to ICEC for the design of the pad are deficient and do not represent the total dynamic load of the cask and the pad." At the hearing, Dr. Ostadan clarified at Tr. 7537 that the table to which he referred in his direct testimony was Table D-1(a) of Calculation G(PO17)-2, Rev. 3. Is the calculation performed by Dr. Ostadan correct?

A7. No. Dr. Ostadan sought to compute the effective acceleration experienced by the cask and the pad system by dividing the average horizontal reaction force on the casks and pad due to dynamic loading shown as Qxd in Table D-1(a) as having a value of 2212 kips by the combined weight of the eight casks and the pad. That computation yields an acceleration of $2212/(2880+950) = 0.59$.

Dr. Ostadan's calculation, however, is incorrect. The maximum dynamic soil reactions presented in Tables D-1(a) through D-1(d) of Calculation G(PO17)-2, Rev. 3, include only the effects of cask dynamic loadings acting on the pad, as provided by Holtec and do not include the inertial loadings of the pad. Therefore, in order to account for the total seismic effect on soil reactions beneath the pad, the inertial load of the pad needs to be added to the dynamic soil reactions provided in the above mentioned tables. The horizontal inertial loading on the pad, based on pad maximum acceleration equal to the maximum horizontal ground acceleration of 0.7g, is 630 kips ($= 0.7g \times 905$ where 905 is the weight of the concrete pad). Thus, the numerator of Dr. Ostadan's calculation should be $(2,212+630) = 2,842$ kips, and the effective horizontal acceleration is 0.75g $(2,842/(2,880+905))$, where 2,880 is the weight of the 8 casks on top of the pad and 905 is the weight of the concrete pad. Such an acceleration is reasonable

considering that the casks on top of the pad, for the case of high cask/pad friction coefficient, will start tipping due to rocking at a cask response acceleration of $0.57g$ ($= 1.0g$ gravity \times one-half diameter of cask ($132.5/2 = 66.25$ inches) / height of center of gravity of cask ($231.25/2=115.625$ inches)). Thus, for the case of cask/pad friction coefficient greater than 0.57 , the casks will tip but not slide. Tipping results in lower horizontal seismic inertial loading on the pad from the casks. For the case of a cask/pad friction coefficient lower than 0.57 , the casks will not tip but will slide at a lower acceleration value equal to the cask/pad friction coefficient value.

Q8. In answer 33 in the Bartlett/Ostadan Direct Testimony Dr. Ostadan contends that Holtec failed to assure itself that it selected appropriate soil spring and damping values for the analysis of the pad and cask movement. In his oral testimony at the May 9, 2002 hearing (Tr. 7565-7587) Dr. Ostadan summarized his concern by saying at Tr. 7576 that Holtec has not demonstrated that the values of soil spring and damping it used represent the peak values at the natural frequency of the pad. Does the concern raised by Dr. Ostadan present a significant problem?

A8. No. Because of the non-linear seismic response of the casks, which requires non-linear time history analyses, approximate but appropriate frequency-independent (constant) soil spring and damping values have to be used. Selection of those values can be accomplished by several methods. One method is to select the values from the frequency-dependent impedance functions that correspond to the fundamental natural frequency of the cask/pad/soil coupled system (as suggested by Dr. Ostadan). Use of this method requires knowing the system frequency beforehand. Due to the non-linear response of the casks caused by sliding and tipping, the system's natural frequencies are not unique and are amplitude dependent. Therefore, the iterative solution suggested by Dr. Ostadan may not work.

The method used by Holtec in its analysis was to select the soil mass, spring and damping parameters using formulae published in a well-recognized technical treatise, Newmark, N. M., and Rosenblueth, E., **Fundamentals of Earthquake Engineering**, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1971. The combination of soil mass and spring parameters produces approximate frequency-dependent foundation impedance functions that cover the frequency range important to the cask response. Use of this method, coupled with the use of three sets of soil

properties (best estimate, lower bound, and upper bound) ensures that a sufficiently large range of frequencies of the cask/pad/soil system is considered.

Furthermore, the analyses performed by Holtec have demonstrated that, despite the large variations of soil parameters used and the performance of analyses in which the soil spring values were deliberately adjusted to “tune” them to the frequency of the peak of the design response spectrum and the damping value was set to an artificially low value of 1%, there are sufficient margins to maintain the sliding and tipping response of the casks within acceptable levels. Such margins have been further confirmed by the analyses performed by the Sandia National Laboratories for the NRC, which did not use soil springs and dampers, but represented the soil by a detailed finite element model.

Q9. Does this conclude your testimony?

A9. Yes.

1 MR. GAUKLER: Dr. Tseng in his rebuttal
2 testimony refers to an exhibit, PFS Exhibit 227,
3 which I think is self-explanatory in terms of the
4 testimony in the document itself. I would move for
5 the admission of that exhibit into evidence.

6 JUDGE FARRAR: What is that exhibit?

7 MR. GAUKLER: It's a --

8 JUDGE FARRAR: It's an e-mail that's
9 attached?

10 MR. GAUKLER: Yeah. It's an e-mail from
11 me to Ms. Chancellor forwarding some information
12 from Dr. Tseng.

13 JUDGE FARRAR: And you want that marked
14 as what?

15 MR. GAUKLER: PFS Exhibit 227. I think
16 the court reporter's already marked it.

17 (APPLICANT'S EXHIBIT 227 MARKED.)

18 JUDGE FARRAR: And now you're moving its
19 admission?

20 MR. GAUKLER: Yes.

21 JUDGE FARRAR: State, any objection?

22 MS. NAKAHARA: No objection, your Honor.

23 JUDGE FARRAR: Staff?

24 MR. TURK: No objection, one question.

25 This will not be bound into the record but simply

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1 put in the exhibit file?

2 JUDGE FARRAR: Right. This is an
3 exhibit.

4 (APPLICANT'S EXHIBIT 227 WAS ADMITTED.)

5 MR. GAUKLER: I have two very brief
6 additional rebuttal questions.

7 Q. (By Mr. Gaukler) Dr. Tseng, you were
8 here yesterday when Dr. Ostadan was discussing the
9 Luk report and Figure 20B of the Luk report. Do
10 you have that?

11 A. Yes.

12 Q. Will you take a look at that very
13 briefly, page 36.

14 A. Yes.

15 Q. You heard Dr. Ostadan say with respect
16 to this Figure 20B that with respect to the 6 g's
17 at 5 Hz that the casks would see this sitting on
18 the pad. Do you agree with that statement?

19 A. Well, the 6g's shown on this Figure is
20 certainly rigorous acceleration spectral value of
21 approximately 22 seconds. That's what we were
22 referring to. And as I understand it, response
23 spectral value is the value of a single degree of
24 freedom subject to the motion that have been
25 calculated. So it is a response of the single

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1 degree of freedom at the damping which was
2 calculated for this response spectra. Now, the
3 damping calculated for this response spectra is not
4 labeled here, so we do not know what kind of
5 damping value for that single degree of freedom.

6 Q. And single degree of freedom means that
7 you have a mass attached to a spring?

8 A. Yes. This is a linear yardstick system
9 with one single mass, single linear spring with
10 certain damping value which we are now missing
11 here.

12 Q. So the only way the cask would see that
13 response is if it were anchored to the pad?

14 A. It's generally a way of characterizing
15 motion, but -- frequency contents of the motion,
16 but it is not necessarily reflected in the response
17 of the casks.

18 Q. You are aware that later in this
19 proceeding we will be introducing rebuttal
20 testimony of Mr. Paul Trudeau where he says that a
21 reasonable long-term estimate of the pad might be
22 something on the order of long-term settlement --
23 long-term static settlement of the pad would be on
24 the order of a half inch. Is that your
25 understanding?

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1 A. Yes, I understand that was the case.

2 Q. And assuming that to be the case, what
3 type of impact would that have on the dynamic
4 motion of the pad, that long-term -- a long-term
5 static settlement of approximately a half inch?

6 A. I do not see, unless the settlement
7 change any of the soil properties, I do not see any
8 effect on the dynamic motion of the pad.

9 MR. GAUKLER: That's all I have.

10 JUDGE FARRAR: Staff?

11 MR. TURK: Yes, your Honor.

12

13 CROSS-EXAMINATION

14 BY MR. TURK:

15 Q. Let me start with the series of rebuttal
16 questions that Mr. Gaukler just asked you. Looking
17 at Figure 20B of Dr. Luk's report.

18 A. Yes.

19 Q. You describe this as a single degree of
20 freedom, that this portrays a single degree of
21 freedom. For the record, could you explain what
22 that term means?

23 A. It's a single mass attached with a
24 single linear spring with a damper attached to it
25 which provide the damping for a single degree of

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1 freedom. Generally characterizes certain fraction
2 of critical damping, and generally they're 1
3 percent damping ratio, 2 percent damping ratio, et
4 cetera.

5 The frequency of a single degree of
6 freedom is the horizontal axis thought as a period
7 which is 1 over the frequency. So if it's 1, 2
8 second would then mean 5 Hz frequency of the single
9 degree of freedom.

10 Q. And it's not a time history. Do you
11 know where the time history -- do you know if there
12 is a time history input to this chart?

13 A. That's correct.

14 Q. And is that correct that that would be
15 Figure 17 that provides the time histories for it?

16 A. So far the label is center point B
17 prime, and the time history on Figure 17 label is
18 center of pad point D. That would mean the time
19 history.

20 Q. So you would agree that because the time
21 histories in Figure 17 are unfiltered and reflect
22 only a single term of damping, that it's the values
23 from Figure 17 that then went into plotting out
24 what you see in Figure 20B? Is that consistent
25 with your understanding?

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1 A. My understanding, of course, is using
2 the time history in Figure 17, and with a single
3 degree of freedom prescribed a certain damping
4 ratio, then you could plot, calculate and plot the
5 response spectra value on Figure 20B. The
6 empirical nature of the time history is quite clear
7 from the response spectra, the very short period
8 range is very high spectral value.

9 Q. I'd like to turn to your written
10 testimony.

11 A. Yes.

12 Q. On page 3 of your testimony in the last
13 paragraph of answer 3 --

14 A. Yes.

15 Q. -- you indicate that displacement along
16 the pad is virtually zero for roughly the left half
17 of the pad and then there is one slowly changing of
18 displacements, and it goes on. Can we tell from
19 the documents you've submitted what the maximum
20 amount of displacement is?

21 A. From that Exhibit 227, they plot, we can
22 identify that to be of the order of .01 feet, which
23 amounts to about one eighth of an inch.

24 Q. Now, also answer 7, at the end of the
25 last paragraph, this appears at the top of page 5,

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1 there's a discussion that indicates that
2 acceleration will "start tipping due to rocking and
3 a cask response acceleration of 0.57 g." Do you
4 see that?

5 A. Yes, I do.

6 Q. When you say "start tipping," do you
7 mean starting to tip over?

8 A. No, not tip over. Start to have --
9 through the base start to have zero compression in
10 the wave.

11 Q. Start to rotate off --

12 A. To start to --

13 Q. Off its vertical axis?

14 A. Yeah, of the pad, yeah, on one end.

15 Q. And the same, later in that paragraph I
16 see the word "tip" and "tipping" again. That's the
17 same sense in which you used the word "tipping"?

18 A. That's correct.

19 Q. In answer 8 at the end of the first
20 paragraph -- well, in that paragraph you discuss
21 the concern expressed by Dr. Ostadan as to the need
22 to describe the soil springs and damping. In
23 Dr. Luk's analysis, as you understand it, are soil
24 springs and damping utilized?

25 A. As I understand, it is a representation

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1 of the soils.

2 Q. So that does not include springs and
3 dampers?

4 A. Not include the springs.

5 Q. And in fact, however, that would account
6 for the effects that are discussed by Dr. Ostadan,
7 correct? I'll read you that last sentence. You
8 say, "Due to the nonlinear response of the casks
9 caused by sliding and tipping, the system's natural
10 frequencies are not unique and are amplitude
11 dependent, and therefore the iterative solution
12 suggested by Dr. Ostadan may not work." That
13 iterative solution would be to do what? To model
14 the soil springs and dampers as they change over
15 time?

16 A. The approach suggested by Dr. Ostadan is
17 a usual procedure if you have a linear system that
18 will work. So you know the system frequency, then
19 you would go to the frequency dependent impedance
20 functions which include soil spring function as
21 well as damping function. Then you go to the
22 frequency of the system and pick out the value.

23 And then if your initial guess is not
24 quite right but on the frequency, then you can
25 recalculate the frequency and go back to the

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1 function so you can enter it that way. And I think
2 that is a very common procedure a for linear
3 system. The problem with the nonlinear system is
4 you really don't have a unique or well defined
5 frequency very well, so you are chasing a number
6 which really is a running target. So in many cases
7 it may work, in many cases it may not work.

8 Now, in the case of Dr. Luk's analysis,
9 he's representing the soil by series of finite
10 elements, and he really bypass the need of going
11 through these procedures.

12 Q. And with respect to the comment you made
13 about the moving target or, as some people have
14 used that term as a constantly changing value for
15 frequency, is that in part because if there is any
16 motion in the cask, as that motion is experienced
17 the frequency will change?

18 A. For example, you get a slide frequency
19 certainly will change. If it's not slide but
20 tipping, then frequency will change to rocking.

21 MR. TURK: Okay, that's all I have.

22 Oh, I'm sorry. May I have one moment,
23 your Honor?

24 JUDGE FARRAR: Yes, you may.

25 Q. (By Mr. Turk) If you would turn to PFS

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1 Exhibit 227. There is a point -- first of all, let
2 me see if I understand this correctly. At the
3 third page of this exhibit you plot out for node
4 No. 2 -- I'm sorry, for -- this presents Figure 2,
5 which is entitled Dynamic Vertical Response
6 Displacements of Cask Storage Pad at 5.285 Seconds
7 Longitudinal Section.

8 A. Okay, that's the second page?

9 Q. No, the third page.

10 A. Yeah, third page.

11 Q. It's entitled Figure 2.

12 A. Entitled Figure 2, yes.

13 Q. I see node 7 at the top of this, at the
14 left-hand margin of this chart. Node 7 appears at
15 zero, node 293 occurs at approximately 67. Those
16 are the nodes that represent the one end of the pad
17 versus the other end of the pad 67 feet away?

18 A. That's correct. If we turn to the page
19 before that, there is a plot of the model for the
20 pad. It has the nodal numbers showing on that
21 Figure, and we can identify a node No. 7. That
22 will be the center line of the pad in a
23 longitudinal or long direction. And the end of
24 that's underlined to be node 293.

25 Q. There's a series of squares that appears

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1 on this Figure 2 commencing at approximately
2 perhaps 36 feet into the pad.

3 A. Yes.

4 Q. Extending down to approximately 50 feet
5 or something of that order?

6 A. Right.

7 Q. Do you see there's sort of a downward
8 slope of that line of squares?

9 A. That's correct.

10 Q. And if I look over to the left-hand
11 margin of this -- I'm sorry. I'm looking at this
12 on its side, so what is now the left-hand margin
13 used to be the bottom. That's the vertical
14 displacement axis?

15 A. Yes.

16 Q. That's a measurement in feet of the
17 vertical displacement --

18 A. That's correct.

19 Q. -- of that axis? So this slope that we
20 see commencing at about 36 or so going down to
21 about 50 or so, that represents the deflection in
22 the pad in the longitudinal direction?

23 A. That's correct.

24 Q. And that's approximately -- goes down
25 from .00 to approximately .01 feet?

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1 A. .01 feet, correct.

2 Q. And that's the maximum displacement you
3 mentioned before about the .01 --

4 A. The particular time histories, yes.

5 Q. Thank you. And just for clarity, the
6 next page, which is Figure 3, that shows the
7 horizontal direction of the storage pad?

8 A. Shows directions.

9 Q. The 30-foot direction.

10 A. Right.

11 Q. And again, to the left side, node 248,
12 that begins at one side of the pad?

13 A. That's correct.

14 Q. And node 30, that's the other side 30
15 feet away?

16 A. That's correct.

17 MR. TURK: Thank you very much. That's
18 all I have.

19 JUDGE FARRAR: All right, Mr. Turk.
20 State?

21 MS. NAKAHARA: Thank you, your Honor.

22

23

CROSS-EXAMINATION

24 BY MS. NAKAHARA:

25 Q. Good afternoon, Dr. Tseng.

1 A. Good afternoon.

2 Q. To follow up on the questions referring
3 to Dr. Luk's report, do you still have that?

4 A. Yes.

5 Q. If you look at Figure 20B on page 36.

6 A. Yes.

7 Q. In your opinion, is the acceleration
8 shown in this Figure too high or too low to cause
9 the pad to move?

10 A. Acceleration of the pad itself?

11 Q. Yes.

12 A. If I want to look at acceleration of the
13 pad, I would then look at Figure 17 that
14 corresponds to Figure 20B. And the question -- do
15 you want me to continue to answer your question?

16 Q. How about if I withdraw that last
17 question.

18 MR. TURK: I would ask that he continue,
19 because I'm going to have to ask him in recross.
20 So I'd ask him to complete his answer.

21 MS. NAKAHARA: That's fine.

22 THE WITNESS: Well, this acceleration,
23 given that the high frequency is so high without
24 filter out, I really can't tell the actual, I would
25 say response acceleration. I would suspect the

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1 actual acceleration would be lower than this. But
2 irrespective of what acceleration value, my
3 testimony have indicated, when you have a cask
4 which has a maximum coefficient of friction of .8,
5 then achieving, when the casks respond up to .8 g,
6 you would expect it would start to slide. Sliding
7 certainly would not increase the cask acceleration.

8 In the meantime, if coefficient of
9 frequency is very high so that a cask is not
10 sliding, then the tipping, without vertical
11 acceleration the tipping will start at about .57,
12 so you would expect that your cask vertical --
13 horizontal acceleration would not be many -- very
14 high, either, just because as soon as you start to
15 tip, the inertia response is so reduced because you
16 won't have the -- it doesn't behave like the
17 anchored casks where you have a sufficient stored
18 energy to amplify the cask response.

19 MR. GAUKLER: Just so the record is
20 clear: I think you mentioned -- you went through
21 two cases there, one for sliding and one for
22 tipping, and I think you mentioned a coefficient of
23 .8 when you were talking about the first case with
24 respect to sliding. Did you mean to say that?

25 THE WITNESS: Well, .8, because the fact

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1 that tipping will start earlier than .8 coefficient
2 of friction, so I would expect it was a tipping
3 response rather than sliding.

4 MR. GAUKLER: I wasn't talking about the
5 friction, I was talking about the case where the
6 cask slid. What coefficient of friction did you
7 mean to say in that case? When you were talking
8 about your two cases on top of the pad.

9 THE WITNESS: Well, I understand that
10 Holtec has analyzed coefficient of friction varying
11 from .2 to .8. So for a low coefficient of
12 friction case, for example, .4, .5, then I would
13 expect the cask to slide first before tipping.

14 MR. TURK: Just for clarity: the figure
15 .8, was that a g force, acceleration force, or was
16 that a coefficient of friction you were referring
17 to when you said if the maximum equals .8? I
18 thought you said at .8 g you would expect it to
19 start to slide.

20 THE WITNESS: Yes, .8 g, yes.

21 MR. TURK: So that was not a coefficient
22 of friction value?

23 THE WITNESS: Well, it tied to
24 coefficient of friction. And a case without
25 vertical acceleration, then .8 g would be equal to

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1 a weight times -- measure of force would equal to
2 :8 coefficient of friction times the weight of the
3 casks.

4 Q. (By Ms. Nakahara) Dr. Tseng, if you
5 look at Figure 20B again, and at 0.2 seconds what's
6 the acceleration in the center of the pad at point
7 D prime?

8 A. Well, again, by looking at this response
9 spectra value, I cannot tell. And the high
10 frequency -- normally if the high frequency is not
11 so high, you would have a zero period of
12 acceleration on the response spectra, and I can
13 infer from zero period spectra of acceleration.
14 But unfortunately, the high frequency is so high
15 that you cannot really get that zero period
16 acceleration to be the pad acceleration.

17 Q. At 0.2 seconds what's the acceleration?

18 A. The 0.2 spectra acceleration is about
19 around 6.5.

20 Q. 6.5 g's, correct?

21 A. At 6.5 g's, that's the spectra
22 acceleration.

23 Q. At 0.2 seconds and 6.5 g's, in your
24 opinion is the motion of the pad at 0.2 seconds too
25 high or too low?

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1 MR. TURK: Objection. I don't
2 understand. Objection to the form of the question.

3 Q. (By Ms. Nakahara) Do you understand,
4 Dr. Tseng?

5 MR. TURK: Well, the record will be
6 unclear whether he understands or not.

7 JUDGE FARRAR: I think the problem is,
8 too high or too low versus what?

9 MR. TURK: Or what terms.

10 MS. NAKAHARA: I can try and clarify.

11 JUDGE FARRAR: Yes, please.

12 Q. (By Ms. Nakahara) Dr. Tseng, is it
13 correct that you testified that Figure 20B is a way
14 to show the motion of the pad?

15 A. It characterize the motion of the pad.

16 Q. Characterize the motion of the pad.
17 Thus, at 0.2 seconds, how would you characterize
18 the motion of the pad?

19 A. Well, this goes back to earlier on where
20 if you have a single degree of freedom in linear
21 system with certain damping value which is not
22 clear here on this Figure, that will respond to
23 that 6.5 g and the motion of the pad.

24 Q. How would you characterize the motion in
25 the pad? As too high or too low?

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1 MR. TURK: Objection.

2 MR. GAUKLER: Objection.

3 MR. TURK: Same question, same problem.

4 MR. TRAVIESO-DIAZ: Also lacks
5 foundation. He hasn't testified that the pads move
6 at all.

7 Q. (By Ms. Nakahara) In your opinion would
8 the pad move at 0.2 seconds?

9 MR. TURK: I'm sorry. DR. SOLER stated
10 that it's a way of characterizing the motion of the
11 pad. He didn't state that the pad moves.

12 MS. NAKAHARA: I didn't ask him that. I
13 withdrew that question, and now I'm asking in his
14 opinion would the pad move at 0.2 seconds.

15 MR. GAUKLER: 0.2 seconds?

16 MS. NAKAHARA: At 0.2 seconds on Figure
17 20B.

18 A. If I want to answer your question
19 straight, I would have to recompose the time
20 history of the pad into frequency components, and
21 to take 0.2, which is 5 Hz window and look at the
22 motion, filter out that window and look at that
23 acceleration. That information is not readily
24 available here.

25 Q. In your opinion, would the information,

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1 unfiltered information in Figure 20B be an
2 indication that maximum acceleration of the pad
3 could be high?

4 A. Well, with the unfiltered it shows high.
5 On the other hand, we really don't know how much
6 unfiltered result would affect us, because as you
7 can see, normally a response spectra you would come
8 down at close to zero period, you come down to peak
9 acceleration value, and if you do look at the
10 unfiltered time history at Figure 17, the maximum
11 here, even with this unfiltered results, is about
12 3. Then the zero period value would be reduced on
13 to 3, and yet I have not seen that spectra value
14 reduced on to 3. So I think there's a lot of
15 filtering need to be done or corrections or
16 something need to be done before we can even look
17 at this Figure and say whether that number was high
18 or low.

19 Q. Would filtering affect the motion at 5
20 Hz?

21 A. Well, it depend on how you filter it.
22 If you filter the motion outside of significant
23 earthquake energy range, which generally below 33
24 Hz, then you would not affect the 5 Hz frequency.
25 But whether you affect the spectra response

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1 calculation, I have no answer at this time.

2 Q. Thank you. With respect to your
3 testimony regarding long-term settlement and
4 Mr. Trudeau's testimony, how do you define
5 long-term settlement of the pad?

6 A. I'm not a soil engineer, but I take it
7 literally as the settlement experience through time
8 for foundation and load.

9 Q. Would long-term settlement include
10 elastic settlement of the pad?

11 A. Long-term settlement would have also
12 initial elastic, and then of course, continuing on,
13 you have continuous element. That's my
14 understanding.

15 Q. Would long-term settlement include
16 primary consolidation settlement?

17 A. I would say so.

18 Q. And would long-term settlement include
19 secondary compression?

20 A. I wouldn't know the detail of all the
21 component according to long-term settlement.

22 Q. Dr. Tseng, are you familiar with what's
23 been marked as State's Exhibit 168, which has not
24 been admitted? It's a page out of the Safety
25 Analysis Report, Chapter 2, Revision 22, and I

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1 apologize for reading over your shoulder, page
2 2.6-50.

3 MR. TURK: Could we have a moment to try
4 to find the document? And off the record.

5 (Discussion off the record.)

6 Q. (By Ms. Nakahara) Dr. Tseng, have you
7 seen this document before?

8 A. I may have seen it, but it's not very --
9 don't have a lot of impression of this document.

10 Q. The title of the section, is it correct
11 that it reads "Static Settlements of the Cask
12 Storage Pad"?

13 A. Correct.

14 Q. And then the bullets, do they read
15 "Elastic Settlement 0.5 inches"?

16 A. Correct.

17 Q. The next bullet, "Primary consolidation
18 settlement, 0.8 inches"?

19 A. Correct.

20 Q. "Secondary compression, 0.4 inches"?

21 A. Yes.

22 Q. And for a total of maximum total
23 settlement 1.7 inches?

24 A. Yes, that's what it states here.

25 Q. If the maximum total settlement or

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1 long-term settlement was in fact 1.7 inches as
2 predicted by PFS in their Safety Analysis Report
3 versus the 0.5 inches you considered, would you
4 change your opinion you gave earlier to
5 Mr. Gaukler?

6 A. Well, the opinion earlier was operating
7 with any long-term settlement effect dynamic
8 response of the pad. And my response was, as long
9 as the soil dynamic property is not transferred to
10 this long-term settlement, then you wouldn't have
11 any effect on it. And that, I think I still stand
12 by that response.

13 MS. NAKAHARA: Your Honor, I believe
14 Utah Exhibit 168 is relevant on this issue,
15 although we maintained it was relevant earlier. I
16 move for admission of Utah -- or State 168.

17 JUDGE FARRAR: Any objection?

18 MR. GAUKLER: I think the objection that
19 we made at the time was that long-term settlement
20 was outside the scope of the case. I think your
21 Honor should have moved to the contrary on that and
22 maintained our original objection. Other than
23 that, we have no objection.

24 JUDGE FARRAR: And why didn't -- seeing
25 how the transcript's here, why didn't we admit it

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1 at that time?

2 MS. NAKAHARA: I didn't offer it, your
3 Honor.

4 JUDGE FARRAR: That's a good reason.
5 Mr. Turk?

6 MR. TURK: I think you had ruled me out
7 on this one. I'll restate the objection I made at
8 the time. You may recall I had supported the
9 Board's -- or had made statements supporting the
10 Board's consideration of the issue of the long-term
11 settlement that in the Staff's testimony had
12 addressed it. I then realized I had erred and I
13 came back with actually some transcripts from
14 depositions noting that the only time the State had
15 raised that issue was not in connection with the
16 issue of differential settlement of the pads -- I'm
17 sorry. That the only way they had raised the issue
18 was with respect to the impact on adjacent soil
19 cement. I don't oppose the admission of this
20 exhibit, because this seems to me to go to the
21 issue of the pad's settlement effect upon the soil
22 cement, if I'm reading it correctly.

23 JUDGE FARRAR: Well, then --

24 MR. TURK: If I'm reading it
25 incorrectly, perhaps somebody else can tell me.

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1 JUDGE FARRAR: Then we will admit the
2 document.

3 (STATE'S EXHIBIT-168 WAS ADMITTED.)

4 MS. NAKAHARA: Thank you, your Honor.

5 MS. CHANCELLOR: If it helps your record
6 keeping, it was offered at page 5598.

7 JUDGE FARRAR: Thank you,
8 Ms. Chancellor.

9 Q. (By Ms. Nakahara) Dr. Singh, with
10 respect to your written rebuttal testimony, your
11 response to question 1 refers to PFS Exhibit MM.
12 Based on the testimony that you've heard in this
13 proceeding or read in this proceeding or based on
14 your rebuttal testimony, have you changed any of
15 your prefiled testimony or oral testimony with
16 respect to PFS Exhibit MM?

17 A. Well, Exhibit MM deals with flexibility
18 of the pad. And I think the result still stand
19 that, based on the parameter they have calculated
20 for that pad, the effect on the foundation
21 stiffness and damping is very small effect to the
22 pad.

23 Q. So is it correct that you have not
24 changed -- today you have not changed any of the
25 opinions that you've given in prefiled testimony or

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1 orally in this proceeding?

2 A. No.

3 Q. In the first sentence you refer to the
4 frequency range of importance to the cask response.

5 A. Yes.

6 Q. What is the frequency range?

7 A. That's 1 to 5 Hz.

8 Q. I believe this is already on the record,
9 but clarify, what is basis for the 1 to 5 Hz?

10 A. Since it's nonlinear response, so the
11 basis of 5 Hz, 1 to 5 Hz was calculated really by
12 Geomatrix consultants using the cask response
13 motion under the earthquake input. And then the
14 ratio that calculated full spectra ratio to the
15 input motion, there you can identify what's the
16 significant amplified range of motion of the pad.
17 And from that full spectra ratio you can identify
18 this 1 to 5 Hz is the amplifying motion for the
19 casks.

20 Q. You state that the frequency of the
21 system is a moving target?

22 A. As far as the entire pad -- cask/pad and
23 soil interaction, the fact that the cask is
24 experiencing nonlinear response under earthquake
25 input, there is not a single unique frequency that

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1 you can identify unless there is no sliding or
2 uplifting, then of course the whole system is still
3 linear. But that would be at a lower level, low
4 level excitation.

5 MR. TURK: Ms. Nakahara --

6 Q. Lower level excitation corresponds to
7 what frequency?

8 A. If the earthquake capacity is lower so
9 that doesn't cause any sliding or rocking appeared
10 in response of the casks, then you will have a
11 linear system. In that case, there will be a
12 station -- or the constant stationary system
13 frequency.

14 Q. And in your opinion that the frequency
15 of the system is a moving target, would it also be
16 moving from 1 to 5 Hz?

17 MR. TURK: May I interject? That was my
18 characterization, that was not the witness's. I
19 used the phrase "moving target," and I said as the
20 State has used that term. I don't know if we can
21 ascribe to DR. SOLER the term that I utilized.

22 JUDGE FARRAR: Can you -- understanding
23 the background, can you answer the question?

24 THE WITNESS: Yes. I think the 1 to 5
25 Hz already was calculated under the condition that

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1 the casks already experiencing nonlinear response.
2 So that would be already in that range but is not a
3 single value. That's what I'm trying to say.

4 Q. (By Ms. Nakahara) In your response to
5 question 1 towards the end of page 1, you state
6 that the maximum local deformation of the pad for
7 the nine cases shown on Table D-1(d) is on the
8 order of 0.01 feet or approximately one eighth of
9 an inch, correct?

10 A. That's correct.

11 Q. In your prefiled testimony, will you
12 clarify, in response to answer 70, in response to
13 answer 70 you state, "Further, the displacements in
14 the table --" if you look at the question -- strike
15 it. Make this clear since I don't have a copy for
16 you. Question 70 asks, Dr. Ostadan also refers to
17 Table D-1(d) at page 234 of your calculation, which
18 appears to be the same table that you're referring
19 to --

20 A. Yes.

21 Q. -- in your rebuttal testimony. But in
22 your response to answer 70 you state, the largest
23 displacement -- the very last sentence. The very
24 last sentence in your response to question 70
25 states, "These --" The second to the very last

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1 sentence, sorry. "Thus, the largest displacements
2 are on the order of three eighths of an inch." Can
3 you explain the discrepancy between three eighths
4 and one eighth?

5 A. Well, the one and one eighths is really
6 the deviation from say like, you know, rigid body
7 average motion. But if you count the rigid body,
8 of course there will be additional --

9 (Off the record briefly.)

10 THE WITNESS: If you count the rigid
11 body component of motion. But we are talking about
12 flexibility of the pad, so we have to use the
13 number deviate from rigid body motion.

14 Q. In response to answer 3 of your rebuttal
15 testimony, the last sentence of the first paragraph
16 you state, "These two plots show the maximum local
17 deformation observed for the pad for the
18 asymmetrical loading of two casks," correct?

19 A. That's correct.

20 Q. What position were these two casks
21 located?

22 A. At the end of the pad, one end of the
23 pad.

24 Q. Did you analyze the maximum deformation
25 for any other loading combinations?

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1 A. We did analyze the case for four casks
2 on one side of the pad as well as the four casks --
3 eight casks on the pad.

4 Q. For the four casks on one side do you
5 recall what the maximum differential was?

6 A. Well, I couldn't recall right now, but
7 as we look at the differential case, the two casks
8 on the one end appears the largest differential.

9 Q. And that's between the two casks on one
10 end and four casks on one side or eight casks?

11 A. For the case of eight casks full
12 loading, you produce mainly rigid body motion,
13 raise more amount of deviation. Then you start to
14 get more, as you get four casks on one side, then
15 it produce the most when you have two casks.

16 Q. Did you look at two casks on opposite
17 ends of the pad?

18 A. You mean two on one end and two on the
19 opposite end?

20 Q. No, two casks total. Are you familiar
21 with the location numbers that Dr. Soler has used
22 in his various reports?

23 MR. TRAVIESO-DIAZ: Ms. Nakahara, if I
24 could make a suggestion to help you?

25 MS. NAKAHARA: Use the exhibit?

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1 MR. TRAVIESO-DIAZ: Yes. Look at Figure
2 1 that has the cask number.

3 MS. NAKAHARA: Thank you.

4 THE WITNESS: Now, the cask number on
5 Figure 1 is the same as Dr. Soler's numbering,
6 correct?

7 Q. (By Ms. Nakahara) Did you consider two
8 casks placed at cask location 1 and cask location
9 8?

10 A. No.

11 Q. Did you consider any other configuration
12 other than -- strike that. Did you consider -- did
13 you analyze casks placed at location 1 and location
14 7?

15 A. No.

16 Q. In your opinion, would either of those
17 situations of casks located in position 1 and 8 or
18 1 and 7 create more deformation?

19 A. Since I haven't analyzed it, I don't
20 know whether you will or not. But based on my
21 engineering looking, there probably would be --
22 you've got a symmetrical conditions at the middle
23 and then you will work similar to the two casks on
24 one end, except that you would now create two
25 dishes, two deformed shape, symmetrical. As this

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1 Figure of Figure 2, you'll have four casks on one
2 end, you'll have this deformed shape on one end,
3 and the other end is virtually flat. And you would
4 now have this similar deformed shape on the other
5 hand.

6 Q. Would you then get, then being in a --

7 A. Perhaps the total deflection could be
8 increased from what they have now, but differential
9 would probably be similar.

10 Q. And that would be for both cases, a cask
11 located at location 1 and a cask located -- strike
12 that. That would be for both cases where two casks
13 are located at position 1 and position 8 and
14 position 1 and 7?

15 A. In terms of magnitude, I would say
16 probably similar. Of course the shape will be
17 somewhat different.

18 Q. Would the shape caused by the
19 alternative locations that you did not analyze,
20 would that create more of a ripple effect as you
21 consider a ripple in your response to answer 2?

22 A. Well, the loading certain -- well, the
23 deflect shape reflect where the load is placed. So
24 if you have a load placed there, you would expect
25 there will be some deflections.

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1 Q. Would a ripple effect -- not to beat a
2 dead horse, I'm sorry -- with respect to casks
3 loaded in position 1 and 7 generate more than half
4 a wavelength, in your opinion?

5 A. Well, it would be one side half
6 wavelength, the other side have one half
7 wavelength.

8 Q. Would that be the same situation for a
9 cask loaded in position 1 and position 8?

10 A. I would expect similar, except there
11 will be some transverse turning or twisting
12 differently.

13 Q. Did you consider the cask combination of
14 three casks?

15 A. For the final design calculation we did
16 not. But very early on actually we have
17 investigated one through eight cask cases, and
18 looking at the results, they were not really as
19 much different. I mean, in terms of design
20 purpose, you try to capture the maximum response.
21 We have determined that two, four, and eight would
22 capture the maximum pad internal force response.

23 Q. And would capturing the maximum internal
24 response also include capturing the maximum --

25 A. Deflection.

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1 Q. Yes. Dr. Tseng, you have shown a
2 vertical displacement at 5.285 seconds along the
3 length of the pad, correct?

4 A. That's correct.

5 Q. Is this displacement based on the forces
6 provided to you by Holtec?

7 A. That's correct.

8 Q. Why did you select 5.285 seconds?

9 A. That's the maximum deflection.

10 Q. At any point in time on the pad?

11 A. Well, underneath the loads, so in that
12 region of pad. And that would be the maximum
13 deflection.

14 Q. Because the casks are moving, the
15 location of the forces acting on the pads -- strike
16 that. Because the casks are moving, are the
17 location of the forces acting on the pad changing
18 with time?

19 A. Well, for the case we are looking at,
20 it's a frictional coefficient of .8, so as far as
21 pad response is concerned, internal force generated
22 maximum by the maximum amount of tipping and
23 rocking response, rather than by sliding. So for a
24 case of pad design, not sliding but maximum rocking
25 response are the controlling cases. So there is

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1 really no moving of the forces.

2 Q. Will you explain on Figure 1 of Exhibit
3 227 where you would find the forces?

4 A. The forces were applied for each cask
5 represented by a circle of the four points, four
6 quadrants of the circle. Each quadrant would have
7 one force and function. And I think earlier on
8 this morning Dr. Soler testified that that's the
9 important time history that they supplied to us.

10 Q. In your opinion, at a coefficient of
11 friction of 0.8 are the casks sliding?

12 A. The initial force of 0.8, yes. But
13 since tipping response will start at a lower g
14 value, it would then start to tip. Once it tipped,
15 then it will response in tipping.

16 Q. Just to clarify, once the cask starts
17 tipping, in your opinion the cask will not also
18 slide? There would be no sliding of the cask; is
19 that correct?

20 A. Unless the vertical acceleration is such
21 that it reduce the effective load down to smaller.
22 And that will be a very small time steps -- I mean,
23 time distance. And there will be maybe a very
24 sharp time distance where one vertical acceleration
25 goes up, goes down, that reduce the contact force

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1 between the casks and the pad.

2 Q. Just to clarify: you did not move the
3 location of the forces acting on the pad?

4 A. In our design, we do not move.

5 Q. Did you request the acceleration
6 response of the pads from Holtec for your
7 calculation?

8 A. Well, I think in the very beginning we
9 did, but the acceleration was not calculated then.
10 So in their final design we did not request. Then,
11 as you know, Dr. Soler testified this morning, I
12 think the raw acceleration cannot be directly used.
13 I think you need to process them in certain way
14 before it can be used.

15 Q. You indicated that you initially asked
16 for acceleration. What was the basis for your
17 request?

18 A. Since they're calculating the entire
19 system, certainly we would like to have not only
20 the forces but acceleration, not only just pad but
21 the casks too. But realizing that there is a limit
22 amount of output that they have calculated, since
23 they have calculated so many cases, restriction
24 vary from .2 to .8 with many, many different
25 variation. So to minimize the amount of data

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1 transfer, we have eventually reduced down to asking
2 just the sufficient loading information that we
3 need to perform our analysis and design for the
4 pad.

5 Q. Are you aware of any calculations
6 performed by NRC staff or PFS that provides the
7 acceleration response of the pad?

8 A. Other than this earlier report, Staff
9 Exhibit T, I'm not aware of any other reports.

10 MR. TURK: For clarity: that would be
11 Dr. Luk's report?

12 THE WITNESS: Yes.

13 Q. (By Ms. Nakahara) Although the
14 accelerations provided in Dr. Luk's report are
15 unfiltered, have the accelerations shown in that
16 report caused you to reconsider any portion of your
17 pad structural analysis?

18 A. Well, for pad per se, no. Horizontal
19 total acceleration really does not cause much for
20 the pad itself. It does change the soil reaction
21 force that the pad stability calculation have to be
22 include. But as far as pad's own forces, you
23 have -- you can apply an acceleration onto a pad
24 horizontally and it behave like implant rigid, so
25 you put -- and uniform inertia didn't really

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1 produce any differential stresses in the pad.

2 Q. Do you agree in-plane rigid means
3 response of one node compared to others are about
4 the same?

5 A. Yes.

6 Q. Do you agree with Dr. Luk's opinion that
7 response may change from one node to another?

8 A. Well, in-plane rigid, if you said
9 infinitely rigid, then it will be identical, but if
10 you are just rigid they would have some
11 differential, depending on how much.

12 Q. Would you characterize that as a
13 significant change?

14 A. I don't think I understand character
15 exact.

16 MS. NAKAHARA: Could you re-read
17 Dr. Singh's last answer, please?

18 (The record was read as follows:

19 "Well, in-plane rigid, if you said
20 infinitely rigid, then it will be
21 identical, but if you are just rigid
22 they would have some differential,
23 depending on how much.")

24 Q. (By Ms. Nakahara) Can you quantify some
25 differential differences from node to node if it's

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1 characterized as just rigid, if the pad is
2 characterized as just rigid?

3 A. Well, I think it's just intuitively, if
4 you have a pad like this, that in plane, in plane
5 direction it will be really quite rigid. Other
6 plane direction is really the best direction, and I
7 think for quantifying a number, I don't think it's
8 really necessary.

9 Q. And the response at nodes -- at
10 different nodes for a pad such as the PFS pad would
11 not be significantly different?

12 MR. TURK: Objection. Are you talking
13 in plane or not in plane?

14 MS. NAKAHARA: In plane.

15 THE WITNESS: If in-plane rigid, then
16 the response would be quite similar to each other
17 at component of points, yes.

18 Q. (By Ms. Nakahara) Dr. Tseng, if you'll
19 look at your response to question 7. In the second
20 paragraph you refer to a maximum horizontal ground
21 acceleration of 0.7 g's; is that correct?

22 A. That's a number used for this
23 calculation.

24 Q. What is your basis for using 0.7 g's in
25 this calculation?

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1 A. That's a maximum ground surface
2 acceleration. I think the correct specific number,
3 it could be .711, but for the purpose of this
4 discussion, we just rounded off to .7.

5 Q. Is that the acceleration response of the
6 pad?

7 A. That's assumed to be if the pad's
8 response the same as is one surface acceleration.
9 And that's assumption for this calculation.

10 Q. On page 5, continuing your response to
11 question 7, you state, "Thus, for the case of
12 cask/pad friction coefficient greater than 0.57,
13 the casks will tip but not slide," correct?

14 A. Yes.

15 Q. Have you reviewed the results of
16 Holtec's cask sliding analysis for the 2,000-year
17 design-basis earthquake?

18 A. I have not reviewed in detail, but I
19 have reviewed some of the report. I think the
20 calculation on this particular answer is trying to
21 offer a ballpark figure for us to feel at what g
22 value we expect what kind of response of the casks.
23 Rather than trying to portray that it will be a
24 particular g value, that the response, realizing
25 that under earthquake loading, mean time history,

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1 there are much more complex response than this.
2 But with all the complex response, it has to follow
3 certain physical parameter. And these are the
4 static physical parameter that you would expect,
5 and dynamic response would be then vary just
6 plus-minus of these values.

7 Q. Dr. Tseng, this is a Holtec report,
8 Holtec Cask Response at PFS ISFSI from 2,000-year
9 seismic event, Revision 2, Report No. HI-2012640
10 dated August 20th, 2001. Are you familiar with
11 this document?

12 A. I think I've seen this document.

13 Q. If you'll turn to page 28.

14 MR. TURK: For clarification, this is
15 Utah Exhibit 173?

16 MS. NAKAHARA: Yes.

17 MR. TURK: Thank you.

18 THE WITNESS: Page --

19 Q. (By Ms. Nakahara) Page 28. For cask
20 No. 2, and Dr. Tseng's copy has a circle, the data
21 that's circled which show the displacement of 1.2
22 inches, do you agree that that's for cask No. 2 in
23 the Y direction at the bottom of the cask, or a
24 coefficient of friction of 0.8?

25 A. I take it that cask No. 2 is referring

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1 to the order of the output of these casks, which
2 correspond to the order of the casks?

3 Q. Yes.

4 A. And the circle one is the one that shows
5 Y displacement for, parentheses, bottom, equal to
6 minus 1.2? That's the number you're referring to?

7 Q. Yes. And this is at a time of 5.5
8 seconds, correct?

9 A. Correct.

10 Q. For a coefficient of friction of 0.8,
11 correct?

12 A. Correct.

13 Q. Now, will you look at page 30 of PFS --
14 of State Exhibit 173 for cask No. 8.

15 A. Yes.

16 Q. What is the displacement at the bottom
17 of the cask in the Y direction?

18 A. That's the last number that you were
19 referring to?

20 Q. Yes.

21 A. Minus 1.2.

22 Q. Now, if you'll turn to Dr. Luk's report.
23 We're back to Exhibit P on page 30. Is this the
24 displacement for a best estimate model Type 2 with
25 a coefficient of friction 1 equal to -- strike

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1 that. What is the displacement for the best
2 estimate model 1 for coefficient of friction 1
3 equals 0.8 and mu 2 equal to 1.0 at the base of the
4 cask in the horizontal direction?

5 A. Referring to U1, 1.46 inch.

6 MR. TURK: I'm sorry. Again, I wasn't
7 sure which one he's addressing. He's looking at mu
8 2 for best estimate?

9 A. U1 on this table. With -- am I correct,
10 best estimate normal, type 1?

11 Q. Yes.

12 A. With coefficient of friction, mu 1 equal
13 to 0.8 and mu 2 equal to 1.0. And then on the row
14 that's marked as base. Am I correct?

15 Q. Yes.

16 A. And then under U 1 column is 1.46 inch.

17 Q. Based on the results of Holtec and
18 Dr. Luk for a coefficient of friction of 0.8, do
19 you agree that Holtech and Dr. Luk showed that the
20 cask will slide at a coefficient of friction of
21 0.8?

22 A. That's correct.

23 Q. In your response to question No. 8, in
24 the second paragraph you state, the method used by
25 Holtec in its analysis was to select the soil

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1 spring -- strike that. You state, "The method used
2 by Holtec in its analysis was to select the soil
3 mass, spring and damping parameters using formulae
4 published in a well-recognized technical treatise,
5 Newmark, N.M., and Rosenblueth, E., Fundamentals of
6 Earthquake Engineering." Is that correct?

7 A. That's correct.

8 Q. Have you reviewed Holtec's calculations
9 of soil mass, spring and damping parameters?

10 A. Have I reviewed?

11 Q. Yes.

12 A. I have seen -- I have -- the number were
13 included this report, yes.

14 Q. Have you reviewed the calculations
15 themselves for their accuracy?

16 A. I did not check the calculation.

17 Q. Were you present when Dr. Soler
18 testified that the force time history given to ICEC
19 did not include the forces in the dash pots
20 earlier?

21 MR. GAUKLER: I think that
22 mischaracterizes the testimony of Dr. Soler.

23 MS. NAKAHARA: I'll withdraw the
24 question.

25 Q. (By Ms. Nakahara) In your response to

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1 question 8 in the first paragraph, isn't it true
2 you indicate that the natural frequency of the
3 system varies, and due to cask sliding or tipping,
4 the method proposed by Dr. Ostadan may not work?

5 A. That's correct.

6 Q. Do you have a copy of the ICEC
7 calculation?

8 MS. NAKAHARA: If I may have a moment,
9 your Honor.

10 JUDGE FARRAR: Go ahead.

11 Q. (By Ms. Nakahara) Look at page 171.

12 A. Yes.

13 Q. The graph for the lower bound soil.

14 MR. GAUKLER: Would you repeat that page
15 again, please?

16 MS. NAKAHARA: 171, for lower bound
17 soil.

18 MR. TURK: Which exhibit are we in?

19 MS. NAKAHARA: I don't believe it's an
20 exhibit. It's ICEC's calculation entitled Storage
21 Pad Analysis and Design Calculation No. GP 017-2
22 dated April 5th, 2001.

23 MR. GAUKLER: That is PFS Exhibit 85,
24 portions of it are. That particular page is part
25 of PFS Exhibit 85.

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1 MR. TURK: Utah Exhibit 170, which
2 appears to be from the same calculation.

3 MS. NAKAHARA: Pardon?

4 MR. TURK: Utah Exhibit 170 appears to
5 be the same calculation.

6 MR. TRAVIESO-DIAZ: I think PFS Exhibit
7 85 has more of it.

8 Q. (By Ms. Nakahara) For the lower bound
9 soil, do you see a foundation frequency of about 5
10 Hz?

11 A. I see a peak of this transfer function
12 of 5 Hz, yes.

13 Q. And on page 181 for the best estimated
14 soil?

15 A. Yes.

16 Q. Do you agree the foundation shows a
17 frequency of 8 Hz, around 8 Hz?

18 A. Well, the peak of the transfer function
19 is 8 Hz.

20 Q. And on page 193 for the upper bound
21 soil, do you agree the transfer function shows a
22 frequency of 11 Hz?

23 A. Somewhere between 10 and 11, yes.

24 Q. Isn't it true they calculate spring and
25 damping at those frequencies?

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1 A. Well, this is only the pad on soil
2 subject to force and function. So what frequency
3 you are referring to here will be pad/soil
4 frequency, not pad -- cask/pad/soil frequency.

5 Q. Soil springs and dash pots represent
6 pads, the pad and soil?

7 A. Well, in our pad designing calculation,
8 since we design the pad, we're only concerned with
9 loading come from the casks. So we model the pad
10 on soil. On the other hand, for Dr. Soler's cask
11 response calculation he would have to include the
12 casks, the pad and the soil. So there are two
13 different purpose and different system frequency of
14 concern.

15 Q. Could you use these frequencies as a
16 check on the soil springs and dash pots used by
17 Dr. Soler, by Dr. Soler in the Holtec analysis?

18 A. It could be used as a way to see whether
19 a range of frequencies that Dr. Soler's three
20 bounds would be approximately same as in this
21 frequency range.

22 Q. Based on your knowledge, have
23 Dr. Soler's soil springs and dash pots been checked
24 against the method using the natural frequencies?

25 A. He has not used the method No. 1 here, I

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1 call it, using this selected frequency and then
2 choose the soil springs and so on. Rather I think
3 he uses a soil mass which, as you know from
4 testimony, that if you have the stiffness mass,
5 soil mass is frequency square, it will produce some
6 kind of frequency variation of the impedance
7 function, and that would cover in the range I
8 believe is up to about 10 Hz or 11, depending on
9 where the lower bound will come from. That's
10 without the cask mass on it. With cask mass on it,
11 that frequency would drop, certainly. Then, depend
12 on which particular case he is analyzing, then that
13 frequency would then further drop for different
14 values.

15 So really couldn't be a unique value.
16 Would depend on whether two casks, one cask, or
17 four or eight casks. And even if you have the same
18 number of casks because the nonlinear response,
19 again, the unique frequency cannot be quite
20 defined.

21 JUDGE FARRAR: Ms. Nakahara, let me
22 interrupt for a minute. Just in terms of planning,
23 how much longer do you think you have?

24 MS. NAKAHARA: Just this one question.

25 JUDGE FARRAR: I spoke too soon.

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1 Q. (By Ms. Nakahara) Isn't it true you
2 testified that you could use Dr. Ostadan's method,
3 iterative method with the soil impedance function
4 at the soil impedance function frequencies on pages
5 171, 181, and 193 in the ICEC calculation as a
6 check on --

7 A. On soil alone.

8 Q. Are you aware of whether that that was
9 in fact -- that was in fact checked?

10 A. I'm not aware whether they have
11 especially checked it, but I think their wide range
12 of coverage covers some of this frequency range.

13 Q. And the frequencies calculated by ICEC
14 on pages 171, 181, 193, those are calculated after
15 you applied the forces provided by Holtec, correct?

16 A. No, it was a frequency under the single
17 point load application for that case that we were
18 talking about. It does show the natural frequency
19 of the system irrespective of whether there is a
20 point load or many point load.

21 Q. Do you agree that it's important to
22 ensure that the spring damping is appropriate for
23 the natural frequency of the system?

24 A. I agree of course for a soil-structure
25 interaction system you have, you know, you have to

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1 get good frequencies. But in the meantime, it all
2 also depend on how much variation of parameter you
3 have, you cover. If you are not -- and this is
4 general, if you use a simplified model, generally
5 you would like it to vary in the wider range so
6 that some of the approximations used can still be
7 covered by the wide variation of parameters. I
8 think all calculation to some degree are
9 approximations, it's just how refined or how crude.
10 And I agree that in any calculation you have to
11 have the right frequencies.

12 MS. NAKAHARA: Thank you, Dr. Tseng. I
13 have no further questions.

14 JUDGE FARRAR: Judge Lam has one.

15 JUDGE LAM: Dr. Tseng, good afternoon.

16 THE WITNESS: Good afternoon.

17 JUDGE LAM: Going to be good evening.

18 Dr. Tseng, the way I read your rebuttal testimony,
19 I understand that you provide testimony in response
20 to three essential claims by Dr. Ostadan. One had
21 to do with the pad's flexibility; two had to DO
22 with the way your company handled dynamic forces;
23 and finally, the appropriate use of soil spring and
24 damping values. Is that correct?

25 THE WITNESS: Yes.

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1 JUDGE LAM: And furthermore, you provide
2 in detail your reasoning about why Dr. Ostadan is
3 incorrect or the concern that he had raised is
4 insignificant. Is that correct?

5 THE WITNESS: For the issue discussed
6 here.

7 JUDGE LAM: Now, if I may categorize
8 your response together with Dr. Ostadan's concern
9 as a dispute, then I basically see three disputes
10 here. And what I would like to ask you to do is to
11 take a step back and think about, without
12 addressing the merits of your response or Dr.
13 Ostadan's claim, can you prioritize for this
14 licensing board as to the importance of these
15 disputes?

16 Now, if I may clarify my question by
17 giving you an analogy. Let's say you are about to
18 buy a used car. There is a claim that there is a
19 rusty spot on the fender; there's a claim that
20 perhaps the windshield wiper needs replacement; and
21 then finally, there is a claim that the
22 transmission may be about to be gone. And we are
23 not certain of these claims, and let us call them,
24 these are disputes between you and the salesman.
25 Now, to me, if you're lucky all three disputes will

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1 be resolved to your satisfaction and all is well.
2 But one clearly is more important than the other
3 two. I mean, the transmission issue would be a lot
4 more important than if there is a rusty spot on the
5 fender or not.

6 So my question is asked in that spirit.
7 I see three disputes here. Are they all created
8 equal, by which I mean presenting the most critical
9 and serious challenge to the Applicant's
10 application, or do they -- or maybe they don't
11 matter.

12 THE WITNESS: Well, I could answer from
13 my perspective not necessarily in trying to see
14 whether -- which one is more important.

15 I think some of the concern or claim
16 raised by Dr. Ostadan certainly from a point of
17 view of analysis, every project you can raise the
18 same question. It's a matter of whether a
19 particular project, some of the parameters become
20 important, some other parameter may be more
21 important for other project. Now, for this
22 particular project he had to raise many of the
23 issues, of course, within the range of my area
24 where the pad design, and then maybe because there
25 is interaction between the pad design and also

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1 Dr. Soler's --

2 JUDGE FARRAR: I think Judge Lam is just
3 talking in your area.

4 THE WITNESS: Okay, in my area. Well, I
5 was going to say that because interface, there is a
6 little bit sort of extend to Dr. Soler's area, but
7 I will -- in my area.

8 I think the pad flexibility certainly is
9 a legitimate issue, but then it depends on whether
10 it affects your response, important or not. In
11 this case the important, the pad response is for
12 design, our design issue.

13 On the other hand, I think for the
14 project the most important is also the cask
15 response. I think that's the major response we're
16 talking about. And I think the fact that the casks
17 and pad has a, if you will, have a surface of
18 discontinuity where you can allow the slide or
19 uplifting, I think many of these parameters are
20 raised may become not so important. Just because
21 many of these parameter variation creates some
22 variation of motions, some variation of maybe
23 acceleration values and so on, go across that
24 surface of discontinuity where you're allowed to
25 slide and uplifting will make it not such an

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1 important issue.

2 Now, important issue will be then
3 whether the cask's motion, and there is always wide
4 variation of parameters that they will have enough
5 margin to accommodate these motions and the casks
6 will be stable. Then of course on our pad design
7 and all this wide variation of forces, do we have a
8 conservative design of the pad with the
9 quantitative forces anticipated.

10 So I don't know whether I answered your
11 question or not, but that's my attempt of trying to
12 answer your question.

13 JUDGE LAM: Yes, Dr. Tseng, but if I may
14 ask you among the three issues in the order of
15 importance of one, two, and three, one being the
16 most important issue here, which one would you call
17 number one? Pad flexibility, dynamic forces and
18 soil spring?

19 THE WITNESS: I think dynamic forces is
20 the most important in terms of pad design, because
21 that certainly controls our selection of how many
22 rebars and shear rebars, no shear rebars. So as
23 far as pad design is concerned, dynamic forces will
24 be the number one.

25 JUDGE LAM: Then which one is the number

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1 two?

2 THE WITNESS: Number two then of course
3 is the casks -- let me rephrase it. Your number
4 three is referring to --

5 JUDGE LAM: Soil spring value and
6 damping.

7 THE WITNESS: The soil spring will be
8 the number two issue, I would say. The case of PFS
9 wide variation has been considered, so I think that
10 issue also have been addressed extensively.

11 JUDGE LAM: And Dr. Tseng, let me also
12 ask you a final question. You had read and
13 listened to Dr. Ostadan's testimony, I presume, in
14 this proceeding. Is that correct?

15 THE WITNESS: Yes.

16 JUDGE LAM: Based on what you had read
17 and heard, may I ask you to do the same type of
18 analysis, without addressing the merits of
19 Dr. Ostadan's claims, which one of his numerous
20 claims would you urge this licensing board to give
21 our most serious attention?

22 THE WITNESS: Well, again, I will limit
23 myself on the pad design --

24 JUDGE LAM: Yes, indeed.

25 THE WITNESS: -- and whether there is

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1 effect on the cask. I will not address the soil
2 portion or soil cement treated or soil cement area,
3 which is not my expertise.

4 JUDGE LAM: I fully recognize that
5 you're on the opposing side of Dr. Ostadan, and
6 therefore I think that your answer would be
7 extremely helpful.

8 THE WITNESS: Well, as I mentioned, I
9 think many of the concern raised certainly is a
10 worthwhile parameter that every engineering
11 project --

12 JUDGE FARRAR: Wait, wait. Give him the
13 answer. He wants to know which of -- it's ten
14 minutes after five; give him the answer.

15 THE WITNESS: Okay. I think, in my
16 opinion, the pad flexibility is not such an
17 important issue as far as pad design as well as the
18 cask motion is concerned. Pad-to-pad interaction,
19 even though today Dr. Soler has shown a model which
20 produce result, given very significant forces
21 between pads, but I believe Dr. Soler's model was
22 designed or created to maximize or to address
23 certain particular issue. If you really want to
24 model this somewhat more properly, my belief is
25 that the pad-to-pad interaction would also not be

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1 such a big issue in terms of the motion of the pad
2 itself. I'm not addressing the effect on the
3 cement treated soil or anything like that. More on
4 demand side rather than capacity side. And I
5 couldn't quite recall an important area that we
6 need really to look at.

7 JUDGE LAM: Okay, thank you for your
8 answer, Dr. Tseng. Appreciate it.

9 JUDGE FARRAR: Mr. Gaukler, do you want
10 to have redirect?

11 MR. GAUKLER: No, I do not.

12 MR. TURK: I have a couple of limited
13 follow-up questions. Do you want to go forward
14 with another witness today?

15 JUDGE FARRAR: Well, I would assume
16 Mr. Gaukler was going to have some redirect. I was
17 about to excuse your other witnesses, but maybe we
18 can do something. How long will you take,
19 Mr. Turk? Because everyone needs a break right
20 now. If you have a couple quick questions.

21 MR. TURK: Five to seven minutes. But
22 if you want to take a break, we can come back.
23 We're going to be here regardless the same amount
24 of time.

25 MS. CHANCELLOR: Your Honor, Dr. Ostadan

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1 is going to have to leave very shortly.

2 JUDGE FARRAR: All right. Go ahead,
3 Mr. Turk.

4

5 RE CROSS-EXAMINATION

6 BY MR. TURK:

7 Q. I want to come back to Dr. Luk's report,
8 Staff Exhibit P. Do you recognize that Figure 20B?

9 A. Yes.

10 Q. Represents a characterization of single
11 nodal points?

12 A. Yes, I believe that's --

13 Q. That chart also bears one axis which is
14 labeled Spectral Acceleration. Could you give us
15 your understanding of that term and how that
16 differs from seismic acceleration?

17 A. Well, spectral acceleration again is the
18 response of a single degree of freedom with that
19 particular selected spectral frequency and spectral
20 damping values.

21 Q. Isn't that the equivalent of seismic
22 acceleration?

23 A. It's not equivalent to seismic -- or
24 maximum acceleration. Although if we were to have
25 time history, you can infer the maximum

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1 acceleration from the response spectra plot.

2 Q. And that would be assuming that the
3 spectral acceleration plot was properly filtered
4 and properly representative of actual conditions
5 that you had experienced in the real world?

6 A. From numerical -- if there were
7 corruptions.

8 Q. Including -- it would require that you
9 have proper filtering and damping, correct?

10 A. Yeah, that's correct.

11 Q. Also, at some point --

12 MS. NAKAHARA: May I interrupt? Sorry.
13 Dr. Ostadan needs to leave to catch his plane. Can
14 he be excused?

15 JUDGE FARRAR: Certainly. Dr. Ostadan,
16 will we see you again?

17 DR. OSTADAN: If needed, sir.

18 DR. BARTLETT: I've got to drive him, so
19 I'm going to leave too.

20 JUDGE FARRAR: Thank you for your
21 contribution here. We appreciate it.

22 MS. NAKAHARA: Thank you, your Honor.
23 Sorry.

24 Q. (By Mr. Turk) There was some discussion
25 about whether nodes in the same plane would

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1 experience the same accelerations. What if the
2 nodes were not in exactly the same plane? How
3 would your answer differ?

4 A. I guess we're referring to nodes in
5 soil?

6 Q. Well, for instance, in Dr. Luk's model
7 he modeled the soil as well as the cement treated
8 soil, the soil cement between pads, the pads and
9 the cask. For any of those systems, if we're
10 looking at nodes for some part of the structure,
11 whether it's in soils or in casks or in the pad, if
12 the nodes were not exactly in the same plane, would
13 the accelerations experienced by those nodes be
14 different?

15 A. In general they will be different.

16 MR. TURK: No other questions.

17 JUDGE FARRAR: Thank you, Mr. Turk.

18 Does that finish this witness? Thank you,

19 Dr. Tseng. Appreciate your contribution.

20 Let's take a -- do you want -- let me
21 ask, do you want to try to get some more business
22 done?

23 MR. GAUKLER: I would like to get

24 Mr. Ebbeson on if we could.

25 MS. CHANCELLOR: I've got like half a

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1 dozen, eight questions. I think we can get
2 Mr. Ebbeson done today.

3 JUDGE FARRAR: It's late in the day.
4 It's 5:15. Let's break until 5:25.

5 (A recess was taken.)

6 JUDGE FARRAR: All right, we're coming
7 down the home stretch here in Salt Lake City. What
8 do you have here, Mr. Gaukler?

9 MR. GAUKLER: I have something marked to
10 be 225, I believe D.

11 JUDGE FARRAR: D as in dog?

12 MR. GAUKLER: Yes, PFS 225 D. And I'd
13 like to have Dr. Soler very briefly explain what
14 this is. This relates to the previous Exhibit
15 225 C, I believe.

16 (APPLICANT'S EXHIBIT 225D MARKED.)

17 JUDGE FARRAR: Dr. Soler, we are on a
18 word limit here. Tell me in the shortest possible
19 time what this is.

20 THE WITNESS: What I have done is, the
21 first page simply repeats the exhibit that was
22 submitted this morning. The four succeeding pages,
23 pages 2 and 3 are simply the first graph on the
24 lower right of the first page split into two
25 components, and pages 4 and 5 are simply the first

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1 graph in the top right-hand corner split into two
2 components so that each one is separate.

3 JUDGE FARRAR: Thank you. Does that
4 satisfy the State's concern?

5 MS. NAKAHARA: It does, your Honor, and
6 we appreciate --

7 JUDGE FARRAR: Okay, then this will
8 be -- without objection, this will be admitted.

9 MR. TURK: We probably wouldn't object,
10 but we don't have a copy.

11 MR. GAUKLER: And I guess we'd like to
12 have the record note that there's actually the word
13 "225 B" on the exhibit. You can correct it. It
14 should be 225 D.

15 JUDGE FARRAR: The reporter has marked
16 that. Then that exhibit will be admitted

17 (APPLICANT EXHIBIT 225 D WAS ADMITTED.)

18 JUDGE FARRAR: Now, we want to do --

19 MR. TURK: 225 C then is withdrawn?

20 MR. GAUKLER: Just in the record.

21 JUDGE FARRAR: Do we want Mr. Ebbeson?

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BRUCE E. EBBESON,
called as a rebuttal witness, having previously
been sworn, was examined and testified as follows:

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DIRECT EXAMINATION

1
2 BY MR. TRAVIESO-DIAZ:

3 Q. Mr. Ebbeson, good afternoon.

4 THE WITNESS: Your Honor, are you
5 telling me I'm sworn in?

6 JUDGE FARRAR: Yes. You've been sworn
7 and consider yourself still under oath. Thank you,
8 sir.

9 Q. Mr. Ebbeson, do you have in front of you
10 a document entitled Rebuttal Testimony of Bruce E.
11 Ebbeson on Section B of Unified Contention Utah
12 L/QQ?

13 A. Yes.

14 Q. Dated June 7th, 2002?

15 A. Yes, I do.

16 Q. Was this document prepared by you under
17 your supervision?

18 A. Yes.

19 Q. Is this document complete and correct,
20 to the best of your information and belief?

21 A. Yes, it is.

22 Q. Do you adopt it as your rebuttal
23 testimony in this proceeding?

24 A. Yes, I do.

25 MR. TRAVIESO-DIAZ: I will move that

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1 this document be admitted into evidence and
2 accepted into the record, bound into the record.

3 JUDGE FARRAR: Any objection?

4 MS. CHANCELLOR: No objection?

5 JUDGE FARRAR: Mr. Turk?

6 MR. TURK: We're conferring for a brief
7 second. We have no questions, your Honor.

8 JUDGE FARRAR: No objection?

9 MR. TURK: I'm sorry. Oh, sorry. No
10 objection to binding in the record, no.

11 JUDGE FARRAR: Okay, this will be bound
12 into the record as if read.

13 (Rebuttal testimony of Bruce E. Ebbeson
14 follows:)

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June 7, 2002

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of)
)
PRIVATE FUEL STORAGE L.L.C.) Docket No. 72-22
)
(Private Fuel Storage Facility)) ASLBP No. 97-732-02-ISFSI

**REBUTTAL TESTIMONY OF BRUCE E. EBBESON
ON SECTION D OF UNIFIED CONTENTION UTAH L/QQ**

**I. REBUTTAL TO TESTIMONY OF STATE OF UTAH WITNESS DR.
FARHANG OSTADAN**

A. Dynamic Interaction Between Soil Cement and CTB Mat Foundation

Q1. In his answer to question 40 in the “State of Utah Testimony of Dr. Steven F. Bartlett and Dr. Farhang Ostadan on Unified Contention Utah L/QQ (Dynamic Analyses)” (“Bartlett/Ostadan Direct Testimony”), and in his oral testimony at the May 9, 2002 hearing (Tr. 7656-63), Dr. Ostadan raises the concern that PFS has failed to analyze the dynamic interaction of the soil cement with the CTB mat foundation. Is this a valid concern?

A1. No. Dr. Ostadan appears to be treating the soil cement around the CTB as an adjacent structure capable of significant dynamic interaction with the building. However, the layer of soil-cement around the CTB is not as massive as another building; it is, at most, equivalent to a layer of very stiff soil. The free-field ground motion, developed by Geomatrix, considered the soil-cement as another soil layer atop the clay. The ground motion thus already considers the effects of the soil cement. The impedance functions for the CTB were developed using the soil profile and properties below the basemat elevation, in accordance with Section 3.3.4.2.4 of ASCE 4-86.

Dr. Ostadan makes reference (Tr. 7658-7660) to a paper by Wong and Luco as supporting the proposition that the soil cement cap around the CTB will reduce

the radiation damping effect of the soil under the building. He asserts that the soil cement will "trap" the energy that would normally be dissipated through radiation damping. However, the Wong and Luco paper cited by Dr. Ostadan addresses the effect on radiation damping of having two adjacent rigid rectangular foundations. The soil cement around the CTB is, however, not a rigid structure. That soil cement will have a Young's modulus much lower than concrete, has no reinforcing steel, has no stiffening walls, and as Dr. Ostadan and Dr. Bartlett have repeatedly pointed out, may exhibit cracking at a number of locations. Thus, the soil cement is unlike the structures cited in the Wong and Luco paper, and therefore the results of that paper are inapplicable.

Even if one were to assume that the soil cement around the CTB is equivalent to having another building in the CTB's proximity, there is no need to consider structure-to-structure interaction in the dynamic analyses. Section 3.3.1.5 of ASCE 4-86 states "structure-to-structure interaction may be generally neglected for overall structural response but shall be considered for local effects due to one structure on another, such as required in Section 3.5.3 for walls." Since the soil-cement does not extend above the bottom of the CTB walls, there is no need to consider structure-to-structure interaction between the soil-cement and the CTB. The Commentary to Section 3.5.3 of ASCE 4-86 states "Explicit treatment of structure-to-structure interaction need not be done in the analysis under the assumption that variability in response due to structure-to-structure interaction is encompassed by parameter variation considerations...". As a matter of fact, every nuclear power plant site has a number of buildings adjacent to each other, and yet each building is typically analyzed without taking into account the potential dynamic effects of other buildings.

Q2. In the same answer in his direct testimony, Dr. Ostadan indicates that the presence of a stiff soil cement perimeter around the CTB impacts the soil spring and damping parameters and kinematic motion of the building mat foundation. What is your response to this concern?

A2. The soil spring and damping parameters for a structure are a function of the soil beneath the basemat and, if present, the embedment formed by any soils around the sides of the building. For a rigid mat sitting at the surface of the soil, only the soil beneath the mat has an effect. There are no kinematic interaction effects for such a mat assuming vertically-propagating seismic waves. As the depth of

embedment increases relative to the dimensions of the mat, the effect of the soil around the building becomes more significant. For the CTB, which has a very large plan area (240' by 279.5') and a shallow embedment (5'), the effects of the embedment are small and can be neglected. Section 3.3.4.2.4 of ASCE 4-86 states that for shallow embedments the effect of embedment may be neglected in obtaining impedance functions provided the soil properties below the basemat elevation are used for the impedance calculations. This was done in the case of the CTB SSI analysis.

Q3. In the same answer, Dr. Ostadan concludes that the shortcomings he identifies in the calculations can “easily” reduce the 1.1 factor of safety against sliding to values less than 1, “indicating instability of the CTB for sliding”. Do you agree?

A3. No. As discussed above, I do not agree that the shortcomings alleged by Dr. Ostadan actually exist. In addition, even if the calculated factor of safety against sliding of the CTB were to be reduced below 1.0, this would not mean that the building would in fact slide in the event of a design basis earthquake. There are substantial conservatisms included in the CTB sliding stability calculation, which provide additional margins of safety against sliding. For instance, the sliding stability calculation conservatively used the static shear strength of the clay below the CTB. As described in the testimony of Paul Trudeau, the dynamic shear strength of the soil at the PFSF would be expected to be 50-100 % greater than the static shear strength. Furthermore, the sliding stability calculation used the largest accelerations from the three soil cases used in the CTB seismic analysis. These largest accelerations resulted from using the upper bound soil properties, and are considerably greater than those from the best estimate and lower bound soil cases. The upper bound soil properties were developed by using a shear modulus 50% greater than the best estimate value (shear wave velocity 22% greater than the best estimate). As described in the testimony of Dr. Youngs, the shear wave velocity measurements at the PFS site show little variation across the site. Therefore, the accelerations calculated, and used in the sliding stability calculations, are conservatively high. Because of these conservatisms, it is unlikely that the building would actually experience sliding even if the calculated factor of safety were to drop somewhat below 1.0. And, as I have previously testified, even if the CTB were to slide, no adverse safety consequences would occur.

B. CTB Mat Rigidity

- Q4.** In the next paragraph of his response to the same question in his direct testimony, Dr. Ostadan criticizes PFS for failing to address the potential flexibility of the CTB mat during a seismic event. He states: "Stone & Webster should have all the necessary data from the structural analysis and design of the mat to make a determination on the validity of the assumption for rigidity of the mat." Have you made such a determination?
- A4.** Yes. As discussed in Answer 24 of my prefiled direct testimony on Section D of Utah Contention L/QQ, we performed a calculation that shows that, for the loading combination with the full peak vertical earthquake acceleration acting downward and 40% of the peak accelerations acting on the two horizontal directions, the maximum variation of vertical displacement along the centerline of the building in the N-S direction is .163 inches over the length of 279.5 ft., which represents a less than 0.005% deflection. The maximum variation of vertical displacement in the E-W direction is .333 inches over the length of 240 ft., or about 0.01% deflection. The results of that calculation are presented in PFS Exh. YY. Such small displacements over an area of 67,200 square feet (240 feet times 280 feet) demonstrate that the CTB basemat acts like a rigid body under earthquake loadings.
- Q5.** In his oral testimony on May 9, 2002 (Tr. 7664-74), Dr. Ostadan discounted the significance of such small displacements in terms of demonstrating that the CTB basemat is rigid. He testified at Tr. 7668 that "[f]or the purpose of radiation damping, it's not important how big or small amplitude of displacement is as opposed to how many times it occurs. If I have this variation of, say, .164 taking place every few feet, then the pad -- mat is flexible. But if it's taking place only at two extreme points and in between, I don't see that, then it tends to be more rigid." How do you respond?
- A5.** I cannot imagine how a 5-foot thick mat could experience such relative displacements over a length of a few feet. It is clear from a review of PFS Exh. YY that the displacements do not take place over short distances, as Dr. Ostadan assumes, but in fact occur over a distance of about 65 feet, and there is only one such occurrence, at the south end of the mat; the north end of the mat is quite rigid. This can be seen on the third page of PFS Exh. YY, where the maximum displacement (designated as MX) and the minimum displacement (designated as MN) are quite far apart. Thus, even applying Dr. Ostadan's suggested approach of concentrating on changes in displacement over small lengths, the conclusion is reached that the CTB basemat is rigid.

I would also note that assuming that the CTB mat is rigid is appropriate in view of the physical configuration of the mat (five foot reinforced concrete, stiffened by shear walls connected to it), which provides the mat with significant resistance to deformation in either the vertical or the horizontal directions. Assuming that the CTB mat is rigid is also fully consistent with Section 3.3.1.6 of industry code ASCE 4-86, which states: "The effect of mat flexibility for mat foundations and the effect of wall flexibility for embedded walls need not be considered in the SSI analysis." Assuming the mat to be rigid is also consistent with the practice in the nuclear industry, which is to treat foundations for safety-related structures similar in design to the CTB at nuclear power plants as rigid.

Q6. Does this conclude your testimony?

A6. Yes.

1 MR. TRAVIESO-DIAZ: Mr. Chairman, a very
2 quick procedural clarification. A copy of this
3 testimony that you have with you, there is also
4 attached another document. This other document is
5 PFS Exhibit YY. This document was already admitted
6 into evidence.

7 JUDGE FARRAR: So this is just a
8 courtesy copy?

9 MR. TRAVIESO-DIAZ: Well, yes, but
10 there's more.

11 MS. CHANCELLOR: The State withdraws its
12 objection to Exhibit YY. We reserved an objection,
13 your Honor.

14 MR. TRAVIESO-DIAZ: The exhibit is in
15 evidence but there was a pending objection that was
16 raised during the testimony of Mr. Ebbeson, and
17 she's withdrawing that objection.

18 JUDGE FARRAR: So you say we had already
19 admitted subject to the objection, and the
20 objection being withdrawn, the record will be clear
21 on that.

22 MR. TRAVIESO-DIAZ: Thank you.
23 Mr. Ebbeson is available for further examination.

24 JUDGE FARRAR: All right. Mr. Turk, you
25 indicated you had no questions?

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1 MR. TURK: Correct.

2 JUDGE FARRAR: Ms. Chancellor?

3 MS. CHANCELLOR: Very few, your Honor.

4

5

CROSS-EXAMINATION

6 BY MS. CHANCELLOR:

7 Q. Good evening, Mr. Ebbeson. At last you
8 get to testify.

9 A. Good evening. I'm ready.

10 Q. Where you come from, I'm sure it is. On
11 page 2 of your testimony there's a reference to
12 energy being trapped that would normally be
13 dissipated through radiation damping, and this is
14 something that Dr. Ostadan brought up. Did you
15 quantify whether, and if so, how much energy would
16 be trapped in the situation of the soil cement
17 barrier around the CTB acting as a cap?

18 A. My use of the word "trapped" there is
19 quoting Dr. Ostadan. I think you asked me that in
20 my testimony. In the transcript I asked the
21 question, what do you mean by trapped, and I never
22 got an answer. So I don't quite understand what
23 he's talking about by trapping. I believe he's
24 trying to assert that the soil cap will prevent
25 energy from radiating away from the base of the

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1 canister transfer building.

2 Q. If you assume that the soil cement would
3 act similar to a second building or second
4 foundation, would that help?

5 A. First off, later in my testimony I don't
6 think the soil cement acts like another building,
7 for reasons I elaborate on below.

8 Secondly, I think you referred to a
9 paper by Luco and Wong, and they demonstrate that
10 there is another adjacent building next to a
11 building. There may be some changes in the
12 impedance parameters. They never used the term
13 "trap," so I don't know what Dr. Ostadan means by
14 the word "trap."

15 Q. If you consider the soil cement as you
16 would a second building as they do in the Wong and
17 Luco paper, would you be able to quantify how much
18 energy may not be dissipated as radiation damping?

19 A. No. There's no way to quantify that.
20 If you're talking about how much energy, you're
21 talking about a percentage or the number of joules?
22 There's no -- radiation damping isn't measured in
23 quantities of energy.

24 Q. I'll move on. In the stability analysis
25 of -- this relates to question two, I believe. In

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1 the stability analysis of the CTB, do you know
2 whether the passive resistance or the passive
3 resistance of soil cement was used in the stability
4 analysis?

5 A. Yes, it is.

6 Q. Does this mean that soil cement is
7 moving with the CTB or resisting a CTB load?

8 A. Well, the soil cement on one side of the
9 building is resisting.

10 Q. If it is resisting, will there be any
11 kinematic interaction?

12 A. There will be interaction. Kinematic
13 interaction is a complex term, and I'm not sure how
14 you're using it here.

15 Q. We're using it as Dr. Ostadan would use
16 it.

17 A. The judges have asked a number of times
18 for a definition of kinematic interaction, a wide
19 variety, and I'm not sure how it applies in this
20 case. Kinematic interaction in this case I believe
21 is referring to how the soil cement cap changed the
22 motion of the -- under the canister transfer
23 building, which is kind of related to the first
24 question about, if you want to call it trapping
25 energy. It amounts to changing the impedance

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1 functions of the canister transfer building and
2 changing the motion underneath the canister
3 transfer building. And then again, as I've said in
4 my testimony and in this rebuttal, I think the soil
5 cement cap around the building behaves more as a
6 soil than it does as another building, in which
7 case I believe that would actually increase the
8 radiation damping, not decrease it.

9 Q. Okay. In answer 3 in the first couple
10 of sentences, the question I'm going to ask relates
11 to the first couple of sentences in answer 3. In
12 your earlier testimony you indicated you use 5
13 percent eccentricity to include accidental
14 torsional loads for the CTB, correct?

15 A. Correct.

16 Q. How did you include this load for the
17 stability analysis of the CTB building?

18 A. Torsional loads have a negligible effect
19 on the stability analysis of the CTB.

20 Q. But did you include --

21 A. By the way, I did not do the stability
22 analysis on the CTB. Mr. Trudeau did.

23 Q. Do you know whether Mr. Trudeau included
24 the torsional loads in the stability analysis of
25 the CTB?

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1 A. I'm quite sure he did not, because they
2 do not contribute to sliding or overturning or
3 bearing.

4 Q. In answer 3 in about the middle of
5 the -- middle of page 3 it states, "These largest
6 accelerations resulted from using the upper bound
7 soil properties," et cetera. Isn't it a common
8 practice to envelope results of three soil cases
9 for design?

10 A. Yes, it is, which is why we do that.
11 When Mr. Trudeau did his canister transfer building
12 stability analyses, he gave the -- he used the
13 forces and moments that we provided it to him from
14 our seismic analysis, which is Calculation SC 5
15 there, tabulated in there. And the numbers that
16 are tabulated are the largest of the three soil
17 bases.

18 Q. Oh, I understand. Okay, thank you.

19 A. What I'm going on to say there is that
20 based on the testimony of Dr. Youngs, the upper
21 bound soil properties probably overestimate the
22 highest range it could be, so our accelerations are
23 probably higher than they would be expected to be.

24 Q. Okay. And the next to last sentence on
25 page 3 states, "Because of these conservatisms, it

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1 is unlikely that the building would actually
2 experience sliding even if the calculated factor of
3 safety were to drop somewhat below 1.0." My
4 question is -- do you see that?

5 A. Yes.

6 Q. Do you agree that the factor of safety
7 of stability of the -- if the factor of safety of
8 stability of the CTB is less than 1 -- scrub that
9 question. Let me start again. This writing is
10 terrible.

11 A. Can't read your own writing?

12 Q. No, nor can I read anybody else's. If
13 the factor of safety -- would the factor of safety
14 of stability of the CTB be less than 1 if soil
15 resistance is not considered?

16 A. Soil cement resistance.

17 Q. Soil cement resistance is not
18 considered?

19 A. Did you say the factor of safety or the
20 calculated factor of safety? There's a --

21 Q. Why don't you give your answer for both
22 cases.

23 MR. O'NEILL: Are we referring to factor
24 of safety against sliding?

25 MS. CHANCELLOR: Of the stability of the

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1 CTB, yes, against sliding.

2 A. Okay, if you read that last -- the
3 sentence you're talking about, I'm saying the
4 building would not slide even if the calculated
5 factor of safety were below one, because the
6 calculated number is a conservative number. So
7 what I'm saying is if we had no conservatism in our
8 calculations and we had everything exactly right,
9 if it went below 1, yes, the building would slide.
10 But I'm saying, even if we calculate a number, say
11 .95, but we know we have these other conservatisms
12 in, so in real life the building would not slide.

13 Q. But if soil cement resistance is not
14 considered in calculating the factor of safety
15 against sliding, would that factor of safety be
16 less than one?

17 A. The way it's calculated, yes. If we
18 were to go back and take the other conservatisms
19 out, it's conceivable it would work without soil
20 cement. We would not need it.

21 Q. Then in also in answer 3 where you refer
22 to Mr. Trudeau's testimony and the dynamic shear
23 strength of soils at PFS would be expected to be 50
24 to 100 percent greater than the static shear
25 strength. Do you see that?

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1 A. Yes.

2 Q. Do you know whether testing of the
3 Bonneville clays has been performed by PFS to
4 demonstrate the claimed 50 to 100 percent increase
5 in strength?

6 A. It has not. That is why we're not
7 taking credit for it.

8 Q. You're not taking credit, but you're
9 saying that there's extra conservatism because of
10 it. Is that correct?

11 A. Yes. And I think that's been agreed
12 upon by State's witnesses also. I know that from
13 reading the testimony.

14 Q. In your opinion is it good engineering
15 practice to introduce a potentially nonconservative
16 design input without verifying the value?

17 A. No. That's why we do not do that.

18 MS. CHANCELLOR: Okay, thank you. I
19 have no further questions.

20 JUDGE FARRAR: Any the board has none.
21 Any redirect?

22 MR. TRAVIESO-DIAZ: No.

23 JUDGE FARRAR: Thank you, Mr. Ebbeson.
24 You waited a long time. Thank you for your
25 contribution.

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1 THE WITNESS: Enjoyed seeing this
2 beautiful city.

3

4

CROSS-EXAMINATION

5

BY MR. TURK:

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9

Q. Could I ask for one clarification? In the oral testimony you just gave you indicated that Dr. Young's upper bound probably overestimated the actual upper bound?

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A. No. Well, the upper bound that was used in the analysis where we follow the recommendations of ASCE-4 where we increase the shear modulus by 50 percent to account for unknowns in the soil properties, during Dr. Young's testimony he said that looking at the results across the site, there's little variability and we wouldn't expect to see a value 50 percent higher than the best estimate.

19

20

21

22

Q. So the oral testimony you gave relates to that statement on page 3, answer 3 of your testimony where you discuss this 50 percent greater than --

23

24

25

A. Right. In other words, we --

Q. I just wanted to clarify.

A. Yes.

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1 Q. That's the same reference you're making,
2 same piece of your testimony?

3 A. Right.

4 MR. TURK: Thank you.

5 JUDGE LAM: Let me ask just one quick
6 question. Mr. Ebbeson, in your response to
7 question 3, at the bottom of page 3 you indicated
8 even if the calculated factor of safety were to
9 drop below 1 you would not expect the building
10 would slide, and even if it were to slide there's
11 no safety consequences, right?

12 THE WITNESS: Yes.

13 JUDGE LAM: And the question is, why, if
14 that's the case, why do you need all of these
15 treatment of the soil?

16 THE WITNESS: Again, that was -- there
17 was a discussion on that this afternoon. That's to
18 meet the regulatory requirement of 1.1 for the
19 factor of safety against sliding. And there was
20 some discussion between Mr. Turk and others about
21 whether that's a strict requirement or it's a
22 requirement for a nuclear power plant but not for
23 ISFSIs or it's a requirement for buildings and not
24 storage pads. But we elected to meet the 1.1
25 factor and not let the building slide, so we went

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1 and put the soil cement in.

2 JUDGE LAM: Okay, thank you.

3

4 RECROSS-EXAMINATION

5 BY MS. CHANCELLOR:

6 Q. One follow-up question. As an engineer
7 is it common practice to meet a factor of safety of
8 1.1 in designing a building?

9 A. A nuclear building or a regular
10 building?

11 Q. Regular building, any building.

12 A. Building codes typically have factors of
13 safety of I believe it's 1.1 for both earthquake
14 and wind. But again, the loads they design for are
15 much smaller.

16 MS. CHANCELLOR: Thank you.

17

18 RECROSS-EXAMINATION

19 BY MR. TURK:

20 Q. One last clarification. When you say
21 regulatory requirement of 1.1, again you're
22 referring to the NUREG 0800 regulatory guidance,
23 correct?

24 A. Yes, section 3.815.

25 MR. TURK: Thank you.

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1 JUDGE FARRAR: Thank you, Mr. Ebbeson.

2 I assume Mr. Trudeau will not be that short?

3 MR. TRAVIESO-DIAZ: I believe he could
4 be very short, but I'm not the determining factor
5 here.

6 JUDGE FARRAR: Are you all -- without
7 your experts are you prepared to cross-examine him?

8 MS. CHANCELLOR: Let me take a quick
9 look. No, I don't think -- I think I'll be
10 floundering.

11 JUDGE FARRAR: What about your rebuttal
12 to Mr. Ebbeson?

13 MS. CHANCELLOR: Don't have any, your
14 Honor.

15 JUDGE FARRAR: Mr. Trudeau, were you
16 planning to be in DC?

17 MR. TRUDEAU: Yes, sir.

18 JUDGE FARRAR: Sitting here all this
19 time, being there will not be an extraordinary
20 hardship?

21 MR. TRUDEAU: Correct.

22 JUDGE FARRAR: Ordinarily we might try
23 to squeeze you in, but it's late, almost six
24 o'clock on the sixth day of the week, and the State
25 does not have its experts here.

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1 MR. TRAVIESO-DIAZ: Mr. Chairman, the
2 only problem with the questioning of Mr. Trudeau
3 will be to fit him in the already crowded schedule
4 we have for Washington.

5 JUDGE FARRAR: Well, let's talk about
6 that. We were going along fine before with direct
7 testimony, and the rebuttal has been -- has added a
8 significant amount of time. We'd like the parties
9 to talk amongst themselves about how we might plan
10 to structure rebuttal in Washington at a faster
11 pace than we had today. If someone puts in two
12 pages of rebuttal, and all parties were equally
13 guilty of this, I'm not sure we need an hour -- I
14 mean, there needs to be some limits on
15 cross-examination of simple rebuttal. And we're
16 coming -- it seemed to us we've heard a lot of
17 these things before, and we've got to have a way
18 that rebuttal doesn't consume, overly consume us in
19 DC. So if you all would put your heads together
20 and come up with a plan for how we can with
21 fairness to everybody make sure rebuttal is
22 efficient.

23 If you fail to come up with such a plan,
24 I will -- let's go off the record.

25 (Discussion off the record.)

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1 JUDGE FARRAR: Back on the record. We
2 can come up with a plan to make sure that -- I
3 think we talked the other day about convergence,
4 and we need to have direct, and I think that cone,
5 Mr. Travieso-Diaz, I think you mentioned, making
6 sure we head for the right end of the cone rather
7 than the wrong end. I'm not sure the sides of that
8 cone are converging quickly enough, so let's see
9 what we can do about that.

10 I take it we are -- oh, we'll have Jack
11 send you all an e-mail Monday about exactly what
12 you have to have. I think I know in terms of
13 security for the headquarters building, but I don't
14 want to give any information and have it be wrong.
15 So give the name, address and social security
16 number and/or date of birth and so forth.

17 MS. CHANCELLOR: Should we use
18 Mr. Whetstine as our contact?

19 JUDGE FARRAR: Yes. We'll have him send
20 e-mail and you just send everything back to him, or
21 whoever he tells you.

22 We are going to -- to make sure we're
23 prepared, we're starting at 9:30 on Monday, the
24 17th, with the soil cement people. That's still
25 the plan, you haven't changed that?

1 MS. CHANCELLOR: That's correct.

2 MR. GAUKLER: That's correct.

3 MR. TURK: Correct.

4 JUDGE FARRAR: And you do want to go on
5 Friday that week, or at least hold that open?

6 MR. TRAVIESO-DIAZ: I think we should
7 leave it open, given the additional amount of
8 things that have to go.

9 JUDGE FARRAR: All right. Then we
10 should probably try to start, since we can only go
11 until two that day, maybe start at eight that day
12 and have it be almost a full day. And then no
13 hearing on Monday, the 24th. Is that --

14 MR. GAUKLER: That's the current plan.
15 We might want to hold that in reserve in case we
16 have problems, but --

17 JUDGE FARRAR: Well, the Board will be
18 available.

19 MS. CHANCELLOR: I've decided to stay
20 over, so --

21 JUDGE FARRAR: Let us know and we can,
22 you know, on the 17th. And no matter what else
23 happens, we're doing aircraft on the 1st, 2nd, and
24 3rd?

25 MR. GAUKLER: Yes.

1 JUDGE FARRAR: So doesn't matter if we
2 finish seismic, don't finish; we're doing aircraft
3 the 1st, 2nd, and 3rd?

4 MR. GAUKLER: That's right.

5 JUDGE FARRAR: And who will the first
6 witnesses be?

7 MR. GAUKLER: It will be the completion
8 of our rebuttal.

9 JUDGE FARRAR: That will be the generals
10 and the officers --

11 MR. GAUKLER: Yes.

12 JUDGE FARRAR: -- with their addition
13 and --

14 MR. GAUKLER: Yeah, I think it's already
15 been introduced, but it will be -- I don't know if
16 they have anything more to say on that or not.
17 Can't speak to that specifically at this point in
18 time.

19 JUDGE FARRAR: And meanwhile the State
20 has been analyzing those additional reports that
21 came in, so you will be prepared to cross-examine
22 them, and I assume --

23 MS. NAKAHARA: Yes, your Honor.

24 JUDGE FARRAR: -- then Col. Horstman
25 will want to take the stand and give his review?

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1 MS. NAKAHARA: Yes.

2 MR. GAUKLER: Just for, your Honor, as
3 planning, I think we also have agreed among the
4 parties after soil cement we then would do the
5 cross- examination of Dr. Bartlett with respect to
6 the Luk report and deal with any issues with
7 respect to the Luk report.

8 MS. CHANCELLOR: But our goal for that
9 week is to get through soils.

10 MR. GAUKLER: And then we go back to
11 soils.

12 JUDGE FARRAR: Okay, great.

13 MS. CHANCELLOR: And then we need to get
14 to Dr. Bartlett's direct testimony on Part E
15 seismic exemption.

16 MR. TURK: Not necessarily that week,
17 but that's something else to accomplish.

18 MS. CHANCELLOR: That's the goal. We
19 would like to get -- we would like Dr. Bartlett not
20 to have to make two trips. He has -- his wife's
21 birthday is on Saturday. He has to come back to
22 Salt Lake.

23 MR. TURK: I'm sorry, which --

24 JUDGE FARRAR: Or not come back.

25 MS. CHANCELLOR: Or yes, stay out of

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1 town.

2 MR. TURK: He has to go back to Salt
3 Lake the week between the 21st and 24th?

4 MS. CHANCELLOR: Correct.

5 MR. TURK: And I do have that problem
6 with scheduling of Dr. Luk. And I've not been able
7 to reach him. I'll try again today. I'm sorry --
8 not scheduling him but scheduling the
9 cross-examination on his report.

10 MR. GAUKLER: And one other date that we
11 set, just for purposes of planning witness, is we
12 set June 26th I think for radiation dose
13 consequences.

14 JUDGE FARRAR: Right.

15 MR. TRAVIESO-DIAZ: And that will have
16 the additional complication of setting a date for
17 Mr. Trudeau's rebuttal that was left over from
18 today.

19 JUDGE FARRAR: Is his rebuttal all that
20 you need to finish on part D?

21 MR. TRAVIESO-DIAZ: Correct. That's the
22 only thing left from part D.

23 MS. CHANCELLOR: I don't think it will
24 take long. I just didn't feel quite ready.

25 JUDGE FARRAR: That's quite all right.

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1 All right, is there any other business we need to
2 transact?

3 MR. GAUKLER: I can't think of anything
4 else, your Honor.

5 MS. CHANCELLOR: Head for the hills.

6 JUDGE FARRAR: We've enjoyed our time in
7 Salt Lake City. The proceedings we've indicated
8 have taken longer than the lawyers predicted, but
9 it's been very complicated and we again commend the
10 parties for their diligence and effort in working
11 through difficulties and helping us do it as
12 efficiently as possible.

13 So we will see everyone at 9:30 on
14 Monday, the 17th, in our hearing room in NRC
15 headquarters in White Flint in beautiful Rockville,
16 Maryland. So thank you all, and we'll see you
17 there.

18 (Proceedings were concluded for the
19 day at 5:55 p.m.)

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CERTIFICATE

p This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Private Fuel Storage, LLC

Docket Number: Docket No. 72-22-ISFSI

ASLBP No. 97-732-02-ISFSI

Location: Salt Lake City, Utah

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

151 Diana Kent
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