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NUCLEAR REGULATORY COMMISSION

Title: Private Fuel Storage, LLC

Docket Number: 72-22-ISFSI; ASLBP No. 97-732-02-ISFSI

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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

U. S. Nuclear Regulatory Commission
Utah State Capitol
Salt Lake City, Utah

On June 8, 2002 the above-entitled matter came on for hearing, pursuant to notice, before:

MICHAEL C. FARRAR, CHAIRMAN
Administrative Judge
Atomic Safety & Licensing Board Panel

DR. JERRY R. KLINE
Administrative Judge
Atomic Safety & Licensing Board Panel

DR. PETER S. LAM
Administrative Judge
Atomic Safety & Licensing Board Panel

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E X A M I N A T I O N

E X H I B I T S

No.		MRKD/ADMTD
APPLICANT EXHIBITS		
86B	Ex. 86, minus additional run	10543/
86C	Ex. 86, with changes by Singh and Soler	10543/10549
86D	Ex. 179, with corrections by Singh and Soler	10543/10550
225	Previously Marked	/10585
225A	Disk of Simulations	10543/10587
225B	Results and input parameters for a run from 225	10543/10597
225C	1 page - slide with graphs	10590/
225D	Graphs relating to pad-to-pad interaction	10787/10788
227	e-mail message from Paul Gaukler with attachments	10728/10729
OO	Previously Marked	/10554
STATE EXHIBITS		
168	Previously Marked	/10751

June 8, 2002 9:08 a.m.

P R O C E E D I N G S

(APPLICANT'S EXHIBITS-86C, 86D, 225A AND 225B WERE MARKED.)

JUDGE FARRAR: Good morning, everyone. We're here at the state capitol. We stopped in the Wasatch Room this morning at the Sheraton, and it was like we were never there. What we did there will live longer than the arrangements did.

We thank the State again for their good offices in making this legislative hearing room available for us.

In terms of the microphones, those of you who were here before, the controls are at the chairman's desk, so if you need to talk privately, you can't turn your microphone off. Push it away from you.

We're here to do the Applicant's rebuttal witnesses.

Any preliminary matters?

MR. GAUKLER: Yes, Your Honor. I've handed out some exhibits. I want to talk briefly

about two, which these are 225 and 226. 225 is the additional cask analyses for the PFSF, and this is identical to the 225 that was discussed earlier this week, the only difference being that the proprietary and confidential has been signed off. So this is a public document, and it should replace in its entirely what was previously marked as 225.

JUDGE FARRAR: All right. What we will do is instruct the court reporter to take this new version of 225 back to their files, discard and, in fact, if -- yes, discard the original of this that was filed and substitute this for it.

MR. GAUKLER: The second document that is in the same category as that one is PFS 226. That was an excerpt from a Holtec calculation. The two-page -- that excerpt has no confidential material, and, therefore, we have just recopied and resubmitted identical to what was 226 before. It's labeled Multi-Cask Seismic Response at the PFS ISFSI, and it's the one that has the calculation for the stiffness springs. And, again, it is identical except the proprietary has been crossed off, and this should replace what is 226.

JUDGE FARRAR: All right. We will have the court reporter do the same with this as with

225, that is, substitute this for those previously filed.

MR. GAUKLER: I would also, then, like to talk about PFS 86C which is the beyond design basis.

JUDGE FARRAR: Now, the problem with that is the copy we have says "Proprietary" on it.

MR. GAUKLER: Yes. That one is proprietary, and this is -- well, this is a document that we had requested be admitted on Tuesday. It will show corrections similar to the corrections that were made to Dr. Singh's and Dr. Soler's testimony in terms of the input data for the simulations that have been seen earlier. We had a lengthy discussion on it. Your Honors denied admission of the revised document at that time because it contained an additional run, without prejudice to our resubmitting a new document with just the changes or corrections, and so this is that new document. It's the same as 86 -- PFS Exhibit 86 except for the changes and -- except for the corrections to correlate with the corrections that Dr. Singh and Dr. Soler made to their testimony on Tuesday.

JUDGE FARRAR: And this is -- has the

vertical lines in the margin indicating what the corrections are?

MR. GAUKLER: Yes, that's correct, Your Honor.

JUDGE FARRAR: And has -- as you indicated, has the extra run eliminated?

MR. GAUKLER: Extra run has been eliminated.

JUDGE FARRAR: But you do want this considered proprietary?

MR. GAUKLER: Yes, because the original 86 was proprietary.

JUDGE FARRAR: And you're moving admission of this at this time?

MR. GAUKLER: Yes, I am. Yeah, and this will be 86C.

JUDGE FARRAR: Right.

Any objection, State?

MS. NAKAHARA: We would renew our objection, if you recall a long discussion --

JUDGE FARRAR: You say you renew your objection?

MS. NAKAHARA: On this document not to give the Applicant --

MR. GAUKLER: This is different.

MS. NAKAHARA: Oh, this is a different document?

MR. GAUKLER: This is a different document, Connie.

MS. NAKAHARA: Thank you.

MR. GAUKLER: This is the one that we had the additional run in initially, and the Board denied it because of the additional run. And we've taken the additional run out of it, and all we've done is identify the corrections analogous to the corrections that were made to Dr. Singh's and Dr. Soler's testimony on Tuesday in what is Exhibit 86B.

JUDGE FARRAR: Mr. Gaukler, 86 will remain in the record?

MR. GAUKLER: Yes.

JUDGE FARRAR: Because I think the State was concerned that they wanted to have in the record the historical record. That one came in --

MR. GAUKLER: Right.

JUDGE FARRAR: -- and needed to be corrected, so we will have both the original and the corrected version in the record?

MR. GAUKLER: Just like the testimony, the original testimony's in the order, and the

corrected testimony was introduced as Exhibit 86B.

JUDGE FARRAR: If I recall, that was the only -- that and the extra run were the only basis for the State's objection at that time.

MS. NAKAHARA: Initially we had an additional objection which we would -- I shouldn't say probably, which we would retain, which is the data only shows displacement for Cask No. 1, and as we observed on the record, some of the casks in various runs appear to move more than Cask No. 1. And so to the extent that this is being proffered for only showing the displacement of Cask No. 1 in each case and not to show the maximum displacement in the -- for the 8 casks in which -- the cases that have 8 casks, we would have no objection, if you could understand that.

JUDGE FARRAR: If I can paraphrase that, you think this document has a shortcoming, but to me that would not be a reason not to admit it. If it, in fact, has the shortcoming that you just urged, that's something that you all can argue goes to its weight and impact in the case.

Does the Staff have any objection?

MR. O'NEILL: No objection, Your Honor.

JUDGE FARRAR: Then we'll admit the

document subject to arguments later about what weight to give it or what deficiencies it may or may not contain.

(APPLICANT'S EXHIBIT-86B WAS ADMITTED.)

MR. GAUKLER: Then one last document I'm going to discuss now, and I'll leave the rest until after Dr. Soler testifies. That is what we have identified as Exhibit 86D.

JUDGE FARRAR: D?

MR. GAUKLER: Yes. And this is identical to State Exhibit 179 which has the results of the VisualNastran runs that are discussed in 86C but, again, making the corrections corresponding to the corrections that were made in Dr. Singh's and Dr. Soler's testimony.

JUDGE FARRAR: And that, again, has a vertical line in the margin?

MR. GAUKLER: What it has -- what it has here, you'll see a vertical line at the bottom of the first page which tells you what's been changed.

JUDGE FARRAR: All right.

MR. GAUKLER: The value 16 has been replaced by the value 34. And the only other changes in the document are we added a title that does correlate it directly to the report to which

these results go, and we made one site clarification in a title for one of the tables at the end.

JUDGE FARRAR: Any objection?

MS. NAKAHARA: No objection.

JUDGE FARRAR: Staff?

MR. O'NEILL: No objection.

JUDGE FARRAR: Then 86D will be admitted.

(APPLICANT'S EXHIBIT-86D WAS ADMITTED.)

MS. NAKAHARA: May I ask a clarifying question?

JUDGE FARRAR: Certainly.

MS. NAKAHARA: The admittance of PFS 86C, that only includes the hard copy, is that correct, and not the animations?

MR. GAUKLER: She points out a good point. At this point I would also move for admission of PFS Exhibit OO which are the simulations that go with the report, and they also go with the results that are in 86D. These are simulations that Dr. Soler showed --

JUDGE FARRAR: Was OO a disk?

MR. GAUKLER: OO was a disk and are the simulations that Dr. Soler showed on the first day

of his testimony back on April -- April 29 or April 30. I forget which day it was.

THE WITNESS: That's the first CD they already have.

MR. GAUKLER: No, that's what we're talking about.

THE WITNESS: Oh, okay.

MR. TURK: And that goes with 86D?

MR. GAUKLER: That goes with 86D and 86C. So Exhibit OO are the simulations of the cases that are discussed in 86C and to which the input data and data are shown in 86D.

JUDGE FARRAR: And that's the disk we got a copy of before we ever came out here back in March or April?

MR. GAUKLER: That's correct, Your Honor.

JUDGE FARRAR: All right.

MR. GAUKLER: It was served a day or two after the testimony was served. And I would move for the admission of Exhibit OO.

JUDGE FARRAR: For the benefit of anyone later reviewing this record, there may be some confusion during the course of the day, since everybody had to box up a lot of materials last

night when we left the Sheraton courtroom. So there may be some confusion today about names of different documents which are now in boxes somewhere.

Any objection to OO?

MS. NAKAHARA: The State objects on the same grounds we raised earlier and even more so now that PFS 86D has been admitted. 86D provides all the input parameters, the results, and it appears -- the State would proffer that 86D provides the best evidence, and there's a potential for the animations to be taken out of context at a subsequent reviewing level in a subsequent jurisdiction.

JUDGE FARRAR: Staff?

MR. TURK: We have no objection, Your Honor. The CD provides a dramatization of what appears on paper. I think it's a useful exhibit. We don't object.

MR. GAUKLER: Also, I would note that it actually clarifies one of the State's objections to 86C, which was that some of the -- some of the casks may have greater movement than that reported in the data, and you can see that by looking at the CD, the simulation.

MS. NAKAHARA: Your Honor, if I might add one small point.

JUDGE FARRAR: Hold on a second.

(A discussion was held off the record.)

JUDGE FARRAR: Go ahead.

MS. NAKAHARA: Mr. Gaukler's point emphasizes the State's point that you cannot quantify the animations, and, thus, they could mislead a tribunal in the future.

JUDGE FARRAR: Before we rule, what's 225A, which looks like another disk?

MR. GAUKLER: 225A is a disk of what we just saw this week earlier, and we'll be seeing some more today and after the completion of Dr. Soler's testimony. I would move for the admission of that as well.

MR. TURK: I'm sorry. I didn't hear the explanation of 225A, or maybe I didn't understand it. Could you say that again or --

MR. GAUKLER: 225A is the disk that goes with the simulations that we saw earlier this week, and we'll see three more today, I believe, which are on there which relate to the report, PFS 225.

(The Board confers off the record.)

JUDGE FARRAR: We understand the State's

objection but think that the danger of anyone being misled by this -- by this simulation is slim because without -- we haven't, of course, started writing our opinion, but I assume there will be a significant section on this animation and on all of Dr. Soler's, and Dr. Singh's calculations, and we will say in that opinion whether that work and the attendant simulation is good, bad or indifferent, so I don't think there's any real danger that anyone would later pick up the simulation and say, oh, there's the answer, if we, in fact, have put in our opinion that it's not the answer. So I don't think there's any danger there.

So we will admit PFS OO.

(APPLICANT'S EXHIBIT-OO WAS ADMITTED.)

MR. GAUKLER: Thank you, Your Honor. With those preliminaries, I think we're ready to begin with the rebuttal testimony of --

MS. CHANCELLOR: I have one more matter.

MR. GAUKLER: Okay.

MS. CHANCELLOR: Your Honor, we requested that PFS put on Dr. Soler first, and they have kindly acceded to that. And the reason for that request is that, if you recall, on May 1 and May 3 we received some additional data from Holtec

with respect to the force histories, and as part of the examination on rebuttal, we would request permission to ask questions of Dr. Soler with respect to the data that we received on May 1 and May 3. And we did reserve those -- that objection to receiving the late information on -- we reserved those objections in early May with the right to recall Dr. Soler or Mr. Trudeau.

JUDGE FARRAR: So, if I understand that, Dr. Soler now would be here for purposes of presenting PFS rebuttal testimony and also -- which you will get to cross-examine, but also you will cross-examine on a matter left over from before?

MS. CHANCELLOR: That's correct, Your Honor.

JUDGE FARRAR: I take it there's no objection to that?

MR. GAUKLER: I recall that being left open, yes. No objection.

JUDGE FARRAR: All right. Staff?

MR. O'NEILL: No objection here.

JUDGE FARRAR: All right. Then we will do that.

MR. GAUKLER: Just a point of clarification. Do you want to do it now or after

cross on the rebuttal?

MS. CHANCELLOR: Ms. Nakahara is going to do it, but I think we'd segregate what was questions on rebuttal and what were questions on the forces but do it all together.

MR. GAUKLER: Okay. So we're going to do rebuttal on it, in other words?

JUDGE FARRAR: Right.

MS. CHANCELLOR: Correct.

ALAN I. SOLER,

called as a rebuttal witness having been previously duly sworn to tell the truth, was examined and testified as follows:

DIRECT EXAMINATION

BY MR. GAUKLER:

Q. Dr. Soler, do you have before you a copy of Rebuttal Testimony of Alan I. Soler on Section D of Unified Contention Utah L/QQ dated June 7, 2002?

A. Yes, I do.

Q. Was that testimony prepared by you or prepared under your supervision?

A. Yes.

Q. Do you adopt that testimony as being true and correct for your rebuttal testimony in this proceeding?

A. Yes, I do.

MR. GAUKLER: Your Honor, I would request that the rebuttal testimony of Alan I. Soler be bound into the record as if read.

JUDGE FARRAR: Any objection?

MS. NAKAHARA: No objection, Your Honor.

JUDGE FARRAR: Staff?

MR. TURK: No objection, Your Honor.

JUDGE FARRAR: All right. Then the reporter will bind the rebuttal testimony into the record at this point as if read.

(Prefiled Rebuttal testimony of Alan Soler follows:)

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 ALAN I. SOLER ON SECTION D OF UNIFIED CONTENTION UTAH L/QQ

I. REBUTTAL TO TESTIMONY OF STATE OF UTAH WITNESSES DR. FARHANG OSTADAN AND DR. STEVEN E. BARTLETT

A. Pad-to-Pad Interaction

Q1. In their answer to question 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 oral testimony at the May 8, 2002 hearing (Tr. 7517-29) Dr. Ostadan and Dr. Bartlett raise the concern that the effect of pad-to-pad interaction may be important, particularly with respect to the sliding motion of the unanchored cask on the pads and the pad-to-pad interaction for pads spaced only 5 feet apart in the horizontal direction. Have you evaluated this concern?

A1. Yes. Holtec Report No. HI-2022878, "Additional Cask Analyses for the PFSF," identified in this proceeding as PFS Exhibit 225 ("PFS Exh. 225") summarizes the results of analyses I conducted using the Visual Nastran ("VN") computer code of the potential effects of pad-to-pad interaction on the stability of HI-STORM 100 storage casks at the PFSF facility. The input data for these computerized analyses are described in Sections 4.1 and 4.3 of PFS Exh. 225; the analyses themselves are described in Section 6.2, and the results are summarized in Section 8.2. Our conclusions with respect to this concern are presented in Section 9.0 of PFS Exh. 225.

Q2. Please describe the analyses you conducted on the pad-to-pad interaction issue.

A2. To evaluate the potential effects of pad-to-pad interaction, we conducted a simplified analytical solution and two sets of computer-generated numerical analyses. The simplified analytical solution and the first set of numerical analyses respond to the claims by Drs. Bartlett and Ostadan at above cited hearings on May 8, 2002 that if two pads are loaded with a different number of casks, the different total masses associated with adjacent pads could cause out-of-phase motion and a transmittal of additional forces between pads. To assess this concern, a VN dynamic model was developed that included two adjacent pads, five feet apart, one pad fully loaded with eight casks, the other having only a single cask. The model included a representation of the soil cement between the pads. We performed two simulations for this model: one in which the soil cement between the pads is assumed to retain its integrity and therefore be able to transmit both tension and compression forces; and another simulation in which the soil cement is assumed to be cracked and thus able to transmit only compression forces.

The second analysis examined the potential effect of having a gap between a pad and the adjacent soil cement layer. The analysis evaluated the impact forces that would be imparted on the pad as a result of its collision with the soil cement across the gap and the effect of those forces on the stability of the casks on the pad. For this analysis, a single pad fully loaded with eight casks was modeled. The pad was allowed to slide on the underlying soil and lift off. A fixed, rigid frame was modeled surrounding the entire pad with a clearance gap of approximately 0.6" to all edges of the moving pad.

Q3. Where do you present the input data and the calculation details for these two sets of simulations?

A3. The input data for these simulations are listed in Table 2 on page 13 of PFS Exh. 225. Additional details on the simulations are provided in Section 6.2 on pages 16 through 18. Appendix A of PFS Exh. 225 contains the calculation details for these simulations.

Q4. Based on purely physical considerations, would you expect that pad-to-pad interactions would only result in small loadings on the pads and casks?

A4. Yes. As described in Section 8.2.1. on pages 26 and 27 of PFS Exh. 225, a coupled two-degree of freedom mass spring system with masses equivalent to those of two fully loaded pads (8 casks each) will vibrate with a first natural

frequency of approximately 4.939 Hz and a second natural frequency of 29.765 Hz. The first natural frequency of approximately 5 Hz is within the range of frequencies for which 2000-year return period design basis earthquake for the PFSF has the largest energy content. This first natural frequency corresponds essentially to in-phase motion of the two pads, in which the pad-to-pad interaction effects are minimal.

The second natural frequency of approximately 30 Hz corresponds essentially to out-of-phase motion of the two pads, in which pad-to-pad interaction effects should be the most severe. However, that frequency is above those for which the 2000-year return period design basis earthquake for the PFSF has significant energy content, meaning that little energy from the earthquake ground motion is available to be transmitted from one pad to the other. Therefore, the effect of pad-to-pad interaction should be negligible.

Q5. Is that conclusion verified by the results of your VN simulations?

A5. Yes.

Q6. Would you please summarize the results of your computer simulations?

A6. The results of the simulations are reported in Section 8.2.2 on pages 27 through 29 of PFS Exh. 225. As more fully discussed there, all three cases predict some interactions between pads or between the pads and the surrounding soil cement, resulting in some loadings being applied to the pads. However, the forces imparted as a result of the interactions do not result in significant motions of the casks on the pads. The maximum peak-to-peak cask displacement observed in any of these cases is six inches, and the maximum cask excursion from its starting location is 3.8 inches.

The insignificant effect of pad-to-pad interactions on the motion of the casks is understandable because of the large area that is available on each pad to absorb any loads produced by the interaction. For example, the simulation of the impact between a pad and the surrounding soil cement across a 0.6" gap predicts a maximum 2,000,000 lb. compression impact force transmitted to the end of the pad, having an area of 90 square feet (30' by 3') which in turn results in only a pressure of 154.3 psi on the pad. Since the allowable stress in compression of reinforced concrete, conservatively ignoring the strength of the reinforcement, is

on the order of 3600 psi, it is evident that the pad pressure produced by the impact between the pad and the soil cement is insignificant.

Q7. In light of the analytical considerations you just described and the results of your N simulations, what are your conclusions regarding the effect of pad-to-pad interaction on the stability of the casks and pads at the PFSF?

A7. The analytical considerations and VN runs confirm that pad-to-pad interaction effects and the potential collision of a pad with the surrounding soil cement across a postulated gap between them do not impart forces of sufficient magnitude on the pads to affect the stability of the casks on the pads. This is true regardless of pad loading and whether a gap is assumed to be present between a pad and the soil cement adjacent to it. Therefore, the concerns expressed about these phenomena in the testimony of Drs. Bartlett and Ostadan are inconsequential.

B. Long Term Pad Settlement

Q8. At the hearing, Dr. Ostadan and Dr. Bartlett expressed concern that long term settlement of the pad, in particular potential "dishing" in the middle of the pad (Tr. 7509-7512), might affect the dynamic response of the casks under earthquake conditions. How do you respond to this claim?

A8. Based on the testimony of Paul Trudeau, a reasonable estimate of long term settlement of the pad is in the range of 0.50 inches. Even if it is presumed that this long term settlement occurred at the pad's center, with no settlement at the edge, resulting in "dishing" of the pad at its center, the average slope measured along the short side of the pad is only 0.159 degrees. Based on my experience with cask stability analyses, this slight angle would have an insignificant effect on the analyses results and would certainly not alter the conclusions.

Q9. Does this conclude your testimony?

A9. Yes.

MR. GAUKLER: As part of the rebuttal testimony, the rebuttal testimony describes three runs that are in PFS Exhibit 225, and I would suggest that Dr. Soler now show the simulations related to those three runs which are discussed in both PFS 225 and his rebuttal testimony with a brief description, telling you what he's showing you just as he has done in the past.

JUDGE FARRAR: Any objection to that?

MS. NAKAHARA: No objection. I just moved so everybody could see.

THE WITNESS: We have to wait till the light warms up here.

If I may add a little clarification to the CD that was just presented, that contains everything that I showed this week, including the three spheres that drop. There are 10 simulations on the disk -- on the CD.

MR. TURK: Can we lower the lights? Is there a switch?

MS. CHANCELLOR: Which CD are you talking about, Dr. Soler, the one that goes with this rebuttal?

THE WITNESS: The one that's just been submitted.

MS. CHANCELLOR: It hasn't been submitted.

MR. GAUKLER: Your Honor, the one that was submitted is a different CD than this.

We'll talk about this CD later, Dr. Soler.

THE WITNESS: Oh, okay. You've got me confused now.

MR. GAUKLER: He's talking about the CD that goes with 225.

THE WITNESS: I performed three simulations, both -- or all three of them -- well, two of the three involving two pads. And this was an attempt to address, I believe, Dr. Bartlett's question concerning pads moving out of phase with the soil underneath the pads remaining elastic but the soil cement between the two pads possibly either being elastic or possibly, during the course of an earthquake, cracking to the extent that the soil cement could only resist compression and not tension.

The first one that I will show -- I'll just check to see if this is in focus here.

MR. TURK: May we go off the record for a moment?

JUDGE FARRAR: Yes.

(A discussion was held off the record.)

JUDGE FARRAR: Back on the record.

THE WITNESS: The first simulation, it is assumed that the soil cement between the two pads, the 5-foot span between two adjacent pads, is able to take both tension and compression. One of the pads will be completely full with 8 casks. The other pad will be -- only have 1 cask on it, and that cask will be in a location which I have been told is the most likely location to install the first cask on an empty pad.

Q. (By Mr. Gaukler) Now, this is real time?

A. This is real time. This will take 30 seconds.

MS. NAKAHARA: And this is at the 2,000-year --

THE WITNESS: This is with the 2,000-year earthquake.

Now, before I shut this down, what you do not see in this picture are the springs that represent the soil cement. In the report I believe they show in the -- in the pictures that are appropriate to this run. But I put two linear

springs at each corner -- I'll use my mouse. There's a linear spring that was attached to two pads along that edge and back along that edge -- and I believe -- well, that's not necessary -- so that I could simulate not only direct compression and tension but also, if the two pads tended to twist relative to each other, the fact that I modeled it with two springs would -- would incorporate that to some extent.

JUDGE FARRAR: And so the record would be clear, you're pointing with the arrow there to the long dimension --

THE WITNESS: The long dimension --

JUDGE FARRAR: -- the area along the long dimension?

THE WITNESS: Yes, with reference --

JUDGE FARRAR: At the --

THE WITNESS: -- to the report, Figure 6 on page 38 actually shows this figure but with the springs denoted in the way VisualNastran would denote a spring, so it locates the springs in Figure 6.

JUDGE FARRAR: This is page 38 of --

THE WITNESS: Page 38 of report 2022878 which I guess is 225?

MR. GAUKLER: Yes.

MR. TURK: May I ask if this is also Figure 2 in PFS Exhibit 225?

THE WITNESS: Yes. Figure 2 is a larger representation, and that shows the spring as sort of a series of coils.

JUDGE LAM: So, Dr. Soler, what does this run intend to demonstrate?

THE WITNESS: This run intends to demonstrate that if you had two pads which had the most, I guess, diverse total dead weight, one of them, the one that's fully loaded, if you count the weight of the 8 casks, you have roughly a 3.8 million total dead weight, whereas the other one you have about a little over 1 million dead weight. So according to Dr. Bartlett's hypothesis, it would be quite possible for these two pads to move out of phase and that -- therefore, generate forces in the soil cement between the two pads and, therefore, affect the motion of either pad modeled.

So this was -- this was an attempt to simulate the hypothesis that the soil cement between the two pads did not fail in any manner and, therefore, could take tension as well as compression.

JUDGE LAM: Dr. Soler, how would you detect any failure in the soil cement in your model even if that were to occur?

THE WITNESS: Well, this model would not detect failure. It would simply report the force in the soil cement, whatever it was. If it went to a high enough tension so that the total force in tension was more than the soil cement could take in tension, it would not care. It would just keep going.

The next run is the other extreme where you assume that the soil cement can't take any tension no matter what -- no matter how small the load is, and the only time it can take load is when the two pads move toward one another so they compress those springs.

MR. TURK: I'm sorry. May I ask one more question about the figure in 225?

THE WITNESS: Which one, Figure 2?

MR. TURK: Figure 6.

THE WITNESS: Hold on a second. Okay.

MR. TURK: To me it looks -- the left hand -- upper left-hand picture of the cask sitting on the pad, to me that looks identical to Figure 2.

THE WITNESS: Well, it is. It's just

smaller.

MR. TURK: Okay.

THE WITNESS: Okay. The next simulation is the same case, but by virtue of programming with -- within VisualNastran, I was able to basically zero out any capability for those two springs to take any tensile load. So while the springs are still there, they now behave as -- I guess I'll call them piece-wise linear springs. And the results of that simulation are a, let me say, picture of the results at the instant in time, and graphs for the entire time span are shown in Figure 7 of the report.

MR. GAUKLER: And I would add that the numerical results are shown on page 28 of 43 for the three runs that Dr. Soler will be showing here.

THE WITNESS: And this is the compression-only soil cement, and it is, again, going to be in real time.

There are some differences in details if you read the report, but from looking at the two movies, you would be hard pressed to see any significant difference between the two runs.

Now, the third simulation is an attempt, I believe, to address the question of asymmetrical

loading. In this case the soil cement completely around one of the pads that's fully loaded is assumed to at time zero have a 6/10-of-an-inch gap between the edge of the pad and the beginning of the soil cement, so it's as if we dropped a rectangle, being the pad, into a picture frame which was slightly larger around the periphery than the pad itself.

In this case, since we knew that, in general, elastic movement of the pad was not going to close that gap, we allowed in this case the pad to slide under the action of the forces, and we assume the coefficient of friction between the base of the pad and the underlying substrate was .31 in order to ensure that the pad would slide and presumably close the gap and impact with the adjacent soil cement.

The difference, to the extent that the model allows it, is the fact that here we will truly get some impactive forces between the soil cement and the moving pad, whereas in the previous case of a compression-only spring between the soil cement, all we are saying is that whenever the soil tries to take tension, it's zeroed out so that it can't take tension and doesn't act during the

period when the solution would indicate that it would take tension. There are no what I'll call impactive forces between the soil cement and the pad in the first two simulations, but there are in this one.

Now, of course, we're only modeling one fully loaded pad here. This, again, will be in real time.

Now, the results from this simulation gave cask displacement where it gave results for at least the cask that we tracked that were much less than the other two runs. And if you look at this before you start the simulation, you have two competing effects. You have -- first of all, you will get impacts between the pad and the surrounding soil cement which would tend to dissipate energy, but, on the other hand, you are getting impact forces which presumably would be larger than the forces you would get from just a spring effect where you would have a gradual application of compression and possibly tension.

So you have two competing effects, so it's not clear which one will dominate, the dissipation of energy, or the higher level of impactive force. But I think from looking at the

simulations and, of course, looking at the data, you find that the greater increase impactive force does not really cause a problem, but the fact that impacts occur, you dissipate energy in another mechanism rather than sending it to the casks to be dissipated.

Now, that completes the simulations that are discussed in the report.

Q. (By Mr. Gaukler) Thank you, Dr. --

A. I believe I can turn this off now and we'll...

MR. GAUKLER: I have a couple more questions, Your Honor, just in terms of additional rebuttal and explanation.

MR. TURK: At some point I'd like to ask a question about that last simulation.

JUDGE FARRAR: Why don't you ask it now while it's fresh in our mind.

MR. TURK: Okay. Dr. Soler, in the last simulation you showed us, Simulation No. 3, we saw a pad with 8 casks sitting on it. We saw no other pads in the area around it.

THE WITNESS: That's correct.

MR. TURK: What does that simulation show us? If there are no other -- if there are no

other pads around it, then does that show anything about the potential action of a surrounding pad upon this pad?

THE WITNESS: Well, in this case the simulation and -- let me -- let me state that this simulation was generated and done prior to the simulations -- the first two simulations with two casks. And this simulation was generated --

MR. TURK: With two pads.

THE WITNESS: Two pads. Pardon me. This simulation was generated to respond or attempt to respond in our own minds to the question of asymmetric loading that was raised at the last series of hearings. So it was the first of the three simulations done before we had considered Dr. Bartlett's questions concerning pads moving out of phase. So our thinking there was to say let us assume that, for whatever reason, the soil cement surrounding one pad is essentially moving with the rest of the ground, and the only thing moving relative to the ground is this one pad that is surrounded by the soil cement. And we have this gap of approximately 6/10 of an inch on all four sides.

MR. TURK: So, in fact, then, if there

was an impact force of the pad against the surrounding soil cement separated by a gap from the pad, then we would see how that affects the movement of the casks above the pad?

THE WITNESS: That's correct. The question was could that impactive force, which was presumably going to be of a larger magnitude than, of course, no force at all, which is what some of our isolated pads have dealt with, whether that impactive force could suddenly -- I'll use the term jerk the casks and increase the deformation. But what is shown here is that, in fact, the energy dissipation into the adjacent soil cement outweighed the increased magnitude of the impactive force, and the casks actually did not see as much energy, so they ended up with less movement relative to the pads.

MR. TURK: And, I'm sorry. Is that because the pads -- some of that energy dissipated with the movement of the pads so it wasn't translated into the casks?

THE WITNESS: Well, some of the energy dissipation is due to the sliding of the pad. The rest of the energy dissipating is due to the impacting of the sliding pad on the adjacent soil

cement which isn't moving. And the net of those two extra mechanisms, if you will, reduced the effect on the casks themselves on the pad.

MR. TURK: Thank you.

JUDGE LAM: Dr. Soler, if there were no soil cement underneath the pad, how do the casks behave?

THE WITNESS: If there were no soil cement underneath the pads. I can only answer that by referring to some of our earlier work. And by earlier work, I mean 1,000-year return earthquake and the initial runs in which we were given moduli that presumably did not include the effect of soil cement, and, therefore, the springs, the soil springs that were generated, presumably did not include any effect of soil cement.

My recollection of these very early submittals is that, of course, the numbers changed slightly, but the conclusions didn't change because the soil cement which is represented by 6 springs, while the numbers changed, they didn't change to the extent that they completely negated our results that basically say the casks won't move more than 3 to 5 inches and they remain stable and they don't impact one another. That has remained constant for

all of the runs. So the presence of the soil cement in the view of Holtec's, was simply well, we reran -- we reran the simulations for different sets of parameters for the soil springs, but the conclusions were always the same.

JUDGE LAM: The reason I ask that question was for two reasons. One, I want to have a clarification as to what is the need for soil cement; two, assuming there may be construction errors in constructing the soil cement and the pad, what would be the consequences of that hypothetical error. So is it true that your answer is -- is telling us with or without soil cement the casks would basically behave the same during the 2,000-year design earthquake?

THE WITNESS: Well, let me say that within the scope of looking at this strictly from the point of view of dynamic analysis of the pad and with the -- I guess the assumption that pad sliding does not occur so that the soil springs remain elastic, then as far as Holtec's simulation is concerned, soil cement is not needed under the pads for dynamic stability of the casks.

Now, I can't speak for the canister transfer building or I can't speak for the

necessity of satisfying a technical regulation of a 1.1 safety factor. But as far as the question of stability of the casks and their response under an earthquake, soil cement is not critical or the presence of soil cement under the pad is not critical.

JUDGE LAM: Are we talking about 2,000-year return earthquake?

THE WITNESS: 2,000-year, 1,000-year, whatever earthquakes were involved in the whole series of simulations from I guess 1997 through the final 2,000-year earthquake, the presence or absence of soil cement would not affect the final conclusions.

MR. TURK: May I inquire, Dr. Lam?

JUDGE LAM: Please.

MR. TURK: When I first heard your question, I thought you were asking about soil cement between the pads, and you --

JUDGE LAM: No. I meant --

MR. TURK: -- meant the cement-treated soil --

(A discussion was held off the record.)

MR. TURK: I apparently had misunderstood. I thought you were talking about

the soil cement between the pads. Now I understand you were talking about the cement-treated underneath the pads.

JUDGE LAM: Right. I meant the soil cement underneath the pad.

JUDGE FARRAR: Is that --

THE WITNESS: That's the way I understood the question.

JUDGE FARRAR: You understood it as the material under the pads?

THE WITNESS: Yes, that's how I understood the question.

MR. TURK: I apologize.

JUDGE FARRAR: Mr. Gaukler you were attempting to ask a few additional questions.

MR. GAUKLER: I just have a few questions.

Q. Dr. Soler, would you please turn to page 28 of PFS Exhibit 225?

A. Yes, I have it.

Q. There was testimony yesterday by Dr. Ostadan and Bartlett on the value of maximum compression load in the soil cement between the pads. Do you remember that?

A. Yes.

Q. Now, the value -- will you please describe what the values listed in this table are in terms of the maximum compression movement of the soil cement under the pads?

A. Okay. If you'll recall my explanation during the presentation of the movies, I noted that the effect of the soil cement in the first two simulations was done by incorporating two springs into the model. With respect to the first two simulations, the third column in this table on page 28 simply lists the maximum value of the force in the sum of the two springs, in other words, the total either compressive or tensile force, as at least in Case 1 would represent, the maximum magnitude from the sum of the values in the two springs.

And that represents -- certainly in the second case, of 1.9 million pounds, it represents a total compressive force. In the first case, I honestly without -- well, I can look at the figure, but I'm not sure whether it was a tensile force or a compressive force that leads to that -- that value. You can see -- well, I can see myself that I reported the tensile load of 1.2 million and a compressive load of 800,000.

Now, the third row or the fourth row in that table which lists the results for the effects of adjacent soil cement around the pads and the value of 2 million simply represents the total of the impact force that you get when -- when you hit in any direction. And I did not go into detail in this table about which direction you got the 2 million because I was only interested in reporting the number.

Q. And on the bottom of that page you show what the effect is in terms of psi of that impact force on the side of the -- or the edge of the pad?

A. Yes. This -- this is a question to address. 2 million or 1.9 million represents a large number to the man on the street, say, but in terms of stress in the concrete, it's a very small number of about 154 psi. And I believe in my direct testimony that I have compared that with the allowable compressive load in the concrete under this condition which would be about 3500 psi, if my memory serves me correctly.

Q. Is that in your rebuttal testimony?

A. Yeah, there it is in my rebuttal, page 4 of the prefiled testimony. 3600 psi would be the limit that the ACI, American Concrete Institute,

code, would say that you could develop in direct compression.

Q. Now, Dr. Soler, in this table on page 28 is there listed anywhere there the forces on the soil underneath the soil cement?

A. No.

Q. Does your program actually calculate those forces and were you able to identify what those forces are?

A. I was able to identify those forces, but the original simulation that led to these tables -- let me explain a little more. The program will calculate anything you tell it to calculate and archive. By any meter that I create -- and by meter I mean any of the pictures on any of the reports that show curves. They're called meters in VisualNastran. If you want to measure something, you define a meter to measure it, and then it records the data in both graphical form and -- if you so desire, you can create an Excel spreadsheet which has the numbers.

Now, in the original simulations that led to the graph on page -- the table on page 28 -- they were done roughly, I guess, about a week and a half ago -- I did not create meters for the forces

in the soil cement springs.

In view of the testimony yesterday concerning the fact that 1.9 million pounds might be additive to the previously estimated soil spring forces by Mr. Trudeau, last night I took the simulation model corresponding to compression-only soil cement, added a meter -- or added two meters to it to generate the forces in the soil cement to determine whether or not this 1.9 million pounds directly adds or potentially subtractions somewhat from the soil cement springs. So while it is a run that was created last night and, in fact, did not go to 30 seconds for lack of time -- it stops at about -- I stopped it at about 22 seconds -- it directly gives the magnitudes of the forces in the soil cement under each of the two pads in that simulation.

Q. And what were those forces?

A. I can put up a slide, if you will, but my recollection is that the maximum force under any of the two pads that would tend to increase or decrease the -- that would tend to predict whether or not a pad would slide, actually decreases somewhat from the value predicted by Mr. Trudeau. I believe that the peak force in -- under any of

the slabs that you would use in a comparison to determine whether or not the pads slide is about 2.3 million pounds, and for the case considered -- and these cases were all done with lower bound, is my recollection of conversations with Mr. Trudeau, that for that case he had predicted about 27 million or 29 million pounds in the soil cement under the pads and from that would lead to his conclusion that he didn't get sliding.

So it appears from the results from this simulation or the rerunning of the same simulation with some extra force meters so I could get the data directly, that over time the forces in the soil cement between the two pads tends to reduce somewhat the force in the soil springs underneath the pad.

MS. NAKAHARA: May I ask a clarifying question?

MR. GAUKLER: That's all I have so --

MS. NAKAHARA: When you say the forces were forces under the soil, do you mean --

THE WITNESS: Under the pad.

MS. NAKAHARA: I'm sorry. The point under the pad on top of the spring? Is that the point of application?

THE WITNESS: No. The way the soil was modeled in these runs was to, in effect, create a series of 6 springs right under the center of the pad at its bottom surface, I guess is the best way to say it, and, therefore, I directly calculated the force in the horizontal direction.

MS. NAKAHARA: At the top or the bottom?

THE WITNESS: At the base of the pad where it contacts whatever I considered was underneath the pad.

MS. NAKAHARA: Okay. Thank you.

Do you have the data for this run?

THE WITNESS: I have a slide, and I also have a hard copy of that slide which could be submitted. The data, the input data does not change from what is in the report. I simply reran the case and added meters to directly track that force. At the time I originally ran the simulation, the only thing I was really interested in was in the response to the cask, so I didn't really track that. Last night I simply opened up the run, added two meters to track the forces under each of the two pads and reran the simulation.

Now, I can show the slide or we can put the piece of paper that -- the picture that I took

of the slide which has the results on it. Your -- your preference is my command.

MR. TURK: Could I ask that we see the slide?

MR. GAUKLER: Certainly.

THE WITNESS: Okay. Let's --

MS. NAKAHARA: I'd do the opposite. I'd ask for the paper --

MR. TURK: I don't omit that either. I'd like to see the slide while we're talking about it.

THE WITNESS: Okay. And this is just a snapshot. I didn't see any need for a movie since it was -- well, since time didn't permit it and, also, the meter is not going to come up with anything. Let me -- let me go get this slide.

MS. NAKAHARA: Your Honor, this doesn't give us an opportunity to rebut anything that Dr. Soler's presenting because we can't analyze an animation without --

THE WITNESS: Well, this will not be an animation.

MS. NAKAHARA: Which case does this correspond to that you added the two additional meters?

THE WITNESS: This would correspond to Figure 7 in the report.

Now -- now, just so that you can track and correspond the results of this slide with the previous run in the report, I have included in the lower left-hand corner the compressive forces in the soil cement that were presented in Figure 7. The two larger graphs on the right represent the soil springs. The top one is called adjacent pad force, meaning the one with -- the pad with only one cask on it, and the lower one is for the full pad.

And it's hard for you to see, but there are forces superposed (sic) on each other. In other words, if you look at the title, you see FX and FY forces given. But as far as we're concerned here, I would direct your attention to the lower right-hand meter in which at roughly, I guess, about 4 and 3/4 seconds, you're somewhere just in excess of 2.3 million pounds, it turns out, in compression in the springs.

Q. (By Mr. Gaukler) Can you use the arrow to point to that?

A. Yeah. There you go, right there.

So I -- I mean this slide provides a

direct correlation between the paper because these two -- in the report because these two are already in the report, and, of course, the picture while -- at least tells you the case that's running, and you will see the fact that the -- when this was run, it was last night. That's how I titled the model.

I have a hard copy. It's in my bag. If you'll excuse me for a minute, I'll get it.

MR. GAUKLER: Ms. Nakahara, does our paralegal know how to get copies of that made?

MS. NAKAHARA: No. We're having problems getting in the office ourselves this morning.

(A discussion was held off the record.)

THE WITNESS: Let me add one thing, that, of course, the input data for this run is in the report. There was no change in input data. It's simply defining the meter.

Q. (By Mr. Gaukler) So the purpose --

A. In this case, two meters.

Q. So the purpose of this run was to respond or address issues that were raised yesterday by Dr. Ostadan and Dr. Bartlett?

A. That's correct. The sole purpose of this run was to directly calculate the soil

springs -- the forces in the soil spring direct from the simulation rather than taking data and using some approximating formula to estimate what they were doing.

And as I believe Dr. Ostadan pointed out a number of times -- he asked the question why was not the data directly transmitted by Holtec to Mr. Trudeau, and the direct answer to that question was nobody asked for it. And having now seen the need for it, we generated it. Our initial data transmission during the course of this project was directly to ICEC who asked us for the forces from the casks on the pad.

MR. GAUKLER: I have no further questions, and I -- I'm going to get the slides marked and ask they be introduced once we get copies back for it.

JUDGE FARRAR: All right.

MR. GAUKLER: I would like at this time to move to introduce PFS Exhibit 225 which is the report -- additional cask analyses for the PFS. That includes the simulations that we saw today as well as the simulations that we saw Tuesday.

JUDGE FARRAR: Had you previously moved admission of that and we deferred action?

MR. GAUKLER: We had previously moved it. That led to the issue with the State objecting that it was really rebuttal testimony, that it was really -- we were going to have Mr. Diaz go through with Dr. Soler and Dr. Singh and have them give the testimony that was put in the report, and then the State withdrew that objection. And we moved it -- moved to admit it at that time, and then the State correctly pointed out we still had additional evidence to present with respect to it, so we held off the admission until today. And now having had Dr. Soler give additional testimony and evidence, I would move for the admission of 225.

JUDGE FARRAR: Any objection?

MS. NAKAHARA: No objection, Your Honor.

JUDGE FARRAR: Staff?

MR. TURK: No objection.

May I ask for a clarification? Does this include 225A?

MR. GAUKLER: I'm coming to that next.

I would actually move for the admission of -- oh, excuse me.

MR. TURK: So I have no objection to 225.

JUDGE FARRAR: Okay. Then 225 will be

admitted.

(APPLICANT'S EXHIBIT-225 WAS ADMITTED.)

MR. GAUKLER: Next we'd move for the admission of PFS 225A. This is the disk, compact disk showing the simulations that were shown on Tuesday and today and which correspond to the runs that were set forth in PFS Exhibit 225.

JUDGE FARRAR: Any objection?

MS. NAKAHARA: For the record, the State would pose the same objections we had to PFS Exhibit OO and even more so with respect to the falling casks and falling balls simulation which our experts pose is not realistic and even more subject to misunderstanding at a subsequent tribunal.

JUDGE FARRAR: And are the --

MR. GAUKLER: Yes. I --

JUDGE FARRAR: -- the casks and the balls on 225?

MR. GAUKLER: Yes, they're on there as well.

JUDGE FARRAR: As well as --

THE WITNESS: The fallen casks.

MR. GAUKLER: Yeah. We have the -- I forget to mention we have the 11 simulations or the

simulations from the report itself plus the simulation of the falling balls which is discussed in the report, but -- I don't know if we've mentioned the fact there was a simulation in the report -- and the three casks corresponding to the balls.

JUDGE FARRAR: And does this also have some material from OO, or this is all different?

MR. GAUKLER: All different from OO.

JUDGE FARRAR: Okay. Didn't we deal with the falling casks and balls before, or was that in terms of their testimony? Did we --

MS. NAKAHARA: Yes. It's in PFS Exhibit 225.

JUDGE FARRAR: No, but it seems to me there was an objection raised about either that testimony or something related to it a few days ago.

THE WITNESS: I don't -- I don't recall but that doesn't mean anything.

MR. GAUKLER: I remember the issue coming up. I forget if there was an objection or not. But it certainly was discussed in cross-examination.

JUDGE FARRAR: Was there a motion to

strike or --

MS. NAKAHARA: I don't believe that we -- the State posed a motion to strike. We have grave concerns with -- that this is not a realistic situation and, in particular, the falling casks are unrealistic. You may be recalling cross-examination --

JUDGE FARRAR: Okay.

MS. NAKAHARA: -- of Dr. Soler to that effect.

JUDGE FARRAR: Okay. And, again, with everything packed up, we don't have the previous transcripts here with us, so we're operating at a little bit of a disadvantage.

(The Board confers off the record.)

JUDGE FARRAR: I think we would add here to the same ruling we made earlier today, that we're expecting our opinion will deal with all these matters, so there's no real chance of confusion by some higher tribunal. And you will be free to argue at the appropriate time that this material should be given little or no weight, and the other side will argue the opposite. So we will admit 225A.

(APPLICANT'S EXHIBIT-225A WAS ADMITTED.)

JUDGE FARRAR: I'm sorry. I didn't ask the Staff what their opinion was.

MR. TURK: We have no objection.

MR. GAUKLER: I now have had distributed and marked -- have you had time to mark it? Would you please mark the one page we just distributed as 225B? That was the last slide shown by Dr. Soler.

JUDGE FARRAR: We'll take a moment and have the reporter mark that.

(APPLICANT'S EXHIBIT-225B WAS MARKED.)

JUDGE FARRAR: Mr. Turk, does the Staff have any cross they'd like to do?

MR. TURK: Yes.

JUDGE FARRAR: Go ahead.

JUDGE LAM: May I interrupt you --

MR. TURK: Yes.

JUDGE LAM: -- for a quick question, Mr. Turk?

Dr. Soler, I'm puzzled with some of the figures in Exhibit 225. May I ask you to go look at Figure 6?

THE WITNESS: Okay.

JUDGE LAM: May I ask you to see the position at the top of HI-STORM net displacement in inches?

THE WITNESS: Yes.

JUDGE LAM: I see 280 inches, 289?

THE WITNESS: The starting point -- the starting point, because of where the cask was and where the origin of coordinates is, is roughly 284 -- at location 284.7, which is the X coordinate squared plus the Y coordinate squared, square root of the sub.

JUDGE LAM: Oh, I see. This is a location marking --

THE WITNESS: This is a location, and then you're tracking the changing location.

JUDGE LAM: Okay. I see. So I should interpret all the results from Figure 5, Figure 6, Figure 7, Figure 8 in that light?

THE WITNESS: Right.

JUDGE LAM: Okay. Thank you.

THE WITNESS: That is why I think the data in at least one of the submittals shows a -- sort of picture of how you interpret displacement results in terms of either excursion from the origin or peak-to-peak excursion.

JUDGE LAM: Right. I thought you may be proposing testimony on the flying casks again.

THE WITNESS: No.

JUDGE LAM: Okay. Thank you.

MS. NAKAHARA: Your Honor, may I ask a procedural question, which I think Mr. Gaukler's getting to? Did you admit Exhibit 226?

MR. GAUKLER: 225. I think I may have made a mistake in labeling, so let me go back and correct my mistake, first of all. The one page that we just handed out I would like to have marked as 226C, please.

MR. TURK: That's what we referred --

MR. GAUKLER: 225C. Excuse me.

MR. TURK: That's what you had previously identified as 225B?

MR. GAUKLER: Right. Because I have another document that I've handed out that is identified as 225B already.

JUDGE FARRAR: Wait. So the one page slide and graphs will be -- you want marked as 225C?

MR. GAUKLER: Okay.

JUDGE FARRAR: Okay. If the reporter would change that marking.

(APPLICANT'S EXHIBIT-225C WAS MARKED.)

THE WITNESS: Your Honor, if I may, may I make a little addition to my testimony in

response to the question by Dr. Lam? And that is the -- the graph and all of the figures that was originally questioned starts at a -- at time zero at 284.7 inches. That has been a meter that has been around in all of my simulations, going back to late April. However, in -- when I generated the second pad with the 1 cask on it and created a meter to track its displacement, I was cognizant of the fact that I would be starting at a non-zero location, and I zeroed the meter prior to start to be approximately at zero. So you will notice that the execution of the lone cask on the second pad, those graphs are -- roughly start at zero.

JUDGE LAM: That's clear enough. You know, I think I may want to suggest to you, Dr. Soler, you know, these figures, the labeling of the vertical axis misled me. Of course, you know, on top of it you did the label of that chart, which is a position on top of HI-STORM. But then I see a label, and that is placement in inches versus time in seconds, and I see -- on your vertical axis I see 289 --

THE WITNESS: Uh-huh.

JUDGE LAM: -- an exponent of 2. That's where the confusion was to me. I'm glad you

clarified.

THE WITNESS: Okay. Thank you.

Q. (By Mr. Gaukler) I had handed out earlier and the court reporter has marked a three-page document identified as PFS Exhibit 225B, and, Dr. Soler, do you have that in front of you?

A. Yes, I do.

Q. And could you just briefly tell me what 225B is in relationship to PFS Exhibit 225? And you may want to refer directly to page 29 of PFS 225.

A. On page 29 of 225 we are doing various what I'll call sensitivity studies to look at the effect of the -- changing certain parameters, namely, the contact stiffness and contact damping on the response of the casks.

Q. And then what does 225B represent?

A. 225B represents what I'll call -- and I'll say what Holtec thought was its base case in the beyond design basis report which has been corrected and resubmitted in that we -- subsequent to submittal of that report, we found that we were not really doing 40 million stiffness and 40 percent of critical damping, but we were doing roughly 19 million stiffness and 27 1/2 percent of

vertical damping.

Q. Now, in terms of what's in 225B, are those the results and input parameters for one of the runs that are shown in 225?

A. Yes.

Q. And which one is that?

A. The first run in 225 is simply the 2K earthquake with 40 million as the contact stiffness, total stiffness for each cask on the pad, and 40 percent of critical damping that goes along with that 40 million.

Q. And this -- and the graphs that are attached and the table correspond to the outputs/inputs?

A. That's right. The input table, this is called Case 12, gives you the input, and the graph summarizes the result for Cask No. 1. Since the movie definitely -- well, for this case, there was no significant difference between the displacement of Cask No. 1 and any of the other casks on the pad, so only Cask No. 1 is reported because that was the one that was tracked.

MR. GAUKLER: Your Honor, I move for the admission of 225B.

JUDGE FARRAR: Any objection?

MS. NAKAHARA: May I ask one question?

JUDGE FARRAR: Yes.

MS. NAKAHARA: You just testified that Cask No. 1 -- there was no other cask that had more displacement than Cask No. 1.

THE WITNESS: In that simulation -- no, actually, I did not actually create a simulation for that, but from visually observing it while the movie -- while the program was running, I observed that the displacements of all other casks, at least from my visual observation, were not significantly different than the one that's reported.

MS. NAKAHARA: And that's based on your visual observation of the movement of the casks?

THE WITNESS: That is correct. In other words, I can -- I can play the movie, if you will, from within the program by just moving the cursor on the -- on the time slider. To create a rendered movie as I've done here requires another three or four hours of work, so I saw no need to do it for this particular case.

MS. NAKAHARA: With that clarification and appreciation by the State that Dr. Soler corrected his mistake, we have no objection.

JUDGE FARRAR: Staff?

MR. TURK: I need to ask a clarification.

It's not clear to me how this impacts PFS Exhibit No. 225. Does the information presented here replace information that's in 225?

THE WITNESS: The results of this run in 225B are reported on page 29 in Exhibit 225.

MR. TURK: And that would be the table that appears on the bottom --

THE WITNESS: The table, yes.

MR. TURK: -- on the bottom of page 29.

THE WITNESS: Yes.

MR. GAUKLER: And if I just may clarify for the record.

MR. TURK: Well, may I -- okay.

MR. GAUKLER: We're putting this in just so we have the analogous input and output in this case that we did for all the other cases in the record. So this input and output is not shown in 225, so we just created a separate document with that so we would have the same input and output shown for this as we do for the other cases.

MR. TURK: If I wanted to understand where to place 225B as I'm reading 225, should it essentially be an insertion at the end of the

discussion on page 30?

THE WITNESS: May I answer that?

MR. GAUKLER: Yes.

THE WITNESS: If you will recall, the results in Exhibit 225B, the proper place for them would have been in the report 86 -- which one is it? 86. And that was the objection raised by the State that we were doing a new run.

If this was a technical report to a client, the proper place for this information would have been in that report. Since we had made a change and then we were trying to show that the effect of that change in text didn't really have an effect on the results that we were giving, the proper place to put it was in that original report. And we did, but it was objected to, so we removed it from that report, made it a separate exhibit. But it is referred to in 225.

I'm not sure whether that clarifies or confuses the issue.

MR. TURK: And just so I'm a little more clear -- and I hope you forgive me if I'm the only one having a problem with this -- can you point to a sentence that addresses this in Exhibit 225?

THE WITNESS: Yes. If you'll go to page

29, above the table it says the first of these analyses varied the damping -- wait a minute -- yes, varied -- varied the damping value used in Case 12 of 3 from 40 percent to just below 5 percent, and the second analysis varied the total contact stiffness using Case 12 of 3 from approximately 40,000 kips per inch to 4,760 kips per inch. Case 12 of 3 is PFS Exhibit 225B.

MR. TURK: With that explanation, Your Honor, I have no objection to the admission of this exhibit.

JUDGE FARRAR: Then 225B will be admitted.

(APPLICANT'S EXHIBIT-225B WAS ADMITTED.)

MR. GAUKLER: And I would move for the admission of 225C.

JUDGE FARRAR: Any objection?

MS. NAKAHARA: Your Honor, the State objects that this would not represent the best evidence. As Dr. Soler himself testified -- Dr. Soler testified that it's difficult, I would pose that it's impossible, to distinguish between the X and Y representation on the time -- on the force time histories in which they're overlaying on top of each other. And we would not have an

objection if -- and we recognize -- the State recognizes that the copies were made off of our copy machine, and we would not have an objection to PFS substituting this exhibit --

JUDGE FARRAR: So your objection is not to the substance but to the fact that this document is a bad depiction?

MS. NAKAHARA: Yes.

JUDGE FARRAR: Then why don't we not admit it at this time, and you can bring in a -- subject to PFS's right to bring in a better or cleaner version at some future time.

MR. GAUKLER: We'll certainly try to work with the State to resolve its concern. I'm not quite clear exactly what that is, but we'll do that.

MR. TURK: May I ask, is there a color version of this page?

THE WITNESS: Well, if you look at the PBF file, yes, but I can, assuming that there might be a printer that I can connect to --

JUDGE FARRAR: We don't need to do it today.

THE WITNESS: Okay.

JUDGE FARRAR: You can do it given some

time?

THE WITNESS: Oh, yes, I mean I can do it with a color printer or I could simply redo the plot with just the one component on it.

JUDGE FARRAR: All right. Let's move on, then.

MS. NAKAHARA: And, Your Honor, one more request.

JUDGE FARRAR: Okay.

MS. NAKAHARA: And I hate to ask this, but subject to the State having additional cross-examination questions based on being able to distinguish the time histories for the different forces that were overlain, we'd like to reserve our right to ask Dr. Soler any follow-up questions.

JUDGE FARRAR: At some future date, you mean?

MS. NAKAHARA: Yes.

MR. GAUKLER: I would suggest that they can look at this on Dr. Soler's screen, and they'd be able to distinguish what they need to find out. I'm sure that we can make that available to them during the break.

MS. NAKAHARA: That sounds reasonable.

JUDGE FARRAR: Yeah. I hate to leave

too many things dangling for later, so if we can do that one that way, let's do it, Mr. Turk.

MR. TURK: I would also suggest if a color depiction is available to Dr. Soler, that somebody be instructed to run to Kinko's, make a copy. Let's finish this today rather than come back with one more open item in the future.

JUDGE FARRAR: We can try to do that and see what happens.

MR. TURK: There's a danger in prolonging too many things for future questioning.

JUDGE FARRAR: All right. Let's -- how much --

THE WITNESS: Well, I --

JUDGE FARRAR: No, no, no. It's over.

MR. TURK: Limited cross-examination?

JUDGE FARRAR: Why don't we see if we can -- how long?

MR. TURK: Probably 10 to 12 minutes, if that much, but I need to consult. I do have some questions about the presentation of soil springs, which I can do now, and I would need to consult to make sure I don't have anything further.

JUDGE FARRAR: Why don't we take a break now. We'll need a little more time, given the

facilities here, so let's take a 15-minute break and be back at 10 of.

(A recess was taken.)

JUDGE FARRAR: While we were off the record, we talked about taking definite time for lunch for the reporters' benefit so they'll know what to do on this Saturday session, so we'll break for lunch at 12:30. It's now 5 of 11:00, and I think we've reached the point for the Staff's cross-examination.

MR. TURK: Yes, sir.

CROSS-EXAMINATION

BY MR. TURK:

Q. Dr. Soler, I want to come back to something that you mentioned orally during examination this morning. You were discussing a statement that 2.3 million pounds of force were needed in order to cause pad sliding and that Dr. Trudeau had predicted 27 or 29 million pounds. And your conclusion was, therefore, there will be no sliding. There's some kind of a disconnect or something missing in that statement.

A. I think the -- and I don't -- you'll have to ask Mr. Trudeau, but the point I was making

is that my prediction of 23 million and his prediction of 27 million, I believe, for the case were the actual forces computed. The force to cause sliding at that location I believe is on the order of 4 -- 4 million.

MR. GAUKLER: Dr. Soler, I think you said 23 million and 27 million. Did you mean to say 2.3 million and --

THE WITNESS: 2.3 million and 2.7 million, respectively, for myself and Mr. Trudeau. But I believe in his calculation as to whether or not that causes sliding under the pad, the -- his calculation for the force necessary to cause sliding is about 4 million, therefore, he concludes that it will not slide, the pad will not slide on the underlying substrate. And the solution that I've presented today is simply to demonstrate that the peak magnitude of the force comes down.

Q. (By Mr. Turk) Just to be clear, your number is 2.3 million?

A. Yes, the worst magnitude.

Q. And the number predicted by Mr. Trudeau was 2.7 or 2.9 million?

A. Something like that, yes. So 2.9 -- 2.9 million -- I'm not sure of the exact number,

but it was higher than 2.3 million.

Q. Okay. So if there's a mention before of a 27 or a 29 million, that's an incorrect statement?

A. That was a -- yes, that was incorrect, but the order of magnitude is reasonably correct, I guess.

Q. As corrected, I believe I understand what -- your statement.

You used the word that you added meters, certain meters?

A. Yes.

Q. As you use the term "meters," are you stating that you added an output data point? What do you mean by the word "meter"?

A. VisualNastran uses the term "meter" for a measuring device. And for instance, if I wanted to measure the time history of displacement at the top of Cask No. 3, for instance, I would have first defined a coordinate at the appropriate location at the top of Cask 3. I would have then embedded that coordinate so it became part of Cask 3, and then I would define a meter for that coordinate which would take -- calculate and put on a graph the three components of displacement of that point.

And then I could put in any programming that I wanted to to compute the net displacement of that point.

So you could read meter in terms of the common -- a graph, if you will.

Q. Could you turn to PFS Exhibit 225C? This is that one page which has not yet been admitted, I understand.

A. Oh. B? Oh, C, okay.

I have it.

Q. Could you explain how this correlates with Figure 7 in PFS Exhibit 225? Is it, in fact -- I believe in your testimony you indicated there was some correlation between the two.

A. Yes. Let me -- the tension of Constraint 88 is VisualNastran's description of one of the springs.

Q. That's the first graph that appears below the picture of the casks?

A. Yes, that is correct.

MS. NAKAHARA: Of both exhibits?

THE WITNESS: I'm looking at both exhibits, and I'm looking now. And they do not appear to be identical. Those two curves -- those four curves, although the -- well, wait. I have to

watch myself because the scales are different.

Q. (By Mr. Turk) Right, but that's something that had appeared to me, and I was wondering if the difference in scales is the only reason for a difference of what appears there.

A. Let me -- certainly I'm looking at the peak that's somewhat less than 5 seconds on 88, Constraint 88, and it's about 1.1 million. And I have to look -- 4, 6 -- if you look at the bottom at Constraint 91, the -- just below 5 -- or just above 4 seconds, which is hard to see on the other one, there's an 800,000. The -- however, at 12 seconds -- let's make sure. 12 seconds and 12 -- there's 800,000 on this one, and there's 800,000 on the other one. And at 12 seconds here on the 91, the curve on the new figure seems to have missed the -- the curve on the old figure which seems to have a 1. -- hard to tell, maybe 1.1 million. I cannot explain that. But it appears to be, as far as I can see, near the only difference, and it may simply be on the point that it saved. But I can't address that issue with the data here as to why the curve today did not pick up the 1.1 million pounds from Figure 7.

And I ought to clarify something else.

The titles of the curves are sometimes not left to my discretion. And since this is a spring, it reports tension or compression, but all of the data goes from zero down to something. The minus sign is not appearing on the curves on Figure 7 simply because of lack of space.

I would say the curves are identical except for that one point, as near as I can see by just looking at it, and I cannot explain why I missed that one point.

Q. And just now you were comparing the -- the graphic demonstrations at the bottom left-hand corner of those two pages?

A. Yes.

MR. TURK: I have no further questions, Your Honor.

May we go off the record for a moment?

JUDGE FARRAR: Yes.

(A discussion was held off the record.)

JUDGE FARRAR: Back on the record.

Then we're ready for the State's cross-examination.

MS. NAKAHARA: Your Honor, in accordance with --

JUDGE FARRAR: 2.733.

MS. NAKAHARA: Yes, thank you. I would request that you permit Dr. Ostadan to pose the questions, the cross-examination to Dr. Soler on the basis that you've already set the precedent with Dr. Stamatakos, you've already acknowledged the earlier exchange between Dr. Ostadan and Dr. Soler on the record and it is extremely more expeditious than if I conducted it and that Dr. Ostadan would meet the criteria of 2.733. He's qualified by scientific or technical training --

JUDGE FARRAR: Right.

MS. NAKAHARA: -- by the testimony --

JUDGE FARRAR: Right.

MS. NAKAHARA: -- and he has prepared himself to conduct a meaningful and expeditious examination.

JUDGE FARRAR: All right.

Mr. Gaukler, any objection?

MR. GAUKLER: No.

JUDGE FARRAR: Staff?

MR. TURK: No, Your Honor.

JUDGE FARRAR: Okay. Do you want to start yourself, Ms. Nakahara, or just Dr. Ostadan right from the beginning?

MS. NAKAHARA: Dr. Ostadan would start

from the beginning, but I would just like to remind the parties that he will ask questions concerning the force time histories that you afforded us an opportunity to question.

JUDGE FARRAR: Okay. So we will start with the --

MS. NAKAHARA: Not necessarily. He's going to proceed in the manner that makes most sense but --

JUDGE FARRAR: Okay. So we will have a mixture of the deferred cross from before and the cross dealing with today's rebuttal?

MS. NAKAHARA: Yes, Your Honor.

JUDGE FARRAR: And trust that everyone in the room will sort it out for themselves if that need be done.

All right. Go ahead, Dr. Ostadan.

DR. OSTADAN: Thank you, Your Honor

CROSS-EXAMINATION

BY DR. OSTADAN:

Q. Thank you, Dr. Soler for the description and additional information.

I'm going to ask you a few questions related to the movies and then some other few

questions as it relates to these forces. But let me just point out that you indicated towards the ends of the presentation about the comment I raised yesterday that no other party has asked for the information, and, therefore, you did not feel obliged to provide it. For what I expressed a concern was acceleration of the pad and not the forces, and I was surprised nobody has asked for it. But I am still wondering if in the course of these new analyses or any one of your previous analyses that you have saved your meters to see what is the acceleration of the pad?

A. Well, as far as the first question is, that, quote, nobody asked, unquote, we were tasked with the -- to get the forces from the casks on the pad and transmit them to ICEC. We were not party to the calculations being done by ICEC, nor were we party to the calculations being done by Stone & Webster in Boston. We wrote the reports. We had conversations with Wen Tseng as to how we should transmit the forces to him, but we were not party to what use he was going to make of those forces. When we were asked for information, we provided information.

Of course, DYNAMO, we had the ability to

calculate the accelerations on the pad without rerunning the information because it was stored. With the VisualNastran runs, in everything we've done with VisualNastran, we have been focusing on what the casks do.

Now, as far as your question on can we plot accelerations of the pad or can we set up a meter to get accelerations of the pad? We can, and the raw data is available to do that. But we have not offered that because I would not offer in the same manner that Dr. Luk said that he was presenting raw data and it should be filtered. I make the same claim with respect to my analyses here because the soil spring between -- the soil cement spring between the two pads is a very stiff spring by the nature of the 5-foot span and the large area and the estimates on the modulus, and, therefore, the direct calculation of acceleration shows these high frequency effects. So since I did not have the ability to filter that data, I did not offer it in this exhibit.

Q. Do you have a feel for what that number would be unfiltered?

A. Unfiltered, I suspect it's the same order as Dr. Luk has presented.

Q. Thank you, Dr. Soler.

May I ask you, do you have that slide still on the one you showed? It might help the discussion --

A. This is -- this is the summary of the one page?

Q. That one page, yes.

A. Let me go get it here.

I guess I could turn this off.

MS. NAKAHARA: That's been marked as PFS Exhibit 225C.

THE WITNESS: I think it will shortly appear behind -- behind you as soon as the light comes on.

Q. (By Mr. Ostadan) Okay. Thank you.

This is the case that you modeled the soil cement between two pads as compression only?

A. Compression only.

Q. Is it fair to say this for tension --

A. Yes. I -- the tension is -- the program considers it a spring, and, therefore, tension and spring, so negative numbers mean compression. And I believe I just -- well, they show on this slide as negative numbers. Figure 7 doesn't show as negative.

Q. Let me see if I understand the physics of this. You have two pads, and these pads are supported by springs. And you have two lateral springs, if you will, or horizontal springs that can act only in compression. And based on that analysis, you are saying the forces in the soil cement are in these two figures on the left?

A. Correct.

Q. Now, if these two pads were to move together in phase --

A. Yes.

Q. -- if you can imagine that, there would not be any force on the soil spring in between the two pads?

A. If it was a pure in-phase motion, I agree.

Q. Okay. Now, the reason that you getting forces in these two springs are here primarily because the mass of the estimate on one pad is quite different from the other.

A. Well, the reason I'm -- the reason I'm predicting forces is because the spring constant is very high and the relative deflections between the two pads is very small, and the product of the two is giving me the force. But the -- if you -- here

you have to go to the movie which, of course, I didn't create. But the pads are generally moving in phase.

If you'll let me digress, I would like to discuss a little bit of my written prefiled testimony along these lines.

Q. Please do.

A. Prior to running the first two of the three visualizations that were presented this morning in movie form, I ran a very simple analytical calculation of two masses, one mass being the total of 8 casks plus a pad, which is about 4 -- I think about 3.8 million pounds total, and the other mass being equivalent to 1 mass plus the pad -- 1 pad -- 1 cask plus the pad, and that is roughly a little bit over 1 million. So it is the case I've run in here, but I simplified it to a 2-degree of freedom linear system in which the two masses are connected to the ground by identical soil springs, but the two masses are connected to each other by the soil cement spring.

Now, if you assume that that simplified problem is completely linear, you can calculate the eigenvalues -- e-i-g-e-n-v-a-l-u-e-s, all one word -- and you find that the natural frequencies

of oscillation for that system, depending upon how many -- I did it for the case of no casks on the second pad, 1 cask on the second pad, and 8 casks on the second pad. And this is reported as part of the PFS Exhibit 225.

And you find that the first natural frequency is about 5 to 6 hertz, and the second natural frequency of this 2-degree of freedom system is on the order of anywhere from 29 to 47 hertz, depending on how you populate the empty, quote, unquote, pad, my conclusion being there that in this case since the earthquake provides its -- the majority of its power in say the low frequency range of 0 to 10 hertz, that this earthquake would primarily excite the in-phase motion. But, of course, in a 2-degree of freedom linear system, you never get exactly the pure in-phase and the pure out-of-phase motion. You get a combination of the two. And the relative importance of those two pure modes to the combined solution depends on the nearness of the natural frequencies to the input power.

So having done that solution, I was confident at the outset that my VisualNastran solutions, the two involving the two pads would

simply serve as confirmation. The fact that I've generated forces in the soil springs simply reflects that nothing is exactly purely in phase and purely out of phase, and the particular choice of 8 casks versus 1 cask was a reasonable attempt to model what would likely be present over a long period of time.

Q. Thank you.

But nevertheless, then, because of the slight differences in the motion, as you said, from one pad to the other and the high stiffness of the soil cement you get the forces that you get there?

A. That is correct.

Q. And do you feel that you used reasonable properties for the soil cement based on the compressive strength of the design?

A. Well, certainly the area is fixed, the distance between the pads is fixed, and I requested and received from Stone & Webster an estimate of the Young's modulus that should be appropriate. The number I received was 350,000 to a million, and since my initial thinking was to emphasize the soil cement, I picked the larger of the numbers to run here rather than the smaller.

Q. Well, we are certainly glad you obtained

this additional information. It's been always the State's position that pad-to-pad interaction is important. And this 900 kips or so, if you look at the total load for stability in the pad in order of 3,000 or so, is a significant number. It's about one-third or so.

And so, now, the next question is for -- please recognize that Dr. Bartlett and I come from the foundation side of the issues -- is that for stability analysis now, we have some forces that are going from the pad to the soil under the pad represented by these two figures on the right, and then we have some additional forces that for one reason or the other, one pad is pushing the other pad. Should we, in your opinion, then add up these forces for stability analysis? How -- what do you recommend --

A. Well --

Q. -- to be used for a stability analysis?

A. Well, I believe the question to be addressed is the stability of the pads -- of the pad with respect to meeting the regulatory requirement of 1.1, so in that respect, what would be most important, in my opinion, would be to know the force in the substrate underneath the pad so

you could compare that force as predicted by whatever analysis program you're using against what is purported to be the limit that you could take before the pad would slide. So in that respect, I would not be doing any addition if I could do it any other way.

And here I attempted last night to do it directly, to simply say, I'm not going to take results from ICEC, which came from inputs that we provided early in the analysis, and I'm not going to, then, try to estimate what the forces from the pad are because I, unfortunately, don't have a pad acceleration, so I have to use my best guess that it's going to be the PGAs, but, instead, simply directly try to measure the time history of those forces underneath the pad. And within the constraints of how the soil is modeled, namely, the 6 springs, you can get, then, the time history of those forces directly.

If you wanted to know whether a particular force added or subtracted at any given time, you, then, probably have to process the data in a more elaborate way outside very this program, although I suspect with a little ingenuity one could create a meter that actually looked at the

difference between the total force and the force in the other meter. But this seemed to be the most direct way to do something in an 8- or 9-hour span.

Q. And let me see if I can ask the question again. The results showed that one pad is pushing the other pad.

A. That is correct, in some instances.

Q. In some instances. This is an additional active force, if you will, that a neighboring pad is exerting on the pad we are looking at.

A. That is correct.

Q. This force needs to be considered in the sliding analysis of the pad, the interaction between the two pads.

A. That is correct.

Q. So would you agree that, therefore, this additional interaction force between the two pads should be added to the force below the pad for stability analysis?

A. No, because the -- if you recall Mr. Trudeau's testimony, the number that he was working with or has been working with is the maximum value of a force underneath the pad that he has estimated by taking some results from ICEC and

then adding some results of his own having to do with the force exerted by the pad.

Now, he has one number which is a maximum value at, presumably, some instant of time, which I do not believe he uses in his analysis, and it was suggested that having this other number of 1.9 million, you should directly add that force to his force. That was precisely the reason for which I did this reanalysis, to determine that while it is true that you may have to add the two forces, you can't be adding forces that may occur at different times and simply add them up.

So, if you will, I submit that the numbers shown in the two right-hand graphs, one above another, include the additive or subtractive effects of those forces because it depends, when I have a compressive force between the two pads, as I obviously do at some instance in time, it is not clear, unless you have this analysis, to determine whether what -- the force in the soil spring is at that instant and whether it is, in fact, tension or compression to decide whether you have to add it or to subtract it. I submit that this analysis bypasses that and simply says this is the total force that you measure in this spring to put the

particular pad in equilibrium with all of the other forces, including the pad-to-pad force and the inertia forces of the pad itself and the casks themselves and anything acting at the contact surface.

So in the simplest case, if one could determine that Mr. Trudeau's force was at 5 seconds, say, for argument's sake, and that you could also determine that a particular pad-to-pad interaction force was at 5 seconds, then it would be correct to either add it or subtract it if you knew the sine at that time because it is clear that Mr. Trudeau's calculation did not include the effect of this pad-to-pad force, but I submit it is too simplistic to simply take its magnitude and add it to his number.

Q. I agree with that, Dr. Soler, but let me understand this. PFS's position has been that pad-to-pad interaction is not important, and I'll let the record speak for itself that one of the inferences on PFS side is that it's a secondary effect and it would not impact the loads.

Now, we have 900 kips here that you have calculated, and apart from what Mr. Trudeau has done, if we have to do a stability analysis from

scratch today, is it your recommendation that we should add the loads on the graph on the left with the one on the right and use that for a stability analysis or just use the ones at the right?

A. Just use the ones on the right.

Q. Okay. Let me move on, then. I think all of us yesterday had the opportunity to look at the figure where it shows the layout of the pads.

A. I'm not sure that I may have been present at that time so --

Q. It's one of the exhibits, I believe, from yesterday.

MR. GAUKLER: Dr. Soler, do you want to turn off the slide now?

MR. TURK: Can I ask for a clarification?

JUDGE FARRAR: Yes.

MR. TURK: At different times there's mention of the graphs on the left and graphs on the right. Just for the clarity of the record, I assume we're talking about 225C?

THE WITNESS: Yes.

JUDGE FARRAR: Thank you.

MS. NAKAHARA: Dr. Soler is looking at PFS Exhibit 84.

Q. (By Dr. Ostadan) Again, let me remind you that Dr. Bartlett and I are primarily dealing with the foundation and the stability of the foundation.

The logic that has been set forth so far has been that the loads from casks would be transmitted to the pad and then from the pad to the soil treated with cement underneath and then to the Bonneville clay underneath and so on. That has been the primary focus of the way the load gets down to the foundation into the soil medium when we are obviously looking at whether the soil has the capacity to carry such loads or not.

And what your new results show, that a significant part of the load is taken out by this ladder of the spring, the soil struts or soil cement struts, so, therefore, looking at the figure that you have in your hand and recognizing that in each column we have 10 pads separated each by 5 feet, if you carry on your analysis, the one you did last night, now, with 10 pads and you ask yourself -- and there are now zillions of combinations on how many casks on each pad -- where do we end up on these loads between the pads? This 1900, would it increase? Significantly decrease?

If you look at these, are they all pushing each other? How could we carry this logic to our foundation design?

A. Well, this is an extrapolation of the largest magnitude. If I had modeled, assuming that I could within the capacity of the program in a computer, 10 pads in a row with any number of casks on each pad but the same soil springs underneath each pad and the same soil cement spring between each pad, I -- obviously the same total load exists and will get back to the soil. It's just which pad will -- let me back off a little bit.

If I had examined each pad separately, I would predict, of course, that all the load goes directly into the soil directly below that pad because I've assumed that nothing surrounds it. As I add pads and if I extrapolate my results here that would say that cask-to-cask interaction because of slight movements of each pad relative to one another, are going to generate a load in each soil cement spring and therefore transfer some of the load that would go into the soil directly possibly over one pad, if that were the case, on the basis of the result that I have and on the basis of all of the other results that I've done

for whichever model you care to pick, I would be willing to hazard a guess, based on engineering judgment, that while the individual results would change from -- from what I've gotten, I do not believe that certainly I would start predicting that a cask would overturn on any one of the pads.

As far as the total load in the soil underneath a respective pad, all I can do is go back to these results and say, of the two pads, certainly while there is a load transfer between pad to pad, and certainly the results of what load goes into the soil directly under a given pad would change somewhat, I do not believe that you would ever come up with a case where they would directly add to the point mathematically where you would exceed the limit for sliding.

Now, that's just an opinion, and it is -- requires a great extrapolation. I would obviously feel more comfortable and more emphatic in my statement if one could model 6 pads. My modeling of only 2 was directed primarily, I think, by Dr. Bartlett's testimony that he thought that 2 pads would be enough to see whether there was some kind of an effect. So that's what I concentrated on.

Q. I appreciate that. I think that was very useful. It just turned out that what you did showed a significant change, at least in my thinking, as how the load goes down to the soil. And I really think that the total load is what the total load is, but let me submit to you that how it goes to the soil is very important from our end of issues. And whether it all goes down right under the pad or part of it is maybe, I guess, transmitted laterally, whether or not you have this progressive compounding compressive effect from one pad to the other, depending how they are loaded, I guess it's fair to say is not known at this time?

MR. TURK: Your Honor, may I interject? Dr. Ostadan is serving as counsel today, not as a witness, so we will not cross-examine him on any of the statements he's making. By the same token, we submit that Dr. Ostadan's statements are not going to be offered as evidence by the State unless he's sitting in the witness chair and is able to be cross-examined.

MS. NAKAHARA: Your Honor, Mr. Turk himself has testified multiple times in this proceeding and has gotten statements on the record about the position of the Staff and has not used

Staff experts to enter the information on the record.

JUDGE FARRAR: Well, let me -- it's one thing -- it's one thing when counsel makes a statement of what he or she thinks is correct because that we know to disregard, in a manner of speaking. I was hoping that Dr. Ostadan's last statement was going to end with isn't that correct, Dr. Soler, but it didn't end with that, so what I heard was more a statement in the nature of testimony. So what I would -

MS. NAKAHARA: Your Honor, if I may make a suggestion that you use Dr. Ostadan's statements in his cross-examination as background to setting up the next question --

JUDGE FARRAR: In other words, Dr. Ostadan --

MS. NAKAHARA: -- not as testimony that will --

JUDGE FARRAR: What he just said we will take as a statement of the State's -- not as testimony but as a statement of the State's position. And now if you'd like to follow up and ask Dr. Soler whether he agrees with that position, we may extricate ourselves from this.

Mr. Gaukler, would that satisfy you?

MR. GAUKLER: Yes, it would, with Dr. Ostadan saying now it's not testimony based on the State's position.

JUDGE FARRAR: Mr. Turk would that satisfy you?

MR. TURK: Yes, Your Honor.

DR. OSTADAN: Your Honor, that is what I said corrected.

JUDGE FARRAR: At the risk of confusing the issue, could you repeat what you said?

MR. GAUKLER: Could we read back --

JUDGE FARRAR: Well, do we need -- do you remember the gist of it?

THE WITNESS: I'm not sure I remember the conclusion which was inferred from the gist of it.

JUDGE FARRAR: All right. Then let's read it back.

MR. TURK: Or ask Dr. Ostadon to ask the question.

JUDGE FARRAR: Yeah. It -- the reason I'm hesitant to read it back is it was a very long statement.

Dr. Ostadan, is there a way you could

ask a -- based on that statement, ask not a very simple question, do you agree, but a slightly more complex question that could be based on that statement?

DR. OSTADAN: Yes, Your Honor, I'll try.

Q. Your result of casks indicated a load transfer from one pad to the other. In this case it turned out to be in the order of 900 kips. The question is if we look at 10 pads and considering various loading combination on these pads from 1 to a few, would there be compounding of these compressive forces from one pad to the other, looking at, let's say, a row of 10 pads?

A. First let me clarify your question. You said 900. Didn't you mean 1900?

Q. I'm sorry. 1900.

A. And you also said in looking at the case of two casks. I assume you meant two pads.

Q. Thank you very much. That's what I meant.

A. Okay. Having clarified that, you could certainly infer that because, from the solution here that presumably predicts when compared to Mr. Trudeau's solution that there is a decrease in force to the pads -- to the soil underneath one

pad, that if you model 10 casks, somewhere along the line there presumably might be an increase in force under one of the pads. Otherwise, at some instant of time, you wouldn't be in equilibrium.

Assuming that's a reasonable assertion, on the bases of what's done, I would proffer the fact that the decrease that I predicted would most likely be on the same order of magnitude as the increase that you might see somewhere else, so I would certainly not rule out the possibility that Mr. Trudeau's number of 2 million 900 kips, as a total soil load, could go down to 2 million 300 and could possibly go up to 3 million 500, that order. However, I don't believe -- and, again, this is just engineering judgment -- that it would exceed the technical requirement of the load needed to give you a 1.1 safety factor, but I can't prove it.

Q. You haven't quantified that?

A. I haven't quantified it. The only numbers I have are two pads.

Q. I don't mean to be impolite, but does this means as we put more inertia on more pads, it's getting better and better?

A. I'm not sure I understand your question.

Q. You're saying the loads are --

transported under the pads are reducing. I'm saying as we increase the pads and add the casks to them, looking at the big project as a whole, does it really basically mean that it's going to improve in terms of reducing seismic loads?

A. No. I think things will just be shifting around. You have to -- you have to draw a boundary around your problem somewhere. I've drawn it as two pads. If you drew it at 10 pads and were able to fit that into the model in the detail that I've done here, then Mr. Trudeau would say, on the basis of the results that he's able to calculate, that his total load into the soil would be 10 times 2 million 900 kips, assuming that everything was lockstep in phase. I have shown here that, in fact, the peak load in this case goes down to 2.3 million. That is not to infer that if I put 10 casks -- 10 pads in a line that I would be reducing the total load in the soil. The total load in the soil remains -- and I -- I'd be comfortable using his as an average -- remains 10 times his number, but it's highly likely that it will -- any individual pad will oscillate one way or another about the number 1/10 of the total. That's the best I can say.

MS. NAKAHARA: Just to clarify for the record, I think Dr. Ostadan and Dr. Soler understood each other. I'm not sure everybody else did.

The question implied that as each cask is subsequently loaded and -- you have more casks loaded, it's more pads loaded. Is that how you understood the question?

THE WITNESS: Well, I think I understood the question as whether you model 2 pads or 10 pads, so maybe I didn't understand the question if that was the real intent.

Q. (By Mr. Ostadan) I am satisfied with your response.

A. Okay.

Q. Let me move on --

MR. GAUKLER: Well, I'd like to have the record clear, and I think that what Dr. Soler just said was he assumed that the question was the modeling of 2 pads versus 10 pads.

Is that how you assumed the question --

THE WITNESS: That was what I assumed the question, that if I had modeled 10 pads, would I not -- and here's my words, not Dr. Ostadan's -- would I not expect some soil loads to go up rather

than down? And I think my answer simply was yes.

MS. NAKAHARA: That question is fine. It answers his question.

Q. (By Dr. Ostadan) Thank you. Do you recall yesterday we were talking about the angle of incidence in Dr. Young's testimony?

A. I don't believe I was present at that time.

Q. Part of that testimony, the discussion went on that if you consider two or three groups of pads with larger plan dimensions, then as small as these angles are, they would translate to a bigger time shift, if you will, in arrival time and phase delay in response. Now, in looking at your results today and the mechanism that you have observed that there will be certainly a load transfer taking place, a significant load transfer, would you now render an opinion as to if one group of these pads and the other group tend to move out of phase on the account of incoming waves which you have not included in your calculation last night, it would aggravate the transfer of loads, then?

MR. GAUKLER: Objection. It's going beyond the scope of his rebuttal, going into the nonvertically propagating waves which was

Dr. Youngs' testimony that we discussed yesterday.

MS. NAKAHARA: It relates to Dr. Soler's calculations of soil cement and how this all ties together, which has been the State's premise from the beginning, that we cannot bifurcate these issues, that the analysis has to be conducted comprehensively.

JUDGE FARRAR: Does the Staff have any thoughts?

MR. TURK: I would reiterate what my position was yesterday with respect to the scope of cross. It's limited by the testimony offered.

JUDGE FARRAR: We have the complicating situation here that we're not only crossing on the rebuttal but crossing the previously reserved opportunity. Which does this tie in to? Or --

MS. NAKAHARA: I submit it ties in to both.

MR. TRAVIESO-DIAZ: If I may say something --

JUDGE FARRAR: Yes.

MR. TRAVIESO-DIAZ: -- since I was here yesterday during the discussion, they attempted for a number of times to get Dr. Youngs to testify to the effect of changes of the angle of arrival of

the nonvertical waves into movements of rows of pads. Now they're trying to do the opposite, trying to take testimony that was given in Dr. Youngs' and was Dr. Youngs' views, the areas to which Dr. Youngs had knowledge and apply to this witness who has not testified on that theory. The State may want to tie all these thoughts together, but that is either for testimonial witnesses or, better yet, for finders of fact. He's now trying to get to that through witnesses, each of which has a different area of expertise. And to ask Dr. Soler who has not testified as to nonvertical propagating waves as to testimony which is in the scope of Dr. Youngs I think is both ineffective and not really fair, in addition to which it's way beyond the scope of the testimony that he has proffered here.

(The Board confers off the panel.)

JUDGE FARRAR: Having consulted with my colleagues, we're all of the view that in situations like this it would be better that, rather than us acting on the lawyers' objections, we ask Dr. Soler if this is something that he's familiar -- familiar with in the context in this case and its proceeding, I don't mean generally

familiar with in your education and background somewhere, but is this question fairly -- in your judgment, Dr. Soler, fairly a part of your testimony and your presentation?

THE WITNESS: I believe I could address what I believe the final sentence of his question is heading toward, and that is isn't it possible that one pad could be moving much more out of phase than another pad at the other end of the row. Is that -- no?

JUDGE FARRAR: But whether or not you can answer that, is that something that you feel deals with the presentation you've made here?

THE WITNESS: Well, certainly I have addressed the issue of in and out-of-phase motion, so I would feel comfortable in fielding a question to the extent that I could dealing with anything that could possibly lead to such out-of-phase motion, although I wouldn't feel comfortable addressing, I guess, the causes of what leads to the waves coming up at different times.

(The Board confers off the record.)

JUDGE FARRAR: All right. Then go ahead and answer it as you understand it.

THE WITNESS: Now, apparently I didn't

anticipate correctly what you're driving at, so --

Q. (By Dr. Ostadan) Let me ask -- maybe that would help, if I ask a simpler question. Did you analyze two groups of pads next to each other, say a group of 10 each with soil cement in between, considering incoming waves?

A. No.

Q. Thank you.

With respect to pad-to-pad interaction again --

JUDGE FARRAR: And, again, Dr. Ostadan, in order to make this go efficiently, let me ask you to try to ask more questions in the nature of that one that you just asked rather than the ones that have a very long preface.

DR. OSTADAN: Yes, Your Honor. I'll try.

JUDGE FARRAR: And then if the witness doesn't understand the question, then we can give more background. I think the way to solve the problem we just had is to ask more of the straightforward questions.

DR. OSTADAN: Yes, Your Honor. I'll observe.

Q. The forces that you got between the two

pads indicates significant load transfer from one pad to the other pad. Dr. Tseng in the past has testified that pad-to-pad interaction is a secondary effect. Have you discussed his result with him and seen his opinion?

A. No, I have not.

(A discussion was held off the record.

MR. TURK: Your Honor, may I request in line with your suggestion a moment ago, there seems to be a characterization before the question, if we could avoid that and just ask the question rather than load it with a conclusion first?

DR. OSTADAN: Very well. I'll do that.

Q. And I have very few more very basic questions. This will hopefully help the testimony coming up. It has to do with forces again.

Going back to your original model that you analyzed the cask and pad for 2,000-year motion, let's concentrate for a moment on the interface between the cask and the pad. And I realize you did various scenarios of 8 casks, 4 casks, 2 casks. Let's just think of 1 cask for a moment. And could you explain what is the boundary conditions between the bottom of the cask and the pad, specifically how many springs, how many dash

pots and in which directions you put those in?

A. Okay.

MR. GAUKLER: That's beyond the scope of the rebuttal.

MS. NAKAHARA: This relates to understanding the force time histories.

MR. GAUKLER: Okay.

THE WITNESS: Just a question to you in clarification. Are you interested in the results from DYNAMO or the VisualNastran?

Q. (By Dr. Ostadan) The analysis that you provided of the forces to ICEC.

A. Okay. That --

MR. GAUKLER: Okay. Just, I guess, for clarification, now we're going into cross-examination of the time histories, correct?

MS. NAKAHARA: Yes.

THE WITNESS: In the DYNAMO solutions or model, the interface between the casks and the pads are represented by 36 contact points around the periphery. I would not classify those locations as boundary conditions. Rather, they are simply relationships between a point on a cask and a point on the pad at a particular location around the periphery consistent with the assumptions of small

motions. At each one of those 36 points there is a normal spring, normal being vertically oriented, and two horizontal springs in the X and Y direction, those being the two horizontal directions. The value of the normal spring is 1/36 of the 454 million pounds per inch.

Q. (By Dr. Obradan) If I may save some time, you do not need to give estimate --

A. Okay.

Q. -- just the nature --

A. The algorithm in the computer program says that at every instant in time determine the -- whether or not the normal spring compresses. If it compresses, then calculate the forces in the horizontal springs from mu times that instantaneous normal force and determine whether those forces are greater than or less than the force necessary to slide. If, of course, there is liftoff at that location, the normal force has no force in it, the force is zero of that spring, and, therefore, there is no ability to resist horizontal loads, and, therefore, sliding is indicated at that location.

There is no other assumption except what is built into the coding to check whether or not, first, the two points that you're tracking are, in

fact, in contact, and, if they are in contact, then comparing the allowable horizontal force based on the coefficient of friction with the calculated horizontal force directly in the two springs. And then you get an either-or condition, either the horizontal springs act elastically in accordance with the very stiff value we put in or we get sliding.

Q. Is there a dash pot at this contact point also for damping or just --

A. Only in the normal spring to represent impact damping.

Q. So there is a dash pot only in vertical direction?

A. Only in the vertical direction.

Q. In other words, only in the compression of it?

A. Only invoked when you have compression.

Q. So the forces that you provided ICEC, I assume, re the time history of the forces in these springs, vertical and horizontal, as you calculated --

A. I believe after -- and this is strictly by memory, but I believe after some discussion back and forth between the two companies we provided

them with the net force per quadrant, 4 quadrants. Rather than giving them 36 individual time histories for each direction, we agreed -- or they requested that based on what they planned to do, it would be simpler to just provide them with the sum of 9 sets for each quadrant.

MR. GAUKLER: Now, quadrant here, you're talking about one -- you're talking about one cask, just to clarify the record?

THE WITNESS: Actually, we provided those results --

MR. GAUKLER: I'm just talking when you're talking about quadrant here, you're talking about --

THE WITNESS: A quadrant for each cask.

MR. GAUKLER: Okay.

Q. (By Dr. Ostadan) And how did you calculate the forces that you gave to ICEC for each quadrant, briefly? Did you add up the forces in the spring in each quadrant time --

A. Time-wise, yes.

Q. So, for example --

A. We have -- DYNAMO saves the complete time history of every spring force that we model, and, therefore, we simply extracted the vertical,

say, in groups of 9 and then, I believe, used a separate program to simply add them up at each interval.

Q. So, for example, for quadrant 1, for the sake of discussion, you have 9 vertical springs, your program has given 9 time histories of vertical forces. You simply went there and added them up --

A. Time-wise, correct.

Q. -- as a function of that?

A. Correct.

Q. What did you do with the force in the vertical dash pot?

A. Well, the force in the vertical dash pot and the force in the vertical spring are reported as a sum, so the forces we provided to them, I guess you could say, were the sum of the components that go through the spring and the components that go through the dash pot.

Q. So you also included the force in the dash pot?

A. Yes. It was the total vertical force between the cask and the ground.

Q. Cask and the pad, you mean?

A. Cask and the pad.

Q. Do you recall how much is it due to dash

pot, how much is it due to spring --

A. I have no capability to separate the two.

Q. Okay. Let me move on on the same -- same -- similar topic for in the pad now and the soil under. You have a set of conditional springs that you use in your model?

A. Correct.

Q. Okay. And I suppose there are three translation and three rocking and torsional springs. Is that fair to say?

A. Here I would have to refresh my memory, but I believe, although I may be confusing projects, since -- since the pad was -- I guess, to be honest, I'd have to look at the appendix to that report to really be sure of my answer.

MR. GAUKLER: What report are you referring to?

THE WITNESS: This would be the one that has the infamous Rev. 2 in its title.

MR. GAUKLER: That's State Exhibit 173, I believe.

JUDGE FARRAR: Does anyone have that?

MR. TURK: We should.

MR. GAUKLER: We have it right here.

THE WITNESS: I think I know the answer to the question.

MS. NAKAHARA: We have it.

THE WITNESS: Yes, the -- the description of the soil was with 6 soil springs, 3 forces and 3 moments, under the pad at its center.

Q. (By Dr. Ostadan) And six dash pots also?

A. And six dash pots, correct.

Q. So the forces that you calculated, the foundation forces, for example, the forces you showed earlier in exhibit to be admitted 225C, are these the forces in the springs or the dash pots or both?

A. Both. They -- the notation "soil springs" is -- since its considered as a spring, it has -- a general spring, it has both spring and damper capabilities. Of course, one can turn off one or the other by simply zeroing either the spring constant or the damping coefficient and make it either a pure damper or a pure spring. But what it reports, it being the meter, is -- is the total of whatever you have defined. If you've defined a non-zero spring constant and a non-zero dash pot, the result you'll report is the total force, and I

believe in the theoretical section of 255 on page --

MR. GAUKLER: You mean 225.

THE WITNESS: .225. In particular, on page 11 of that report, there was a formula which relates force to deformation and velocity. F is what is reported, both in what we sent to ICEC using DYNAMO and what we've reported when we reported it in all of the simulations using VisualNastran.

Q. (By Mr. Ostadan) Do you have a feel how much of this force is due to spring and how much of it is due to dash pot?

A. I have no feel at all, and without manually creating another meter which simply, say, tracks C delta dot or KX -- KX just together -- I could not begin to offer an opinion.

Q. I assume in the set of results you have provided it would not be possible to get that information either?

A. Not -- not -- not without setting up meters and redoing the runs.

DR. OSTADAN: Thank you, Dr. Soler.

MS. NAKAHARA: Your Honor, that concludes our cross-examination.

Thank you. Dr. Soler.

JUDGE KLINE: I would like -- give me some sound here.

I have to ask the boss for sound.

I've been sitting here wondering how your 2-pad interactive analysis applies to the full array of pads also. And my understanding from your Question and Answer 4 is that when we have in-phase forces that we really don't have much to worry about, that is to say, that the pads move in phase and then interact to a very small degree. Is that -- that's -- that's my understanding of your testimony. Is that correct?

THE WITNESS: Well, yes. If I had a pure -- think of it this way: If you assume that my simple model exactly represented 2 pads, which it doesn't, and I solved that problem exactly and then I imposed a sinusoidal input to represent the earthquake, now if I adjusted that earthquake so it exactly had a frequency of 5 hertz or whatever the appropriate number was, then I would purely excite the pure in-phase motion of those 2 masses. On the other hand, if I said that the earthquake really had -- was equivalent to a sine wave with -- let's take one of the cases -- 29 hertz as the peak power

point of the earthquake, then in this simple model I would excite the purely out-of-phase motion.

Now, the fact that the real earthquake has distributed frequencies from -- important ones from, say, half a hertz on up to 33 hertz and perhaps beyond, you will obviously in the real problem -- and if you'll forgive my modesty, the real problem being the VisualNastran solution, you will excite both, and it's only the degree of excitation of each case.

Now, the compounding problem here is that you have a very stiff spring between the 2 pads, and therefore the slightest bit of relative motion between the 2 can excite a large force. But the important thing is whether -- whether -- at least from our point of view, is whether or not this large force could do any damage to the casks in terms of increasing the displacements, increasing the propensity of them to move. This last solution, of course, is attempting to aid in the understanding of what happens in the -- in the soil.

Now, have I answered your question or not?

JUDGE KLINE: Well, we're going to go on

from there.

THE WITNESS: Okay. Then let me stop there and see what you've got.

JUDGE KLINE: So let's stop there. And, now, do consider the out-of-phase portion of your answer and back away now and take an artist's view of the whole array of casks. Would it be fair to say that for the out-of-phase motions that the summation of forces across the full array would sum to zero, well, for the pad-to-pad interactions? That is, even though this is -- for individual pads there may be forces on one to the other, across the full array of pads, they would sum to zero, would they not --

THE WITNESS: Let me think about that.

JUDGE KLINE: -- for the out-of-phase -- for the out-of-phase motions?

(A discussion was held off the record.)

THE WITNESS: Ready?

JUDGE KLINE: Yeah, I'm ready. I've been ready.

THE WITNESS: I'm not sure I would necessarily agree or disagree. It's impossible to construct a simple free body --

JUDGE KLINE: Yeah.

THE WITNESS: -- which would enable you to get to that conclusion.

JUDGE KLINE: Well, let me put it this way: Look at your Figure 225C, and let us add a third -- a third pad down to the lower left of the pad that has a single cask on it.

THE WITNESS: Okay.

JUDGE KLINE: And ask, now, for the two pads that you show a compressive force acting between the two pads, is it fair to say that the forces between our imaginary third pad and the second one would be tension, would be in tension?

THE WITNESS: Well, except for the fact that in this case I have precluded any tension.

JUDGE KLINE: Well, I understand your model. What I'm asking is the physics of it.

THE WITNESS: Well, I think the physics says, I've been led to believe, that it's highly likely that may get some cracking if you develop tensile forces, and without me addressing yes or no, I simply did the two cases.

JUDGE KLINE: Okay.

THE WITNESS: Now, I could certainly in my mind imagine a situation with 3 casks -- 3 pads and some motion which at some instant in time the 2

outer pads were moving toward one another --

JUDGE KLINE: Ah, that -- okay.

THE WITNESS: -- and the pad in the middle wasn't moving at all. And in that case you would have compressive loads in both cases, and I believe in that case you'd probably find they add up to zero.

JUDGE KLINE: Yeah, that was my next question. Really it has to do with whether -- assuming that there's an array of some kind of tensile forces and compressional forces across the full array of pads, setting aside for a moment whether they sum exactly to zero -- I don't know if they do either, but is there any physical means by which these forces might in some sense focus such that several pads acting together just coincidentally focus their energy on one pad in such a way that is non -- that's noncancelling, in other words, in such a way that it's additive?

THE WITNESS: I don't believe -- and this is a real leap --

JUDGE KLINE: Yeah.

THE WITNESS: -- that I could conceive of some pad in the middle or whatever it is --

JUDGE KLINE: Yeah.

THE WITNESS: -- having things line up to the extent where at a particular instant in time the forces from each adjacent cask --

MR. GAUKLER: Each adjacent pad.

THE WITNESS: You can see where my mind is after such a long period.

-- each adjacent -- you're lucky I'm not talking about racks in the pool -- in each adjacent pad could add up so as to drastically affect the force in the soil underneath the pad.

Now, at the risk of saying too much, I will say I have certainly had experience with racks in spent fuel pools. Now, granted there's water that's kind of distributing everything amongst everything else, but in that case, you do -- if you step back far enough, you generally see everything going back and forth and you do not see any anomaly where one particular rack suddenly seems to get much, much larger forces than all the rest as far as the reactions on the floor.

JUDGE KLINE: All right. Now, just one more -- one more brief series, then, and that is there are some -- in the full array of pads, there are some -- what you might call asymmetries, or what you've called half-space in other contexts,

which occur at the outside border of the array of casks. That is to say, at the outside border, there are pad-to-pad interactions arising from the interior of the array, but none arising from the exterior.

THE WITNESS: That's correct.

JUDGE KLINE: Is there any kind of focusing of forces that might occur by virtue of the pads being on the outside border of the array?

THE WITNESS: Well, I mean for the particular analyses I've done, both casks are on the outside border --

JUDGE KLINE: Well, I --

THE WITNESS: -- but that's just --

JUDGE KLINE: No. I'm thinking of the full array where there could be some coincidental convergence of forces that might momentarily focus on one or especially situated cask that's, for example, in the outer boundary.

THE WITNESS: I can't answer that truthfully yes or no, but if you'll permit me, I would like to extend my remarks as far as they refer to cask stability and sliding of pads.

I know that the -- the whole thrust of the State's questions to me today are directed

toward admitting, if I could or would, the possibility of the forces under a particular pad getting so large as to cause the technical requirement of the 1.1 safety factor of sliding to be exceeded momentarily. I would like to go on record as saying, as far as the casks are concerned, I really couldn't care because the casks will only see less energy if they're momentarily sliding, and in real life, real life meaning outside of the technical regulations, I, again, do not have a problem with -- with casks sliding -- pads sliding as long as we're talking small numbers. I obviously wouldn't want to have a pad sliding a large distance, but minute amounts of sliding to me are just bound up in this technical regulation which really was not written with this particular problem in mind. We just have to live with it.

JUDGE KLINE: Okay. Thank you. That's as far as I'll pursue it, and I'll leave it to the State if they want to take it any further.

JUDGE FARRAR: Let me just ask a clarification. When you just used the terms "large" versus "minute," give us some idea what you mean by that.

THE WITNESS: Well, I guess if I were standing somewhere in the vicinity of a 30-foot be 67-foot pad with 8 casks that were roughly 20 feet high on them, I would get somewhat perturbed if I saw it coming toward me a foot, foot and a half, but an eighth of an inch, I wouldn't even see it.

JUDGE LAM: Now, Dr. Soler, a pad, an empty pad without any casks sitting on it weighs slightly less than a million pounds.

THE WITNESS: Correct.

JUDGE LAM: Now, when I'm seeing forces between pads approaching 2 million pounds, are we seeing any pad -- pads sliding here?

THE WITNESS: No. This -- this particular analysis that we're talking about did not -- the soil springs were elastic, and they could take tension as well as compression. Only the soil cement between the pad was restricted to be a compression-only pad. The one case that I did, which was the -- what I'll call the case where one pad was surrounded by a picture frame, that was the only case in which I allowed the pad to slide. Otherwise, I could never close the 6/10-of-an-inch gap. And sliding did occur in that calculation because I allowed it to occur if it wanted to.

JUDGE LAM: Oh, I see. I see. So you are not testifying that these forces --

THE WITNESS: Right. I -- I have to -- I can either model the soil with sliding -- I can either model the pad/soil relationship as one of simply the -- a set of 6 linear springs, or I can model it as I did for that one simulation in a manner which would allow the pad to lift off from the soil if it tended to rock and also slide relative to the soil if the dynamic forces got large enough.

JUDGE LAM: Now, in Dr. Ostadan's question to you, Dr. Soler, I remember hearing him repeatedly saying these are significant pad-to-pad loading. I don't recall hearing your response to that statement.

THE WITNESS: Would you repeat the statement, and I'll see if I responded to it.

JUDGE LAM: I remember Dr. Ostadan saying, well, these are significant pad-to-pad loading, and I don't recall you had any response to that.

THE WITNESS: Well, I believe in response to that question that I said certainly, to the layman, 2 million pounds force or 1.9 million

pounds force could be viewed as a significant number. The results of my analysis showed that, for this particular case, it certainly didn't adversely affect the force in the soil springs, and it did not change significantly the conclusions about pad motions -- cask motions.

JUDGE LAM: Thank you.

JUDGE FARRAR: Do we have any redirect by the Applicant?

MR. GAUKLER: Let me just take a couple minutes.

JUDGE FARRAR: Certainly.

MR. TURK: May we go off the record?

JUDGE FARRAR: Yes.

(A discussion was held off the record.)

JUDGE FARRAR: Mr. Gaukler?

MR. GAUKLER: Yes. I have several brief questions.

REDIRECT EXAMINATION

BY MR. GAUKLER:

Q. First of all, we've been talking with respect to the forces from the soil cement between the pads. Now, in your modeling of the soil cement between the pads, did your model take into effect

any transfer of force from that segment of soil cement between the pads downward into the soil below the soil cement?

A. No.

Q. And so is it fair to say, therefore, there would be some transfer of force from the soil cement down --

A. Presumably the soil cement at the -- at its lower interface would have a certain shear capacity and that could transfer any force developed in that soil cement directly to the soil. My solution here did not attempt to model that and have to deal with some other assumed capability. I assumed in this model that any force generated in that soil cement could only go to either one pad or the other adjacent to it.

Q. So your solution would maximize --

A. It should -- it should, then, give a maximum result because if any force went directly down into the soil below the soil cement later that I was modeling by springs, that would reduce the peak force that I predict here, but I could not tell you how much.

Q. Also, you were talking with Judge Lam in respect to sliding of the pads. Assume that the

pads did slide a foot or more. What effect would that have on the casks?

A. Well, the more sliding of the pads you have, as far as the casks are concerned, the less energy the casks have to deal with. So the -- from the selfish point of cask stability to the pads, I would love to have a completely isolated foundation with a coefficient of friction of zero because then I wouldn't have to do any analysis of the pad overturning. So in that respect a pad sliding helps the casks, but it runs afoul of a regulation.

Q. And you're not taking credit for this in your calculation, correct, any sliding of the casks?

A. No. The only calculation which I did which allowed sliding of the pad in these recent VN simulations has simply been to assure that I could get the pad to move at least 6/10 of an inch so it would close the gap in one or more directions to this hypothetical fixed soil cement surrounding the pad so it could study the effect of impacts.

Q. And with respect to sliding of the casks or sliding of the pads, whatever the case may be, in your analysis you're not taking credit for that, you're just allowing what happens happens?

A. Well, the -- except for that one simulation, the model assumes that the effect of the substrate on the pads is elastic and that there is no sliding. Whether or not the total load is consistent with sliding or not, I don't know. But the pads are not allowed to slide in any of the simulations that I've done, save the one with the 6/10-of-an-inch gap and the earlier runs with DYNAMO submitted in a report before the hearing.

Q. You were also asked a question by Dr. Ostadan about accelerations on the pad, and you mentioned that you had -- could see or might see some raw accelerations on the same order that Dr. Luk saw and reported in his report?

A. Yes.

Q. Would they be meaningful?

A. To me, not without filtering.

Q. Please explain.

A. The acceleration results would be, and I'll use the word "corrupted" without necessarily meaning that in a bad sense, by the fact that I have very stiff springs and there's going to be some high frequency effect introduced into this raw acceleration data and that before I would present it as physical accelerations of the pad, I feel it

would have to be filtered in order to remove the effect of -- the high frequency effect.

The forces that I've presented do not show that effect simply because those forces are calculated from displacements which are integrated from the accelerations, and the integration process effectively serves as a filter to get rid of these high frequency, raw peaks.

I can give you an analogy where this is actually used in the licensing of transport casks where we were required to, first of all, develop a hopefully simple model to predict the peak accelerations of the cask when it's dropped from 30 feet with impact limiters on it and then show that the model has some meaning by conducting quarter scale drop tests with a system that is accurately instrumented with accelerometers.

We did, as part of our transport submittal, this drop test, and, of course, when you read the raw accelerometer data, you find peak accelerations all over the place. I mean we're purporting to show that we are limiting the real accelerations to, say, 60 g's in the case of the transport cask, and the recall accelerometer data would show maybe 150 g's.

But this is all wave propagation effect, and when you filtered this data at about 350 hertz for that particular problem, you got -- as did Lawrence Livermore Labs with their test data, you got what we named the rigid body accelerations of the cask subject to this condition, and those were the numbers that we compared with the 60-g limit which had to do with the capacity of the fuel.

So there is precedence for filtering acceleration data in the licensing arena, and before I would look at pad accelerations here, I would make sure that I filtered the data appropriately. But, in my mind, to directly address the question of does the pad slide, the VisualNastran solution gives it to you directly because it gives you the force in the soil spring and you can compare that force with whatever the limit is that is presumed to initiate sliding. And if you exceed that limit, then presumably the cask slides and your solution isn't really --

Q. You mean the pad slides?

A. I mean the pad slides, and your solution isn't really correct. But if it's below that limit, then you're okay.

MR. GAUKLER: No further questions,

Your Honor.

JUDGE FARRAR: Does the Staff have any?

MR. TURK: Yes, very limited, Your Honor.

JUDGE FARRAR: Okay.

RECROSS-EXAMINATION

BY MR. TURK:

Q. In redirect just now, Dr. Soler, you indicated that you wouldn't be concerned about pads sliding because that reduces forces that the casks would have to face.

A. Correct.

Q. Correct?

And you indicated that you thought that ran afoul of a regulation. When you stated that, were you, in fact, referring to regulatory guidance?

A. I guess to be correct I was referring to regulatory guidance.

Q. The regulation itself would be 10 CFR 72.122, is that correct, which addresses structures, safeties and components important to safety and their ability to withstand natural phenomena?

A. I believe so, yes.

Q. Are you familiar with the Staff's SER -- consolidated SER which is Staff Exhibit C?

A. On this project? I have not read it.

MR. TURK: I would ask if the parties have a copy, to turn to it. I'll read it into the record.

Q. I'd like to read from page 2-60 of the SER and ask you if this statement is consistent with your view. Quote -- incidentally this is the statement that appears in Section 2.1.6.4 entitled Stability of Subsurface Materials which commences at page 2-55 of the SER.

At page 2-60 the following statement appears: Quote, the Staff agrees with the Applicant's conclusion that sliding of the pads would not constitute a safety hazard because pad sliding tends to increase the stability of the casks against sliding or tip-over and there are no safety-related external connections to the pads or casks that may rupture or be misaligned as a result of pad sliding. Therefore, the Staff concludes that the proposed cask/pad design is acceptable, considering the potential for instability resulting from sliding of the pads under dynamic loading,

close quote.

Is that statement consistent with your views?

A. Yes.

MR. TURK: That's all we have at this time, Your Honor.

JUDGE FARRAR: All right. Any recross by the State?

MS. NAKAHARA: Just a little bit, Your Honor.

JUDGE FARRAR: All right.

RECROSS-EXAMINATION

BY MS. NAKAHARA:

Q. In response so Judge Kline and Judge Lam's question, you attempted to quantify the amount of sliding that you would not be concerned with as an eighth of an inch.

A. Well, on strictly layman's physical terms, I wouldn't -- because -- putting myself next to a pad during an earthquake -- and I have gone through an earthquake so I know what's going on, I guess -- I probably wouldn't have time to be concerned in reality before the event was over or it had reversed. But I would surmise that if I saw

the pad plus 8 casks moving toward me, if I had time to react, I wouldn't stand there. But I suspect I would not see -- with this earthquake see that much of a movement where I have the time to gather my facilities and -- and move away. That's -- that's about the best I can give you as an answer.

Q. Dr. Soler, you would still move away when you were absolutely certain the casks would not tip over?

A. I can only -- I can only give you an example of a case where a 20,000-pound spent fuel rack began to move. It was on a truck, and it was not near me. And it wasn't an earthquake. It was just an instability at what's called center of gravity over corner. And it jerked from one position to another, and the reaction of everybody in the truck bay was, well -- half of the people, their immediate reaction was to put their hands out as if they were going to stop the rack. The remaining people simply stood in place. And by the time anybody would have been able to do anything, it was over, and it was in a new position.

Now, I recognize in -- an earthquake takes place 30, 40 seconds, whatever's really going

to happen, I don't believe that I would physically react. I think I'd be more concerned with just standing there, wondering what was going on and whether I should be laying down or covering my head or running which way and the other. But from my own personal experience, you generally just stay where you are, and that's probably what would happen regardless of how these pads tend to move toward me or away from me.

My physical feeling based on --

JUDGE FARRAR: Well, I think we've -- you've had rebuttal.

THE WITNESS: Okay. I'll quit while I'm ahead.

Q. (By Ms. Nakahara) Would you be concerned about a 0.6-inch sliding as you modeled in your assumption of a clearance gap of 0.6 inches?

A. I don't believe with the scale of the cask, that unless I was standing right next to an edge of the pad -- pardon me, with the scale of the pad, unless I was standing right adjacent to the edge of the pad, I don't think I'd be able to notice a half an inch of movement during an earthquake.

Q. And the case that you modeled, the second case, if -- if the pad with a single cask saw the forces of 1900 kips applied on it, how much would you expect it to slide?

A. Well, I think -- I think my analysis, if you accept those results, shows that it doesn't slide. It's held -- it's held by the soil springs.

Q. So are you saying that a pad at the end of the row -- a row of 10 pads with one single cask on it, weighing approximately 1300 kips, seeing a force of 1900 kips would not slide?

A. Well, remember, you have to balance the force coming -- sticking strictly with my model, you have -- the pad is being acted upon by inertia forces from the casks, by the force transmitted from the soil cement adjacent to that pad in one direction and the soil springs, and the sum of those three forces, if you will, tells you -- it should be, of course, in equilibrium and add up to zero at any given instant in time. The only thing that determines whether the pad slides, in reality, would be if the force in the soil spring exceeds its capacity. Then my solution would not be correct subsequent to that, but it would certainly answer, at least for that instant of time, a yes or

no whether the pad slid. And in this solution that force in the soil spring never exceeded the limit.

Q. Mr. Gaukler asked you a question whether the accelerations on the pad that your model generated was meaningful if it wasn't filtered, or something to that effect. What would -- in your opinion, what would meaningful -- strike that.

In your opinion what would be the value of meaningful accelerations you would expect out of your 2000-year model on the pad?

A. I would hesitate to give an answer to that. The only thing I would say is that I would probably filter it at about 20 hertz to make sure that I included the major power from the earthquake and then see what the filtered data gave me. I -- I cannot give you a definite answer to the question you've asked.

Q. Could you estimate -- do you have an opinion whether they would be greater than freefield accelerations?

A. They could be somewhat greater, but I couldn't give you a number. Certainly -- certainly they wouldn't be 6 g's, as the raw data might indicate.

Q. What is your basis for filtering at 20

hertz?

A. Well, the major -- the major power from this earthquake is at roughly 5 hertz, and I would filter at some frequency above that to make sure I wasn't deliberately excluding some effect that -- that really is there. But it would be -- it would be a matter of engineering judgment as what to filter at.

MS. NAKAHARA: That's all I have. Thank you.

MR. GAUKLER: Two very quick questions that I think can be answered yes and no.

JUDGE FARRAR: Excellent.

THE WITNESS: I hope so.

FURTHER REDIRECT EXAMINATION

BY MR. GAUKLER:

Q. Dr. Soler, in terms of all the discussion we had about concern -- your potential personal concern about sliding, you were speaking in terms of a person, specifically yourself, being in the vicinity of the cask and the pad; is that correct?

A. Yes.

Q. And do you have any concern from a

design viewpoint?

A. No.

MR. GAUKLER: Thank you.

JUDGE FARRAR: All right.

MS. NAKAHARA: And I can't resist. I apologize. One question.

JUDGE FARRAR: All right.

FURTHER RECROSS-EXAMINATION

BY MS. NAKAHARA:

Q. Dr. Soler, in response to Mr. Gaukler's question that -- you were reacting as a person -- you were reacting as a person who's knowledgeable about the modeling that he's conducted on the HI-STORM 100 cask and is assured that these casks would not tip over, correct?

THE WITNESS: Yes.

MS. NAKAHARA: Thank you.

JUDGE FARRAR: All right. Then with that, it's almost 12:50, so let's come back at 1:50, and we will have at that point Dr. Win Tseng?

MS. NAKAHARA: We have very short rebuttal on Dr. Soler with -- to Dr. Soler's testimony, to Dr. Soler's testimony, with Dr. Ostadan.

JUDGE FARRAR: Right, that was our plan to do it that way.

MR. GAUKLER: I missed the time you said, Your Honor, when you said we'd be --

JUDGE FARRAR: 10 of.

(Lunch recess was taken.)

JUDGE FARRAR: We're back for the afternoon session, and the State was going to do its rebuttal of Dr. Soler's rebuttal.

MS. NAKAHARA: Your Honor, to probably make things more confusing but hopefully expedite things, would you permit the State to put on Dr. Ostadan like you did yesterday with Dr. Ostadan with surrebuttal to Dr. Soler's rebuttal testimony in addition to any rebuttal testimony that Dr. Ostadan has with respect to Dr. Soler's prefiled and oral direct testimony?

JUDGE FARRAR: Yes. We found that to be efficient yesterday, so we'll do it again today.

DR. FARHANG OSTADAN,

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

DIRECT EXAMINATION

BY MS. NAKAHARA:

Q. Good afternoon, Dr. Ostadan. Is it important to distinguish the amount of force in the dash pots and soil springs?

A. Yes, in my view it is. As I indicated before, unfortunately the Holtec report, which is the basis of the entire CSA design for this facility, is extremely brief. It doesn't provide enough information for a reviewer like me to make a complete assessment of the results. We have discussed this a number of times in the past, and PFS experts also express opinion specifically with respect to damping, that the damping could be very large and damping associated with the SSI effects of pads. And I think it would be important to be able to separate these forces in the springs and dash pots as well as indicated by Dr. Soler that can be done. So that will give us a better opportunity to better understand the results.

Q. I'm asking a foundational question after a question, but it's your understanding that Dr. Soler did not distinguish between the dash pot forces and the soil spring?

A. That's correct. He indicated that these

forces are the total effects, and he did not know the breakdown in the forces for spring and dash pots.

Q. Dr. Ostadan, based on Dr. Soler's rebuttal, written rebuttal testimony and oral testimony this morning, given the transfer of loads that Dr. Soler observed from pad-to-pad interaction, does the design of the soil cement now play an increased role and important?

A. Yes, in my view it has now become much more important. We have, all in all the State has been concerned about pad-to-pad interaction and that's the position we have been taking. PFS position has been, my understanding, that it is a secondary effect that is not important, and Dr. Soler results indicated that it indeed is important. And therefore the role of the soil cement in the pads becomes much more important in their ability to transfer the loads.

And further down the road it also changes the entire design concept, at least in my mind, as to what is the load path now, how the loads from the casks coming to the pad are really transmitted to the clay layer under the pads. It seems to me that significant amount of force is

being transmitted on the side through the soil cement. And now when you think about this whole array of the pads and various combinations that may take place in real life when these pads are loaded, I have not seen any really systematic assessment of complication of foundation loads to be sure that the most critical facility loads now have been calculated and used.

Q. Dr. Ostadan, in PFS Exhibit 225 C, if you assume the schematic of the two pads, one pad with a single cask on it and the other pad with the eight casks, and you assume that that pad and cask configuration occurs at the end of a row of ten pads, in your opinion, what would the sliding effects be?

A. I think it's important just to work with some basic numbers here rather than bogging down to this, really the numerical analysis. If I think of one pad, one cask as was mentioned earlier this morning, the pad being 900 odd kips and one cask being 360, it's about 13, 1,400 kips total weight of this one cask and the pad, this is located on the surface of a weakly treated soil cement, and this 13, 400 kips of weight is now receiving about 1,900 kips of lighter load. I can't see how this

can stay in place. Without doing any really calculations, it is very easy for me to see this is a serious situation.

Q. In your experience in the design of nuclear facilities, have you ever observed a case where the foundation is allowed to slide as a design philosophy under the design-basis earthquake?

A. No, never, never, no. Foundations always been a very important component of any building, specifically when it comes to nuclear structures. We have always, in my experience, made sure we have enough margin to design foundations.

Q. Dr. Soler appeared to be indifferent about the 1.1 factor of safety for the pads. As an engineering design expert, will you explain the purpose of the factor of safety and give your opinion on the importance of meeting factors of safety?

A. As a foundation engineer, I certainly do not appreciate ignorance of how good or bad the foundation could be. I think foundation is always an important component of any building design, and like any other engineering design, it needs to be treated properly, designed adequately to make sure

it performs to its function.

With respect to the factor of safety, this is very common in our engineering design and analysis. We realize we don't know enough about the parameters that we adopt to use, both on the capacity side, both on the demand side. Factor of safety is a measure for us to make sure we have the margin for these uncertainties and unknowns so that the building at the end would perform to its function.

Q. And finally, after reviewing Holtec's many analyses that they've submitted for the licensing proceedings and through the -- through this hearing, are you satisfied that the cask stability has been adequately analyzed?

A. Are you referring to the cask or the pad?

Q. Cask stability.

A. No, I remain very concerned with respect to the stability of the foundations for this facility, and particularly the pads. I think there are enough unknowns and parameters, assumptions being discussed and disputed by both sides that easily could change the balance here for a factor of safety. And that probably makes a very

difficult situation for the Board, I believe, on one hand recognizing the foundations and the margin allowed or lack of it, and on the other hand, trying to see what will be the ultimate failure and performance of the cask, which goes beyond my expertise. But in my opinion the foundation and design at this time is not adequate, and it would not have enough margin to perform as we typically design it.

MS. NAKAHARA: Thank you, Dr. Ostadan. We have no further questions.

JUDGE FARRAR: Mr. Gaukler?

MR. TRAVIESO-DIAZ: Mr. Chairman, not to break with tradition, I think I'm going to take this one myself.

JUDGE FARRAR: All right.

CROSS-EXAMINATION

BY MR. TRAVIESO-DIAZ:

Q. Dr. Ostadan, I'm mystified or at least somewhat unclear as to your first, the answer to your first question, which was why is it distinguished and differentiate between the forces on the dash pots and the forces on the springs. Aren't you more interested in the resultant force

in any case?

A. No, I think if I look at it from the foundation design perspective, as you know, a number of issues has come up as to why Stone & Webster, for example, has used acceleration of .71 g to estimate the inertia of the pad. I think the designer himself, I believe he will testify later how he believes damping could be as high as 48, 50 percent. He said it when he typed up his opinion.

I found it very difficult to believe that we could have such a high amount of damping, and I think one way to get there is have Holtec separate the forces in the spring and dash pots so you have another angle to look at this damping.

Q. Oh. So what you're saying is not that it makes a difference as far as, if you will, loadings or whatever, which component of the model you will compute as one thing or the other, but rather you are saying that in order to better understand how certain parameters behave, such as the remediation damping, it will be helpful to be able to say what force goes one way, one force goes the other. Is that what you're saying?

A. I think I remain concerned about these forces not to be adequate. And to help out the

matter, I think one way to get there is to try to provide additional information which is not presented in this brief report to start with. And separating these forces will be a good thing to do.

Q. Just so that the record is clear: your interest in seeing this separation is so that you can better understand, if you will, the physics of the problem and trying to Figure out whether the assumptions that the Applicant is making as to remediation damping are correct or not. Is that right?

A. It goes back to the foundation forces. As I indicated, I remain concerned, as was -- I was concerned until yesterday about pad-to-pad interaction, and we saw today that was a valid concern. I remain concerned about adequacy of foundation forces. And therefore how significant it is, I can't express an opinion. I have not calculated it myself.

Q. I'm sorry. I can see that I'm not making my question clear. Are you saying that the only way that you can tell whether the predicted forces as made by Holtec are correct is by knowing which component of each of the forces given by the force attributable to dash pot and the force

attributable to the soil spring? Is that what you're saying?

A. I would change the word "correct" to "adequate," and then my answer is yes.

Q. I'm sorry?

A. If you ask the question if the forces are adequate, if you separate the forces, my answer is yes.

Q. So you need to see them separated into components just to form a judgement as to whether a certain force has been adequately computed?

A. Correct.

Q. Now, you said a moment ago that the fact that Exhibit 225 C documents a number or Figure for pad-to-pad interaction forces changes the load path. Can you explain to me a little more what you mean by that?

A. Yes, sure. The design philosophy so far has been primarily having the loads from the casks going to the pad and then going to the treated soil under the pad and then going to the clay and so on. It has been viewed on the part of Applicant that pad-to-pad interaction is secondary effect. Now, this limited study done shows that about 30 percent of these horizontal loads is being transmitted

laterally from one pad to the other, so that changes the picture as far as the foundation and soil is concerned quite a bit.

Q. Did I hear you say horizontal?

A. I think we discussed the horizontal forces.

Q. What I'm trying to understand is how that affects the load path, given that if you're talking forces transmitted to the soil, that will be vertical loadings, won't it?

A. No, no. I think the key here, although vertical is important, the key is horizontal forces, and the shear stresses in the clay and ability of clay there to take the force.

Q. I thought the pad-to-pad interaction analysis was intended to determine how the forces seen by one pad from the seismic loads get transmitted to the other pad. What does that have to do with the shear strength of the soils underneath either?

A. Oh, a lot. You know, when you -- the total load from pad and eight casks is a number. Now, where is it going? Until yesterday they were all believed to be going to the soil cement and clay underneath. Now, while 30 percent of it is

now being transmitted laterally, so let's say 70 percent of it. In this case the studies goes on, it's less.

If you think of the whole area of pads in these various scenarios, now, would you have a scenario where you have all these added up at certain locations and you have concentration of the loads, and you're going to have much loads to deal with and carry through the foundations. How many scenarios we need to look at, I don't think it has been sorted out on the part of the Applicant. I think this was done on the part of Dr. Soler, in my view, to indicate that if pad and pad interact stresses on the concrete pad is small, and he has made that point, and I don't think we have to worry about structural design of the pad, for that matter. At the same time it changed the picture as to how these loads are now being transmitted.

Q. Well, here is my concern. I thought that all along in this proceeding our concern has been with the stability of the casks, which are the material that contains the radioactive matter. And I thought that when pad-to-pad interaction was traced by you some time ago, always the concern was pad A is going to produce a force on pad B and that

could change the loading that the casks could see, could make them less stable. Why do I care how much force goes down to the soil? My interest will be how much force goes up onto the cask. Can you illuminate that?

A. Yes. I think the record will speak for itself. One of the concerns has always been the effect of pad-to-pad interaction on the sliding analysis, and basically that means how much one pad is pushing the other. And this has not been picked up or analyzed, and now we are seeing an evidence of it.

To answer the second part of your comment as to what is the impact on the stability of the cask, I have always stayed away from that subject as not my area of expertise. I believe I have expressed a concern that if the impact or the gapping due to movement may create additional source of energy on the pad, that could also increase the motion of the cask. I think perhaps that concern has been expressed. The main concern, again, being an expert on the foundation here, has been really on the stability of the foundation.

Q. On the stability of the foundation, you mean the stability of the soil underneath the pad?

A. Yes, the pad and the soil.

Q. So your concerns are really having to do as to the extent to which the soil underneath the pad is going to remain stable; but this doesn't address directly the loads on the casks, does it?

A. Very much so. I think we've got to look at the load pad and how it comes down to the soil. Are they going to accumulate and then go down -- you see, the fact that you transfer a load from one pad to the other doesn't mean that this load disappears forever, because it goes down somewhere. Because it keeps the constant regime. The load just doesn't go away because you have a neighbor. This load has to get down to the clay a certain stage.

So I think that hasn't been carefully studied on the part of PFS. It has now only shown that there is this interaction. I think there's some careful thinking needs done and a study to see what is the critical thesis and critical condition.

Q. One more time. You just said it I think very well. The concern here is that this load is not going to disappear, it may go from pad A to pad B, but ultimately it's going to go down to the soil, isn't it?

A. Right.

Q. So why do we care with respect to the casks above which way the loading goes?

A. Well, if you create a condition that you may have a concentration of this load for various reasons on a specific pad, you're going to also impact the motion of the pad.

Q. Oh. Then what you're saying is that the effect, the potential effect that you are positing will be one in which there could be some circumstance in which a pad for some reason could accumulate these loadings from various directions. Is that what you're saying?

A. Various directions and various neighboring pads, yes.

Q. I take it you don't agree with what Dr. Soler said a moment ago that he couldn't envision how that would happen?

A. Given his assessment that he hasn't quantified it, he said he can't see, or something to that effect. But he has certainly not analyzed this. Nobody I think has really thought through this.

Q. I thought he said he couldn't even conceive how you could have such a preferential

loading on a single pad as opposed to --

A. Oh, no. He just went through one example in response to State's counsel. He assumed just one pad with one cask at the end of the row of ten pads as receiving certainly 1,900 kips kick. Can you tell me the motion of this pad is same as before or not?

Q. Before we go on to that, which we will, let me ask you a question of your understanding of what Dr. Soler was doing in this analysis that is presented on 225 C. Is it your understanding he was trying to create a case that was intended to maximize in all possible ways the possibility of the loadings from one pad to another due to pad-to-pad interaction, decided to put a boundary to assess what a maximum value will be?

A. In all honesty, I think Mr. Soler, and he can correct me, probably did not understand our concern accurately. He tried to calculate the stresses in the concrete pad due to this pad-to-pad interaction, which he did, and he showed these are smaller. This was never our concern or statement.

Q. Excuse me for a second. To go over to my last question, is it also your understanding that Dr. Soler was doing a run that was intended to

maximize the potential loadings, forces that would result in this effect?

A. It might be his opinion. I don't remember that. But I don't agree -- if that was his opinion and his intent, I don't agree that this limited study shows that this is the worst case.

Q. The reason why I'm asking you all this is, I remember very clearly, I think I have the transcript here to show it, that when I asked you way back in May what your concern here was, you continued to express the view that the concern with pad-to-pad interaction is that you will increase the loading from one pad to the other through potential transmission to the soil cement, ultimately resulting in greater loadings on the casks. And now you're telling me all this story about potential loadings going down to the soil, making this potentially through forces to the clay, and I have to say that in fairness to Dr. Soler, what he was doing in his analysis was answering the concern you raised. And my question to you was whether you understood that that's exactly what he was trying to do in the analysis he presented today.

A. Well, I think answer is given what

Dr. Soler concluded out of his two cask analysis. In my view, he did not understand the concern. As I said, he ran and attempted to calculate the stresses in the concrete pad and show these 150 PSI or so. That was never my concern anywhere. Many you can explain to me, if you understand, where do we express the concern about the structural design of the pad with respect to pad-to-pad interaction?

Q. Let me ask you another thing. I'm not sure I got -- at least I understood you are particularly focusing on an assumption of the situation which you had an eight-cask array -- eight-cask array, one pad, and a single cask configuration on the other; and these two pads being at the end of the row, can you tell me what that particular instant will prove?

A. Like I said, this hasn't been really studied thoroughly through various scenarios. We just take the case that has been studied. For the moment let's assume it's at the end of a row of ten pads. So at the very end you have one pad and one cask. And this body weighs around 1,300 kips. And then you have next to it a pad with eight casks, and this analysis shows now that a fully loaded pad is going to put a 1,900 kips lateral load on this

lightly loaded pad. It's a pretty serious situation right there.

Q. Well, but will that serious situation depend to some degree on whether the combined forces that are applied to that cask exceed the resistance capability of the soil underneath the pad to sliding?

A. Yes, you could say that.

Q. All right. And in your positing that hypothetical, do you consider or are you suggesting that in fact the number which Dr. Soler testified is never approached was exceeded in that case? If I remember, Dr. Soler said that it was 2,300 kips under the pads.

A. Now, keep in mind I'm only looking at the 1,900 kips additional loads coming from the neighboring pad. You still have the load of its pad and the single cask that needs to be taken into account.

Q. I want you to explain to me how you manage to add the 2,300 which Dr. Soler said was the maximum and you put 1,900 on top of it.

A. As I said, I haven't done any calculation. All I realize is, the picture here is, you have a body of something, the pad and one

cask which weighs about 1,300 kips. That's all. And you place it virtually on the surface of the soil here, and now you're kicking it with 1,900 kips. It just doesn't make sense to me to automatically assume this is going to stay stable.

Q. I apologize, I don't understand the point you're trying to make, and it's just that I need a second to think about it. I thought what Dr. Soler testified to was that if maximum force that he computed, which is already taken into account in Mr. Trudeau's calculation, is less than what Mr. Trudeau's had in the first place, I don't see how, if that conclusion is right but you may not agree with, you have a situation very worse, no matter what the location of the pad is. That's what I'm trying to understand from you.

A. I beg your pardon. Could you be more specific in your question? I'm also lost.

Q. I guess it shows I am lost myself. I thought that the analysis that Dr. Soler produced was trying to determine -- maybe we can look at it together -- what the maximum force on the pad would be in a situation in which -- in addition to whatever other forces you have on the pad, you have a configuration in which you have two adjacent pads

in which one exerts a force on the other. And I understood the 2,300 that Dr. Soler testified to being in total, not being the contribution of soil-structure interaction alone, being the total forces with soil-structure interaction and pad-to-pad interaction added to it. So I don't understand your mathematics what you're adding to what when 2,300 is said to be the total.

A. If you want my opinion, I will reserve my opinion until I receive the breakdown of soil spring and damping acceleration of the pads.

Q. And maybe Dr. Soler can add some more. I apologize if I sounded combative or argumentative. I just don't understand your argument.

One moment, please.

Okay. Just one brief reference again to, and I think this has been touched upon by various witnesses before, but since you brought it up I think it may be well to try to define what we mean here. Is it your understanding that a factor of safety of 1.1 that you referred to a moment ago was the relevant guidance applicable to nuclear power plants?

A. I think it's in one of the guidance,

yes.

Q. Would that be perhaps because in nuclear power plants when you have buildings that are connected through piping and other lines, the possibility of sliding could have safety consequences?

A. I will say no, because for any other building that do not have pipelines or anything connected, we make sure we have enough margin against sliding.

Q. Well, let me ask the question a different way. Is it your understanding that the guidance that was developed by the NRC with respect to nuclear power plants that resulted in a 1.1 factor of safety against sliding, was that intended to preclude having adverse safety consequences in the event that sliding takes place?

A. I do not know the basis and what was the thinking of the authors of the regulations. I can only tell you that my view of it is probably should not have been, because as I said, any other buildings, interconnected or not, would not allow sliding to take place.

Q. But in order to determine whether breach of the 1.1 factor of safety against sliding

constitutes a safety concern, will you need to know in fact what the safety consequences would be in not meeting that 1.1 factor of safety against sliding?

A. I don't know what would be the consequence of nonperformance of the foundation on the cask and radiation release. All I know, it's a requirement to have this factor to be met.

Q. Could you perhaps be willing to modify your answer by saying not requirement but a guidance Figure that is offered in documents that are not regulations?

A. I can only say that for every project I have worked on nuclear, we made sure we exceed that.

MS. NAKAHARA: Dr. Ostadan, could you clarify what you mean by that, factor of safety?

THE WITNESS: The factor of safety, in all different foundation design we have done for nuclear structures we've made sure a factor of safety exceeds 1.1 for sliding.

Q. (By Mr. Travieso-Diaz) By the way, Dr. Ostadan, going back for a moment to -- I'm still trying to understand the implications of this end of the row scenario you posited. Isn't it true

that the potential applicability, if you will, assuming that the forces that you say are additive on having that 1.9, 1.9 million pounds applied on one pad to the other would depend, first of all, where the pad -- what directions the pads were moving? Because there will be situations in which, I think we discussed this before, there will be some questions in which in fact there will be zero effect because the pads were in fact not impacting each other?

A. If they move in phase there will not be any force.

Q. All right. And also this -- well, I'll let it stay at that for a second.

Dr. Ostadan, I'm going to read you from the transcript of May 8th, pages 1759 -- I'm sorry -- 7519 to 7521. The reason I'm going to go through the time of taking this is, I understood, Dr. Soler understood and perhaps the Board understood that if the position of pad-to-pad interaction that you gave us --

(Off the record briefly.)

Q. Strike that question and I'll ask it again, and I'm going to ask it a much more simple way. The transcript of the May 8th, 2002

testimony, starting on page 7519, at the bottom of the page, Question, "By influencing each other, you mean potentially impacts with the pad? That's what I'm trying to --" Answer, "Okay. Basically what would happen here, the concern is that, remember there is the soil cement in between the pads on the sides of the pad. And the soil cement are very poor in tension, but they are pretty good in compression. So once one pad is trying to move in one direction, and if the motion of the other pad is out of phase, each pad is going to be pushing the other pad. There will be extra force coming to the pad because of the interaction of these pads."

I'll go down through some intervening questions, and I ask again, question, "I understand. But again, I'm not asking you to accept the results, but if you accepted the results that the element of this concern we're talking about, which will be potential impacts of effects from the sliding would not be present. Is that correct?"

And your answer was, "No, no, I would disagree with that. Whether they slide or not, even if they do not slide, by the mere fact that this one pad is moving to the left, neighboring pad

is moving to the right -- due to shaking; there is no sliding here -- there will be extra force above and beyond what is considered now will be exerted on the pad."

If I understood that testimony I just read you, you were expressing a concern about what forces are going to be in the pad on the pad given the potential transmission of forces from one pad to the other. Is that correct?

A. That's correct, yes.

Q. Okay. Did you -- I don't recall at the time that you gave that testimony that you said that a concern was not the forces on the pad but the load path going to the soil and so on. I'm just trying to understand what you're telling us today that you didn't tell us on May 8th.

A. Nothing, really. I think the load pad is a consequence of load going to the pad, and maybe this is new to you, but basically the issue is when the load is extra load you're talking about here goes to the pad, how is it really transferred to the soil. Do we have really a foundation stability above and beyond what's been considered? That's what it boils down to.

Q. I'm sorry. Could you tell us now what

this boils down to?

A. In my viewpoint, this is primarily foundation stability.

Q. So it's not transmitted?

A. The concern has been expressed, and some of it is here and there may be other places, I don't remember, that the impact may cause additional vibration on the pad that could have some effect on the cask.

Q. And your understanding of what Dr. Soler was attempting to do with this exhibit is what?

A. My understanding of Dr. Soler's exhibit are two. First, he tried to show that the structure design of the pad is okay, additional stresses is not going to impact the structural design. And the second was the movement of the cask on the pad are still within a few inches.

Q. And do you have a dispute with either portion of Dr. Soler's conclusions based on this exhibit?

A. I never have the concern with the structural design of pad with respect to pad-to-pad interaction, so it's good information to have. As to the additional vibration cause, the case that has been studied shows that displacement are still

small. Whether this is the worst case, now recognizing there's interaction, a chain action going on, is it the worst case or not remains to be seen.

MR. TRAVIESO-DIAZ: Thank you very much. That's all I have right now.

JUDGE FARRAR: Staff have any?

MR. TURK: Yes, I do, your Honor.

CROSS-EXAMINATION

BY MR. TURK:

Q. Dr. Ostadan, you've just stated that you've never had a concern about the structural impact upon the pad, correct?

A. As far as the pad-to-pad interaction is concerned.

Q. And is that correct for the State in this proceeding?

A. To the extent I can testify is that --

MS. NAKAHARA: Objection. Dr. Ostadan can't speak for the State.

JUDGE FARRAR: Mr. Turk, that seems -- he can speak for his portion of the State's position, but it did strike me that that's a broad question, but I'll hear you on it.

MR. TURK: If my understanding of the State's concerns is correct, I thought that the State was raising that concern, perhaps not through Dr. Ostadan but through Dr. Bartlett. If the State shows me that that's not the issue, I'll drop it.

JUDGE FARRAR: I think that's not how I heard the question. Let us hear it back.

(The record was read as follows:

"And is that correct for the State in this proceeding?")

JUDGE FARRAR: Why don't you re-ask that and make it a little more specific what you're getting at.

Q. (By Mr. Turk) In your testimony which you presented jointly with Dr. Bartlett concerning Part D of this contention, I recall that -- excuse me so I can get the testimony out.

At page 2 of your combined testimony, in answer 4 you stated that Dr. Bartlett and yourself have worked closely together in your analyses and your review of the PFS design concept, dynamic loading and the effects of loading, effects that loading will have on the casks, pad, and building foundations and soils. And you did present joint testimony with Dr. Bartlett, and I just want to see

if I understand. The State is not raising a concern as presented through your joint testimony about pad-to-pad interaction as that may affect the structural capacity or structural design of the pads?

A. I already expressed my view and opinion. Whether or not I represent the State, that is up to counsel.

Q. Let me -- so to the extent that if the State has raised any concern about pad-to-pad interaction as it affects the pad itself, that's not the concern you're presenting, that would be presented by somebody else?

A. I never expressed a concern about the structural design of the pad relating to additional forces caused by pad-to-pad interaction.

Q. At several points during your rebuttal testimony you indicated that without doing any calculations you nonetheless had certain concerns. Have you done any calculations with respect to the issues you've raised in this proceeding?

A. I have not done any calculations.

Q. With respect to the factor of safety of 1.1 against sliding, where does that appear? Do you know which document, regulatory document that

appears in?

A. I don't remember the number right now.

Q. I would ask you to turn to Staff Exhibit EE, which is Section 3.8.5, foundations of NUREG 0800.

MS. NAKAHARA: Can you provide him a copy?

MR. TURK: I have only my own copy.

MS. NAKAHARA: Well, we need a copy also.

MS. CHANCELLOR: Maybe you could stand over there.

MR. TURK: If I may approach DR. SOLER?

JUDGE FARRAR: Certainly.

MR. TURK: May we go off the record?

JUDGE FARRAR: Yes.

(Discussion off the record.)

Q. (By Mr. Turk) Have you seen this document before?

A. Yes.

Q. Is this the regulatory document which forms the basis for your belief that there's a factor of safety of 1.1 specified for an ISFSI storage pad?

A. Yes.

Q. And do you understand that NUREG 0800 in which this section appears is regulatory guidance specifically applicable to nuclear power plants?

A. Yes.

Q. There's no discussion in this document of independent spent fuel storage installations, is there?

A. I can't be 100 percent sure, but I suspect not.

Q. And you recognize this is regulatory guidance?

A. I recognize that, yes.

Q. You mentioned that in all nuclear projects in which you've been involved, determining that there was a sufficient factor of safety of 1.1 was always an issue and that you always looked to meet that, correct?

A. I did not say it was an issue. I said we always made sure we meet that.

Q. And you also mentioned that in that work you were dealing with buildings, correct?

A. That's correct.

Q. In any of your work did you deal with storage pads that did not constitute buildings?

A. Can you repeat the question? I'm sorry.

MR. TURK: Could you read it back, please?

(The record was read as follows:

"In any of your work did you deal with storage pads that did not constitute buildings?")

THE WITNESS: I have not dealt with the storage pads.

Q. (By Mr. Turk) So all of your work was with respect to buildings?

A. Buildings and other types of structures.

Q. But not storage pads?

A. I'm thinking back in order to give you an accurate response. I certainly have dealt with pads that support heavy machineries, but pads that stored nuclear fuel on top, no, I haven't.

Q. And the pads that you mentioned that support heavy machinery, those pads also support structures, correct?

A. No, just the machine. Maybe a turbine or a diesel generator or various pieces of equipment.

Q. Were they freestanding pieces of equipment?

A. No, they were always anchored.

Q. So is it fair to say, then, that all of the structures that you examined with respect to the factor of safety against sliding of 1.1 had something anchored to them, either a building or heavy machinery or something of that nature?

A. I think it's fair to say that, yes.

Q. And you recognize that the storage pads for the PFS ISFSI will not have something anchored in them or attached to them, correct?

A. Unfortunately, yes.

Q. During your testimony I often saw the word "unprecedented" used in connection with the PFS ISFSI design. And that's one of the things that's unprecedented in your review, isn't it?

A. Yes.

Q. In Dr. Soler's analysis that was described today in PFS Exhibit 225 C, how did he deal with forces imparted to the soil cement between storage pads?

A. I think Dr. Soler explains that he analyzed two scenarios. In one he modeled the soil cement within the pads, the capacity to take both tension and compression as one scenario, and the other scenario was soil cement to take compression only.

Q. Did he assume that the force that would be imparted from one pad into the soil cement would be transferred to the pad next to it?

A. That model, yes, would be able to calculate the transfer of load from one pad to the other.

Q. Did he diminish that load at all as the load traveled from one pad to the next, or did he just take that load and say, I'm going to apply it to the next pad through the soil cement?

A. No. The model was a combined model of two pads, two pads and the soil spring in them. So for this case, whatever load gets transferred is what he showed.

Q. And my question is, the load that originated at one storage pad before it moved into the soil cement, was that same load at its origin point then transferred directly to the next storage pad? Do you know?

A. I'm not sure I understand your question. It's a complicated interaction going on here. I'm sorry, I don't understand.

Q. There was an assumption that there's a certain load that would be transferred from one pad to the next pad, correct?

A. (No audible response.)

Q. What load -- I'm sorry; that was yes?

A. I'm listening to you. Please go ahead.

Q. No, could you answer that question? Do you need it read back?

A. Yes.

(The record was read as follows:

"There was an assumption that there's a certain load that would be transferred from one pad to the next pad, correct?")

THE WITNESS: There was a concern that a certain amount of load could be transferred from one pad to the other. How much of it was unknown.

Q. (By Mr. Turk) When you say how much was not known, in other words, you don't know how much?

A. I didn't know until Dr. Soler's evaluation.

Q. Is there a document you can point us to where we can find the answer?

MS. NAKAHARA: Answer to what?

MR. TURK: To the question of how much load was assumed to transfer from one pad to the next.

A. It was not assumed. It came out of the analysis results and is shown in Dr. Soler's

results. I forgot the exhibit number. It shows the load and the springs.

MS. NAKAHARA: PFS Exhibit 225 C.

MR. GAUKLER: PFS Exhibit 225 is where the table appears, I believe.

Q. (By Mr. Turk) Are you familiar with that document enough to point me to the load that was calculated to be transferred from one pad to the next?

A. Okay, I'm looking at Exhibit 225, page 28. There's a table there, and under the maximum compression loads in soil cement within the pads, under that column you can see the load for various scenarios.

Q. And the soil cement between the pads, is that essentially, you mentioned it was modeled as a spring?

A. Yes, that's what's indicated.

Q. Did Dr. Soler take into account any potential for absorption of energy within that spring?

A. I did not hear him talking about that. I don't know his model in detail to give you my opinion.

JUDGE FARRAR: Let's go off the record

for a second.

(Discussion off the record.)

Q. (By Mr. Turk) Would you agree that the soil cement between the pads is compressible as compared to the pads?

A. It's more compressible as compared to the pads.

Q. So that if one pad does start to move in the direction of another pad, there would be some compression of the soil cement, in effect some crushing of the soil cement?

A. There will be compression of soil cement, and if the compression is excessive, there will be crushing.

Q. And that compression or, as you say, if you get enough compression crushing, that would tend to reduce the amount of load that is transferred to the pad next door, correct?

A. After the crushing takes place the load transfer will be less.

Q. And if the soil cement does crush, that would take place over a certain period of time; it's not an instantaneous thing, correct? If you would picture a pillow, you place your hand on the pillow and it compresses, it doesn't happen all at

once, there's some amount of time required for the load to be absorbed?

A. Now, here we are getting to engineering behavior of materials. It depends whether it's brittle or ductile material. If it acts in a brittle manner it will crush very quickly.

Q. And whether it's brittle or not would depend upon the stiffness of the material?

A. In part.

Q. And the soil cement is designed to have a stiffness of how much? Do you recall?

A. I think -- I'm not sure of the numbers, but it's the brittle mix on the side of the pads, I believe it's like two or three hundred PSI.

Q. Approximately 250 PSI, would that refresh your recollection? Yes?

A. Yes.

Q. And for material that has a 250 PSI, when it's placed in between the storage pads which have a PSI, comparative PSI of approximately how much?

A. I would say three to four thousand, I would guess.

Q. Would you expect that the soil cement would crush if there was to be enough pad-to-pad

interaction such that a load from one pad would attempt to be transferred into the pad next door?

A. It depends. Now, we need to look at the physics of the problem. In the worst case a neighboring pad let's say does not move, and one pad is pushing towards that and the force becomes excessive, then yes, you have the crushing of the soil cement. But the real scenario here, you have all these pads laid out, and as the force builds up within the pads, the neighboring pads tends to move away so you don't necessarily end up crushing the soil cement if the neighboring pad slides and moves.

Q. Well, you wouldn't crush that soil cement, necessarily. In other words, if pad A is moving in the direction of pad B and pad B moves away, you wouldn't get a crushing. But accepting that scenario, you might get that crushing if the force was strong enough to cause it, correct?

A. If the force was large enough, it will cause that, yes.

Q. And again, that would not be instantaneous, that would take some amount of time, however you measure it? You wouldn't see it happen in one snap in a millimicrosecond, correct?

MS. NAKAHARA: The question is the millimicrosecond.

A. No, I don't think it would take a millimicrosecond.

Q. Okay, I'm not asking you to calculate exactly how long it would take. Of course it would depend upon velocities and other factors at the time, and that would tend to vary the time arrival of the impact of one pad to the next from a condition where you would assume a static condition where there's an instantaneous transfer of energy. Do I need to rephrase that?

A. Please, I appreciate if you can be very specific.

Q. Okay. One of the concerns you addressed I believe in your testimony yesterday was the potential for non vertically propagating waves to arrive at different pad groups at different times. And in the same line I'm asking you whether if a seismic force was to be directed or to arrive at two adjacent pads at approximately the same time, would that be fairly reasonable?

A. I think it's fairly reasonable.

Q. If there was to be a crushing of the soil cement between those pads, then that would

delay the timing at which the impact of one pad would arrive at the adjacent pad, correct? It wouldn't arrive at the same time as the seismic wave that hits the two pads, correct?

A. I'm sorry. I cannot follow your thinking. I don't understand the question.

Q. Seismic waves travel at great velocities?

A. The velocity that the soil material has at the site, yes.

Q. And it travels in cycles?

A. There are different frequencies traveling in the wave, yes.

Q. If a seismic wave or seismic force was to arrive at two adjacent pads, as you've indicated, virtually simultaneously, correct?

A. Yes.

Q. Then the impact of one pad due to that seismic force, or the motion of that pad due to that seismic force would be somewhat delayed before the impact of that pad being in motion would arrive at the adjacent pad, correct?

A. I'm sorry again. I don't follow your question. I just do not understand.

MS. NAKAHARA: May I ask a clarifying

question? Are you talking about wave with different angle of incidence, or talking about --

MR. TURK: No.

MS. NAKAHARA: -- pad-to-pad interaction?

MR. TURK: Pad-to-pad interaction.

THE WITNESS: Let me explain. Maybe this helps. The pad-to-pad interaction as analyzed by Dr. Soler, the reason you have pad-to-pad interaction has nothing to do with the wave arriving at different times. All waves are arriving at the same time. The reason he has pad-to-pad interaction in his model is because one pad has larger mass, larger wave, and the neighboring pad has a different wave, lighter. As a result, the movement of the pads are different, maybe slightly different. And that causes these additional loads being transmitted to the soil cement.

Q. (By Mr. Turk) Did Dr. Soler take any credit in his analysis for the potential crushing of soil cement between the pads?

A. I don't think so, no.

Q. Incidentally, the 2,300 kips that was discussed previously, is that a combination of the inertial load and the seismic force? I'm sorry.

What does that represent, in your mind?

A. After asking Dr. Soler questions, he indicated that the forces in the spring at the bottom of the pad are the total loads.

Q. Let me state my question in statement form. Maybe I just misunderstand what's happening here. The seismic force that arrives from the seismic source at two adjacent pads --

A. Seismic waves.

Q. The seismic wave. -- will arrive at essentially the same moment at both adjacent pads.

A. Very well.

Q. The concern that I understand you to express is that in addition to the seismic wave and the force that that causes upon the structure upon the pad, in addition to that you may get some additional force imparted to a pad due to the adjacent pad's motion in the direction of that pad of interest. Is that your concern?

A. Let me reiterate the concerns I have. Maybe that helps what we have said in the past. One had to do with the incline waves, and that incline wave, even if you assume all pads are loaded equally and they're all symmetric, the effect of incline wave is to create asymmetric

loading acting on the pads.

Now, this effect is less when you deal with individual pad dimensions. The interval time is very close. But when you look at groups of pads with larger plan dimensions, then their arrival time and delay time could be larger. So that effect would create additional interaction between these groups of pads. This, in my view, has not been addressed or analyzed by any fashion in these documents.

Q. The question I'm asking about today is not non vertically propagating waves as Ms. Nakahara clarified, but I'm asking about the pad-to-pad interaction issue. In summary, my understanding, and I'll ask you to tell me if this is correct, is that because the soil cement will experience this crushing, assuming the force transmitted from one pad to the adjacent pad is strong enough, that that force from the adjacent pad will not arrive at the pad of interest simultaneously with the seismic wave that has reached those pads. There will be some slight delay, correct?

A. I don't think that analogy is quite right. The seismic wave arrives, the casks

vibrate, the pad vibrates. At a specific time during the shaking, let's say 30 seconds of shaking, there is a moment that the loads in within the two pads in soil cement would reach its maximum value. That moment may be in the middle of the 30 seconds, maybe during 10 seconds after shaking, 15 seconds after shaking. It all depends. I cannot see how come the sequence that with the arrival time of the wave, it has arrived and the load has reached its maximum and shaking is going on.

Q. There's a cycling going on, essentially, because the wave is not just a steady constant force being applied, but it's a series of --

A. Of course, yes. It is moving back and forth. And one of those cycles is of course when the soil cement reaches its maximum value.

Q. Is it correct to say that there is no direct additive effect where you can state that if a certain seismic wave arrives, that at precisely that moment a force will be imparted from one pad to the next due to that cyclic seismic wave? Can you agree with that or you can't?

A. I'm afraid you cannot -- it's a very complex situation, a lot of interaction going on with the soil and soil cement.

MR. TURK: I thank you. I have nothing else. I apologize if that was a little lengthy, but it's difficult to get a handle on it.

(The Board confers off the record.)

JUDGE FARRAR: The board has no questions. Is there any redirect by the State?

MS. NAKAHARA: I have a few.

JUDGE FARRAR: Well, I could be dead wrong here, but your witness didn't concede anything, so what more have you got to ask him? Now, maybe my characterization is too flip, but we've got a bunch of witnesses here we're trying to get to.

MS. NAKAHARA: That's fine, your Honor. They're just minor points.

JUDGE FARRAR: Okay. Well, but, I mean, I don't want to cut you off from asking them.

MS. NAKAHARA: That's fine.

JUDGE FARRAR: But we don't need to hear him say again what he's already said. If there's something new you want him to say, we'll have him say that. But --

MS. NAKAHARA: I would like to ask one question.

JUDGE FARRAR: Go ahead.

REDIRECT EXAMINATION

BY MS. NAKAHARA:

Q. Dr. Ostadan, Mr. Travieso-Diaz asked you a question about factors of safety and the need to meet a factor of safety based on consequences. In your engineering practice, is it typical to disregard factors of safety established by codes or guidance based on a consequence?

A. No, it is not typical. In fact, I think it will not be considered proper engineering if you disregard factor of safety.

JUDGE FARRAR: Hold on a minute. Now that I look at my notes and see how long two sets of cross went on, don't feel compelled to listen to what I said before. So go ahead and ask whatever you need to ask.

MS. NAKAHARA: No, that's fine. That was the main point I wanted to make.

JUDGE FARRAR: You sure?

MS. NAKAHARA: Yes.

JUDGE LAM: I share Judge Farrar's sentiment that Dr. Ostadan is a capable witness more than willing and able to defend himself on the

stand, so then I think Ms. Nakahara is doing the right thing by just asking you one question.

JUDGE FARRAR: Because the more you ask, the more the other guys get to ask in response.

MS. NAKAHARA: Unless you're trying to give me a hint.

JUDGE FARRAR: No, but I try not to ever cut people off, but just --

MS. NAKAHARA: I understand, your Honor.

JUDGE FARRAR: I sense we've gotten what we can from this witness. Then let's --

MR. GAUKLER: Your Honor, I do have a few brief points I need to make with Dr. Soler in terms --

JUDGE FARRAR: Wait. We're not to Dr. Soler yet. Then we can dismiss Dr. Ostadan or remove him from the hot seat for now?

MS. NAKAHARA: Yes, your Honor.

JUDGE FARRAR: Thank you, sir. Appreciate your testimony. So now Mr. Gaukler, you want --

MR. GAUKLER: A few brief points to make with Dr. Soler.

JUDGE FARRAR: Which we would call --

MR. GAUKLER: To respond to some of the

things Dr. Ostadan said.

JUDGE FARRAR: Which is so far into the chain of rebuttals that it doesn't even have a name. Go ahead.

MR. GAUKLER: That is probably correct, your Honor.

DR. ALAN I. SOLER,

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

JUDGE FARRAR: Dr. Soler, do you recall previously you were sworn?

THE WITNESS: Yes, I do, your Honor, many times.

DIRECT EXAMINATION

BY MR. GAUKLER:

Q. Dr. Soler, I'm going to ask you a few brief questions about your analysis that has been the subject of discussion today. First of all, you heard Mr. Diaz read into the record claims that Dr. Ostadan had made in his previous testimony in terms of interactions between pads, i.e., that there would be loads created by out-of-phase motion

and these would impact the pads. Correct?

A. Correct.

Q. And the purpose of the model that you developed was to maximize those loads to test that thesis; is that correct?

A. Correct.

Q. And was it ever a purpose of your model, modeling that you did to evaluate the adequacy of the structural design of the pad?

A. No.

Q. Now, what steps did you take in order to provide a maximum force pad-to-pad interaction force being represented by the soil cement?

A. First of all, I made sure that there was the greatest mass difference between the two pads, assuming that there was at least one cask on each pad. Secondly, I maximized the Young's Modulus of the soil cement.

Q. Excuse me, Dr. Soler. With respect to one cask on one pad and eight casks on the other pad?

A. It's the maximum mass difference.

Q. Okay. So that would match the out-of-phase motion?

A. Correct.

Q. Go ahead.

A. Secondly, I assumed a maximum value for the Young's Modulus of the soil cement. This would maximize the stiffness and therefore maximize the force on the spring.

Thirdly, I did not assume any force transfer between the soil cement directly into the soil. Any forces developed in the soil cement between the pads went directly to both pads on either side of that spring.

And lastly, I did not assume any damping in the soil -- in the springs that represented the soil cement between the pads.

Q. And the purpose was to maximize this pad-to-pad interaction?

A. All four of those will maximize that force.

Q. Now, you heard Dr. Ostadan express concern in his testimony about this one -- the pad with the one cask on, I think he said it was about 1,500 kips for the pad and the casks. Is that approximately --

A. That sounds about right.

Q. And he stated you have 1,900 kips of force, pad-to-pad interaction force --

A. That's correct.

Q. -- acting upon it, and you couldn't see how you wouldn't have some type of problem with that. Do you remember that testimony?

A. Yes.

Q. What did your model show in that respect?

A. My model showed that the force in the soil underneath the pad and the soil springs underneath the pad did not exceed 2,300 kips.

Q. Now, what did it show with respect to the stability of the casks?

A. It showed that the movement of the cask was the same order that we have been obtaining in all analyses using the 2K earthquake.

MR. GAUKLER: No further questions.

JUDGE FARRAR: Mr. Turk?

MR. TURK: One quick one.

CROSS-EXAMINATION

BY MR. TURK:

Q. Dr. Soler, you say you assume no damping in the springs between the pads. Does that mean you took no credit for any potential crushing of the soil cement?

A. That is correct.

MR. TURK: That's it.

JUDGE FARRAR: State?

MS. NAKAHARA: I have a couple.

JUDGE FARRAR: Go ahead.

CROSS-EXAMINATION

BY MS. NAKAHARA:

Q. Dr. Soler, in your attempt to maximize the pad-to-pad interaction with the one pad, one cask, adjacent to the pad with eight casks loaded on it, what position is the single cask on the adjacent pad?

A. In terms of my notation that I've consistently used, it is in location No. 5.

Q. And what is your basis for selecting that particular location?

A. I asked Mr. John Donnell from PFS had he decided how they would load pads in what sequence. He said most likely they would load the first cask as close to the center of the pad as they could so as to minimize any eccentricities. I had a choice of four locations that would fit that bill. I arbitrarily chose position 5.

Q. Do you know if PFS will have a license

condition that requires PFS to load in the center of the pad initially?

A. I do not know.

Q. And assuming PFS would not load in the center of the pad, what would be the worst case for pad-to-pad interaction for the location of a single cask?

A. In my engineering judgment, I think it is immaterial where you put that first -- that one cask on the pad. My primary reason for this model was mass driven, not location driven.

Q. Did you conduct any analyses with a single cask located in what you have used as the first position?

A. Only with respect to the 10,000-year earthquake. One of the simulations in the beyond design basis report was a single cask in position number one. The rest of the pad was empty.

Q. I'm sorry, let me clarify: with the pad-to-pad interaction.

A. No. I've only run the cases in that report.

MS. NAKAHARA: Thank you. I have no further questions.

JUDGE FARRAR: All right, Mr. Gaukler,

do you have any?

MR. GAUKLER: No, I have no follow-up.

JUDGE FARRAR: All right, then we're -- Dr. Soler, you're once again excused momentarily. Where are we now? Dr. Wen --

MR. GAUKLER: We're ready to call our next witness, Dr. Wen Tseng.

JUDGE FARRAR: Should we jump right into that?

MR. GAUKLER: I would suggest taking a short break.

JUDGE FARRAR: It's almost 20 after. Let's come back at half past and see how much progress we can make.

(A recess was taken.)

JUDGE FARRAR: Dr. Tseng, you've been sworn before, so consider yourself still under oath, please.

DR. WEN S. TSENG,

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

DIRECT EXAMINATION

BY MR. GAUKLER:

Q. Dr. Tseng, do you have in front of you a document entitled Rebuttal Testimony of Wen S. Tseng on Section D of Unified Contention Utah L/QQ dated June 7, 2002?

A. I do.

Q. Was this testimony prepared by you or under your supervision?

A. Yes.

Q. Do you adopt this testimony as being true and correct of the rebuttal testimony in this matter?

A. Yes.

MR. GAUKLER: Your Honor, I move that the rebuttal testimony of Wen Tseng be bound into the record as if read.

JUDGE FARRAR: Any objection from the State?

MS. NAKAHARA: No objection, your Honor.

JUDGE FARRAR: Staff?

MR. TURK: No, your Honor.

JUDGE FARRAR: Then the testimony will be bound in as if read.

(Rebuttal testimony of Dr. Wen S. Tseng follows.)