design calculation prepared by ICEC?

DR. TSENG: Yes, I did.

Q. Are you familiar with the PFS site specific Hi-storm drop tipover analysis performed by Holtec?

DR. TSENG: I did not review in detail but I'm aware there is such a document, yes.

Q. Are you aware that the purpose of that document is to determine the deceleration experienced by the spent fuel in the Hi-Storm 100 system during postulated vertical drop and tipover accidents?

DR. TSENG: I understand that is the objective of that document.

Q. Are you aware that the design basis deceleration or acceptance criteria stated in the calculation is a maximum deceleration of 45 g's?

DR. TSENG: That, I'm not aware.

MS. NAKAHARA: I should ask the question first to opposing counsel. This Hi-Storm drop tipover analysis is proprietary; correct?

MR. GAUKLER: It's proprietary. You can ask questions about it if you want to.

MS. NAKAHARA: Can I show Dr. Tseng --

MR. GAUKLER: Yes.

MR. TURK: May I ask what portion of the testimony it relates to?

MS. NAKAHARA: Pad flexibility. Dr. Tseng's opinion that the pad is rigid.

MS. CHANCELLOR: Your Honor, I'd like to bring up a point in terms of confidential documents so we know how to handle them. We have obtained some documents from PFS under a confidentiality agreement and the Holtec documents are a case in point. And what we have done in the past is to submit those, anything relating to those documents to the Board as a proprietary filing and then we rely on PFS to submit an affidavit to state that the document meets the trade secrets or whatever. And part of our testimony, in Dr. Khan's testimony, there was a question that we did file as a proprietary question. So we can work that out with PFS, but I just wanted you to be aware of how we have handled this.

JUDGE FARRAR: Okay.

MR. GAUKLER: I meant to talk to counsel for the State before today and I forgot. I think we can reconcile it and there should be no problem.

MS. NAKAHARA: May I approach the witness?

JUDGE FARRAR: Yes.

MR. TURK: Your Honor, I won't object, these are not my witnesses. But I don't understand how this proposed exhibit or this document relates to anything that these witnesses are talking about in their testimony. And what I perceive happening is this is the Applicant's first panel of witnesses. That doesn't mean they are the witnesses for all issues under the contention but it seems like the State is asking them questions that really should be directed to other panels of witnesses. I looked at the pad rigidity discussion and I don't see the discussion of the deceleration rate for casks in a seismic event.

JUDGE FARRAR: Let's see if we can get a better answer to your question when you say what part of your testimony does it relate to. Do you have a question or answer or section of their --

MS. NAKAHARA: No. It relates in general to the pad flexibility, Dr. Tseng's opinion that the pad would behave as a rigid mat in the cask stability analysis. And these questions directly go to the basis for Dr. Tseng forming his opinion.

JUDGE FARRAR: Someone help us. Where

does he talk about that in his testimony?

MR. GAUKLER: He does not talk about --

JUDGE FARRAR: Wait, wait. Give them a chance to say whether they think he does.

MS. NAKAHARA: 65 discusses rigidity of the pad. I think there were other sections, to my recollection. And Dr. Tseng also uses his ICEC's design calculations to estimate maximum deflection in support of his opinion that the storage pad behaves as a rigid object.

JUDGE FARRAR: Let's see Question 58 and Answers 60 and 65, I think you said?

MR. GAUKLER: He discusses pad flexibility but he never represents his calculation or refers to it or relies upon it or describes it.

MR. TURK: Based on my reading of the testimony, I think the question should be directed to the Singh and Soler panel which talks about cask tipover and cask response. I don't think every question is fair to raise with every panel.

MS. NAKAHARA: Your Honor, it doesn't help me establish the basis for Dr. Tseng's opinion. I'm not asking how the calculation was performed. I'm asking whether he is aware of what the purpose was and some of the design criteria for that analysis. Acceptance criteria. And on Page 19, starting with Question 58, there is an entire section that discusses pad rigidity.

MR. GAUKLER: There's no question we discussed pad rigidity in Dr. Tseng's testimony. But the tipover calculation is not part of it and doesn't rely upon it, doesn't refer to it, doesn't discuss it, and it has nothing to do with it. Nothing to do with the basis of this analysis.

JUDGE FARRAR: Ms. Nakahara, where is the exhibit you were just going to approach the witness with?

MS. CHANCELLOR: I approached, Your Honor.

JUDGE FARRAR: Did you give it to us?

MS. NAKAHARA: I'm sorry. I only have one copy. If it will help, I will explain what I'd like Dr. Tseng to look at in that document. It's basically the acceptance criteria and the input material properties used in that document as opposed to what Dr. Tseng considered in the design of the storage pads in his calculations or his opinion on pad flexibility.

JUDGE FARRAR: Consistent with the prior ruling, we are going to give the State some leeway here, and let me say again why we are doing this. This testimony, the four sets of panels, at least as I read it, is complex and interrelated. It is very difficult to draw the hard and fast lines that some of these rulings are asking us to make. When witnesses talk about a subject, we are hesitant to say we can't examine them on something related to that subject because the questioning is really going in another direction. I think we have got to allow some leeway to do this, to ask these questions. It may be for background, it may be for a specific limited subject. And again, I urge the witnesses, and all the future witnesses anxious for their turn over there, if this is beyond what you worked on, just say so and that's the end of the discussion. If you want to volunteer that so and so of your colleagues is better equipped to answer that, that would help all of us. You won't be offending the Board if you -- I would rather you say you are not comfortable talking about it than that we tell the State or any other party that they can't talk to you about it. So with that, we will overrule the Staff's and the Applicant's objection.

MS. NAKAHARA: Your Honor, may I offer that if opposing counsel is willing to stipulate to the maximum deceleration acceptance criteria, the input properties as 4200 psi concrete for a three-foot pad and input parameter of 75,000 psi for a two- foot treated soil cement layer, followed by the 26-foot thick 6000 psi soil, and the seven-foot thick 12,000 psi soil, and that the document assumes a 28 day compressive strength of 3000 psi, I can skip a lot of the formalities of asking Dr. Tseng to look it up so I can determine whether he considered some of these issues when he formulated his opinion.

JUDGE FARRAR: Before you all answer, we had urged a long time ago that you enter into as many stipulations as possible. You did that in one aspect and then said it was probably more effort to enter into stipulations than to proceed with the case. So I am not urging you one way or the other. But is this a scenario where a stipulation would simplify things?

MR. GAUKLER: I'd have to check with my technical people. I can't do it on the spot.

MR. TURK: I'd like to see it on paper and show it to our witnesses and see if we can do it.

MS. NAKAHARA: I only have three

questions. I can go ahead and ask.

JUDGE FARRAR: Let's ask the questions. Thanks.

MS. CHANCELLOR: May I approach the witnesses?

JUDGE FARRAR: Certainly.

Q. Dr. Tseng, is it correct that you have before you the PFS site-specific Hi-Storm drop tipover analysis?

DR. TSENG: That's correct.

Q. Please turn to Page 8. And if you will look under the acceptance criteria, Section 3. Will you state what the design basis deceleration of the Hi-Storm 100 system is?

DR. TSENG: You would like me to read it out loud?

Q. How about if I do it this way: Is it correct that the design basis deceleration of the Hi-Storm 100 system is 45 g's?

MR. GAUKLER: Excuse me. What are you reading from, Counsel?

MS. NAKAHARA: Section 3, Acceptance Criteria.

MR. GAUKLER: Okay.

DR. TSENG: Yes. Section 3, Acceptance

Criteria, is on this document. It does say that the deceleration experienced by the soil field of Hi-Storm 100 system during each of the postulated vertical drop and tipover accidents must be below the design basis deceleration of 45 g's specified in table 3.1.2 of the FSAR 11.5.

Q. Dr. Tseng, if you will turn to Page 8 under the Section 5.0, Input Data.

DR. TSENG: Yes.

Q. If you will read that first sentence.

DR. TSENG: Site specific ISFSI pad at PFSF consists of, starting from top of the pad, a layer of three-feet thick 4200 psi concrete pad, the two-feet thick 75,000 psi soil cement, followed by the 26-foot thick 6000 psi soil, and the seven-foot thick 12,000 psi soil.

Q. And then if you will look at the next paragraph, starting, "The nominal 28 day compressive strengths." If you will read the first two sentences, please.

DR. TSENG: Nominal 28 day compressive strength of the Hi-Storm 100 over pack concrete is 3000 psi. Two additional compression strengths (i.e. 3600 psi and 4200 psi) are used in the tipover simulations.

Q. Thank you. And then if you will turn to Page 17 under Section 10.

DR. TSENG: I don't have 17 here.

Thank you.

Q. If you will look under Section 10, I believe it is Summary and Conclusions.

DR. TSENG: Yes.

Q. You will insure that this is the same document that we have been talking about?

DR. TSENG: Yes.

Q. If you will read the second sentence under Section 10, please.

DR. TSENG: Second sentence reads, "The results from the tipover analysis demonstrated that the maximum deceleration at the top of the active field region is 43.82 g's for the case with 28th day compressive strengths of the cask. Concrete is 3000 psi which is below the Hi-Storm design basis variable of 45 g's."

Q. Thank you. Isn't it correct that the maximum deceleration calculated in that document is 1.18 g below the 45 g acceptance criteria?

DR. TSENG: Based on this number, yes.

Q. And you can probably do it in your head but I won't ask you to. If you assume that 1.18 g is about 2.6 percent, based on this margin of 2.6 percent below the acceptance criteria, isn't it true that any increase in the stiffness of the pad in the vertical direction could potentially cause exceedence of acceptance criteria for maximum deceleration?

DR. TSENG: I couldn't render that conclusion just based on this number because I do not know how all these calculations come to these g's.

Q. In your opinion do you believe the pads must have an amount of flexibility to meet the maximum deceleration acceptance criteria based on the inputs to the drop tipover analysis that you just read?

DR. TSENG: Could you say that again? I didn't understand.

Q. Probably because I didn't read it right. Sorry. In your opinion, do you believe that the pads must have an amount of flexibility to meet the maximum deceleration acceptance criteria specified in the Holtec drop tipover document based on the inputs that you just read?

DR. TSENG: Again, I do not know all the analysis that go into to come to this number. But

I can render my own thinking in this. I think tipover at the point of g depends very much on the local point. It may or may not be related to the entire pad flexibility. I think it is more related to the contact points. That is just my opinion, not based on what I have read thus far.

Q. Dr. Tseng, in response to Question 11, is it correct you indicate you are familiar with the site-specific soil characteristics at the PFS site?

DR. TSENG: Excuse me. You are referring to Question 11?

Q. I'm sorry, yes. Are you looking at your testimony?

DR. TSENG: Yes.

Q. If you look in the second paragraph. I'm sorry.

DR. TSENG: Yes.

Q. Please describe your understanding of the soil conditions at PFS.

DR. TSENG: The soil condition? You are asking the soil condition?

Q. Yes.

DR. TSENG: The pad is three foot thick, supported on cement-treated soil between one to two feet thick, and then supported on the in situ soil below that.

Q. Can you describe the in situ soils beneath the cement-treated soil?

DR. TSENG: For the dynamic analysis, it is characterized by a profile of shear wave velocities, mass density profiles, as well as soil damping profiles. And that's all documented in the ICEC calculation.

Q. Do you have an opinion whether the soils are compressible?

DR. TSENG: I can render an opinion whether the soil is, based on the shear velocity presented for design, whether it is high or low. And based on the shear wave velocity profile that I have seen in the calculation, I think going to somewhat softer sites.

Q. Do you agree there is a silty clay layer beneath the PFS site?

DR. TSENG: I beg your pardon?

Q. Do you agree there is a silty clay layer beneath the PFS site? And for the record, Dr. Tseng, would you identify what document you are looking at please?

DR. TSENG: I'm reading the ICEC

calculation where they say a page, describe this site.

Q. Thank you.

DR. TSENG: Yes, there is a silty clay layer beneath the site.

Q. On what page is that? I'm sorry.

DR. TSENG: This is Figure 1 in ICEC calculation, Page 10. This site soil profile which was based on Reference 1. Reference 1 of the calculation is PFS project design criteria.

Q. Thank you. What is the long-term settlement characteristics of the silty clay layer, if you know?

DR. TSENG: I'm not a soil expert, so I cannot render an opinion on the long-term settlement part.

Q. Did ICEC account for the short-term and long-term total differential settlement in the design of the pad?

DR. TSENG: In our design, the design combination were seismic conditions, dead load, live load, and snow load. Long-term settlement is not in our calculation.

Q. And your answer, your response to Question 27 --

DR. TSENG: Yes.

Q. Is it correct you stated at capacity PFS would have 500 storage pads?

DR. TSENG: Yes. That's my understanding.

Q. Excuse me. Isn't it true that the 500 pads will not be loaded with casks simultaneously?

DR. TSENG: Presumably they will be loaded as the casks come, but I don't know whether one or how they will be loaded simultaneously.

Q. Did you consider the effect of settlement caused by the pad being recently loaded from the previously loaded adjacent pads?

DR. TSENG: Could you state that again?

Q. Let me try and ask it a little more understandably. Assuming that the pads are not simultaneously loaded, did you consider the effect of settlement caused by the pad being loaded on -- strike that and let me try this one more time.

Assuming that the pads are not simultaneously loaded, did you consider the effect of settlement caused by the pad or by a pad recently loaded on a previously loaded adjacent pad?

DR. TSENG: The specific condition you

talk about was not addressed. But the design is for the pad capacity or capability to resist the cask loading.

Q. Isn't it correct that ICEC considered concrete cracking in its design analysis of the pad?

DR. TSENG: In designing strengths of the concrete, yes, the cracked section is assumed.

Q. Where did you -- is there any place in your calculation that you can point to that specifically addresses concrete cracking?

DR. TSENG: In the design section of ICEC calculations, Section 6, the capacity of the concrete section is presented. The calculation was based on cracked section of concrete. And that's for just following the conventional design for designing concrete, you have to assume cracked section for conservatism.

Q. Thank you. In response to Question 70, is it correct that you state the amplitude of displacement of the pads is in the order of 3/8th of an inch?

DR. TSENG: The largest displacement under the earthquake condition was 3/8th of an inch. And that's a dynamic condition.

Q. And do you derive the 3/8ths-inch displacement from Page 34 of ICEC's calculation table D-1(d) for the lower bound for an eight cask condition? And for the Board's convenience, that's included in PFS's Exhibit 85.

MR. GAUKLER: Page 234?

Q. Yes. Page 234, and Exhibit 85. And while Dr. Tseng is checking, if I may have two exhibits marked.

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

JUDGE FARRAR: Yes.

(Discussion off the record and EXHIBITS-170 AND 171 WERE MARKED.)

JUDGE FARRAR: Back on the record, please. Ms. Nakahara just had the court reporter mark two exhibits as 170 and 171. Is that right?

MS. NAKAHARA: Yes, that's correct.

JUDGE FARRAR: And 170 is an excerpt from PFS Exhibit 85?

MR. GAUKLER: It includes some pages that are not in PFS Exhibit 85.

MS. NAKAHARA: And there are some duplicate pages.

JUDGE FARRAR: So we will avoid

reference to PFS 85. But that's the ICEC calculation cover sheets. And then 171 is tables on vertical soil bearing pressures? Is that right?

MS. NAKAHARA: Yes.

JUDGE FARRAR: Then those have been marked for identification. Go ahead.

Q. (By Ms. Nakahara) Dr. Tseng, if you will look at State's Exhibit 170, Page 20, is it correct that this is a schematic of node numbers for a storage pad?

DR. TSENG: That's correct. This is a node number of the model that we used to analyze the pad.

JUDGE FARRAR: Ms. Nakahara, this is the document that says "calculation sheet" on it and has sheet number 20?

MS. NAKAHARA: Yes.

JUDGE FARRAR: Okay. Thank you.

Q. I'm looking at sheet 20, thank you, Your Honor. And is it correct that nodes 7, 150, and 293 --

DR. TSENG: Yes.

Q. -- correspond to the center line of the pad along the longitudinal axis?

DR. TSENG: That's correct.

Q. And if you will look at State's Exhibit 171, which is a table that the State created based on the data in State's Exhibit 170 from the ICEC calculation sheet number 234, will you verify that we have transferred the numbers correctly for nodes 7, 150, and 293 for the lower bound eight cask case?

DR. TSENG: Yes, I verified it.

Q. And if you will look at the first page of State's Exhibit 171. Isn't it correct that the displacements for -- isn't it correct the displacements in the center which these nodes represent of the pad in the longitudinal direction -- strike that.

Isn't it correct that the displacement in the center, node 150, is approximately 1.5 to 2.5 times smaller than the displacements at the two ends?

DR. TSENG: Based on this number, this is maximum displacements, and the maximum, yes. They are smaller at the center and larger at the two ends. But these numbers don't necessarily occur at the same time.

Q. If you will look back at State's Exhibit 170, on sheet 20, for nodes 1, 144, and 287.

DR. TSENG: Yes.

Q. Is it correct that these nodes are on the left side of the pad along the longitudinal axis?

DR. TSENG: That's correct.

Q. And now if you will turn to the second page of State's Exhibit 171, would you verify whether the maximum displacements for the lower bound eight cask case for nodes 1, 144, and 287 are consistent with ICEC's values from page or sheet 234 of State's Exhibit 170?

DR. TSENG: Yes, I verify that.

Q. And if you will look at sheet 20 again, I apologize, isn't it correct that the displacement for -- strike that.

If you will look at the second page of State's Exhibit 171.

DR. TSENG: Yes.

Q. Isn't it correct that the displacement for node 287, which is at the left corner, which you will want to refer to sheet 20 from State's Exhibit 170, is about half the displacement than the other two nodes along the same left edge?

DR. TSENG: Yes. Based on this maximum value, the maximum value at 287, that's the corner, one corner, is about half of the other. Again, I want to verify those are the maximum value, and they don't necessarily occur at the same time.

Q. And I only have one more exercise. Will you look at State's Exhibit 170, sheet 20, and locate nodes 13, 156, and 299.

DR. TSENG: Yes.

Q. And is it correct these nodes are on the right side of the pad along the longitudinal axis?

DR. TSENG: Yes.

Q. And now if you will turn to State's Exhibit 171, third page, and verify that the maximum displacements for the lower bound eight cask case for node numbers 13, 156, 299 are correctly taken from ICEC's calculation sheet 22, State's Exhibit 170.

DR. TSENG: Yes, I verify that.

Q. And isn't it correct that these displacements on the right side of the pad are essentially the same?

DR. TSENG: The variations are smaller, yes.

Q. Dr. Tseng, you indicated that the displacements are maximum displacements; correct?

DR. TSENG: The number on Exhibit 171

that transcribed from ICEC calculations were all maximum values, and they occur at particular instances of time. Each node may have its own particular maximum time that it will occur.

Q. If the pad is rigid, wouldn't the displacements be the same regardless at what point in time they occur?

DR. TSENG: If the pad is rigid and translates vertically, constrained to move vertically, then yes, they will be the same. On the other hand, given the pad is rigid, they will allow for six degrees of freedom movement, there still would be variation across the length as well as across the width.

Q. Isn't it true, based on the maximum displacements in State's Exhibit 171, that the pad is deforming along the longitudinal axis?

DR. TSENG: Yes, they are deforming along the longitudinal axis as well as the transverse axis.

Q. Isn't it also true that there is nonuniform displacement along the longitudinal axis of the pad?

DR. TSENG: There is slight variations due to the variation in the dynamic loading conditions, and this is really to be expected. But the number of variation is a very small amount. As you have marked here, the numbers are in terms of ten to the minus 3, which is .001 feet. So it is a small number. As indicated here.

Q. Isn't it true that as the pad settles due to short- and long-term settlement, that the pad will become dish-shaped or concave down along the longitudinal axis?

DR. TSENG: The shape of deformation and the long-term loading, depends on how the pad has been loaded. If they were loading certain patterns then they would deform more in conforming to that pattern.

Q. Do you agree that there will be additional deformation of the pad due to settlement than what ICEC calculated on sheet 234, State's Exhibit 170?

DR. TSENG: Sheet 234 only tabulated the dynamic loading and the earthquake conditions. Certainly it does not include other loading such as elastic deformation due to dead load and live load. They were tabulating different tables in ICEC calculations.

Q. Thank you. Just to clarify, have you

quantified any of those static deformations?

DR. TSENG: I believe in the ICEC calculation table labeled as Tests, it should contain the -- I'm referring to ICEC calculation sheet number 229. And 229 has a Table S-2. That calculates the maximum vertical displacement and soil bearing pressures under live load conditions. And sheet 228, table labeled as S-1, tabulated maximum vertical displacements and soil bearing pressure under a dead load condition.

Q. The values on sheet 228, the dead load values, are those short-term elastic settlement calculations or are they long-term consolidated calculations?

DR. TSENG: It is a short-term elastic, a short-term deformation.

Q. And just to clarify one more time, your analysis did not include any long-term settlement calculations?

DR. TSENG: It's not part of our load combinations.

JUDGE FARRAR: Ms. Nakahara, did you just refer to a sheet 228?

MS. NAKAHARA: Yes. I'm sorry. These are not included in the exhibit, 228 and 229.

Q. (By Ms. Nakahara) Dr. Tseng, does the displacements on Page 234 include the effect of concrete cracking in your maximum displacement calculations?

DR. TSENG: It doesn't expressly include concrete cracking, but there is a modulus of concrete being included as a whole section. And that modulus was used in the dynamic analysis and there are the result of reflecting that modulus value.

Q. If you know, what was the value of that modulus?

DR. TSENG: The modulus value used is presented in ICEC calculation sheet number 22; specifically, that if concrete Youngs modulus equal to 3122 ksi, for 3000 psi compressive strength concrete.

Q. Is the 3122 ksi, is that the concrete strength for the modulus for the concrete cracking condition?

DR. TSENG: No. This is just the modulus value for the concrete material.

Q. And if Your Honors would like copies of these pages Dr. Tseng is referring to, we would be happy to enter them, if you find it has any value to you.

JUDGE FARRAR: If you think we need it for the completeness of the record, we would be happy to have them. If not, we don't have to.

Q. Okay. Dr. Tseng, do you still have State's Exhibit 168 --

JUDGE FARRAR: This is a new subject?

MS. NAKAHARA: No. It still goes with flexibility.

JUDGE FARRAR: Okay.

Q. (By Ms. Nakahara) Out of the Safety Analysis Report, which provides PFS's estimate of maximum total settlement --

DR. TSENG: Are you referring to the Safety Analysis Report?

Q. Yes. Page 2.6-50 and 51.

DR. TSENG: Yes, I do.

Q. Based on PFS's estimate for maximum total settlement, isn't it correct that the pad deflection is larger than the 3/8ths inch that you calculated?

MR. GAUKLER: Objection. Identify what he testified to before, and this is going off on a different thing entirely.

MS. NAKAHARA: Your Honor, if I may

respond.

JUDGE FARRAR: Go ahead.

MS. NAKAHARA: This goes to the flexibility; and Dr. Tseng, as I represented earlier, Dr. Tseng's opinion on whether the pad is rigid or, in fact, flexible.

JUDGE FARRAR: Okay.

MS. NAKAHARA: And the assumptions that he considered.

JUDGE FARRAR: I think we need a more specific question about what you are asking him. But on this line, maybe it would be a good time for a question I had. On this State's Exhibit 171 which has the different charts, just to get a range so we know what we are talking about in terms of inches, am I correct that, for example, node 13, which is 31.22 times ten to the minus three feet, is that essentially 3/8ths of an inch?

DR. TSENG: That's .03 feet and then times twelve. That's about .036. I'm sorry. It's .36 inches, roughly 3/8ths of an inch, yes.

JUDGE FARRAR: Does that help clarify? Now when you switch to State 168, does that help ask a more specific question?

MS. NAKAHARA: Let me have one moment.

Q. (By Ms. Nakahara) Isn't it true, Dr. Tseng, that you did not consider static settlement in your analysis of pad deflection?

DR. TSENG: The testimony on the seismic behavior of the pad is strictly dynamic conditions. And the number cited in our testimony under the dynamic conditions, as you have tabulated in this State exhibit as well as in ICEC calculations, the flexibility behavior is relating directly only to the seismic behavior which is what would affect the cask's response. So whether the static or long-term has an effect on the seismic behavior, I think that is not part of this testimony.

Q. I understand it is not part of your testimony. But isn't it true that there could be some static settlement of the pad, causing deformation prior to a seismic event?

DR. TSENG: Yes. I think there will be some static -- there will be static deflections prior to earthquake conditions.

Q. Is it your opinion that settlement, prior settlement of the pad, will have no impact on the casks' response to a seismic event?

DR. TSENG: The testimony referred to just entered dynamic conditions, the pad will behave or will move. Whether it will move more like a flexible pad or if the flexibility is small, it will be close for a global response, which I will refer to will be the response of the entire pad interacting with the casks and so on. That was the part of the opinion we tried to draw, not in terms of long-term and other load conditions that will be rigid or flexible. And it is true that all the structure will be somewhat flexible, specifically under different loading conditions. But the effect of the flexibility on the earthquake behavior of that particular pad characterized in terms of some of the contention that the foundation, flexibility on the foundation stiffness per se and the flexibility on the foundation damping or energy dissipation, that's the part we are rendering our testimony here.

Q. Dr. Tseng, you referred to a global response determination for a cask response analysis. Is that correct?

DR. TSENG: It is the global response of the pad, per se, and of course the pad is supporting the casks so it will involve the cask response.

Q. Dr. Tseng, isn't it true that you have not quantified the actual effects of modeling the storage pad as a flexible structure on cask response?

DR. TSENG: That's correct. We have not modelled or analyzed the cask response due to pad flexibility. Our opinion is based on the pad flexibility effect on the input parameters to cask analysis. And based on the effect of those input parameters, we ran whether it is significant or insignificant.

MS. NAKAHARA: And as a procedure, Your Honor, that I continue to forget, I'd like to move into the record State's Exhibit 170 and 171.

JUDGE FARRAR: Any objection?

MR. GAUKLER: No objection, Your Honor.

MR. TURK: No, Your Honor.

JUDGE FARRAR: All right. 170 and 171 will be admitted.

(STATE'S EXHIBITS-170 AND 171
WERE ADMITTED.)

Q. (By Ms. Nakahara) If the pad is indeed rigid, do you agree the springs along the edge of the pad are much stiffer than the ones at the middle or in the middle?

JUDGE FARRAR: Did you say the springs?

MS. NAKAHARA: Yes. Soil springs.

DR. TSENG: If a perfectly rigid pad resting on a half space foundation, yes, the spring value near the edge will be larger than near the center.

Q. Will you explain how you distributed your springs in the ICEC calculation?

DR. TSENG: Our springs were based on the lump spring for the entire pad. And then for our pad design purpose, which is not the same as global response, that we need to obtain the internal stresses to the pad. For that purpose we distributed a spring uniformly across the pad. And that is only for structure analysis purpose, to obtain the internal stresses in each pad.

Q. And is it correct if you do not uniformly distribute the springs across the pad, in your opinion do you believe the relative deformation of the pad will be more than ICEC indicated on Page 234 of State's Exhibit 170?

DR. TSENG: Well, I think there is a difference between perfectly rigid, which is very rigid, almost mathematically rigid. In those cases, then of course distribution will be, like I say earlier, that the spring near the boundary will be higher than in the center. But in real structures would have some degree of flexibility. And the degree of flexibility, whether it is important to certain particular behavior, in this case the seismic response of the pad, may or may not be the case. Distribution of soil spring uniformly is for the purpose of designing the pad. It may not imply whether this is flexible or is rigid.

Q. Thank you. Dr. Tseng, will you remind me, did you use SASSI to evaluate the foundation flexibility effects on soil spring and damping for the site specific condition at PFS?

DR. TSENG: We did run SASSI to validate the ICEC Sup computer analysis for design of the pad. But that validation run was not as you characterize validation for severity of the pad. It is to validate under the same loading condition would the two approaches give reasonable consistent results so that if so, then we can then go ahead to use the ICEC sup computer program, which is more adaptive to structure design analysis, to continue to do all the rest of the analysis.

Q. Thank you. And isn't it true that you stated in your deposition -- strike that.

Do you believe that the soil cement and the pad are not structurally integrated and cannot be viewed as an integrated mat?

DR. TSENG: For -- because there are no structural or reinforced elements going across that, structurally they are separate.

Q. In your testimony, and I don't have a reference, do you recall that you state some passive resistance is provided by the soil cement abutted to the pad?

DR. TSENG: I don't recall.

Q. If you will look in the vicinity of your response to Question 80, Page 27. Is it true that you state during the seismic event the majority of the soil resistance to pad motion is from the resistance of soil underneath the pad, and only relatively very small amount of resistance will be contributed by the side soil?

DR. TSENG: In the answer or response to Question 80, I did testify that if the pad sliding stability is a factor safety of more than one, then the pad would be, then resist more by the soil underneath the pad. The majority of that resistance will come from below the pad. The soil below the pad.

Q. And do you agree that the pads are five feet apart in one direction; longitudinal direction?

DR. TSENG: Yes. I'm aware that the spacing between, clear space in between pad in a longitudinal direction is five feet.

Q. Isn't it true that the passive resistance of one pad becomes an active force on the next pad because the pads are only five feet apart?

DR. TSENG: That may or may not be the case, depending on how much resistance is being invoked out of the side soil. Since the pad has a dimension of 30 feet by 67 feet, which is close to 2000 square feet of contact area underneath the pad, with the underlying soil. That would provide the bulk of the resistance for this pad. The side soil is three feet tall and in the long direction would be only 30 feet long. And it should provide relatively small amount of resistance to the pad.

Q. Did you quantify that amount?

DR. TSENG: We did not do or express an amount to say how much would be, because for conservatism the design was purely based on resistance, only resists by soil beneath the pad.

Q. Do you know how much strain is required to mobilize that resistance?

DR. TSENG: I did not make that calculation.

Q. Dr. Tseng, is it correct that the time history of forces acting on the pads that you used or ICEC used in the pad design were generated and obtained from Holtec's cask stability analysis?

DR. TSENG: That's correct.

Q. Did you examine the force time histories to see if there is sliding and separation between the pad and the casks?

DR. TSENG: The time history per se presents a history of vertical and horizontal force, at the contact point of the casks on the pad. Some time history, once you examine them, you could identify there will be up lift or impact down. Sliding, you may or may not be able to see. If they are a constant force, at a certain time, then you could infer that there would be sliding. But I strictly examine; you cannot tell exactly one and at what time the sliding would occur.

Q. Can you tell whether sliding occurred for a short period or an extended period, not when it occurred, by evaluating the force time histories?

DR. TSENG: Just by looking at it, I think generally the sliding would be only short time. Short time duration.

Q. In your opinion, would any separation that occurs between the cask and the pad, would that be for a short period or an extended period?

DR. TSENG: I did not catch the first few words.

Q. In your opinion, if separation between the cask and the pad occurred, would that be for a short period or an extended period?

DR. TSENG: Did you say separation?

Q. Yes. Separation between the cask and the pad, if it occurred.

DR. TSENG: I first have to clarify, your separation means at one point? Or you mean the whole cask separated?

Q. Uplifted from the pad. The cask is uplifted?

DR. TSENG: So it is a partial uplift, tilting of the casks?

Q. Yes.

DR. TSENG: It will have some frequency of its own and obviously separation would be of a short duration at the peak of that cycle. So it should be a short duration.

JUDGE FARRAR: Ms. Nakahara, just to make sure the record is clear, maybe the witness understood it but were you talking total vertical separation or were you talking tilting?

DR. TSENG: Tilting.

JUDGE FARRAR: You understood it as tilting?

DR. TSENG: Yes.

MS. NAKAHARA: For the record, I didn't.

Q. (By Ms. Nakahara) In the force time histories, Dr. Tseng, did you observe any impact loading upon the closing of the gap after tilting?

DR. TSENG: When the casks presumably tilt and come back down, you would generally observe a sharp repeat in the forcing function. And we do observe the presence of some of the sharper peaks.

Q. Dr. Tseng, is it correct that ICEC could have used, as input into their pad design, that they could have used the free field time histories generated by Dr. Youngs directly into your soil structure interaction analysis, hypothetically?

DR. TSENG: If the cask rests on the

pad, does not experience sliding or uplifting or partial tilting, uplifting, by uplifting I mean tilting, then we could do that. But since the casks in the seismic conditions have the possibility of sliding as well as tilting or uplifting, partial uplifting, then we could not generate that without going through the same type of analysis that Holtec International had done. And so that's why we obtained these forcing time histories directly from Holtec's analysis.

Q. And isn't it correct that your contract with PFS required you, required ICEC to use the force time histories generated by Holtec?

DR. TSENG: That's the scope statement, yes.

Q. In response to Question 88, is it correct you discussed the necessity to obtain spring and damping values in a manner suitable for nonlinear analysis?

DR. TSENG: Is that question --

Q. Is it correct that you discussed that in this response?

DR. TSENG: Yes. In answer to Question 88 we discussed the derivation of soil springs, dashpots, and virtual soil masses, parameters for

Holtec's analysis.

Q. Isn't it correct that this methodology you refer to by Newmark and Roseblueth, R-O-S-E-B-L-U-E-T-H, was developed in the 1970s?

DR. TSENG: Yes.

Q. Are you familiar with the methodology used by Geomatrix to calculate spring and damping values for the Canister Transfer Building?

MR. GAUKLER: Object. It's beyond the scope of his testimony. We haven't got anything here on the Canister Transfer Building.

MS. NAKAHARA: Your Honor, it goes to why there are two different methodologies and his opinion, Dr. Tseng's opinion, why the methodology used for Holtec is adequate.

JUDGE FARRAR: Objection overruled. It is fair cross-examination.

DR. TSENG: I'm not directly involved with the cask transfer buildings seismic analysis. But I have general knowledge about the method that they are using.

Q. Are you aware of what that method is?

DR. TSENG: Pardon?

Q. Are you aware of what the methodology that Geomatrix used is?

DR. TSENG: Based on my understanding, Geomatrix has used the equations or formulas published in the book, Newmark and Roseblueth's book to derive the soil spring, dashpot, and virtual soil mass values for Holtec analysis.

Q. To the extent you know, Dr. Youngs, did Geomatrix rely on the Newmark and Roseblueth's methodology for the spring and damping values calculations for the Canister Transfer Building?

DR. YOUNGS: Geomatrix, our calculation involved determining the strain compatible velocities and damping values beneath the site in the free field. And those are the basic parameters that are used both for the Canister Transfer Building and for the pads. The pads, the type of analysis done by the pads requires springs and dashpot values. So we took the same velocity data that we were using for the Canister Transfer Building and used the Newmark equations to calculate springs from those velocities.

Q. For the Canister Transfer Building?

DR. TSENG: No. For the pads. So the same velocity data were used for both the free field velocities for both the Canister Transfer Building and the pads. The pads required an additional step to calculate springs and dashpots and virtual masses from that same set of data, and we used the Newmark and Roseblueth sets of equations.

Q. I apologize if you already answered. What methodology did you use to calculate the spring and damping values for the Canister Transfer Building?

DR. TSENG: We didn't calculate springs for the Canister Transfer Building.

Q. Isn't it true, and this is for both of you, isn't it true the Newmark and Roseblueth's methodology is not as accurate -- strike that.

And I apologize if you already answered this one, also. Are you both aware of the methodology used by Stone & Webster to calculate the spring and damping values for the Canister Transfer Building?

DR. YOUNGS: I am not aware of the details of their calculations for the dynamic response for the Canister Transfer Building.

MS. NAKAHARA: Dr. Tseng?

DR. TSENG: I am not involved in detail calculations, but I am aware that they are using a different method to calculate.

Q. Dr. Tseng, do you agree for layered soil sites the spring damping coefficients are highly frequency-dependent?

DR. TSENG: In general, yes. If the site is layered, then the frequency dependency of soil foundation repeatings function will be more frequency-dependent.

Q. Dr. Tseng, if you will turn to Dr. Youngs's answer to Question 18. I think you are actually both responding. Do you agree that the lump approach or the Newmark and Roseblueth methodology for determining damping is frequency independent? And I will point you to Page 7 towards the end of your response to Answer 18.

DR. YOUNGS: The lumped -- the frequency, or I mean the soil is represented by, as indicated in the testimony, a time and variant single value for the springs and the mass in the dashpot. And it is characterized to capture the fundamental mode of the response of the soil.

Q. Dr. Youngs, did you verify your spring and damping values using the Newmark and Roseblueth methodology against another approach or another methodology such as SASSI?

DR. YOUNGS: No, we did not. Or I'm not

aware that that technique will work in terms of what we were trying to do with this problem. I'm not sure that using SASSI can be used for this evaluation. It's not really my area of expertise.

DR. TSENG: If I may supplement?

Q. Yes.

DR. TSENG: There are specific reasons why the constant value of soil springs, dashpot, and virtual mass were used for the storage pad rather than a presumably more rigorous frequency-dependent impedance function approach, and that is because the necessity for Holtec to analyze their casks response which involved nonlinear response. And once you have to do the nonlinear time history response analysis, a frequency-dependent impedance function cannot be directly incorporated into that methodology. So it necessitates a step where you approximate the frequency-dependent foundation impedance by constant parameters which involve the constant spring value, constant dashpot value, and that coupled with a constant virtual mass will give you an approximate frequency variation up to the first mode of the soil response.

Q. Isn't it true, Dr. Tseng, that although you calculate or one could calculate, one such as Dr. Youngs could calculate the soil spring and damping values using Newmark and Roseblueth to obtain a frequency independent value, that you could still verify those values derived from the Newmark and Roseblueth methodology with another frequency- dependent method?

DR. TSENG: Yes, I think the answer generally is true; yes, you can verify them directly if you desire to do so. But the formula published in Newmark and Roseblueth's has been or is a well-recognized equation and if we had used SASSI to calculate the spring value under the same Newmark and Roseblueth model, we would expect they will come to be very close agreements. And in ICEC's calculation we have used the lump soil spring dashpot and virtual mass derived by Geomatrix in our ICEC Sup analysis. And we also had done the SASSI. That even, though, is not expressive validation. But the reasonable agreement shown by those comparison sort of indirectly gives you confidence that there will be not too much of an approximation.

Q. Can you specify where in the ICEC calculations it shows those values that could be compared to Dr. Youngs's Newmark and Roseblueth?

DR. TSENG: There were no express, that's why I stated earlier, no explicit calculation of that. But the agreements on the response between ICEC's Sup analysis, which uses the constant or the redistributed constant soil spring, dashpot, and virtual soil mass that had been used or derived by Geomatrix, or that Holtec International used, and we run the SASSI analysis for the same condition and both give us interdynamic condition. That very good agreements indirectly give us confidence that they would be or compare reasonably.

Q. Dr. Tseng, if you will turn to your response to Question 56.

DR. TSENG: Yes.

Q. Is it true that you state variation of soil properties from lower bound to best estimate to upper bound are intended to cover for many uncertainties?

DR. TSENG: Yes. That was intention of varying soil properties sometimes beyond what was realistic range that you would obtain at a site investigation.

Q. What is your familiarity with the extent of the soil property variation?

DR. TSENG: Based on the data that we are using for Holtec analysis, I believe the upper 30 feet to have a variation of 1.5 factor, and below 35 feet there is a factor of 2.0 variation.

Q. Dr. Tseng, are you familiar with the approximate size of storage pad area at PFS?

DR. TSENG: For each pad?

Q. The entire area for the 500 pads.

DR. TSENG: It's approximately 2000 square -- no. It's 2000 by 2000 feet area that have 500 pads.

Q. Are you aware that only two shear tests were performed on one sample from the same boring to develop the most critical design parameters for all 500 pads covering that area?

DR. TSENG: I'm not aware of that.

DR. YOUNGS: May I ask for clarification what you mean, the most critical parameters developed from two -- there are 16 or 17 down-hole velocity, seismic cone and down-hole velocity measurements across the area. And the shear wave velocities are the critical parameter for evaluating the response of the soil.

Q. With respect to direct shear tests for sliding?

DR. YOUNGS: I understood the question to be the dynamic response.

Q. Did I misstate? Is it correct, Dr. Youngs, that there are only two direct shear tests for sliding?

DR. YOUNGS: Maybe I misunderstood your question. I did not --

Q. I may have said it wrong.

DR. YOUNGS: I don't know how many direct shear tests there are for sliding. It was not -- I understood it to deal with the dynamic response.

Q. Dr. Tseng, in your analysis of the pad you applied, is it correct you applied -- strike that.

In your analysis of the pad, is it correct you applied the force time histories provided by Holtec?

DR. TSENG: That's correct.

Q. Do you agree that those loads are caused by the casks, and the casks sliding on the pads? These force time histories?

DR. TSENG: The force time histories may include the behavior of sliding and tilting, uplifting, yes.

Q. Please explain how you applied the loads for pad analysis and design from the force time histories.

DR. TSENG: The force time history were provided to us for analysis of the pad, at four points for each cask. And the four point, if we want zero, 90, 180, and 360 degrees around the contact circle. And this was provided for each cask that were considered in each case.

Q. Did you move the loads during your analysis, or were those loads applied to a fixed node?

DR. TSENG: They were applied to fixed nodes.

Q. Why did you apply them to a fixed node?

DR. TSENG: Well, for structure analysis once we developed the structural model which has fixed node, and those model node points was specifically selected underneath the casks. So we applied where the casks are supposed to be placed.

Q. Is it correct you did not consider any potential movement of the node location due to sliding of the cask?

DR. TSENG: Not the location, but the

sliding would give you, say -- the cut-off of the loading function were included, but not the location of that load application point. But based on my understanding, the amount of sliding is very small, so it doesn't really affect the design.

Q. If the amount of sliding --

MR. GAUKLER: Your Honor, I don't know where this goes in terms of testimony. It doesn't link to testimony at all. I just want to make that observation.

MS. NAKAHARA: Do you want me to respond?

JUDGE FARRAR: No. Keep going. We will entertain a more specific objection, but we did note on one of those questions, one of those objections we did later come to a question that tied cross- examination directly to the direct testimony. So we are still on the path that we announced before.

Go ahead.

Q. (By Ms. Nakahara) If larger or greater -- strike that.

If larger sliding occurred, would you modify your opinion that the load should be or the nodes should be moved or the loads should be --

strike that.

If larger sliding occurred, would it modify your opinion that the loads should be moved, in your analysis?

DR. TSENG: If the sliding indeed is getting to be very large, in a hypothetical case, then yes, we will have to consider the variation of that location.

Q. And also, would you need to consider how movement of the application of loads on -- strike that.

Would you also have to consider the effect of moving the loads on deformation of the pad?

DR. TSENG: I didn't quite understand the question. But if we moved the load, certainly the deformation will be somewhat different, yes.

Q. Thank you. That was the point of my question.

You stated that the force time histories used in pad design were obtained from Holtec. Isn't it true that for seismic loading of the pad itself, you estimated acceleration values from input motion?

DR. TSENG: I didn't quite understand

your question.

Q. Isn't it true for seismic loading of the pad, you estimated acceleration values from the free field ground motions?

DR. TSENG: For our pattern analysis, we did take the free field ground motion developed by Geomatrix as our input to the pad analysis.

Q. Why didn't you use the acceleration response of the pads from Holtec's calculations response time history?

DR. TSENG: Because of the need for us to couple the soil in, in obtaining internal stresses to the pad, we would have to model the pad together with the soil and subject that system to the Holtec cask loading function so we can obtain internal stresses that is required for our design.

Q. Look at State's pre-marked Exhibit 115.

MS. CHANCELLOR: May I approach?

Q. Page 33.

JUDGE FARRAR: This is the Luk report?

MS. NAKAHARA: Yes. Thank you, Your Honor.

Q. (By Ms. Nakahara) State's Exhibit 115, which is pre-marked but it has not been offered yet, is excerpts from the NRC project on seismic behavior of spent fuel storage cask system, seismic analysis report on Hi-Storm 100 casks at Private Fuel Storage dated March 8, 2002, prepared by Vincent K. Luk and others. It includes the cover sheet, Page 32, Pages 33, 35, 36, and 37. And Dr. Tseng, if you will look at Page 33.

DR. TSENG: Page 3?

Q. Yes.

DR. TSENG: Okay.

Q. Are you familiar with this document?

DR. TSENG: I have looked at this document but not carefully. But I have read through it.

Q. If you will --

MR. TURK: Before we continue, Your Honor. I may just note for the record that the Staff will be introducing the entire Luk report dated March 31, which supersedes the exhibit that the State is now discussing.

JUDGE FARRAR: Are those tables any different, do you know?

MR. TURK: The tables that we are looking at on --

JUDGE FARRAR: Or figures, rather?

MR. TURK: To my knowledge, these are

not different. They appear on different pages. I don't have the State's exhibit in front of me. I'm not sure which pages it comprises entirely.

MS. NAKAHARA: For the record, Your Honor, we did not have the Staff's document when we filed pre- filed testimony.

JUDGE FARRAR: Right. The only issue, I think, Mr. Turk is raising is possible confusion between the March 8 document, which was all you had, and the later version. But subject to making sure that the record gets clarified at the appropriate point, is there any problem with asking questions based on this figure?

MR. TURK: I think it might be more clear if we refer to the final report. The State should have a copy of that with them. We argued in the motion in limine that it would be duplicative to have this in as well as the Staff's exhibit. Just for clarity, because the page numbering is slightly different in the March 31 report, I think it might be cleaner to use that report.

JUDGE FARRAR: Unless there's a point, Ms. Nakahara, where you want to rely on the Luk document changed between an earlier version and a later version and want to ask questions about that, which you would have a right to do, why is the final version different than the other version? If we could use the final figure, that might solve some problems.

MS. NAKAHARA: Your Honor, until we have the opportunity to depose Dr. Luk, I would request that we defer a decision on this, to determine whether we have any additional objections to the admission of Staff's document.

JUDGE FARRAR: Why don't you just go ahead and ask your question based on either Figure 17 or Figure 18.

MS. NAKAHARA: Figure 17.

JUDGE FARRAR: On Page 33. And we will later make sure we have -- if that figure number or page number changes in the final, we will take care of that.

MS. NAKAHARA: Thank you, Your Honor.

Q. (By Ms. Nakahara) Dr. Tseng, if you will look at Figure 17.

DR. TSENG: Yes.

Q. Is it correct, it shows accelerations in almost a 3 g value.

DR. TSENG: As I understand this figure, this figure has two time history acceleration plots; one is for point A, and one is for center of the pad, Point D.

Q. If you will look at point D, at about seven seconds.

DR. TSENG: Yes.

Q. What is the acceleration, the maximum acceleration at about seven seconds?

DR. TSENG: It is minus 3 g's shown on this graph, almost minus 3 g's, at seven seconds.

Q. Do you believe as a result of soil structure interaction, an acceleration of 3 g's would show large values of radiation damping?

MR. TURK: Your Honor, I'm not sure the record is going to be very clear in the use of this exhibit without pointing out to the witnesses what it is. And I think the witnesses should read the caption on it to make sure they understand what the assumptions were that went into generating it to see whether they are, in fact, consistent with the same assumptions that they are talking about from their testimony.

MS. NAKAHARA: Thank you, Mr. Turk.

MR. TURK: It might help if they read the report that references this so they understand what it is.

Q. (By Ms. Nakahara) Dr. Tseng, will you read the title to the figure, please?

DR. TSENG: The Figure 17 has the title of Time Histories of Accelerations in U1 Direction at Points A prime and D prime to Demonstrate the SSI in Effect.

JUDGE FARRAR: Would you also read the material at the top of the figure?

DR. TSENG: The caption there reads Soil Structure Interaction Comparison. Best Estimate Soil Profile Data. And subcaption is Topsoil Surface Solutions in U1 Direction. And underneath that it calls for Friction mu equal to .2 cask to pad. And below that is friction mu equals 0.31 is for soil to soil cement, and soil cement to pad.

JUDGE FARRAR: With that in mind, does that change your previous answer or create in you a desire to explain your previous answer?

DR. TSENG: With respect to the most recent question, I have not answered it.

JUDGE FARRAR: No. The one about the maximum acceleration in seven seconds.

DR. TSENG: Right. The figure does display that there is a minus 3 g's at seven seconds at the center of the point D prime.

Q. Dr. Tseng, have you estimated radiation damping for the storage pad at PFS facility?

DR. TSENG: The dashpot values derive by Geomatrix or used by Holtec include the radiation damping in that.

Q. Do you recall what that value was?

DR. TSENG: I did not recall expressly. There are six values, each for one component of motion.

Q. Dr. Youngs, do you recall the value?

DR. YOUNGS: No.

DR. TSENG: But I'm not quite sure the question itself relates to this figure because this figure plots acceleration versus time, and your question is radiation damping and I cannot make connections in these two.

Q. Do you believe it is possible to have accelerations in the 3 g range for a site with large radiation damping, in your opinion?

DR. TSENG: Speaking out of just my general understanding of this, the radiation damping will be a damping between the pad and the soil, if they were integrated together. I believe, if I read this subcaption correctly, they have postulated that the pad and soil cement interface have certain friction coefficients, implying they are not behaving integrally. So I'm not too sure that the radiation damping question and this not integral case would be consistent.

JUDGE FARRAR: Ms. Nakahara, let me know when you are going on to a new subject, as we are needing a break and we have our next court reporter here to switch. But before you let me know, I'm not sure we have talked about what radiation damping is. Can you explain that to me?

DR. TSENG: Very general conception is when you just take the pad as an example, if you vibrate on the pad it will create a wave in the subsoil and the wave will then go or propagate deeper and deeper and never come back. That would be a form of wave energy loss. And that wave energy loss would then or can be characterized as a radiation damping.

MS. NAKAHARA: Your Honor, I'm not actually going onto a new subject but if it's convenient for everyone else, let's take a break.

JUDGE FARRAR: Why don't we take a break. It is just almost 3:15. To give the court reporter a chance to switch, we will come back at 3:30.

(A break was taken.)

JUDGE FARRAR: Back on the record. Ms. Nakahara, you were passing out a document during the break.

MS. NAKAHARA: And, Your Honor, Mr. Nelson just notified me, and I appreciate that, that this page is included in PFS's Exhibit 85. Not that you need any more paper to discard, but I would be happy to use PFS's Exhibit.

JUDGE FARRAR: All right, fine. So we don't need to --

MS. NAKAHARA: Mark it.

JUDGE FARRAR: -- mark this. Okay. Thank you.

Q. (By Ms. Nakahara) Dr. Tseng, do you have PFS Exhibit 85 in front of you?

DR. TSENG: 85?

Q. Eighty-five.

MR. GAUKLER: It's your calculation, Dr. Tseng. It's your calculation.

DR. TSENG: Yes. Yes, I have it.

Q. (By Ms. Nakahara) Will you please turn to page 231?

DR. TSENG: Yes.

Q. Dr. Tseng, isn't it true that on page

231 of the ICEC calculation in PFS Exhibit 85, Table D-1(a) shows the reaction force for the case of eight casks for the upper bound soil parameters to be 2,212 Kips?

DR. TSENG: Yes.

Q. If you assume, rather than making you do the calculation, if you assume that the weight of the pad and the cask is equal for 908 plus 200 -- strike that. Let me start over.

If you assume that the weight of the pad and the cask is equal to 908 Kips, plus 2,852 Kips, and you divide the reaction force by that value for the weight of the pad and the cask and you get 0.59 Gs, and I'm not asking you to verify whether that number is correct. If the acceleration you calculate is 0.59 Gs, and if this is for the case where the casks slide at an acceleration of 0.8 Gs, do you agree that if the effect of acceleration is 0.59 Gs this shows the dynamic loads given to you by Holtec are deficient, assuming that you get 0.59 from Holtec?

DR. TSENG: Assume I get this 0.59, I think it's a condition that when the casks start to slide or start to tilt, the acceleration will be lower than if the casks will be rigidly support on the pad. Then the casks will be responding to higher g value. So in other words, the fact that casks is allowed to slide, cut down the g value that the force will be imparted from the cask to the pad.

Q. Isn't it true for -- at a coefficient of friction of 0.8 that the casks won't start to slide until it reaches 0.8 Gs?

DR. TSENG: For pure sliding, yes. But then the casks also will tilt and that tilt alone would, you know, would lower the g values also.

Q. Have you quantified at what acceleration the casks will tilt or tip?

DR. TSENG: Well, I did not look into detail calculation of Holtec, but the time history, per se, would come out of the Holtec analysis and the number we -- you cited here is the sum of those reaction numbers. It does imply to me that the sliding and tilting are base partial uplifting would really lower down the g value onto the pad.

Q. And did that appear consistent with the horizontal displacements being approximately four inches for the casks?

DR. TSENG: I cannot say this will correspond to four inch, but the fact that it allow to slide cut down the force but increase the displacement. If you allow -- does not allow it to slide, then you have zero relative displacement but a higher g value.

Q. Assuming my 0.5 g calculation is correct --

MR. GAUKLER: Is that 0.5 or 0.59?

MS. NAKAHARA: 0.59, thank you.

Q. (By Ms. Nakahara) Would a tipping cask account for the lower acceleration, the difference between 0.5 g acceleration and the peak ground acceleration of .711 g?

DR. TSENG: It could. Part of the reasons, once you try to tilt then your center of gravity will start to raise and that would have to overcome the potential energy of the gravity.

Q. And, Dr. Tseng, have you quantified the effect on cask and pad movement from modeling the storage pad as a flexible structure?

DR. TSENG: I didn't quite understand question.

Q. Have you quantified the effect on cask and pad movement from modeling the storage pad as a flexible structure, not a rigid structure?

DR. TSENG: I still don't quite

understand the question.

Q. Isn't it true that you believe that the pad will perform as a rigid structure in the global analysis for cask response? Did I misstate that?

DR. TSENG: In the context of whether the pad flexibility have much effect on global response, I think there's more flexibility relative to the pad motion. I think that's secondary effect. On the other hand, for our pad design very flexible and we have to -- flexible in the sense of we induce internal stress, and we have include that in our calculation.

Q. And isn't it true you have not quantified the effects of flexibility of the storage pad on cask motion?

DR. TSENG: We have not quantify on cask motion, but we have made assessment on the effect onto the pad motion.

Q. And isn't it true you have not quantified the effect of pad-to-pad interaction on the cask response or on cask motion?

DR. TSENG: Since we are not calculating cask response, we have not quantify that part.

MS. NAKAHARA: Thank you. And I've finished my cross if Ms. Chancellor can ask --

MS. CHANCELLOR: I don't have too many questions, I hope, Your Honor.

JUDGE FARRAR: Go ahead.

CROSS-EXAMINATION

BY MS. CHANCELLOR:

Q. Good afternoon. My name is Denise Chancellor for the State of Utah. If you would turn, Dr. Tseng, if you would turn to your answer on 78 of your testimony on page 26, please.

DR. TSENG: Yes.

Q. In your answer you're referring to a calculation as described in an August 6, 2001 Holtec letter PFS forwarded to NRC and in answer 79 you refer to a sliding parametric study by Holtec. The reference to the Holtec letter on the parametric study, isn't it true that this was part of Exhibit MM as originally filed and that Mr. Gaukler did not introduce today? It's the letter by Mr. DeLong from Holtec.

DR. TSENG: I didn't quite understand the question.

JUDGE FARRAR: Did you say Mr. Gaukler did not introduce today?

MS. CHANCELLOR: Yes. Exhibit MM, Your

Honor, originally consisted of, as prefiled, MM included a letter dated August 6 from Holtec from a Mr. Max DeLong to -- by Mr. Gutherman to Mr. Max DeLong. And there's also a cover letter, commitment resolution dated August 7 by John Donnell to the NRC. And the testimony -- Ms. Nakahara will give you a copy.

MS. NAKAHARA: Of the original prefiled.

JUDGE FARRAR: We have --

MS. NAKAHARA: For the witnesses, I mean.

JUDGE FARRAR: All right. We have the one that was prefiled, but for some reason I think we didn't get -- did we get the new version this morning?

MR. GAUKLER: I gave -- everybody should have got a book this morning that was labeled Applicant's Unified Contention L/QQ Exhibits. I would like to point out for the record that the letter that State counsel is referring to is actually identified as PFS Exhibit NN in the book that you received and is referenced in the testimony of Dr. Chris Singh and Dr. Alan Soler.

JUDGE FARRAR: Let me see if I can reconstruct this. You gave us an Exhibit MM that was prefiled. Then you included in this book you gave us today of Exhibits is an MM that you said had some material removed from it?

MR. GAUKLER: Right.

JUDGE FARRAR: And now you're saying the removed material is somewhere else?

MR. GAUKLER: I removed two things from MM that was in the book. And I don't know whether those materials were filed in the transcript or not. I did not go back and check the electronic filing. All I know is that the book that I had while I was looking at these books had materials under MM that were not intended to be part of that Exhibit so I took those materials out. Those materials consisted of two things. One is the letter that counsel is referring to, which in fact is correctly identified as PFS Exhibit NN, and it's discussed in the testimony of Dr. Chris Singh and Dr. Alan Soler. The other part that was mistakenly included in there was some material on ASCE 4-86.

MS. CHANCELLOR: But my point, Your Honor, is that Dr. Tseng refers to what was originally this extraneous portion of MM in his testimony, and we can refer to it as NN, if that clarifies the record.

MR. GAUKLER: Why don't we do that, Ms. Chancellor.

MS. CHANCELLOR: Okay, that's fine.

Q. (By Ms. Chancellor) Do you agree that question 78 refers to what has now been marked PFS Exhibit NN, the letter, the August 6, 2000 letter from Holtec to the NR -- the Holtec letter which was forwarded to the NRC on August 7, 2001? Do you have that document in front of you?

DR. TSENG: I do have this MM here that just handed to me by Ms. Nakahara.

Q. And would you look at answer 78 and let me know if the Exhibit NN in your hand, which you have as labeled MM, is the same document that you are referring to in answer 78 and also answer 79, the parametric study undertaken by Holtec, whether that is the document that you are referring to in your testimony?

DR. TSENG: I understand the MM part that I'm referring to is the front part where there is a calculation by Stone Webster on the effect of the stability on foundation impedance.

Q. No. If you would look at the Holtec letter dated August 6 from Mr. Gutherman to Mr. DeLong, and in there Mr. Gutherman does some calculations, there's a table there and it's got a percent of soil damping values, maximum pad movement, etc.

DR. TSENG: I do see this letters in this package.

Q. And in answer 79, is the parametric study undertaken by Holtec, is that the study that is in the letter from -- by Mr. Gutherman to Mr. DeLong?

DR. TSENG: I believe it refers to that.

Q. And did you rely at all on this parametric study by Holtec for your answer in either 78 or 79?

DR. TSENG: Could you state the question again?

Q. Did you rely on the parametric study undertaken by Holtec in your testimony in answer 78 and/or 79?

DR. TSENG: In answer to 79, I did not rely on this particular letter to answer that.

Q. And 78?

DR. TSENG: 78 answer simply restated the State's claim. So it's not -- no opinion in that.

Q. As described in the calculation by

Holtec, right?

DR. TSENG: Correct.

Q. And have you reviewed that calculation by Holtec, the one that's in your hand from Mr. Gutherman to Mr. DeLong?

DR. TSENG: I have seen this document before, but did not review in detail.

Q. And in question 78 it asks, do you understand -- "What do you understand to be the nature of the State's claims regarding the effect of soil cement around the pads once the pads undergo sliding motion?" And in 79 you respond as to whether the State -- as to your view of the State's assertion; is that correct?

DR. TSENG: In the answer in 79 my testimony is that since the pad is not expect to slide. So --

Q. And we're talking about the effects of soil cement around the pads once the pads undergo sliding, correct?

DR. TSENG: Right.

Q. And in your answer in 79 you rely on the factors of safety of 1.27 against sliding; is that correct?

DR. TSENG: Right.

Q. And you also state that sliding of the pads -- skip that. In question 80 you refer to pad stability analysis. Is that G(B) 04-9 the pad stability calculation that you're referring to?

DR. TSENG: That's the pad stability calculation by Stone Webster's.

Q. Is that Mr. Trudeau's?

DR. TSENG: Yes, correct.

Q. And you talk about friction alone -- that friction beneath the pad alone is sufficient to resist the seismic shear load imposed on the pad; is that correct?

DR. TSENG: Right.

Q. And if you look at -- and you state that the factor of safety against sliding is 1.29 -- 1.27, correct?

DR. TSENG: Right, based on Stone Webster calculation.

Q. If you would look at PFS Exhibit UU, do you have that?

DR. TSENG: I don't have.

Q. We'll give you a copy of what PFS handed us out today. If you would turn to page 41 of Exhibit UU.

DR. TSENG: Yes.

Q. And on page 41 of this calculation, isn't this -- isn't the case that is referred to there limited to friction alone? If you look at the second paragraph, "Considering one north-south row of pads, assume that the shear strength available on the base of the pads to resist sliding is limited to that provided by friction alone"; is that correct?

DR. TSENG: That's the hypothetical condition that they are assuming in this case, I understand that.

Q. And if you turn to page 42, in the middle to the bottom third of the page, factor of safety against sliding is 0.40 in one case and 0.4 in another; is that correct?

DR. TSENG: On this particular page, yes. But the number that I cited in my answer, 1.27, that would be the design basis calculation that I assume that the -- well, they have the resistance of the underlying soil not only with friction, but also have some correlation numbers there.

Q. Do you wish to change your testimony? Your testimony states that one of the cases is friction alone is sufficient to resist seismic load imposed on the pad. You've got friction or shear resistance.

MR. GAUKLER: Where is counselor reading from?

MS. CHANCELLOR: Page 80 of Dr. Tseng's testimony. I mean answer 80, I beg your pardon, page 27.

DR. TSENG: This friction in seismic shear resistance in my answer refer to really the same thing. I didn't -- I am not referring to the case study you recited in page 41/42 because they resistant to pad without either control by the friction at the interface or the shear strength of the soil. And the design basis calculation, I indicate that with the cohesion and the friction and shear strength they will have a factor of safety of 1.27 so the pad will not slide. That was the basis of my answer as stated here.

Q. (By Ms. Chancellor) Didn't you testify earlier today that you are familiar with soil dynamics but not soils, per se?

DR. TSENG: That's correct. I'm not a soil specialist, but the number as cited is not calculated by me, it was calculated by geotechnical engineer of -- engineers of Stone Webster's.

Q. Aren't there a variety of cases
presented in G(B) 4-9?

DR. TSENG: There were a lot of cases, but the design basis that I'm referring to is the one that I rely upon for these answers.

MS. CHANCELLOR: Your Honor, I would move to strike answers to 78, 79 and 80. Dr. Tseng is not an expert in soils. He is relying totally on somebody else's calculations and those calculations in some instances have a factor of safety as low as 0.4.

MR. GAUKLER: Your Honor, an expert can rely upon the work from another expert. In fact, I've been making reference to that fact today from all testimony of experts that we're relying upon, taking something another expert has produced and stating their own opinion as it relates to what they're doing. That's what's happening right here.

MS. CHANCELLOR: Your Honor, here we have Dr. Tseng talking about -- referring to a parametric study by Holtec with respect to certain claims that the State has made relying on a calculation that is done by Mr. Trudeau at Stone & Webster and the calculation done by Mr. Trudeau from Stone & Webster deals with soils. Dr. Tseng has testified that he is not an expert in soils. There are lots of cases in GB0 4-9 and we can go through them all with Dr. Tseng, if you want, but Dr. Tseng is not a soils expert and this portion of his testimony I think should be stricken.

MR. TURK: May I offer an opinion?

JUDGE FARRAR: Yes, sir.

MR. TURK: We had reason to hear argument on a similar matter when we discussed motions in limine where the Staff had moved to strike, and I believe the Applicant moved to strike also, the testimony of Dr. Resnikoff in which he was citing, often incorrectly, the opinions of other experts being proffered by the State, and Your Honor has allowed the testimony to stand. And I think the ruling was you would look at it at a later date. I think here the witness has clarified the extent to which he's relying on another expert rather than proffering his own opinion. And I think if there's any flaw in the testimony it really should be developed on cross-examination of the expert upon whom this expert is relying and I would recommend that -- I would oppose the motion to strike.

JUDGE FARRAR: Ms. Chancellor, if you'll

address this question, we've been try to run this proceeding on the basis that you would have teams of people working and there's not bright lines between what one does and when they talk to each other. We have also made rulings that an expert is entitled to rely on the opinions of other experts. And so if you're to prevail on this motion you have to convince us that this is a different situation than those.

MS. CHANCELLOR: I think this testimony does not belong in Dr. Tseng's testimony. It is -- I mean, Mr. Trudeau may be able to testify to this or maybe somebody from Holtec can testify to it, but Mr. -- Dr. Tseng is not competent to testify about soils. He's already admitted that he doesn't know about soils. He knows about the dynamic properties of soils. He doesn't deal with the sliding of the pad analysis.

It's one thing to say at the motion in limine stage that you should let testimony in, but once the testimony has been tested and found to come up short, to be deficient, then I believe it's appropriate to strike it. If PFS wants to get this in through rebuttal, through Mr. Trudeau or through some other witness, maybe they can find another competent witness, but in this case Dr. Tseng is relying on a factor of safety against sliding and that's not the only factor of safety against sliding in this calculation. And Dr. Tseng doesn't know anything about soil. So I think it is appropriate to strike his testimony in this instance as just being outside the scope. I mean, we're looking at a butcher, not a brain surgeon here, I believe, Your Honor.

MR. GAUKLER: Your Honor, I mean the State has been asking questions about witnesses all day that we thought were going beyond the scope of their expertise. Now they're trying to say, well, he's not an expert in some areas, we ought to strike his testimony. I think he's quite clear in terms of what he's relying upon, in terms of his testimony. I don't think the State has pointed out any deficiency. To the extent that the State disagrees with it they can develop their case in their own rebuttal, whatever the case may be.

(The Board conferred off the record).

JUDGE FARRAR: Ms. Chancellor, we're going to deny your motion on two grounds. We have let Ms. Nakahara cross-examine liberally over objection on the theory that these are very complex cases and everything is woven together and it's hard to draw bright lines. I may be wrong, but I seem to think in our December 26th opinion denying summary disposition we denied an Applicant motion to strike on similar reason, that these are complex cases. I think they wanted to take material out of your contention or out of your affidavits and we said, no, this case all weaves together and you can't take something out and say, "Well, that's fine."

I mean, we're trying to look at this case as a whole. These witnesses, and I assume your witnesses are interwoven together, and we don't think it's profitable to grant the motion to strike. You're free through your cross-examination, through your cross-examination of other witnesses to show there may be weakness in the testimony or the witness didn't know it of his own mind, and that's something we will take into account in evaluating the weight of it, but we are generally disinclined to grant motions to strike because of the interwoven nature of all this testimony. So we'll deny your motion.

Q. (By Ms. Chancellor) Dr. Tseng, isn't it true that soils are variable at the PFS site, that they aren't uniform?

DR. TSENG: All soils have some variability, yes. And I think PFS site is no exception, yes.

Q. Would you agree that velocity -- that shear wave velocity increases with depth?

DR. TSENG: In general, yes.

Q. And isn't it true that shear wave -- that soil velocity changes in different soil waves?

DR. TSENG: Yes.

Q. In general?

DR. TSENG: If they are given characteristic, yes, they will change in different layers.

Q. Would you look at PFS Exhibit 85? And that's the document you developed to show the dynamic deformation of a pad.

MR. GAUKLER: That's your calculation.

DR. TSENG: Did you say page 85?

Q. (By Ms. Chancellor) No, Exhibit 85.

DR. TSENG: Okay.

Q. Do you have that?

DR. TSENG: Yes.

Q. In Exhibit 85, on the second page PFS Storage Facility (Best Estimate Soil, Two-Cask

Case, Pad Dimension Longitudinal; do you see that?

MR. GAUKLER: What page is that?

MS. CHANCELLOR: Oh, is that 85? What's this Exhibit?

MS. NAKAHARA: Eighty-six?

MS. CHANCELLOR: What's this Exhibit, the one you handed out?

MR. GAUKLER: I didn't hand that out.

MS. CHANCELLOR: You haven't introduced this?

MR. GAUKLER: No, I have not.

MS. CHANCELLOR: It's what Paul sent us last night.

Your Honor, if I may, I just want to establish one thing with an Exhibit that I thought that Mr. Gaukler had introduced. He sent it to me last night and it's a -- could you explain what this page is in front of you, the longitudinal pad diagram?

MS. NAKAHARA: Excuse me, Ms. Chancellor. We can make copies in hopefully two minutes if you want to wait.

JUDGE FARRAR: Well, let's first see if the witness can explain what it is.

DR. TSENG: Okay. What it's referring

to is a plot of vertical displacement and against longitudinal distance across the pad at one particular time instance of the pad response during the earthquake under the cask load.

JUDGE FARRAR: And who prepared that?

DR. TSENG: We -- ICEC prepared it.

Q. (By Ms. Chancellor) And does that show pad deformation in the longitudinal direction?

DR. TSENG: That's correct.

MS. CHANCELLOR: Thank you.

MR. TURK: May I see it? No one has yet shown me this.

MS. CHANCELLOR: Well, I just got it from Mr. Gaukler last night. This is what I'm referring to. I'll make you a copy.

MR. TURK: Okay. I'll hold off until I get a copy.

JUDGE FARRAR: Can someone make a copy of that? Are you going to question him further on it?

MS. CHANCELLOR: No, Your Honor.

JUDGE FARRAR: Why don't we get copies made and when we get them we'll mark it. And did you want to introduce it?

MS. CHANCELLOR: I'll see.

Q. (By Ms. Chancellor) In estimating pad damping, would it be reasonable to use the average soil velocity for the depth equal to the pad in the longitudinal direction?

DR. TSENG: In using equivalent shear wave velocity, generally we are using the equivalent radius. That mean if you have a pad of 30 by 67 plan dimensions then you will equivalent that to a equivalent circular pad or circular dimension and use that radius as the equivalent dimension.

Q. But would another way to do it be looking at the depth of the longitudinal dimension of the pad?

DR. TSENG: That will be somewhat of weighted more to longitudinal direction, but that may or may not be giving you better results. In general, you're using the equivalent area is like, again, either equivalent square or equivalent radius.

Q. If you would turn to PFS Exhibit MM, I think you have the book there?

MR. GAUKLER: MM as in Mary?

MS. CHANCELLOR: Mary, Mary.

Q. (By Ms. Chancellor) Do you find it, Dr.

Tseng?

DR. TSENG: Yes. You're referring the calculation --

Q. This is an Evaluation of Storage Cask Flexibility. It's a Calculation No. SC-21 prepared by Bruce Ebbeson and reviewed by yourself. You reviewed it on 3-31-02, correct?

DR. TSENG: Correct.

Q. On the fourth page of that calculation there's a caption called Assumptions?

DR. TSENG: Correct.

Q. "The paper used as a basis for this evaluation was based on a square foundation on an elastic half-space of uniform properties"?

DR. TSENG: Correct.

Q. Does the PFS site have elastic half-space of uniform properties?

DR. TSENG: I state in earlier testimony, the PFS site does not have uniform half-space. But in the evaluation where you want to utilize a publish results, well, they only have uniform half-space solution. You would then derive equivalent half-space properties for the person.

Q. If you would turn to the next page of the calculation, page 5 of the calculation, do you

have a calculator with you, Dr. Tseng?
DR. TSENG: I do, but I may or may not have brought with me.
Q. I believe Dr. Bartlett would share his with you. If you know how to run a Hewlett-Packard.
DR. TSENG: Okay.
Q. That's a lawyer's question to an engineer.
DR. TSENG: Let me check here. Yes.
Q. This calculation calculates a dimensionless parameter Delta, correct?
DR. TSENG: Correct.
Q. And one of the -- one parameter is a; do you see that?
DR. TSENG: Yes.
Q. And it's got a = square root of 67 times 40 divided by 4, correct?
DR. TSENG: Correct.
Q. Would you take the square root -- would you multiply 67 by 40, take the square root of it and then divide by 4? Sorry, 67 by 30, and then let me know your answer.
DR. TSENG: Yes.
Q. And your answer is?

DR. TSENG: 11.

Q. 11.2?

DR. TSENG: 11.2.

Q. And this calculation is equal to 22.4; is that correct?

DR. TSENG: I beg your pardon?

Q. (a) on page 5 of calculation SC-21 is equal to 22.4; is that correct?

DR. TSENG: That's correct.

Q. Should the formula be 67 feet times 30 feet divided by 4 and then you take the square root?

DR. TSENG: It should be square root 67 times 30 divide by 2.

Q. Not 4?

JUDGE FARRAR: It's the same thing.

MS. CHANCELLOR: Oh, yeah, right. Okay.

Q. (By Ms. Chancellor) So which is correct, Dr. Tseng, the formula or the answer?

DR. TSENG: Let me -- it should be divide by 2. The answer is correct but the formula is divide by 4.

Q. Okay. And the purpose of this calculation is to determine the damping compared to a rigid foundation; is that correct?

DR. TSENG: The purpose of this calculation is to assess based on the pad's flexibility -- or pad's rigidity parameter relative to soil. That's this formula Delta parameter is defined to characterize. Since is a uniform half-space solution and also a square plate solution, a square plate solution. So we have to convert this rectangular into a convert square plate. And this particular calculation of (a) is trying to calculate that dimension. And the purpose is using this flexibility parameter and the frequency range of interest which is, again, the calculation below that top -- that Delta, a parameter called sub, a sub zero. And then using these two parameters and base on Guchi and Luco's paper he has a solution for square plate. Then we can infer or at least enter the curve and see how much that flexibility of the mat or pad would affect the two quantities. One is the soil spring value and as well as soil damping or foundation damping value.

Q. And on attachment A-1, the Guchi and Luco paper, you've got area of interest marked on the graph on the top right-hand corner, area of interest, the damping is somewhere over, run about

7; is that correct?

DR. TSENG: These graphs have several lines in it. The top line, which is correspond to Delta parameter equal to infinite, and Delta parameter equal to infinite means the pad is rigid. And then there is second line lower than that would be Delta parameter equal to .5 meaning that the pad will be somewhat flexible. And then there are additional two lines, .05, Delta equal to .05 and Delta equal to .005.

Q. And are you getting more flexible as the number --

DR. TSENG: As the number Delta getting to be smaller then the pad will be more flexible.

Q. And you came out with a Delta value of 0. --

DR. TSENG: And then base on the equivalent area calculation, equivalent rectangular -- square plate calculation, the Delta value is .7, which for the chain of curve for Delta equal to infinite and Delta equal to .5 in between that. That's why the line marked "Area of Interest" is in between these two lines.

Q. Okay. We'll go through a little exercise, if I can get the math right.

JUDGE FARRAR: What are you handing out now?

MS. CHANCELLOR: This is State's Exhibit -- what's our next number?

MS. NAKAHARA: State's Exhibit 172.

JUDGE FARRAR: All right. Then we'll have the court reporter mark it for identification. So wait until that's done.

(STATE'S EXHIBIT-172 MARKED.)

Q. (By Ms. Chancellor) Dr. Tseng, we have taken your calculation and changed one value, and that is the sub S, which is the shear wave velocity through the soil and used the -- if you look down at the bottom of this document, shear wave velocity using the average velocity over a depth of 67 feet. Do you see that?

DR. TSENG: Yes.

Q. And we can go through the numbers. On the second page is a calculation sheet by ICEC, it's on sheet number 8, and if you look at the best estimate soil properties, and to get the weighted average, is it correct that you would take -- find out the thickness of the layer, so you go to the depth at the top, the depth at the bottom, find out the thickness of the layer, take -- for the first example it would be take 5/67ths of that layer and multiply it by the Vs, which is 1,497 in this case?

DR. TSENG: That's one way of obtaining the average value.

Q. Weighted average?

DR. TSENG: Right.

Q. Assume that the weighted average and the numbers are all there on the very last line on this page, assume that the shear wave velocity is 1081 feet per second.

DR. TSENG: Well, I want to connect -- can I point out that in this particular table the upper value of 1 to 2 feet, that's at 1,497, that's a value that the soil is treated, cement treated soil. Now, the pad thickness is already three feet thick. So the first three feet ought not to be used in this weighted average. But I understand the calculation and that's one way of obtaining weighted average.

Q. And if you substitute 1,081 feet per second instead of 750 feet per second you come out with a Delta value of 0.353?

MR. GAUKLER: Substitute what into what?

DR. TSENG: That's the number on your right-hand column?

Q. (By Ms. Chancellor) That's correct.

DS. TSENG: Yes. If you were to use the average shear wave velocity of 1,081 and then the larger dimension of 67, certainly you would calculate a smaller Delta value.

Q. And that Delta value, if you look at the Guchi and Luco paper on A-1, the graph that we were referring to before on the upper right-hand corner.

DR. TSENG: Right.

Q. You would be below the line, the second line where it says 0.5?

DR. TSENG: If Delta are equal to .35?

Q. Yes.

DR. TSENG: Then it will go below the second curve.

Q. And the damping will be about what, 4, 3.5?

DR. TSENG: I think will be slightly lower than that second curve, will be maybe between 5, 5 to 6. Between 5 to 6. Because the other curve is .05 which is much smaller parameter.

Q. And if you use this weighted average, the damping would show that the pad is acting more flexibly than in the computation you made; is that correct?

MR. GAUKLER: I think he's already said that he took exception to when the average was calculated.

DR. TSENG: If we accept all this parameters then the damping would be lower than what we stated equal to .735, but it is my opinion that the first layer should not be used in this weighted average. And secondly, to get equivalent pad it ought to be using the equivalent area rather than taking the larger dimension.

Q. And it's also true that this capability --

DR. YOUNGS: Your Honor, may I introduce a third point here?

MS. CHANCELLOR: Certainly.

DR. YOUNGS: That the method used here to calculate the average velocity I don't believe is the proper method for calculating the average velocity.

Q. And how do you calculate the average velocity?

DR. YOUNGS: The average velocity should be calculated by calculating the travel time from the surface -- or from the starting point to the bottom point to each of the layers and dividing by the total thickness to get the average velocity rather than taking a weighted average of the velocities themselves.

Q. Dr. Tseng, did you use the method that Dr. Youngs just described in the shear wave velocity in your calculation?

DR. TSENG: We did not specifically use that method. Like I say, there several ways of doing that. Each carry a different emphasis on certain parameter.

Q. Why did you -- oh, excuse me?

DR. TSENG: I am not taking particular issue on the method of calculating. It's that the first layer, which is really occupied by the pad, should not be enter into this calculation. And that's one point. The second point is that in enter into the comparison we ought to use the square that the solution is rather than taking the larger dimension. Certainly if we always want to err to larger, everything taken larger then you would get something which may not represent the situation over here.

Q. Why did you use 750 feet per second as a shear wave velocity?

DR. TSENG: It's a average of the shear

wave velocity beneath the pad over the dimension of equivalent rectangular -- not rectangular, square dimension.

Q. And where does this 750 feet velocity come from? Where did you obtain that number?

DR. TSENG: I think, you know, the strict number is not really the matter because we are using the published data and using a uniform half-space solution. So the purpose here is to get to the order of magnitude. And 750 is by looking at the soil profile within the dimension that the equivalent square dimension. That 750 is the order of magnitude of shear velocity.

Q. Is the what magnitude?

DR. TSENG: Order of magnitude.

Q. So, order. Thank you.

DR. TSENG: So all this specific number is probably is not a point to contest. It's the order of magnitude whether we are very flexible as compared to we are not so flexible.

Q. And when you say the shear wave velocity is an average, is it an average to a certain depth?

DR. TSENG: That's correct.

Q. And what depth is that?

DR. TSENG: That's the equivalent square

dimension.

Q. And what's that depth?

DR. TSENG: That's 40 feet, 44 feet, if I would calculate it.

Q. And isn't it true that this Guchi and Luco paper doesn't fit the PFS site, that the PFS site has soil variability?

DR. TSENG: As I said earlier, the real site assume you have layer variations, but to use a published data which only have solution for uniform half-space we have to draw equivalent uniform space parameters to get some judgment on where we are, and in this case the parameter Delta give us that kind of index to see where we are.

Q. So this is an approximation; is that correct?

DR. TSENG: That's correct.

MS. CHANCELLOR: Thank you. I have no further questions.

JUDGE FARRAR: That finishes your State's cross?

MS. CHANCELLOR: Yes, that's correct, Your Honor.

JUDGE FARRAR: Judge Lam has some questions.

JUDGE LAM: Dr. Tseng and Dr. Youngs, in your testimony you indicated most, if not all, of these calculations rely on couple computer programs, CECSAP all in capital letters, and SASSI. May I ask you to describe what type of validation has been done against known data for these two computer programs?

DR. TSENG: Okay. Your Honor, as far as these, both computer were verify against many published solutions in journals. Some may be also test data. For example, the SASSI computer program, has been compare with some of the experimental data in they call it low ton SSI experiments data. CECSAP has been compared with other industry standard programs and all is documented in the verification report, which are available in our company.

So in general, to answer your question is that they have been compare with known solutions solving the same problem that have been publish in the known solutions and compare with solution come out of this computer program and these known solution to control validity of the solution -- of the programs.

JUDGE LAM: So it has been developed

with fundamental principles, been benchmarked and validated against known data, been published?

DR. TSENG: That's correct.

JUDGE LAM: Has been peer reviewed and has been published?

DR. TSENG: The known solution that we use to compare, the proven solution have all been peer review journal solutions and published data.

JUDGE LAM: Dr. Youngs, would you respond to that?

DR. YOUNGS: I'm not familiar with the details of SASSI or the other program.

JUDGE LAM: Now, some of these analysis involve both linear and nonlinear analysis. Now, has there been any -- for this particular issue here under dispute, has there been any sensitivity studies performed?

DR. TSENG: For nonlinear analysis, which is more relate to sensitivity, I believe Holtec has done many sensitivity studies. But as far as our patent design is concerned, there are more like linear analysis because we are using the Holtec floating function as an input to our solution, to our patent design, and the model that we set up is basically a linear problems.

JUDGE LAM: Okay.

DR. TSENG: And if I may add, is that we do vary parameters where I think the certainty need to be accounted for. For example, a soil property we use as lower bound, best estimate upper bound, to bound the variability of the soil property as well as some of the unquantifiable modeling uncertainties and so on.

JUDGE LAM: Dr. Tseng, the reason I ask that question is just the nature of the analysis when you do nonlinear calculations, sometimes it could be great deal of sensitivity to your input parameter, am I correct?

DR. TSENG: This is correct. Nonlinear will be more sensitive to parameter variations.

JUDGE LAM: Now, that being the case, would it strengthen your argument if some has been perform because, as aptly demonstrated by Ms. Chancellor's questions, they are uncertainty in the modeling, they are uncertainty in the approximation and they are uncertainty in the input.

DR. TSENG: Well, as I respond earlier with the nonlinear response of the casks, I believe Holtec has done many calculation and I will defer that to later on when Holtec testify. As far as the patent design and response, per se, which in our -- where I am testifying, is a linear problem so is less susceptible to sensitivity, but irrespect of that we also have vary our parameter. The most important is the soil parameter variation, and we did that.

JUDGE LAM: In reading some of the testimony here, specifically PFS Exhibit 85, I see results sometimes are presented to four or five significant figures. To what level of precision would you gentlemen want us to rely on?

DR. TSENG: Civil engineering, we generally rely only three significant digit. And many of these calculation were based on computer calculation. As you know, computer will output as many digit as you allow it to. But in our design we certainly limit our accuracy to three significant digits.

JUDGE LAM: But perhaps you should only rely on one significant figures here? Are you talking about one inch because I hear from your earlier testimony you're really interested in the order of magnitude, are you not?

DR. TSENG: In some cases maybe yes, we may be less than three digits. I'm talking about more like forces, you have three significant digit, come to displacement, especially a small displacement, we maybe rely on only one significant digit.

JUDGE LAM: And Dr. Tseng, in some of these testimony I see you are the final reviewer of some of these calculation. For example, in PFS Exhibit 85 I see that they are four prepare and checkers and then you are the fifth signature on that. May I ask you to describe what were you doing when you were doing the independent review? I mean, are you applying fundamental engineering judgment or are you just checking the number of notes or are you doing both?

DR. TSENG: Certainly the most important part is the fundamental engineering principle and that part is very important responsibility of independent reviewer. Independent reviewer would not really check into every number whether they calculate it correctly, but looking at the -- whether the method is correctly applied and would the result adhere to engineering judgment and engineering principle. And I think that's the major responsibility of me.

JUDGE LAM: And if I may ask you

gentlemen one more question, if I asked you not to rely on the computer programs, can you describe to me why should we be persuaded that for the magnitude of earthquake that's being postulate here nothing would happen to the cask? By nothing I would say small displacements. Can you describe to me in first order in engineering principle terms why is that the case? Is it the pad are fake, is it the casks are big? What are we dealing with here?

DR. TSENG: A lot of this certainly would be in the Holtec International's testimony. My own opinion, of course, is a lot depend on this cask's own design, its sizes, the aspect ratio. And I think Holtec International have take that into account in their evaluation demonstrate that the maximum amount of movement, for example, sliding, is in a reasonable 3-4 inch range. Maximum amount of tilting or uplift, partial uplifting is in a very small degree. So that indicate to me that there are inherent stability in these casks.

JUDGE LAM: Perhaps I did not make myself clear. What my focus of my question is really I see in your gentlemen's testimony that you are saying the effect on nonvertical propagating wave is insulated. You are testifying that the effect of pad flexibility will be small. You're testifying only second on the effect on stability of the casks and you're saying that the soil, spring and damping values are a good approximation and then you're saying the fault fling was conservatively incorporated. That's the totality of your gentlemen's testimony.

My question to you is, if I asked you not to rely on the computer models, can you persuade this licensing board that your conclusion is correct? And if that is possible. Let me give you an analogy. If somebody carrying a .22 calibre handgun and shooting at a 10-feet containment barrier then one can argue with first principle that, hey, that bullet is not going to penetrate without doing any calculation. Of course, there are extensive experimental data and extensive calculation with tools. I'm asking you, Dr. Youngs and Dr. Tseng, is that possible, could you explain to this licensing board without relying on your computer models, is that possible? If not possible, that's fine.

DR. TSENG: I think to explain in a very

simple term maybe, you know, piece of earthquake input is such that it has accelerations, velocities and they all interplay together. So to that degree we in many cases have to rely on computers to trace these through. If it is static or something easier then we can visualize it much easier. So in that sense of counter earthquake engineering we more or less have to rely very much on this detail dynamic calculation through modern day computer examinations.

JUDGE LAM: So what you're saying is you would not be able to walk up to the site and look at it visually and say, aha, this thing is big enough, nothing will happen to it?

DR. TSENG: You will get a feeling, but certainly you could not get an answer directly just by that.

JUDGE LAM: Dr. Youngs?

DR. YOUNGS: Well, structural response is not really my area of expertise. So I'm not sure that I could say one way or other whether a cask of this dimension would or would not have significant motion under this earthquake. I can say that we, in terms of where the waves would be coming from, that the hazard is coming primarily from a nearby fault that dips beneath the site. So we would expect the waves to be coming up from below and therefore to be nearly in the vertical direction based on just the general location of the energy released. Beyond that we would need to do calculations to estimate what those angles would be. But we would expect because the primary source of energy is a fault dipping beneath the site, that the energy would be coming from below instead of the side.

JUDGE LAM: Thank you, Dr. Tseng and Dr. Youngs.

JUDGE FARRAR: When you say where the energy from the fault would be coming from, this may be an area that the parties have stipulated to, how do you know there aren't unknown faults under there which could also be a source of energy?

DR. YOUNGS: Well, as the part of the investigations for the site we did, and we obtained geophysical data and the project did additional geophysical data, and through that investigation we located a fault that is in the vicinity of the site. But that also places the energy deep beneath the site. So that would not affect the basic location that the energy is coming from a depth below the valley.

JUDGE FARRAR: Is this Parts A and B which the --

MR. GAUKLER: It's all Parts A and B which were part of the --

JUDGE FARRAR: So there's no longer any issue about whether the definition of the nearby faults -- or whether the investigation has indeed pinpointed the nearby faults?

MR. GAUKLER: We made the correct determination in terms of a hazard, a geological earthquake hazard.

MS. CHANCELLOR: I correct that, Your Honor. We're not going to litigate over that fact.

MR. TURK: I would also add, Your Honor, that the use of a probabilistic seismic hazard analysis method considers many sources, many potential sources, not just the fault that dips underneath the site and the piezo values that you get reflect an amalgamation of probabilistic hazards from all these different sources. And I think in part you can probably ask some of those witnesses more about that.

JUDGE FARRAR: Okay. One of Dr. Lam's early questions went to do -- had to do with validating the computer models. I wasn't sure if your answers or to what degree your answers talked about validating it against real experimental data as against -- as opposed to other people's computer models which had come up with similar solutions.

In other words, where's the real word data here? I know you send them to a computer model and you run something for a year and you see that the results are different so you change the model. Then after two years the results are different. And after enough years now you're sure your model is correct. What similar assurance do we have here based on real world data that these models are legitimate, or did I not understand your previous answer?

DR. TSENG: Well, I -- earlier on the answer to Judge Lam's question was more on the validation of the computer program.

JUDGE FARRAR: Validation --

DR. TSENG: Of the computer program used in this calculation.

JUDGE FARRAR: But validating it against what?

DR. TSENG: There were many method of trying to validate it, and the method generally use is if you have a published journal solution and then you can model that same problem --

JUDGE FARRAR: But the published journal solution is somebody's computer model that was peer reviewed and everyone says this is a good model but they haven't tested it against the real world yet, or have they?

DR. TSENG: Some they have.

JUDGE FARRAR: And that's the part of the question I want to focus on. Where in the system are the real world results that let you say, aha, this other model has been proven in the real world to work and our model matches up with that one?

DR. TSENG: For the particular program SASSI, we -- in the validation process there was available a model test with actual recording of earthquakes, actual recording of a model response and so on. And that particular experiment was sufficient for computer modeling using that particular program, then you can calculate or predict the response and prepare to record it motion and that has been done for this particular program called SASSI. But then the availability of this test program for you to be able to model and test it are not many.

So it may not be always possible for us to compare against real world experimental results. So you would then use other people's solution which may or may not be the real, but at least uses different theory, different approach and they get a solution and you model it based on the same intent and so on and the program, of course, given the sound theory. And you model and then you get the solution and compare with the solution publish in that paper or thesis or journal.

Then you get a good result and at least you get a confidence that base on the computer's own internal theory and your modeling process that you have get an agreeable -- a same result -- or a result very agreeable to the solution of the published results. So with this experience you then go to the general project and apply all these principle to the engineering project, and of course this kind of comparison eventually the confidence that you are at least modeling based on the principle that you have compare with the solution.

JUDGE FARRAR: Did you want to follow-up on anything?

JUDGE LAM: No.

JUDGE FARRAR: Thank you, sir. Another question, we had you go through some definitions this morning. Did you ever, either this morning or in your testimony, define uniform half-space?

DR. TSENG: I'm --

JUDGE FARRAR: If not, will you go ahead.

DR. TSENG: I may not have. But uniform half-space is a mathematical model to model the soil if you go very long distance. It's a mathematical model where you have half-space instead of the full space. So you have a free surface boundary and beneath that the soil property or the properties are uniform. So that's why we call uniform half-space. Is very commonly used for study soil and foundation and traction problems.

JUDGE FARRAR: Now, this one I think is real simple, PFS Exhibit 84, the layout of the casks. Is there any reason why in one direction their center to center is 15 feet and another direction center to center is 16 feet? Is that of any significance at all?

DR. TSENG: That particular question I have to rely on Stone Webster and Holtec to answer. I think the particular arrangement consideration which I am not aware or knowledgeable of.

JUDGE FARRAR: And they'll be on the stand later?

MR. GAUKLER: Holtec will be on the stand.

JUDGE FARRAR: Okay. At some point I'll want -- I mean, there's several -- I mean, they're simple geology questions about this.

MR. GAUKLER: I think I know what the answer is. I can talk to -- John Donnell is probably the one to provide the answer to that.

JUDGE FARRAR: Isn't he always. At some point, I don't care, I just want to make sure there's no significance there that we should be considering. Jerry?

JUDGE KLINE: Nothing.

JUDGE FARRAR: I think that ends the Board's questions.

MS. CHANCELLOR: Your Honor, could I do one housekeeping thing? I forgot to move an exhibit into evidence.

JUDGE FARRAR: Yes, go ahead.

MS. CHANCELLOR: I would like to move State's Exhibit 172 into evidence.

JUDGE FARRAR: Okay.

MS. CHANCELLOR: That was the calculation of the retro --

JUDGE FARRAR: Any objections?

MR. GAUKLER: Yes. We object, Your Honor. Our witness doesn't agree with it. We think the State ought to sponsor it through their own witness.

MS. CHANCELLOR: The witness described its differences and what his concerns were with the Exhibit.

MR. GAUKLER: Also, the witness did not do the actual calculations, he was just relying upon representations. And given those two facts I think it's more appropriate for the State's witness to --

JUDGE FARRAR: Do you have a witness who can sponsor it?

MS. CHANCELLOR: I do, Your Honor. I just think the record might be a little more clear now, but we can wait.

JUDGE FARRAR: This is a question we can avoid by having your witness sponsor it.

MS. CHANCELLOR: Okay. That's fine.

JUDGE FARRAR: Mr. Gaukler, how much redirect do you think you would have?

MR. GAUKLER: I think I would have 15 minutes. If I can have a break to check the record for a few things.

JUDGE FARRAR: It's three minutes to 5:00. Let's come back at 5 after 5:00 and see if we can't finish these witnesses today.

MR. TURK: I would support that as well. I have a few follow-up questions and I want to introduce some of the regulatory guidance documents.

JUDGE FARRAR: Okay. Let's see if we can't finish these folks today.

(Recess taken.)

JUDGE FARRAR: Mr. Gaukler, if you're ready we'll call everybody back and have you do your redirect.

MR. GAUKLER: Before we go into that, I have checked with John Donnell and I will say on the record the reason why the dimension is 16 feet in one direction as opposed to 15 feet in the other in terms of the cask spacing, I guess this is information I got directly, which I thought was correct and John Donnell confirmed it, the 16 feet in one direction because they increased the spacing last March or April to allow more room for a wider transporter, a bigger transporter. And since they were changing the seismic analysis at that time anyway they went ahead and changed the spacing to accommodate a larger transporter. So that's the reason why they went from --

JUDGE FARRAR: I take it that 35 feet between rows, that's where the transporter runs?

MR. GAUKLER: That's where the transporter would go in between the rows.

JUDGE FARRAR: And if anybody comes up with any information different from that, feel free to add it into the record at the appropriate time. All right, Mr. Gaukler, you may do your redirect.

REDIRECT EXAMINATION

BY MR. GAUKLER:

Q. Dr. Youngs, you will recall in your cross-examination counsel for the State was asking you about different types of earthquake waves and the extent to which you had calculated the angle of -- the difference in angle off vertical those waves were. Would you briefly define the types of earthquake waves that were discussed, the P waves, the shear waves and the surface waves and then tell us which one you focused on in your analysis and why?

MR. YOUNGS: Okay. The -- there are two general types of waves that could be generated by an earthquake. The first are called body waves which transmit, if you were in a uniform velocity material they would transmit directly from the source to the site. And the second type are surface waves which are generated near the surface of the path of the free surface where the waves, the body waves were interacting with the surface waves.

In terms of the -- or the fact that our earthquake sources are very near to our site, generally the main energy is coming from faults that are within nine kilometers of the site. Body waves will be the dominant source of energy transmission from the earthquake source to the site. So we concentrated on body waves rather than surface waves. If we were out at much larger distances well beyond, say, 40 or so kilometers and that's where all our sources were coming from, then we wouldn't perhaps have to look at surface wave effects.

In terms of body waves themselves, there are two general types of body waves. There are what are called compression waves and what are called shear waves. Compression waves are what would be equivalent to a sound wave. They represent back and forth motion in the direction of the wave propagation. So as the wave propagates away from the source to the site the motion of the ground particles are back and forth along that path. And they are what are called compression or sometimes called P for primary waves and they travel the fastest. The highest velocities are the P wave velocities.

The second type of wave is called the shear wave in that the particle motion of the ground particles is transverse to the direction of propagations, a shearing motion. And they have generally what -- you can classify those generally into two polarities. SH waves are shear waves in which the motion is primarily horizontal back and forth and SV waves are motions where the primary motion is vertical. And in earthquake effects on structures, the primary energy or main source of energy is in the shear waves.

And if you look at the time history that was generated you can see a very low amplitude set of motion for about the first four seconds, and though that represents primarily the P waves coming in early because they travel faster, then you see large amplitude motions coming in and those are the shear waves coming in later and carrying the largest amplitudes of motion. So we focused our attention on estimating the arrival angles of those shear waves because they're the primary source of motion of energy transmitted to the casks, and if we look at the time history of cask displacement there's very little movement until those large amplitude shear waves come in.

Q. Thank you, Dr. Youngs.

Dr. Tseng, at various times you referred to published sources, DeLong and Luco, and another Luco paper where you were making judgments based on uniform elastic half-space, and we know that that site does not necessarily have uniform properties. My question is, is difference of the site properties from the uniform half-site -- half-space of the published articles you were referring to significant, in your determination?

DR. TSENG: I think to assess certain gross behavior to render a judgment whether is a significant effect or not, I think the model where there is a uniform half-space or a layer detail velocity structure would not make so much difference. Of course, when we do the detail design calculation we would not use that. However, he we would use the detailed velocity calculation. But to render judgment on whether a certain parameter is significant or not, I think is very common to use a uniform half-space solution to give you that judgment.

Q. Dr. Tseng, at another point you were discussing the soil at the site and the compressibility of the soil and you made a statement that this was a softer soil site, something to that effect. Softer soil in what, compared to what?

DR. TSENG: Well, in the context that I mentioned softer soil site is as compared to, say, a rock site. Certainly it will be softer than a rock site.

Q. And so you were saying, therefore, the compressibility would be different from a rock site is what you meant by that statement?

DR. TSENG: It may or may not. It may not have a direct correlation, but a certain softer site may have a smaller or softer compressibility.

Q. Dr. Tseng, at another point you were

asked a question, counsel for the State was discussing with you the possibility that the cask may slide on the surface of the pad. And if the cask slid, how would -- if the cask slid it would no longer be known at which you applied the force to the cask in your analysis. And my question for you, would you expect a significant change in the local deformation if the cask were to slide somewhat on the pad more than in the three or four inches that you referred to from the Holtec calculation?

DR. TSENG: In a structural model like we have for the pad, I think the accuracy will be about the half thickness of the pad, which will be around a feet and-a-half. So somewhere in that range, if the movement doesn't exceed that amount, it shouldn't affect the accuracy of the result too much. If, however, the movement beyond that range, then it may have some effect to that deformation.

Q. You also mentioned in the context of the spring values that you used in your analysis that -- I believe you said that you used uniform spring values for -- soil springs for your analysis even though if you assumed a perfectly rigid pad the spring values would be greater around the edges. Of what practical significance, if any, is that to the determination of whether the pad acts as a rigid body for purposes of the global response?

DR. TSENG: For global response where you model the whole pad spring is one single spring. The sum of the two cases -- actually, the total soil spring is the same, it's just the distribution is different. So if the model uses a total spring value for the entire pad, then you should have not any effect on the global response.

MR. GAUKLER: I have no further questions, Your Honor. I will let the Board know, I met my estimate this time.

JUDGE FARRAR: The Board was careful to stay within it's estimate, but we didn't brag about it.

(Laughter.)

JUDGE FARRAR: Well, done, Mr. Gaukler. Mr. Turk.

MR. TURK: Thank you, Your Honor. May we go off the record for one moment?

JUDGE FARRAR: Yes.

(Off the record.)

MR. FARRAR: We're back on the record

having decided on how to handle some Exhibits. Go ahead, Mr. Turk.

MR. TURK: Thank you, Your Honor.

REDIRECT EXAMINATION

BY MR. TURK:

Q. We have passed out to the parties and the Board and court reporter as well as to the witnesses, a copy of Section 3.7.2 of NUREG-0800 which is entitled Seismic System Analysis. I would ask the witnesses if they are familiar with this document?

DR. TSENG: Yes, I am.

DR. YOUNGS: Yes, I am.

Q. I would also ask the witnesses in particular, if you look at page --

MS. NAKAHARA: Excuse me, Your Honor. We would be willing to stipulate -- well, I won't stipulate. We don't have any objection --

JUDGE FARRAR: To the admission of it.

MS. NAKAHARA: Right.

JUDGE FARRAR: Mr. Gaukler?

MR. GAUKLER: We have no objection.

JUDGE FARRAR: All right. We will --

MR. TURK: I appreciate that, Your

Honor, but --

JUDGE FARRAR: You still have some questions?

MR. TURK: I have questions based on the document.

JUDGE FARRAR: Go ahead.

Q. (By Mr. Turk) I would ask the witnesses to please turn to page 3.7.2-2 and do you see a section there entitled Soil-Structure Interaction?

DR. YOUNGS: Yes.

DR. TSENG: Yes.

Q. In fact, that's an area of review for the staff, if I'm not mistaken, that's under Part 1 of the document, correct?

DR. YOUNGS: Yes.

Q. Then also if you would, turn to page 3.7.2-5. Do you see Roman Numeral II, Acceptance Criteria?

DR. TSENG: Yes.

DR. YOUNGS: Yes.

Q. And then if you would please turn to page 3.7.2-8, do you see item 4 near the bottom of the page entitled Soil-Structure Interaction?

DR. TSENG: Yes.

DR. YOUNGS: Yes.

Q. And that is, in fact, the regulatory guidance for how nuclear power plants, in particular, should analyze soil-structure interaction; is that correct?

DR. TSENG: That's correct.

Q. Did you follow the guidance in this section in performing your analyses?

DR. TSENG: Yes.

MR. TURK: Your Honor, at this point then I would offer into evidence this section of the Standard Review Plan with the precise number to be identified overnight.

JUDGE FARRAR: All right. And as we indicated off the record, we'll follow that procedure because we don't have the last numbering of the staff Exhibits from the hydrology hearing. So we will find that out or counsel will find that out tonight and we'll have these marked properly tomorrow. But the document will be admitted.

(STAFF EXHIBITS- ADMITTED.)

MR. TURK: And, Your Honor, I think it might help also to understand some of the questioning that has taken place today. If I ask the witnesses to look at particular sections here to see if this may, in fact, help them to understand the regulatory framework in which they conducted their analyses or put that on the record.

Q. (By Mr. Turk) If you look, please, to page 3.7.2-10 near the bottom do you see a section entitled Specific Guidelines for SSI Analysis?

DR. YOUNGS: Yes.

DR. TSENG: Yes.

Q. And going on to the next page, in the middle of the page there's a bullet that begins, "Unless the site is well investigated, the variation in soil properties should be considered by performing SSI analyses using three sets of values." Do you see that?

DR. TSENG: Yes.

DR. YOUNGS: Yes.

Q. Is that what you did, then, did you use three sets of values as described in this document?

DR. TSENG: That's correct.

DR. YOUNGS: Yes.

Q. And that would have included the best estimate of the lower bound and the upper bound values as described in this paragraph, right?

DR. YOUNGS: Right.

DR. TSENG: Correct.

JUDGE FARRAR: Mr. Turk, let me

follow-up. Maybe I'm missing something. It says to do three analyses, but the way the document describes the three analyses doesn't conform to my understanding of the three analyses that were used in this case, or am I mistaken? That's of the witness. In other words, that doesn't say lower bound and upper bound.

DR. TSENG: It doesn't say, but it does call for taking into account the uncertainty in the soil properties and it call for variation of soil property from lower value to higher value. And in the PFS analysis we call it lower bound or upper -- lower range and upper range.

JUDGE FARRAR: So are you saying you just called it something different or you did something different?

DR. TSENG: We do the same as intended here, but call it slightly different name.

Q. (By Mr. Turk) If I'm not mistaken in this bullet they describe the best estimate value and then go on to say a value that's twice that number as well as a value that's half that number?

DR. TSENG: If you decide is not well investigated then you use this 2. And I think that was the basis of the upper range selection.

DR. YOUNGS: Let me speak directly to that. It calls for if the site is not well investigated to use factors of 2 in the shear modulus of the materials. The data for the site consists of 17 measurements in the upper 30 feet of the soil, which show a very small variation across the site. So we felt that the upper portion were adequately characterized and we would not need to use the factor of 2 for the upper portion of the soil profile.

The lower portion of the soil profile we have one downhole measurement and some other geophysical information. So we used a factor of 2 in characterizing the variability in the velocities for the material below 30 feet and also for the material velocities in the treated soil cement and cement treated soil.

For the range of 0 to 30 feet where there is sufficient information to indicate very low variability across the site we followed the guidance in ASCE 4 which recommends that you do not do -- you consider variability of at least a factor of 1.5 in modulus, so plus 50 percent or minus -- multiplied by 1.5 or divided by 1.5. So we varied the properties in the 0 to 30 foot range. I mean the below the site natural soils below the portion removed for soil cement and to a depth of 30 feet we varied by a factor of 1.5 instead of 2.

MR. GAUKLER: Doctor, you said in accordance with 4. I think you meant to say 4-86?

DR. YOUNGS: Yes. ASCE 4-86 which is a American Society of Civil Engineers guidance document on analysis for nuclear facilities.

Q. (By Mr. Turk) And in your opinion, is the way you performed that analysis consistent with standard industry practice?

DR. YOUNGS: Yes.

Q. While we're talking about the AS --is it ASCE?

DR. YOUNGS: ASCE, yes.

Q. The American Society of Civil Engineers?

DR. YOUNGS: American Society of Civil Engineers.

Q. Document 4-86, that document also contains some guidance on the use of a 5 percent eccentricity value, correct?

DR. YOUNGS: Yes, I believe it does.

Q. And is it also correct that under the ASCE 4-86 document the use of a 5 percent eccentricity would apply to things such as inclined angle of waves?

DR. TSENG: That's correct.

Q. Is it also correct that this 5 percent value is deemed to bound the possible cases or to envelope possible cases?

DR. TSENG: Base on the small angle of instance that estimate for the site and the testimony of the evaluation of the variation in motion only in a range less than 5 percent, 5 percent should encompass, yes.

Q. So the use of the 5 percent here would be a bounding value?

DR. TSENG: That's correct.

Q. I would like to distribute another -- I would like to identify this document, Your Honor. And again, I would ask Mr. O'Neil to please pass this out, with the same caveat that we'll get the precise Exhibit number overnight.

(STAFF EXHIBIT-   MARKED.)

Q. (By Mr. Turk) We are passing out a Section 3.7.1 of NUREG-0800. This is entitled Seismic Design Parameters. Gentlemen, do you have this document in front of you?

DR. TSENG: Yes.

DR. YOUNGS: Yes.

Q. Are you familiar with it?

DR. TSENG: Yes.

DR. YOUNGS: Yes.

Q. Could you please turn to page 2, I guess it's 3.7.1-2, and is there a section there entitled Design time History?

DR. YOUNGS: Yes.

DR. TSENG: Yes.

Q. And could you review that section briefly, going onto the next page, and indicate whether this regulatory guidance document gives you the option of using a single time history or multiple time histories?

DR. YOUNGS: Yes.

Q. It does?

DR. YOUNGS: It does.

Q. And then again starting at page 3.7.1-4, the acceptance criteria are identified and on the next page it indicates for design history you have two options; Option 1: Single Time History, or going on several pages later it says Option 2: Multiple Time Histories. Do you see that?

DR. YOUNGS: Yes.

DR. TSENG: Yes.

Q. And did you utilize the single time

history consistent with the guidance in this document?

DR. YOUNGS: We developed a single time history consistent with the guidance in this document, a single set of -- three single -- a three-component set of time histories.

Q. And when you say a single set with three components, that included two horizontal components and a vertical component?

DR. YOUNGS: That's correct.

MR. TURK: Your Honor, at this time I would offer this document into offer as well with the precise number to be identified overnight.

JUDGE FARRAR: Objections?

MR. GAUKLER: No objection.

MS. NAKAHARA: If we may have a moment, Your Honor.

Q. (By Mr. Turk) In your cross-examination testimony --

JUDGE FARRAR: The State has not decided whether they want to object. While they're thinking about that, the purpose for introducing these is just -- I mean, these are not regulations, they're practices the Staff follows which have that weight, but not the force of regulation, as I understand it?

MR. TURK: That's correct, Your Honor. The regulations are not as precise as what you see in the regulatory guidance. The guidance provides means for applicants to understand how they have to satisfy the regulations or for the Staff to believe that the regulations are complied with. And I would note that in the witnesses' testimony at various times they referred to NUREG-0800 in a general sense without picking out specific sections or sentences from the guidance.

MS. NAKAHARA: Your Honor, we would object pending a couple of questions on recross.

JUDGE FARRAR: All right. Then we'll carry the motion along with the case for the moment.

MR. TURK: Incidentally, if I didn't say it clearly enough, I would point out that regulatory guidance documents provide one acceptable means of complying with regulations. As you know from the aircraft crash testimony, there may be other means of complying and we've talked about that.

MS. NAKAHARA: Your Honor, I would object, counsel is testifying.

JUDGE FARRAR: Well, we were just trying to make sure the record reflects what the status of these documents is in the regulatory system. They're something less than regulations, and the key there is regulations cannot we challenged in licensing proceedings unless you go through some sort of process, whereas, regulatory guides are not binding on companies if they can come up with a better way, and they're not binding on you if you want to challenge them.

MR. TURK: May I continue then, Your Honor?

JUDGE FARRAR: Yes, go ahead.

Q. (By Mr. Turk) In the testimony earlier today, I believe this was Dr. Tseng, you were asked whether you were familiar with any other nuclear facilities that float at their sites. Or I'm sorry, maybe I'm using the wrong term. Maybe the term was freestanding.

DR. TSENG: Freestanding.

Q. And you indicated at that time you couldn't think of any other freestanding nuclear facilities?

DR. TSENG: At that time I believe I cite example of a containment structure support on rock site.

Q. Are you familiar at all with nuclear plants such as the Waterford Plant in Louisiana or the Riverbed Plant?

DR. TSENG: No, I'm not familiar with that.

Q. You just don't know whether those plants are freestanding or not?

DR. TSENG: No.

Q. Also, Dr. Youngs, you indicated that the PFS site is the only site at which I believe you said you generated, yourself generated peak ground accelerations in excess of 0.4 Gs. Do you recall that part of your testimony?

DR. YOUNGS: Yes. Where I generated, I believe it had to do with -- I'm not sure -- I believe the question had to do with time histories. I believe the question that I responded to was whether it was my only site, only nuclear site where I generated time histories where the peak acceleration was in excess of .4 Gs.

Q. Do you mean to suggest by that that there are no nuclear facility sites where the peak ground accelerations are in excess of .4 Gs?

DR. YOUNGS: No.

Q. In fact, there are sites where the PGAs are greater than that, aren't there?

DR. YOUNGS: Yes. It's just that I have never generated time histories for them personally.

Q. There was some questioning earlier today about a figure that appears in Dr. Luco's report dated March 8th. I believe you were shown Figure 17 of that report. Have you read the entire Luco report?

DR. TSENG: I have read the report in a not a very detailed sense of the earlier version of the report.

Q. Do you know whether figure 17 represents an actual prediction of ground accelerations at the PFS site or is it a hypothetical case?

DR. TSENG: I have to read the text again to ascertain whether there's a hypothetical or a PFS site. But from the condition that shows there it looks like it's a parametric study to see what happen if certain coefficient friction is -- certain friction sliding is occurring at certain layer. But to answer your question fully, I have to review the document again.

Q. Do you recall whether or not the report indicates that that figure is a means or a study that was done in order to assess the impact of soil structure interaction? Do you recall that or not?

DR. TSENG: Again, I have to review the report to see the particular relevance of that figure on soil structure interaction or they intend to show something else.

Q. So when you gave your testimony about that figure you were not aware of its significance in the report or what it was being used for?

DR. TSENG: No.

Q. No meaning no, you were not aware?

DR. TSENG: No, right.

Q. Correct?

DR. TSENG: Right.

MR. TURK: My Army behind me says they're satisfied, Your Honor.

JUDGE FARRAR: Remember, Mr. Turk, an Army marches on its stomach. So don't keep them here too long.

MR. TURK: In this case I think they're going to march on me.

JUDGE FARRAR: All right, thank you. Ms. Nakahara?

MS. NAKAHARA: I just have a few. Thank you, Your Honor.

JUDGE FARRAR: I would remind you the Board's and Mr. Gaukler's and Mr. Turk's questions were fairly brief so you have a limited area for recross.

RECROSS-EXAMINATION

BY MS. NAKAHARA:

Q. Dr. Tseng, if you recall in response to a question from Judge Lam, is it correct that you stated your pad design analysis is linear and thus not sensitive to input parameters, as sensitive to input parameters? Is that correct?

DR. TSENG: That's correct.

Q. Isn't it correct your linear analysis conducted in the pad design relied on four time histories from Holtec's nonlinear analysis?

DR. TSENG: Well, the Holtec time history is of course obtain in their analysis which is found in there, as I understand, and that become our input to our system. And our system's model is linear, but, you know, in a sense it will be like a equivalent linear.

Q. And is it correct -- I'm sorry, I didn't quite hear. Is it correct that Holtec's analysis is a nonlinear analysis that generated the four time histories that you used?

DR. TSENG: That's correct.

Q. Dr. Youngs, Mr. Turk asked you a few questions with respect to NUREG-0800, 3.7.1; is that correct?

DR. YOUNGS: That is correct.

Q. If you turn to page 3.7.1-3, is it correct that Option 2 for multiple time histories, the option for multiple time history is expressed?

DR. YOUNGS: Yes, option.

Q. Will you read the second paragraph under Option 2?

DR. YOUNGS: "In some instances a nonlinear analysis of the structures, systems and components may be appropriate, (e.g., the evaluation of existing structures). Multiple time history analyses incorporating real earthquake time histories are appropriate when such analyses are proposed. The adequacy of time histories used in the analyses is reviewed."

Q. Thank you. And will you turn to page 3.7.1-7? And under Option 2, Multiple Time History, will you read the third paragraph starting with the review?

DR. YOUNGS: "The review of the

real-time histories used in the nonlinear analysis is conducted on a case-by-case basis. Some of the specific items of interest are the number of time histories, frequency content, amplitude, energy content, duration, number of strong motion cycles, and the basis for selection of time histories."

Q. And just to clarify the record, Dr. Youngs, is it correct that you were instructed by PFS to generate a single set of time histories?

DR. YOUNGS: We were asked by PFS to follow option 1.

MS. NAKAHARA: Thank you. I have no more questions. And, Your Honor, I withdraw my objection to Staff's Exhibit to be determined tomorrow.

JUDGE FARRAR: Okay. Then we'll formally admit those tomorrow when we get the numbers. They will be admitted at that point.

MR. GAUKLER: I have one quick follow-up question.

MR. FARRAR: All right.

FURTHER REDIRECT EXAMINATION

BY MR. GAUKLER:

Q. Dr. Youngs, you stated that for the top

30 feet you used a sensitivity of plus or minus 1.5, I believe it was, for the modulus for the soil?

DR. YOUNGS: Yes.

Q. The soil properties. What were the actual measurements from the 17 or 18 holes that you had there in terms of those soil properties?

DR. YOUNGS: The variation of modulus of a factor of 1.5 corresponds to a variation in shear wave velocity of the square root of that value which would be about 22 percent and the largest layer would be measured at a variation of 13 percent.

JUDGE FARRAR: Thank you, Mr. Gaukler.

MR. TURK: May I just clarify one thing with that last question?

JUDGE FARRAR: Yes.

MR. TURK: Does that mean that the use of a factor of 1.5 bounded the actual shear moduli that you found?

DR. YOUNGS: It bounded the variation that we found. It was approximately twice as large as the variation in shear wave velocity that we found across the site in that upper 30 feet.

MR. TURK: Thank you.

JUDGE FARRAR: All right. Then that wraps it up. We thank the witnesses for their testimony. We started an hour late today with -- well, we started on time, but we spent an hour on the various matters so I consider it a good day's work. We got this panel done and I appreciate counsel and the witnesses having observed the Board's admonitions. We have 21 panels in a 15 or 20-day target, so we'll half time encourage you that we'll have to do even better than this. I notice the testimony tomorrow is much lengthier or somewhat lengthier than this so we will -- am I right, Mr. Gaukler, that Dr. Singh and Dr. Soler will be on tomorrow? So let's press on and see if we can move quickly.

MR. GAUKLER: One quick housekeeping matter. We'll be introducing the Exhibits of Dr. Singh and Dr. Soler's testimony. One of the Exhibits are those simulations and we were going to show them on a computer on a screen.

JUDGE FARRAR: That's the CD you sent us some time ago?

MR. GAUKLER: Yes.

JUDGE FARRAR: Have you arranged with the hotel for that capability?

MR. GAUKLER: We have it sufficient capability to put the film on, yes.

JUDGE FARRAR: Fine. Have you all checked with Will? I would like to get, so the witnesses don't have to sit there with straight chairs, bring in some tables. So we'll bring in several for each and just leave the small spectator section. So anyone who is a prospective witness will be able to sit at a table if they want to.

MR. TURK: Is it possible also to ask counsel how long cross-examination would run on Singh and Soler?

JUDGE FARRAR: You could ask.

MS. NAKAHARA: It depends on how much endurance I have tonight. I'm sorry, I really can't answer.

MR. TURK: More than today, less? I haven't seen the cross-examination plan your Honors have. I have no idea what we're looking at a larger scope or a smaller scope.

MS. NAKAHARA: I would expect a larger scope from the standpoint that the testimony is longer.

MS. CHANCELLOR: Of course you haven't seen our cross-examination pledge.

JUDGE FARRAR: Well, I think we've made all the progress we can. It's 10 of 6:00. We'll see you back here tomorrow at nine o'clock in the morning.

(The proceeding was concluded for the day at 5:58 p.m.)

CERTIFICATE

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

Name of Proceeding: Private Fuel Storage, LLC

Docket Number: Docket No. 72-22-ISFSI

ASLBP No. 97-732-02-ISFSI

Location: Salt Lake City, Utah

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

/S/ Diana Kent
Diana Kent
Official Reporter
Neal R. Gross & Co., Inc.