72-22 ISFSI - State Exhibit 112 - Rec'd 5/8/02

RAS 5571

CONDENSED TRANSCRIPT

DOCKETED
USNRC

2003 JAN 29 PM 3: 12

OFFICE OF THE SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

In the Matter of PRIVATE FUEL STORAGE, LLC, (Private Fuel Storage Facility)	Deposition of: Farhang Ostadan Docket No. 72-22 ASLBP No. 97-732-02-ISFSI

March 8, 2002 - 10:30 a.m.

Location: Parson, Behle & Latimer

201 South Main Street, #1800

Salt lake City, Utah 84145

Reporter: Diana Kent, RPR

Notary Public in and for the State of Utah

State's
Exhibit 112

CitiCourt, LLC
THE REPORTING GROUP

50 South Main, Suite 920
Salt Lake City, Utah 84144

801.532.3441 TOLL FREE 877.532.3441 FAX 801.532.3414

Template=SECY-028

SECY-02

'CLEAR REGULATORY COMMISSION

Docket No. ______ Official Exh. No. 112

In the matter of PFS

Staff ______ IDENTIFIED ✓

Applicant ______ RECEIVED ✓

Intervenor ✓ REJECTED ______

Other ______ WITHDRAWN ______

DATE 5-8-02 Witness ______

Clerk pmp

A. That's right.
Q. Okay. Very good. Is there any portion of the calculation that led you to conclude that the pads are not rigid?
A. Yes. So many of the results towards the end of the calculation that summarize the displacements, vertical displacements. I think they performed two analyses. One was with C-Star or a SAP program. I forget. And the other with SASSI. They showed the results.
Q. This may refresh your memory. I'm going to mark this one as Exhibit Number 30.
(EXHIBIT-30 WAS MARKED.)
Q. Let me identify for the record this document. It is a document titled Declaration of Dr. Farhang Ostadan, it is dated January 30, 2001, and it bears the caption of this proceeding. Are you familiar with this document that's been marked as Exhibit 30?
A. Yes, I remember it.
Q. Did you prepare it?
A. Yes.
Q. Okay. Now, you will turn to Page 6 of Exhibit 31.
A. Okay.

Q. Paragraphs 24 and 25.
MS. CHANCELLOR: Just want to place an objection on the record. To the extent this deals with Contention L, it is not part of this deposition. The witness may go ahead and answer. I notice that it relates to summary disposition of Utah L.
MR. TRAVIESO-DIAZ: I am happy to represent to you that the question and the answers are not going to deal with Contention L at all.
MS. CHANCELLOR: Okay.
Q. (By Mr. Travieso-Diaz) Take a look at Paragraphs 24 and 25.
A. I read that, yes.
Q. And 25.
A. Yes.
Q. Now, looking at Paragraph 25, does that refresh your memory as to what portions of the calculations --
A. Yes.
Q. Is that table 5.2.5-1 on Page 214 the one you are thinking about?
A. And there are other tables. There are a bunch of tables. But this is one place, one example you can find this.
Q. All right.

(EXHIBIT-31 WAS MARKED.)
Q. For the record, I would identify what Exhibit 31 is. Exhibit 31 is comprised of the cover page of I believe the same calculation that you made reference to on Paragraph 25 of Exhibit 30. And the second page of the exhibit is Figure 5.1-1 of the calculation.
A. Right.
Q. The next page of the exhibit is Section 5.2.5 of the calculation. The next page of the exhibit is table 5.2.5-1. And the last page is table S-2?
A. Right.
Q. Will you turn to table 5.2.5-1?
A. Yes.
Q. Which I believe is the one you made reference to --
A. Yes.
Q. -- on the other exhibit.
A. Yes.
Q. Would you tell me, perhaps by reviewing that table, where the excitation, where the load was applied in this analysis?
A. I don't think it indicates where the loads were applied, if that is what your question is. I can't see that here.

Q. Would you look at the notes under the table itself in the first sentence. That could help you.
A. Which table?
Q. Same table. Just the explanatory note.
A. Just the note?
Q. Yes.
A. Okay. I understand the note. But it does not tell you where the loads were applied, if that was your question.
Q. The way I read the note, and maybe you can correct me if I'm wrong, says the application of the load was on node 249.
A. No, that's not true. What he is saying is that near application of the load, that's near application, there's 10 percent difference between the two results.
Q. Okay.
A. But the loads are applied at the interface point between the cask and the pad, depending on how many casks you have; if you have two, four, or eight.
Q. So it would be at the edge of the cask, the place where the cask --
A. No. I think for vertical, if I'm not mistaken, you have or they provided Holtec four vertical time histories, force time history, at four points. And

PAGE 93

93

for horizontal, I think they provided one time history for each direction and CEC divided the nodes on the contact points. It's all in the calculations.

Q. Why don't you turn to the page that has text that is labeled 5.2.5. Look at the second paragraph on that page and tell me if that refreshes your recollection of where the force was applied or the load was applied.

A. This is one case they studied which they are talking about single vertical time histories applied at the second quadrant of the first cask, node 249. That is one study case. But that is not their basic case for design.

Q. What I'm trying to see if I understand from you is for the case that is displayed on Table 5.2.5-1, whether your understanding, by looking at the note under the table and explanatory text on the preceding page, whether your understanding is that for that case, the load was applied at node 249.

A. I need to look at the whole calculation. I think what you see here in this table is not what is talked about in the second paragraph.

Q. Is it your view that the description 5.2.5 doesn't apply to the computation which results are shown on Table 5.2.5-1?

PAGE 94

94

A. No. The description of 5.2.5 is very general in the first paragraph. They talk about what they did and the time histories shown and the figures and so on and so forth. I'm not certain these results you are showing relates to the specific case they are talking about in the second paragraph or does it relate to a generic case where casks are all there and loads are employed at a contact force. But I can assure you -- it's a very good calculation, actually. But I can assure you that there are other tables that they show clearly where loads are applied and what the results are.

Q. I do happen to have the calculations here. I hesitate to introduce it as an exhibit because it is several hundred pages long. This is what I would like to do in the interest of saving time: If you could look at this at a break and tell me after the break whether you agree or disagree, based on your review, that in fact the load is applied on node 249.

A. Okay.

Q. So to save time, let's proceed on the assumption that the load is applied at node 249 and if it is not, then all your answers would be of no significance.

A. That's a pretty poor assumption. But it

PAGE 95

95

doesn't reflect the reality that the loads are applied only on one node.

Q. But that's actually what I'm trying to get to. I guess that in order to assess the results on table 5.2.5-1 you have to understand what case was analyzed.

A. Fair enough.

Q. And what load was applied where. So my understanding, and I think it is pretty good, is that for that case the load was applied on node 249. We can do it two ways. We can take time off now, take a break, and give you whatever time you need to review this calculation, or else we can proceed on the assumption that it was on node 249 and you can confirm that it was or tell me that it was not.

MS. CHANCELLOR: I'd instruct the witness to review the calculations so that he is not guessing or that the record will accurately reflect what his opinion is.

Q. Okay.

(A break was taken.)

Q. While we were on the break we decided that we are going to mark as a separate exhibit, and that will be number 32, another table, table D-1(d) of the ICEC calculations, parts of which were previously marked

PAGE 96

96

as Exhibit 31.

(EXHIBIT-32 WAS MARKED.)

Q. And what we are going to do, if I understood our conversations during the break, first I'm going to ask you questions on Exhibit 31 under the assumption that the load for the table that is presented on Table 5.2.5-1, that the load on that case is applied in node 249. And then we will talk about Table D1(d). Is that agreed?

A. Very well. That's fine.

Q. Assuming that the load, the single load, is applied on node 249 -- would you refer back to Figure 5.1-1 on Exhibit 31. It's the second page of the exhibit.

A. Yes.

Q. Is that sort of a map showing where the pads and the casks are with respect to the nodes that were considered in the analysis?

A. Yes. It is a finite-element model of CECSAP, yes.

Q. So the record is clear, what do we mean by "nodes" in the finite-element analysis?

A. The mat has been discretized and element node numbers have been assigned for the analysis.

Q. So again for the not trained, including

myself, that means that the model essentially represents the structure as a series of points or nodes?
A. **That's right.**
Q. All right. And you take a look at Table 5.1-1. Node 249 would be essentially at the edge of Cask 1. You could say on the lower quarter of the pad, if you will, that is under Cask 1. Is that correct?
A. **Yes. That's correct.**
Q. All right. Now, if you applied a single load on a node located such as node 249, would you expect to get uniform responses or uniform deformations across the entirety of the casks and the pads underneath?
A. **Assuming the load is applied only at node 249?**
Q. Correct.
A. **I would not expect to see constant displacement on all nodes.**
Q. Turn for a second with me to Table 5.2.5-1 and you will have to flip back between the map and the table. Let's look at nodes 222, 235, 248, 261, and 274. Would those nodes represent the left edge of the pad where the load was applied on node 249?
A. **Would you slowly go over the node numbers again?**

Q. 222, 235?
A. **Just one second. Okay.**
Q. 248?
A. **Yes.**
Q. 261?
A. **Right.**
Q. 274?
A. **Yes.**
Q. If you take a look at the table, what I believe are displacements?
A. **Yes.**
Q. And would you look at the displacements for each of those nodes that I mentioned to you; 222, 235, 248, 261, 274. Those are the nodes that are the closest to the applied load; right?
A. **That's right.**
Q. Do you see a difference in the amount of vertical displacement when you go from, say, node 222 to node 274?
A. **A small difference.**
Q. Is that what you would expect in a case like we are talking about; a single load applied to a single node and you have different displacements depending on your distance from the application of the load?

A. **Let me make the observation based on the assumption we have made. That the load is being applied only at node 249.**
Q. Absolutely, yes.
A. **As you indicated before, rigidity is a relative measure. If that is the case, only one load is applied to the pad, this is unrealistic with the real field condition that we might have, two, four, six or eight casks. So the total earthquake loads are not being applied here. If our assumption is correct, this seems to be a parametric study which just applied at one node, one vertical time history.**
Q. And if, in fact, the assumption that the load was applied at node 249 is correct, would it be appropriate to look at the displacements shown on this table as representing the behavior of the pad under an earthquake excitation?
A. **No, it would not. Exactly my point.**
Q. Okay. So this, in fact, looking at this table for purposes of determining displacement would not be the thing to do?
A. **With that assumption that we have made.**
Q. Of course. Assuming that the load was put where we said.
A. **That's correct.**

Q. Let's turn to your Table D1(d) for a second. And since you suggested we look at it maybe you can tell us what we should look at it for.
A. **Maybe I should do what?**
Q. Tell me what we should look at it for.
A. **What we are looking at now, ICEC calculation page number 234 in which they show a summary of the vertical displacement and the bearing pressure for various scenarios they have analyzed. And the scenarios are for load bounce soil properties, best estimate, and upper bound. And each case has been analyzed for cases with two cask conditions, four cask conditions, and eight cask conditions. And we see vertical displacement at various nodes. So if I go, for example, to a two cask lower bound case, I'll see node 1, 7, and 13 have a displacement amplitude of 4 to 4.7. Of course there's a scaling factor on top of the table. But then for the same load case, same soil case, if you move down to node 287, 293, 299, you see displacement three to five times larger there.**
Q. Okay. Are nodes 287, 293, and 299 on the same pad as nodes 1, 7, and 13?
A. **I expect them to be all on the same pad, yes.**
Q. So this would be going from the -- we are

PAGE 101

101

going to look at the map, assuming that 1, 2, 3 is the edge of the pad. And 287, 288, and 289 are at the other edge.

A. **That's right.**

Q. Tell me what learning we derive from looking at the displacements across the two edges.

A. **Well, what you are seeing is the displacement varies by a factor of four to five times.**

Q. Now, is this a case in which there was uniform loading applied to the cask or what conditions under which the load was applied?

A. **If you look at the two-cask column, the two casks are being loaded and the loads responding to two casks are being applied.**

Q. I'm sorry. Where is that load applied?

A. **Okay. For two casks, at the beginning of the calculation they clearly define which nodes are being loaded for two casks, which nodes are being loaded for four casks, and so on. It's not in this table here, but it's been defined in the cask.**

Q. My question to you is are they placing a single load or loads on various nodes? What loads are applied where?

A. **And my understanding is, again, we are talking about the loads which are dynamic loads. They**

PAGE 102

102

are time histories provided by Holtec. For vertical force, Holtec provides four time histories at the four corners of the cask. And for horizontal, if I'm not mistaken, they provide one in each direction. But CECSAP divides to four location? So they are uniform. I can't tell which nodes are being loaded here based on this table. We have to go back to the few earlier pages of calculations to identify. I don't know those nodes.

Q. Well, what I'm trying to see if I can understand you help me to figure out, is with respect to nodes 1, 7, and 13, whether the load that has been applied are symmetrical with respect to those three nodes 1, 7, and 13 as the load that is applied to a corresponding other edge of the mat, which would be 287, 288, and 289?

A. **There's no load applied to the edges of the mat. For example, let's look at the two-cask. I'm looking on page or sheet number 20 of Exhibit 31 where they show the final element for CECSAP. So for example, let's say they are analyzing the two-cask scenario. We see on the top part of this figure there's Cask 1 and Cask 2. So what I expect to have done is the vertical time histories for each cask were applied at the four corners of the cask. For example, cask 1 would be 249, 225, 253, 277 if I read this correctly. And so on for**

PAGE 103

103

Cask 2. So that's how the load is applied.

Q. So your understanding is that the load is applied at the four corners, if you will, of Cask 1? And where would the load be applied with respect to Cask 2?

A. **The same four corners. Just follow the same logic here; 254, 231, 259, and 283.**

Q. So this is the situation in which you would apply load -- would you assume that the other casks are present on the pad or only those two casks?

A. **There are three scenarios they analyzed. In one, only two casks were present. The other one, four casks were present. And in the third one, all eight casks are present. So they have analyzed the three scenarios.**

Q. All right. And for the eight-cask scenario, you would be looking at the tables on this Exhibit 32 that are labeled "8 casks"?

A. **That's right.**

Q. And I see that those tables have LB, BE, and UB as captioned. What do you think those are?

A. **Load bounce profile, best estimate profile, upper bounce profile.**

Q. So if you wanted to find out what is the computation's best estimate of the displacement, you

PAGE 104

104

look at the middle column?

A. **That's right.**

Q. If you were to look at, say, the eight-cask case, and you assumed that the load combinations are as you described before and now applied to all eight casks, the best estimate of displacements would be on the column that says BE, 8 casks?

A. **That's right.**

Q. All right. And what you would ask us to concentrate on would be, for example, the displacements on nodes 1, 7, and 13 versus the displacements on nodes 287, 293, and 299?

A. **And you have the middle one, too; 144, 150, and 156 here.**

Q. What conclusion do you derive by looking at that column?

A. **I look at this and I see node 150 has a value of 12.39. And the maximum value I see in this column corresponds to node 1, which has 23.66. So almost a factor of two.**

Q. And what physical reality, if you will, what does that --

A. **That tells me the cask or the pad is not deforming rigidly. It has little deformation.**

Q. Would you translate the dimensions of this

SHEET 14 PAGE 105

105

displacement to me into inches or parts of an inch? It says, "Maximum displacements Zd (x 10-3 feet). Is that thousandths of a foot?

A. **Yes.**

Q. How many inches is a thousandth?

A. **Very small.**

Q. So you are saying that there is a factor or two difference between 12 (x 10-3) and 23.66 (x 10-3)?

A. **That's correct.**

Q. So your assumption as to whether this cask is flexible or rigid will be based on the difference in the displacement between those two points, whatever that is?

A. **Exactly. They are very small.**

Q. If it is very small, like a fraction of one inch, that would still lead you to the conclusion that there is flexion?

A. **It could be large. But if the difference wasn't there, you would assume it is rigid. They are small but there is a difference.**

Q. How small does the difference have to be before you can practically assume it is rigid?

A. **Well, I haven't done any separate calculation to suggest that number. But I think that suggests to me that the assumption of rigidity, full**

PAGE 106

106

rigidity of the mat, is not supported by these results.

I would like to point out another point as long as we are on Exhibit 32.

Q. Yes.

A. **Basically you were talking about whether the soil spring dash spots that were calculated and used by Holtec are appropriate or not, with respect to the foundation agility. If you go back to the column of two casks, and you notice the difference in sign, node 1, 7, 13 are positive, node 144, 150, 156 and others are negative. Do you see that?**

Q. Yes.

A. **What this tells me is that part of the pad is uplifting, it is moving up, whereas the other part is moving down. I don't know whether this movement is large enough to cause any suppression or not. But that also concerns me that under some condition, like two casks, while it vibrates you can potentially have the other edge of the pad separate from the soil which again goes back, in the assumption of calculation of spring and dash spot, assuming pad is rigid and in full contact with the soil is quite valid here. But this also violates that assumption.**

Q. Well, in terms of physical reality, understanding as we do that everything is deformable to

PAGE 107

107

some degree, wouldn't you expect that if you have a body and you apply force and there's deformation, a part of it will go up and a part of it will go down? Is there any way to avoid that?

A. **Yes. I agree there is always deformation. And I frankly would not bring up any of these comments if we had enough margin in our designs and in our foundation stability calculations. One would oversee these, and these differences might not be important. But when we talk about a very slim margin, these points become important. One has to make sure that they are properly reflected conditions we have.**

Q. Let me ask you a different question because we talked about this a little bit before, in connection with the angle of arrival of the waves and so on. But the question here is different. Can you tell from this table whether all the displacements occur at the same point in time?

A. **I cannot tell that, no.**

Q. Is it possible that if you were to compute for the eight cask case, the displacement at node Number 1 which is minus 23.66, and you would compute the displacement at node 150, which is minus 12.39, and the times were different, that you could get a different result?

PAGE 108

108

A. **It is likely possible.**

Q. And all the table says is this is the maximum displacement. It doesn't say it was the maximum simultaneous displacement; right?

A. **I agree with you.**

Q. Any other observation you want to state on this?

A. **I want to follow, based on your notion, if you look at the specific time, the differences could be larger or smaller.**

Q. That is true. Are you familiar with this ICEC calculation, not just this table but in general; what he was doing it for and the purpose and so on?

A. **Yes, I am.**

Q. Would you describe for the record why the calculation was run?

A. **ICEC calculation was primarily done to design the pads; structural design of the pad to come out with the rebars and the steel and the location of the rebar and steel.**

Q. So it was a design calculation?

A. **It was a design calculation.**

Q. You refer -- Interrogatory Number 5, the response. You refer to the Holtec calculation and I believe -- actually you refer to several calculations

PAGE 109

109

which have the same apparent problem. You have the stability calculation performed for Stone & Webster is on Page 13.
A. Yes.
Q. And you refer to the Holtec calculations at the beginning of the Answers to Interrogatory.
A. Right.
Q. Is it your view that all these calculations are similarly flawed in that they assume that the pads are rigid, whereas you --
A. No. You are talking about two different rigidities here. Let me explain that.
Q. Okay.
A. The rigidity that I talk about with respect to Holtec calculations is really deformation of the concrete pad.
Q. Okay.
A. And whether or not that is valid. And the impact of that would be on the calculation of soil spring and dash points.
Q. Okay.
A. And coefficient of friction.
The rigidity I talk about with respect to the Stone & Webster calculation, stability analysis, has to do with the way they have calculated the seismic load

PAGE 110

110

in the stability calculation. And the way they have calculated the seismic loads for stability analysis, they took the weight of the concrete pad, they took the weight of the casks, and for example for coefficient of .8 they observe a limit of the sheer that can be transferred to the pad based on that coefficient. But then they went ahead and calculated the inertia of the pad by using peak ground acceleration, which is a design motion and has nothing to do with the structural response or pad response. So this is only valid if the foundation, and I'm talking about the soil and whatever is under the pad, was fully rigid. If that was the case, then one could use the pga to estimate the inertia of the pad. But that is not the case; we have soil, and this foundation has a natural frequency, and therefore they should have used acceleration that corresponds to the natural frequency of the system, which is truly the structural response of the pad and not the design motion.
Q. See if I understand what you are saying. Even though both concerns you raised referred to rigidity, they are different structures that are covered by the concern, if you will. In the one case is the pads in the Holtec analysis, and in the other case it is not only the pads but the soil underneath in the case of

PAGE 111

111

the Stone & Webster analysis. Is that correct?
A. Yes.
Q. Now, concentrating for a moment on the Holtec analysis, what is your understanding of what that analysis was done for? For what purpose?
A. The purpose of that analysis, 2000-year motion, was to show that casks sliding on the pads have limited displacements, they would not impact each other, and they would not tip over due to seismic excitation, and also generate seismic loads so it can be used to structurally design the pad.
Q. Is the Holtec calculation a design calculation that results in design calculations and materials or --
A. No. It just produced results that was used by ICEC.
Q. Is it your experience in the many years of practice that when you have two calculations that are used for different purposes you may make differing assumptions and both calculations still remain valid?
A. As long as the assumptions are conservative, that could happen, yes.
Q. So if they are conservative, you could, for example, in the design calculation for the pads, take into account some stability because you are trying to

PAGE 112

112

come up with number, sizes, and so on. Whereas in analysis you could presume they are rigid; providing, as you said, that conservative assumptions are made. Correct?
A. The assumption of rigidity of the pad in the Holtec analysis is unconservative.
Q. Why is that?
A. Because once you assume the pad is rigid, calculation of soil spring and soil damping, which play a very important role here, would not be correct. It overestimates the damping of the pads, and damping takes out seismic loads.
Q. Would that overestimation depend on the extent of the actual deformation of the pad?
A. Yes, it does.
Q. So if it was a small deformation it might be unconservative but the error would be small?
A. I think what is important in radiation damping is not really the amplitude of the displacement but the relative motion of the nodes. If the pad is rigid and moving together, it has a tremendous radiation capacity. It dissipates energy as it impacts the soil. But whereas when it is flexible and moves differently at different locations, no matter how much that difference is, you don't have this uniform motion and dissipation

phenomena. Therefore, the radiation damping would be overestimated by rigidity assumption.

Q. But what I'm trying to get a sense from you, if you have it, is how much does the loss of the ability to take credit for that rigidity and the way you described is impaired or reduced, if you have some flexibility in --

A. I don't have a number to propose but I said if I had a large number margin in design I wouldn't have raised this issue. We should view it in light of the margin we have.

Q. Is this calculation by Holtec you referred to the one in which they estimate -- well, what is the purpose or what are they looking at in that calculation? What are they computing?

A. The purpose of that calculation was to estimate the movement of the cask, whether or not the cask tipped over, and then generate seismic loads for design of the pads.

Q. Okay. And this is different from the calculation which we spoke about before that had to do with the potential tipover of the cask; is that right?

A. Yes. That's a different one.

Q. And your view is that this other calculation also has a very small margin?

A. Yes. All events translate to the stability of the foundation which has a very small margin.

Q. Do you recall, based on your review, what the margin is in the calculation?

A. I think for sliding we are as low as 1.2.

Q. And you have or you don't know sitting here today how much would that margin be used if the extent of deformation of the pad as shown in Exhibit 32 were to be taken into account; do you?

A. I do not know how much it would impact that. But this issue, plus other issues combined, concerns me with that margin.

Q. Okay. Would you know how much the loads on the pad would change or the downward loads from the pad on the soil would change on account of taking the flexibility of the pad into consideration?

A. I know -- let me provide you with this observation: ICEC received the loads from Holtec and they applied it to the cask, the model of the pad, I'm sorry, the soil spring attached. As a result of this calculation, they calculated the total forces from the cask and the pad transferred to the soil and they are summarized in these tables. There's a force for X direction, Y direction, Z direction.

If you take the force that is, for example,

one horizontal X direction, and you divide it by the total weight of the pad and the cask, you come out with the effective acceleration is something less than .6 g. This tells me a good deal of the force is missing. If we have this cask with this much weight and you had the pad with this much weight, even though the cask is sliding at .8, total inertia should add up to something larger than pga of design motion, which is .71 or so. So I think the ICEC calculation shows me that the loads that are given to them are not adequate. They do not reflect the total load of the cask and the pad.

Q. Let me clarify, because again I need to understand. When we talk about the load, are we talking about vertical loads or horizontal loads here?

A. At this moment I was talking about horizontal loads.

Q. Horizontal in terms of sliding.

A. Yes.

Q. You don't have any feel, sitting here today, how much of the horizontal loads would change?

A. Could be anywhere from 20 to 60, 70 percent.

Q. And is this based just on your prior experience?

A. It's a general judgment.

Q. Okay. Would there be an impact on the vertical loads?

A. Yes. The vertical load, we have another dilemma. Stone & Webster performed a stability analysis of the paths. One key assumption there is you will look at the sliding and overturning of the pad, assuming horizontal earthquake and vertical earthquake are acting. And typically this calculation is done assuming the vertical force is working against you, is lifting the building in the opposite direction. And they have done that logic right, except that in selection of an acceleration to estimate the vertical inertial force, they again use the pga of design motion, which has nothing to do with the structural response. This is the lowest number on the design curve. There's no justification why they use the smaller number. I would have expected the number would be higher.

In fact, when I look at the ICEC set of results, they show the natural frequency of foundation when they apply the Holtec forces. The natural frequency for lower bounds are around 5 hertz and this estimate is on 8 hertz. Upper bounds is around 11 hertz. So if I have to pick acceleration for inertia, I will go to my design response spectrum using these frequencies and read off the acceleration rather than a

PAGE 117

117

pga, which is a very high frequency and smallest number on the curve.
Q. So that the record reflects this clearly, when you are talking about the natural frequency of foundations, what do you encompass in the term "foundation"? Is it a pad with soil underneath?
A. Pad, soil, and cask combined.
Q. So that the natural frequency will be an ensemble that comprises the cask, the soil, and the pads?
A. That's correct.
Q. And your view is that the natural frequency on that combination of soil, cask, and pads is somewhere between 5 and 11 hertz?
A. That's correct. And it is shown in the ICEC calculation.
Q. How is it shown in the ICEC? I take that calculation will give you information only as to how the pad behaves; right?
A. No. There's much more in there.
Q. Oh, tell me.
A. They have plotted what they call transfer functions. And that shows the frequency response of the system of soil, pad, and cask. And when the transfer function peaks to highest value, that's the natural

PAGE 118

118

frequency of the system. And it is clearly shown. If you go for lower bound, you see a number around 5 hertz, 8 hertz, 11 hertz. Now, on top of that, what you could do is take the weight of the pad and the cask, and do a simple frequency calculation of stiffness over mass. And the stiffness is given by ICEC in all directions. You would come out with the same numbers. You get about 5, 8, and 11, which is very consistent.
Q. Do you have a view as to what the natural frequency of the soil alone, assuming you have no pads or casks, is?
A. I haven't thought about this. I could look at it and come up with a view. But it doesn't really affect the design issues we are talking about. Not in my mind.
Q. Why not? Wouldn't you want to know the contribution that the pad would make, for example, for a natural frequency as opposed to the contribution you get from the soil?
A. No. I talk about the natural frequency of the cask, pad, and soil together. That's important. But you just talk about the natural frequency of the soil column alone, no. That is already included in the design motion in Geometrics' calculation and reflects in their time history. So it is taken care of.

PAGE 119

119

Q. Are you saying that what would be omitted, then, would be the contribution of the pads and the casks to a natural frequency, because you already have the soil included in the input?
A. What is immediate here is in the Stone & Webster estimate of seismic load for the path, in the horizontal and vertical direction, they use the pga of design motion, which has nothing to do with the structural response, the pad response. They should have used acceleration corresponding to the pad response. And there's a disconnect there. And we go on.
When you look at this, the calculation for canister transfer building, they went to the dynamic analysis of canister transfer building, identified the structural response in terms of acceleration, multiplied by the mass, and obtained a load, which is correct. But when it comes to the cask and pad, for some reason that's not clear to me, they could have gone to Holtec and said, "What is the acceleration of the cask? What is the acceleration of the pad," a similar philosophy as canister transfer building, and estimated the load. Rather, they choose to use the design motion value, pga to get the load.
Q. What is pga?
A. Peak ground acceleration.

PAGE 120

120

Q. And does that correspond to a horizontal frequency and natural frequency?
A. It has nothing to do with any structural response. It is one number in the design motion.
Q. And it could be corresponding to the response at any of a number of frequencies, then?
A. No. It represents the response at very high frequency.
Q. Okay.
A. Which is the smallest number on the curve.
Q. Okay. So that I finally understand what you are saying, what you are saying is that in their analysis, Stone & Webster picked essentially a ground motion acceleration that corresponded to very high frequency, natural frequency, if you will. Whereas they should have moved further down in the curve --
A. They should have used an acceleration corresponding to the response of the pad.
Q. Okay. Now I understand. Thank you.
Go back for a moment with me to the -- did you review the Holtec calculations also from the viewpoint of determining whether they used the correct natural frequency in their analysis of the forces on the casks themselves?
A. One concern I have about that aspect of

CALCULATION COVER SHEET

JOB NO.	1101-000
FILE NO.	
CALC NO.	G(PO17)-2
NO. OF SHEETS	289

PROJECT Private Fuel Storage Facility (PFSF)

SUBJECT Storage Pad Analysis and Design

RECORD OF ISSUES

NO.	DESCRIPTION	BY	DATE	CHKD	DATE	APPRD	DATE
0	Initial Issue	DH	10/18/99	DH	10/18/99	WT	10/18/99
1	Revision 1 (see notes below)	DH	12/6/99	DH	12/6/99	WT	12/6/99
2	Revision 2 (see notes below)	DH	2/4/00	MY	2/4/00	WT	2/4/00
3	Revision 3 (see notes on Sheet ii)	DH	4/5/01	DH	4/5/01	WT	4/5/01

[X] Nuclear Quality Assurance Category [ ] Non-Nuclear Quality Assurance Category

This set of calculations documents the engineering analyses and detailed calculations required for structural design of the reinforced-concrete spent-fuel cask storage pads to be constructed at the Private Fuel Storage Facility (PFSF) project site.

This set of calculations has been prepared in accordance with CEC's quality assurance procedure for nuclear projects.

Revision 1 was made to correct (1) typographical errors on Pages 5, 29, and A-3 and (2) insert computer output file names and explanation notes on Pages 43 and 51.

Revision 2 was made to correct typographical errors and to include additional clarifications on Pages 17, 21, 28, 236, 298, and 312.

NAME		INITIAL	SIGNATURE
Anwar Mirza	(Preparer/Checker)	aum	Anwar Mirza
Donald Hamasaki	(Preparer/Checker)	DH	Donald Hamasaki
Ming S. Yang	(Preparer/Checker)	my	[signature]
Kiat Lilhanand	(Preparer/Checker)	kl	K. Lilhanand
Wen S. Tseng	(Independent Reviewer)	WT	W. S. Tseng

International Civil Engineering Consultants, Inc.

Ex 31

CALCULATION SHEET

CEC

		CALC. NO. G(PO17)-2	REV. NO. 3
ORIGINATOR [illegible]	DATE 3/14/01	CHECKED [illegible]	DATE 3/30/01
PROJECT Private Fuel Storage Facility			JOB NO. 1101-000
SUBJECT Storage Pad Analysis and Design			SHEET NO. 20

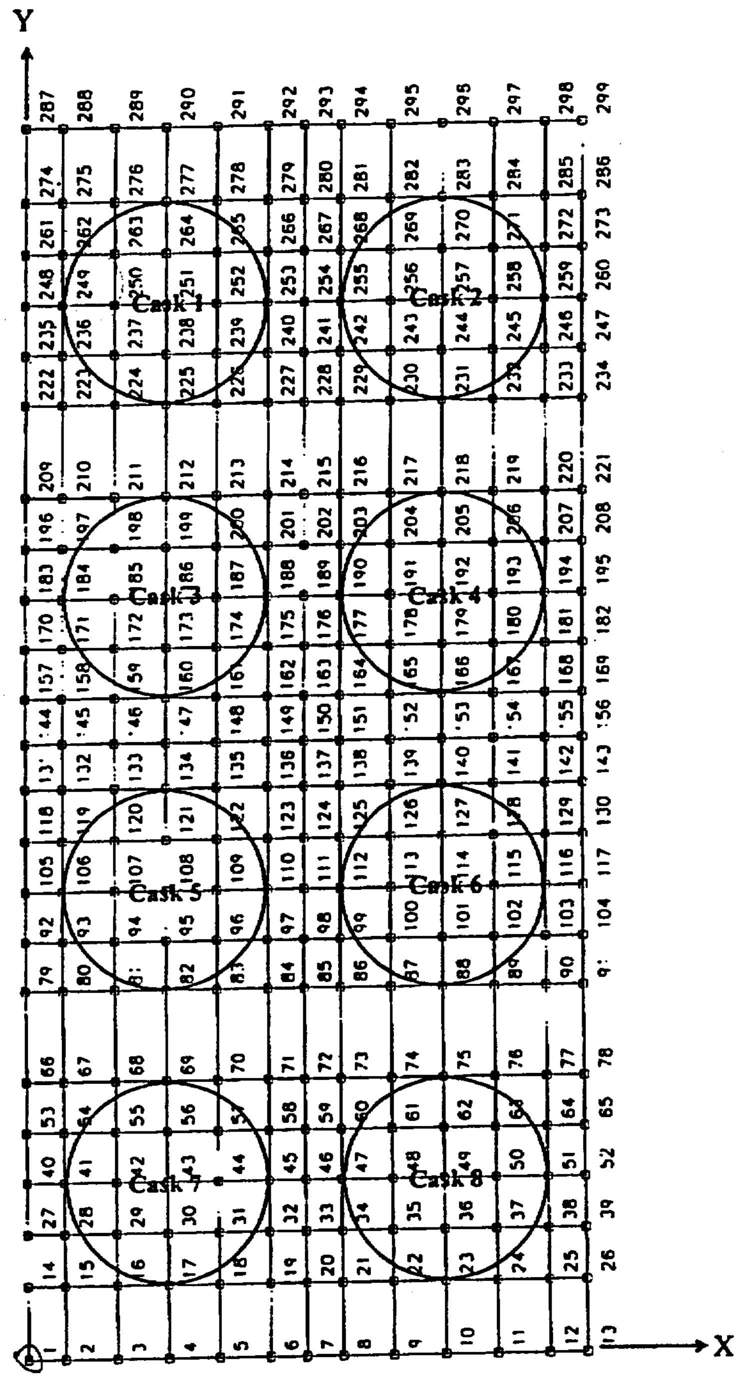

Figure 5.1-1 CECSAP Finite-Element Model with Node Numbers

5.2.5 COMPARISON OF CECSAP AND SASSI RESULTS

Results of the CECSAP and SASSI analyses, in terms of maximum displacements, maximum bending moments, and maximum shear force are shown and compared in Tables 5.2.5-1, 5.2.5-2, and 5.2.5-3 respectively. This comparison is performed for lower-bound, best-estimate, and upper-bound soil conditions as shown in the tables. The displacement time histories at selected nodes for SASSI and CECSAP are compared in Figs. 5.2.5-1 through 5.2.5-9 for lower-bound, best-estimate, and upper-bound soil conditions. Similarly, moment time histories for plate element 217 from SASSI and CECSAP are compared in Figs. 5.2.5-10 through 5.2.5-18. The printed input and output files for SASSI and CECSAP analyses are given in Attachment B.

The CECSAP dynamic models are the same as given in Section 5, except a single vertical force time history is applied at the second quadrant of the first cask (Node No. 249). Analyses are performed for the lower-bound, best-estimate, and upper-bound soil conditions.

The maximum displacements from CECSAP are consistent with the displacements from the SASSI. Maximum bending moments and maximum shear forces from CECSAP are consistently higher than the results from SASSI. Thus, the maximum bending moments and shear forces from CECSAP are used for the design of the pad.

Table 5.2.5-1

Maximum Vertical Displacements (ft) at Selected Nodes

Selected Node No.	Lower-Bound Properties			Best-Estimate Properties			Upper-Bound Properties		
	SASSI (A)	CECSAP (B)	% Diff. [(B)/(A)-1]100	SASSI (A)	CECSAP (B)	% Diff. [(B)/(A)-1]100	SASSI (A)	CECSAP (B)	% Diff. [(B)/(A)-1]100
144	0.0067	0.0058	-14	0.0055	0.0027	-51	0.0043	0.0014	-67
157	0.0076	0.0069	-9	0.0061	0.0035	-43	0.0047	0.0018	-61
170	0.0086	0.0084	-2	0.0069	0.0046	-34	0.0052	0.0026	-50
183	0.0099	0.0101	2	0.0078	0.0059	-25	0.0057	0.0036	-37
196	0.0114	0.0120	5	0.009	0.0076	-16	0.0066	0.0049	-26
209	0.013	0.0141	8	0.0102	0.0094	-8	0.0077	0.0065	-16
222	0.0164	0.0180	10	0.013	0.0134	3	0.0095	0.0099	5
235	0.0182	0.0202	11	0.0142	0.0153	8	0.0106	0.0117	10
248	0.0195	0.0220	13	0.0152	0.0165	9	0.0113	0.0130	15
261	0.0201	0.0230	14	0.0152	0.0172	13	0.0111	0.0127	14
274	0.0203	0.0236	16	0.015	0.0173	15	0.0104	0.0125	21
287	0.0202	0.0242	20	0.0146	0.0182	25	0.0096	0.0119	24
288	0.0184	0.0279	52	0.0132	0.0162	22	0.0087	0.0103	18
289	0.0161	0.0184	14	0.0112	0.0131	17	0.0074	0.0083	12
290	0.0138	0.0155	12	0.0096	0.0109	13	0.0063	0.0062	-2
291	0.0116	0.0128	10	0.0082	0.0086	5	0.0052	0.0048	-8
292	0.0098	0.0120	23	0.0067	0.0069	4	0.0043	0.0034	-20
293	0.0083	0.0085	3	0.0057	0.0057	1	0.0038	0.0028	-25
294	0.0069	0.0070	1	0.0049	0.0047	-4	0.0031	0.0023	-26

Notes: The displacements obtained from CECSAP at nodes near application of load (the pad interfaced-forcing function) at Node 249, are about 10% higher than those obtained from SASSI. However, the displacements obtained from CECSAP at nodes away from application of the load, which have relatively smaller magnitude than those at nodes near the application of load, are somewhat lower than those obtained from SASSI. For location of nodes selected in this Table, see Fig. 5.1-1.

See Attachment B for SASSI and CECSAP comparison results.

CALCULATION SHEET

			CALC. NO. G(PO17)-2	REV. NO.	3
ORIGINATOR	KV	DATE 3/27/01	CHECKED	DATE	4-5-01
PROJECT	Private Fuel Storage Facility			JOB NO.	1101-000
SUBJECT	Storage Pad Analysis and Design			SHEET	229

Table S-2
Maximum Vertical Displacements and Soil Bearing Pressures
Live Load

Node No.	$(Z_l)max$ (x10^{-2} ft.)							
	subgrade modulus = 2.75 kcf				subgrade modulus = 26.2 kcf			
	2 Casks	4 Casks	8 Casks	7 Casks + OLT	2 Casks	4 Casks	8 Casks	7 Casks + OLT
1	13.06	11.29	-50.97	-57.81	0.61	1.16	-4.83	-5.30
7	13.02	11.28	-50.97	-41.84	0.59	1.14	-4.84	-4.42
13	13.06	11.29	-50.97	-25.83	0.61	1.16	-4.83	-3.50
144	-11.82	-26.36	-52.73	-78.21	-0.70	-2.89	-5.78	-7.95
150	-11.93	-26.35	-52.71	-61.06	-0.76	-2.89	-5.79	-6.31
156	-11.82	-26.36	-52.71	-43.87	-0.70	-2.89	-5.78	-4.65
287	-42.54	-62.26	-50.97	-100.20	-5.13	-5.98	-4.83	-11.81
293	-42.59	-62.25	-50.97	-80.88	-5.16	-5.98	-4.84	-8.48
299	-42.54	-62.26	-50.97	-61.84	-5.13	-5.98	-4.83	-5.47
	Maximum Soil Bearing Pressure $q_{zl}$$^{(1)}$ (ksf)							
1	0	0	-1.402	-1.590	0	0	-1.264	-1.390
7	0	0	-1.402	-1.151	0	0	-1.267	-1.159
13	0	0	-1.402	-0.710	0	0	-1.264	-0.917
144	-0.325	-0.725	-1.450	-2.151	-0.185	-0.757	-1.514	-2.082
150	-0.328	-0.725	-1.450	-1.679	-0.199	-0.758	-1.516	-1.653
156	-0.325	-0.725	-1.450	-1.206	-0.185	-0.757	-1.514	-1.219
287	-1.170	-1.712	-1.402	-2.756	-1.345	-1.567	-1.264	-3.094
293	-1.171	-1.712	-1.402	-2.224	-1.352	-1.565	-1.267	-2.222
299	-1.170	-1.712	-1.402	-1.701	-1.345	-1.567	-1.264	-1.434

Notes:
1. $q_{zl} = k_s \times Z_l$ where k_s = 2.75 and 26.2 kcf for lower-bound and upper-bound subgrade moduli, respectively, and Z_l are obtained from CECSAP analysis results (Att. A)
2. Negative displacements imply downward movements.
3. The locations of nodes listed are shown in Figure 5.1-1.
4. For snow load, the soil bearing pressures is .045 ksf (Ref. 11).