UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the matter of:

DIABLO CANYON UNIT 1 DESIGN VERIFICATION PROGRAM - SEISMIC ANALYSIS OF BURIED TANKS

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NUCLEAR REGULATORY COMMISSION

DIABLO CANYON UNIT 1 DESIGN VERIFICATION PROGRAM -

SEISMIC ANALYSIS OF BURIED TANKS

Nuclear Regulatory Commission
Room P-118
7920 Norfolk Avenue
Bethesda, Maryland

Wednesday, July 6, 1983

The meeting convened, pursuant to notice, at 9:40 a.m.

PARTICIPANTS:

<u>On Behalf of the NRC:</u>

H. SCHIERLING, Presiding
H. POLK
P. T. KUA
G. KNIGHTON

<u>On Behalf of BNL:</u>

C. COSTANTINO
C. MILLER
A. PHILIPPACOPOULOS
M. REICH

<u>On behalf of DCP:</u>

H. HOCH
R. ANDERSON
W. WHITE
B. SARKAR
B. LEW

On behalf of EŁT:

T. UDAKA

On Behalf of RLCA:

L. LUI
V. STEPHENS

On Behalf of TES:

M. HOLLEY
S. CHIN

On behalf of PG&E:

R. LOCKE

On Behalf of HLA:

K. WONG

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P R O C E E D I N G S

MR. SCHIERLING: Good morning, gentlemen.

This is a meeting between the NRC, its consultant Brookhaven National Laboratory, the Diablo Canyon Project and the Independent Design Verification Program.

The meeting is a continuation of an earlier meeting which took place on June 17th. The subject is seismic analysis of buried tanks.

A verbatim transcript of this meeting will be taken, and for that reason I request that everybody please identify himself the first couple of times you are talking and also speak clearly and above all have only one person at a time talk so that we have a recognizable transcript.

I think everybody knows each other from the many meetings we had before. Let me just introduce George Knighton who is the Branch Chief in the Division of Licensing in the branch where the Diablo Canyon Project is being reviewed.

At the meeting on June 17th there were a number of issues discussed and I briefly would like to summarize those again, identify those, because these issues will be discussed again today.

It is our understanding that the Diablo Canyon Project will provide us with additional information on these subjects, information that addresses the concern raised by the staff and its consultants.

These concerns relate to, first of all, a numerical instability in the computer code that was used in the analysis of the tanks, the FLUSH computer code, and I think it relates in particular to the use of the Poisson ratio for values greater than .49.

The second issue relates to fluid element modeling. On the one hand, we have the lumped mass model and, on the other hand, we have the finite element model. Again, it is our understanding that the project will provide us with additional information.

The third item relates to stress computation, the application of dynamic forces as compared to dynamic plus static forces in that analysis.

As I mentioned before, we will take a transcript, and the information will therefore be available for all parties to review.

Let me state at this time that it might be useful for all parties at this meeting to afterwards carefully go through the transcript and indeed find out that this is information that you wanted to provide and this is the information that you wanted to hear.

I think there is a possibility that maybe later on these issues should be documented on a more formal basis. Maybe we will send you a letter and ask for your response on those issues or maybe you would like to come forward with that response even prior to our requesting so.

I think that might be in particular helpful when we are looking for a more concise record, rather than a rather voluminous transcript where you have to search for information and maybe people say one thing on one page and ten pages later it provides additional information on a particular subject and if you read the transcript it unnecessarily is there. I am thinking about putting that information on a more formal basis at a later time.

The second thing we want to discuss today is our and our consultants' response to certain requests that have been made by PG&E in a number of telephone calls prior to this meeting.

By the way, for the record, these telephone calls purely related to items that we wanted to discuss. There were no technical discussions per se of substance at these telephone calls. That is my understanding. If anyone disagrees, please say so. I want to make that statement for the record.

The information that we will provide to you today, hopefully to your satisfaction, will be the output of the FLUSH computer code, the horizontal and vertical loads, secondly, we will privide you with additional clarification on the safety factor and, thirdly, we will address how axial stresses were considered in the seismic analysis of the tanks, in addition to the bending stresses that Brookhaven talked about last time.

This is the way that I see that the meeting will be going today.

Let me add one more thing. We have available here one copy of a computer output of various calculations that Brookhaven has made. This is the first time the staff sees it and this is the first time that PG&E and the Project will see it.

Unless there are any objections by anyone, I would recommend that shortly after these introductory remarks or any other statements anyone would like to make, that we make this document available to the Diablo Canyon Project for your use and study for, I would say, about an hour. If you think more time is needed, let me know, but maybe that will give you an opportunity to go through the computer output.

We will be available at that time, not to discuss the details, but to show to you where the information is that you are looking for.

Then we will reconvene and you can address any questions based on what you have seen.

MR. CLOUD: Hans.

MR. SCHIERLING: Yes.

MR. CLOUD: We would also like to have some time to glance through it if it is possible.

MR. SCHIERLING: If at all possible, maybe you can do that simultaneously, unless the Project indeed wants to first go through the material by themselves and afterwards we will make that available to you.

However, to expedite matters, we will copy this information, and it is my understanding that we will have copies available by Friday early afternoon at which time we will make copies available to selected parties because I do not want to go on board notification with this information. It will be of very little use to most people. But at that time I most certainly will make a copy available to you, Bob.

If you need it today hopefully to get things rolling, you could do it either afterwards or together with the Project. I leave that up to both of you.

MR. LOCKE: Hans, I think in that regard it would be more preferable for the Project to see it alone. There has been a lot of discussion and innuendo about independence, and I think having Bob in the same room as the Project reviewing this information would probably be inappropriate.

MR. SCHIERLING: I appreciate that point. It is very well taken. So therefore afterwards I will make it available to you. Hopefully you don't also the entire hour because that would mean the meeting doesn't start until 12 o'clock.

MR. CLOUD: We can see probably what we need in 15 minutes.

MR. SCHIERLING: Fine. Let me do this then. Are there any other comments that you would like to make at this time regarding what we want to accomplish today and what the purpose of this meeting is?

MR. HOCH: We are going to have some opening remarks and we are going to introduce people to make sure you understand who everyone is this morning and take a little extra time to do that, but why don't we do that when we reconvene.

MR. SCHIERLING: Well, why don't we do that right now. Well, okay, as you please.

MR. ANDERSON: We would like to look at the computer output first and then in about an hour we can get back together.

MR. SCHIERLING: Let me do one more think, Dick.

Brookhaven has prepared a number of slides that contain additional information. We will go and provide you with that information when Brookhaven makes their discussion. I think that might be better rather than now.

Secondly, in here are some paper clips and they indicate where a new output starts.

George, would you like to mention anything at this time?

MR. KNIGHTON: Not at this time, no.

MR. SCHIERLING: I tell you what, why don't we interrupt then right now and go off the record.

MR. ANDERSON: Hans, before we do that I have a suggestion. If we could give the Brookhaven people a copy of our slides and if we could get a copy of their slides, it might be helpful as we review the computer printout to have that and then we could have a discussion that perhaps goes a little faster later, if that would be acceptable.

MR. REICH: No, and I will tell you why, because I think we want to make a statement before we have the slides and I think that would be more helpful. So I would rather wait.

MR. SCHIERLING: Well, Morris, would you like to make that statement now and let PG&E have the benefit of looking at this material because it will enable them to focus their questions on issues at hand.

Could we go off the record for just a moment.

(Discussion off the record.)

MR. SCHIERLING: Back on the record.

Morris, maybe you could identify to PG&E the seven outputs that you have included here or maybe you want to do it, Mike.

MR. PHILIPPACOPOULOS: In the front of each output here I have a little description that will give you an idea.

The first is the horizontal response of the soil tank system with the value of the Poisson's ratio for the fluid elements equal to .499, and I have five iterations included here.

The second one is again the response of the soil tank system horizontal direction FLUSH output with a Poisson's ratio for the fluid elements equal to .4999, and again this is after five iterations.

The third output is a FLUSH output for the lumped mass model that we used and the results are for five iterations.

Next is the output for a vertical analysis with deconvolution.

The next is the results for the vertical analysis without deconvolution.

The next is the results for the horizontal analysis with deconvolution.

The last is the horizontal analysis results with no deconvolution.

So this is a description of that.

MR. CLOUD: Excuse me. Are these results the basis for the numbers that were presented in the previous meeting?

MR. PHILIPPACOPOULOS: Yes, indeed.

MR. REICH: Yes.

MR. PHILIPPACOPOULOS: Any other questions?

MR. SARKAR: How many iterations do you have on the vertical analysis?

MR. PHILIPPACOPOULOS: On the vertical analysis, five. All of them, I would say, there are five iterations.

MR. SCHIERLING: Before we get off the record, one more comment. As far as I can see, there are no other parties represented at the meeting than those that I identified earlier.

Yes, one comment.

MR. LEW: Let me confirm Hans' understanding of our telephone conversations. They were all purely administrative in nature and I just wanted to confirm Hans' understanding of conversations between the Project and the NRC.

MR. SCHIERLING: Okay, thank you.

It is now 5 till 10. I think at about 11 o'clock we can reconvene after you have had a chance to look through the material.

(Whereupon, a recess was taken from 9:55 a.m. to 10:55 a.m.)

MR. SCHIERLING: Okay, I think we are all back together. Shall we go on the record, please.

Before we go into any discussions, we note that two new attendees, Cris Holley and Sam Chin, from the IDVP have joined us.

At this time I think it might be best if PG&E, if the Project would go ahead with your presentation on the three issues identified before, or do you propose a different approach?

MR. ANDERSON: I think we would like to go ahead.

MR. SCHIERLING: Okay, fine, why don't we do that.

MR. HOCH: Bear with us a minute, if you will, Hans. As I said, we would like to take a moment and make a few introductions and make sure everyone understands everyone's proper role in this picture before we begin today.

I am John Hoch. I am Project Manager with the Diablo Canyon Project organization. I am going to introduce three people to you and then bow out of this picture.

First, the two, and I will call them

non-technical, people who are here with us today are Dick Locke, who is an attorney with PG&E, and Barclay Lew who is the Licensing Supervisor on the Diablo Canyon Project.

I would also like to introduce to you another member of the management team, and that is Dick Anderson who is Engineering Manager for the Project and who is going to be the overall manager for our portion of this meeting.

MR. ANDERSON: Thank you, John.

I would like to introduce the other technical people that we have here. We have Dr. White who is the Assistant Project Engineer on the Project in charge of seismic design.

Then we have Bimal Sarkar that you meant last time. He is an Engineering Supervisor in the civil structural group on the project.

Then we have Dr. Udaka. He is from Earthquake Engineering Technology, EET. Dr. Udaka has some considerable background on this problem. He was not only the author of the FLUSH computer program when he was at U.C. Berkley doing his doctoral thesis, but he also was the engineer that did the original analysis work for Harding Lawson on this particular problem, the particular tank that we are looking at. Later he left Harding Lawson and formed this companym, EET, and he is now a consultant to Harding Lawson.

Then we have Ka: Wong who is from Harding Lawson and has been involved in this work.

That really concludes our technical group that we have here. What we wanted to do today is to go through these issues that Mr. Schierling has outlined earlier, and we would like to give a little presentation on each one.

We have done some further analysis work and we have done some studies that I think will help in all of our understanding of where we are on this work.

We would first like to talk about the stress combinations, the critical section and the calculation of total stresses as subject, and if we could get through the presen:ation on this and then have discussion afterwards, I think that would be helpful.

Then we will talk about the Poisson's ratio thing and the numerical instability in the program, or possible numerical instability in the program.

Then we will talk about the concerns that you raised in the last meeting that we had here on the model being perhaps more crude than it should be and it did not capture all of the wave propagation properties of the fluid.

We have done a new anlaysis using a finer mesh that we think confirms the original cruder model that we had.

Then after all of that we would like to have a discussion of overall safety factors which I think relates to all of those subjects.

We believe that the original work was adequate and appropriate and reasonable here. We believe that there are no errors in the Harding Lawson work and I think the studies we have done will show that.

We also recognize clearly that Brookhaven has done some very careful looking at this and that they have chosen to use different analytical techniques. Obviously there will be differences then when different techniques are used, but some of the work we have done looking at what you have done shows that if we put the work on the same basis we come up with results that are quite similar and quite compatible and we hope to be able to show that to you.

So without going any further myself here, I would like to turn it over then to Dr. White, Bill White, who will carry through the presentation part with help from Dr. Udaka as appropriate.

MR. WHITE: Let me just start off with the slides and, as Dick mentioned, the first subject we want to cover deals with the critical section.

MR. SCHIERLING: Do you have some copies of the slides?

MR. WHITE: Yes, I have a whole bunch of them there if you want to pass them around.

(The copies of the slides were distributed.)

(Slide.)

MR. WHITE: The last time I think there was some discussion about combining stresses and where was the critical section and this kind of thing. The discussion has kind of been summarized in this particular table at two particular nodal points.

The first one I will draw your attention to is nodal point 6, and these results are from the dynamic analysis. Then combining the results of the dynamic analysis with the static results in the lower table allows us now to combine the moment from static and dynamic analysis as well as the axial forces.

Just going through one of these particular items, here at nodal point 6 we have got a bending moment of 40, 40 pound-feet. That is this particular line item, and we also have an axial force of about 35,000 pounds, and that is this particular item.

Combining those with the bending moment from the static analysis of 318, 318 plus 40 gives us the 358 as the moment resulting from the combination now of the static and dynamic bending moment, and combining the axial force in a similiar manner we get about 6,000 combined with the 358 and that gives us essentially 42 Kips as the axial force.

When you go through the interaction equation, or just calculating the combined stress, you end up with about 20 KSI as the stress on the outside fiber. That is for nodal point 6.

Doing the same kind of thing for nodal point 7, which has a higher dynamic component to the overall stress, but a smaller static component, going through this again and evaluating the combined stress at the outside fiber, here we get about 15 KSI.

So in order to come up with the final stress, again you need to combine static and dynamic, and I think this kind of summarizes the result of the discussion from back on the 17th.

Now before I proceed to the next subject, are there any questions on this particular item?

MR. REICH: One question.

MR. WHITE: Sure.

MR. REICH: This is 1978. What about 1982? Do you have your combinations for that for nodal 6 and 7?

MR. UDAKA: We used the same approach.

(At this point in the proceedings paperboard was produced for Mr. White's use.)

MR. WHITE: Let me just see if I can write these on the pad here. Do you want me to list all nine of them?

MR. REICH: No, just list the 6 and 7.

MR. WHITE: Okay 6 and 7, and then this is the safety factor and let's say outer fiber. In 6 we get 2.26 and at 7 we get 2.18.

MR. REICH: So you are getting less at 7 than at 6.

MR. WHITE: Yes.

MR. REICH: So your numbers at 7 are higher than at 6.

MR. WHITE: Yes.

MR. REICH: All right. That is all I wanted to know.

MR. CLOUD: Bill, let me see if I understand correctly. Based on your '82 analysis nodal point 7 would show higher stresses than the stresses at nodal 6; is that correct?

MR. WHITE: Well, the safety factor is indicating that and I have got to make sure that there isn't something else going on here, but that is the situation right here.

MR. CLOUD: That is correct?

MR. WHITE: Yes.

MR. REICH: One more question. You had several calculations for '82. This is one calculation for '82. If I am not mistaken, there was more than one calculation.

MR. WHITE: This particular one is for the model that had the fluid elements in it or is this the lumped mass model?

MR. UDAKA: In '82 we revised the element of inertia. We put in a new moment of inertia.

MR. REICH: But that changed your nodal stresses.

MR. UDAKA: Yes, that is what happened, but that procedure we used is an identical procedure which we used in 1978.

MR. REICH: No, that is not what I am asking. You had tables which had different values, two different tables.

MR. WHITE: You mean the static stress?

MR. REICH: No, I am not talking about the static at all. We never checked your statics and we don't know what is in your statics. We are accept them at the moment. I am just asking about your dynamic results. We saw two.

MR. SCHIERLING: At the last meeting?

MR. REICH: No. We are talking what was sent to us in the writeup of the '82 meeting.

MR. WHITE: I think that later on we are going to be talking about the results from a finer mesh and perhaps we can talk about the results of the dynamic anlaysis at that point.

MR. REICH: You are saying these are the results of a different mesh?

MR. WHITE: Well, I think here what we are trying to point out is that in order to select a critical section that we are considering the combination of the static and the dynamic analysis. When we get around to the finer meshes, again we are using this kind of combination. That is the point we wanted to make on this particular slide here.

MR. REICH: Well, I thought that you wanted to make the point that 6 was higher than 7.

MR. SARKAR: No, that was not the point, Morris. Let me explain that situation. I think a concern was expressed in the last meeting that the report indicated that BNL originally did not identify the most critical section in getting to the factor of safety. So that was the issue.

I think in order to alleviate that issue what we are trying to show to you is that for all the nodal points the stresses were taken both for the dynamic and the static components in order to calculate the total stress and the safety factor was identified, plus going to the different nodal points.

It so happened that the examples that you had outlined in your June 17th presentation there in nodal points 6 and 7 you find that the dynamic stresses were larger in 7 than in 6 and your question was why is it that the lesser amount of dynamic stress was taken as to the critical section compared to the one at nodal point 7.

So we are trying to address that particular issue that in terms of getting the final safety factor we have appropriately taken both the dynamic and the static stress because the dynamic is only one component.

MR. REICH: I understood that fairly clearly. What I was trying to say is that you had three tables and we saw three values of stresses, and in one 6 is higher and in one 7 is higher, as you just yourself said. Then in the other one I don't know what it is because you haven't told us yet. I am just trying to bring this across to you that we saw three tables.

MR. HOCH: Well, I should think the point we are trying to make is that whichever number is higher that the two stresses were properly combined and the critical section is indeed proper stresses.

MR. WHITE: Okay. Let's talk about the next topic of discussion from the last meeting, and that is the influence of Poisson's ratio on the numerical answers, and primarily the Poisson's ratio as it goes beyond .49 approaching .5.

(Slide.)

We have gone back and made I think perhaps a little more detailed study than was available to us last time showing the behavior of the results as you add more 9's onto Poisson's ratio. In particular let me show you the variation of the soil properties that we have considered in this sensitivity study.

Here we have considered Poisson's ratio varying from .499 to .4999, three 9's and there is also four 9's. So we have gone through and done an analysis based on those particular Poisson ratios.

MR. LEW: Bill, to clarify the record, could you reference the page numbers at the bottom when you introduce each slide, please.

MR. WHITE: This is slide No. 3.

So like I say, we have gone back and taken a look at the sensitivity of the results when you go through these particular variations.

Now I should point out that when making the variation of Poisson's ratio, here what we are trying to do is to model incompressible fluid. So we fix or have as the node quantities Poisson's ratio as well as the compression wave velocity. Once you have those two, then you are able to calculate the other of the elastic constants.

MR. CONSTANTINO: You are not trying to model incompressible fluids since they have a shear wave speed of 7,000 feet a second. If shear wave speed is 7,000 feet a second, by definition that is not a compressible fluid. What you are doing is trying to model a fluid which has no shear strength.

MR. WHITE: Let me retract that statement.

What we are trying to model is a fluid that has a compression wave velocity of about 7,000 feet per second. The point is we are holding Poisson's ratio and the compression wave velicity and then calculating the other constants.

(Slide.)

The equation that is in FLUSH, and this is slide No. 4, these are the equations that are used to back calculate the other particular quantities.

As I mentioned earlier, knowing the compression wave velicity and the density, you can calculate E sub p from here and come up to this point and calculate E, use this equation and calculate G. So out come all of the constants.

(Slide.)

The next slide I have shows the results of the sensitivity analysis. This is slide No. 5. Here we have the bending moment and axial force shown as a function of Poisson's ratio varying with two 9's, three 9's and then four 9's.

You can see that there is some change in these quantities, but it is a fairly modest change. Things are fairly well stable.

Any questions on these?

(No response.)

MR. WHITE: As I mentioned earlier, have also gone back and done some more studies using refined mesh, and I wanted to briefly describe the procedure that was used in order to develop the finite element model and also the static model just briefly.

In the static analaysis what we did is go back and reconstruct the construction sequence.

MR. SARKAR: Bill, before we go to the next point, I would like to see if the issue for the Poisson's ratio and the so-called numerical stability problem is now resolved in your mind, that yes, indeed, there is no numerical stability problem in the FLUSH analysis.

MR. REICH: We will talk about that. That was our introductory statement that we made before, that when you finish your presentation, then we will give our statement.

MR. HOCH: But you don't have any more questions?

MR. REICH: No. If we have a question we will raise it right away.

(Slide.)

MR. WHITE: Going to the refined model, again just briefly going through the procedure, we did a finite element analaysis to determine the static stresses which included the construction sequence, the compacted backfill as well as the hydrostatic pressure from the diesel oil inside the tank.

Then for the dynamic analysis, again the same soil prop. ties and we refined the mesh to get a better resolution of the fluid, the tank wall and also the soil.

Here we did a horizontal analysis where we went through a number of iterations of the soil property for the horizontal analysis.

Then for the vertical analysis we took those same properties from the horizontal analysis and used that as the soil properties for the vertical analysis.

(Slide.)

Now let me show you the three models. This is slide No. 7.

These were the three models that were used. This one you have seen before. This is the one that was used back in '78. We simply subdivided the fluid elements into a rectangular pattern to give us Mesh B and then for Mesh C, we essentially took these cords and subdivided them by a factor of two and then put the quadralateral mesh that went along with it.

So now these are the three models that we have gone back and made a more detailed study on and we will be referring to these as Mesh A, B and C.

MR. REICH: One question.

MR. WHITE: Yes.

MR. REICH: These two are a direct result as of our last meeting?

MR. WHITE: These two, Mesh B and C?

MR. REICH: Yes.

MR. WHITE: During the discussion last time Howard Friend indicated that the Project would go back and do some refined calculations and these are the result of those two. So these have been done in the last two weeks or so.

(Slide.)

This is a composite diagram showing the safety factor for Meshes A, B and C and again the approach for calculating these safety factors, as we have indicated before, combine the static and dynamic forces, use the interaction equation from AISC and here we are using as the allowable 90 percent of FY and FY as coming from mill certs.

MR. CONSTANTINO: Are these all for soil property Z-Z?

MR. WHITE: Yes.

MR. CONSTANTINO: Just Z-Z.

MR. WHITE: Yes.

MR. REICH: And no deconvolution, just being applied to the base.

MR. WHITE: Yes, no deconvolution coming in at the base.

MR. MILLER: Also, if you really looking to see to what extent the mesh is critical, it would be more interesting to look at the variation in bending moments and axial forces since they tend to vary oppositely and looking at safety factors, you can make an error on both sides and they wash out when you look at safety factors. Do you have data indicating what the bending moments are?

MR. WHITE: Let's see, I think we do. No, I take that back. We have got more detailed results for each individual one, but we don't have an overhead for axial force and bending moment.

MR. MILLER: Well, you really have to look at that to really see if in fact all those meshes are really giving the same result or if in fact you are trading one error off for another error because as you go to a finer mesh it could well be that you are decreasing the axial force and increasing the bending moment, which is in fact what really happens.

MR. WHITE: Could be.

MR. MILLER: That was one question. It would be interesting for us to see the bending moments for each of these cases and the axial forces for each of those three cases.

MR. WHITE: I think in terms of comparing mesh size, the influence of the mesh, comparing these two guys, is really the meaningful comparison.

MR. MILLER: No, no, I don't think so, because the issue is really whether the results generated with Mesh A are valid or are not valid. The point I am raising is that, and there are still big differences even in safety factors, but what you are looking at is a very homogenized kind of result at the end of a batch of calculations.

If you really want to look at sensitivity, you should do what you did with the Poisson's ratio. You have a table where you have axial force and bending moment and then you can say okay, that is the basic ingredient that comes out of the calculation.

If they agree, then I would agree that the process is converged and your Mesh A is okay and all the results derived from Mesh A are okay. But I think you have to look something back from a factor of safety to really draw that conclusion.

MR. WHITE: Well, of course, it depends on your point of view. We are trying to show the tank is qualified.

MR. ANDERSON: And a crude model in fact was used to show that, and the crude model we think was adequate.

MR. MILLER: We will show some results in a while that indicate that in fact what I am saying is exactly true, you are trading one error for another error, and Mesh A is grossly an inappropriate mesh even though it may turn out that the tank is still fine.

If you are addressing the issue of whether Mesh A is good or not, I think if you look at the bending moments and axial forces you are going to find Mesh A is not good enough. I mean we will have to look at your results.

MR. ANDERSON: It is not good enough to qualify the tank, is that what you are saying?

MR. MILLER: No. It doesn't predict the physics of what is going on. It seems like the last picture like that that we looked at your Mesh A, there was a factor of safety of 1.55.

MR. REICH: 1.55 and all the sudden you have got higher numbers.

MR. HOCH: Excuse me, but we are doing the same thing we did last time. I hate to interrupt you, but the last time when we read the transcript there were some things that weren't in the transcript because you were simultaneously talking at the same time.

MR. MILLER: The other part of this question, and that is my first concern, is I would like to see a moment comparison for these three meshes and an axial force comparison for these three meshes before I would be satisfied that Mesh A gave adequate results, and by adequate I don't mean by luck give you a qualified tank. What I mean is in fact predicts within some reasonable percentage the physical behavior of the tank. It is either more bending or less bending or more axial force.

The other point on the slide is that it seems to me the factor of safety on Mesh A the last time was 1.55 as the low number. 2.18 is the smallest number on here. So why is there a difference between those two?

MR. WHITE: I think these numbers were based on mill cert data and I don't think that was available previously when the 1.55 was calculated. So that is the difference.

MR. MILLER: So you are saying that the '82 results that we had before that gave a factor of safety of 1.55 are not really accurate any more?

MR. SARKAR: Bill, I think it would be helpful is you present Slide 12 first and start from there.

MR. HOCH: Before you do, let me recharacterize what was just said. What we saying is that these are different results. Since they used mill cert data, perhaps the earlier results may be characterized as being overly conservative compared to these. I didn't want to let it pass that we are saying these are inaccurate.

MR. MILLER: I mean that was my one concern. The other concern is still that I would like before I would buy you off on the fact that Mesh A is a reasonable mesh, I would like to see a comparison of moments and a comparison of axial forces.

Now if you are changing the criteria for evaluation, that will obviously give you a different factor of safety than we had before.

MR. WHITE: These are the values for FY that had been used to generate the safety factors that were shown on the previous slide. So the stiffener has a yield stress supported by mill certs of 49 KSI and the tank wall is about 36.

MR. MILLER: Now what was used to give the 1.55

number?

MR. SARKAR: Could I explain that one, please. As this slide shows that if you go from the top it gives you a chronology of all the events that happened since '78 up to the present analysis.

So why don't you take some time to read this slide and then if you have some questions perhaps we can answer those.

MR. LEW: Bill, I would like to expand on your point and Dick Anderson's point. We did the '80 analysis and the '78 analysis for the purposes of qualifying the tank. That is opposed to perhaps the questions that Chuck brought up which is doing studies to determine the accuracy of the mesh.

If I could just expand on Dick Anderson's point, we didn t do our studies in '78 to answer the question of the accuracy or the inaccuracy of the mesh. We used the model to qualify the tanks, and maybe that is part of the problem of our dialogue. We are at different purposes.

MR. MILLER: When you qualify for something presumably you use the techique that give you the right answer.

MR. LEW: Well, right answers for the purpose.

MR. MILLER: If I have a structure that is subjected to axial force and bending moment, I would only be satisfied that the qualification was reasonable if I predict the right bending moments and the right axial force.

If it turns out that I make a mistake on both axial force and bending moments so that when I go do P over A plus M over the section modulars and I get the right total stress, to my mind that is not an adequate qualification. Unless I predict the moment correctly and the axial force correctly, I would only accept that as a reasonable qualification.

So if you are asking me to say did you do a reasonable analysis in qualifying the tanks, I will say you only did it if you got the right bending moments and the right axial forces.

If may be that you were very lucky and when you added up P over A and M over S you were minus 10 KSI on one plus 10 KSI on the other one and that those two errors balance each other out, but don't ask me to accept that as a reasonable qualification procedure.

MR. ANDERSON: On the other hand, you can't really ask us to accept your statement that we came out with the right answer by luck, because certainly a great deal more than luck goes into the analysis that we are doing here and that is what we are trying to explain, how this was done and how we came to a conclusion that the tank was qualified.

It may have been a crude analysis and there may have been off-setting factors, but we certainly don't want to characterize this analysis as being lucky.

MR. MILLER: I think it was. I think we will show something later, Bill, that indicates that it in fact turned out that way and it was very lucky that it did.

MR. ANDERSON: Our later analysis shows the tank is qualified. Now is that luck also? It shows that if you do a finer analysis and if you do a more detailed analysis, you come out with an acceptable answer.

MR. MILLER: If you want me to buy you off in general on everything you have done on the tanks, andassuming also your static analysis, if you use that Mesh A, all I am saying is if you want me to buy off on everything, then you have to show me that Mesh A reasonably predicts moments and reasonably predicts axial force.

Now if you want to do all the analyses with both A and with Mesh C and show that it qualifies for those, okay I will certainly buy that. But don't give me one example that shows in this case the final homogenized resultl is adequate. As a matter of fact, there were big differences in safety factors that you got from one mesh to the other. Now they all happened to be above one, but I think if I want to also now accept your static anlaysis using that mesh, it seems to me I would like to know that you can predict moments and axial forces correctly and not some sum of the moments and axial forces.

MR. SCHIERLING: Bob, did you have a comment?

MR. CLOUD: Yes, I did. No one enjoys a good argument better than I do, but I would really like to see all of the data presented before we get into this kind of spirited discussion so that I can better understand what we are talking about.

MR. SCHIERLING: I think for that purpose it might be best if you proceed with your presentation, but before we do that, Professor Holley, you had a comment.

MR. HOLLEY: My comment is a little parallel thought. It is clear that the effect of the mesh size is something we are going to be talking more about. If you have with you all of the nodal moments for each of the three mesh pieces and all the axial forces similarly, it would seem to me worthwhile to the people who have them to scribble them down on a piece of paper and get some copies or something so as the day wears on we will have them before us rather than argue now about whether it is right or wrong, and which some of us aren't prepared to accept at this point until we see some numbers.

MR. SCHIERLING: Do you have that information available?

MR. HOLLEY: Do we have that information with us?

MR. SARKAR: Yes.

MR. SCHIERLING: I will tell you what, let me go and run some copies of that and make them available to the people and that we can have a common basis to talk from.

MR. HOLLEY: Let me ask another question. Could I ask those of you who are concerned about mesh size, are you concerned about its effects as it relates to dynamic only, static only or both, because they can give you these things in sum, if you are satisfied with that, or they can give them to you, I am sure, in other ways.

If they tabulate for you the sum of the dynamic and the static "P" values in each node for each mesh size and the same thing for moments, is that what you need or not?

MR. MILLER: When we made our presentation, we really affect both static and dynamic.

MR. HOLLEY: I understand, but I am simply saying if they are going to give you some data, I want to know now if they give it to you for applying static and dynamic ---

MR. MILLER: I would rather see it first for the dynamic case.

MR. HOLLEY: You would rather have the dynamic than the static?

MR. MILLER: Separated by itself, yes.

MR. HOLLEY: That is what I wanted to know so we don't have to go through it twice.

MR. SCHIERLING: Do you have that information available in both forms.

MR. UDAKA: Yes.

MR. SCHIERLING: Could I have those?

MR. UDAKA: Yes.

MR. SCHIERLING: We can run some copies and at least we have something coming that we can talk about.

MR. CLOUD: I have a minor practical question. On the FY dynamic, FY for the stiffener, it is higher than the static FY. It is the same material I presume.

MR. WHITE: It is the same material, but here we took the 49 KSI to go along with the Hosgri loads going baci to the Hosgri report idea of using mill certs for dynamic loading, but for the static case we went back to the more conservative nominal design value.

You are correct in that it is the same material undoubtedly.

MR. CLOUD: I just wanted to make sure what the number is. It is the static test value of FY?

MR. WHITE: In all cases these are statically determined values from tests. For the dynamic load component we are using 49 KSI as the allowable, but for the static portion we are using the more conservative nominal design value.

MR. HOLLEY: But none of them have been increased for dynamic loading?

MR. WHITE: Correct.

MR. REICH: I have one question which I want to clarify. Your mesh now in the Figure 8 is really a new analysis because you use different types of safety factors, different types of material properties. You have just told us that, am I correct?

MR. WHITE: Yes.

MR. REICH: So that is not the same one you sent us. I just want to clarify that. The thing that you sent us in the mail, the report from Harding and Lawson which we received, the 1982 report, and not 1980 as was mentioned previously, did not have these properties. You just now took different properties?

MR. WHITE: That is correct.

MR. REICH: So this is another new mesh. When you say over here 1982 Mesh A, you should also say with 1983 properties.

MR. WHITE: Correct me if I am wrong, but I think the mesh is the same. The evaluation of the safety factors are different.

MR. REICH: The properties.

MR. WHITE: The evaluation of the safety factors are different.

MR. REICH: The evaluation of safety factors are using different properties.

MR. WHITE: Correct.

MR. SCHIERLING: Let me interrupt for just one moment. John Hoch, you made a point earlier, and let's try to remember that. We want to have an understandable transcript. Please have only one person talk at a time and extend each other some courtesy.

Okay, Bill.

MR. WHITE: Any other questions on this particular slide in terms of what it means and the information contained on it?

(No response.)

MR. WHITE: In response to Dr. Cloud's comment, the difference between the FY static and dynamic, all of this is done on test data and for the static case we just drop back to the more conservative nominal design value.

MR. SCHIERLING: Let me ask one question and I am picking up on Morris' question. Are we looking at any information here now that the staff and Brookhaven did not use in our evaluation?

MR. WHITE: No.

MR. SCHIERLING: So it is new information that we are looking at.

MR. WHITE: Yes. What we wanted to do was provide the results from Mesh A, B and C all on a common basis. That was the reason for redoing the safety factors associated with Mesh A.

MR. SCHIERLING: Okay.

MR. WHITE: Now going back to this particular slide, we will see if we can come up with some moments to go back to Chuck's comment about having this thing broken out in terms of axial force and bending moment, but from a composite point of view, these are the kinds of safety factors that we end up getting.

Again, this is the analysis based on the fluid element approach, and I also have some results that we obtained by going back to the lump mass approach that was used by BNL and we give you a summary of that.

(Slide.)

In this particular table, the first column is the bending moment due to the horizontal analysis that we got from you guys last time. We went back and did the analysis on our version of FLUSH and got essentially the same answers for the bending moment. So we have got good compatible results as far as that is concerned.

MR. SARKAR: Bill, excepting that BNL had done five iterations and we have done two iterations. So this table shows that the result of additional iterations does not make that much difference.

MR. WHITE: That is correct.

(Slide.)

MR. WHITE: The next slide is again a condensation or digestion of the axial force and bending moment, and let me describe the information that is contained on this particular slide.

The numbers in the squares are the safety factors that BNL reported last time, and the numbers in the circles or the elipse is a result of the reanalysis of this by the Project and now using two new pieces of information as oppposed to what was in the BNL safety factors.

Those two new pieces of information are the vertical analysis is different because we didn't have the vertical analysis of yours available to us and so we went back and generated those numbers, and then also the numbers here include the mill cert information which you did not have available to you previously.

So those are the two differences that show up. I think the major difference is using the mill cert information as opposed to the other.

MR. HOCH: The slide you are referred to here, Bill, is page 10 of the handout; is that correct?

MR. WHITE: Yes, page 10.

MR. CLOUD: Did you say this is a vertical analysis? How did you described this?

MR. WHITE: No. This is the combination of the horizontal and the vertical static and dynamic. The previous slide showed a comparison between a horizontal analysis done by BNL and the Project, and those two are very, very similar. The only differences there were quite minor. Then it explained the difference between the two safety factors. The major contributor to the difference is just the mill cert information.

Now one thing that is I think interesting to note is that in the area where the safety factor ends up being the smallest in this zone here where you have transition between the compacted backfill and the sand, that here the safety factors going to Meshes B and C and comparing here are similar.

So our conclusion is that the tanks are qualified and the results are showing similar results.

MR. REICH: Question.

MR. WHITE: Yes.

MR. REICH: If you don't use the mill spec do you have the same safety factor that we have?

MR. WHITE: I think we back calculated that and the safety factor was a little bit lower as I recall.

MR. WONG: It is 0.72.

MR. WHITE: The .81?

MR. WONG: Yes.

MR. WHITE: The .81 goes to .72.

MR. REICH: In other words, this is all due to your new mill spec that you just put in? In other words, the highest safety factor that you are getting includes that?

MR. WHITE: Yes.

MR. SCHIERLING: You did not use the mill certs in your calculations, did you?

MR. CONSTANTINO: These are new things that they are talking about.

MR. KUO: The 49 KSI mill cert, is that an average value?

MR. WHITE: Average.

MR. KUO: Do you have all the documentation on that?

MR. WHITE: Do we have that with us, Bimal?

MR. SARKAR: I have a piece of paper which gives all these values. I can make that one available.

MR. HOCH: We don't have the actual mill certs with us.

MR. WHITE: You can take a look at this, P.T. and see if it will do you any good. Personally I don't think that this is the kind of documentation you are looking for. It just shows a range and that kind of stuff.

Any other questions or comments about what we have shown here so far?

(No response.)

MR. WHITE: I am just wondering before we get into the individual moment and axial forces, if it is not a good idea to take a break rather than continue.

MR. SCHIERLING: Well, it is a quarter of 12 now. If we take a break now we might as well go for lunch.

(Discussion off the record.)

MR. SCHIERLING: I think the consensus is to keep on going.

MR. SCHIERLING: I have just one question, Bill.

MR. WHITE: Yes.

MR. SCHIERLING: Do you have the same information, and someone raised the question before, but do you have the same information without the mill cert data so that you can go and compare the BNL analysis and your analysis both based on the same information?

MR. WHITE: We didn't recalculate every point. We calculated that value at the point where the lowest safety factor occurred, and that .81 reduced to .72, but we didn't it at all of the points.

MR. HOCH: Let me point out, Hans, the interested reader can ratio the two allowables and correct the safety factors or change them as he sees fit. We didn't provide the numbers, but it is easy for someone who is interested to reconstruct that number.

MR. REICH: Yes. Now let me ask you that question. What were the factors that you used in '78 because we reconstructed them and we would to know? What was FA and FB that you used in '78? You must have used a number. What were they?

MR. SARKAR: You mean allowable values?

MR. REICH: Yes.

MR. SARKAR: Oh, that is there on page 12. Page 12 summarizes all the allowable values which are the basis of the safety factor calculations in '78, '82, '83 and the present analysis.

MR. REICH: Okay.

MR. PHILIPPACOPOULOS: Let me make just a comment at this point. I have done some back work kind of analysis calculations, and I think the yield stress for the '78 analysis, for the yield stress I would say the percent, the allowable, and this is rough now, but it is around 50-something percent of the yield and for the bedding it is around 80 percent of the yield.

Now here you give us the stiffener allowable. What is the allowable for your section? Is this what you used?

MR. SARKAR: The section is composed of the plate on the inside and the stiffeners on the outside. So if you draw a cross-section, you will see the angle, our standing angle sticking out of the plate with the body of the plate. So you take that cross-section and that is your input to your FLUSH program, both the cross-section and the moment of inertia.

When we say the outer fiber stress, we mean the stress in the stiffener, which is on the outside and the inner fiber stress means the stress in the body of the tank. The '78 calculations did not differentiate between the allowable stresses in the stiffener and the tank.

As you can see on page 12, in 1978 the F sub Y was taken as 30 percent above the nominal value of 36, which is 46.8 KSI. However, according to the AISC specification, the allowable was taken as .6 times F sub Y.

MR. PHILIPPACOPOULOS: That is for axial?

MR. SARKAR: Right.

MR. PHILIPPACOPOULOS: So I have about 50-something. And bending ---

MR. SARKAR: Bending, I think it was 175 or 166. I forget which one. If it is a compact section you get one kind and if it is a noncompact section you get another. So it is definitely less than the final stress, it is less than 36 KSI. So that is according to the AISC specification. That is not written here, but we have written a note that the factor of safety is computed according to AISC spec, which means that whatever coefficients you apply to your F sub Y were taken appropriately during that period.

MR. WHITE: Now the evaluation that is being done now on the inside, we will use 36. There we are making a distinction between the two materials.

MR. PHILIPPACOPOULOS: That is why I wanted to get that distinction between '78, 1982 and 1983, the changes in the allowables.

MR. SARKAR: May I explain to you the '78 now. Back in '83, the present analysis, we had the information available and we went back and searched the mill cert records and identified the ---

MR. PHILIPPACOPOULOS: Excuse me, Mr. Sarkar. I am not interested about 1983 right now. I think I have got the rest of it. So I have the question for 1978 and you answered to me. Thank you.

MR. SCHIERLING: Okay, these are the data that we talked about before.

Let's go off the record for a moment.

(Discussion off the record.)

MR. SCHIERLING: Let's go back on the record.

We will continue our discussion on the three pages that we just handed out. They are Mesh A, B and C. I think Professor Holley had a question on the units.

Cris.

MR. HOLLEY: For example, for axial load, are the total axial forces in the same units or what are we looking at?

MR. UDAKA: The same units.

MR. HOLLEY: They are force rather than stress?

MR. WONG: For all three meshes, A, B and C, the moment is in foot-pounds and the force is in pounds. For the outer and inner fiber stresses as well as the actual stresses, they are in KSF.

MR. MILLER: Hans?

MR. SCHIERLING: Yes.

MR. MILLER: I would also like to make a comment to follow up on what I said before. These data indicate that in fact Mesh A gives results that nothing like even Mesh B or Mesh C. Certainly these data do not support the fact that Mesh A is a reasonable mesh to do the problem.

MR. SCHIERLING: That was your original

contention, right?

MR. MILLER: That was my original contention on these data.

MR. SCHIERLING: Do you want to address that, Bill?

MR. WHITE: Yes. I think that in all of this stuff there has to be a certain amount of engineering judgment that goes into the whole construction of this entire process.

MR. CONSTANTINO: Can I say something?

MR. SCHIERLING: Yes.

MR. CONSTANTINO: The thing we said two weeks ago was that we felt Mesh A, which is all we were looking at, was an incorrect mesh to use. It turns out we are right, and the bit about qualification really is not our problem. We said last time and we say now that the mesh data that was presented to us was an improper way to perform the analysis and that was our only comment and I think you will see the result Mike presents will show that to you.

The other comment associated with qualification is if you say okay, Mesh A is crude, Mesh B is better and Mesh C is still better, if you look at even your safety factors, the new safety factors, if I look down at the spring line or below the spring line of the sand support, it seems to me the safety factors don't go in a nice orderly convergence. So I look up at the top and I don't see an orderly convergence.

The orginal contention though was that Mesh A was an improper mesh to use for that analysis because it turned out you had the fuel holding up the tank.

MR. REICH: Well, let's discuss that after the presentation.

MR. WHITE: Like I said, there is a lot of judgment that goes into this. One of the things that influenced the decision was there was no deconvolution.

MR. CONSTANTINO: Deconvolution had nothing to do with the mesh.

MR. REICH: It had nothing to do with that.

MR. WHITE: That is true, but mesh size was not what this study was all about. It was qualification of the tank.

MR. CONSTANTINO: Very good. Now may I make a comment?

MR. WHITE: I think if you zero in on this one particular aspect, we can go around forever. The point is is the tank qualified or isn't it?

Now I recognize that you have got a problem of extrapolating this into the other areas. This is the only tank in the whole plant that is done like that.

MR. CONSTANTINO: Okay. Can I say something now?

MR. WHITE: Sure.

MR. CONSTANTINO: As I say, qualification is not my problem. My problem is I have been running finite element studies since 1963. You know, I don't enjoy running finite element studies. What I like to do is run a problem and run the problem such that I am duplicating what I anticipate in the field. Now we contend that Mesh A was a problem that was incorrectly posed and not that the tank is qualified or not qualified.

We say the data we looked at in reviewing the output from Mesh A, that Mesh A was an improperly posed finite element, and that is all we said last time. We did not say the tank was qualified or unqualified. That is not our job.

Our job was to review the finite element calculation and judge whether that was adequate or not; and we judged and we will show, and you will see the data also, we judged that the finite element calculation was wrong.

MR. REICH: Bill, according to you, you didn't have to have a grid or anything. You just could have picked these numbers and said these are my safety factors and don't do an analysis. As long as they are higher, they are good.

MR. MILLER: I would like to get a couple of numerical values on the record just to support what we are trying to say over here.

If we look at the important node according to your data it is like around node 7 on Mesh A and B, and if you look at the bending moments Mesh A gives you a bending moment of 463 foot-pounds and Mesh B gives you a bending moment of 2,663 foot-pounds. To my mind that says there is something grossly different between those two numbers. If you look at safety factors, Mesh A gives you a safety factor of 2.18 and Mesh B gives you a safety factor of 1.13.d

Granted both those numbers are bigger than one. That is the only thing that reasonably you can say about those two comparisons. They clearly don't support the contention that Mesh A is a reasonable representation. There is a factor of 10 difference in moments, which I think is a number we quarreled with last time, and there is a factor of two difference in safety factors.

So I think it may have turned out that even by using Mesh A you have come on the same side of one with either Mesh A or Mesh B or Mesh C. I still say that is very fortuitous and it turns out you wouldn't have if you went back to the original material properties.

MR. WHITE: Let me talk about the fortuitiveness of the situation. An engineer is given the responsibility of providing the qualification for the tank or whatever the thing is. You go through an analysis and once you have performed this analysis you evaluate what your safety factor is and then you reflect on the adequacy of your overall analysis, and, you know, where do you strike a balance on this?

As an example, let's say we use this Mesh A and we came up with a safety factor of 1.1. More than likely a person would have judged that overall analysis process, including a number of steps, not to be good enough.

When you go through the analysis and you come up with a safety factor of one and a half or two, you take a look at the behavior of tanks and you say has there ever been a tank failure from this kind of thing?

So there are a lot of things that go into the overall judgment of was this analysis adequate to draw my bottom line? Here the bottom line was not was the mesh good, bad or indifferent, but was my tank qualified.

I think you have to view this as a tool in coming to that final evaluation and not a step isolated all in itself.

MR. CONSTANTINO: Bill, you would agree that using the wrong tool to give you the right answer is not proper.

MR. WHITE: We all agree with that, right.

(Laughter.)

MR. CONSTANTINO: And we all agree that a buried tank has a hard time of failing and bending. But the question was to evaluate a dynamic analysis done with a finite element mesh. We contended last time and we still contend that the analysis performed with Mesh A was an improper use of "the finite element" and we will show you that. It is all the same.

MR. SCHIERLING: I think, Bob, you were next.

MR. CLOUD: It seems to me that you and others are saying the tank is qualified. It seems to me that these gentlemen that Mesh A is improper. It seems to me that those two arguments completely cross each other.

I think from my point of view it would be more helpful to get the data on the table and then we have hopefully a more profitable argument.

MR. HOCH: My problem, Bob, and let me see if I can help a little bit. I don't think there is a disagreement here. I think we are saying different things, but there is no disagreement.

MR. CLOUD: That is right, we are talking about different things.

MR. HOCH: I think we are saying that taken by itself without considering any other factors, there is no question, I think we would agree that the mesh size used in the analysis taken by itself with no consideration of additional conservatisms, the work we did confirms what you said, that that is an inadequate model.

MR. ANDERSON: But again, taken in the overall process, if we are dealing with the engineering process, it may have been used appropriately.

MR. SCHIERLING: That is a separate issue.

MR. MILLER: Can I address this? I mean this bothers the hell out of me. I mean you can't possibly have known that until you ran the finer mesh. I mean it seems to me if you ran the finer mesh enough times so that you could say the cruder mesh gives you not correct results, but they balance each other and overall they work and things work out fine, but when you only have that Mesh A, how can you tell me that you are going to believe moments that are a factor of ten wrong?

MR. ANDERSON: You are not giving the original designer any credit for understanding what he is doing in the overall context of how he is doing it.

MR. WHITE: One way to qualify the tank is to bury it.

MR. SCHIERLING: But, unfortunately, we do not know, at least from what I see, is what was in the original designer's mind when he said okay, I have this bending moment, but there is this additional one that I have to throw into the pot and that gives me the right thing.

I think what Chuck is saying is you have to look at the model separately and then combine it with other considerations.

You had another point.

MR. SARKAR: My point is I am a little bit confused. I think that we are discussing here some kind of very purely academic issues.

MR. CONSTANTINO: Oh, no.

MR. MILLER: No, very practical issues.

MR. SARKAR: Let me finish first. The bottom line, as we have repeatedly said, is that I don't know what the NRC wanted from BNL because, as Bob says, our whole review process and the way we were asked to do the job by NRC is to review the original analysis and perhaps they divorced themselves completely, which may be the fact, from the other considerations, and we as designers, as the licensee, we are taking the whole thing into consideration when you qualified the tank as a licensing basis.

Now there could be differences of opinion as to the model and how the model could be done. Back in '78 somebody, the designer sat down and tried to mathematically present a physical structure in his own way and he found that to be adequate, and the bottom line is we have done some refined analyses to address and alleviate some of the concerns expressed by BNL the last time, and yes, indeed, our bottom line still is that that is qualified.

However, I think that BNL has a problem not with the bottom line. It really does not matter to them whether the tank is qualified or not. I think that their understanding, the way I understand it from you, Hans, and perhaps you would like to shed some light on that, is whether the original qualifying analysis is correct or not.

That perhaps should not be the issue at this. Others can go on discussing that and any two people may have a difference of opinion and perhaps both of them are right. That should not be the concern before us now.

MR. KUO: Let me say a few words. I think we understand the point you are trying to make. Your bottom line is whether the tank is qualified or not.

As to whether this is of academic interest or not by BNL now, let's not make that conclusion yet. Let's wait until BNL makes their presentation, as Bob suggested. Let's see everything. Then we will make that conclusion whether that is indeed an academic interest only.

MR. SCHIERLING: For that purpose let me recommend that we go ahead with the BNL presentation and then everybody will have something to stew over over lunchtime.

Okay, let's proceed with the BNL presentation.

(Slide.)

MR. PHILIPPACOPOULOS: Our basis for arguing that the HLA model is inappropriate is a comparison between the results that we obtained with the HLA model versus the results with the lumped mass model.

The lumped mass model was contructed from an HLA model by simply throwing out all these fluid elements here and computing the mass or lumping the mass at these points.

We compare moments, axial forces and shear forces for those two models and from their comparison we concluded that the only difference between the lumped mass model and the HLA model is that the lumped mass model does not include the sloshing frequency, the frequencies from the fluid. Therefore, a model like the middle one here could give a difference between those two models.

At that point I sat down with our consultants, Professor Miller and Professor Constantino and based on their experience they never saw tank solutions in which the sloshing effect could justify the difference between the lumped mass model and the HLA model. That was one indication that this model was inappropriate.

(Slide.)

Another indication we had was that with the HLA model, with your model that uses four fluid elements to represent the fluid inside the tank, you could get this bedding flexor mode for the tank. This is a sine kind of a mode.

The reason for that is in this mode this portion of the tank is in compression and this is in tension. But with your element discritization here, it seemed to us that these elements, they will take a lot of tension and they will pull back the tank and will put this part in compression and this goes already in compression. So it will put the whole section in compression. That justified the fact that your axial forces basically were overestimated, whereas your bending moments, they were underestimating the real situation.

MR. CLOUD: Question.

MR. PHILIPPACOPOULOS: Yes, sir.

MR. CLOUD: The diagram that you have on the blackboard, could you explain to us exactly what all these lines are?

MR. PHILIPPACOPOULOS: The heavy line here is the finite element model of the tank. These are the nodes and these are the beam elements that were used to describe the cell. These lines here ---

MR. CLOUD: No, the dotted lines.

MR. PHILIPPACOPOULOS: The dotted line represents a flexor mode shape that you would anticipate if you have the tank as a cell without having the soil outside.

MR. HOLLEY: What mode?

MR. PHILIPPACOPOULOS: It is a flexor mode.

MR. CLOUD: Are these the classical mode things for a tank or did you calculate them or where did they come from?

MR. PHILIPPACOPOULOS: Well, these are the sine kind of modes, the ring kind of modes, the flexor modes that you get on a ring.

MR. CLOUD: So these sines are theta?

MR. PHILIPPACOPOULOS: Yes, sined two theta, sined four theta, et cetera.

MR. MILLER: The significant thing I think is if a tank wants to go in flexure, these are asymmetric sine modes, sine two theta, three theta, four theta. What really wants to happen in a fluid that can't sustain shear stress is the fluid on the bottom part of that tanks wants to move up to the top part.

With the four element model of the fluid, that is impossible because the node at 90 degrees and the node at the origin can't move. So that say the fluid from the bottom of the tank can't move into the top of the tank. The only alternative, if you are going to get this kind of a mode, is you put the fluid in the top intention and fluid in the bottom in compression which is forcing the fluid to hold up the tank which obviously doesn't.

In a real world what really happens when you get this kind of a mode is the fluid is going to flow because there is no shear strength from the bottom to the top and you are going to get a distortion of the fluid. The mesh of the fluid does not allow that kind of fluid deformation.

So what that model does is it basically eliminates this kind of a mode or response. That is why, as Mike suggested before, what happens when you eliminate this is you eliminate the bending and because you are now putting the fluid in compression and tension, now you are putting a big axial force on.

So if you look at the difference between Mesh A and Mesh B of HLA, the Mesh A gives you big axial forces because you are forcing the fluid and the fluid is pulling and pushing on a tank.

MR. PHILIPPACOPOULOS: The numbers that we have today are from the HLA analysis.

MR. CLOUD: But the important thing is that the dashed lines are mode shapes of a ring that you have superimposed on the model for illustrative purposes.

MR. MILLER: It is something that, it seems to me, that you should have looked at to start with to conclude that that kind of a modeling of the fluid is not really acceptable because it is equivalent to saying you can't have those kind of modes in a tank.

MR. PHILIPPACOPOULOS: In other words, this is a very significant mode for calculating the response in your tank, asnd in the HLA model this kind of mode cannot exist with this kind of modeling of the fluid element. That is our point.

MR. SCHIERLING: Cris.

MR. HOLLEY: Could I make sure I understand you. I think I catch Bob's difficulty. These are not calculated for the earthquake. These are simply mode shapes. The top one is the first mode, the middle is the second mode.

MR. PHILIPPACOPOULOS: This is a sine theta mode, sine three and four theta modes.

What is happening here is simply we didn't put the symmetric part in the bottom part of the tank. I mean normally you would see the mode coming symmetrically on the other half. Let me just kind of draw it here. It would come like that.

(Indicating and drawing)

MR. SCHIERLING: Again, the important thing I think, Bob, is these are not calculated. They are conceptual models.

MR. PHILIPPACOPOULOS: These are the modes you get on the ring mode. So it is not conceptual. These are the modes.

MR. CLOUD: These are the modes for a ring not supported by soil or anything else.

MR. WHITE: I was just curious what these mode shapes were for.

MR. SARKAR: Any circular ring will bend whether it is above ground, below ground or anywhere as a series of mode shapes, sine in theta and there is one to infinity. The first few cause large bending and the higher the modes you go, the less bending you get, that makes sense, whether the soil is buried or not.

The only difference is the magnitude of each mode component for a particular problem. Whether there is soil backfill or no soil backfill, that would change the magnitude of the first mode, the second mode, et cetera.

What we are saying is that the model, the fluid model prevents bending from occurring in that tank if it wants to occur.

MR. SCHIERLING: There is question over here.

MR. LUI: I believe that when you have constraints on the structure, you won't have the same mode shape.

MR. CONSTANTINO: That is not true. Every circular ring or flexor tank, two-dimensional tank bends to sign in theta no matter what the support conditions. The only difference is the magnitude in each mode depends upon the loads and the support condition.

All we are saying is that the model prevents some of the primary bending modes from occurring if it wanted to occur. That is just a conceptual argument

MR. SCHIERLING: Cris.

MR. HOLLEY: I guess I would agree that it would depend on how you define the medium that it is in.

MR. CONSTANTINO: If I can just add one thing to Cris' thinking. As Mike will point out later on, this has a big impact on whether you use Z-Z soil or Y-Y soil because the Y-Y soil is very much softer.

MR. HOLLEY: I think that I would have to think that your second case there, if you truely said that it was independent of being in a medium and the shape is the same as a free ring, you would get in trouble because if your nodes of that mode shape are all equal and you are in a finite soil shape you are going to get different forces on the nodes down below than you have up above and the damn thing is going to move.

So I don't think it is always true that the mode shape is independent of whether you are in a medium or not.

MR. CONSTANTINO: The mode shape is there for every problem, Cris. The only difference would be the magnitude of each mode shape in a particular problem.

Mr. REICH: The main thing that Mike is trying to say is that the original model would not allow these things to happen. That is what we were trying to say two weeks ago.

MR. PHILIPPACOPOULOS: At the last meeting we had I think it was clear stated by us here, by Professor Constantino, that your model did not have a very good presentation of the fluid.

When we went back we made a final mesh for this model only in the portion of the fluid. We used the same discritization outside and we obtained axial forces here, forces and moments. I have some tables of comparison and I would like to go through them.

(Slide.)

The first table demonstrates a comparison between moments. This is the HLA model, the refined model that I displayed before, and this is the lumped model.

This number was demonstrated to you in our previous meeting, the refined model moments that we obtained at the nodes, at least here, and you can see by observing this table these moments and the moments on the lumped model are pretty much on a ball park close.

MR. CLOUD: Mike, are the values not in parentheses for horizontal and vertical static?

MR. PHILIPPACOPOULOS: I am going to demonstrate three tables basically. The three of them, they are demonstrating the responses for horizontal dynamic analysis, No. 1.

No. 2, in all these analyses we did not use deconvolution, but we applied the Hosgri break at the base. Now the numbers in the parentheses here, the red numbers with the red ink here are the moments again that you obtained from the refined model when you used Y-Y properties. Y-Y properties are the properties that correspond to the measured data and from lab tests data for the soil.

Now we can see clearly here that the Y-Y section is definitely more critical than the Z-Z section. This is not surprising to us.

Is there any question?

MR. REICH: If this were partially filled, we think that the results would even be higher.

MR. CLOUD: If what were filled?

MR. REICH: This assumes that the liquid is completely filling the whole void inside the tank. If it were partially filled and with deconvolution it might even be much higher.

MR. CLOUD: The oil crisis is over.

(Laughter.)

MR. PHILIPPACOPOULOS: Are there any other questions on that table?

(No response.)

MR. PHILIPPACOPOULOS: The green numbers are the numbers that correspond to the Z-Z section and the red numbers are the numbers that correspond to the Y-Y section. All these numbers are moments here. All these moments are coming from the beam elements that we use in the three models to represent the cell, the tank. The moments are in feet-pounds.

(Slide.)

The next comparison again was on the level of the axial forces. The green numbers are axial forces in Kips from the Z-Z section and they correspond to the HLA model, a refined model with a Z-Z and a lumped model.

In addition, we have here a list of the numbers that we obtained with a Y-Y section for the axial forces. By inspection we can see similar results in the refined model of the Z-Z section and the lumped model which again is a Z-Z section are pretty much close. However, the HLA model overestimates clearly the axial forces.

Also here we can see that again the Y-Y section is more critical than the Z-Z section.

MR. HOLLEY: These are Y-Y properties or it is the property difference of the soil?

MR. PHILIPPACOPOULOS: The Z-Z properties are properties that they use based on similar soils. The Y-Y properties are properties based on their lab tests, and that is the big difference between those two. Usually what it is is basically Z-Z properties are an upper kind of bound properties. They are higher than the Y-Y properties. It turns out to be now that the Y-Y is more critical than the Z-Z properties.

Finally, I would like to demonstrate to you a comparison of the level of shear forces.

(Slide.)

This again is a similar type of comparison. The shear forces in pounds from the HLA model, the refined model Z-Z section and the lumped model Z-Z section and also shear forces with our refined model, but with Y-Y section properties.

From inspection we can see the same kind of result that observed in the previous two comparisons. The

HLA model and the lumped model are completely different. The refined model is closer to the lumped model. The third observation is that the Y-Y section results are higher and more critical overall, not a one-to-one basis of course. They are critical in the Z-Z section.

This is the third type of comparison we made. We used our refined model.

Let me make a few more comments.

One other comment is that we used a certain discritization for the fluid. The results, they can also be obtained by using a finer mesh. We tried a few runs by using a 90 percent filled tank, a hypothetical number, a 90 percent filled tank, where the green stops to a certain level here so that you get 90 percent fluid there.

Those results again both indicate the moments at this section and they even become higher than the filled tank, the completely filled tank.

One very important point is that clearly from three of these comparisons that I demonstrated to you we can see that the Y-Y section is more critical than the Z-Z section.

All of these analyses were done by using the Hosgri-Newmark earthquake as the input level at the foundation here, the base, the slab. If deconvolution was applied using the Y-Y section results, and the Y-Y section is softer than the Z-Z section, and the deconvoluted input at the base, the pulse would be stronger than the pulse that you would have gotten using deconvolution by using the Z-Z properties, and we can say that these numbers are going to be even higher.

That concludes the presentation.

MR. HOLLEY: I want to be sure I have the units right. On on moments, those are foot-pounds per foot, correct?

MR. PHILIPPACOPOULOS: On the moments it is foot-pounds per foot for the length of a tank and again Kips per foot.

MR. HOLLEY: But shear is pounds per foot?

MR. PHILIPPACOPOULOS: Yes, shear is pounds per foot.

Any more questions?

MR. SARKAR: Yes, I have a question, Mike. Do you now conclude that your lumped mass model is the most appropriate way of doing that analysis or the refined model? What is the conclusion based upon that you arrived at?

MR. PHILIPPACOPOULOS: Well, I think the refined model would be a better model, but when we say refined I have to make clear this point. This refined model had one purpose and the purpose was to demonstrate, to prove with numbers what we have said in our previous meeting. The modeling of the fluid was very close and that is why you are getting all these funny answers with using your model.

Now if you refined this farther and farther, then you can have a feel if you are getting the right numbers. We have to try a couple of measurements to see where you are.

At this point I want to bring our consultants into the discussion if they have a different feel about what I just stated.

MR. CONSTANTINO: It should certainly be that the lump mass analysis has got to be a conservative analysis.

MR. SARKAR: So what I understand from what Mike said and what you said is that if you go on refining the model that you oppose the lumped mass model?

MR. CONSTANTINO: Yes.

Did you mention the other thing about the Poisson's ratio?

MR. CLOUD: I was going to ask about the fluid properties.

MR. PHILIPPACOPOULOS: On the Poisson's ratio, the results that you presented to us today, after we have the discussion we will look back into that thing.

What we are trying to do there is we want to put the right number for the bulk models of fluid there. The whole discussion was about the wave propagatigon here and you are using the definition of the p-wave velocity to define the properties of the fluid there. Our point was that the propagation of the p-wave, to accurately represent the fluid in terms of material properties.

MR. CLOUD: Why were the values you used for the fluid properties used to obtain the numbers you just showed us.

MR. PHILIPPACOPOULOS: That is a good question.

The values were used for HLA analysis, and if you want me to go more into that, I can.

MR. CLOUD: No, that is enough. Which one?

MR. PHILIPPACOPOULOS: 1982 reanalysis. Four with three 9's, 4.999 Poisson's ratio.

In addition to that, we speak of fluid elements of that code ourselves. We find that the difference between putting the bulk models of the fluid of the elements and simulating the thing with 4.999, with three 9's, it was the same number and we were getting no difference in moments or stresses.

Any other questions?

MR. HOLLEY: On your table showing axial forces where there was a significant reduction from the HLA model to your refined model and then a further reduction when one compares the refined model with the lump model, I personally am more interested in axial force and I would be very interested to hear you describe your judgment as to those reductions, the reasons for them and what you infer from them.

MR. MILLER: Part of it I think it tied to what we said before, that when you restrain that bending moment forward, and the reason, first of all, for reduction from the HLA to the refined model is when you restrain that bending mode in the shell you do it by the fluid applying tensile and compressive stresses. Obviously when a fluid does that it builds up axial force and that is the price you pay for getting rid of the bending moment. That is why the HLA model is higher than the refined model.

Going from the refined model to the lump model the crude mesh still restrains somewhat the movement of the fluid around the tank.

There is the other question and that is when you have a full tank you in fact, since the fluid is so stiff compared to the flexor of the shell, you in fact are forcing the shell to form in constant volume kind of deformations.

So I think part of that reason might well be resolved if you ran a tank 95 percent full or something like that, or ran a vented tank where you didn't confine the volume of the tank. That is really what is happening now. The fluid is going to keep the same total volume and so the inside area o1 the tank has to stay the same. You can't really come in like you could if you had a 95 percent full tank and the fluid could move up a little bit.

So I would think if you ran a refined model and also ran a model where it was not quite so full, you probably would see these numbers going to more like a lump parameter model.

MR. HOLLEY: So you think the lump mass numbers are more nearly the appropriate ones?

MR. MILLER: We made some numbers on sloshing masses. The only differences are if you had a solution and you have a fourth column which would be the lumped mass model where some of the mass attaches to the sloshing mass, I would say that is really what the answer has to be.

For some of the few sloshing numbers that we made, the sloshing mass is like one percent of the total mass of the tank. So based on that, I would guess that that lumped model is very close to what the right answer is going to be.

MR. HOLLEY: Of the three you think that is the most reliable for axial loads?

MR. MILLER: I think probably so.

MR. HOCH: I would like to ask a question, and I am sorry to jump in. Could you characterize the HLA model as shown up here, the very simplified model, one could characterize it as being conservative with respect to axial force.

MR. MILLER: It is probably unconservative with respect to bending.

MR. HOCH: The reason I am saying this is I am a little concerned that there is a tendency to throw rights and wrongs around here a lot and we are talking about mathematical constructs. We are talking about your lumped mass model being, and you used the word conservative I believe, being conservative with respect to at least one set of parameters.

I guess I am concerned about the rights and wrongs. I think if we talk a little more in terms of conservatism rather than rights and wrongs, I think it is a better characterization of the models.

MR. MILLER: This sort of gets back to our original discussion, but if you look at all of the results that have been presented today, your results, those tables and these results, the lumped mass model, all the numbers are roughly in the same ball park except for the original HLA model.

I think if you take all the runs that have been made by yourselves, HLA and ourselves and ask me to believe something, everything gives you like in the same order of magnitude numbers for everything, except for that first model.

All I am saying is that first model, it seems to me, is a totally inappropriate model for this. I don't see you can use it to draw any conclusions from it. Most of the other models give you models that are at least in the right ball park.

I mean if you talk about a finer mesh, you hope in a fine element analysis that as you make the mesh finer and finer you converge to an answer. That doesn't always happen, but for most fine element problems in fact you can prove that that is the case.

Going from the HLA to any of these other models, your model or ours, is not really a matter of refining the mesh. It is a totally different problem and the characteristics are different. They don't look the same.

MR. HOCH: By comparing the refined model with some degree of refinement, maybe even a finer mesh than is here, with the lumped mass model, then we are comparing three different ways of modeling things and we have more difficulty saying right or wrong.

MR. MILLER: Now we are back into the realm of whose mesh is finer and triangles instead of rectangles. That is a typical kind of fine element argument as to whose mesh is better. The other I think is a qualitatively different arguement. I think it is like your using thrust elements and I am using beam elements. It is the same kind of a thing. You are not really talking about niceties of the problem. You are talking about very fundamental characteristics.

MR. SARKAR: Following on what Professor Holley said, and I think that is a point that should be well taken, the bending should not be a matter of concern and axial forces should be perhaps the dominant forces. I mean if you are getting large bending moments in some analyses, perhaps the model will have to be refined a little bit to cut down the moment.

If that is true, and if you have said that, then could we perhaps say that the HLA model was overly conservative?

MR. MILLER: Bimal, if in your evaluation criteria, your qualification criteria you state that as an assumption and if all you are concerned with is qualifying the axial loads, then I will say the HLA model is going to give you conservative results.

MR. SARKAR: No, I am talking about an overall basis.

MR. MILLER: Then I will never buy that. I think it is clearly demonstrated here that there are such far differences.

MR. SARKAR: But you have said the fact, which Professor Holley also mentioned, that the bending may not be the matter of concern. It is the axial force in the tank which perhaps will be the predominantly large force and you are getting substantially large ---

MR. MILLER: Bimal, let me answer that with a number again. You had a number of a safety factor, using your numbers the last time, of 1.55. If you stuck with those original stress allowables and didn't go to the mill spec, your tank would not be qualified right now. The reason you went to the mill spec is when you make the safety factor number it was less than one. So you can't say that it wasn't important. It clearly was important there. You don't have as much safety in a tank using these other analyses as you did before.

So the refined model gives you lower factors of safety in fact by your own tables than the HLA model. I mean you proved that. So you can't say the HLA is going to be conservative. You just proved that it is not always conservative. In fact, it is always unconservative as far as the safety factor.

MR. HOCH: My feeling is that once again we may have reached a point of diminishing returns.

MR. WHITE: Personally, I think the NRC is going to have to take a look at this overall analysis and take into consideration the charge they gave BNL and the real bottom line is is the tank qualified from our point of view. Now what you have to do is judge from your own point of view where are we on the subject. I think we are looking at one piece of the overall analysis which is not the overall engineering process that went into this thing.

MR. SCHIERLING: Well, the question comes from what I hear you say now of is there any need to reconvene after lunch?

MR. HOCH: I think there is, Hans.

MR. SCHIERLING: Let me just check for one moment.

(Discussion off the record.)

MR. SCHIERLING: I recommend, and it is now a quarter till one, that we reconvene at 2 o'clock and hopefully identify the issues that have to be resolved at that time.

MR. REICH: There is one correction we would like to make. Mike inadvertently referred a few times to our consultants who are colleagues.

MR. SCHIERLING: Okay. We will reconvene at 2 o'clock.

(Whereupon, at 12:45 p.m., the meeting recessed, to reconvene at 2:00 p.m., the same day.)

AFTERNOON SESSION

(2:10 p.m.)

MR. SCHIERLING: Shall we come back on the record and reconvene our meeting?

We have a new recorder this afternoon -- the first time that happened -- so, please try to refrain yourselves from having more than one person talk at a time, and identify yourself the first time until she becomes familiar with us.

What I would like to do this afternoon to start out with, have the staff and our consultant explain to you where we believe that there are some discrepancies or inconsistencies in the analyses and in the models that the project is using where sometimes we use this and other times we use that without any discussion on it as such.

I then would like Brookhaven to also identify where we see differences between what you did and what we are doing.

I would like the project to comment on that. I do not think at this time that it would be fruitful to go into any furthar discussion much beyond that. Instead, I would propose that we use the transcript as a start to identify -- and for that I want to have a summary this afternoon -- what the issues are.

I would recommend that the project then maybe come in with some kind of a formal submittal, be it a supplement to the Phase 1 final report; be it addressed in the next semimonthly report. But somehow in the context of the project, of your internal technical program, it should be addressed.

We will ask at the same time that Brookhaven put down their concerns in writing and probably the results of their analysis. I realize that some of that will be going on in parallel and it would be more fruitful if it could be sequentially. However, I do not think we have quite the time to do that.

With that, do you have any comments, John, Dick?

MR. ANDERSON: That's fine.

MR. SCHIERLING: Again, I would personally like Brookhaven identify the discrepancies both the way we see it internally in your own work and with what we are doing, number one; and then I would like you to come up with a parallel analysis.

Morris, with that why don't you identify what the issues are, the way you see it?

MR. REICH: All right. I would like my colleagues to come in and comment as I am speaking.

The first one that I see is the presentation given this morning where more refined models are shown. It was fairly clear that the answers which were obtained for the moment were many times higher than those for the old 1978, 1972 core element fluid model we talked about last June 17.

That was essentially the thing we wanted to get across last time. In other words, we wanted to say that the model which was used was not physically modeling what was happening to the tank.

I think this actually validated what we said. That is the first inconsistency that we have seen. We do not understand why PNG said it was not doing that.

MR. MILLER: On that same line, I think it is important to note that the safety factor calculation using the small model is not conservative as compared to safety factor calculations using the refined model. We always get bigger safety factors wich the small model than you do with the more refined model.

MR. REICH: Yes.

Now, the second item that I want to bring out is again that in presenting the results today, new material strength properties were used to compute the factors of safety which were not ever used in the pieces of information that we had gotten from PG&E to date -- not in the 1978 information and not in the 1982 information.

To be honest, if one would use the old material properties with the refined mesh, we see that they might not meet the allowables. They do, however, meet them with the new material properties.

Another item that I would like to mention is that all the models presented today used ZZ soil property properties. Now, as we showed, if you use the YY section properties you would get higher values of moments and so forth. The stresses would probably come out higher, in particular if one would use deconvolution which was not used in any of the analyses that we saw today. All the input was applied to the base.

Another item that we would like to see, and we feel these would also give higher values --

MR. WHITE: Morris, pardon me for interrupting. But could you talk about the deconvolution thing again? I missed your particular point.

MR. REICH: All right. In the analysis that you showed today there was no deconvolution used. It is our feeling that if one did the YY model with deconvolution, the values would be higher.

MR. WHITE: Okay.

MR. REICH: To qualify that a little bit, in one of your documents the ZZ was used because the old model, ZZ model, gave higher stressesm more conservative stresses, than the YY model.

We believe this would not be the case for the YY model today, the more refined one. We believe those results were due because the ZZ model was incorrect.

There is one more item. We would like to see a partically filled -- for example, about 90-percent filled --

refined grid which we also think will give somewhat higher values than a full tank.

Now, there is one more item which I would like Chuck to mention, and this concerns the outer and inner fiber results.

MR. MILLER: This is probably more of a question than it is a comment. I guess the answer would decide that.

When you now have different allowable stresses on the inside and outside, it seems to me you have difficulty combinging the axial force and moment from the FLUSH type analysis to make sure you really picked up the worst case.

If you had the same allowables inside and outside, if you had P over A and M over S, you would get the worst case.

Unless you do that and compare it with the minimum allowable, it seems to me you have a hard time totally resolving that picture. So, I think we would be interested in seeing how you really did that.

MR. WHITE: Yes. The safety factors were calculated so far on P over A term. We have used 36 ksi for the entire cross section. We have not made a distinction between the portion of the axial load carried by the stiffener.

So, from that point of view we have taken a conservative position.

MR. MILLER: But how do you combine the M over S, then?

MR. WHITE: For, just say the outer fiber where the P over A term was was really a 49 ksi kind of thing, we have used it as though it was 36. We combined the 36 P over A with the 49 MY over I. And then on the inside, of course, the four 36s.

MR. MILLER: Right. And then on a bending you just added it. Okay.

MR. WHITE: We didn't get to that level of detail of safety factor evaluation, but that is what happens.

MR. SCHIERLING: Morris, if you could, I would like you to talk or to express your opinion on the validity of the various models, A, B, and C that we were looking at this morning. Not necessarily a judgment which you believe is the proper one but identify the deficiencies, if any, in the way you see it.

MR. REICH: Well, "A" is something we spoke about in great detail. I think we showed that it does not transmit, really, what is happening in reality. Those elements cannot move, so therefore you have a situation which is not real.

Now, we think that "B" and "C" is going in the right direction, and the question of course is, what should be the detailed grid.

That is hard to say at the moment. I think that requires some checking. It is better, much better than "A".

MR. SCHIERLING: Dick?

MR. ANDERSON: Well, Hans, I think that we certainly understand the discrepancies or issues that have been identified. We would not have any problem writing up a transmittal that would address these issues in as much detail as we can come up with.

The issue here is a fairly broad issue, it involves the essence of the design process. Obviously, in this case a fluid model was put together originally considering all of the factors -- some of which Dr. White has mentioned. Considering all the factors that fluid model was considered to give adequate results.

In itself it may be subject to question in certain areas, but as part of the overall process, the original designers felt that the tank was indeed qualified.

I think that the work we have done, and I think that certainly the work Brookhaven has done, supports the idea that the tank is in fact qualified. So, it is a matter of how we get there and what analyses we have to have on record to show that the tank is qualified.

We are quite happy to go to a more detailed analyses that is more academically suitable with the kind of scrutiny that the tank has gotten in this light today, and we certainly would be happy to put up all of the analyses that we have done to support the issue, or support our contention that the tank is indeed qualified.

It will be up to, then, the NRC to make some judgment as to the appropriateness of the original design, design techniques, and whether that is acceptable or unacceptable.

We feel the tank as it stands, as it sits there, is acceptable and we will go to any length that we need to to show that.

As we go to finer and finer analyses, then we can use more realistic data that was perhaps part of the thinking of the original designers right from the beginning.

Bill maybe you could comment on that a little further.

MR. WHITE: Well, as has been discussed, we have been asked to look at a piece of the overall design process. I think that taking that as an isolated event, some improvements could be made. There is no question about that.

But from our point of view the whole question is, you know, how is the tank? The tank does not care about the kind of modeling we use, and experience shows that buried tanks are extremely difficult to do anything to from an earthquake point of view.

I think that it is not an easy job to evaluate the adequacy of the overall design process. But that is really what we are talking about. We have zeroed in on one piece. We have seen where improvements could be made. But in terms of the overall design process there are a number of things that get considered.

When a guy does an analysis and comes up with a stress and compares that with his allowable, the difference between those two, he has to go back and reflect and see if his original model was good, bad, or indifferent; was it adequate.

In making that judgment, you have to consider how conservative is that allowable stress that you are using as your yardstick. If you use the interaction requation, you know, is that really the most realistic yardstick? It is certainly one that is adequate. If you can satisfy that, everything is okay.

But if for instance a movement should cause some yielding, is that in itself a real problem? The axial stress is the thing where you really have some problems, which does not appear in the yardstick of using the interaction equation.

So, I guess the point I am trying to make is, there are many, many things that go into the overall design process. We have looked at one portion of that, the modeling. I guess we will take a look at ways of improving that to see if we still come to the same conclusions, qualification integrity.

MR. KUO: If I may comment. I think we understand the project's position. We also tend to agree with you that there are still some conservatisms in the design.

But I think the overall purpose here in this exercise is to demonstrate that the qualification of this tank meets the licensing criteria.

You mentioned about certain things like, for instance, testing without this and that. It is there, we all know.

But I think the most important thing here is to demonstrate that the tank does meet the established licensing criteria that we have before us.

Also, I would like to point out, we are not interested to pursue any -- interest as Dick pointed out before. I certainly agree with that. Our interest is to find out whether the tank is adequately designed.

But so far, from what we have seen, I do not think there is sufficient demonstration that the tank is adequately designed.

As Morris pointed out, there are discrepancies there. I would like to make a few follow-up comments. For instance, we had in 1978, 1982, 1983 analyses. I would like the project to point out to us which one you would be using as a licensing basis for this case.

I am looking at so many analyses, '78, '82 and '83. Which one am I going to have my SER basis; that is the first thing.

The second thing, you point out the mere certification of the 49 ksi properties, and you showed this morning a sheet of papers with a few numbers there. I do not think that is sufficient basis for you to use in new properties, I think you will have to show.

MR. WHITE: Oh, yes; sure. And this morning when we had a piece of paper, that is not the kind of evidence that you need.

MR. KUO: We need more than that. That is one thing.

A second thing, you have to look into it, what was the original licensing criteria.

And then the third point I would like to follow up is this --

MR. SARKAR: Excuse me, P.T., would you extend that one, what was the original licensing criteria?

MR. KUO: Right. By the original licensing criteria, what I mean, allowables. What was used, or on what basis this plant, or the adequacy of the tank, was accepted.

MR. ANDERSON: But P.T., if we are looking at this in a more refined way, then we certainly can look at what is actually there. That is typical of all of the review of existing tanks.

MR. KUO: No question about it.

MR. CLOUD: Excuse me, could I ask a question for clarification?

I am Bob Cloud. I was under --

MR. SCHIERLING: They can't hear you, Bob.

MR. CLOUD: A question for clarification about the actual material properties.

It was my impression that that was accepted and was part of the Hosgri report.

MR. KUO: Yes.

MR. CLOUD: Is that true? and if that is true --

MR. KUO: That was the licensing criteria, a general licensing criteria. For each of the structures we do have different allowables. Say, for instance, auxiliary building, the concrete strength is different from the concrete strength from containment.

MR. CLOUD: I see.

MR. SARKAR: But what Bob is saying and what I wanted to find out also, P.T., is that the licensing criteria said that you can use the actual distant value.

MR. KUO: No question about it.

MR. SARKAR: And with adapted value, in the case of the concrete, is 2,000 psi or 5,000 psi, 6,000 psi, it is not the quanititative value but the actual physical value that you have been contesting.

MR. KUO: No question about it, that is what I am trying to say. But when you have to look at the original values, there was the mill certified value, 36 ksi, or 49 ksi, or what?

In other words, I am saying you have to show sufficient data to support whatever the number.

MR. WHITE: That is no problem.

MR. KUO: Okay. And the third one is this ZZ and YY problem. I still recall at the '78 time frame, when we reviewed it we were told -- as Professor Miller pointed out -- we were told that ZZ properties produced more critical results and on that basis we accepted it.

Now, if we were to believe that the YY properties would produce more critical results, then the project would have to look into that.

MR. SCHIERLING: One comment I had, Dick, on a number of occasions you referred to, "Well, this is the model that was used and it is only one element in the overall design process." You made reference that this very well could have been what the designer had in mind, or this waS the designer's judgment.

You have to keep in mind, unfortunately we do not have that available to us right now and it is very hard to re-establish that. I think therefore it is only more so of importance to us to do it right now; whatever we do have the bases put down.

MR. ANDERSON: We will certainly do that. We will put down the bases very clearly for our new analysis.

The point I was trying to make is that when we go back and look at an old design and we say something is in error, we often do a great disservice to the original designer because we really do not know what the original designer was thinking in the overall design process.

We do know that engineering design is a very complex process, and one thinks of a lot of things as one goes forward and does specific analyses and calculations. The analyses and calculations often are only a part of the overall design process.

MR. SCHIERLING: And judgment.

MR. ANDERSON: I think we do prcfessionally, we do a great disservice to an original designer to ignore some of the things that were probably considered and we have every reason to believe were considered as they went through that thinking process that developed the original design, or the original analysis that said the tanks were indeed qualified for the Hosgri earthquake.

MR. SCHIERLING: Go ahead.

MR. CONSTANTINO: I would like to make two comments. One is, I have to object a little bit -- as P.T. did -- to this "academic exercise" this morning. As far as I was concerned, it was not an academic exercise. I do not enjoy running finite element runs for prosterity.

As far as your final comment goes, it seems to me no one around the table could justify an incorrect analysis to qualify any structure. Our contention is the regional analysis performed to qualify the tank is wrong. That is what we are saying.

MR. ANDERSON: Maybe we would ask Harding Lawson to respond to that. Would you like to respond to what the thinking was?

MR. UDAKA: My name is Tac Udaka.

We know if you change, the response at a certain point may differ. But we believed at that time, in 1978 and 1982, we modeled it good enough to show the tank is stable, including all the conservatisms. For example, we ignored the timing of maximum moment.

So, we knew the stress. We know, we have another stress from the tested value. But we did not divide the factor of safety because if I can show the factor of safety more than once, you know, I believe it is safe.

Then, BNL pointed out, "Okay, if you define the mesh you are getting a different response. Then we went back and have done all the analyses until we found a different response.

But still, we can succeed to show the factor of safety is one, although I have to use new tested volume, you know.

So, we reached the same conclusion this time in the last few cases.

MR. REICH: I don't see how you reached that conclusion.

MR. UDAKA: We took out the conservativeness.

MR. REICH: That is not true because you still did the ZZ and we were trying to mention over h're that you should do this with the YY because the reason you had more conservative results previously with the ZZ is because you had the wrong model, physically the wrong model, modeling the physical event.

If you have the correct, more correct, model modeling the physical event, we think that the YY would give you higher stresses, especially with deconvolution.

Now, you might not -- I am not sure -- even with the new properties meet the qualification.

MR. UDAKA: I had the wrong model. It is a closed model.

MR. REICH: Well, I think it is a model that does not physically model the true events that happen. As we showed you this morning, you are not allowing certain modes to act.

MR. UDAKA: Considering the old conservatism, we --

MR. REICH: Well, let me ask you this, if you have 45 at one number and 500 at the other number, would you say that is a correct model? I do not know how to say it differently.

MR. PHILIPPACOPOULOS: At that point I would like to make another observation. Dick mentioned before that BNL analysis met the time qualification requirements, or something close to that, but that the tank is qualified.

I would like to emphasize at that point that we did not prove that. What we proved it did is that the analytical procedures that were used for the analysis at the time were inappropriate.

At no point in our presentation, my presentation on this before, I said that my analysis proves that the tank is qualified.

MR. WHITE: I think what Dick was meaning to say there is that the results from more refined models that were put together agree or give similar results to the one that you put together. From that point of view they are both talking about the same level of response.

I think before we are able to complete the qualification of the tank --

MR. PHILIPPACOPOULOS: We did not talk about the same response. I am sorry I interrupt you because if you look at the level for response individually, in terms of response in moments, an actual force and response in shear forces, the level is not different -- it is different, okay, between the original model and the refined model.

MR. WHITE: No, I am talking about the refined model that we got and your model.

MR. PHILIPPACOPOULOS: Okay, so you are getting a response.

MR. WHITE: That is what Dick was referring to. I think in order to be able to close out the qualification of the tank we are going to have to go back and take a look at Section YY; that is relatively straight forward.

MR. PHILIPPACOPOULOS: You mentioned before that when set up the model you obtained time histories of stresses of the fluid elements.

MR. SARKAR: We did not.

MR. PHILIPPACOUPOULOS: You obtained time histories for spreading movements, or --

MR. SARKAR: No, we didn't. We just simply add -- ignoring the timing which happens when it is opened maximum.

MR. PHILIPPACOUPOULOS: Now I realize, I understand why you did not see the high levels of tensile stress in the fluid elements, especially of the torque, carried with your model, which is an indication that the model of the fluid elements were not good, representative of the action of the fluid inside the tank.

MR. SCHIERLING: Do you have anything else, Bill, Dick? If not, Bob, do you want to add anything?

MR. POLK: From my point of view these discussions are very helpful in that they tend to highlight the issues involved regarding the qualification of the tank and to a certain extent makes our job easier -- which is not to say you have to keep having them.

(Laughter)

MR. SCHIERLING: Let me add this: Dick, you mentioned earlier, I think, that the staff has before it evaluations by Brookhaven, by you, and indeed we also will have before us the evaluation by the IVDP, and that is another element that will enter into our evaluation and we have to keep that in mind.

MR. ANDERSON: But we will send to you a revised analysis that qualifies this tank and will address the issues that have been raised. We will also, of course, send that to the IVDP and it will be up to then the IDVP and the NRC to make a judgment on it.

MR. POLK: One additional question, Hans, is the timing on this. Of course, we can get it at a later time. But since we are not in that close contact with Brookhaven, if they know what their timing is for their submittal, it would be helpful for us.

MR. SCHIERLING: You mean the Brookhaven submittal to us?

MR. POLK: Yes. You had asked earlier that they do one. So, my question is, does anyone know at this time when that would be.

MR. SCHIERLING: Not at this very moment, no. I hope very soon we will know.

MR. POLK: Excuse me, one other thing. I would only add, from our point of view, the sooner it were done, the better off we would be.

MR. SCHIERLING: Yes.

One final question is, this morning we discussed -- I am sorry, go ahead.

MR. LUI: My name is Larry Lui.

I have two questions concerning the fluid properties. I remember at the last meeting Tac Udaka talked about 6,000 feet per second of fluid unit weight of 65 pounds per cubic foot. This time I see the variants have been changed.

MR. UDAKA: The last time I was talking about water, and this is -- fluid. So, we went back and looked at the output.

MR. LUI: So, you were using --

MR. UDAKA: The right properties this time. The last time I was talking about the water. Water is 2.5.

MR. LUI: I would like to know on what basis you chose 7,000 feet per second.

MR. UDAKA: I have to go back to the office, I don't remember. It wouldn't make a big difference.

MR. LUI: Thank you.

MR. KUO: It wouldn't make a big difference in what?

MR. UDAKA: In the response.

MR. KUO: In the response.

MR. SCHIERLING: Also, it is my understanding that there is no need to distribute this output. In case you do have a need for it, let us know, the BNL FLUSH output.

If there are no further questions or comments, the meeting is adjourned. Thank you very much.

(Whereupon, at 2:45 p.m. the meeting in the above-entitled matter was adjourned.)

CERTIFICATE OF PROCEEDINGS

This is to certify that the attached proceedings before the NRC COMMISSION

In the matter of: DIABLO CANYON SEISMIC ANALYSIS

Date of Proceeding: July 6, 1983

Place of Proceeding: Bethesda, MD

were held as herein appears, and that this is the original transcript for the file of the Commission.

Mary C. Simons
Official Reporter - Typed

Mary C. Simons
Official Reporter - Signature

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Elizabeth Hansen
Official Reporter - Typed

Elizabeth Hansen
Official Reporter - Signature

MEETING WITH NRC/BNL

ON BURIED FUEL TANKS

July 6, 1983

Prepared by HLA/EET

Selection of Moments & Forces to Compute Combined Stresses

N.P.	ELM	MOMENT (FT- LB) H	n*	V	n	TOTAL	n	AXIAL FORCE (LB) H	n	V	n	TOTAL	n	SHEAR FORCE (LB) H	n	V	n	TOTAL	n
1		.4319	-10	1.361	+1	1.361	+1												
	1							9.321	+3	2.350	+3	1.167	+4	7.198	+0	6.942	+0	1.414	+1
2		1.610	+1	1.916	+0	1.802	+1												
	2							1.461	+4	1.871	+3	1.648	+4	1.599	+1	1.809	+0	1.780	+1
3		1.746	+1	3.153	+0	2.061	+1												
	3							2.258	+4	1.005	+3	2.359	+4	3.849	+0	3.002	+0	6.851	+0
4		1.012	+1	6.181	+0	1.630	+1												
	4							1.942	+4	2.318	+3	2.174	+4	6.212	+1	7.250	+0	6.937	+1
5		1.295	+2	1.128	+1	1.408	+2												
	5							1.452	+4	5.241	+3	1.976	+4	7.370	+1	3.557	+0	7.726	+1
6		3.546	+1	4.607	+0	4.007	+1												
	6							3.007	+4	5.722	+3	3.579	+4	4.864	+1	1.913	+1	6.777	+1
7		1.366	+2	3.521	+1	1.718	+2												
	7							4.000	+4	1.503	+3	4.150	+4	4.976	+1	1.570	+1	6.546	+1
8		3.301	+1	3.014	+0	3.602	+1												
	8							2.609	+4	2.775	+3	2.887	+4	1.476	+1	2.926	+1	4.402	+1
9		.2086	-10	6.289	+1	6.289	+1												

*n means 10^n

TABLE IX SUMMARY OF MAXIMUM MOMENT AND FORCES UNDER DYNAMIC LOADING (Z-Z SECTION)

Case	Static		Dynamic		Total		Combined outer fiber stress (ksi)
	Moment (Ft.-lb)	Ax. Force (lb)	Moment (Ft.-lb)	Ax. Force (lb)	Moment (Ft.-lb)	Ax. Force (lb)	
Node 6	318	6230	40	35790	358	42020	20.2
Node 7	0.46	5940	171.8	41500	172	47440	15.1

Study of Numerical Stability of FLUSH Analysis for $\nu > 0.49$

Case	ν	G (ksf)	V_s (ft/sec)	V_p (ft/sec)	γ_{fuel} (pcf)	β
1	0.499	134.75	315.7	7066	43.54	0.001
2	0.4999	13.5	100.0	7066	43.54	0.001
3	0.49999	1.35	31.6	7066	43.54	0.001

Note: It is important to keep K_p constant and vary G and V_s.

ELASTIC MATERIAL PROPERTIES

Elastic Modulus: $E = 2G\,(1+\nu)$

Lames Constant: $\lambda = \dfrac{2G\nu}{(1-2\nu)}$

Constraint Modulus: $E_p = \dfrac{E\,(1-\nu)}{(1+\nu)\,(1-2\nu)}$

Shear Wave Velocity: $V_s = \sqrt{\dfrac{G}{\rho}}$

P-Wave Velocity: $V_p = \sqrt{\dfrac{E_p}{\rho}}$

where G = Shear Modulus

ρ = Mass Density

ν = Poisson's Ratio

Sensitivity Study of Poisson's Ratio, $\nu > 0.49$

(Horizontal Excitation)

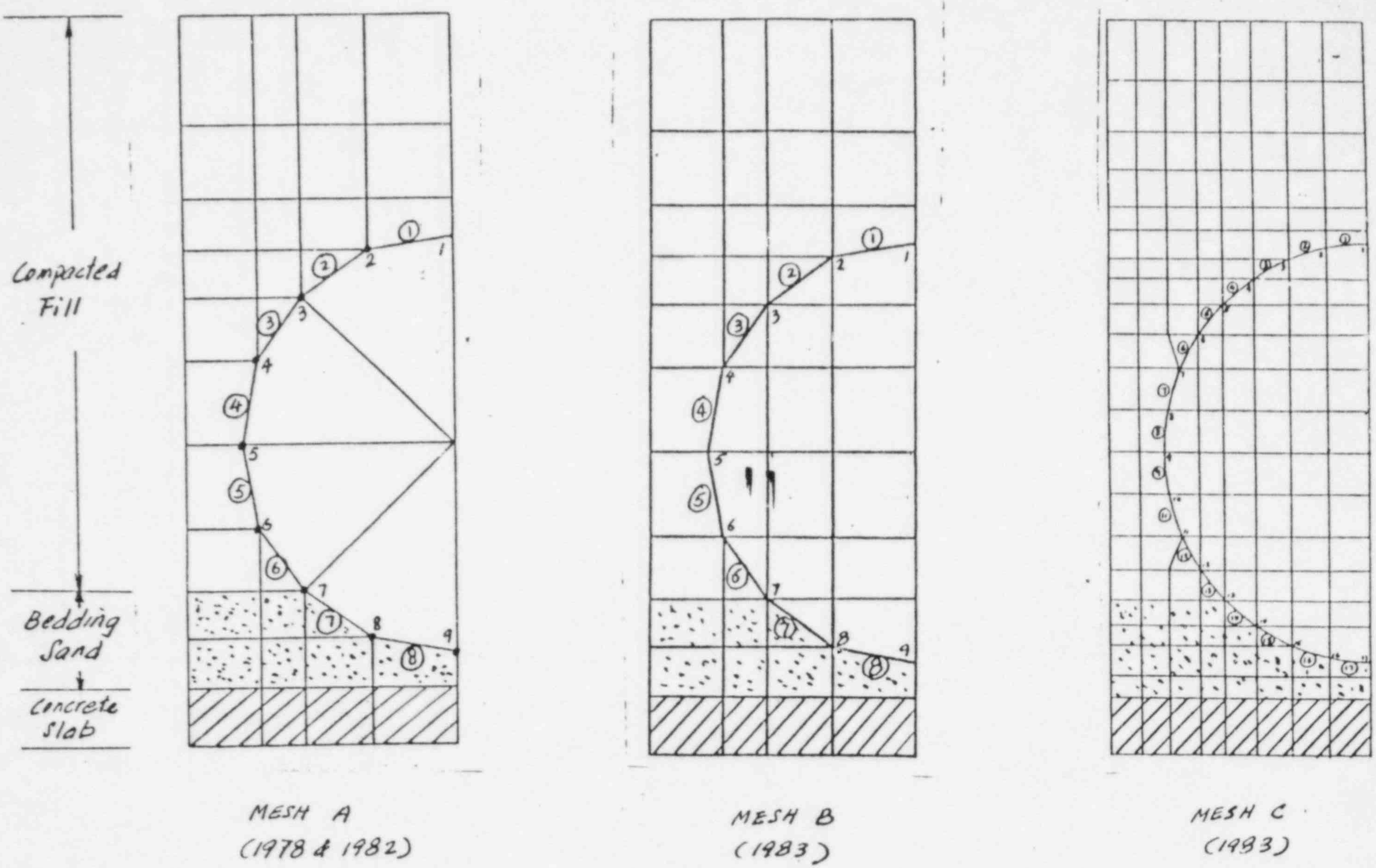
		Moment (ft-lb)			Axial Force (lb)		
N. P.	Ele.	$\nu = 0.499$	$\nu = 0.4999$	$\nu = 0.49999$	$\nu = 0.499$	$\nu = 0.4999$	$\nu = 0.49999$
1		0	0	0			
	①				9145	9221	9228
2		40.57	45.23	45.74			
	②				14300	14440	14460
3		24.85	35.55	36.73			
	③				21530	22120	22180
4		8.59	11.40	11.71			
	④				18140	18880	18960
5		329.3	353.6	356.2			
	⑤				-14200	-14310	-14320
6		-81.13	-83.93	-84.22			
	⑥				-28740	-29490	-29570
7		-337.7	-360.5	-363.0			
	⑦				-37910	-39150	-39280
8		-99.16	-95.36	-94.94			
	⑧				-24680	-25490	-25580
9		0	0	0			

Procedures used in Dynamic Finite Element Analysis

- Direct input of earthquake motion at the base of concrete slab without deconvolution.

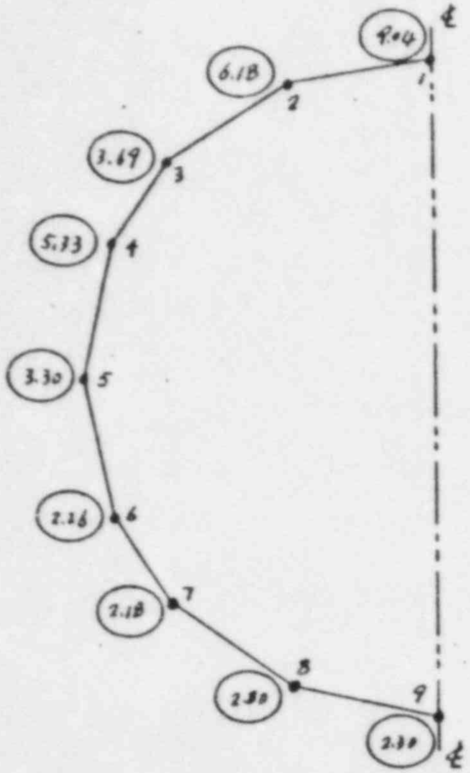
- Analyze horizontal excitation case with two iterations

- Analyze vertical excitation case using properties obtained from the horizontal excitation case without further iterations.

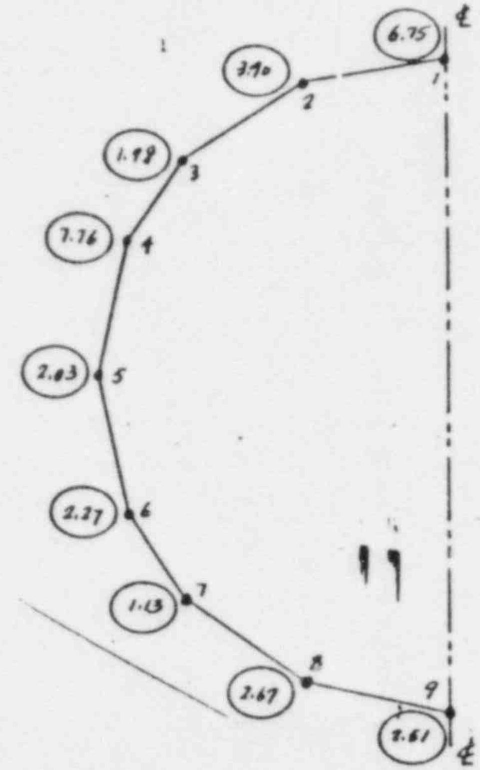


FINITE ELEMENT MODEL
CROSS SECTION Z-Z & YY

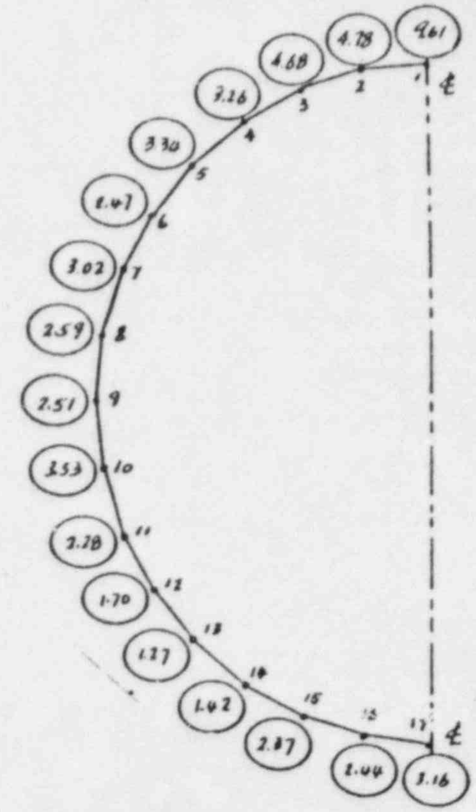
Factors of Safety Against Yielding at Outer Fiber



MESH "A" (1982)

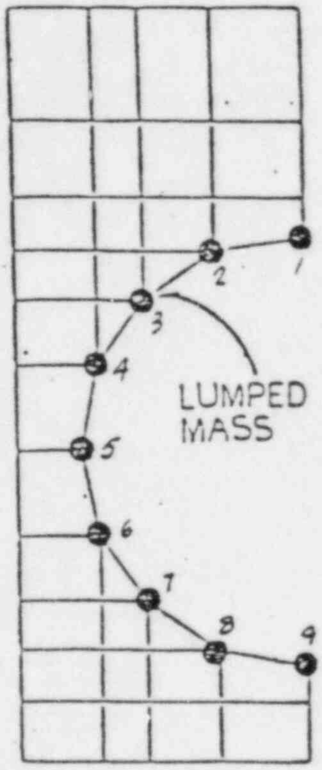


MESH "B" (1983)



MESH "C" (1983)

Comparison of Lumped-Mass Analyses



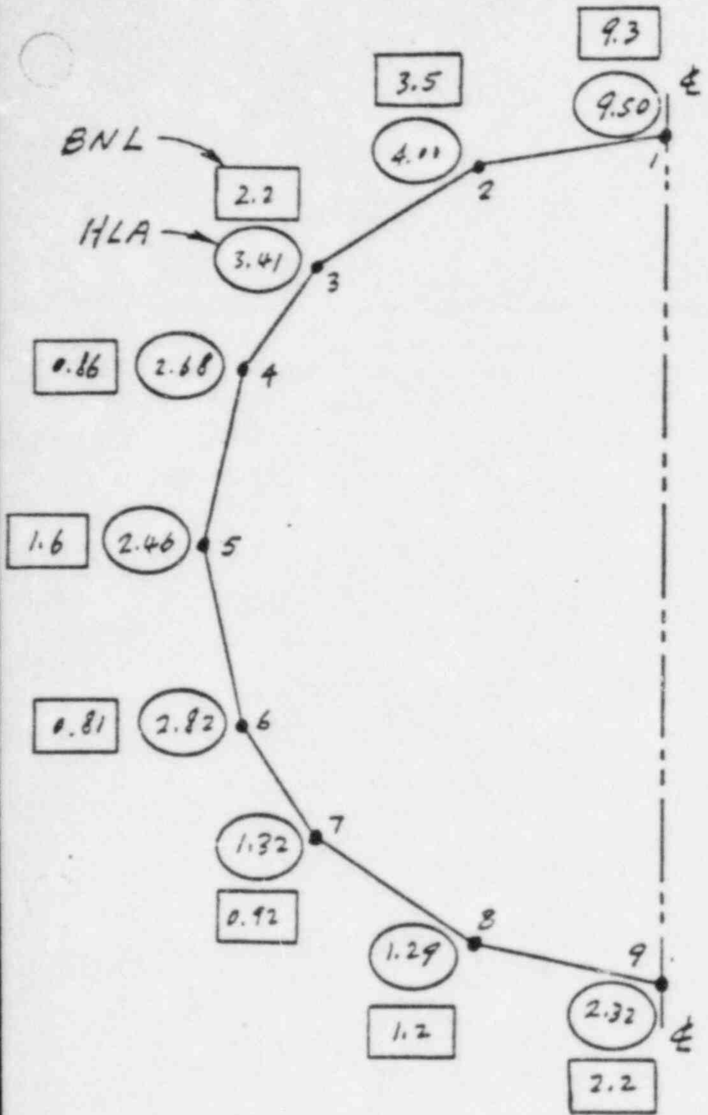
LUMPED MODEL

Element No.	Moment (Ft-lb)*	
	BNL	HLA
1	0	0
2	588	588
3	348	416
4	1133	1014
5	1038	1022
6	199	152
7	2285	2210
8	2356	2398
9	0	0

* Horizontal excitation only

BNL = 5 iterations

HLA = 2 iterations



	Factors of Safety	
N.P. No.	Inner Fiber	Outer Fiber
1	15.8	9.50
2	9.31	4.00
3	8.23	3.41
4	7.48	2.68
5	6.65	2.46
6	7.02	2.82
7	5.36	1.32
8	5.08	1.29
9	6.96	2.32

HLA : $\frac{f_a}{F_a} < 0.15$

$$\frac{1}{F.S.} = \frac{f_a}{F_a} + \frac{f_b}{F_b}$$

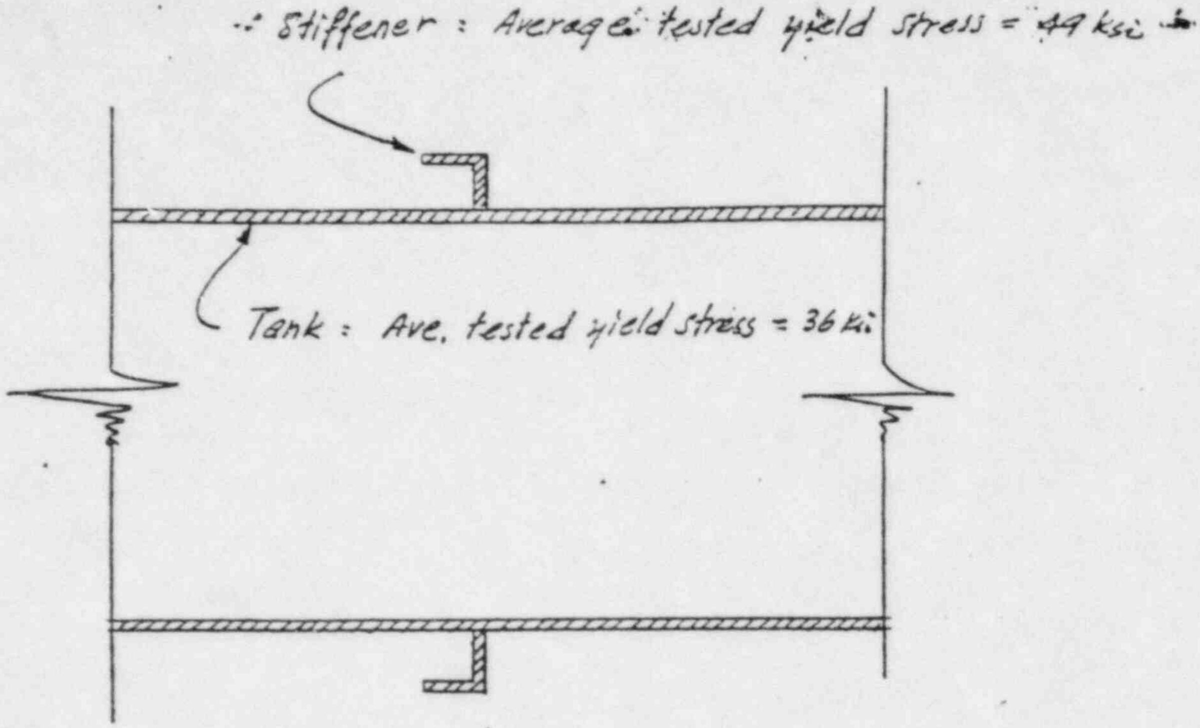
where f_a = computed axial stress

f_b = computed bending stress

F_a = 0.9 * 36 ksi (axial)

F_b = 0.9 * 49 ksi (outer bending)

F_b = 0.9 * 36 ksi (inner bending)



AISC Code (Section 1.6)

For $\frac{f_a}{F_a} > 0.15$:

$$\frac{f_a}{F_a} + \frac{C_m f_b}{\left(1 - \frac{f_a}{F'_e}\right) F_b} \leq 1.0 \qquad (1.6-1a)$$

$$\frac{f_a}{0.6 F_y} + \frac{f_b}{F_b} \leq 1.0 \qquad (1.6-1b)$$

For $\frac{f_a}{F_a} \leq 0.15$:

$$\frac{f_a}{F_a} + \frac{f_b}{F_b} \leq 1.0 \qquad (1.6-2)$$

COMPUTATIONS OF FACTORS OF SAFETY

1978 -- Stiffener: $F_y = 1.3 * 36 = 46.8$ ksi

Tank: $F_y = 46.8$ ksi

Factors of safety computed according to AISC specification.

1982 -- Re- analysis of 1978 case, ZZ - Section.
Factors of safety computed by direct proportion based on 1978 results without re-calculation using AISC specification.,

1983 -- BNL lumped mass analysis.
Factors of safety computed by direct proportion based on 1978 results without re-calculation using AISC specification.

1983 -- HLA analyses

	Static	Dynamic
Stiffener Tank	$F_y = 36$ ksi $F_y = 36$ ksi	$F_y = 49$ ksi $F_y = 36$ ksi
Design Values	$F_a = F_e = 0.6 F_y$ $F_b = 0.66 F_y$	$F_a = F_e = 0.9 F_y$ $F_b = 0.9 F_y$

Factors of safety computed according to AISC specification.

Diablo Canyon Proj. MESH "C"

Dynamic FLUSH Analysis — 16 BEAMS

NODE	ELM	MOMENT HORZ	MOMENT VERT	MOMENT TOTAL	AXIAL HORZ	AXIAL VERT	AXIAL TOTAL
1	1	0	.5892+2	.5892+2	.1644+4	.1999+4	.3643+4
2	2	.4326+3	-.3654+2	.4691+3	.3731+4	.1795+4	.5526+4
3	3	.5030+3	.3204+2	.5350+3	.4172+4	.1347+4	.5519+4
4	4	.7813+3	.9526+2	.8766+3	.5170+4	.7546+3	.5925+4
5	5	.6439+3	.9330+2	.7372+3	.5173+4	-.2053+3	.5378+4
6	6	.1024+4	.5751+2	.1082+4	.3134+4	-.9504+3	.4084 [illegible]
7	7	.7940+3	-.2386+2	.8179+3	.3793+4	-.1716+4	.5509+4
8	8	.1131+4	-.5013+2	.1181+4	.2775+4	-.2584+4	.5359+4
9	9	.1090+4	-.9591+2	.1186+4	-.3391+4	-.3158+4	.6549+4
10	10	-.2528+3	-.1354+3	.3882+3	-.9283+4	-.3007+4	.1229+5
11	11	.7346+3	-.1003+3	.8349+3	-.1035+5	-.2463+4	.1281+5
12	12	-.1215+4	-.1576+3	.1373+4	-.1253+5	-.2390+4	.1492+5
13	13	-.2031+4	-.1954+3	.2226+4	-.1237+5	-.1928+4	.1430+5
14	14	-.2156+4	-.4200+2	.2198+4	-.8398+4	-.1550+4	.9948+4
15	15	-.9061+3	.5611+2	.9622+3	-.8420+4	-.7372+3	.9157+4
16	16	-.6977+3	.2560+3	.9537+3	-.3283+4	-.4265+3	.3710+4
17		0	.3909+3	.3909+3			

Diablo Canyon Project

MESH "B"

NODAL PT NUMBER	ELEMENT NUMBER	MOMENT (FT-LB)	MOMENT OUTER FIBER (KSF)	MOMENT INNER FIBER (KSF)	AXIAL FORCE FORCE (LB)	AXIAL FORCE STRESS (KSF)
1		.1946 +3	308.01	47.39		
	1				.8805 +4	250.142
2		.654 +3	1035.15	159.25		
	2				.5378 +4	152.784
3		.149023 +4	2358.74	362.88		
	3				.23769 +4	67.526
4		.11669 +3	184.70	28.41		
	4				.8390 +4	238.352
5		.135973 +4	2151.06	330.93		
	5				.13574 +5	385.625
6		.65499 +3	1036.71	159.49		
	6				.16812 +5	477.614
7		.266334 +4	4215.51	648.54		
	7				.13548 +5	384.886
8		.72077 +3	1140.83	175.51		
	8				.131376 +5	373.227
9		.3913 +3	619.35	95.28		

TABLE FLUSH Analysis – Combined Horizontal & Vertical Excitations
(8 BEAM FINE MESH)

PREPARED BY ____________ DATE __________

REVIEWED BY ____________ DATE __________

Diablo Canyon Project

MESH "A"

NODAL PT NUMBER	ELEMENT NUMBER	MOMENT(FT-LB)	MOMENT OUTER FIBER	MOMENT INNER FIBER	AXIAL FORCE FORCE(LB)	AXIAL FORCE STRESS(KSF)
1		20	32	5		
	1				11700	334
2		57	90	14		
	2				16331	467
3		52	82	13		
	3				23004	657
4		24	38	6		
	4				21078	602
5		392	620	95		
	5				19359	553
6		92	146	22		
	6				35110	1003
7		463	733	113		
	7				40719	1163
8		107	169	26		
	8				28018	800
9		167	264	41		

TABLE 1982 ZZ-Section Horiz. + Vert. Excitation

PREPARED BY KSW DATE 7/2/83

REVIEWED BY ______ DATE ______

MEETING WITH NRC
ON BURIED FUEL TANKS

JULY 6, 1983

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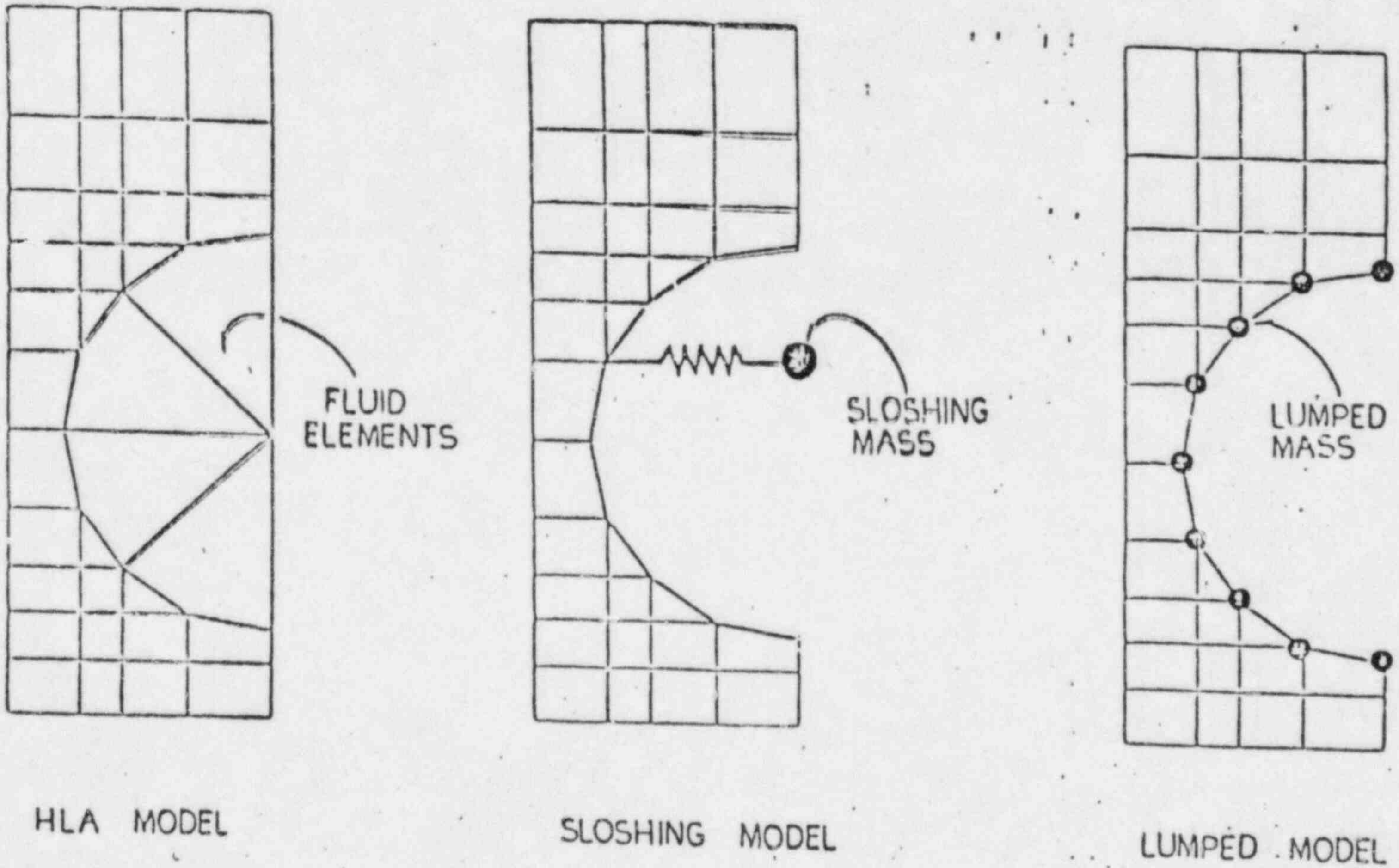
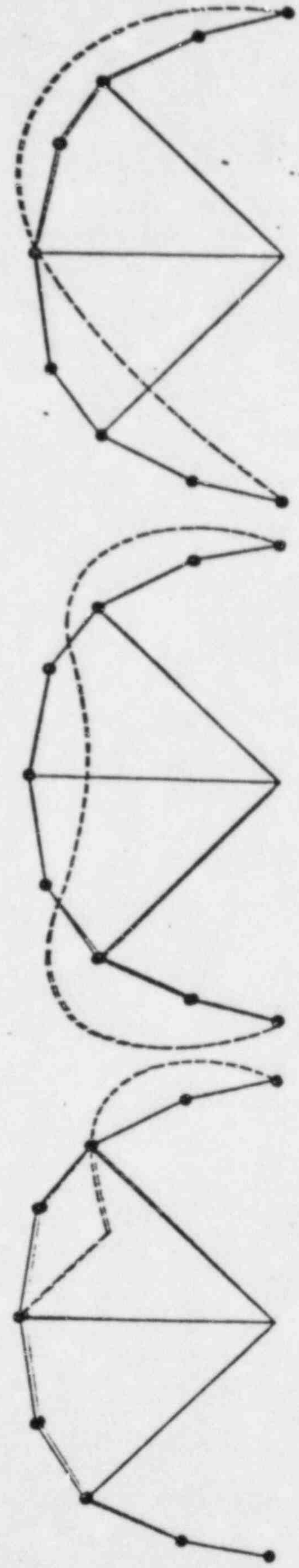
1


FLUID ELEMENTS
SLOSHING MASS
LUMPED MASS
HLA MODEL
SLOSHING MODEL
LUMPED MODEL



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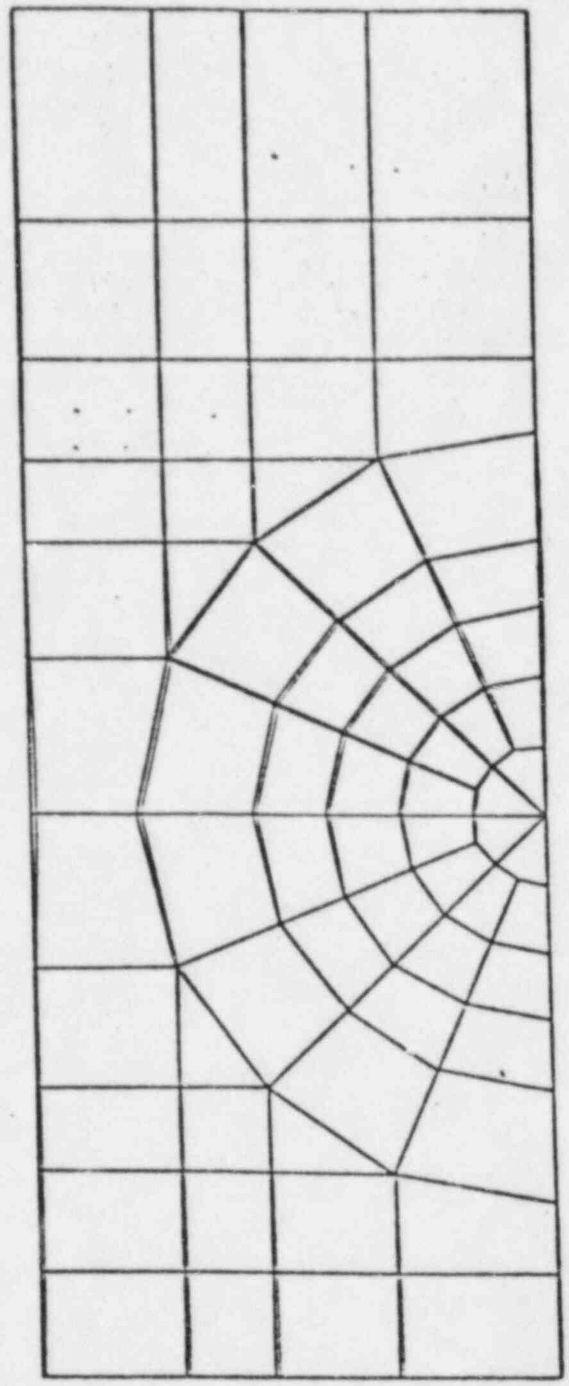
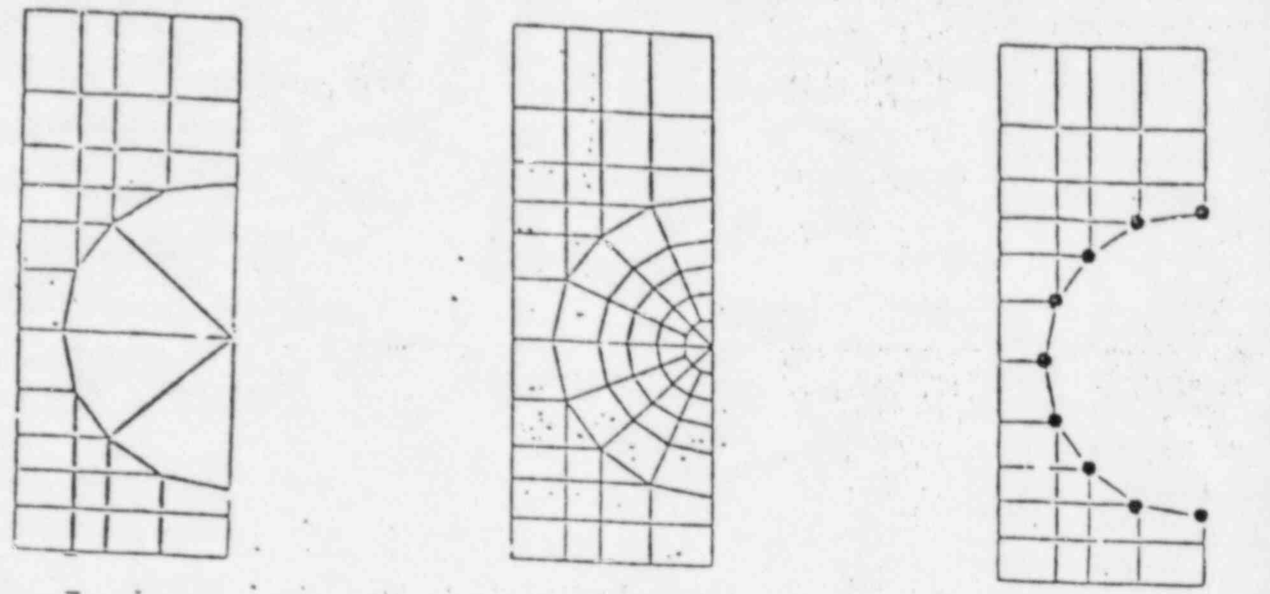
3



SSI MODEL WITH REFINED FLUID GRID.



HLA MODEL — REFINED MODEL — LUMPED MODEL

NODE	ELEMENT	HLA MODEL	REFINED MODEL		LUMPED MODEL
1		0	[illegible]	(0)	0
	1				
2		45	347	(863)	538
	2				
3		35	295	(1160)	348
	3				
4		11	788	(1589)	1133
	4				
5		354	629	(600)	1038
	5				
6		34	273	(1225)	199
	6				
7		361	1216	(1711)	2235
	7				
8		95	1669	(2232)	2356
	8				
9		0	0	(0)	0

Moments in ft #
(Horizontal analysis)

[( ) : Y-Y section soil properties]

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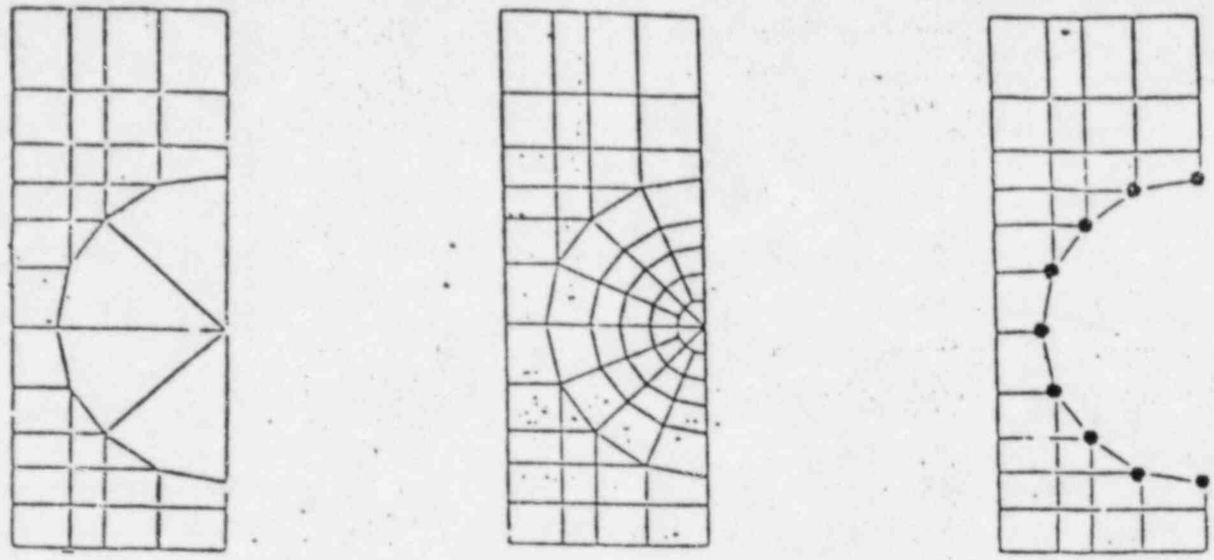

HLA MODEL   REFINED MODEL   LUMPED MODEL

NODE	ELEMENT	HLA MODEL	REFINED MODEL		LUMPED MODEL
1					
	1	20	155	(386)	263
	2	38	25	(142)	118
3					
	3	12	233	(232)	180
4					
	4	162	71	(470)	76
5					
	5	176	403	(799)	526
6					
	6	133	458	(259)	1036
7					
	7	127	222	(276)	70
8					
	8	42	746	(998)	1054
9					

Shear forces in #/ft
(Horizontal analysis)

( ): Y-Y section soil properties

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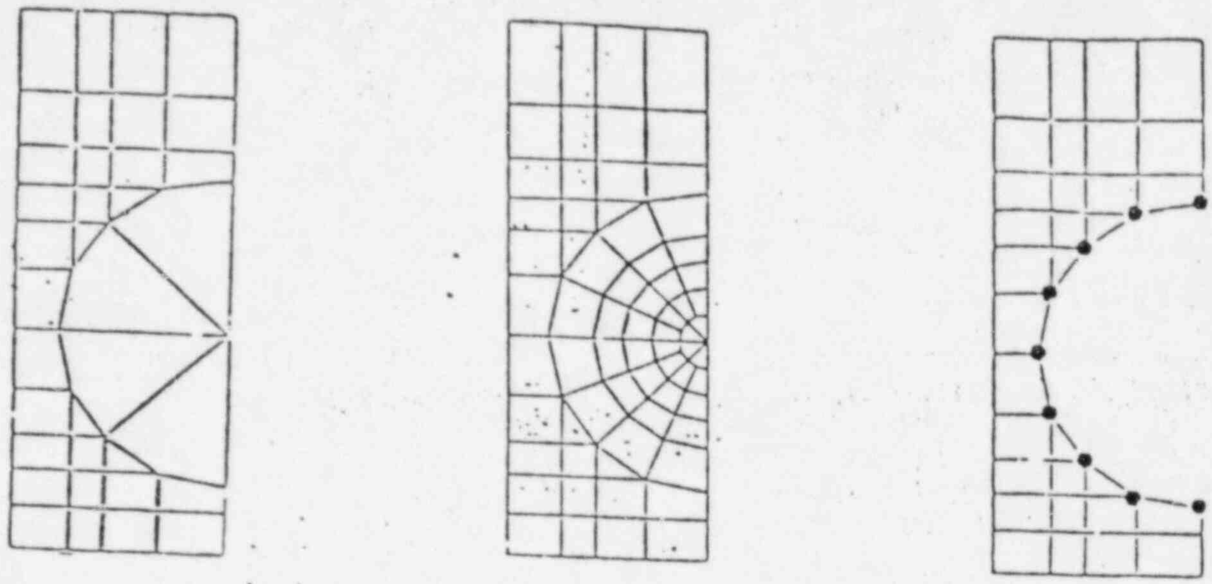

HLA MODEL　　　REFINED MODEL　　　LUMPED MODEL

NODE	ELEMENT	HLA MODEL	REFINED MODEL	REFINED MODEL ( )	LUMPED MODEL
1					
	1	9	3	(5)	2
2					
	2	14	9	(17)	5
3					
	3	22	11	(21)	5
4					
	4	19	6	(10)	1
5					
	5	14	4	(3)	5
6					
	6	29	19	(21)	11
7					
	7	39	24	(25)	12
8					
	8	25	9	(9)	4
9					

Axial forces in Kips
(Horizontal analysis)

( ) : Y-Y section soil properties