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UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

June 19, 2008

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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SUBCOMMITTEE ON ESBWR

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THURSDAY

JUNE 19, 2008

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Dr. Michael Corradini, Chairman, presiding.

COMMITTEE MEMBERS:

MICHAEL CORRADINI, Chairman

JOHN D. SIEBER

CHARLES H. BROWN

DENNIS C. BLEY

J. SAM ARMIJO

WILLIAM J. SHACK

OTTO L. MAYNARD

JOHN W. STETKAR

CONSULTANTS TO THE ACRS PRESENT:

GRAHAM B. WALLIS

THOMAS S. KRESS

NRC STAFF PRESENT:

AMY CUBBAGE

CHANDU PATEL

MOHAMMED SHAMS

JIM XU

DAVID JENG

SAMIR CHAKRABARTI

HAROLD VANDER MOLEN

ALSO PRESENT:

JEFF WAAL

CLEMENT RAJENDRA

AI-SHEN LIU

RICH MORANTE

JOSEPH BRAVERMAN

T-A-B-L-E O-F C-O-N-T-E-N-T-S

P-R-O-C-E-E-D-I-N-G-S

8:29 a,m.

CHAIRMAN CORRADINI: Okay. Let's begin the meeting.

I am not going to go through the complete and total welcome. I'll just welcome already back from yesterday. And I'll simply remind everybody the transcript of the meeting will be kept, it will be made available as stated in the *Federal Register* notice.

And it's requested that speakers first identify themselves and speak with sufficient clarity and volume so they can be readily heard.

Mr. Waal, you're up first to talk to us about Sections 3.7 and 3.8 Okay.

MR. WAAL: Thank you. All right.

Good morning.

My name is Jeffrey Waal. I'm with the Regulatory Affairs Staff of GEH in Wilmington, North Carolina, ESBWR Project. And we're here today to discuss Sections 3.7 and 3.8 of the ESBWR DCD.

With me is Mr. Ai-Shen Liu and Mr. Clement Rajendra, who will do the presentation on this section.

MR. LIU: Yes, I will do the presentation.

MR. WAAL: Okay. Okay. Good. I'm glad somebody will.

MR. LIU: Clement had his share yesterday.

So my name is Ai-Shen Liu. I'm with GE Hitachi, ESBWR Project. And physically and I'm still stationed at San Jose, California.

It is my honor to be here today to present to you an overview and a summary of Sections 3.7 and 3.8 of ESBWR standard plan design.

Chapter 3 overall describes the design of structures, components, equipment and the systems.

Sections 3 of which I am going to discuss to you describes the seismic analysis methods for designing structures, systems, components to withstand the effects of Safe Shutdown Earthquake (SSE).

So in our design the so called Certified Seismic Design Response Spectra (CSDRS) is an envelope of Reg. Guide 1.60 response factor entered to .3G and North Anna early site permit site-specific spectra. It's a hybrid curve, as you can see the next slide.

In addition to the SSE, we also considered the effects of the reactor vibrations caused by the suppression pool hydrodynamic loads. This is, you know, although we still maintained the pressure suppression concept for our design, same as other

EBWRS.

MEMBER SIEBER: These are the dynamic loads due to the discharge thing in the suppression pool?

MR. LIU: Yes, sir.

MEMBER SIEBER: Okay.

MR. LIU: In addition to seismic Category 1 structures we have another category which is a seismic Category II.

MR. WALLIS: I'm sorry. The second bullet refers to something happened and it doesn't refer to a seismic interaction with the suppression pool. It refers to the suppression pool.

MR. LIU: Subject to the loading interactive from the discharge.

MR. WALLIS: Well, I notice you've got some nice -- as far as I can tell on model of the structures. But you model the water as well when you shake the building?

MR. LIU: The water weight are included in the model. Yes, sir.

MR. WALLIS: Yes. Okay.

MR. LIU: Right.

MR. WALLIS: Just the weight

MEMBER SIEBER: But not the slosh?

MR. WALLIS: Not the sloshing mechanism or--

MR. LIU: That's a separate calculation dynamic response.

MR. WALLIS: It's a separate calculation. Okay. So you'll get to that, presumably.

MR. LIU: Yes, if you -- no. I can discuss in more detail later on.

MEMBER SHACK: Let me just ask Amy a question. We had the discussion on Chapter 19.

MS. CUBBAGE: Yes.

MEMBER SHACK: So we have this spectra for this analysis and you're still discussing with GEH whether they can use a site specific analysis for the seismic margin calculations? Is that the discussion we were having in Chapter 19?

MS. CUBBAGE: Right. That's exactly right.

MEMBER SHACK: Has that been settled?

MS. CUBBAGE: That has not been settled. No.

CHAIRMAN CORRADINI: So what are they using for Chapter 19? You say it again, because I'll say it wrong.

MS. CUBBAGE: This way they -- as far as

I know, they've -- and you can correct me if I'm wrong. As far as I know they've designed -- they've done the seismic margins analysis with the certified spectra. And then at the post-construction phase they're going to verify to the site specific and try to reconcile any differences there.

CHAIRMAN CORRADINI: Can I say it back to you so I get it right?

So right now what we're going to see is an analysis with a double --

MS. CUBBAGE: Yes.

CHAIRMAN CORRADINI: So then the discussion when we were together on June 3rd implied that they're going to go back to a different spectra, a single -- thank you -- but for what purpose there? That's where I'm a bit confused. I'm sorry.

MS. CUBBAGE: I'd like GE to explain what their plan is.

MR. LIU: If I may, yes. Let me try to clarify, if I may.

In the context of seismic margin in Chapter 19 we were trying to taking into account a more realistic ground motion. In view of the double-hump spectra we have considered in the design, we recognize this double-hemp is very conservative. So as a result the design has, you know, a lot of margin. To do it in a realistic way in the context of PRA we think is rational to take into account more realistic ground motion input.

CHAIRMAN CORRADINI: So you get rid of a hump?

MR. LIU: In a way, yes sir.

CHAIRMAN CORRADINI: Okay.

MR. LIU: You know, and that realistic spectrum we'll label it as a so-called a performance based.

MEMBER SHACK: Well, no. That's a little different, too. Because as I believe in the early sites permit for North Anna, they used the 1.165 way to come up with the seismic hazard.

MR. LIU: I understand.

MEMBER SHACK: But now you're going to go to 1.208.

MR. LIU: Not exactly. Not exactly.

MEMBER SHACK: Oh, see. Okay.

MR. LIU: You know, we're trying to utilize the current knowledge of ground motion which has -- you know, other COL applicants, you know, are addressing for their specific sites. But for the purpose of standard plant design we don't have the luxury of that specific information. Because our intent is to address a wide range of sites.

CHAIRMAN CORRADINI: So can I ask a less educated question on this? So just to make sure. So what we're going to see today is this stylized spectrum which adds the North Anna component? But for Chapter 19 you've taken away the North Anna component and have a different stylized curve? Pardon my simplified --

MR. LIU: Right. You know, we did not take away the North Anna contribution at all.

CHAIRMAN CORRADINI: Or it's not there anymore.

MEMBER SHACK: It is. It is. It's all North Anna.

CHAIRMAN CORRADINI: No. The second part is going to changed for Chapter 19.

MR. LIU: May I?

CHAIRMAN CORRADINI: Yes, I'm sorry.

MR. LIU: Would you please clarify what you mean by the second part?

CHAIRMAN CORRADINI: Well, can you go to slide 6?

MEMBER SIEBER: That's a composite of two different --

CHAIRMAN CORRADINI: That's the composite of two different spectra, right?

MR. LIU: Right.

CHAIRMAN CORRADINI: Okay. And that's being used today in our discussion?

MR. LIU: Yes, sir.

CHAIRMAN CORRADINI: Okay. But as you explained it, and I don't mean to go back but I'm just trying to get it all straight, in Chapter 19 this spectra was or was not used? Was not?

MR. LIU: Was used together with another curve for the purpose to calculate the fact of safeties associated with each of the important parameters relative to the response.

And is there anything I can draw on? Anyway. Let me try to describe it.

CHAIRMAN CORRADINI: Okay. Why don't you try words.

MR. LIU: Okay. All right.

CHAIRMAN CORRADINI: And I apologize. It's my fault for --

MR. LIU: That's okay. You know, let me try to describe it in words.

So this is a design spectrum we call CSDRS. Okay. For size margin evaluation we have another curve, which basically you know try to imagine a curve which is, you know, smaller than this curve up to about 9 Hertz.

CHAIRMAN CORRADINI: Okay.

MR. LIU: Okay?

PARTICIPANT: I mean, if I try to explain it, it would be --

MEMBER MAYNARD: You've got to be at a microphone.

MEMBER SHACK: It's the North Anna curve.

MR. LIU: No. That portion, no frequency is not North Anna curve.

MEMBER SHACK: Right. The low frequency is the one 1.60 contribution.

MR. LIU: For seismology is not in the 1.60 either.

MEMBER SHACK: Right.

MR. LIU: Yes. It's a curve. Basically is the curve is unlocking curve all soil sites among the 28 sites. But using this, no. This ground motion calculations methodology. Okay. So that's the envelop of all soil site among 128 except local.

CHAIRMAN CORRADINI: Okay.

MR. LIU: So that's the curve. You know, we tend to cover the soil sites up to roughly 9 Hertz.

Okay. From that Hertz and up we maintain the North Anna curve. Same magnitude. That's the design that the site include second peak.

MEMBER SIEBER: And that came from all the soil sites. That makes sense.

CHAIRMAN CORRADINI: And that's what you do for the equipment for the standard plants?

MR. LIU: Yes, sir.

CHAIRMAN CORRADINI: Okay. But in Chapter 19 you remove the black line at the lower frequencies and replace it with something close to the red line that is up there?

MR. LIU: Right. But just for the purpose to show the conservatisms in the design which is based on that design curve.

CHAIRMAN CORRADINI: Okay. But just to ground it off in my understanding, but that conservatism is not generic anymore because you took away your enveloping --

MEMBER SIEBER: Right.

MR. LIU: No, it's generic because that lower red curve is enveloping of all soil sites.

CHAIRMAN CORRADINI: Then what's the black curve? I thought you said that's what the black curve was. I apologize.

MEMBER MAYNARD: You're saying that the Reg. Guide curve is overly conservative.

MR. LIU: Yes, you know relative what we know right now for the soil sites.

CHAIRMAN CORRADINI: Okay. Good. That's enough. At least I understand that. So the Reg. Guide curve is conservative relative to your enveloping of soil sites. And then we'll let you guys fight it out with staff. I just wanted to make sure I understood it.

MR. LIU: Right.

CHAIRMAN CORRADINI: I get it.

MS. CUBBAGE: Right. And the issue that staff has is the COL item has the certified design pairing -- let's see. The COL holder shall compare the as-built SSE HCLF to those assumed in the ESBWR seismic margin analysis. Deviation from the HCLF values or other assumptions shall be analyzed to determine if new vulnerabilities have been introduced.

So they're comparing to site-specific spectra at that time, the as-built.

MEMBER SHACK: But you're agreeing with that then?

MS. CUBBAGE: No.

MEMBER SHACK: No.

MS. CUBBAGE: This statement can be interpreted as allowing the COL holder to analyze the as-built HCLFs with respect to the site spectra. We want it against the certified spectra.

CHAIRMAN CORRADINI: That I get. But aren't you putting -- I mean, I'm mischaracticizing so you can recharacterize. Aren't you putting the COL holders at risk by essentially taking it from the black line to the red line and making them have to reanalyze at the black line? Am I missing something here?

MR. LIU: No. I don't think so. Because we're not really changing the design. The design is still based on the black line. The design is still based on the black line. Just when it comes to identification of the margins. The margins in my mind only makes sense, you know, that they are related to a known quantity. Then the known quantity in this sense is site-specific.

CHAIRMAN CORRADINI: Okay. All right.

MR. LIU: So in our view this stage in standard plants -- you know, this is already --

CHAIRMAN CORRADINI: Okay. I see what you're saying. Let's leave it there. I get it.

MEMBER SIEBER: But still the PRA will

have a site specific site -- what are these to somebody else will have their terms and chapter --

MR. LIU: Yes. The red curve, the site-specific curve already in COLA FSAR in Chapter 2. And COLA applicant obligated to demonstrate that the red curve is below the black curves.

MEMBER SIEBER: With your analysis?

MR. LIU: Yes.

MEMBER SIEBER: Okay.

CHAIRMAN CORRADINI: Thank you. Go ahead. I'm sorry. We'll go back to 3?

MR. LIU: Okay. Category II. Okay. In addition to Category I structure, you know we have another category or Category II intent is to address those components and structure which are not safety related. They have a potential for interaction with Category I. So we put those things and call them as Category II. So we commit our design of Category II to the same method of analysis and design as Category I.

MEMBER SIEBER: That's different is the QA?

MR. LIU: Yes, sir.

Okay. In Section 3.8 we describe the loads, load combination acceptance criteria for designing seismic Category I structures.

In ESBWR standard plan design the Category I structures include the concrete containment and internal structures, the reactor building and the fuel building, you know. In our design the containment structures is enclosed by the reactor building and integrated with the reactor building. And within the control building we also firewater service complex structure. The roles at the Category I structure in our design.

As I briefly mentioned to you --

MEMBER BROWN: Can I -- not really understand. The equipment would be designed to the black curve that they have to put in the plant regardless of the PRA and the foundations. But also the hardware and everything else that goes in has to consider the seismic response of the black curve?

CHAIRMAN CORRADINI: Right. The complete black curve.

MEMBER BROWN: Okay. Okay.

CHAIRMAN CORRADINI: Right.

MEMBER BROWN: So the only thing that alternate curve could be -- I'm sorry I'm so slow it just took a minute to integrate this, is just PRA type stuff --

MS. CUBBAGE: I think the staff is

concerned that there could be some loss of standardization. Because they could justify because of the --

MEMBER BROWN: Reducing the design?

MS. CUBBAGE: Possibly in some areas just from the perspective of if they could pick up or use the additional margin that's there. I think that's the concern.

CHAIRMAN CORRADINI: Would it change the way you classify equipment for later on? I guess what I'm trying to understand is the effect of showing larger margin because I went from black to red. So -- or is actually going to change the way maintenance, inspection and equipment usage --

MS. CUBBAGE: It's a question of whether they're going to take advantage of that extra margin and change the design in the site-specific area.

MEMBER BROWN: Or not require the design to be as robust?

MS. CUBBAGE: Now, it won't impact Chapter 3, as I understand. Chapter 3 is what it is. But from a margin --

MEMBER BROWN: This can only effect equipment that isn't categorized here as I, II or the RTNSS stuff. If you sound something else in the PRA, you could maybe shave the margin here. But you're stuck here.

MS. CUBBAGE: Maybe go to the other microphone.

MR. SHAMS: Mohammed Shams. I'm with the staff.

I think that Dr. Corradini asked the right question: What are you qualifying the equipment for, the standing equipment? Is it the black, the red or is it the site-specific? Because the site-specific is a whole other spectrum that -- all the way down there.

For instance, if we look at Grand Gulf, for instance, that would be like way down, four or five times less than what we're looking at.

So my question to GE would be what are you qualifying the equipment for?

MR. LIU: But the equipment is qualified to the black curve.

MR. SHAMS: Then only the margin calculation will be based on the site-specific. Right. So that means he's just showing the conservatism relative to the site-specific curve. However, the design is going to be the red or be the black, they're both high anyway. We can sort this out which one is the appropriate one.

CHAIRMAN CORRADINI: Okay. That helps. Thank you. Thank you very much. I appreciate it.

Does that help?

MEMBER BROWN: Yes. I apologize. I just didn't quite get all --

CHAIRMAN CORRADINI: Don't apologize. We're still talking over here about it. He's explaining to me quietly.

Go ahead.

MR. LIU: Okay. Section 3.7.1 is a section describes seismic design parameters. As I mentioned briefly to you, our design spectra so called a CSDRS follows Reg. Guide 1.60 and the North Anna at high frequencies. The reason we choose North Anna is because, you know, it is representative of most severe rock site in the Eastern US.

We also recognize that although we take this conservative in the design, is really it's not realistic because to our knowledge none of the recording seismic events, you know simultaneously contains low frequency and excitation and high frequency excitation. We recognize that, you know, by taking double-hump, you know, we are really conservative.

MEMBER ARMIJO: So this double-hump is

physically unrealistic?

MR. LIU: Yes, sir.

MEMBER ARMIJO: Even let's say this Japan earthquake where the Kashiwazaki site's at, was there anything close to this --

MR. LIU: No, sir. No.

MEMBER ARMIJO: So it's conservative even with respect to what we have from there?

MR. LIU: Yes, sir.

MEMBER SHACK: Well, you've got to remember this spectrum is anchored at .3g.

MEMBER ARMIJO: Oh.

MEMBER SHACK: So the Japanese spectra may not have two humps --

MR. LIU: But it would have more gs.

MEMBER SHACK: More gs.

MEMBER ARMIJO: Yes, I understand.

MR. LIU: Correct me if I may, you know, our design's really anchored to .5g. Peak acceleration is .5g. Because that high frequency, yes, is .5 although the portion of the low frequency spectra of Reg. Guide 1.60 is --

MEMBER ARMIJO: Okay. Yes. This discussion came up before. Okay. Now the 1.60 is anchored to .3. But you're telling me it's really .5?

MR. LIU: For the composite curve.

CHAIRMAN CORRADINI: Can we go to the figure if you're going to explain that.

MR. LIU: All right.

CHAIRMAN CORRADINI: Tell me what you mean by anchored at what frequency, please?

MR. LIU: You have to have that actuation value at 100 Hertz. Okay. That's .5g.

MEMBER ARMIJO: Okay. There it's .5g. You have to put numbers on these.

MR. LIU: That's .5g.

MEMBER SHACK: Okay. So you're saying the high frequency is anchored at the .5g?

MEMBER BLEY: What's it mean to anchor?

CHAIRMAN CORRADINI: It strikes me it means normalizing by some sort of shape function.

MR. LIU: That's .5.

MEMBER SIEBER: You shape it on top of the acceleration and you make an assumption as to everything looks all right.

MR. LIU: Can everybody hear that?

MS. CUBBAGE: Yes.

MEMBER BROWN: No. I took it as the point at 100 Hertz.

MR. LIU: That's the .5. That's what we

call a peak acceleration of the SSE. What I meant by .3g SSE basically is this is .3g Reg. Guide 1.60 what I meant. So this curve up to 9 Hertz follows Reg. Guide 1.60.

If I continue this curve at higher frequency, this curve drops down. Then the acceleration at 100 Hertz will be .3.

CHAIRMAN CORRADINI: Okay.

MR. LIU: That's what I mean by .3g Reg. Guide 1.60. Because in our design we did not use that lower amplitude of .3g 1.60.

CHAIRMAN CORRADINI: Got it.

MEMBER SHACK: But I mean for a soil site you'd really be a .3g. Because the soil site looks more like the 1.60?

MR. LIU: Yes, that's a reality. Yes. You know, for a given site the curve may look like this.

MEMBER SIEBER: You mean you'd have even more margin?

MR. LIU: No, we designed to this.

MEMBER SHACK: Motion frequency.

MR. LIU: We designed to the black curve.

CHAIRMAN CORRADINI: So just to complete the circuit back to Dr. Armijo's question, if we take a real event such as what occurred in Japan, your answer to that is that spectrum is below both of these? That was what he was asking.

MEMBER SHACK: For that site in Japan, would that spectrum be below this black curve?

MR. LIU: As in a spectra shift wise, yes. But I couldn't answer you on the acceleration level.

MEMBER SHACK: The actual acceleration, yes.

MR. LIU: But our design is .5. As in that Kashiwazaki site, as in the record motion is pretty high.

MEMBER ARMIJO: But the design of the ABWR was basically .3g at some frequency. I don't know what it was. But it was --

MR. LIU: The ABWR's designed purely to Reg. Guide 1.60 .3g.

MEMBER SHACK: Yes. So this is a .3g if you think of it as comparing with the ABWR? .3g at 100--

CHAIRMAN CORRADINI: So it's a .3g reactor sitting on a site with a higher acceleration?

MR. LIU: In the context of the Japan earthquake?

CHAIRMAN CORRADINI: That's what he was asking.

MR. LIU: Oh. A little bit -- you know, in Japan they designed to Japan criteria. They did not follow Reg. Guide 1.60 at all.

MEMBER ARMIJO: I thought they stuck with the .3g, though. You know more about it than I do. But I'm just trying to see how well your design methods actually protected that plant which went through a severe earthquake. That's really what I was trying to get at. You know, would you have margin against that kind of an earthquake using --

MR. LIU: Oh, yes. I think the margin has been clearly demonstrated by this recent Japan earthquake. Also, although the recorded motion was so much higher than what has been designed to, but really no major damage has occurred to the plant.

MEMBER ARMIJO: Right.

MR. LIU: So that's a very, very good demonstration of adequacy of the design.

MEMBER ARMIJO: Some day I'd like to see a curve drawn on that --those curves that say this is what really happened in Japan using these methods and the plant was fine. So, I don't know if you guys can do that. But I understand what you're doing.

MR. LIU: Yes. We don't have that information.

CHAIRMAN CORRADINI: Thank you very much.

MR. LIU: Now given we have this double-hump, that curve. So for the purpose of analysis we need to generate the artificial time histories. So the time history were generated such that they meet the NUREG, you know, criteria as the latest requirements. Because this curve we'll have to discuss quite extensively. This is the horizontal components of the earthquake and this is a vertical component. Basically follow the same approach as we did for the horizontal.

This particular one is, you know, for the frequencies up to 10 Hertz which follow Reg. Guide 1.60. Above 10 Hertz.

MR. WALLIS: No. No. This is a frequency. You say the time has -- you have to say how long this goes on for.

MR. LIU: Oh.

MR. WALLIS: That's where your NUREG --

MR. LIU: Yes. Our time history duration is 40 seconds.

MR. WALLIS: Where is that?

MR. LIU: You know, the reason for 40 seconds because we found out in order to match lower frequency -- to match the spectra at the lower frequencies, we need to have a longer duration.

MR. WALLIS: But how long is the typical earthquake?

MR. LIU: Twenty seconds, I would say.

MR. WALLIS: Twenty seconds at point .01 Hertz --

MEMBER ARMIJO: It feels longer. If you're there, it feels longer.

MR. WALLIS: But .01 Hertz is kind of meaningless, isn't it?

MEMBER SIEBER: What you're trying to do is get everything to wind up.

MR. LIU: .01 is because, you know, the curve methodology for developing the site-specific spectra start at .6 Hertz.

MR. WALLIS: Okay. Well, you have to put in time somehow.

MR. LIU: Yes, sir.

MR. WALLIS: Thank you.

MR. LIU: Okay. All right. So this slide describe Section 3.7.2 which is for the system analysis. So it applies to the building structures. As I mentioned earlier, that we have a category -- the Category I structure in our design consists of reactor building, fuel building, control building and the firewater service complex.

The reactor building and the fuel building is integrated structure sitting on a common basement.

For the response calculation of the reactor building, we also include the reactor pressure vessel, although the vessel itself is not a structural component. We just want to get the proper interaction of the vessel and the supporting structure.

MEMBER SHACK: It's a reasonable mass.

MR. LIU: Right. So for the response calculation, the mathematic model we use is a lumped mass stick models. We also -- this model was confirmed to be adequate by comparison with the finite element model.

MEMBER BLEY: I'm sorry. With the what?

MR. LIU: For the calculation for the design basis response we used a stick model, the conventional stick model for seismic. Okay? But in order to convince ourself to demonstrate, the stick model is adequate. Then we compare it with the finite element model, which is more, you know, refined.

CHAIRMAN CORRADINI: So can I ask a question there, if I may? Just to go back to Professor Wallis' question. So with water, large bodies of water what check calculation did you do to make you feel good about the fact that a point mass with a damper was a good model for a big pool of water?

MR. LIU: Okay. Let me address this. For the purpose of prediction of a global response of the structure --

CHAIRMAN CORRADINI: Right.

MR. LIU: Okay. We lumped the water to the structure. This meaning is to maximize the mass effect. Okay. We did not take advantage of the sloshing and the rigid mass, you know, because --

MEMBER ARMIJO: You treat the water is a solid then?

MR. LIU: We treat the water as solid.

MR. WALLIS: I can understand that when the wall is pushing the water. But when the wall is moving away from the water, does it drag the water with it?

MR. LIU: That will be a separate calculation in our design. Like I indicated to you, that to do the global response calculation --

MR. WALLIS: You got any cavitation in the water?

MR. LIU: Cavitation?

MR. WALLIS: Like the pulling the wall

away from the water?

MR. LIU: You'll have a negative pressure from the sloshing calculations.

MR. WALLIS: Doesn't it make bubbles or displacement? Does it stick to the wall or does it separate from the wall and leave a space?

MR. LIU: Well, I don't think there's any separation.

MR. WALLIS: Well, I don't know. You have to calculate it, presumably.

MR. LIU: Well, no. The only potential separation is the water mass nearest a free surface, which is, you know, they occur in the form of sloshing. Because, you know, the reason I have a flat surface when seismic occurs, you know, the wave -- the certain portion of the pool surface depress, another portion raise up. But for the portion which is below the free surface, they basically move together as a structure.

MR. WALLIS: But if you subject the water to a negative pressure, it will tend to separate from the wall. It will tend to evaporate.

MR. LIU: Unless it's a dynamic event. But on top of that I have this type of static.

MR. WALLIS: And it'll slosh when it comes back again.

I just don't know this, I'm just asking you about it. It seems to me you have to consider it somehow.

MR. LIU: Yes. Well, we consider in the design calculations. We follow the standard --

MR. WALLIS: So when we get to the design, I can ask you the question again?

MR. LIU: Sure.

MR. WALLIS: In two years' time, perhaps.

MR. LIU: In our design, as I mentioned, we consider this water effect.

MR. WALLIS: You do?

MR. LIU: Yes.

MR. WALLIS: And you know how to do it?

MR. LIU: Well, the math is not really that sophisticated. You know, it has been developed for a long, long time.

CHAIRMAN CORRADINI: So I thought you were going to answer it differently. I thought you were going to answer in saying that you would look at the local conditions that you got a large and a negative pressure that might cause cavitation, you'd start worrying and checking. But otherwise, you weren't worried.

The finite element model is you treat the water element as if it were something will generate a negative pressure --

MR. WALLIS: You calculate an interfacial pressure.

CHAIRMAN CORRADINI: Right. But you can check that. Then you start worrying about the behavior where you see them.

MR. WALLIS: Especially if it starts doing this. Get one of Dick Leahy's bubbles going into the wall.

CHAIRMAN CORRADINI: I'm sorry. Go ahead. Go ahead.

MR. LIU: Okay. Let's see. We did a seismic soil-structure interaction. And other details we documented in Appendix 3A.

The next slide shows, you know, an overview what SSI analysis cases we considered.

In our design we basically, you know, considered two sets of sites, which are uniform sites and the layer sites. Okay.

A uniform site, basically you assume the soil is uniform, have space. In that sort of calculation, you know, we did not include environmental effects, which is a conservative approach.

For the layered sites, which you know the condition illustrated in that figure in this slide, basically we vary the stiffness, you know, into different three layers. The top layer stiffness we, you know, assigned pretty much a soft condition. And for the layer immediately below the reactor building, you know, we did some variation on what the stiffness of the soil for that. Then the bottom layer is basically is --

MR. WALLIS: Does it make a difference if the water -- if the soil is saturated with water?

MR. LIU: Yes. And that will increase the Poisson's ratio. The water effects mainly is a compression wave. So that -- basically that, you know, the compression wave for water -- I forgot exactly. What, is 4800 feet per second?

CHAIRMAN CORRADINI: Sounds right.

MR. LIU: So to achieve that we adjust the Poisson's ratio to simulate that saturated soil.

So for the --

MR. WALLIS: Were you ever concerned with fluidization of the soil or where the soil sort of becomes like a fluid when you jiggle it?

MR. LIU: No. No, we did not.

MR. WALLIS: That was never a concern?

MR. LIU: Well, that's a separate evaluation for potential of a liquefaction. You know, this is a site-specific COLA action for a site to demonstrate.

MR. WALLIS: Okay. So your design is not designed to float in a --

MR. LIU: No.

MEMBER ARMIJO: It's not a barge.

MR. LIU: No.

MEMBER ARMIJO: It's not a floating nuclear power plant, let's just start there.

CHAIRMAN CORRADINI: It's not supposed to be.

MEMBER SHACK: They expect to have a foundation.

MR. LIU: Yes. Next one, please.

MR. WALLIS: So it's up to the COL people to decide if there might be some soil fluidization?

MR. LIU: Yes.

MR. WALLIS: Okay.

MR. LIU: So Section 3.7.3 deal with the seismic design for subsystems.

It applies to both Category I and Category II equipment and the piping.

And the dynamic qualification can be performed by analysis, testing or a combination of both.

MR. WALLIS: So a fluid soil wouldn't break the building. It would probably transmit lower forces. But it might tilt it?

MR. LIU: Right. Right. So what's why we're to confirm there's no potential for liquefaction.

MEMBER BLEY: And, Graham, that would break pipes.

MR. LIU: The method of analysis for subsystem basically is the same. You know, they are the same as for the systems. You know, you can do a time history analysis, response spectrum analysis or equivalent study analysis.

And the damping values we use are consistent with Reg. Guide 1.60 Rev. 1.

Then the last subsection in Section 3.7 we deal is 3.7.4 dealing with seismic instrumentation. So we follow Reg. Guide 1.12 for the instrumentation program. And we also follow Reg. Guide 1.16 and the Reg. Guide 1.167 for procedural plant response to earthquake, you know, by referencing the EPRI reports, which are permitted by these two Reg. Guides.

Provided details of soil-structure interaction analyses in Appendix 3A. And we provided details of response structure to containment loads in Appendix 3F.

Okay. This is just, you know, a representative response spectra for seismic. This location at the refueling level of the reactor building, which is pretty far up.

MR. WALLIS: Well, this damping is a parameter. But --

CHAIRMAN CORRADINI: We were waiting for this one. We were waiting for this one.

MR. WALLIS: -- which one do you take?

MR. LIU: It depends on the equipment. Yes. It depends on the equipment and piping to represent a -- of damping curves for the equipment design, they can choose the proper one.

MR. WALLIS: They choose their own damping?

MR. LIU: Well, they have to follow requirements. Yes.

MEMBER ARMIJO: Could you give me an example of type of equipment that would have the most severe acceleration? Or, I guess it's the highest damping.

CHAIRMAN CORRADINI: Lowest damping.

MEMBER ARMIJO: Lowest damping. Lowest damping. So what kind of equipment would be represented by the highest g --

MR. LIU: Okay. The lowest damping represents 2 percent. Two percent damping -- let's see--

MEMBER BLEY: I believe that's on welded steel structures?

MR. LIU: Welded steel structures is 4 percent.

MEMBER BLEY: Okay.

MR. LIU: Oh, four percent for SSE. Two percent --

CHAIRMAN CORRADINI: What's this? Just one cast piece of metal right to the foundation?

MR. WALLIS: Two percent is a lower limit, is it? Because zero percent might be interesting.

CHAIRMAN CORRADINI: Kind of like homogeneous flow for Areva, huh?

MR. LIU: No. I think two percent -- I don't -- we used two percent, no? It used to be, you know, in the old Reg. Guide, Reg. Guide 1.61 we, you know -- some small-bore piping use -- I forgot.

MR. CHAKRABARTI: Small-bore piping used

to be the lowest.

MR. LIU: Like two percent, you know, some small-bore piping two percent? I think the latest Reg. Guide 1.60 increase that damping value for piping to three percent.

MR. CHAKRABARTI: Four percent.

MR. LIU: Four percent? Okay.

So probably in reality this two percent is not too many equipment we use two percent SSE.

CHAIRMAN CORRADINI: So can we just back up just for my edification since you guys are talking to each other, it means you all understand it. So there's been some empirical testing with certain shapes and arrangements that say if I have to this and this to that, I can model in a spring-damper system as if it were a mass of somehow and a damping between them with that sort of damping ratio and you get a good match? Is that what I'm getting at? I'm just listening to how you're talking about this. That means there's been some empirical testing and then modeling of those tests to determine what's two, four, eight?

MR. LIU: Yes, I think that basically is the basis for the latest Reg. Guide 1.60.

CHAIRMAN CORRADINI: Okay. Okay. Then,

I'm sorry, Graham, I didn't mean to interrupt you. Did you have another question. Did you have any other questions, Graham?

MR. WALLIS: No, I am just thinking about it.

CHAIRMAN CORRADINI: Okay. So I guess my question is just for understanding. Since the spectrum that you showed us at the beginning is the forcing function that puts in the energy, this is just redistributing the energy into some sort of like resonance that these guys are wiggling at a higher g?

MR. WALLIS: Right.

MR. LIU: At the --

CHAIRMAN CORRADINI: Let's just take a case where there's no damping just so we don't get dissipation involved. By conservation of energy if I wiggle it down here and I get a wiggle up there at a bigger g, that means I'm redistributing the energy near a resonance for the structure.

MR. LIU: Right. Right.

CHAIRMAN CORRADINI: Is that essentially it?

MR. LIU: Right.

CHAIRMAN CORRADINI: Okay. Fine. Thank you.

MR. LIU: Right. This basically now is just an input to the equipment which is attached to that particular location in the structure.

MR. WALLIS: This puzzles me. Because damping doesn't say anything about resonance, does it, or am I somehow confused?

CHAIRMAN CORRADINI: No. I was just trying to understand because --

MR. WALLIS: But you have to get the resonance to have this amplification. But all this -- the parameters on the curves is damping, it's not resonance.

CHAIRMAN CORRADINI: They got a forward --

MEMBER SHACK: He's got a structure. He's got a structure built in there that gives him that.

MR. WALLIS: He's got it built in.

MR. WAAL: You know, the response spectra is like the response of a --

MR. WALLIS: Of the floor --

MR. WAAL: -- family of single degree of freedom system damp oscillators --

MR. WALLIS: Okay.

MR. WAAL: -- and its objective --

MR. WALLIS: Okay.

MR. WAAL: -- natural frequency, you

compare the frequency that you have with the response factor there.

MR. WALLIS: And the cabinets stay attached to the floor?

MR. WAAL: They're bounded to the floor. No bounce?

MR. WALLIS: They're all bolted, are they?

MR. WAAL: Prewelded.

MR. WALLIS: Because the Japanese earthquake, furniture moves around a lot.

MR. LIU: That's a non-safety.

MEMBER ARMIJO: Not if you're sitting there.

CHAIRMAN CORRADINI: Go ahead. Go ahead, move forward.

MR. LIU: Okay. They are not a representative spectra, you know, the top of the control building.

Then the next one, you know, this is the spectra at the top of the firewater storage tank.

And this one, basically, you asked me how conservative, you know, are these. And really is by conserving the high frequency components of the ground motion input. You see we have this high peak, around 20/30 Hertz.

MEMBER STETKAR: What kind of -- I'm not a structural guy, so I don't understand most of this stuff so I refer to tables and things like that.

You have a table in DCD that applies damping values for various types of equipment.

By the way, two percent damping applies to the control rod guide tubes.

MR. LIU: Oh. Thank you.

MEMBER STETKAR: There is something in the plant that has two percent damping.

I've noticed in all of the discussions, you happened to mention the upper elevation of the control building, which is an area that's near and dear to my heart. That's ventilation down below. I don't see any typical damping values for electrical switch gear and cabinets. What do you use for those in your analysis? I mean, there aren't any values here. I was just curious.

MR. LIU: Yes.

MEMBER STETKAR: You have a equipment, but that's mostly pipes and valves and they don't behave the same as cabinets. So do you use --

MR. LIU: Probably is, you know, is basically is made of the welded plates. You know, so it would be the welded structures.

MEMBER STETKAR: They're tall narrow thing, they're not -- I mean, the base is. Like I said, I'm not a structural engineer so maybe I don't quite understand that.

CHAIRMAN CORRADINI: So your answer then is that if it's a welded structure, that would be like a four percent damping approximation, is that your point?

MR. LIU: Yes.

CHAIRMAN CORRADINI: Okay. Okay.

MEMBER STETKAR: Thanks.

CHAIRMAN CORRADINI: Identify yourself and speak in a mike.

MR. MORANTE: My name is Rich Morante. I work for Brookhaven National Laboratory. And I worked with the staff on the revision to Reg. Guide 1.61.

Categorization 1.61 there is certain mechanical and electrical equipment that is designed at three percent SSE damping in the Reg. Guide 1.61. These values pretty much are values that have been historically assigned or used.

I believe that GE's table here follows very closely with what Reg. Guide 1.61 Rev. 1 says. And it's probably just a single line there that says electrical equipment.

CHAIRMAN CORRADINI: Okay.

MR. MORANTE: And it'll say three percent.

MEMBER STETKAR: It just says "equipment," that's why I was curious what types of equipment.

MR. MORANTE: It just says equipment in the Reg. Guide --

MEMBER STETKAR: I mean it could be, you know, a pump or a diesel generator or a cabinet. Thanks.

MR. MORANTE: You did identify that they were consistent with the regulatory guide.

MR. WALLIS: What is the damping for the massive water in the pool? I would think there's dampen it. It's just a mass of water that's going to move to-and-fro. And I don't see a mechanism for dampening it.

MR. LIU: For the sloshing modes.

MR. WALLIS: No, just well for --

MR. LIU: That go with the structure together. So there's --

MR. WALLIS: But it's not damped, is it?

MR. LIU: The follow --

MR. WALLIS: I don't see a force to damp the --

MR. LIU: No, no, it's not damped. It's

not damped itself.

MR. WALLIS: So it's zero dampening of the water? It sloshes.

MR. LIU: Basically that, you know, once we treat this -- that part of a water as a region mass attached to the structure, then that body of water will respond together with the structure. As a result, the dampings are associated with the structure, or at least that's what I think.

MR. WALLIS: But that's only for the structure part.

MR. LIU: No, that takes into account of the water.

MR. WALLIS: But if they put a bigger mass on, the effect of damping must be less.

MR. LIU: No, no.

MR. WALLIS: Yes, surely. I mean, you have a damping on a wiggly wall and you attach it to a huge mass of water, the damping in the wall has no effect on the motion of the water.

MEMBER SIEBER: It has an effect on the structure --

MR. WALLIS: It has an effect on the structure, but the water damped.

MEMBER SIEBER: The effects of damping

causes viscosity.

MR. LIU: Yes, the water is not damp out. The water is not damped.

MR. WALLIS: But the water itself can have -- can try to get a bigger amplitude.

MR. LIU: That's why the water will impose a huge mass to the structure.

MR. WALLIS: So if it's going up and down, it can leap off the floor.

MR. LIU: But the tank is fully anchored.

MR. WALLIS: But the water itself -- you said the furniture is attached to the floor.

MR. LIU: Right.

MR. WALLIS: So it doesn't jump around. But the water can jump in the tank. Jump off the floor. It's not damped at all.

MR. BRAVERMAN: Excuse me. My name is Joseph Braverman. I also work for Brookhaven National Lab and assisting the NRC in reviewing the structural area. Perhaps I can help a bit.

As Ai-Shen mentioned, when you analyze pools of water in a structure, there are two components. One is the overall building response. And for that industry practice has always been to lump the mass of the water on the structure. Separately from that, I think you consider the type of concerns that you're raising. And there are a series of equations that go back since the Army Corps of Engineers that analyze tanks filled with water and what happens under seismic event. The water sloshes, it does this.

MR. WALLIS: Right.

MR. BRAVERMAN: And the equations consider the water as two components for the water. One is a certain percentage of the water acts as a rigid mass. And another portion of the water acts in a sloshing mode as if it has a spring in a dash pond.

And to answer your question about damping for the water, GE has a Section 3.7.3.15 its called Methods for Seismic Analyses of Above-Ground Tanks. And one of the bullets reads as follows: "In determining the spectral acceleration in the horizontal convective mode," that's the sloshing mode, "the acceleration SA sub 2 the fluid damping ratio of one-half percent of critical damping is used unless a higher value can be --"

MR. WALLIS: A half of a percent?

MR. BRAVERMAN: Half a percent.

MR. WALLIS: So it's very small? It's very small?

MR. BRAVERMAN: Yes, which means it's

going to have a high acceleration. Lower damping gives you high acceleration.

MR. WALLIS: Can it not separate from the floor? If you accelerate vertically enough, the water is going to separate from the floor.

MR. BRAVERMAN: Well think of it this way: If you have a glass of water, there's two components, horizontal excitation that when you do that, you can imagine --

MR. WALLIS: Vertically, you can, pull the cup away from the water.

MR. BRAVERMAN: Yes, but you have to go higher than gravity. And they don't have, I don't think--

MR. WALLIS: He's got more than 1g.

MR. BRAVERMAN: In the vertical direction, I don't think --

MEMBER BLEY: Very seldom. There was an earthquake out in L.A. about ten years ago that threw the roadbed off of the pedestals on one of the ramps. A big surprise that it was higher than the horizontal acceleration.

MR. BRAVERMAN: That's very rare.

MEMBER BLEY: It's very rare, but it has happened.

MR. BRAVERMAN: Okay.

MR. WALLIS: See, he's got 20g or something in some of these curves here.

CHAIRMAN CORRADINI: But that's the response.

MR. WALLIS: Yes. So that's why the water--

CHAIRMAN CORRADINI: That's why I asked about the forcing function being -- if you go back to the slide, whatever it is, it's below a g.

MR. WALLIS: But if the water -- if the floor is going to 20g --

MR. BRAVERMAN: Excuse me. Let me just clarify that. Again, that is not the acceleration of the floor. That is the acceleration if you attach a lump mass and a spring onto the floor, and it has perfect resonance at that frequency.

MR. WALLIS: Yes.

MR. BRAVERMAN: Only then could it achieve those kind of g forces.

MR. WALLIS: Yes. Yes. So it's not -- right. Okay.

MR. LIU: Yes, please. Okay. All right.

I would like get to into discussion of 3.8.

3.8 deals with design of seismic Category of I structures.

Section 3.8.1 is for the concrete containment. You know, we have used regular reinforced concrete containment in our design. The containment structure is totally enclosed and it integral with the reactor building.

The design details are enclosed in Appendix 3G.

The concrete containment design meets all the requirements of Section II, Division 2 of the ASME Code.

This figure shows the configuration of the concrete containment. So the containment consists of a drywell and the wetwell.

And for the drywell, it further divides into the so called upper drywell and the lower drywell. And the wetwell is a space we have a suppression pool.

This is the finite model we have used for the containment vessel. We use a -- computer code.

And this just a cut away view of the model.

The steel components of the containment are discussed in 3.8.2. They consist of: Personnel air locks; equipment hatches; penetrations; drywell head, and; the passive containment cooling system condenser.

We have six PCCS condensers. They form an integral part of the containment boundary.

The steel components of the containment were designed in accordance with ASME Division 1 Subsection NE.

Section 3.8.3 discussions of concrete and the steel internal structures. They include: Diaphragm floor; the vent wall; the gravity driven cooling system pool walls; reactor shield wall; RPV support brackets, and; the miscellaneous platforms.

This shows another view of the containment system and the internal structures.

The green portion are the upper pools for PCCS and IC. The blue portion in the middle represents the GDCS pool. Then the blue portion on the bottom represents the suppression pool.

MR. WALLIS: What are those things on the very bottom there, those things that are like big test tubes?

MR. LIU: Heat exchangers.

MR. WALLIS: Those are heat exchangers. All right.

MR. LIU: Yes. And this is the finite element model for the containment internal structures. This is just --

MEMBER BLEY: I am just -- a piece of the thread of the analysis. Now when you're doing the finite element analysis is this where you treat the water as a solid mass or do you let the water be water in calculations here?

MR. LIU: The effect of water in this analysis we include a hydrostatic effect of the water. We include a dynamic effect of the water.

MEMBER BLEY: What about the dynamic?

MR. LIU: The dynamic -- okay, dynamic. We include the wall -- we calculate the wall pressures.

MEMBER BLEY: And you let the water freely move as it will?

MR. LIU: No, we do not monitor the water explicitly. We do the calculation of -- the separate calculation to compute the pressures.

MEMBER BLEY: Can you back up to -- right there.

MR. LIU: Yes.

MEMBER BLEY: We've several different elevations, very large masses of water--

MR. LIU: Right.

MEMBER BLEY: That may not be moving in phase in the middle of an earthquake. They start moving together but then as they start sloshing and moving, some will be moving in one direction and some are moving in the other and then they'll come back in phase. Where is that combined effect of these different large masses of water.

MR. LIU: The phasing relationship already included in the results of assessment response calculation. In assessment calculation in the model we lump the water originally to the structure.

MEMBER BLEY: Yes, I heard that. And then I heard you go back and you look at the water, the sloshing effect separately. But do you look at the three different levels of large water masses at the same time, how they interact with the structure?

MR. LIU: Like I say, you know, those are the local effects. The global effect we accounted for by the --

MEMBER BLEY: I understand that.

MR. LIU: When it comes to local design for the wall and the floor of that particular pool, then we did a separate calculation to compute --

MR. WALLIS: Well how is the water attached to the wall? Because, I mean, if it's pushing on the wall, it's part of the wall. But it's sliding along the wall, it isn't part of the wall. All right. So you've got a coupling between the water and this structure shown in the finite element wall has to be done right.

CHAIRMAN CORRADINI: So can I just repeat what you said to Dennis and Graham?

So for the overall structural response the water is a dead weight.

MR. WALLIS: But attached to what? How attached?

CHAIRMAN CORRADINI: Well, I think he said there are three different sets of analyses. But, all right, let's make sure I understand.

The first set of analyses is essentially a lump mass and it's just a dead weigh with some sort of damping.

Then you said you actually do a finite element where it's still the load, but it's a hydrostatic load.

And then you said to Dennis that if you're going to start designing the local wall, then you start worrying about the sloshing. So only in the local event do you actually consider the water motion out of phase with the walls? Do I understand that correctly?

MEMBER SIEBER: That's what I got out of it.

MR. LIU: Yes. In the third calculation you just mentioned, the separate calculation for the wall design, yes, we do a calculation to predict the pressure distributions you know of the water sloshing.

MEMBER SIEBER: That tells you how thick the wall needs to be.

MR. LIU: You know, along the height of the wall --

MR. WALLIS: How is it modeled when you have this water in there? Is it attached to the wall or is there some kind of an interface with the wall?

MR. LIU: We have these standard equations which has been developed since 1950s.

MR. WALLIS: So there's some sort of an interfacial model between --

MR. LIU: Yes. Right.

MR. WALLIS: -- this mass of water which is in there and wall --

MR. LIU: Yes.

MR. WALLIS: -- which lets it slide along the wall but not push on it and maybe pull it?

MR. LIU: That calculation would predict

what is the highest positive pressure and what is the highest --

MR. WALLIS: So I would assume that this is --

MR. LIU: No, this methodology has, you know, Joe was pointing out is well established methodology.

MR. WALLIS: '50s, yes.

MR. LIU: Yes.

CHAIRMAN CORRADINI: So now let's roll back. So we have three different calculations. To get back to Dennis' question, what convinces you that the local phenomena does not need to be fed back into the global phenomenon? That's really what he's asking, right? That's what I think you were asking.

MEMBER BLEY: That's what I'm asking. And why is it okay to treat each of those pools separately for the wall calculation but not fed back the possible interaction in global? Yes, that's a good way to put it.

MR. LIU: The interaction, you know, interaction among the various pools already, you know, is built in modeling parameters in the global analysis.

MEMBER ARMIJO: But in the global analysis the water's not sloshing. It's fixed.

MR. LIU: But sloshing is local -- very localized effect. Sloshing is very localized effect. Only, you know, at the surface of the pool.

CHAIRMAN CORRADINI: So can I try something on you? The only way I'd buy that argument is if the relative masses of the pool relative to what's holding it is either minimal or at least less than.,

MEMBER ARMIJO: It's large.

CHAIRMAN CORRADINI: If it's a large mass held by a skinny water tank, then its sloshing out to have a feedback effect that I'd worry about.

MR. LIU: In our design -- yes --

CHAIRMAN CORRADINI: I think everybody's worried here.

MR. LIU: In our design really, although we have many, many, many pools as you can see --

CHAIRMAN CORRADINI: Yes.

MR. LIU: -- you know, our structure is a heavy structures.

CHAIRMAN CORRADINI: Okay.

MR. LIU: We have, you know, thick wall, you know --

MR. WALLIS: When you present the results of this analyses, would you present please the pressures and the motion of the water and the amplitude of the sloshing and that sort of thing so that we can get a feel for what you say is happening?

MEMBER ARMIJO: I would like to see that.

MR. LIU: Yes. I don't have those things, no.

MR. WALLIS: Not today. Not today. But some day when you do it --

MR. LIU: Okay. Sure.

MR. WALLIS: -- I'd like to see a detailed description of what you say is happening to the water. And then we can see if it cavitates or if it sloshes and how big these effects are. And maybe we can be convinced it's all fine. But I don't think we could possibly do it today.

CHAIRMAN CORRADINI: But you understand the question that they're asking? I want to make sure we're communicating.

The concern really is that we understand that you're doing these layers of analyses. But I think the concern -- the question is is there a feedback so that the local washing machine effect of these pools doesn't cause an adverse feedback to the global response.

MEMBER SIEBER: Structure of the building.

CHAIRMAN CORRADINI: Yes.

MR. LIU: Yes.

CHAIRMAN CORRADINI: Thank you. Go ahead. I'm sorry.

MR. LIU: Section 3.8.4 covers other Category I structures. In our design they include: Reactor building structure; the fuel building structure; control building, the firewater service complex.

The reactor building and the fuel building are integral to each other and founded on a common basemat. Represent the details of the structure design is Appendix 3G.

This is a flow chart indicating how we perform our design calculations. Okay. Basically we started with, you know, we know the structure configuration is, what kind of material we plan to use. And we also definite what are applicable loads. Then we build our finite model. We perform the linear stress analyses. Then for the design of concrete sections, we have to do the section design. We need to the effect of cracking for thermal load, so we took that into account in the design.

Then we do a load combination for all

applicable loads.

Then for the overall design you'll see in the section design.

And then we make sure that the resulting sections code requirements.

So that's a standard process, typical process we have used in our design analysis.

MEMBER ARMIJO: So you do this analyses for all operating states, refueling as well as full power, hot standby, you do this seismic analyses for all conditions?

MR. LIU: The seismic analyses?

MEMBER ARMIJO: Yes.

MR. LIU: Seismic analyses we do it for operating conditions.

MEMBER ARMIJO: How about refueling where you got a lot more water in the vessel and over the vessel, does that make any difference?

MR. LIU: Not to the structures. I don't even think that's in the effect of the vessel itself.

MEMBER ARMIJO: Okay.

CHAIRMAN CORRADINI: Can I just say it back? Because I guess I want to sure.

So is it true since I don't know very much about the details that we're hearing, is it true that you've added substantially to the water masses involved when you go --

MR. LIU: Only to the RPV itself.

CHAIRMAN CORRADINI: Only to the RPV?

MR. LIU: Yes. The RPV needs to be flooded.

CHAIRMAN CORRADINI: Okay. Right. And your answer back then is that there's not much difference you say?

MR. LIU: Okay. Right.

This is a finite model, you know, for the reactor building and the fuel building. This is a cut away view of the same model.

This is the model for the control building. The control building is a relatively simple structure. The cut away view for the control building.

This is the model for the firewater service complex. It's made of two identical water storage tanks and in between we have the so-called valve pump enclosures for the structure.

CHAIRMAN CORRADINI: So what is this? I'm sorry. Excuse me.

MR. LIU: The one in the middle?

CHAIRMAN CORRADINI: No, the tank.

MR. LIU: The firewater tank.

MR. WALLIS: So in there probably the weight of the water is more than the weight of the structure.

MR. LIU: But the tank is a concrete tank. Yes, is a heavy concrete tank. It's not a steel tank.

MR. WALLIS: Even so, the water's probably heavier than the structure?

MR. LIU: Yes, it's lots of water. Yes.

And Section 3.8.5 discusses the foundations.

The reactor building, including the containment and the fuel building, share same common foundation mat.

The control building is a separate -- has it's own separate foundation.

The foundation for firewater service complex is also separate.

Again, the design details are included in Appendix 3G.

So in summary, Sections 3.7 and 3.8 provide details of seismic analysis of the ESBWR and the loads and load combinations and acceptance criteria for the design of seismic Category I structures for the ESBWR standard plant.

CHAIRMAN CORRADINI: Thank you.

MR. LIU: That's all I have.

CHAIRMAN CORRADINI: Thank you very much.

MR. LIU: You're welcome.

CHAIRMAN CORRADINI: Questions, to the Committee.

MR. WALLIS: Well, the worst thing that could happen, probably, would be if the water cavitated. You've got a big separation and then it came back again, and then you've got a transient impulse on the wall which would be excessive compared with it just being an impact. It wouldn't just be a gentle oscillation.

I have no idea if such a thing can happen. That's the worst thing I can think of would be the separation of the water form the wall, a big cavitation and then a collapse.

CHAIRMAN CORRADINI: I think wouldn't the frequency have to approach the sound speed and break the wind scale for that to occur.

MR. WALLIS: I would think so.

MR. BRAVERMAN: Excuse me, could I add something.

MR. WALLIS: You could shake it with enough--

MR. BRAVERMAN: Excuse me. Could I add something again? My name is Joe Braverman.

CHAIRMAN CORRADINI: Speak.

MR. BRAVERMAN: I spoke earlier. I'm from Brookhaven Lab.

Once again, the second analyses that Ai-Shen Liu was talking about, which is the local effect, which has been a series of equations developed over the years, I think it goes back to Army Corps of Engineers, that addresses your concern. It treats entire water mass as two components. There's a percentage of the water that acts as a rigid mass and then there's another portion of the mass that acts as a dynamic mass with the spring and dash pond.

Generally, the rigid mass is the largest percentage. And a smaller mass that vibrates would be--

MR. WALLIS: Yes. But the concern I had was you cannot oscillate water by pulling on it.

MR. BRAVERMAN: That's right. You can create a vacuum at most.

MR. WALLIS: It's not exceed. Negative pressure must not be exceeded too much at the wall or the water separates from the wall; that's the concern I had. I don't know where it's i your equations.

MR. BRAVERMAN: Okay. Well, again, generally the water will not separate. It's going to do this for horizontal excitation.

MR. WALLIS: Shake it enough, it will separate from the wall.

CHAIRMAN CORRADINI: That's why I made the point that you have to shake it at a frequency such as you approach the sound speed or the median before you cavitate. Otherwise, it's going to move.

MR. BRAVERMAN: I think it's going to build that kind of excitation.

MR. WALLIS: No. There is nothing about that. It's have a big enough negative pressure, that's all you have to have.

CHAIRMAN CORRADINI: But you've got to pull it at a velocity that approaches the sound speed at the interface--

MR. WALLIS: No. No. The water just can't follow that. It doesn't have to be a sound speed.

CHAIRMAN CORRADINI: Well, I think it does.

MEMBER SIEBER: I think it does.

MEMBER BROWN: Didn't the Army Corps of Engineers design structures in New Orleans for the levies and --

MR. WALLIS: I can do an experiment. I can put water here and I can pull the wall away. You don't have to move the wall at sonic speed before it--

CHAIRMAN CORRADINI: I guess my point is if I pull the wall slowly, the water will fill. If I pull the wall away very fast relative to the sound speed of water, then it'll create a void and cavitate.

MEMBER SIEBER: A different calculation.

CHAIRMAN CORRADINI: Right.

MEMBER SIEBER: So it's a function of the viscosity and it's a function of the --

MR. SHAMS: Mohammed Shams with the staff.

I'd like to add, as Joe was pointing out, the equations that we have are in some respect a rational conservative way of resolving a very complicated issue. And they do consider both, a sloshing mode as well as an impulsive mode. I got the phrases, he said an impulsive mode.

As far as water separating from the structure, we've seen that analyses of dams. And, as you can imagine, there is a large body of water there. And it doesn't really have to get to a -- you know, if there is enough of tension, there is no attachment between the water and the structure right next to it.

So I don't think the models that we do

account for that or perhaps sophisticated enough to describe that. But it could be done. But what I'm trying to say from our experience in the analyses, the equations that we have conservative enough to capture that effect without having to go to the sophistication of modeling a body of water right next to a structure. If you take a conservative assumption of what the portion of the water that's going to cause the pressure on the wall, which is the sloshing mode, and if you take another portion which will contribute to the dynamic effect, that essentially captures what we're looking for.

CHAIRMAN CORRADINI: And this is a technique that has been well established?

MR. SHAMS: It has. And it was tested considerably for dam analysis. I came from the dam industry, part of my previous work was. And we compared the equations, Westagard equations and the other type of equations to a full dynamic analysis of a water body modeled right next to a dam with all sorts of sophisticated attachments to capture the separation. And it worked properly.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. XU: My name is Jim Xu from staff. Maybe I can add some insight to this issue.

CHAIRMAN CORRADINI: Please do.

MR. XU: I think the issue the member one asked how to do it, full structure reaction phenomena. And this phenomena have been researched and studied for many, many years and primarily by Professor Andy Velesos from Rice University. Okay.

And what they knew is the full containment structures, okay, the response of fluid in the structure has two components. One is move harmonically with the structure and the other is independent components and that we call slosh. Slosh mode.

The reason we call slosh mode is because it's only the surface of the water that is needed, okay, in the form and vibrate at a very low frequency. And the methodology for this have been established for a long time. I believe GE also used the methodology established by Professor Andy Velesos. And I think the cavitation issue should not be applied here because the seismic excitation are generally in very low frequency range between 1 and 35 Hertz. So you will never have cavitation phenomena occurring in this--

MR. WALLIS: The reason I worry about it is because the seismic --

MR. XU: Because it's a low frequency

phenomena.

MR. WALLIS: If you had big enough accelerations for enough time, you could produce cavitation.

MR. XU: You could have a high acceleration, but the acceleration would create a very low frequency, therefore they will not cause cavitation.

MR. KRESS: These empirical fractions, dynamic versus the solid, seem to me ought to depend on the geometry of the current. Are these for rod circular cylinders? Are they all --

MR. XU: The study have been performed for now is the geometry, it's an integral geometry, rectangular and the vibration of water behave in very similar fashion. Okay. And as far as interaction is concerned, the impulsive mode are the part of the interaction that will move with the structure. Okay. The convective mode is independent mode. That means nothing local phenomena and that be the portion that does not interact with the structure response. Okay.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. XU: So I hope I've clarified.

CHAIRMAN CORRADINI: Thank you. Other questions by the members?

Okay. We'll take a break until five after. Thank you.

And the staff will come back and tell us more.

(Whereupon, at 9:50 a.m. a recess until 10:05 a.m.)

CHAIRMAN CORRADINI: Okay. Let's get started. I know people will catch up with us.

MR. PATEL: Good morning. My name is Chandu Patel. I'm the lead project manager for Chapter 3, again. David Jeng will present Section 3.7.

MR. JENG: Good morning. I am David Jeng. I am on the staff of SED Division of Engineer, Office of New Reactors. And I am the person who did review Section 3.7 Seismic Design.

The review currently set out sections and specs. I would like to start the regulations and the regulatory guidance we based upon in performing our Section 3.7 review.

The major regulations we used is the GDC 2, Part 50 Appendix A.

And we also we did use the Seismic & Geologic Siting Criteria, which is a Part 100 Appendix A.

And in addition we applied the Earthquake Engineering Criteria. This is Part 50 Appendix S.

There are also regulatory guides we based upon in our 3.7 review. Number one is Reg. Guide 1.60, which the seismic response spectra for nuclear plant designs. And this defines the so called standardized 1.60 spectra, which has been in discussion that is part of the picture GE put up earlier.

The second reg. guide we based upon is 1.61. Again, this is part of a earlier discussion in which the staff defines what considered the acceptable range of damping barriers for different type of material and stress ranges.

Next one is 1.92, Reg. Guide 1.92 which gives guidance to how to combine the modal responses in the seismic analysis. And they also give the guidance on how to combine different components of seismic responses either from X, Y and Z; three directional components, how you go about combining those effects into a design basis data or application.

And the last reg. guide we used is Reg. Guide 1.122, which is the variance given to the public in the review about how to develop for response spectra given the input margin. And this provides a very detailed way of how to develop the flow of response spectra, which in turn is used by a component and type and designers at different floor in a structure or reactor building.

And the last one, which is very important, is the revised SRP Section 3.7. This is a Rev. 3 version, which has been completed March 2007. T h e main implication of this revised reg. guide is we have last revised earlier reg. guide provision in 1980s. And then in the last two decades we have never updated but, you know, we have learned and the new development in technology and the analysis. So I was happy to be the responsible person in revising SRP 3.7, 3.8. And this encompasses all the past two decades of new development, analyses, testing results as well as the lessons learned. So we are very proud that GE's application is being reviewed against this most updated review plan, 3.7. And I think that GE did a very competent job in complying to the 3.7 provisions.

Next, I like to review highlights.

Because of the nature of the ESBWR, design specification is first of a kind, in a way. And also, once we certify the design, this will be used almost automatically for next five, ten plants. So we took the very prudent posture and tried to do a very thorough job. For that reason we have performed two on-site audits. The audits which took place at the GE offices included discussion of the design methodology, the issues raised by the NRC during the RAI processes.

And also we checked the summary calculations and discussed their codes used and the assumption of the codes.

So the audit not until one whole week's of intense interaction between the staff and the applicant, in this case GEH. And the nature of the discussion and the types of interaction was quite thorough. And by doing such a work, we gained additional level of confidence in how the applicant is doing their analysis design to compare to Commission regulations.

And so, we believe this audit effort is very proactive and very positive, particularly important for design stratification type of review.

And in addition besides the audit, we decided that we need to perform a confirmatory analysis of selected subjects. This is another way of trying to find out how thorough and professional job that GE has done in their detail analysis and design calculations.

So we basically took a very independent

analysis of the control building. And we decided to use the same stick model that GE originally adopted for the control building. And we used our own SASSI modeling representing the layer site. In the case staff used nine layer site conditions, whereas GE only used 4 layered cases. And we did an independent analysis and compared the results.

And in the course of comparison there are some differentiations between theirs and ours because of some minor deviation in the way they did the stick analysis compared to ours. But in the end the overall result, GE has been using the design curve, which is so conservative. They are forcing about a factor of two safety margins over whatever the stuff came up. So based on this finding and the conservatism involved in their final curve, we have come to the conclusion that the confirmatory analysis is consist, you know, verified and reasonable within the two results. And we are very happy with the outcome.

And this outcome further reenforces the staff's confidence in being able to reach a reasonable assurance that seismic design with safety related subjects are well done and they should perform intended safety functions. So the staff feels we are very happy and with a sense of achievement.

And the next one, also performed several correlated development in the course of analysis. For instance, how do you define so called effective minimum strengths of the soil? And nowhere is the soil content is defined by the shear wave velocity of the soil material. And the SRP do recommend the minimum allowable shear weight velocity is 1000 foot per second. And there is a layer situation. So each layer has different variable shear wave velocities. And how you determine that this layer minimum last meet the intent of 1000 foot per second.

And GE proposed this weighted concept. They are weighting the layer, shear wave velocity based on the thickness of each layers. And they compute the separate *10:14 shear wave velocity, which has been shown to be higher than 1000 foot per second.

And the staff reviewed their approach and decided that the method presented by GE is very reasonable and we agreed to the evaluation that minimum wave velocity was meeting that provision of the SRP requirements.

So this is one aspect of how detailed their stuff cut into the design calculation and checked the specificity of the numbers. So this shows one level how deep we perform our independent analysis and audit.

So because of all this effort, the audit and the interaction conference calls, which lasted several months, and the resolution of all the issues, difficult and some easier, we have come to a very good understanding. And the overall impression the applicant give us was really something to be commended.

Now review status right now is we have issued altogether 64 RAIs for 3.7. And out of that 62 RAI has been resolved. And right now there are two RAIs open. So we are in a very good position.

Let me talk about the two open RAIs.

MEMBER ARMIJO: Just before you do that, I have a quick question.

MR. JENG: Yes.

MEMBER ARMIJO: You did the confirmatory analysis of the control building.

MR. JENG: Yes.

MEMBER ARMIJO: Now the reactor building or the containment structure is obviously more complex, at least it seems to me. Is there any reason why you choose the control building instead of the containment?

MR. JENG: We did also perform the control

-- reactor building, fuel building aspect insofar as the development of the input motion to ground surface motion and the overall characteristics. But for more detail, look at the structure design response at the different floor level. We concentrated on the selected basis. So we decided optimive for the control building. But methodology and criteria which are used identical for reactor building, fuel building and control building. It's a matter of optimization of the resources and the selection of some selected items.

MEMBER ARMIJO: So you have no reason to believe that had you done that same confirmatory analysis on, let's say, the containment structure that you would have gotten anything significantly different?

MR. JENG: No. Based on the same computer codes, same analysis methods and assumptions.

MEMBER ARMIJO: Okay.

MR. JENG: So if you had the good result on one, should be equal on it.

MEMBER ARMIJO: Thank you. Okay.

MR. JENG: We do have two open items. The first open RAI relates to RAI 3.7-52 and this pertained to the concrete tunnels and trenches which connect between the major Category I structures. And in this aspect the staff wanted GE to clarify the specific safety classification of these tunnels and trenches. And also we want them to describe and discuss more about the piping and the conduits and ducts which are audited within these trenches and tunnels. And this item we want GE to provide more information regarding the service response, which GE *10:18 foundation input response which is going to be applicable for the design of the tunnels and the trenches.

So this is a type of information I believe GE should be able to timely provide. And so the expectations of resolving this RAI is very good.

MEMBER STETKAR: Well, yesterday I learned, anyway --

MR. JENG: Yes.

MEMBER STETKAR: -- about the new ancillary diesel building that appears in the DCD Rev. 5. I'm assuming because of its location it'll have underground cable tunnels to connect into the reactor building. Is that part of your concerns? I know your review, the building didn't exist in your review, but are those the types of underground cable tunnels and things that you're concerned with with that RAI?

MR. JENG: Yes, exactly.

MEMBER STETKAR: Okay.

MR. JENG: At least the tunnel trenches are, so called Category I tunnels and trenches they encase and protect and support safety related conduit and wires and so on.

MEMBER STETKAR: How does your analysis, because I didn't read all this stuff, treat RTNSS-type systems? Those are Category II, right, according GEH's design?

MR. JENG: It's even less than Category 2. Mohammed, he did review the RTNSS aspect.

MR. SHAMS: Mohammed Shams with the staff.

RTNSS components are in several bins. The one that we're concerned with with regard to seismic is the category B, which are the ones needed for long term safety. And those were able to get GE to do them in a Category II classification.

MEMBER STETKAR: And those Category II, is that RAI the first one there, does that also apply to tunnels and conduits that are -- you know, underground cable tunnels that are classified as Category II, or are you only --

MR. JENG: We are talking about the Category I trenches and tunnels. Now, trenches and tunnels may -- I said may contain some Category II wiring. But in general the things -- region of the tunnel are hiding the conduit and ducting which are safety related.

MEMBER STETKAR: Does GEH categorize these -- again, tell me if I'm wrong. I'm assuming that there are going to be underground from this ancillary diesel building just because of its location and you have to get somehow the cables over to the reactor building. Has GEH categorized those underground tunnel -- let me call them cable tunnels for the lack of a better term, as Category I structures?

MR. LIU: This is Ai-Shen Liu, GEH.

Yes. We have both Category I and Category II tunnels, okay. Category II tunnel for this new ancillary building, diesel building we're going -- you are correct. We are going to have tunnels, you know. They are inevitable. Yes.

MEMBER STETKAR: Are those going to be Category I or Category II tunnels?

MR. LIU: I believe they are Category II. I don't think they contain any Category I components.

MEMBER STETKAR: I would --

MS. CUBBAGE: RTNSS B is Category II.

MR. LIU: Category II. RTNSS B is Category

II. Yes.

MEMBER SIEBER: But structure of those --

MEMBER STETKAR: So if I have a large earthquake that damages these tunnels and destroys the cable connections from the diesels that have to supply power for response after 72 hours, I won't have that power supply?

MR. LIU: Well, the tunnel -- you know, although the Category is Category II, but it's designed to the same criteria as Category I.

MEMBER STETKAR: That was why I was asking are you looking at both Category I and Category II structures or only Category I. You said only Category I. So you have no concerns with these tunnels because they're not Category I?

MEMBER SIEBER: I thought Category I--

MR. MORANTE: Excuse me. This is Rich Morante from Brookhaven.

The open item on this particular RAI is asking GE to specifically identify which ones are Category I, which ones are Category II. GE has committed to seismically analyze Category II using the same methods as seismic Category I. We are concerned about both categories here.

MEMBER STETKAR: Okay. Thanks. That

helps.

MR. JENG: That's why my question -- well, first bullet is classification. We want them to clarify some of the tunnels whether they're Category I, Category II. It was not quite clear and we're asking them to clarify.

MEMBER BLEY: I'm sorry, I'm still a little confused on this. They're going to design them to Category I criteria. Are you going to analyze -- are you going to review their Category II analyses?

MR. JENG: Okay. Once the items is categorized as Category II, yes, we're planning to understanding from the part of SRP that though shall design to Category I, seismic requirements analysis process. Only on the 2A and procurement in the construction aspect they can be *10:24. But as far as analysis recall the modeling and course design, it's equal to and identical to category and design. That's by definition of Category II.

MEMBER ARMIJO: But by structurally, whether they're Category 1 or Category II, they're --

MR. JENG: Equally strong.

MEMBER ARMIJO: -- equally strong.

MR. JENG: Except --

MEMBER ARMIJO: But you don't have the

documentation --

MR. JENG: Yes, sir. Not back.

MEMBER BLEY: It sounds to me like you're saying even they're the same --

MEMBER ARMIJO: But PRA guidance --

MEMBER BLEY: -- you aren't going to redo them because that review is not required by the SRP?

MR. JENG: Well, it's required. They have committed and been required by SRP, but they use the same methodology and assumptions aspect of calculations that are required for Category I *10:25. So they are required to review, yes.

MR. MORANTE: This is Rich Morante again.

From the review perspective Category I and Category II structures would be reviewed equally. There would basically be no difference. There would be no difference in how we would conduct the review of Category II versus Category I.

MEMBER STETKAR: You were pretty careful to say how you would conduct a review. I think what Dennis was asking is will you conduct a review of the seismic Category II structures?

MR. JENG: Yes.

MR. MORANTE: As of right now we're waiting for General Electric to respond to our supplement Reg. Guide RAI 3.7-52. Okay. In that response we expect that they will identify the seismic inputs, the seismic analysis methodologies that they will apply and we will review that. Now understand that as part of our review process we do not review every possible calculation that General Electric has before it. It's a sampling calculation review. Okay.

If we feel that it's appropriate after we review their final response on this RAI that a specific calculation on a tunnel size requalification should be reviewed, then we will arrange with GE to perform that review. As of right now that is uncertain whether we will do a detail review of one of these calculations or not.

MR. JENG: But I have to stress --

MEMBER STETKAR: But at least the Category II calculations are part of your universe for your sample?

MR. SHAMS: Absolutely.

MEMBER STETKAR: Okay.

MR. LIU: This is Ai-Shen Liu, General Electric.

As the applicant we have a -- you know, a different understanding. Our understanding is that for, you know, SRP requirements only applicable to

Category I as far as the design details are concerned. So for Category II structures, yes, we'll commit ourselves to follow the same method of analysis of acceptance criteria as Category I. But it is our understanding that, you know, we do not have to provide the same level of details as Category I structures for Category II.

MR. JENG: In term of qualification QA/QC and procurement --

MR. LIU: No, that's not part of what I'm asking you. For instance that for the Category I structures we have a document in detail the analysis performed in the DCD. Okay. It is not in our plan to include the same level of details for Category II in the DCD. It has been our understanding as last week we commit in DCD for the requirement aspects of the design, but that will be sufficient without having to provide details of the analysis.

MR. JENG: Okay. You may already provide less detail in the submittal, but you are clear that your analysis method, modeling, acceptance criteria for those Category analyses are identical and equal to those which are required and implemented --

MR. LIU: Yes, that was our design --

MR. JENG: But are not done clear cut, right?

MR. LIU: That will be our design requirement.

MS. CUBBAGE: I think by us doing our audits and our confirmatory calculations on a sample and the fact that they're using the same methods would give us assurance that we understand their techniques. And I understand what GE is saying that they wouldn't be intending to provide that level of detail in DCD. Of course, the staff if we had any concerns, we have the option to audit anything we need to.

CHAIRMAN CORRADINI: Move on.

MR. JENG: Okay. On RAI 63. And this one pertains to the firewater surface complex. And GE propose some sort of arbitrary way of trying to define the surface response spectra by multiplying a vector of 1.35 to the foundation input spectra as their basis for their input design to the structure, service firewater, service complex structure. And the staff feels that we need more clarification on how this 1.35 can perform. So we are asking more rationale about the way they jacked up this 1.35 vector. And also, we want to know more about their methodology analysis which are intended for the firewater service complex as well as the other surface spectra plotting which we think they should provide.

So these are additional information we have discussed with GE on the conference call earlier, and they understand what is needed. And, again, as a reviewer I would like to indicate that resolution of this issue is not that difficult and it should resolved in due course.

So these are the two still open RAIs. The rest, 62 RAIs have been interacted and evaluated and discussed and they're resolved.

And so this summarizes my presentation about 3.7. And I am subject to your questions.

CHAIRMAN CORRADINI: Questions? Okay.

MR. JENG: Thank you very much.

MR. PATEL: Samir Chakrabarti is our reviewer for Section 3.8. And he's going to make the presentation on 3.8.

MR. CHAKRABARTI: Okay. Thank you, Chandu.

I am Samir Chakrabarti. I am with NRO Division of Engineering.

I reviewed Section 3.8 and we had Brookhaven National Laboratory helping us with the review and performing audits and confirmatory analysis. They have been included also here with us today.

The regulatory guidance and standards that were used for this review are listed over here, which is GDC 1, 2, 4, 5, 16 and 50.

And the ASME Section III, Division 2, "Code for Concrete Containment."

ASME Section III "Class MC Components" were used for the steel components of the concrete containment.

Appendix B was the quality assurance criteria.

Regulatory Guides used 1.94, 1.57, 1.136, 1.142 and 1.143. And these are the guidances provided for design of the concrete containment with Category I structures, internal structures, et cetera.

ACI 349 the code for nuclear safety concrete structures.

QA and ANSI/AISC N690 for the steel structures.

Now the review highlights. We reviewed Section 3.8 and Appendix 3G. 3.8 has the description, it is there, and Appendix 3G contains the design detail information.

Along with that we also referred to the appendices that were referred in these appendices Appendix 3G for getting the loads and stuff for the concrete containment and the other Category I structures.

Section 3.8 is really a big section. It documents the design for all Category I structures. And we reviewed quite a few calculations. And we had four design audits that we have done so far. We are planning to have one more next week. And hoping to get in a better shape than we are right now. I'll talk about that later.

We also had performed a confirmatory analysis of the containment basemat. We really did not do a confirmatory analysis of the whole nuclear island structure, but we took a small -- we took the basemat up to a certain height and into TRUMPA in model code analysis just because of the resources that is there so you could compare the confirmatory analysis.

One item that I would like to mention is that majority of our review questions required additional technical information which resulted in significant enhancement of the DCD content.

The way when we had the first initial review of the DCD the main 3.8 Section had about 51 pages in that section and the Appendix 3G had about 245 pages.

When we started the review we saw that a lot of information, technical information that we think should go into the DCD but are not quite there. So a lot of our RAIs really asked for more information and more information. And GE was very good in responding to those. They provided the added stuff, significant in the DCD. And as of revision 5 Section 3.8 has 71 pages, which is 50 percent more than what we had before.

And Appendix 3G instead 245 is now 380 pages. It has a lot more schedules and design results included in Appendix 3G.

And also another thing is that in our review one of the reasons that it has taken us the time that it has taken is that the design has really gone through some kind of evolution. As we went through there were changes in the design and it had to go back to review those. Some of the stuff that we reviewed go back, *10:37 we had to go back and review them again.

Examples are like we need firewater service complex that was added in Revision 4 we did not see before. We still have not looked at it. We plan to look at it and some of the details.

The reclassification of the turbine

building, we thought we were good with the turbine building when it was called Category II. Then it was categorized as nonsafety. And that brought us into some of the issues of interaction of that building with the other Category I structures, how it is going to be addressed.

And changing the liner with GE which has come up in Revision 5. We're just about to look sometime before Revision 5 was issued. And we already have some questions about this changed material.

The PCCS reclassification is a real issue. It was not part of the containment boundary. Now it has been included as part of the containment boundary and that raises some questions about how this is going to be handled.

CHAIRMAN CORRADINI: Can you expand on that? I thought when we first had a presentation about this that it was part of the containment boundary?

MR. CHAKRABARTI: Before Revision 4.

CHAIRMAN CORRADINI: Oh, not before Revision 4? Excuse me. Okay.

MR. CHAKRABARTI: That was done in Revision 4.

CHAIRMAN CORRADINI: And the two questions are? It raises two questions.

MR. CHAKRABARTI: No. I said there are questions about it how it is going to be handled, like which code to apply to it.

CHAIRMAN CORRADINI: Oh, excuse me. I see.

MR. CHAKRABARTI: Yes. Now it's a boundary. We have defined design requirements for the containment boundary and the *10:39 internal piping and all those stuff.

CHAIRMAN CORRADINI: Does this go back to the question that I didn't understand from the staff where you wanted to have isolation valves on the --

MR. CHAKRABARTI: No.

CHAIRMAN CORRADINI: Okay.

MS. CUBBAGE: Well, it's not his question, but it's someone else's question, absolutely.

CHAIRMAN CORRADINI: It all revolves around -- just so I'm clear.

MEMBER SHACK: Whether it's containment or not?

CHAIRMAN CORRADINI: Yes. It all revolves around whether it's part of containment or not, right? It's philosophically in the same bailiwick?

MR. CHAKRABARTI: Yes, probably. We are trying to find out since the containment boundary there have no requirements for special testing and which code to follow. Like we usually used Class MC for a containment boundary, whether that Class MC is going to be used or not or some other *10:40 will be used for it. Those are the issues we need to resolve.

CHAIRMAN CORRADINI: So this is still in discussion?

MR. CHAKRABARTI: It's a very -- in discussion.

MS. CUBBAGE: Right. It started with the isolation --

MR. CHAKRABARTI: The one thing to use this --

CHAIRMAN CORRADINI: Right. Thank you. Thank you very much.

MS. CUBBAGE: It started with the question on the isolation valves and has now migrated more into this area technically because of the --

CHAIRMAN CORRADINI: Just for the sake of those that are old and remember that, whatever happened with the isolation valve part of it?

MS. CUBBAGE: It's still open.

CHAIRMAN CORRADINI: Okay. Thank you.

MR. CHAKRABARTI: Now the review status, we had so many open items I did not list the numbers.

We have total 123 RAIs. I'm sorry. The RAIs. Total 123 RAIs we had. We had resolved a majority of them. We still have 19 RAIs that are still open. And one of the purpose of the audit that we are doing next week along with looking at some calculations, we want to have face-to-face discussions on some of those open items. Because some of them have gone through like part of four supplements and I'm having a feeling that we are not probably -- probably getting well. Because there are aspects on some things, not getting the response what we are looking for, they are writing that will help resolve that and bring the open issues to conclusion somehow.

And the confirmatory analysis has been completed. And we have concluded that the computer analysis GE has performed for analyzing the Category I structures, they are adequate. And in general we have a good conformance with our analysis and the analysis that GE has performed.

And I talked about the issue of design audit.

Now out of the 19 total open items I didn't want to -- not all of them are really -- a lot of them are on details issues and I didn't want to talk about the details of why this stress did not match that, and that kind of issues we have quite a few.

I wanted to talk about only of the major ones --

CHAIRMAN CORRADINI: Good. We appreciate that.

MR. CHAKRABARTI: Thank you. Major ones that I think we need to discuss in this meeting.

RAI 3.8-107. It has a lot of other issues regarding, like, the details that I talked about. But the main issue that I want to talk about is the applicant has done thermal analysis and a thermal tracking analysis as GE already presented in their section. But during our review what we noticed that the thermal tracking analysis, it has reduced the thermal moment significantly, which --

CHAIRMAN CORRADINI: Could you repeat?

MR. CHAKRABARTI: Thermal moments. And in thermal moments, which give us the impression that there has been significant nonlinear behavior in the structure.

And then we are interested in the stresses from the other loads which are calculated elastically and we are using this superposition to add those stresses to get the final. And our concern is, is it appropriate to use elastical linear and elastic and *10:43 results with the nonlinear *10:43.

And GE, we asked this question. And GE has provided an answer to that. We received that recently. We have not yet completed review of that one. We hope to discuss this during the audit.

I think what we had asked for they did. I went to audit and did glance through it. They did compare like using the other loads. I shouldn't say other loads, the special loads, also they used a nonlinear analysis and combined the thermal nonlinear analysis and tried to show that it's not very different. But on my first look I thought I saw that this which we will still need to look into it.

So that is the kind of issue on this one. The significant nonlinear. Because this thermal moment they use it reduces some places in cases, but major reduction.

RAI 3.8-79, this is about -- primarily came from the reclassification of the turbine building and also we had radwaste building, which is designed to another Category area. This is not Category I, it is not Category II. It has it's one Reg. Guide 1.143, which is a different seismic design criteria which says that if you design it under this criteria, it will be okay. But does not quite satisfy whether it will meet the safety interaction criteria that is laid out in Section 3.7. I believe it's 3.7.28 or something.

MR. PATEL: Yes, it's 3.7.28.

MR. CHAKRABARTI: Yes. 3.7.28. And we had a question about that one how they demonstrate that because these buildings are located close towards nuclear island building, safety *10:45 the turbine building and the radwaste building.

So that is one of the issue that we plan to resolve.

MEMBER BLEY: Let me just ask a question, or ask me one. The difference between what we just heard on Chapter 3.7 and what you do on Chapter 3.8 is that 3.7 was a review of the analytical methods and 3.8 is really looking structure-by-structure to say did --

MR. CHAKRABARTI: Absolutely.

MEMBER BLEY: --they apply the methods appropriately to each structure? Is that fair?

MR. CHAKRABARTI: Little bit different. What 3.7 does, like the main structure it says that because of seismic determines what will be the response of the structure to the ground shaking. It stops about there.

MEMBER BLEY: So it's the response analysis, where this is --

MR. CHAKRABARTI: The response analysis, yes. And this 3.8 designs the structure with the response that is obtained from 3.7.

MEMBER BLEY: Okay. And it's an audit of how well they follow the rules and --

MR. CHAKRABARTI: How they apply all the rule, they obtain results of 3.7 applies those loads to -- and model of the structure and determines the detailed forces and moments in the structure itself.

MEMBER BLEY: Okay. Thanks.

MEMBER BROWN: How can you do the first if you don't have a design?

MR. CHAKRABARTI: The structure response?

MEMBER BROWN: Yes. If you don't know what the design is, how can you do what 3.7 was doing before you --

MR. CHAKRABARTI: The action of the structure, mass and stiffness properties, they have actual dimensions at least. They file for completion. Because to determine the response -- when you say you don't have a design it's not that there is nothing there. Design is the first like you *10:47 something and then verify it with the actual notice.

In 3.7 we assume the structure shape, size, stiffness and in those discover the thermal the size response.

MR. BRAVERMAN: Excuse me. This is Joe Braverman from BNL.

I'd also like to add I agree with what you said. When you go to the design stage and you use the seismic loads and apply it to the structure and you design the building, usually you're not going to change your thicknesses. If it turns out the loads a little too high, you may additional steel enforcement. And that would not negate the assumptions in the seismic analysis.

If it turns out you do have to make the walls thicker, then you may have to iterate another time.

MEMBER BROWN: Okay. So fundamentally the building, there is a design of the building.

MR. BRAVERMAN: A preliminary design.

MEMBER BROWN: That's fine, yes. And then you go do what 3.7 did and try to develop the response -- the forcing functions and the spectra, blah-blah, all that good stuff. Then if your responses are such that the building break, then you change something. If it doesn't, then you're okay.

MR. BRAVERMAN: Usually you would add more steel enforcement in the concrete.

MEMBER BROWN: All right.

MR. BRAVERMAN: If that's not enough, then you have to change the thickness.

MEMBER BROWN: All right. I just lost the level between 3.7 and 3.8.

MR. CHAKRABARTI: Yes. No. You're right. If in the intend design phase we find that we cannot live with what we assume, we may have to go back and do the 3.7 analysis again.

MEMBER BROWN: Okay. So it's just a little bit more of an iteration back and forth.

MR. CHAKRABARTI: Yes.

MEMBER BROWN: Okay. There's a design to start with. They do the analysis. The spectra. Go back and say is it okay. And you say, yes, it's okay. You do nothing else. If it's not, then you --

MR. CHAKRABARTI: That is correct.

MEMBER BROWN: Okay.

MR. CHAKRABARTI: In RAI 3.8-94. Okay. In this one what we have seen GE has come up with their design and came up with a very large bearing capacity requirements. And our concern was that why is it considered reasonable value that can be met at potential plant sites.

For example, like say like for hard rock the varying capacity requirement for it is 112.8 is for feet per square feet. For medium 152.5 is for square feet. For soft rock 56. **10:50 varying bearing capacity requirements.

As far as we know for very hard rock sites where you may be able to met it, but for medium and soft soil is when these appear to be too high. And we just wanted to find from them how the plant site located in the medium rock or soil site, subsoil site you're going to be able to use this design.

CHAIRMAN CORRADINI: Meaning what?

MR. CHAKRABARTI: Bearing capacity requirements.

CHAIRMAN CORRADINI: Meaning that it's too massive sort of for the soil it's put on? I'm not still understanding your --

MR. CHAKRABARTI: Yes. Yes. The structure that we put on the soil requires soil to have a minimum bearing capacity of that much, which is not a reasonable value for soft and medium soils.

CHAIRMAN CORRADINI: Requiring a bigger footprint to make it -- okay.

MR. CHAKRABARTI: Yes. To bring down the soil bearing capacities, you need a bigger footprint.

MEMBER BROWN: You want to distribute the load over a greater area?

MR. CHAKRABARTI: A greater area. And what we are saying that for very hard rock sites probably the design should be okay. But it will not be useable for soft and medium soil sites. That is our question. They may have an answer. We don't know. We find out.

MEMBER BROWN: So the --

MR. LIU: This is Al-Shen Liu, GEH again.

Yes. You know, we agree with you. Our bearing demand are high. Okay. Because that's the price we are paying for standard design, you know.

And as far as the applicant -- as far as whether actual -- you know, with standard high demand is concerned, we have looked at our two COL FSARs using ESBWR technology. One is North Anna, another being Grand Gulf. North Anna is the rock site. Grand Gulf is soil site.

Based on what information they presented in the FSAR, you know, their incapacity are higher than our demand values.

MEMBER BROWN: At which site?

MR. LIU: Both. North Anna and Grand Gulf.

MR. CHAKRABARTI: Not that the rock site, it shouldn't be a problem. Grand Gulf we have to look at it. Well, it's just a question that we had. And like I said, they'll have an answer.

MEMBER BLEY: Is this something you have commented on and I missed in the SER or you intend to put a condition like that on sort of --

MS. CUBBAGE: No. The bearing capacity is a condition of the certification. It's the responsibility of the COL applicant to demonstrate that they fall within that criteria, the site --

MEMBER BLEY: In terms of the capacity, not in terms of the language that we don't think this is good for a soil site?

MS. CUBBAGE: Yes. I don't think that he said that. I think that he had concerns with the site parameter being bounding of the sites that would be expected to try to use an ESBWR. And I think what you just heard from GE is that the two COL applicants that have applied, their site meets this parameter. So I think GE's formally responded to this RAI--

MR. CHAKRABARTI: Currently a lot of sites will not be able to meet these.

Okay. RAI 3.8-96 the staff requested GE

to explain some of the assumptions made for evaluation of sliding resistance of foundation. And they have raised such concerns as I understand, and which we have some questions like in evaluating sliding resistance the -- water pressure has been considered and we thought the water pressure really should not be included to provide sliding resisting because it probably will be both sides of the building.

And the assumption of static coefficient of friction along passive soil resistance in our mind that's not a conservative assumption because before you can engage the passive resistance of the soil, you probably need to have slight movement of the foundation before engages passive resistance from soil. And for that it's probably more appropriately the dynamic coefficient of friction instead to static cohesion, which is like less than static.

And also considering additional sliding resistance due to cohesion. This part we also want to talk with them like if cohesion is used for sliding resistance, that probably should be also a site parameter -- into the site parameter.

Another area, 3.8-120. GEH has recently proposed the use of ASTM A-709 HPS 70W material for the containment liner. This material is different than what GEH had up to Revision 4, which is SA-516 material, which is about 38 psi and the 709 material is -- has a yield of 70 psi.

Now because of these two, we just want to ask them how it effects their analysis that they have done. And also to what extent are they using. It's not very clear. It looks from the -- we verified that it's a generic statement of an alternate material which someone can use for the internal linear. Whether it is being used for the internal liner or is it being used locally for attachment, which they have with the main tunnel structures, A-709 structure members, that's the question that we have asked them asking how it impacts the analysis of the containment.

MEMBER ARMIJO: Well, I presume GEH has a reason for proposing a stronger material. And I hope it would have, presumably, good ductability, but --

MR. CHAKRABARTI: Yes.

MEMBER ARMIJO: -- can anybody tell me what those reasons are?

MR. LIU: Yes. This is Ai-Shen Liu, GEH.

The reason we have to use this material originally is because of the concern of using this material as an attachment to the containment liner. Because existing CC material list does not include this particular material as a permitted attachment material. And we intend to use the material for measure containment internal structures. So that's how we started with this code case process.

MEMBER ARMIJO: So that's ongoing?

MR. CHAKRABARTI: Yes.

MEMBER ARMIJO: In that code case.

MR. LIU: The code case is, you know, supposedly to get a final approval from ASME and get published in two weeks. It's getting there.

So in this code case we stated, you know, this code case because this particular material has been commonly used as a bridge material, has been tested extensively. And we also did additional tests to confirm the adequacy of the material behavior, especially in the aspect of welding. An we determined that this material does not have to do a post-weld heat treatment at all.

So in the code case we say okay if you wanted to use this material to not post-weld heat treat.

And the application of this material as a linear in all these lines very limited. We do not intend to apply this material to the entire containment. Because this material is quite expensive relative to 516. And we only intend to use this material at two locations where the measured internal structures are attached, mainly the diaphragm floor and the van wall joint with the pedestal.

So these particular locations, the liner materials not only serve as a leakage barrier for the containment, the other function really is the structural function to provide adequate load transfer from the attachment into the concrete.

MEMBER ARMIJO: ASME?

MR. LIU: Yes, And so that's why we, you know, we have this code case and we intend to use as a per limited location instead of entire containment.

MEMBER MAYNARD: It sounds like -- is this a recent change? What I'm really going to is your analysis, your containment analysis, was it done with the new material factored in or was it done with the 516?

MR. LIU: From analysis point of view since post-516 and this A-709 are both carbon material. So in analysis itself at a liner, we only considered *11:01 and the Poisson's ratio. And those value are identical between the two materials.

MEMBER MAYNARD: It's only the --

MR. LIU: Yes. Yes. The activity is in

several analysis slightly lower than 516, you know. Twenty-one percent versus 19 percent.

MR. CHAKRABARTI: Yes. And that was part of the question that we had in this RAI. The DCD Revision 5 when it was introduced to use this material. It does not spell out where they are using it like he explained. It probably should go in the DCD.

And also since the analysis has not been done with this material, and I agree with him if it is locally used, it will not have significant or layer impact of the analysis. So once they clarify those things, it probably should be okay.

But sure enough, the analysis should represent what has been used.

MR. BRAVERMAN: Excuse me. This is Joe Braverman.

I just want to add one little thing there. Not only does ASME code have to approve the code case, but also typically the NRC reviews code cases and has to endorse them. So there are several more steps to go.

MR. CHAKRABARTI: That is true.

Okay. That's what I plan to present today. And if there are any questions, I'll answer. If

I cannot, I'll seek help from BNL.

CHAIRMAN CORRADINI: Okay. Questions from the Members? Okay.

Well, thank you very much.

MR. CHAKRABARTI: Thank you very much. I appreciate.

CHAIRMAN CORRADINI: So this concludes the day's events.

MS. CUBBAGE: The one thing I would ask from the Committee if we could get some guidance on the full Committee meeting, what topics you would be interested in hearing. You obviously heard some very detailed presentations from the staff and GE over the last day and a half. And when we come back for full Committee there's not a lot of time. And I know it's been dissatisfying in the past, the level of detail that was presented at the full Committee. So we'd like to come with something that is satisfying. And if you could identify topics you're interested in hearing, that would help us.

CHAIRMAN CORRADINI: Are we off the record? We're not. Okay. Fine. Just let it go.

I had a comment, which is you'll never satisfy us so there's no point in trying. But I think your question is a good way to go around the table to see comments by the day and suggestions relative to what you want to hear in the full Committee for our colleagues that haven't been here, but are probably --

MS. CUBBAGE: Right. Because they won't have the benefit --

CHAIRMAN CORRADINI: -- dying to understand.

MS. CUBBAGE: They won't the benefit of the last day and a half. So we need to use the time wisely at the full committee.

CHAIRMAN CORRADINI: Right. Jack, let me start with you this time, if I may.

MEMBER SIEBER: Yes. I think that it would be worthwhile to go through the classification systems. And particularly why the various systems are chosen the way they are, you know, Cat I, Category II and that. And from a design standpoint why that's important. And the fact that most of the issues that are pointed out.

I also believe that the seismic issues are interesting and important in light of recent events. And I think that that's pretty well along and pretty well understood by the applicant and the staff. And so I would include that.

I think it would be interesting to include a discussion of the steps that are being taken by GEH on steam dryer integrity, not a departure from current practice, it is an extension of it and has value, not only for ESBWR, but for current plants.

And I think those are the -- you only have like two hours.

CHAIRMAN CORRADINI: Correct.

MS. CUBBAGE: Right.

MEMBER SIEBER: And I think that would be about it.

MS. CUBBAGE: On the dryer, I'd like to propose that the staff has not issued RAIs yet on the PBLE method. So it probably would be appropriate to defer that to a later meeting and not attempt to get into a lot of detail at the full Committee, which will happen before we issue our RAIs.

CHAIRMAN CORRADINI: Okay. That sounds fine.

MEMBER BROWN: Just an expansion. For an electrical guy, the seismic discussion this morning not only just on the categories, which you brought up, but the curve, the methodology of the curves, the double-hump. That was a very good -- at least, you know gives me a good boundary conditions within which this thing is being considered. I don't know what the expertise of the other people -- well, I know some of it, but I know I'm way down the fire curve on it. So that was a very good discussion relative to the reasons and the questions were good. So I thought a little bit of an elaboration on that along with the categorizations.

MEMBER SIEBER: The Committee has already had discussions and meetings on the characterization including the soil structure underneath and the holes and the impact of Charleston and liquified soil findings and so forth. So the Committee does have some background there and --

CHAIRMAN CORRADINI: Certain Members of the Committee. I'm more in his camp.

MS. CUBBAGE: Right. But I would say that the actual curve itself was presented in Chapter 2 as far as that being the site parameter for anyone who was there.

CHAIRMAN CORRADINI: For good educational purposes, in other words.

MEMBER SIEBER: Yes. Review is not a bad thing.

MEMBER BROWN: I'm not saying you should spend two hours on it. I was really referring to the summary of the double-humps and the under -- the lower curve and this .3 versus .5, whatever Bill called it, anchoring on the -- at the 100 Hertz --

MEMBER ARMIJO: It would help a lot, I think, if somebody would just make a better figure showing how this double-hump is created. There are actually two different spectra and they're combined. And that makes it a lot easier to understand.

CHAIRMAN CORRADINI: That or a blackboard.

MEMBER STETKAR: Well, there is a figure in Chapter 19 that shows that it was a finite enveloping curve.

CHAIRMAN CORRADINI: Yes, right.

MEMBER STETKAR: But that piecemeal assembly would kind of be nice.

MEMBER SIEBER: The argument though is a practical curve versus a regulation curve.

MS. CUBBAGE: Right. The how it was constructed, I'm sure that's easy.

MEMBER BROWN: Yes, the other we understand. The other piece was the interesting discussion on the pools and the impact of those pools on the structure relative to the seismic response. That was things they'd considered. Again, not very detailed, but it has been considered and there are some factors in it. If that's already done, I didn't know because I wasn't here for the previous meetings.

MS. CUBBAGE: No, it hasn't.

MEMBER BROWN: So that seemed to me a different throw in relative to just these big buildings that are sitting there that are getting shaked and baked. That's my thing.

CHAIRMAN CORRADINI: Dennis?

MEMBER BLEY: I would like to start with a thank you to GEH and staff. The last two days have been very helpful for me.

I agree with all that's been said, and there are three little things that I think if they could be added in as part of the presentation, we eventually got to them through questions, it might make things smoother and they're going to come up anyway.

One was eventually someone on staff gave us a little story about how the staff looked to the PRA and importance measures to see if equipment should be added to the classification list. May as well start with that, because it'll come up.

The other one that was finally addressed was how staff verifies the EQ certification including looking at the complete test histories and the walkdown of the plant. I think that's a very important issue. It just ought to be right out front.

And I kind of hate to say it, we had the little discussion on the curve that's used in the seismic margins analysis and the disagreement, even though that's not what this is about. That one will surely come up. So if there could be a little tight presentation on that and what the objections are, it might save time.

CHAIRMAN CORRADINI: Take that under advisement.

MEMBER BLEY: Well, yes. We have separate meetings on the PRA, but it's for sure going to come up if we're talking about those curves. So just get on it ahead of time might save some time.

MEMBER BROWN: Yes, I meant to include that subset that he mentioned also.

MEMBER BLEY: And it's not seismic PRA. It is margins analysis.

MEMBER BROWN: No, margins analysis. It's not in the PRA.

MEMBER SHACK: It's a PRA based seismic margins analysis.

MEMBER STETKAR: It's a seismic margins analysis. It is not --

MS. CUBBAGE: How about if we don't mix

applies and oranges? Maybe the seismic margin discussion we can come back to August.

MEMBER BLEY: I'm sure that's fine, but it'll come up from a couple of our other Members who are not here today.

MEMBER STETKAR: Well, because we may not have time in August the way that we're planning --

MS. CUBBAGE: Well, we're not going to have time on July 8th or 9th either.

MEMBER SIEBER: Well, maybe it won't come up.

MEMBER STETKAR: Just satisfy the other Members.

MEMBER SIEBER: Well, the Chairman will decide what will be discussed.

MEMBER ARMIJO: I'll blame you.

MEMBER STETKAR: That's fine. Blame me. I'll take responsibility.

MR. VANDER MOLEN: Dennis, could you please repeat your middle point? I got your first one and your third one, and I'm writing full blast here.

MEMBER BLEY: Toward the end yesterday, and I forget who it was, one of the members of staff stood up and explained how staff verifies the environmental qualification including how they go to the site, they go through the complete test histories. That those test histories include the failures and successes and what was done to the equipment. And then they walk down the site to verify that the orientations are in agreement with those in the tests.

CHAIRMAN CORRADINI: And just to emphasize the point. I can't remember the staff member either.

MS. CUBBAGE: It was Paul Shemanski.

CHAIRMAN CORRADINI: Shemanski. And his point was this is one of the last things that is done because you have to see it in the as-built condition.

MEMBER BLEY: Exactly. But that it is a thorough review of all those issues.

CHAIRMAN CORRADINI: Okay. You got it, Harold?

MR. VANDER MOLEN: I got it, yes.

I take these things independent of the transcript.

CHAIRMAN CORRADINI: Sam?

MEMBER ARMIJO: I don't have anything to add. I think that's plenty of comments.

I agree with the prior --

MEMBER SHACK: Yes, I mean I think it's going to be very difficult to get through this. I'm just trying to think how this can be done.

And I think I'm sort with Dennis. I would emphasize the number of audits that have been done, the confirmatory calculations, the depth of the review.

It didn't come across almost until the last day here. And I think, you know, I think that helps everybody's degree of confidence in the system. There's an awful lot to grasp here.

And, again, I think the classification is important. And I'd even like some clarification because I don't think you used importance measures. At least as I understand RTNSS requirements they're not in there. That was Tom's wish list of how it would have been classified, but I don't think it really was done that way.

And I don't think that's a discussion here. That's a different discussion.

MEMBER BLEY: One of the staff members did give an example of things that they brought forward and requested being appropriate, unless I misunderstood what was said.

MEMBER SHACK: We'll find out.

CHAIRMAN CORRADINI: We'll find out. But good luck.

MEMBER MAYNARD: I have no earthshaking

addition to suggest.

MEMBER STETKAR: I don't either. Nothing. Nothing. Everybody said it all. In this classification that's good enough.

CHAIRMAN CORRADINI: I guess I wanted to thank the staff and GEH for their presentations. I think it was actually quite thorough.

I guess the one thing I was going to say is that maybe it was where it sits amongst all the other chapters, it came through much more clearly on both the GEH side and the staff side on how much you've talked, done audit calculations, done comparative calculations, had a conversation about things. And you apparently at least see from the most part a path forward with the open items and how you want to approach them, however significant they might be. I guess it might be just where this is all placed relative to the other chapters, but I think that came through. I really appreciate it on both sides.

Other than that, I guess I've gotten everyone else's comments. If there's additional comments you want to send me as I get a draft of a letter to you all about this really fun and very focused chapter, let me know.

MS. CUBBAGE: You are right. And, again,

you know the focus that we've been -- the theme for the previous meetings if you have questions that you don't think are being covered by RAIs or haven't been covered in the review, that's what we're really trying to draw out of this process and make sure they can be addressed. So --

CHAIRMAN CORRADINI: And then I'll talk to you on the side relative to the organization of it with Harold. And if you have more suggestions, I'll gladly take them.

I guess my only thought is with only two hours you'll not satisfy us, so don't try. And we will try to do a better job of staying on track, which we never do. But we will try. Because I do think this is so wide ranging, unless we're very disciplined we'll go nonlinear more than the structures will.

So thanks. Thank you all.

MS. CUBBAGE: And I very much appreciate the Committee's comments and feedback over the last day and half.

CHAIRMAN CORRADINI: Okay. Thank you.

Meeting is adjourned.

(Whereupon, at 11:15 a.m. the meeting was adjourned.)

CERTIFICATE

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

Name of Proceeding: Advisory Committee on Reactor Safeguards

Docket Number: n/a

Location: Rockville, MD

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

Charles Morrison
Official Reporter
Neal R. Gross & Co., Inc.

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 3 – Design of Structures, Components, Equipment, and Systems
(Sections 3.7 and 3.8)

June 18, 2008

U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review
Chapter 3.7 – Seismic Design
David Jeng – NRO/DE/SEB2

June 18, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Section 3.7 – Seismic Design

Regulations and Regulatory Guidance

- GDC 2, 10 CFR Part 50, Appendix A
- Seismic & Geologic Siting Criteria, 10 CFR 100, Appendix A
- Earthquake Engineering Criteria, 10 CFR 50, Appendix S
- Regulatory Guides 1.60, 1.61, 1.92, 1.122
- SRP 3.7, Rev. 3, March 2007

Review Highlights

- Conducted Two Design Audits at GE's Offices
- Performed Confirmatory SSI SASSI Analyses of Control Bldg (CB).
- GE and Staff Used Same Single-Stick Beam Mass Model for CB.
- GE Used DAC-3N and SASSI for Unif. And 4 Layered Sites, Respectively. Staff Used SASSI for 9 Layered Sites.
- GEH and Staff results found to be in reasonable agreement after resolution of RAIs
- 1000 Ft/Sec Min. Soil Shear Wave Velocity Met via Use of Soil Layer-Thickness Weighted Approach

Review Status

- 64 RAIs Issued
- 62 RAIs Resolved
- 2 RAIs Remain open (RAI 3.7-52 and RAI 3.7-63)

ACRS Subcommittee Presentation
ESBWR Design Certification Document Review
Section 3.7 – Seismic Design

Open Items

RAI 3.7-52

For Concrete Tunnels and Trenches, Need Clarification of (1) Seismic Classification; (2) Seismic Analysis Methodology; (3) Piping/Conduits/Ducts Housed in Tunnels and trenches; and (4) Seismic Input Motion Applied at the Surface.

RAI 3.7-63

For Layered Soil Cases, Define the Seismic Response Spectra at the Surface; Define Basis for Selecting the Surface Spectra for Analysis of the Fire Water System Complex (FWSC); Define Corresponding FWSC-Related COL Applicant Action Items.

ACRS Subcommittee Presentation
ESBWR Design Certification Document Review
Section 3.7 – Seismic Design

Open Items

RAI 3.7-52

Provide Seismic Classification and Analysis Methodology for Each Concrete Tunnel and Trench

Describe Seismic Category I FPS Yard Piping, SC I Elec. Conduits/Duct Banks, and SC RW IIa Radwaste Piping Supported in the Tunnel and Trenches.

Define Seismic input Motion at the Surface, Consistent with the Single Envelope Design Response Spectrum Defined at the Bottom of the RB/FB Foundation

ACRS Subcommittee Presentation
ESBWR Design Certification Document Review
Section 3.7 – Seismic Design

Open Items

RAI 3.7-63

GEH needs to submit a comparison of (1) the surface spectra derived by placing the input motion at the bottom of the RB/FB foundation to (2) the surface spectra derived by placing the input motion at the bottom of the CB foundation, for each of the 4 SASSI layered soil cases.

GEH needs to (1) re-assess its method for selecting the surface spectra for seismic design of the FWSC; (2) provide the technical basis for its selection (including the basis for the selection of 1.35 amplification factor); and (3) identify the necessary COL applicant action items to ensure the seismic adequacy of the FWSC at each site.

ACRS Subcommittee Presentation
ESBWR Design Certification Document Review
Section 3.7 – Seismic Design

<u>Open Items</u>

RAI 3.7-63 (continued)

GEH can define any surface spectrum it chooses to, for design certification of the FWSC. COL applicants will need to demonstrate that the site-specific surface spectrum is enveloped by the spectrum GEH has used for design certification of the FWSC.

Otherwise, a site-specific analysis of the FWSC will be required at the COL stage. This will be in addition to the required comparisons at the RB/FB and CB foundation levels.

The surface spectra used for seismic analysis of the FWSC should envelope the 8 surface spectral plots that the staff has asked GEH to submit as a supplement to its RAI 3.7-63 response.

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Presentation to the ACRS Subcommittee

ESBWR Design Certification Review

Chapter 3.8 – Seismic Category I Structures

Samir Chakrabarti – NRO/DE/SEB2

June 18, 2008

ACRS Subcommittee Presentation
ESBWR Design Certification Review
Section 3.8 – Seismic Category I Structures

Regulations and Regulatory Guidance

- GDC 1, 2, 4, 5, 16, and 50
- ASME Section III, Division 2, Subsection CC, "Code for Concrete Reactor Vessels and Containments"
- ASME Section III, Division 1, Subsection NE, "Class MC Components"
- Appendix B to 10 CFR Part 50, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants"
- Regulatory Guides 1.94, 1.57, 1.136, 1.142, 1.143
- SRP 3.8.1, 3.8.2, 3.8.3, 3.8.4, and 3.8.5
- ACI 349, "Code Requirements for Nuclear Safety related Concrete Structures"
- ANSI/AISC N690, "Specification for Safety-Related Steel Structures for Nuclear Facilities"

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Review Highlights

- Performed four design audits to review design reports, review calculations, and discuss open issues
- Performed confirmatory analysis of nuclear island foundation base mat
- Majority of the review questions required additional technical information which resulted in significant enhancement of the DCD content
- Review addressed ESBWR design evolution
  - Structures added (e.g. FWSC)
  - Reclassification of turbine building

Review Status

- Substantial number of issues identified during review have been resolved
- Confirmatory Analysis completed
- 19 RAI's are still open
- Additional design audit planned for week of June 23, 2008 to discuss remaining open items

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Significant Open Items

RAI 3.8-107

In view of significant nonlinear behavior of containment structure due to thermal loading, the staff questioned the appropriateness of combining results from thermal analysis with the elastically calculated results for other loads by linear superposition. GEH response is being reviewed.

RAI 3.8-79

The staff requested GEH to demonstrate that there would be no unacceptable seismic interaction between seismic category I structures and adjacent non-safety structures, e.g., Turbine Building and Radwaste Building.

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Significant Open Items (continued)

RAI 3.8-94

The staff requested GEH to explain why the extremely large bearing capacities reported in the DCD are considered reasonable values which can be met at potential plant sites.

RAI 3.8-96

The staff requested GEH to explain some of the assumptions made for evaluation of sliding resistance of foundation, e.g., considering water pressure on only one side of foundation in resisting sliding, assumption of static coefficient of friction along with passive soil pressure, considering additional sliding resistance due to cohesion.

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Significant Open Items (continued)

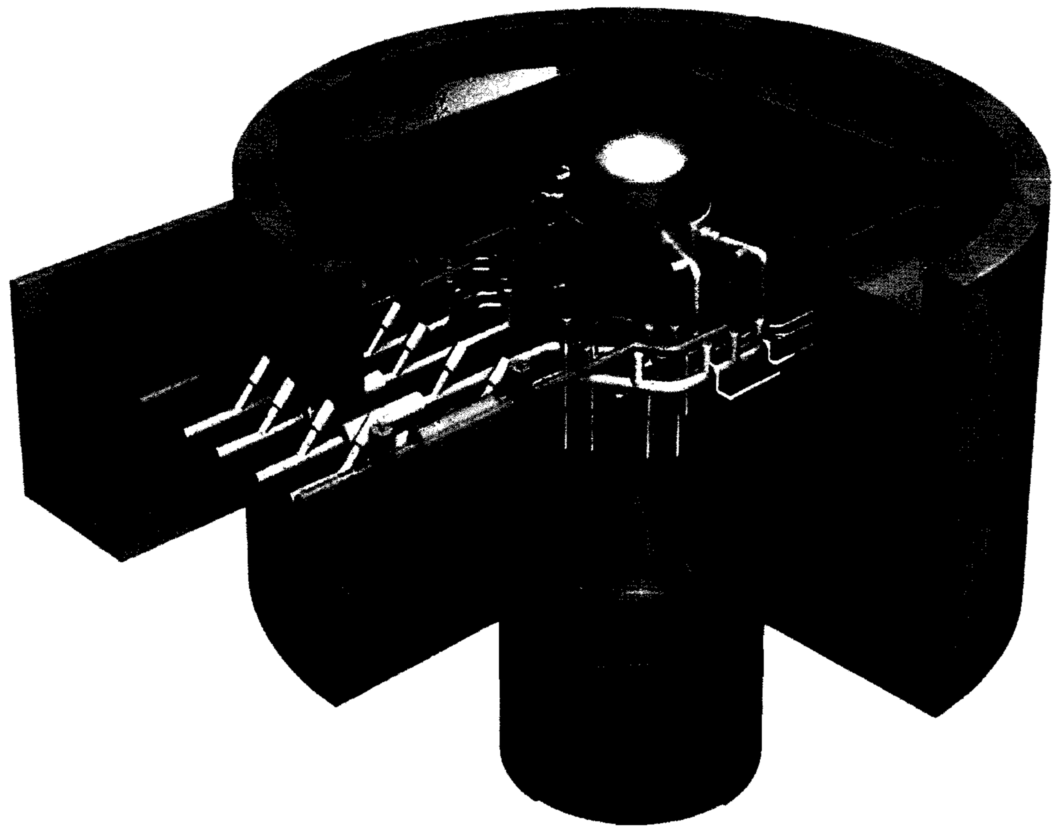
RAI 3.8-120

GEH has recently proposed to use ASTM A-709 HPS 70W material for containment liner as an alternate to ASME SA-516, Gr.-70 which is not yet approved by ASME or endorsed by NRC. Additionally, the staff requested GEH to explain how this material with much higher yield strength affects the analysis and design of the containment.

ESBWR DCD Chapter 3 Sections 3.7-3.8

Seismic Design & Seismic Category I Structures

Advisory Committee on Reactor Safeguards



Ai-Shen Liu
Clement Rajendra
Jeffrey Waal
June 18-19, 2008
GE Hitachi Nuclear Energy

Presentation Content

- Chapter 3, Sections 3.7-3.8 Overview
- Section Descriptions
- Summary

Chapter 3, Sections 3.7 – 3.8 Overview

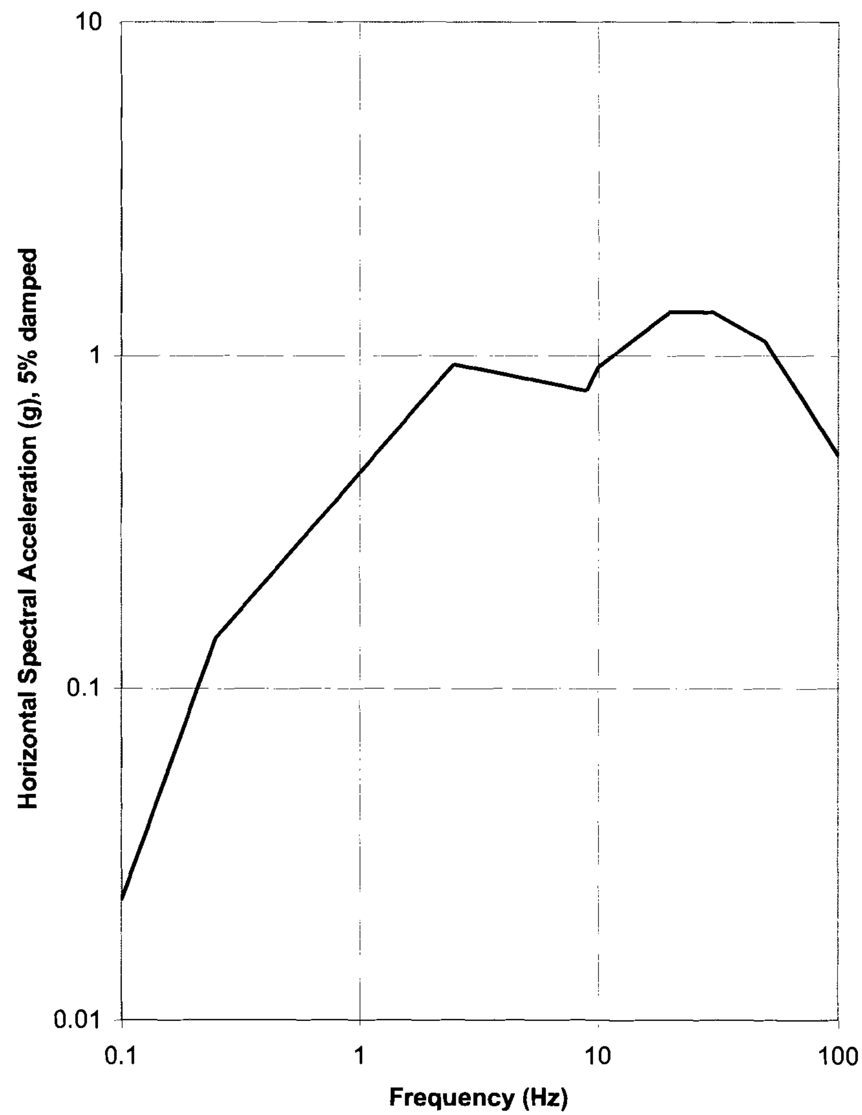
- Chapter 3 describes the design of structures, components, equipment and systems.
- Section 3.7 describes seismic analysis methods for designing structures, systems and components to withstand the effects of the Safe Shutdown Earthquake (SSE).
  - > The Certified Seismic Design Response Spectra (CSDRS) for the ESBWR Standard Plant is an envelope of RG 1.60 spectra and North ESP Anna site-specific spectra.
  - > The effects of Reactor Building vibrations caused by suppression pool dynamics are also considered in the Reactor Building complex design using methods applicable to seismic design.
  - > Seismic Category II structures are designed using the same methods of analysis and design as Seismic Category I structures, however, procurement, fabrication and construction are in accordance with industry practice.

Chapter 3, Sections 3.7 – 3.8 Overview

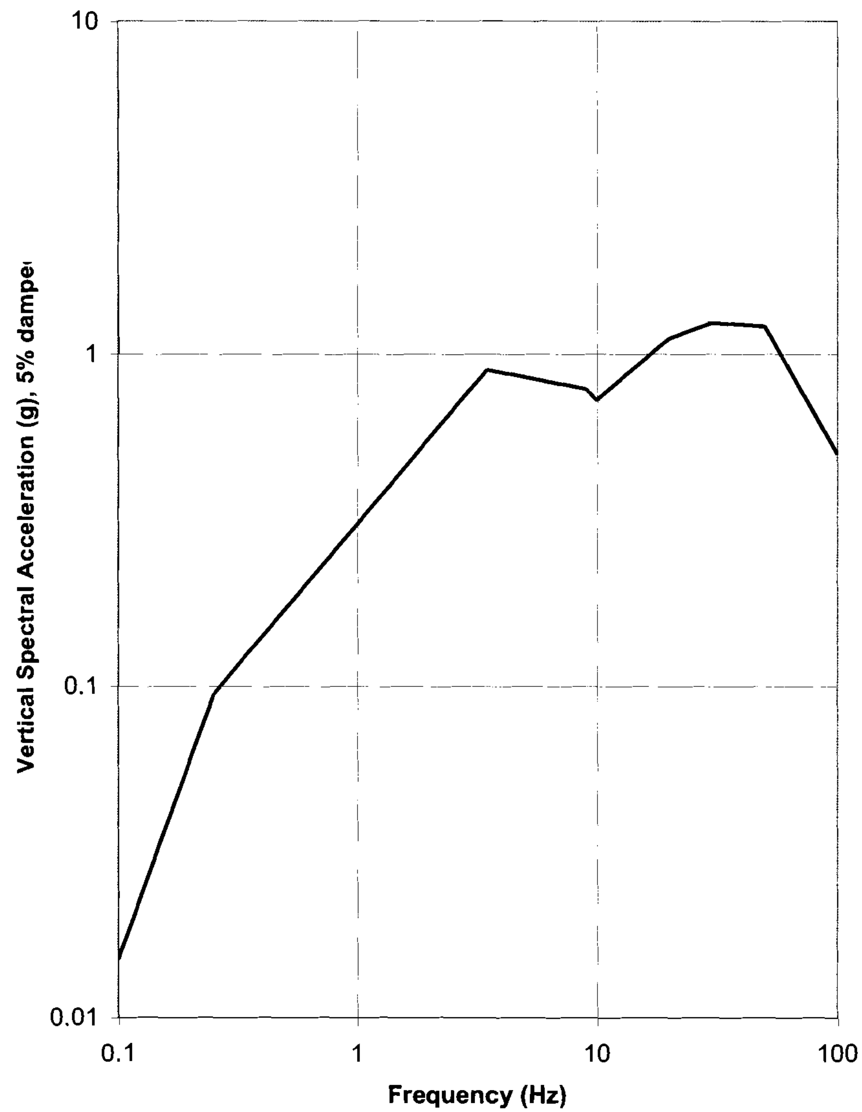
- Section 3.8 describes loads, loading combinations and Acceptance Criteria for designing Seismic Category I structures.
  - The Seismic Category I structures include the Concrete Containment and internal structures, Reactor Building/Fuel Building, Control Building and Firewater Service Complex.

Section 3.7 – Seismic Design

- Section 3.7.1 provides seismic design parameters.
  - >The CSDRS follows RG 1.60 spectra and North Anna ESP site-specific spectra at high frequencies.
  - >North Anna spectra is representative of most severe rock sites in the Eastern US.
    - Note: No recorded seismic event contains simultaneously very high low-frequency and high-frequency motions. CSDRS is very conservative.
  - >Artificial time histories were developed to match the CSDRS spectra per NUREG/CR-6728 criteria.



ESBWR Horizontal SSE Design Ground Spectra at Foundation Level



ESBWR Vertical SSE Design Ground Spectra at Foundation Level

Section 3.7 – Seismic Design

- Section 3.7.2 discusses seismic system analysis.
  - > Applies to Reactor Building, Fuel Building, Control Building and Firewater Service Complex.
  - > The Reactor Pressure Vessel is considered a part of the Reactor Building for the purpose of dynamic analysis.
  - > Lumped mass stick models are constructed of the structural systems for seismic response analysis of primary building structures. Adequacy of stick model is confirmed by a finite element model.
  - > Seismic soil-structure interaction analyses of Category I buildings are performed for a range of soil conditions and are presented in Appendix 3A.

Section 3.7 – Seismic Design

- The soils for uniform sites are represented by soil springs at base without embedment effect and SSI analysis performed using DAC3N computer code

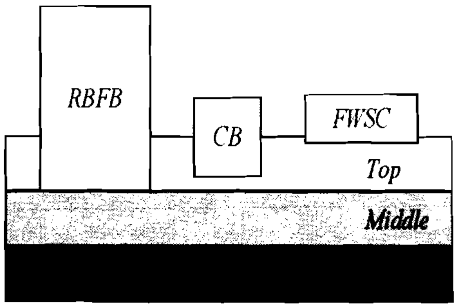
- The soils for layered sites are represented by finite elements with embedment included and SSI analysis performed using SASSI2000 computer code.

Generic Site Properties for SSI Analysis

	Soft	Medium	Hard	Fixed Base
Shear wave velocity (m/s)	300	800	1700	>1700
Mass density (kg/m^3)	2000	2200	2500	NA
Poisson's ratio	0.478	0.40	0.35	NA
Material damping (%)	5	4	3	NA

Layered Site Cases

Layer	Shear Wave Velocity (m/s)/Depth (m)			
	CASE 1	CASE 2	CASE 3	CASE 4
Top	300/20	300/20	300/20	300/20
Middle	300/20	800/20	300/40	800/40
Bedrock	1700	1700	1700	1700



Section 3.7 – Seismic Design

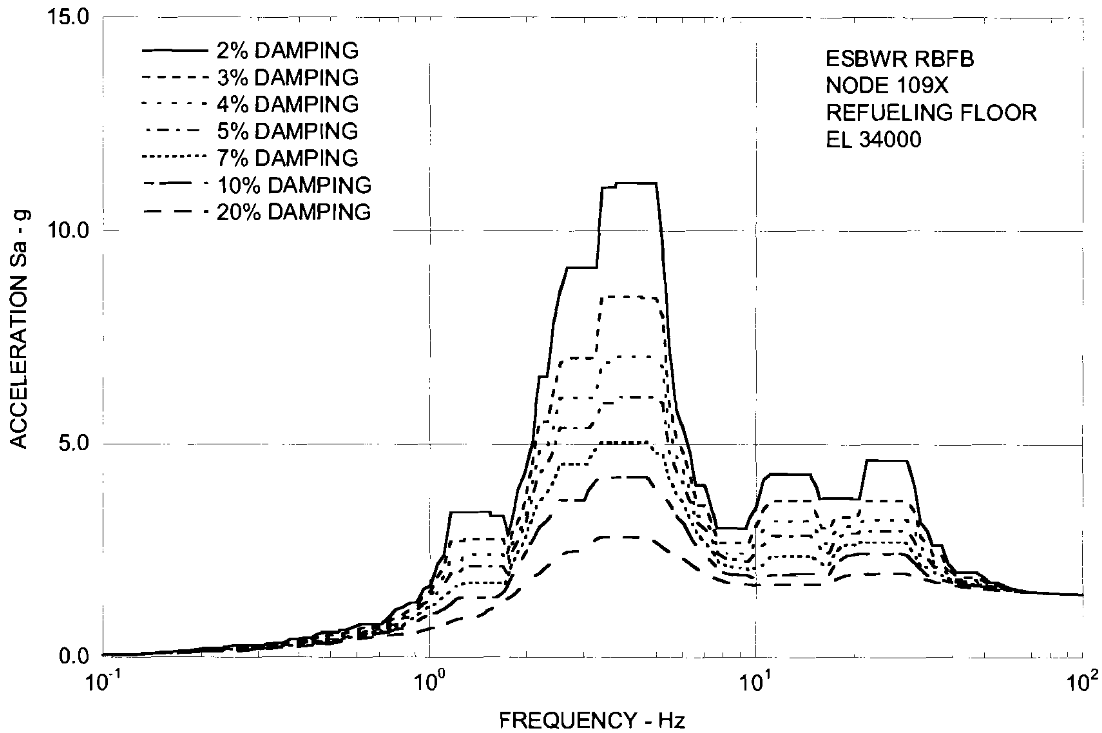
- Section 3.7.3 discusses seismic subsystem analysis.
  - >Applies to Seismic Category I and II equipment and piping.
  - >Dynamic qualification can be performed by analysis, testing or a combination of both.
  - >Applicable methods of analysis are the same as those described in Section 3.7.2.
  - >Damping values are consistent with RG 1.61 Rev. 1.

Section 3.7 – Seismic Design

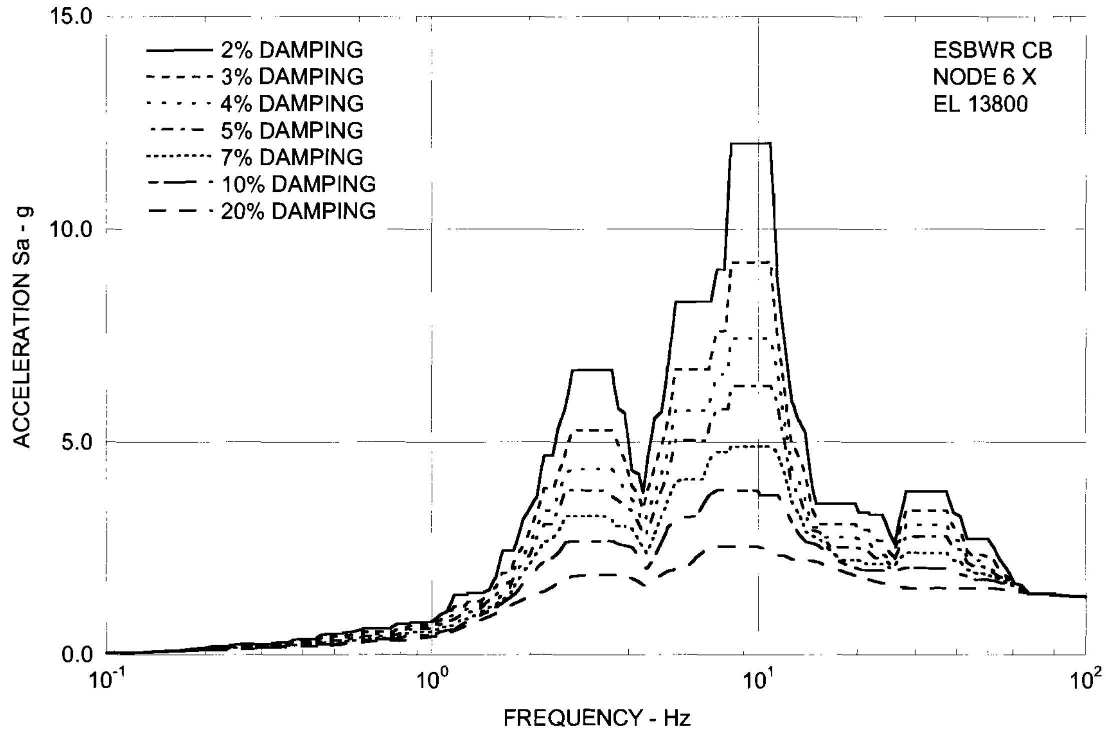
- Section 3.7.4 discusses seismic instrumentation.
  - >The seismic instrumentation program is consistent with RG 1.12.
  - >The procedures for plant response to earthquakes follow the guidelines of the Electric Power Research Institute (EPRI) reports NP-6695, NP-5930 and TR-100082, as permitted by RG 1.166 and RG 1.167.

Section 3.7 – Seismic Design

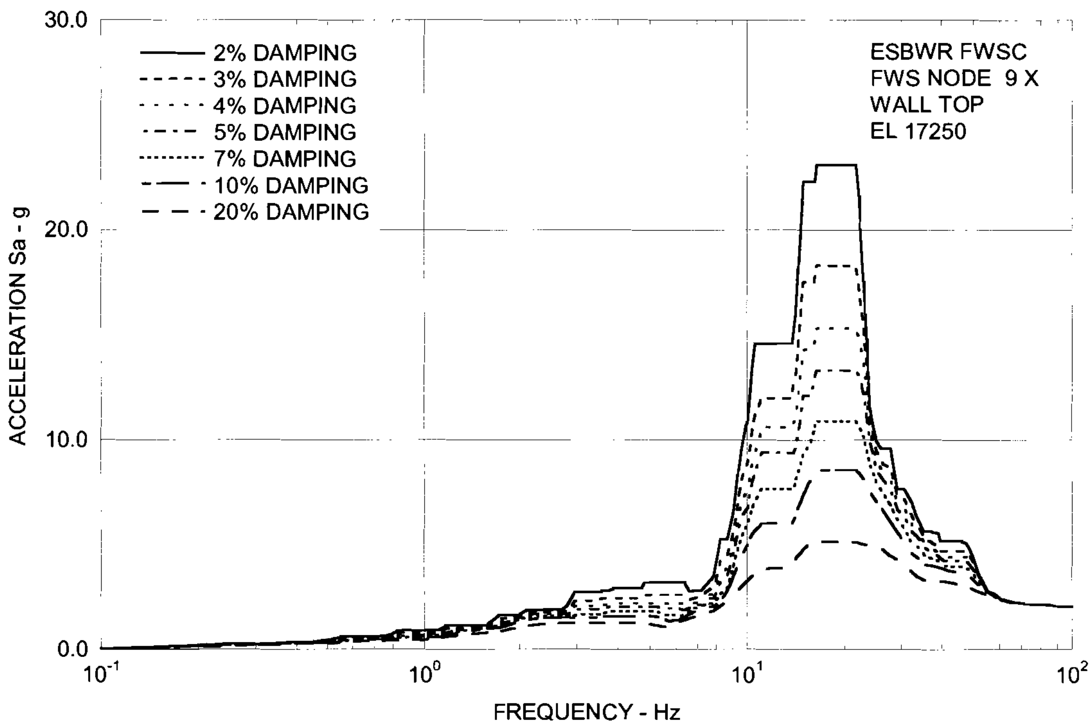
- Appendix 3A provides details of seismic soil-structure interaction analyses.
- Appendix 3F provides details of response of structures to containment loads.



Enveloping Floor Response Spectra – RBFB Refueling Floor X



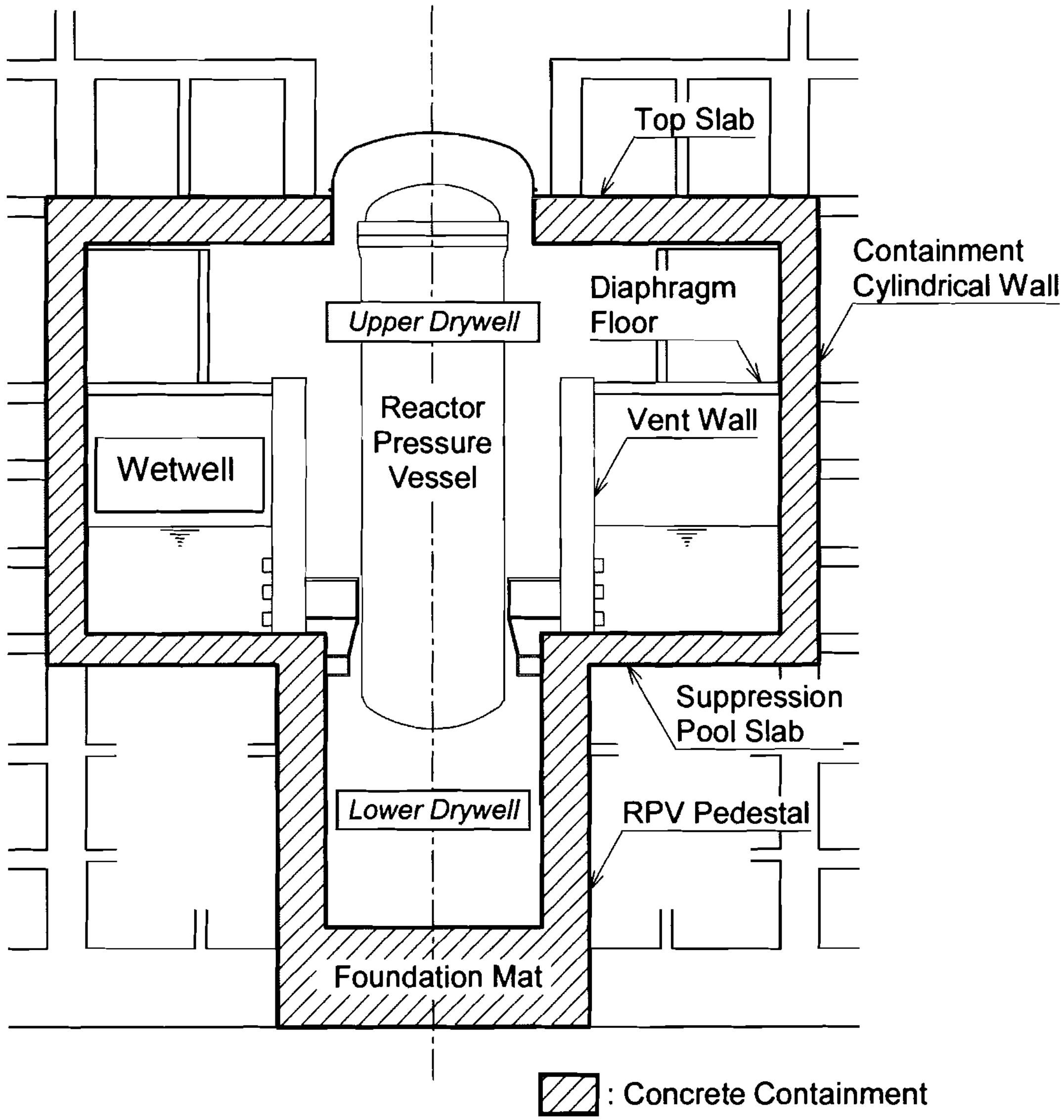
Enveloping Floor Response Spectra – CB Top X



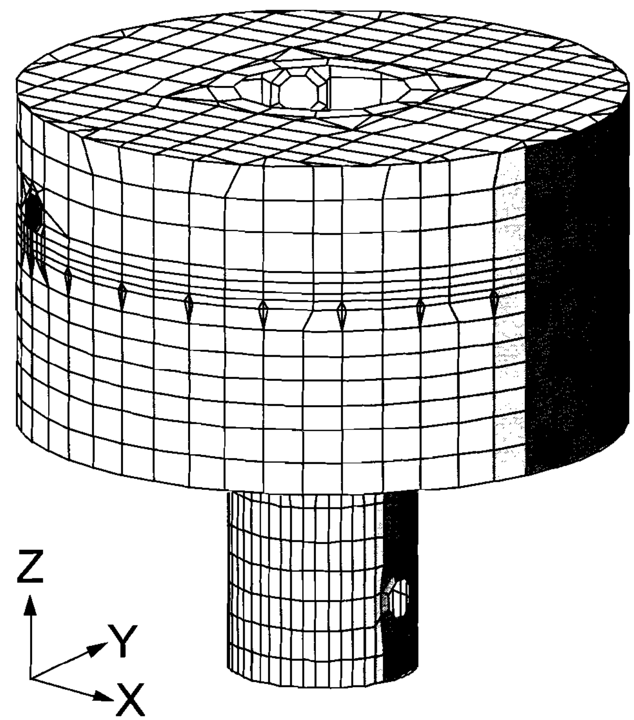
Enveloping Floor Response Spectra – FWS Wall Top X

Section 3.8 – Seismic Category I Structures

- Section 3.8.1 discusses the concrete containment.
  - > The reinforced concrete containment vessel houses the primary nuclear system and confines the potential release of radioactive material in the event of a LOCA.
  - > The containment structure is totally enclosed by and integral with the Reactor Building.
  - > Appendix 3G contains a detailed description of the containment and the analytical models, analysis methods and results.
  - > The concrete containment meets the requirements of Section III, Division 2 of the ASME Code.

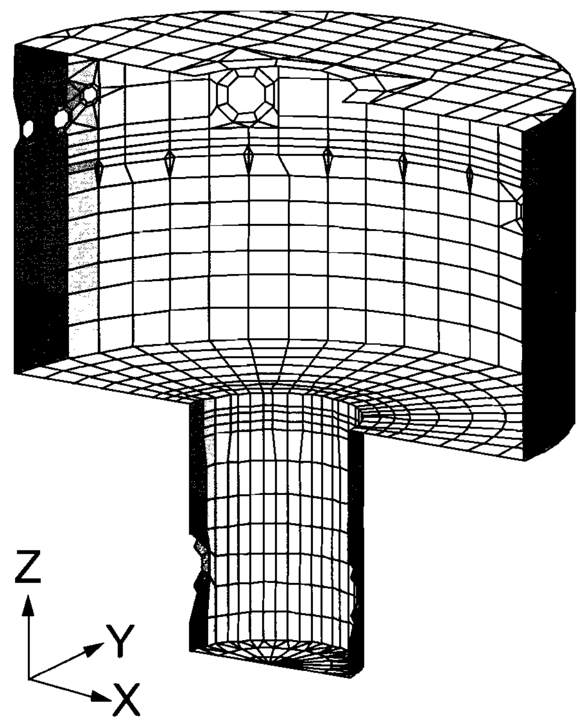


Configuration of Concrete Containment



Finite Element Model of the Reinforced Concrete Containment Vessel

Full View



Finite Element Model of the Reinforced

Concrete Containment Vessel

Cut View

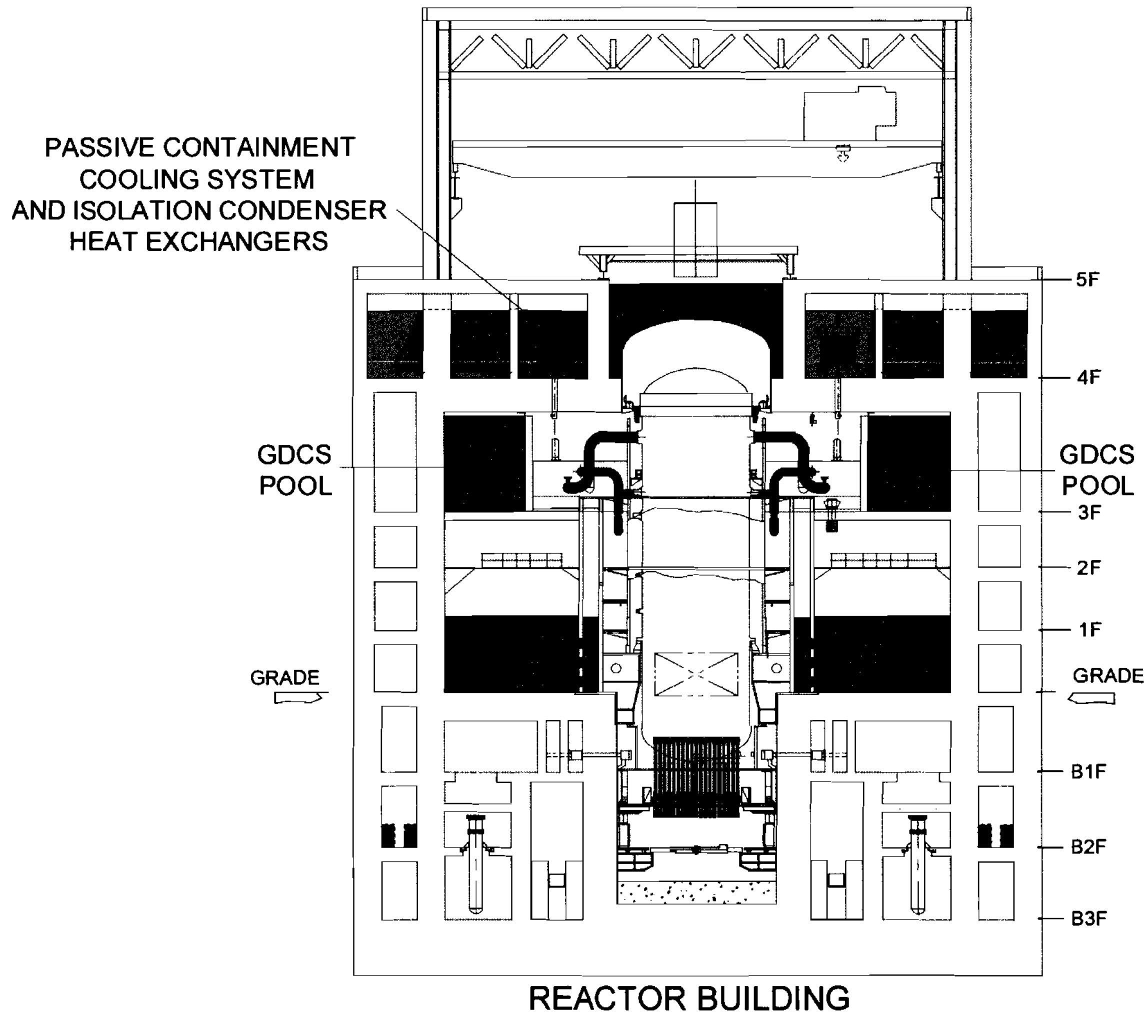
Section 3.8 – Seismic Category I Structures

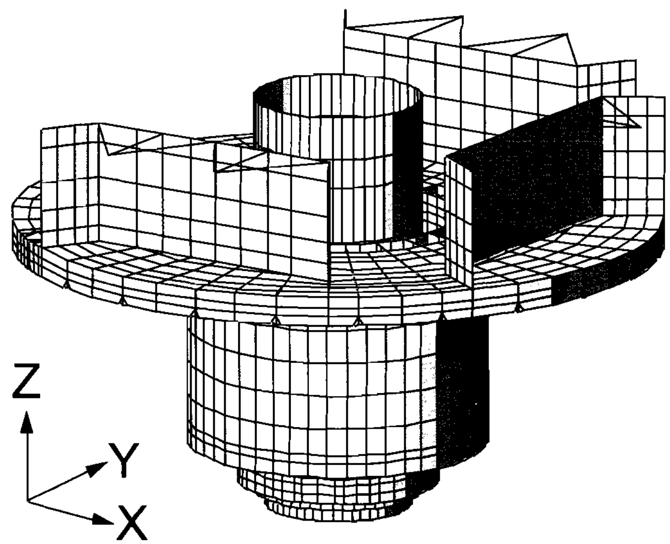
- Section 3.8.2 discusses steel components of the reinforced concrete containment.
  - > Steel components of the concrete containment vessel include:
    - Personnel Air Locks
    - Equipment Hatches
    - Penetrations
    - Drywell Head
    - Passive Containment Cooling System Condenser
  - > The six PCCS Condensers form an integral part of the containment boundary.
  - > The steel components of the RCCV are designed in accordance with ASME Division 1 Subsection NE.

Section 3.8 – Seismic Category I Structures

- Section 3.8.3 discusses concrete and steel internal structures of the concrete containment.
  - >The containment internal structures include:
    - Diaphragm floor
    - Vent wall
    - Gravity Driven Cooling System pool walls
    - Reactor shield wall
    - RPV support brackets
    - Miscellaneous platforms

ESBWR Reactor Building Section B-B

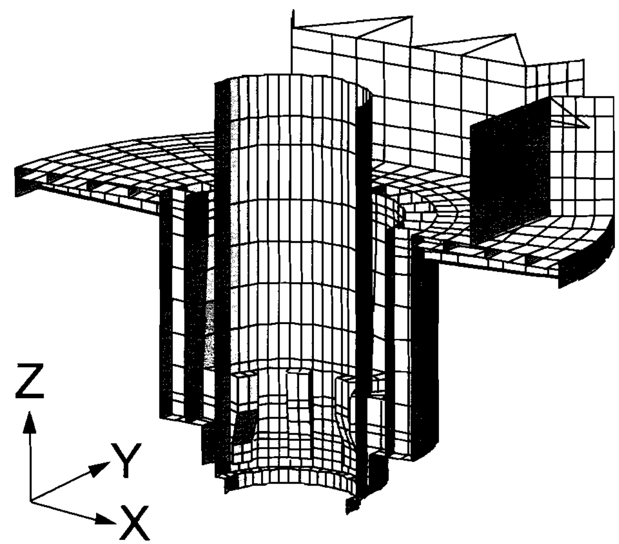




Finite Element Model

Containment Internal Structures

Full View



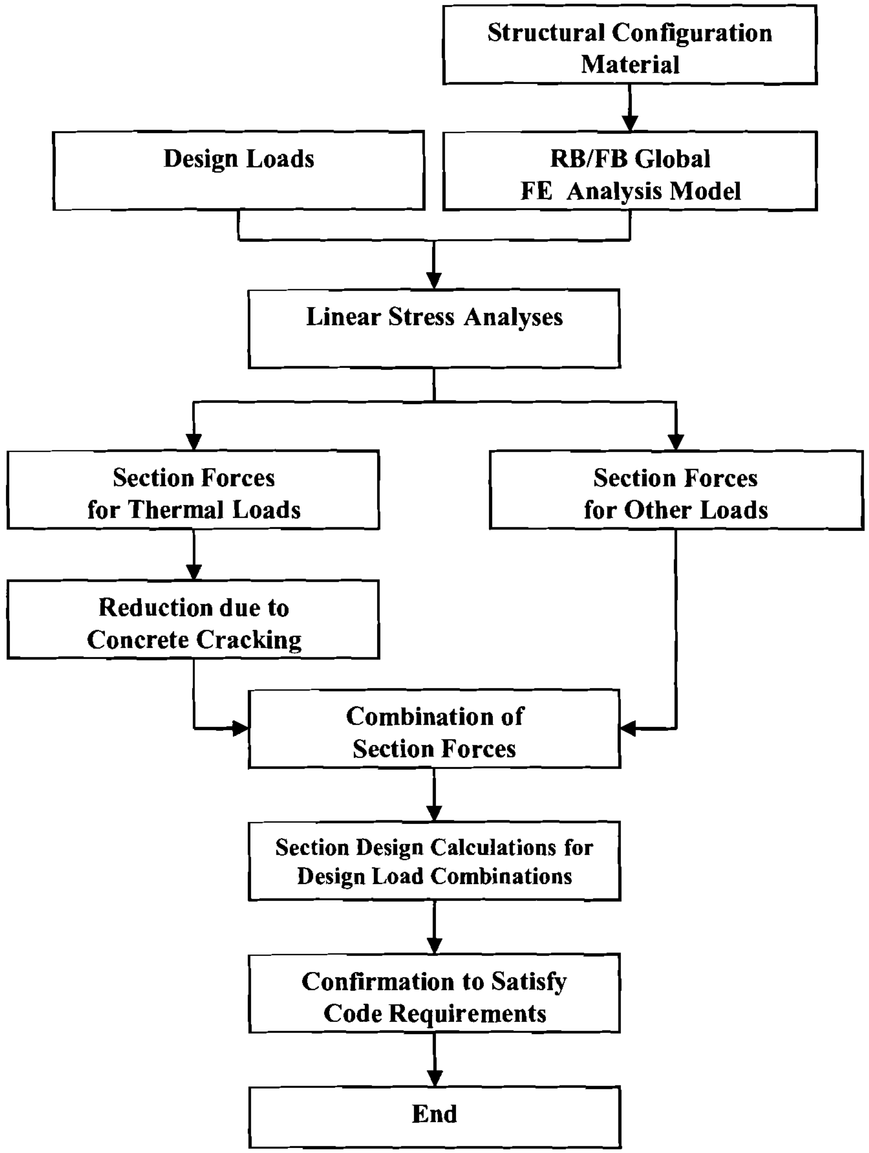
Finite Element Model

Containment Internal Structures

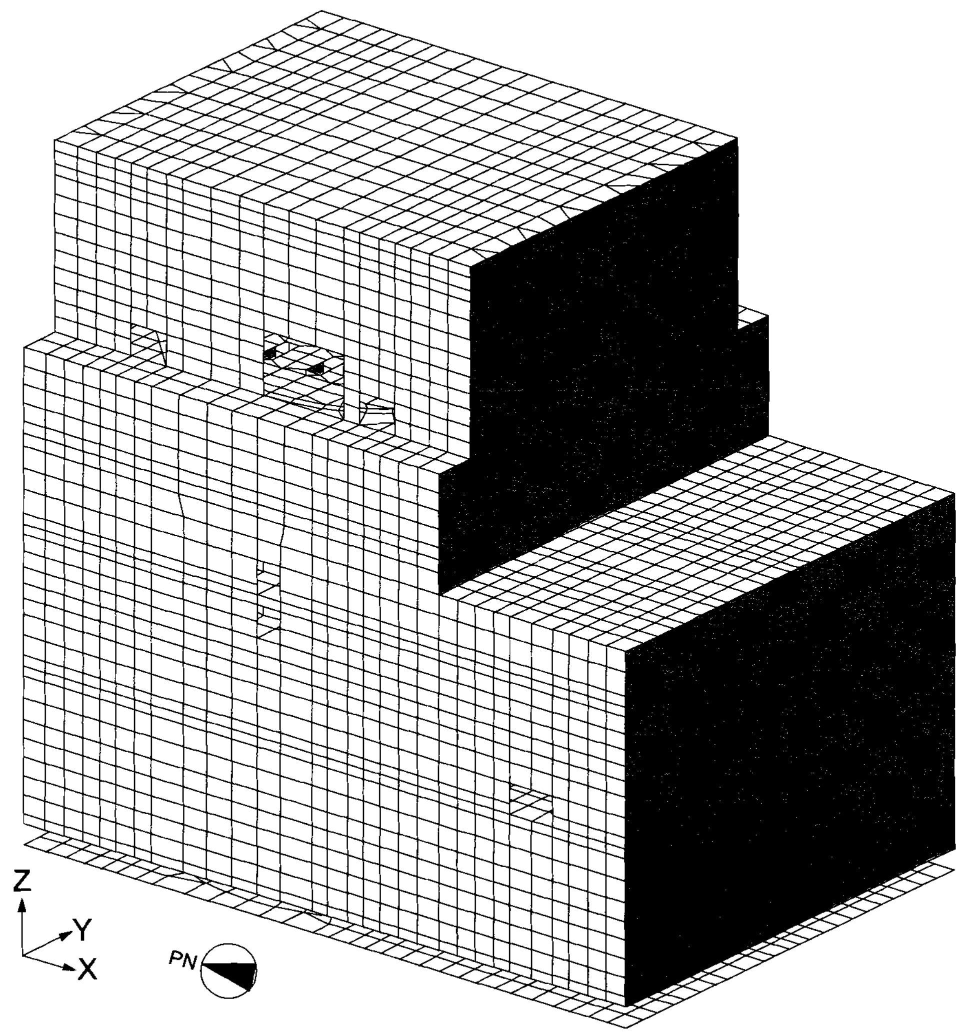
Cut View

Section 3.8 – Seismic Category I Structures

- Section 3.8.4 discusses other Seismic Category I structures.
  - Other Seismic Category I structures are:
    - Reactor Building Structure/Fuel Building
    - Control Building
    - Firewater Service Complex
  - Reactor Building and Fuel Building are integral to each other and founded on a common basemat.
  - Design details and analysis results for the design of these structures are also included in Appendix 3G.

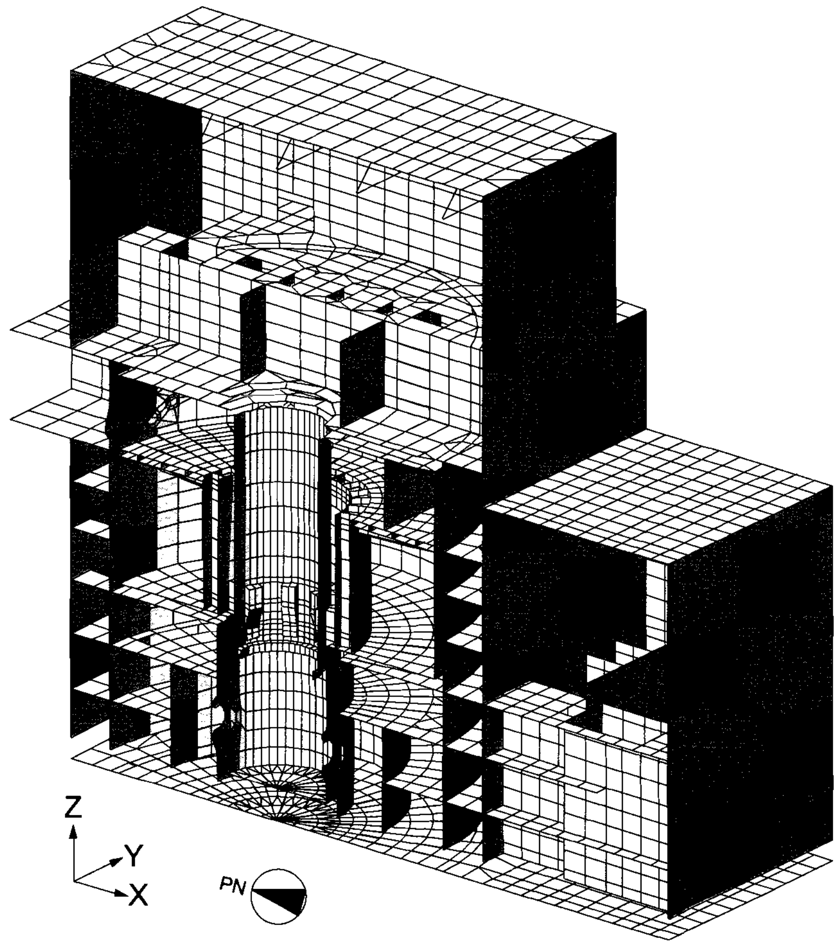


Flow Chart for Structural Analysis and Design



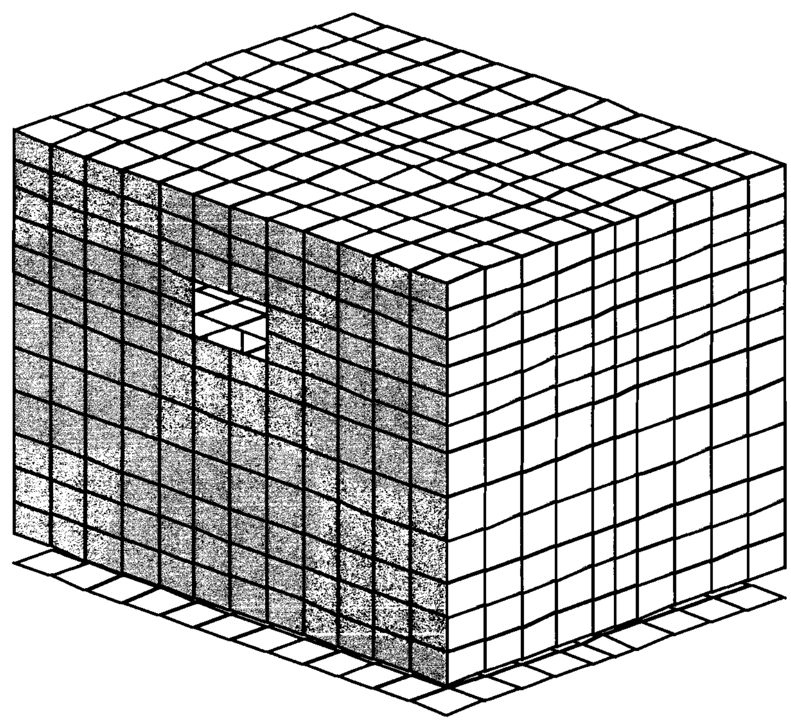
Finite Element Model of the RB/FB

Full View



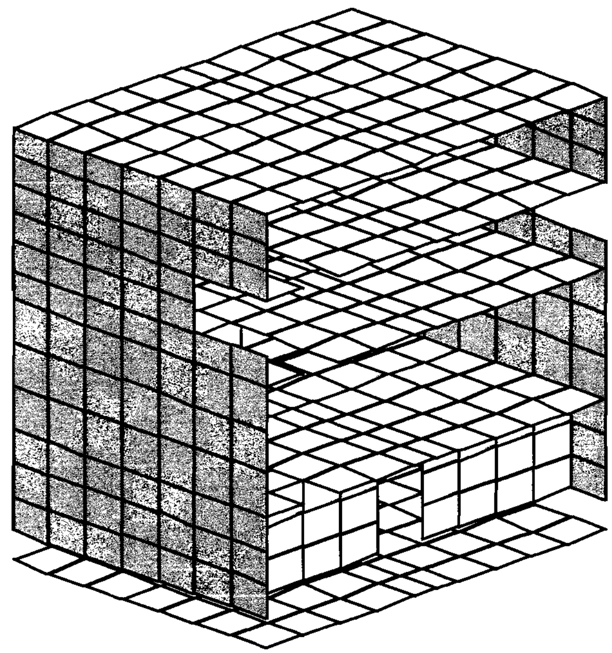
Finite Element Model of RB/FB

Cut View



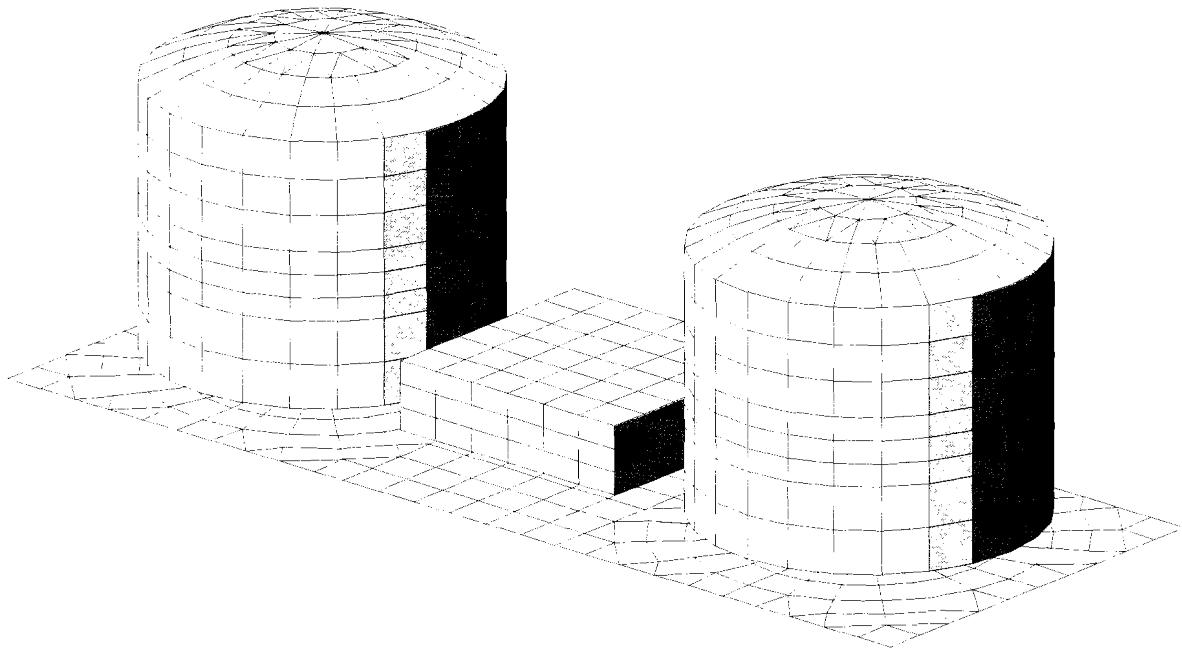
Finite Element Model of CB

Full View



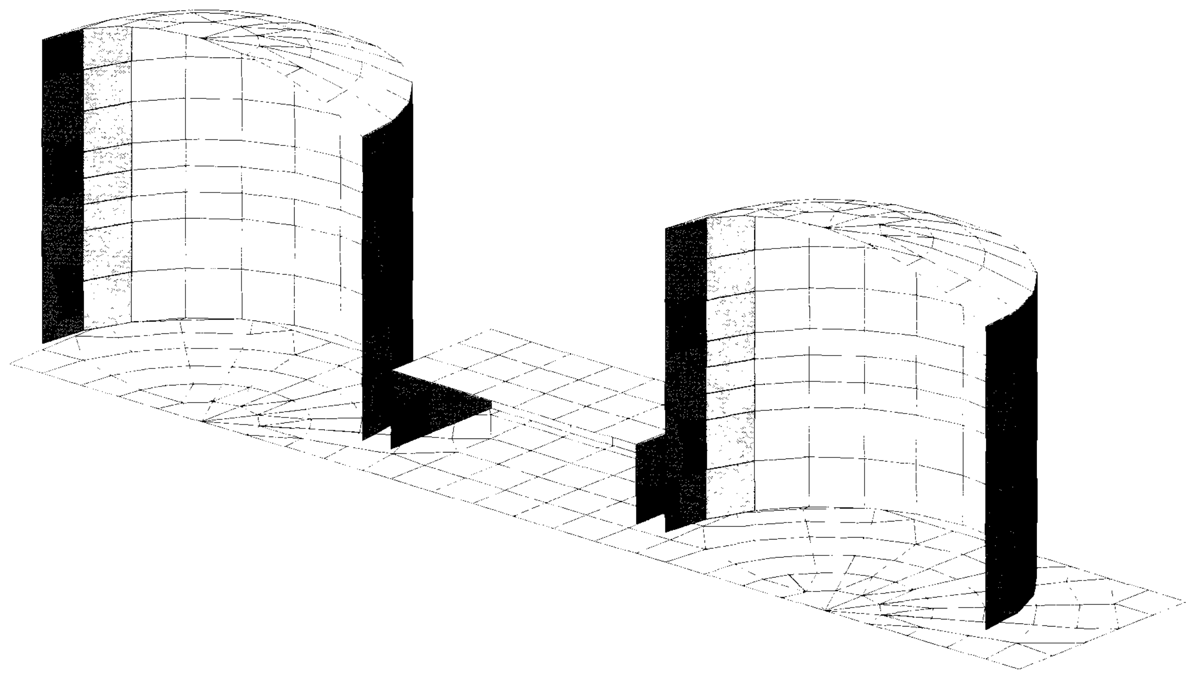
Finite Element Model of CB

Cut View



Finite Element Model of FWSC

Full View



Finite Element Model of FWSC

Cut View

Section 3.8 – Seismic Category I Structures

- Section 3.8.5 discusses foundations.
  - > The Reactor Building, including the containment, and the Fuel Building are integral and built on a common foundation mat.
  - > The Control Building foundation is separate.
  - > The Firewater Service Complex foundation is also separate.
  - > Design details and analysis results for the foundations design and stability evaluations are included in Appendix 3G.

Summary

- Chapter 3, Sections 3.7 – 3.8 provide details of seismic analysis of the ESBWR and loads, loading combinations and acceptance criteria for the design of Seismic Category I structures.