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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

In the matter of:

MEETING ON RECALCULATION OF
SEISMIC RESPONSE SPECTRA:
COMANCHE PEAK

Docket No.

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NUCLEAR REGULATORY COMMISSION

MEETING ON RECALCULATION OF SEISMIC RESPONSE SPECTRA:

COMANCHE PEAK

Room P-422
Phillips Building
7920 Norfolk Avenue
Bethesda, Maryland
Tuesday, June 18, 1985

The meeting in the above-entitled matter convened, pursuant to notice, at 9:10 a.m., Mr. Spottswood B. Burwell presiding.

ATTENDEES:

S. Burwell	NRC/NRR/DL/LB
L. Shao	NRC
B. Bosnak	NRC
A. Vietti	NRC/NRR/DL
V. Noonan	NRC/NRR/DL
D. Terao	NRC/NRR/DL
D. Jeng	NRC/NRR/DL
F. Rinaldi	NRC/NRR/SGEB

ATTENDEES: (continued)

R. Lipinski	NRC/NRR/DL
C. Hofmayer	BNL
D. Enos	Teledyne/NRC Consultant
D. Landers	Teledyne/NRC Consultant
J. George	TUGCO
R. Cloud	RLCA
P. Rizzo	Gibbs/Hill/Rizzo Assoc.
K. Scheppele	Gibbs & Hill
C. Jan	Gibbs & Hill
M. Holley, Jr.	HH&B/TUGCO
J. Redding	TUGCO

PROCEEDINGS

MR. BURWELL: Good morning. My name is Spottswood Burwell. I am with the NRC. I am one of the project managers on the Comanche Peak project.

We are gathered here this morning to discuss the recalculation of the seismic response spectra for Comanche Peak. We have gone around the room and made introductions. At this point in time I would like to ask the Applicant to give us an overview.

I assume that you have prepared some type of presentation?

MR. GEORGE: Yes, Spotts, that is correct.

If I might again, I am Joe George, Vice President, E&C, for the Comanche Project. We appreciate this opportunity to brief you on the status of the reanalysis we have done on our 1974 model response spectra and in light of 1985 technology.

We will be giving you a detailed status, and we will be making an official submittal on our docket of the results of this reanalysis soon.

The purpose this morning is to brief you and solicit your input to the results thus far. I would propose to proceed this morning. I would like to reintroduce Mr. Ken Scheppele, who is the senior Gibbs & Hill Vice President who has been associated with the Comanche Project for a number of years, and Dr. Cloud with R.L. Cloud Associates is a consultant to TUGCO on this matter as well as other CPRT matters.

MR. NOONAN: I wonder if I can interrupt you. I would like to know about background before you start out. Tell me why we need to do this. Where do you plan to use it? I'm looking for impact on your program.

MR. GEORGE: Vince, the program -- the way we proceed will, I think, move right into that detail. I would really defer to Mr. Scheppele. This entire program, by the way, will only take about an hour for the presentation. We have slides. It is in very much detail, and I would like to let Ken proceed, with Dr. Rizzo, and then I would like to close at the end and then maybe give you some detail.

MR. SHAO: Eventually we want you to address whether you are going to change the FSAR. We want to know whether we need to change the FSAR.

MR. GEORGE: It is our view that we will need an amendment for the FSAR, and I would expect to have that in hand soon.

This program has been going on for a number of months. As a matter of fact, it has been going for quite some time as far as revisiting our response spectra, going back quite some time, and there has been a lot of work done as far as rigorous analysis on this particular issue.

MR. SHAO: Before you go into detail, another thing we want to address is suppose you have to make an amendment to the FSAR. Do you still meet the Standard Review Plan?

MR. GEORGE: Yes.

MR. TRAMMELL: I have to make a brief administrative announcement. I'm sorry. I am the one who arranged for the recordings in this part of the building, so one of the things we are supposed to caution you is this is a non-secured area of the building. It is not like the public meeting rooms that you see downstairs on the first floor. There is a recording device in this room which is only allowed by special permission, security. The Intervenors may be showing up with a recording device also. I am supposed to announce that that is what we have here. You are not supposed to discuss safeguards information, proprietary information or, you know, the other stuff in SA -- what is that called? Nuclear material, the other stuff, in this room.

With that I will close. Thanks.

MR. NOONAN: Where I am coming from -- when we were down at Dallas last week, Ed Siskin in the piping and piping support analysis said he was going to use the present FSAR methods.

MR. GEORGE: That is a matter of timing, Vince. We would like very much to use our view response spectra, and I proposed to use that at risk of it not being acceptable to

NRR, but the final conclusion on that matter was that the reanalysis of the 300 problems on Unit 1 would at least start with the existing response spectra. But we would propose -- when I say "soon" on the submittal, I have a status meeting with Ken Scheppele and the folks in New York next Tuesday, and I hope to come away from that meeting with a first draft of that submittal.

MR. SHAO: One area I want you to address today is has this methodology been used in any other plant or is it first of a kind?

MR. GEORGE: They will be prepared technically.

MR. TRAMMELL: Do you have time to wait through? You are going to get the whole program now unless you ask for an abbreviation.

MR. NOONAN: Go ahead and go.

MR. GEORGE: I think if you get 30 or 40 minutes into it, you will appreciate it.

MR. SCHEPPELE: I am standing not because of formality but I figure this will be the last time I will be able to stand for an hour or so, so that's why I'm on my feet.

First of all, we appreciate, as Joe said, this opportunity of meeting with you gentlemen this morning. I had planned on introducing some of my colleagues in our contingent this morning. They have introduced themselves, but let me just reinforce that. Jerry Jan is our chief structural engineer from Gibbs & Hill, Paul Rizzo is President of Paul Rizzo Associates, and Chris Holley is from MIT and is a consultant.

I will explain in a few moments the role of each of these individuals in our program of developing in-structure response spectra based on 1985 technology, but first let me put in perspective our program for you.

At the time of our licensing Comanche Peak in 1973 and 1974, Gibbs & Hill was the architect engineer working directly with Dames & Moore, who had been selected by TUGCO as the seismology soils consultant for the Comanche Peak PSAR. With Dames & Moore, we established the soil/structure interface for our structural seismic models.

These seismic models and the criteria for the structural seismic analyses themselves, including the in-structure response spectra, were developed based on the technology available at that time in 1973 and 1974, and that information was incorporated into the licensing documents culminating in the granting of a licensing of a construction permit in December of 1974.

Dr. Jerry Jan, who was our chief structural engineer, led that work in 1973 and 1974, just as he has led the work today on this same subject matter.

Now, when TUGCO authorized us to proceed with the development of in-structure response spectra based on the latest technology available in 1985, we selected Dr. Paul

Rizzo as our consultant in seismology and soils because of the close working relationship that we developed with Dr. Rizzo over the years. Our Gibbs & Hill staff and Dr. Rizzo have worked together on nine previous nuclear installations, three here in the United States, three nuclear power plants in Spain, two in Italy, one in Brazil, and I personally worked with Dr. Rizzo in the advancement of the concept of the floating barge-mounted nuclear facility.

Now, to provide an independent review of the methodology and approach and using 1985 technology and developing in-structure response spectra, TUGCO selected several additional well-known consultants in the field of soil/structure interaction and also structural seismic analysis.

We met with these consultants bi-weekly to receive their comments and suggestions on the work as it progressed. These are Professor Holley, here this morning, Professor Mel Biggs, Professor Edward Castle, all of MIT. Also Dr. Chris Margot of Terra Corporation, and Jean Lieu Shmieu of Purdue University.

As a result of their review, our final report will have the endorsement of these consultants.

For our meeting today, as Joe indicated, the purpose of the presentation is to provide you with the approach that we have taken in the development of in-structure response spectra based on 1985 technology and to share with you some of the preliminary findings that we have produced to date.

MR. SHAO: What do you mean by 1985 technology? Do you mean brand new? Nobody has ever used it?

MR. SCHEPPELE: I think what we are doing, as will be evident by the presentation, is we are, in effect, updating the state of the art to today's technology as opposed to that which was apparent to us in 1973 and 1974, and I think that will be apparent from the presentation.

MR. SHAO: When you say 1985 technology, it bothers me.

MR. SCHEPPELE: Let's say this. Let's use different terms and let's say most recent technology by our judgment, and this will be spelled out in the presentation. Our approach and findings will, of course, be submitted in a report which will come to you folks within a few weeks.

Now, for the technical presentation today I have asked Paul Rizzo to make this presentation, primarily because the refinements which have been made in the in-structure response spectra relate primarily to the soil/structure interaction. At the conclusion of the presentation, certainly Dr. Jan or Dr. Rizzo will respond to any questions or clarification which you may wish to make, and I can fully appreciate the fact that this is the first time that you, of course, are aware of our approach, and obviously you want to study this matter further. But if you care to make any comments or clarifications which you request from us, certainly we will do our best to provide these for you today.

[Slide]

MR. BURWELL: This is a small series, 35 millimeter slides. Are you prepared to give us copie of these?

MR. RIZZO: Yes.

[Slide]

MR. RIZZO: We are going to discuss today the status of our reanalysis of the rock-structure interaction. We do have rock at the site as opposed to soil, so the terminology is rock-structure interaction throughout the presentation. AS that relates to the in-structure floor response spectra development. I will mix the terms "in-structure" and "floor response spectra," and this means the dynamic response of the floors to input. And you will see from the presentation that what we are talking about is the impact of rock-structure interaction on the floor response spectra.

Ken mentioned that we are going to discuss 1985 versus 1974 technology. Mr. Shao raised a comment on that, and let me speak to that for a moment. What you are going to see really is changes that have occurred over the past decade in rock-structure interaction analysis. You will see references in here back as early as 1973 and 1974. I would think that it would be better characterized by saying that we are looking at improvements in the technology that have occurred since the FSAR was developed in the early 1970s.

I don't think anybody in the room would be surprised at the changes that we are talking about. We are speaking state of the practice, not state of the art. In applying these changes in the technology in the past year to our rock-structure interaction analysis, we have, of course, by way of passing incorporated minor changes in our structures to the models. It is not the prime purpose of our effort, but it has been done as we are going along.

We will cite these a little bit today in our report where they have occurred.

MR. SHAO: What is the shear velocity of the rock?

MR. RIZZO: The shear velocity of our rock -- I will get to that in a moment, but it varies basically from about 4000 to 6000 feet per second. It could be very well classified as a rock site where fixed base motion is appropriate. We have not taken that path primarily because the profession has not always agreed on when you can use fixed base, although rock site certainly are commonplace.

We have incorporated rock-structure interaction into our analysis, and as you can well expect, the effect of rock-structure interaction is not that great on the overall response of the structure. You will see that as we go through it. But nevertheless, we include it in our analysis, and you can do that as a conservative step or, technically speaking, the best way to go about it.

[Slide]

This presentation has four segments to it. The first two are relatively brief. They are simply to bring you up to date or reupdate you on our basic seismic design criteria and a very quick review of our site conditions so we are all talking the same terminology, we all see the same conditions in what we are dealing with.

The meat of the talk is dealing with the major steps of the reanalysis. We go into a lot of detail here on a step-by-step basis of what we have done this past spring in reanalyzing the rock-structure interaction and its impact on floor response analysis. Once we get through the reanalysis, I'm going to show you some typical results. Of course, we are doing this for all of our Category I buildings, and I have simply chosen the aux building as typical examples of what we are getting as far as response, the kind of margin we are seeing in our calculations as compared to what we had in the past.

[Slide]

The next slide is basically a summary of the fundamental criteria, all of which are seen in the FSAR. We have a .12 g SSE in the aux building, a .06 g, a relatively low seismic area based on historic seismicity. Our response spectra for the horizontal direction satisfies Reg Guide 1.60. Our vertical satisfies Newmark's vertical for 1973. This is about the time when we were making this submittal tht the Reg Guide 1.60 was just being published. Our structural damping satisfies 1.61, and again, it was in the same time frame.

MR. SHAO: You say the vertical and the horizontal use a different spectra?

MR. RIZZO: The vertical is Newmark, the basis under which 1.60 was developed. The difference is at the tail end of the response data.

MR. SHAO: What was the reason for using a different spectra for the vertical?

MR. RIZZO: In 1973-74, there was no Reg Guide 1.60. We only had it in the Newmark Report paper, and the NUREG backed it up. When we made the application, this is what we used. We have never changed it.

Does that ring a bell? That is going back 12 years. That is what happened. The only difference in vertical is between 33 and 50 hertz. It tails off the high frequency end. Everywhere else is the same as Reg Guide 1.60. We have an artificial time history that we used to generate our floor response spectra. The artificual time history that we use is the same as in the FSAR. It envelopes the design response spectra at all points, a little bit difference than what the

Standard Review Plan would allow today. It is 10 second duration. Our control motion location is at the foundation elevation. The ground motion was specified at the surface. We have not taken any credit for attenuation or frequency shift at the foundation elevations. It is the same as the site grade.

MR. JENG: You mentioned the only difference is in the 33 to 50 hertz. It is 3.5 hertz.

MR. RIZZO: It is a minor shift.

MR. JENG: You should be more precise in your statement.

MR. RIZZO: The most significant part is the tail end I did not pay much attention. We envelope our response spectra for the artificial time history. Our rock-structure interaction approach then was a lumped parameter. It is now lumped parameter again. The terminology shifted in the last ten years to substructure. The name changed. It is more sophisticated but it is the same thing.

The final note is that in the analysis we are discussing today, we have introduced no changes in any of these basic parameters using all of these same parameters in the analysis that we are discussing today.

MR. LANDERS: Does that mean you have used the same time history?

MR. RIZZO: Yes, the same time history. We are looking at the time history a little bit because it is enveloping everywhere and there is deservedly some review of that requirement. Today the results we are showing you, we are using the same one as in the FSAR.

The next group of slides gives you an appreciation of our actual site conditions, a very generalized plant layout or plant view is here, with the two containments.

[Slide]

These are all individual buildings on individual mats. This is a singular building with a singular mat. Auxiliary electrical. It is two functions but it is a singular building on one mat, structurally tied throughout this point here, and it is one mat at the foundation level. I put it in color because that is the one I am using for an example later on. I want to give you an idea of where that is located with respect to the other buildings.

I mentioned earlier we have a rock site. This is an artist's sketch, basically, of describing showing you how our buildings are situated. This happens to be through Unit 2 on the left side of the previous figure, the fuel building being on the right side here. This formation is the Glen Rose limestone, highly competent limestone that you will see in other slides. It overlays on this scale between mountainous formation, which is a sandstone. These beige layers shown interspersed are clay stone lenses that are part of a marine depositon, part of the Glen Rose limestone.

We point these out because we do factor the layers one by one into our analysis as we generate the rock-structure interaction parameters. The grade at this site on the slide was about here before we took off the overburden [indicating]. This is an elevation of about 805 to 810 at the site, and this is about 793. This is about 769. That is 40 feet. We have taken off 40 or 50 feet of overburden, and we are basically on rock. We have taken off rock, which you will see on a subsequent slide all of the overburden has been removed.

[Slide]

The next four slides are photographs of the site during the excavation stage. I show these because it is ten years or a few years since that work has been done. For those who did not see it when the work was being done, you really do not have an appreciation for the foundation conditions. You can see that the rock has been basically carved out to receive the foundations or these plants, these units.

This is the 793 that I referred to down in here, 769. You can see the rock right in this area exposed. That is the uppermost limestone [indicating]. This is also a cutback of the weather overburden rock.

[Slide]

The rock has been excavated by drilling and shooting, loading out with front end loaders, and the banding through here that you see in this particular face is the clay stone layers that I mentioned earlier. Of course, the rock stands very vertically. You can see in this closeup view that the clay stone, while being a little bit softer than the limestone, is not that much different than the rock itself.

[Slide]

Before proceeding with a step-by-step analysis of what we have done, I want to clarify some terms and compare a little bit what we are doing now with what we did in 1973-74 time frame. We are using a substructure in our lumped parameter for all of our buildings. We account for embedment effects. We have 6 degrees of freedom, 3 shown here, 3 in the other direction.

I point out to you that MF is mass of foundation, and in parentheses, we have the mass of the soil that had traditionally been considered in this kind of an analysis.

[Slide]

The reanalysis. One of the first areas we got into which represents a change in technology was exclusion of the soil mass from the addition to the foundation mass for lumped parameter analysis. It was included earlier. It is now excluded in our analysis, and that is clearly a change in technology that occurred early on in the past decade.

The FSAR. We used a uniform modulus value that was representative of the entire formation. The reanalysis is a little more sophisticated. We have looked at the actual layered system itself and accounted for layers, the effect of layering on the damping as well as the stiffness coefficients for the analysis.

Damping as a whole. In the FSAR the rock-structure interaction damping was taken as 10 percent translation and 5 percent for rotation. This was hysteretic-type damping. The analysis accounts for damping as it should be in the analysis and also material damping of hysteretic nature. The material damping throughout our reanalysis has been taken as 2 percent, geometric damping being a function of geometry that is different for each building.

The embedment effects were included in our previous analysis. Since that time there has been a fair amount of work done on embedment effects. We have incorporated that improvement information, updated information in our reanalysis.

In the FSAR we varied our stiffness parameters basically around a best estimate value by taking 25 percent of it and 200 percent of the K values in each situation. In our reanalysis we have looked at each building and then looked at the embedment effects, how they might range. We have looked at the rock properties that were already measured, incorporated that into a variation analysis. That leads to a range of variation between 65 and 150 percent. That is building dependent. You will not find this range in every building. This is the outermost range that you will see in our results.

In some of our buildings this tightens up to around 75 percent on the lower side, maybe 130 percent on the upper side. It is building dependent on geometry of the building, specifically the bevin effects and the rock properties measured at the site. I will get to it later. We have looked at that on a special study effort at each building itself.

[Slide]

Now, the main part of this presentation is a step-by-step description of our reanalysis. I am going to show this slide seven times, so you need to try to memorize the whole thing as you go through it.

The first step is simply to define for our analysis the profile under each building and the specific dynamic rock properties that apply to that building. We do this for each building specifically using the borings that are closest to that building or immediately beneath that, and we use the laboratory tests that were conducted in those same borings under those same samples. The site is highly uniform when you look at the gross cross-sections across the site.

We have chosen to be as detailed and as refined as we possibly can in our analysis, and therefore we look at the specific borings beneath each building. I point out to you a little cross-hatched area referred to as May 1985 program area. I will refer back to that.

MR. NOONAN: You said you wanted to look at -- you are taking each one of these borings and using that in a detailed sense, not just generically applying --

MR. RIZZO: For example, the aux building sits in here.

MR. NOONAN: Why are you doing that? That's a lot of complexity you are putting into this.

MR. RIZZO: We are using computer codes that accept the detail readily, so why not? It's not a problem for us.

[Slide]

A typical analysis profile. This happens to be beneath the aux and electrical building. The gray is the limestone. This whole formation, of course, is the Glen Rose limestone. The beige are the interbedded clay lenses. The yellow here is the Twin Mountains formation.

This column is derived from shear wave velocity measurements, as are the ratio of values which come from laboratory tests. We have adopted a material damping of 2 percent for our entire -- for all of our rock layers. We believe that that is a relatively low value. It is one of the primary purposes of the May 1985 program mentioned on an earlier slide.

We are going back and obtaining new samples for laboratory testing to measure the material damping of the rock, which we expect to be more in the range of 5 percent, and we are also measuring some new shear wave velocities at the site.

[Slide]

The next step in our analysis is to define the foundation geometry. It is usually relatively straightforward, and it is not unusual at this site either. We have a couple of foundations, and this is by way of an example. The aux electrical building is stepped at mid-mat. The structure is tied at the superelevations and across here [indicating].

We account for this step geometry in our analysis for a number of reasons, not the least of which is that we recall in the artist's rendering of the rock there are clay stone layers high up in the formation which must be accounted for, and the stepping, because those layers are horizontal, the stepping is through here. The layering is considered in our analysis.

The safeguards building has three basic elevations to it, and again, we account for that in the stepping in the foundation mat in our analysis in this particular step.

[Slide]

Step 3. After having obtained the rock properties and the analysis profile beneath each building and looked at the geometry of each foundation mat, now we get into the meat of the analysis of determining the stiffness and damping parameters for the six modes of freedom, six degrees of freedom.

We are looking a rigid mats on elastic layered systems. We are using a substructure approach, which I illustrate on this slide to show you how we are doing it versus how some other people might view typical substructure approaches. The upper half is taken from a recent NUREG. It is a common slide. It shows the approach to substructuring using impedance analysis. Basically the free-field motion is subjected to analysis with the elevation of the foundation. Impedances are calculated for the mass of the foundation. The structural model is done independently. They are married and you use the altered ground motion with the total structure for the impedance function, which is frequency dependent.

Our reanalysis uses the free-field motion directly as input motion. We do not reduce it or change frequency content with the depth of our embedded foundations.

We generate stiffness and damping values in two approaches. First we do it as a typical half-space calculation using the layered half-space theory for stiffness calculations, work that has been done since 1974 basically on half-space theory. It is frequency independent.

We also generate impedance. The functions for the same geometry and the same rock, again considering the layering. This, of course, is frequency dependent. We compare the two and then adopt a frequency independent stiffness set of stiffness parameters and damping parameters for use in a lumped parameter model. The structural model, a finite element model that has been condensed onto a lumped parameter model which is married into a three-dimensional time history analysis.

MR. JENG: In this substructuring procedure you are presenting there, in your opinion, where is the earthquake motion applied?

MR. RIZZO: Right here [indicating].

MR. JENG: On the top picture. This is the embedment.

MR. RIZZO: It is accounting for embedment, yes.

MR. JENG: In your FSAR commitment, you are supposed to apply the motion in the free field at the foundation level by using the substructure procedure. Because you are using the geometric relationship, there may be a reduction in the motion at the surface level, reduction to the bottom line.

MR. RIZZO: From here to here.

MR. JENG: Yes, and you have not addressed that.

MR. RIZZO: We are not doing that. We are using the full motion.

MR. JENG: I want you to show some information in your submittal which indicates the motions that indeed apply at the foundation level in the free field.

MR. RIZZO: Yes, up here.

MR. JENG: Yes.

MR. RIZZO: Do we agree that the motions here are less than here [indicating]? We do not have any serious non-linear problems. I can do that, David, but understand, do we agree that doing what we are doing is -

MR. CLOUD: I think there is some -- what you said is that we apply the free-field motion at its full exactly as it is at the base of the foundation, and I think all you asked was that we document that in the submittal.

MR. JENG: At the lower reaches. You don't mean at the surface level, right?

MR. RIZZO: We apply the same motion to surface at the foundation level.

MR. JENG: This has raised quite a few items of contention, so we would like you to address this one.

MR. RIZZO: Sure.

MR. SHAO: What is the original FSAR? Is it as the free field?

MR. JENG: The free field at the foundation level.

MR. CLOUD: That is what we are doing.

MR. JAN: The upper part is for comparison. We are doing the lower part.

MR. JENG: Then why did he say earlier that the embedment effect was not accounted for?

MR. RIZZO: That is separate.

MR. JENG: How did you account for it? This procedure the way I know is based on the ring conception. You take different rings, embedment depths to account for the stiffness resistance.

MR. RIZZO: I will show you in a few minutes how we take care of embedment.

Now, I have two choices, basically, David. You are obviously very familiar with the subject. I can use the same motion, the free field at depth, and counteract change by damping values for embedment, or I can take the reduced motion at elevation and take a lesser effect of embedment on my spring.

MR. JENG: Can you address that issue, the second point? I thought you should mention this one. What is the objective of the reanalysis? The earlier analysis was no good, or in your opinion it was good enough and had too much safety margin? You wanted to improve the safety margin to reflect more closely and provide a safe response? If it is he latter, I want you to show.

MR. RIZZO: It is the latter. I am going to how you in our example that we have excess safety, excess seismic margin in our floor response spectra.

MR. SHAO: There can be lots of implications. You have margins that are all frequencies or certain frequences? Maybe this method may go higher? Are you going to requalify all of the equipment?

MR. RIZZO: We will have, we believe at this point, and we are not finished yet, Larry, but we believe that we are going to have floor response spectra at the same level or lower than at all frequencies than we have done previously, than we had in the previously one.

MR. SHAO: Suppose the certain frequency, you have to requalify all of the equipment?

MR. RIZZO: We understand the implications of what we are doing very well.

MR. SHAO: Are you going to apply this throughout the plant, that everything will meet the new analysis?

MR. RIZZO: You're talking to the wrong guy. My area is structure interaction.

MR. SHAO: But when you ask for this, there are lots of implications involved.

MR. GEORGE: We have not seen any excursions as far as the response spectra are concerned that would require requalifying the equipment. We have not identified any excursions that require equipment requalification.

MR. DENTON: Watch out, for any elevation, any spectra for certain frequencies can be higher than the original spectra. Then you have to requalify.

MR. GEORGE: Yes. When you see the curves, the examples, it might be a good time to discuss that.

MR. RIZZO: We understand your concern. That was one of ours at the very beginning.

MR. DENTON: I don't know whether the management at TUGCo realizes what they are getting into. I'm trying to warn them ahead of time. There may be cases, certain areas where the spectra may be lower at certain frequencies, and then it wasn't designed right.

MR. RIZZO: A new frequency, a new response spectra may be higher than the old.

MR. DENTON: I cannot believe you would have a frequency as high at all elevations, at all frequencies. I don't think you can envelope everything. There will be certain areas that would be lower than the original curve.

MR. LANDERS: If that's what falls out, that's what falls out. And they are aware that they have to look at that.

MR. TRAMMELL: We'll get there.

MR. JENG: Do you expect that the new analysis would show generally lower than what you had before, most frequencies?

MR. RIZZO: Yes.

MR. JENG: The reason it is lower comes from several parameters. One is removing the soil mass?

MR. RIZZO: That is one of them. That is not the most important, but it is certainly one of them.

MR. JENG: And a second is to try to redesign a higher material damping from 2 to 5?

MR. RIZZO: We're using 2 percent. Everything here is 2 percent.

MR. JENG: But you mentioned earlier to change the 5.

MR. RIZZO: That is a possibility. We are not committing to do that. The results we are showing today are 2 percent.

MR. JENG: And the third approach is to use --

MR. RIZZO: To improve the substructuring method. Then you have higher damping values, geometric damping.

MR. JENG: All of these have to be justified. I feel that your presentation is just to run through quickly, okay.

MR. SHAO: We're not proving anything today. We're just listening.

MR. JENG: Go ahead.

MR. RIZZO: We're giving you the status of where we are.

MR. GEORGE: This is a briefing on the status, and we solicit your input, as you desire. We will be making a detailed, formal submittal on our docket to justify everything that we will be modifying.

MR. RIZZO: Don't hesitate to tell us our comments.

MR. JENG: To my knowledge, this procedure does not account for the so-called stepping in the mat that you mentioned, that you mentioned was accounted for.

Can you explain how?

MR. RIZZO: It is not that difficult to do. You analyze the building --

MR. JENG: By what?

MR. RIZZO: By CLASSI, the elastic computer model or the WIDGEMOD program, which I'm going to describe in a moment, at two different elevations. The higher elevation -- the higher and the lower elevation, you proportion the stiffness for the moment of inertia, depending on rocking or translation. You marry the two together and come up with basically an equivalent stiffness value for that mat. You have to account for the layering up at the top.

MR. JENG: I am talking about the mat covering the auxiliary building and the control building. You mentioned it was accounted for. I did not follow how you did it.

MR. RIZZO: First, I placed the entire mat at the higher elevation. Then I did a reanalysis of the mat at a lower elevation, and then I proportioned the stiffness of the two areas in proportion to the area of the foundation.

MR. JENG: Stiffness of what? That's a general term. You're throwing it up and down. What stiffness are you talking about?

MR. RIZZO: I have two foundations. At one foundation, two elevations. I take the entire mat, assume that it is at the upper elevation --

MR. JENG: Even though there is a void at the lower level?

MR. RIZZO: No void. Run the layers on through. You calculate the stiffness, both frequency-dependent and frequency-independent. Two different approaches. And then take the entire foundation, assume it is the lower elevation with the same horizontal layering of the soils. Regenerate the stiffness again, and now the stiffness is proportional to the area in the case of the translation of each of those two.

In the case of rocking or torsion, it is in proportion to the moments of inertia -- proportion the two stiffnesses to get one stiffness, a combined stiffness.

MR. JENG: The question is, is there a need for such a refinement, given all of the assumptions factored into the analysis? And your answer is yes?

MR. RIZZO: This is the most refined approach practical for this site. And rather than being accused of being unrefined, we have taken a refined approach.

MR. CLOUD: Excuse me. You asked a question: Is there a need for? And it's not so much an issue of need, it is just that Paul is trying to do a good job all the way through, using consistent technology. The different features that are included in the analysis are not done in response to any specific need.

MR. JENG: I'm not saying that being more detailed, more refined, does not lead to more -- or a better solution. This point, you may want to address.

MR. RIZZO: Engineers have to make some judgments, especially in this field, and the better the analytical tools you have, the more detailed your analysis. You are able to refine your judgments.

MR. JENG: There are some cases, if you are having basic assumptions, it does not make common sense. You may end up with garbage.

MR. RIZZO: Yes. Garbage in, garbage out. Your basis assumptions have to be refined to start with. We agree.

MR. HOLLEY: As I hear from the back of the room, I think you would like to know to what extent that refinement was a significant contribution to the difference. If you had done it by a single elevation approach, would it have made an enormous difference in the results?

MR. RIZZO: Not an enormous difference, no.

MR. JENG: That's what I suspected. We are talking technically. The current Standard Review Plan asks for a foundation of this type. I believe you said 6000 feet.

MR. RIZZO: 4000 to 6000.

MR. JENG: Now the SRP only requires a fixed base analysis. We will not stop you from doing this, if this helps you reach your goal But I want TUGCo management to understand that the fixed base analysis could have been considered to be adequate. It is up to you, as I said. So the refinement is fine, but do not, you know, go beyond what is considered to be good judgment.

MR. RIZZO: I'd like to spend a little time with you at another time discussing how we would pursue that.

MR. JENG: There is a reduction of motion that has to be addressed. We would not like to see a reduction without justification for the basis, especially what we are working with, having a strong belief that what we are doing is just right, is safe.

MR. RIZZO: Yes. One comment, and then I will go on.

We have not reduced our ground motion. We have used the field, the free-field ground motion.

[Slide.]

The next two slides describe in a flowchart method the two procedures that we used to generate the frequency-independent stiffness and damping values and the frequency-dependent damping values and stiffness values.

The first slide deals with the calculation of the frequency-independent parameters. We used here work that was done by Christiano, et al., reported in 1974, for assessing the stiffness and damping for a layered system, frequency-independent parameters. Basically it is using the half-space theoretical solutions, calculating the strain energy in each layer, proportioning the modulus in that area, and proportioning the energy stored in that layer, computing the external work done, and then deriving a stiffness parameter for each mode based on the stress field, the strain energy associated with that layered system.

We then generate a back equivalent shear modulus, use that to generate a damping effect, damping values corresponding to the half-space, correct it for embedment, and then in a subsequent slide, we will see -- we compare those results with the real part and the imaginary parts of the impedence analysis.

Going through this flowchart results in a set of rock stiffness and rock damping values corresponding to a layered system, assuming the parameters are frequency-independent, which is a typical -- has been the typical substructure or lump parameter approach for rock structure interactions.

The next slide --

[Slide.]

MR. JENG: The particular methodology you presented in the earlier slides, and as Ken said, the 1985 technology. What you have here, as far as we know, they were already publicly known in the '70s. So when you say refinement, '85 technology, we need to know more specifically, are you applying some particular specific techniques of the 1974 methodology?

For instance, you say you're going to change the 2 percent material damping to 5 percent. Are you going to actually do some boring of the comparative levels or low strain level measurements to justify your five percent. What are you doing in specifics which are new from 1975, the methodology presented here?

MR. RIZZO: All right. There are two parts to your question.

[Slide.]

This paper, this work, as you well know, was originally published in 1974. In the timeframe from '74 until about '80, that was put into a code and refined several times. It is called the WIDGEMOD code. Those are only minor refinements that were published originally in 1974. It is an old Boston Institute paper.

MR. JENG: So there were a couple of changes in the computer codes.

MR. RIZZO: But we did not use this in the 1974 FSAR submittal.

MR. JENG: I'm more interested in since that time. Besides changing the computer codes on paper, has any observed response of a similar type of structure shown that such a methodology indeed predicts better the observed response in the earthquake situation? Observed data, not just a couple of high technology computer program changes here and there in the computer code.

MR. TRAMMELL: I'm going to have to break in here. Vince and Annette have limited time. We can get to these questions afterward.

Either that, or we can -- can you summarize, and can we continue? Thesa two people have to leave, and I want them to get the benefit of some frank discussion on why these changes are necessary and other factors that are not as technical as this.

MR. GEORGE: We will be available to follow up.

MR. TRAMMELL: Can we proceed, then? You're about ready to finish anyway, aren't you?

MR. RIZZO: No.

[Laughter.]

MR. TRAMMELL: You said originally you needed 45 minutes, and we are over an hour now.

MR. RIZZO: If you want me to zip along, I will.

How much time do you want me to zip through?

MR. TRAMMELL: I don't want to rush you. I'm trying to calibrate the problem. We don't have time for unlimited back-and-forth like you're doing now.

[Slide.]

MR. RIZZO: The other method for generating the stiffness and damping was the frequency-dependent analysis. We use here the CLASSI computer program developed by Luko and Long. It accounts for the geometry and plan view. It also accounts for the layering effects. It generates impedence values or functions for stiffness and damping, which we separate into real or imaginary parts, and in this slide compare the two types of -- in this case, we're talking about the three horizontal or three translation stiffness -- Kx, Ky, and Kz. The horizontal lines represent frequency-independent, derived from the first procedure that we discussed.

These are the frequency-dependence stiffness and parameters generated from the CLASSI program.

I have four slides, and then let me show you very quickly, they are for stiffness, two for stiffness and two for damping.

You will find when you review our work that these functions are very well-behaved, as you would expect for a rock site with non-linear behavior. We do not see large peaks and valleys in these functions in our frequency range of interest. We do not see any of the stiffness or real terms going negative, as you often do.

These analyses are very comparable to what has been done in half a dozen or so NUREGs by Lawrence Livermore on design studies, part of the safety margins program.

We conclude from our series of slides that we are using very acceptable frequency-independent parameters, checked and verified by frequency-dependent analysis.

I will just skim through these quickly.

[Slide.]

These are the rocking. For example, the rocking at the X axis, rocking at the Z axis, and the torsion. I would point out, in our analysis, X and Z are in a horizontal plane. Y is vertical.

[Slide.]

The next two slides are damping, geometric damping. This happens to be the coefficients, not percentages.

[Slide.]

[Slide.]

The next step, having generated the stiffness parameters for both frequency-independent and frequency-dependent analyses, we correct for embedment. We follow the lead of several investigators over the past ten years, where basically you take the unembedded foundation, develop a correction factor for it, and basically upgrade the stiffness and damping values to account for the embedment effects.

We use three different investigators for our stiffness, and they do not vary that much. Our best-estimate stiffness parameters, we use basically a mean value. When we vary our stiffness parameters, we take the lower bound for the lower-bound estimate and the upper bound for the upper-bound estimate.

The most significant effect on embedment is in the torsional mode in this particular building. It varies with the building, of course.

These values are indicative of the correction factors applied to the unembedded damping values. And of course the percentage beta values are lower than these, are marked up lower than this when you go to the accounting for embedment effects on the percentage damping, because of the stiffness term as the denominator.

[Slide.]

Step 5, we take the springs that we developed for the singular mass on the elastic foundation, and in the case, for example, of the auxiliary building and the safeguards building, we distribute those springs to the locations in those structures where the structural model is compatible with it. This is a simple mathematical distribution of a rigid body, showing two springs that assure geometric compatibility and statics. Nothing more than that.

In this case it is three different locations.

[Slide]

The next step, we take the rock-structure interaction parameters that we talked about in the first five steps and marry those with a structural model for the building which has been derived from a three-dimensional analysis and condensed down to a lumped parameter model. It has 6 degrees of freedom. At each node point we used three-directional input motions, three motions. We develop a modal damping. We have a value in our analysis, and we vary our rock properties, embedment effects. I mentioned earlier that we took a lower bound and an upper bound estimate of our stiffness and repeat the analysis. After we repeat the analysis, we envelope and peak broaden.

Here is a specific flow chart, the first five steps. This is the model. This is basically the same as reported in the FSAR, generates the value, computes the modal damping valuves, participation factors, repeat and compute the time histories in each mode, three directions of input. Typical modal position analysis.

We have a series of time histories for output. We compute the floor response spectra at the center of gravity. In this point here we go look at the floor geometry. We go to the edge of the slab, accounting for the rotation of the slab about at the center of gravity.

We combine the response into the three directions of input by the sum of the squares, and we repeat the analysis for the lower bound and upper bound springs, put them on a plot, envelope the results totally, and then peak broaden beyond those another 10 percent up and down.

MR. NOONAN: Have you combined those?

MR. RIZZO: These are enveloped. The square root of the sum of the squares. SRSS.

[Slide]

I would point out to you a change in the FSAR. In the FSAR we had only hysteretic damping, 5 and 10 percent for the translation mode and rocky modes. When we moved to the inclusion of viscous or geometric damping, we change our calculation of modal damping, and basically we use the Biggs and Roesset equation to estimate, calculate the damping that should be applied to each particular mode.

We are in the process of this, as you can see from the earlier slides. We are coming up with viscous damping values that are somewhat higher, and we are considering the impact of these higher damping values, and this equation on modal position analysis as part of our work.

[Slide]

The final step of this is to show you some results. I am going to show you floor response spectra for the auxiliary building. These are meant to be typical results. This building, as I mentioned earlier, is a singular large structure. It is structurally tied at the common walls here, and it is structurally tied at the mat.

Here is a side view of it showing the interconnections. This is an elevator shaft.

[Slide]

The model for this is very simply -- and this sketch is for talking purposes only. The two buildings, the mat tied across the structural length. The springs that I mentioned earlier. The coordinate system in the plant is xz, and then the vertical is y.

[Slide]

This is a summary table of the spring constants we are using for this building, or the best estimate upper bound. I am going to show you a slide that compares them with the FSAR values in a moment. These all account for the layering embedment effects.

This particular building, I would point out the range, for example, in the vertical worked out to be about 75, 78 percent of the best estimate for the lower bound. The upper bound may be 130 percent. That range varies from building to building. It can be as much as 65 to 150. Typically it is in this range, 72 to 130.

[Slide]

Now, here is a comparison of the spring constants used in the auxiliary building from the FSAR versus our reanalysis. This is after the springs have been distributed. You can actually find these in the FSAR if you go dig into the tables. You will see throughout our analysis, not only for this building but for all of our buildings, that our translation springs, these three, the horizontal and the vertical are softer than what we reported in the FSAR. Our rocking springs and torsion springs are stiffer than what was reported in the FSAR.

Sometimes -- in this case, for example, it is three times. Other times it is as much as ten. The main difference is geometry considerations, layering effects, and the embedment effects. They all come into play in changing these numbers. We are softer in the translation, much stiffer on the rocking and torsion. Here is a factor of 10 on about 1 axis. This is primarily a geometry consideration.

[Slide]

Damping values. These are the geometric damping values that we are using in our analysis for this particular building. They have been reduced to account for layering and embedment effects using the two procedures described earlier. They also have been checked by frequency-dependent and frequency-independent analysis, and therefore we feel strongly that we have got a handle on those and they are highly competent in their values.

The material damping, we are using 2 percent, which we believe to be a conservatively low number. We are going back in the field and doing new borings, taking new tests, and we will subject samples to strain-dependent analysis to verify that number or a more appropriate higher number, in my opinion.

[Slide]

I mentioned earlier that these equations, these terms, then, are those beta values that appear in the Biggs and Roesset equation for viscous damping. They are probably viewed by many in the profession as relatively high numbers. They certainly impact on response of the building. They certainly impact on a modal damping value, and as a consequence, we are considering the impact of those kinds of values on our overall analysis procedure. They are the numbers that result from impedance analysis of the type described in the NUREGs done by Lawrence Livermore, and also the numbers generated from the half-space theory.

MR. NOONAN: Those numbers are very high, aren't they?

MR. RIZZO: They are not very high. They are numbers that can be high depending on the structure, but not this particular case, but they can be substantially higher, particularly the translation modes. These are geometric damping values, not hysteretic damping values.

MR. BURWELL: Could I caution you to refer to, when you point to different columns, to use the title of the column. If you just say "this" or "that," the transcript becomes very confusing.

MR. RIZZO: Yes.

One comment, Mr. Noonan. Damping is clearly the significant parameter that affects our response. There are several, but damping is clearly the most -- has the most serious impact. Typical results. I have nine slides for the aux building, three corresponding to each of three directions. This happens to be the AX. There is a high point in the building. I am going to show you X direction, high, medium foundation level, Z, high, medium and foundation, and then a vertical high, medium and foundation.

The line on this plot, the response spectra previously defined from the FSAR is the solid line. The dashed line is the results of this reanalysis. Comparing the peaks, for example, is an indication of the margin that exists from the analysis. This number basically is about 5.6 versus 3.7, 3.8 reduction in peak motion.

Now, in response to Larry Shao's comment earlier, you can see that across this particular elevation, this particular direction, we are below our previous response spectra at all points except here [indicating], at about 1.8

hertz.

[Slide]

Here is a mid-elevation again in the X direction. These are all 2 percent damping. A reduction in peak from about 4.2 to 3. We are everywhere except out in this range of 1.5 to 1.8 hertz.

MR. NOONAN: What is the number at 7 hertz?

MR. RIZZO: If you take that as the peak, it is about 3.7. Here it is maybe 2.8, about a g.

[Slide]

The foundation level. It is not much different, quite frankly. Frequency shift is evident from here to here, but other than that, we are basically having the same motion in the foundation level as we had before. None of that is to scale because we are blocking it. Much reduced motion.

Here the frequency shift occurs. We have a slight overage on the response spectra.

[Slide]

The other direction, the Z direction, the trend is the same. Reduction in peak, general reduction in the high frequency side.

I would remind you that this is after running three cases, lower bound, best estimate, upper bounding. It is also after peak broadening, so we have an apples to apples comparison.

[Slide]

Mid-elevation, again at the foundation elevation.

[Slide]

Again you see the slight frequency shift. Vertical direction. The results are somewhat more dramatic. This is a attributed primarily to the much higher damping in the vertical mode that you saw in the previous slide, and if you are of the school of thought, as many people in the profession are, that foundation should move the same or less than the ground motion, you see that this is much more indicative of what you should expect under real life behavior under an earthquake at that site.

[Slide]

Those slides are typical of what we are finding for all of our buildings. Substantial reduction in peak, portion of reduction across the other frequency ranges. We are in the process -- we have done that for about, I guess, four or five of the six buildings we have there. The results are typically the same throughout.

MR. JENG: Would you please rank the parameters of what contributed such a drastic drop in the high level of springs?

MR. RIZZO: It is dependent upon the building. It is dependent upon the frequency, but the primary contributor to the reduced response is damping, geometric damping. In some cases it is the treatment of the layering in the rock, but not so much, because the stiffness parameters did not change very much, and the somewhat consideration of the embedment effects.

MR. JENG: How about the effect that you are finding the rocking and torsion increase by ten times? Would that be a major contributor in the reduction of the upper level response?

MR. RIZZO: The 10 is a rocking.

MR. JENG: To me rocking is a major contributor.

MR. RIZZO: That is a geometry calculation.

MR. JENG: The bottom line is to make sure of the way that you have reduced the movement for the foundation was proper. I would like you to articulate that point. That is a main contributor besides the damping.

MR. RIZZO: Fine.

MR. RINALDI: I have two short questions. One, you refer to peak broadening. You use plus and minus 1(percent. I want to caution you that the new requirement is 1: percent unless you can prove otherwise. Just a comment.

The o*her thing is a question basically on he spectra yc.u showed for 2 percent damping. Can you com ent on 5 per.ent damping? Is there significant change from wh t you show?

MR. RIZZO: The changes we have shown are amplified at 2 percent because of the damping. It is not as important. It is reduced effect. But the trend is the same. It is just more dramatic at 2 percent than everything else.

We would like to spend one minute on the peak broadening issue, if you don't mind. I want to check the thought processes on that with you folks. I do not want to belabor the issue, but I think that we ought to spend two minutes on it if we can.

MR. NOONAN: Let me suggest something here. I would like to call for a short break. I have to go off to another meeting pretty soon. Let me take a short break. And one thing I would like you to do, I would like you to continue the discussion you were having with David before we cut it off to get through your presentation. I would like to get on the record some of the things David was talking about. Okay?

Let's take about a ten-minute break.

[Recess.]

MR. BURWELL: Back on the record.

MR. CLOUD: On the issue of the peak broadening, I guess we have felt that the Standard Review Plan was slightly different than you stated it. We felt that it called for 15 percent, but that 10 percent would be acceptable, provided it was justified with additional studies.

MR. RIZZO: It is on the first slide.

MR. JENG: Let me comment. What he says is correct. The Standard Review Plan calls for 15 percent boring, if you do not do any specific justification. However, if you are justifying in any other way, the 10 percent can be used.

MR. CLOUD: We feel that it is justified, and Paul is going to present it.

MR. RIZZO: We do not need to present it, as long as we have that from David Jeng.

MR. TRAMMELL: We have the groundrules for this thing.

MR. RIZZO: First we have to have the groundrules straightened out.

[Slide.]

The top part of the text is the Standard Review Plan wording, and if you go back and look at Reg Guide 1.122, the Reg Guide is substantially the same wording. And basically it says, the first sentence says that you have to peak broaden after you account for variations in structural properties, damping, and so on and the soil structure interaction, and any reasonable method for determining the amount of peak widening can be used, but in no case should it be less than 10 percent.

If no special study is performed for this purpose, the peak width should be increased by a minimum of 15 percent, plus or minus.

For our site, we have first a rock site. And for those of us who helped participate in the development of that kind of wording, there was an immense concern about non-linear behavior of soils. We do not have a non-linear situation. We have a linear rock, and therefore a good deal of the concern about soil structure interaction, in fact, is taken away once you go to the linear analysis.

Be that as it may, we are using --

MR. SHAO: A lot of concern on the structure stiffness. The concrete may crack or not crack. What kind of structure stiffness are you using?

MR. JAN: It is based on uncracked, except the containment. It is a cracked and uncracked model, subject to --

MR. SHAO: When you develop the spectra, you use the --

MR. JAN: We used the upper bound and lower bound, the best estimate. We have six different models, and we envelope.

MR. SHAO: But that is only for the containment building. What about other buildings? What do you use?

MR. JAN: Uncracked.

MR. SHAO: Suppose the structure does crack? What would be the spectra?

MR. JAN: It is not subject to pressure. We recognize concrete has to crack in order to develop the action of the reinforced concrete function.

MR. SHAO: We have studied this, that it can happen six or seven times on the shear wall. We went the 15 percent for that reason.

MR. CLOUD: Isn't it true, however, that the containment building, by virtue of its greater height, has higher, much higher response than the other buildings, and that is the basis for -- doesn't that provide a basis for studying them separately from the other buildings?

MR. JAN: Because of the pressure.

MR. SHAO: If you want to justify it, it is not easy to justify it. There are all kinds of things that people worry about.

MR. GEORGE: We would expect to justify this on our submittal.

MR. JAN: In the existing FSAR, it is 10 percent.

MR. SHAO: But you want to reopen the box? It may have been reviewed by a different staff at that time. As far as we are concerned, it was closed, but if you want to reopen it, the whole thing is reopened.

MR. RIZZO: Our response is that we are doing a specific study, have done a specific study on a building-by-building basis, specific to rock properties, the embedment effects on the stiffness parameters. And from the analysis, basically lower-bound, best-estimate, upper-bound, and envelope those results and then peak broaden an additional

10 percent.

In our view, that satisfies this approach (indicating). Any reasonable method for determining the amount of peak widening, and we add 10 percent on top of that. It says "plus or minus." We take 10 percent on top of the widening.

MR. LANDERS: That was the question that I had earlier when broadening was first brought up. I understood what you said. You were doing lower bound, upper bound, best estimate. You were enveloping those, and obviously those were the shift frequencies. And you envelope that and then broaden it 10 percent. The best estimate, you could come into us and say that on the average, we may be plus or minus 17 percent or something like that. I think that is an important point that you should make in your submittal.

MR. RIZZO: Fine. That is what we can do.

MR. HOLLEY: This probably is a larger effect. It probably tends to mask the structural flexibility question you are asking about, other than in containment, where, for obvious reasons, you have to go to a fully cracked situation. These kinds of aux building structures, for example, the earthquake levels we are talking about, you never get a, quote, "fully cracked" situation. You only get approximate.

I think the kind of thing you are doing by taking the upper, lower, and enveloping it in, plus or minus 10, is pretty conservative.

MR. LANDERS: It might be meaningful to give the number of -- that number of peak broadening of the best estimate.

MR. RIZZO: I'm going to draw a plot of the acceleration on the coordinant and the frequency on the abscissa, and you saw that it looks something like this.

Now if I go over here, I get one that looks like this (indicating) with the lower bound, and then the upper bound looks like this. We're doing this, and then we're going like this (indicating).

MR. LANDERS: What I am suggesting you do, instead of rigidly sticking to the plus or minus 10 percent, is tell us how you are broadening the best estimate.

MR. GEORGE: We will have that in our submittal. This, again, is a briefing, and we will be making an official submittal on this soon to justify these type issues to your satisfaction, or we're going to change it.

MR. JENG: One was supposed to apply, going to 10 percent or 15 percent. Is that your understanding with the SRP? You have three curves. Before you come to the application of broadening, you are supposed to apply from a line of 10 or 15 percent. That is the way you are supposed to do it.

MR. RIZZO: Right.

MR. JENG: What is the best justification for going 10 percent and not 15 percent?

MR. RIZZO: It is that we looked at the specific building on a building-by-building basis. We accounted for variation in embedment, for variation in rock properties, and we have linear behaving rock.

MR. JENG: That is the point of deviant behaving rock.

I have a question to ask you. The property of the soils damping modulus was primarily established on the cross bore test, low strain; am I correct?

MR. RIZZO: Yes.

MR. JENG: The strain is 10 percent, and when actual SSE hit, could the strain be much higher, to the extent that some of the soil in the high-stressed zone could be going into the nonlinear or the nonlinear range? I would ask you to qualify that statement.

MR. RIZZO: We have estimated the strain behaviors for the SSE under the rock. It is not exceeding -- I will recall this now from memory -- about 10 to the -3, 10 to the -4 percent.

MR. JENG: SSE, if you are anywhere in the range of 10 to the -2, if you look at the curves, which you have seen many, you may have to think about it and talk about it. I am saying that you have the behaving rock, and the SSE range may not be correct or quite accurate. I would like you to reserve that.

MR. RIZZO: We will substantiate that we are in a linear range where the strain dependency is on the modulus and the damping. We have checked that already and have convinced ourselves that we are all right.

MR. JENG: I presume you are going to have an organized line-by-line justification for why you are going to 10 percent in your submittal.

MR. RIZZO: Yes.

MR. JENG: Anything else on this one?

MR. LANDERS: If I can go back to the presentation, for the boring you talked about an '85 study. One of the questions that I had was, you said you had relative uniformity. One of the questions that I had was, for example, what is the difference between a P-12 and a P-4?

It looks to me like you are going to do your '85 work -- and you have to, obviously -- outside of the foundations, and you're going to use that and maybe increase your material damping.

I think if you're going to do that, we need to know the kind of comparisons you are getting between P-12, P-34, and the borings that are actually under the foundation.

MR. RIZZO: We have shear wave velocity measurements up in here, which are the basis for our analysis. And that is, you look at all of that data for the shear wave velocity, and you see that the numbers we are using are typical for the Glen Rose limestone, the claystone, and Twin Mountains formation.

Now what we don't have from the FSAR are strain-dependent dampings for that particular formation. We are using 2 percent. We are going down into the plant where we have access, obtaining core from that formation, down to 500 feet in fact. We extract cores, and then we test cores of that formation for that property.

Now it is a sedimentary deposit, relatively uniform. We do not expect any significant deviations in shear wave velocity or material damping across that site. We do expect changes in thicknesses, and that is why we look at each building on a case-by-case basis. Some places the claystone may be five feet thick; in other cases it may be four feet thick, and we account for that in our analysis. That is the main purpose.

MR. LANDERS: I understand the purpose. I'm just telling you that in doing that, just verify what you said.

MR. CLOUD: The key thing is the limestone itself will have the same properties, regardless of what it is, and the claystone will, the other borings, so the trick is just to be sure to account for how much of which there is.

MR. TRAMMELL: I would like to ask a couple of licensing questions when the technical thing has run its course.

Are we through with that?

MR. JENG: With the technical?

MR. LANDERS: I have one more question. In making all of the changes that you made, just as a matter of interest, why is it that you did not pick up the Reg Guide?

MR. RIZZO: I have one answer; you have a different answer. Do you want to give yours first?

We did not want to change basic seismic input. That's what we did not want to change. We thought that would be subject to more concern on your part than if we just changed our analysis procedures.

MR. TRAMMELL: How is it that you can reach the Reg Guide --

MR. JAN: When we submitted the PSAR for this project, it was in early '73. And then I think I remember in March or April at the San Francisco conference the Newmark paper was presented. And at that time, I guess, everyone attending the seminar realized the curves to be used in the future, so I guess quickly we changed our input in the PSAR based on that paper. And then towards the end of that year, I think the Reg Guide 1.60 was published, and the Reg Guide 1.60 Revision 0 was somewhat different from the original paper.

But we already submitted the curves based on the paper. We did not both to change because the difference was rather small.

MR. LANDERS: But here we are now in '85, and I'm wondering why you did not change that. And what I heard was, you did not want to change the basis for seismic analysis, when in fact you have done that. You have changed input which has an impact on that.

MR. JAN: But the difference is rather minor.

MR. LANDERS: But one of the differences is the high frequency range, and the high frequency range can be a concern with respect to operating equipment.

MR. SHAO: But the minute you reopen this, everything is subject to review, all of the assumptions.

MR. RIZZO: That is a rather broad comment.

MR. SHAO: The whole subject relating to the spectra, the soil structure interaction analysis. If you change that portion of it, you change the whole thing.

MR. TRAMMELL: You're opening up the box here. This was all reviewed and accepted back in 19-- -- whenever it was you got your construction permit. You're opening it up, and who knows what is in that box. You're going to find, who knows?

Do you want to do this?

Let me ask a couple of other questions. You want to update yourself to 1985, yet you are sticking to your old --

Reg Guild 1.60 for horizontal and not Reg Guide 1.6 for vertical. The point is, at what point do we go back and amend the construction permit? And that is my licensing question.

You have a construction permit which is tied to what we have already accepted, and we are going to need a discussion from you on why it is that you do not need an amendment to your construction permit.

This is pretty major, seeing accelerations going from 5 gs down to 3 and that kind of thing. It is of substantial benefit to you. But I think you are going to have to face that issue.

MR. CLOUD: Why would it be necessary to amend the construction permit?

MR. TRAMMELL: Put the shoe on the other foot. Why isn't it necessary? You're making substantial reductions to the safety margins in the structure.

MR. CLOUD: I would say on the face of it, the reason that it is not necessary is because we have changed none of the fundamental design-basis parameters.

MR. TRAMMELL: Just discuss it when you make the submittal and see how it comes out. It certainly raises that question.

MR. GEORGE: Could I speak to your question and Mr. Bosnak's question before he left as to really why we are doing this?

MR. TRAMMELL: I would like to hear why. This is not just research and development.

MR. GEORGE: Could we start with the Comanche Peak piping system and the electrical system, the supports for the piping systems as well as the supports for our -- the supports for the conduit in the raceway as well as the piping?

The capability of these supports to behave under the seismic events and carry the loads they are subjected to, of course, has been called into question.

Now if you go into the prerequisites of all of the design process to design for these forces, to decide what loads they should be able to carry, we feel, from an engineering point of view -- and it is based on pilot studies -- that certainly there is conservatism, that in a number of the prerequisites -- and the response spectra, of course, being one -- we think that there is conservatism there, that by reevaluating and by reanalyzing this spectra, certainly there could be some insurance down the line when the Comanche Peak response team, whom you have heard last Thursday and Friday, are responding to the NRC technical review team issues, and they told you down there that they would be using the existing parameters, the existing response spectra, with Stone & Webster in their analysis.

And Mr. Bosnak was questioning me on that at the break. There seemed to be a conflict there. And I stated --

and the project would like to make this submittal -- we feel that the reanalysis of this CPRT, using the existing parameters, that we can satisfy all parties, if they are okay with possibly some modifications.

We view this down the line as insurance, because if the Staff does accept what we submit -- and certainly we are aware that there are a lot of aspects involved here with equipment qualifications and the things you raise -- we do not take this lightly -- and in the submittal that we make, we would expect it to be documented and self-supporting to your satisfaction.

That is an attempt on my part to summarize why we are doing it. It has been under way, really, for a long, long time as far as reviewing the response spectra over in the engineering area. There has been considerable rigorous analysis put into it in the last several months as to where we need an amendment to the construction permit. Certainly we will evaluate that, and I will get John Beck and the licensing folks involved. And again, the purpose of meeting here today, I feel, has been very successful in meeting our objectives, in meeting your response to the status of our analysis at this point in time.

I told you earlier we were expecting to make a formalized, well-documented submittal on this matter soon and would appreciate your timely response to it.

MR. SHAO: One other question I have. Can you mention some other plants in the United States that have used this particular methodology?

MR. RIZZO: Every plant that is using the lumped parameter analysis is doing the same thing. The use of the impedance analysis is a verification of our frequency-dependent parameters. There is nothing unusual. Other rock sites, like Diablo, are fixed base.

MR. CLOUD: Yes and no. Ultimately it turned out to be fixed base.

MR. SHAO: You propose to meet the Standard Review Plan?

MR. RIZZO: Yes. Does anybody want to challenge that? I don't think there is any issue with that. Frank, you seem to know it fairly well.

MR. JENG: There is some concern as to whether you actually met commitment to motions that it is applied in the free field at the foundation level because of the way that the substructuring approach is done. There could be a Classi factor in the reaction of the motion. That is the point I mentioned earlier. If you would stress in your submittal why you think that is not the case.

Coming up to Larry's point, some specific quotatation of other licensing plants which use the specific thing as a basis for the interaction.

MR. RIZZO: Eduardo Cossell reviewed it.

MR. JENG: You could call it another name, but this particular substructuring of any other plant which you know of has used this one as a licensing basis, he wants you to quote it. That's the point.

MR. RIZZO: All of the work that Lawrence Livermore has done, Classi runs.

MR. JENG: This is a good point for me to point to you --

MR. SHAO: I am familiar with the Lawrence Livermore work. I was in charge of it. But the actual application of plants I want you to cite if there are any plants. I am talking about actual application.

MR. RIZZO: You understand the use of Classi and that computer method for the frequency-dependent analysis.

MR. JENG: The point is that you mentioned earlier the NUREG report such and such here does not consider different than the NUREG.

MR. RIZZO: I know. I have published NUREGs too.

MR. SHAO: You have mentioned that Lawrence Livermore -- this is all research. The Regulatory Staff has not adopted a position. My point is if you can cite any plant that has used this, maybe two or three or whatever you have.

MR. RIZZO: We both have to appreciate that the amount of soil-structure interaction analysis that has been done in licensing in the last few years has been minimal. There have only been a copule of plants. And here you have an advancement of the state of the practice; not the state of the art, the state of the practice, and you should not penalize us for trying to do a refining and as technical a job as possible.

MR. JENG: We are not doing that.

MR. RIZZO: Then fine.

MR. SHAO: But then why aren't the other plants using it?

MR. TRAMMELL: This is a construction permit issue. That's why there has not been any traffic in this area, and that gets back to my first question. Is this one of the principal engineering and architectural criteria for this plant? And if it is, we need an amendment to your construction permit.

MR. CLOUD: I would say it is not.

MR. TRAMMELL: That's fine. I will not debate it with you. But I would leave you with a question. This is a CP issue, basically.

MR. CLOUD: I understand.

Larry, in response to your question, I think the method -- in our submittal what we can do is identify the differences between the work that Paul has described and all of the other -- what I would like to call the regular lumped parameter approach, but most of the plants in this country were licensed on the basis of a lumped parameter analysis, and I think the work that you describe differs very litte, if at all, from all of the other lumped parameter analyses presented in the past.

MR. SHAO: There is a difference.

MR. JENG: You mentioned in your opinion there are very small or insignificant differences between the other methods versus this method.

MR. CLOUD: I said we would identify the differences.

MR. JENG: Let me turn it around and ask a question. Would you find it more useful to use a regular fixed-base and still find that it serves the purpose which you mentioned? A simple fixed-base model, which would have been much easier with the -- my question is, can you do that? Would that help you enough? I would like to know. That would be much easier and less at issue if you used that one, and then you are entitled because of the rock foundation there, and the SRP says you can use fixed-base analysis.

MR. RIZZO: You agree we are clearly rock. Are you alone or do you have universal support for that position, David? If you do --

MR. GEORGE: We started out on this several months ago. In fact, that was our objective, to go with the fixed-base model, but when we got into the issue of the layering, we were trying to go the extra mile, and we are aware that this is taking us more time. If we had gone fixed-base, I guess we would have been in here two or three months ago. But we have done all of this. I have tests going on site just right away, redoing the cross-hole measurements and the shear wave velocity, all of this layering.

So we have been trying to go the extra mile to make sure we are doing the right thing.

MR. JENG: Is that because if you were doing that method you had proposed here, the outcome, the preliminary outcome would have shown lower than that you would obtain from a simple fixed-base method? That's not the case?

MR. RIZZO: No. The shear wave velocity is between 4000 and 6000. The 4000, the lower number, is the equivalent shear wave velocity for the entire formation. The Glenrose. But the those interbedded claystones in there, they can be as low as 3000 or 2300 feet per second. When you put it all together, you get 4000. The limestone itself may be 5000. That's the real problem, by your definition. Clearly I have to shoot it to get it out. You begin to look at the clay. You are going to question, if they come in with a fixed-base analysis, if it is, in fact, the same.

MR. CLOUD: That is exactly what we were concerned about.

MR. TRAMMELL: We will have to talk one at a time.

MR. JENG: If you are talking the 4000 to 6000, I really have difficulty arguing of treating that as a soil. We commend you trying to do the best job, but if you are going to do this particular type of approach, it may be more of a detailed review on the part of the Staff because of not being quite often used in the past compared to other generally practiced approaches.

I could quote you 30 or 40 plants using the fixed base. I think you can find plenty of cases where your type of rock can support the simple fixed-base model.

MR. RIZZO: My concern with that problem is that when you rewrote the Standard Review Plan between 1975 and 1981, you took out the criteria for what is a rock site. The 1975 Standard Review Plan says -- 3500. In '81 there is no mention of that.

MR. JENG: But you can quote the precedents. The point is can you do this particular fixed base model and serve your purpose? If the answer is yes, I would suggest that you consider that approach to meet the least resistance and more efficient, but if you cannot achieve what you intend to achieve, then that is a different story.

MR. RIZZO: Give me a criteria under which I can tell you that I have a rock site or not. If you can give me a criteria, then we will decide whether we are going to take that approach. Right now we are lacking a criteria.

MR. JENG: I'm not here to say anything, but if you ask what are the rock materials you have there, essentially what is shown in the past, there are no changes or not even a mention on your part, then we will consider it.

MR. SHAO: The minimum shear velocity is 4000?

MR. RIZZO: We have in those claystones the same bands that I showed I showed you on that one slide. Shear wave velocity could be as low as 2300. Now, those are 5 feet, 6 feet, 3 feet thick.

MR. JENG: Out of how many?

MR. RIZZO: Out of 400 feet.

MR. JENG: As competent engineers, is such a refinement really in the best interest of this analysis? You should think about it. Five or six hundred feet. You have ten lenses of five to ten feet interspersed somewhere.

[Slide]

MR. RIZZO: Beneath the aux building, there are two layers here, one here and one here.

MR. JENG: That is to scale.

MR. RIZZO: The foundation, 784.6. This is 776.9. That is eight feet. I have a couple of feet of limestone, I have 3 feet more claystone. Here is 5 feet of claystone. Here is 10 feet of claystone.

MR. JENG: In the order of 3000 -- 2300. We are remeasuring it, though.

MR. RIZZO: 2300, maybe 3000.

MR. JENG: Why can't you apply the weighting approach that you did on the other stepped mat? To me --

MR. RIZZO: When you weight it you get 4000.

MR. JENG: Many people have done that. I am wondering why you did not feel that could be there.

MR. RIZZO: We would be very happy to do that, David, if you accept it as a criteria.

MR. JAN: Is 4000 acceptable?

MR. JENG: Unofficially, subject to upper management approval. I think it is a --

MR. LANDERS: We have accepted 35.

MR. JENG: Maybe you would reassess the situation.

MR. HOFMAYER: Perhaps one consideration would be if you had comparisons for fixed-base versus the method. They do not substantially differ. Then you have justified that it is a fixed-base site.

MR. GEORGE: The pilot studies were done on fixed-base. I hired consultants to do pilot studies a number of months ago. The results are probably even more significant than this.

MR. RIZZO: For some frequencies we see a more dramatic reduction.

MR. HOFMAYER: But that establishes whether or not there is a fixed-base site. After all of this refinement, the results are not substantially different.

MR. GEORGE: We did not want to come in here and say we have a fixed-based site and we have shear wave velocities that we are going to be discredited for. Again, we were trying to overdo it.

MR. HOFMAYER: You could reverse it. If you came in with a fixed-base site, people would ask you a whole lot of questions.

[Laughter]

Maybe you are home now and you could meld the two arguments together.

MR. JAN: It is more or less in line with what we have in the FSAR.

MR. JENG: Let me take a summary of what I would like to say, and then I will pass it on to other people. You have presented a procedure which I feel there are these following weaknesses. Number one, you should articulate more as to why you are doing this reanalysis. The question could be asked, given the environment we are operating under, what is wrong with the earlier one? And please answer the question. That question is very important.

Secondly, I think Don Landers has a good point, and Larry mentioned this earlier. You should strongly consider the use of Reg Guide 1.60, although I agree they are not much different. If they are not much different, then why -- make it easier. You should consider it using the 1.60, but that is subject to Cnarley's point, whether this would be a major change that would require the CP revision.

Now, let me go to several points I mentioned. If you are right to persist to use this approach, the Staff in the past have encountered some concerns, and that concern -- I'm not saying it is unsurpassable, but it is a concern you have addressed in more detail, and the point is the three or four. And then in the next one, I would like to say --

MR. SHAO: The three or four plants that --

MR. JENG: The three or four parameters of concern. The potential reduction of the motion from the upper to the foundation level, and how did you account for the embedment as you indicated you did? And also, how are the material damping justified to be changed from 2 to 5 percent potentially? It may not be the finite. And also, the spectra has dropped so much from before and after, and there would be some questions asked as to why. Is it the right thing to do? Did we do wrong things before? And that you should articulate and do your best to defend or justify.

In regard to the submittal, if you are going to use this method, fine. One question would be how does it compare with down to earth fixed-base with the damping model? Would the result differ too much or are they about the same? If they are about the same, what is wrong? In regard to that, you talk about your concern about the rock or soil. I think unofficially we feel that if you were talking 4000, on the average, on the weighted basis, I think that we are quite confident it will rock.

MR. CLOUD: What if it were 3500 on a weighted average basis?

MR. JENG: I still maintain you could quote the precedence of earlier licensing actions, and Larry mentioned that there are 31 positions there. Based on that position, many plants have been licensed, and that makes a good argument, in my opinion.

MR. SHAO: There are lots based on -- anything more than 3500 is a rock site.

MR. JENG: You know and we know that anything above 2500 -- and Newmark was quoted many times to me. The response does not differ so much. It does not show up.

The increase of ten times in the rocking. That is one of the main considerations of the reduction in the peak.

MR. RIZZO: On that building.

MR. JENG: Yes. If you are having that result on other buildings with active or more thorough --

MR. RIZZO: Only on that building do we have that dramatic change.

MR. JENG: The last point, Don Landers' point. You are going to do a simple boring outside of the plant area. I think one can conclude that the system within the plant complex will be identical. It is made with some variation in the thickness, and if you're going to prove nonlinear behavior, you may prove it; otherwise I see no point in doing it, unless you want to prove some nonlinear behavior of the material to prove it is 5 percent rather than 2 percent. For that purpose, I can see it. But one may not be enough.

MR. RIZZO: We're doing three borings. One area, three borings.

MR. JENG: I don't think that is variable. That's an opinion of mine.

MR. RIZZO: Before we leave that, --

MR. JENG: What do you want to know?

MR. RIZZO: If I can show the shear wave velocity equivalent is higher than 3500 -- and we think that we can justify a fixed base -- that is important.

MR. JENG: Don't you know that as shown in the earlier boring? You mentioned the rig. You have shown 15 or 20 borings.

MR. RIZZO: When I come in to argue with you guys about whether it is 3500 or 4000 or 3300, you are going to take issue with me on the data.

MR. RINALDI: Can I interject something? I guess this review was done several years ago, right?

In the previous evaluation, you took this as rock. You took this layering effect. Did you consider the layering?

MR. RIZZO: Only in equivalent value.

MR. RINALDI: You took it as a rock site?

MR. RIZZO: With a shear wave velocity of 4600, something like that.

MR. RINALDI: Basically, I don't know if we're going to be reviewing the submittal that you have in mind, but from what I hear, you have two limiting conditions. You're taking it as a layered site, and you're taking it as -- you've done some preliminary studies to be fixed base, and you have all of the information. It is just a matter of presenting it, I guess, the way I see it.

MR. GEORGE: We have a world of information, and I might point out, as Mr. Scheppele stated earlier, Professor Holley and a number of other professors concurred with what we were doing. They, in the early meetings, the biweekly meetings, the concern with layering and the one with fixed base is one of the things that led us to go the way we're going. We definitely started out on verifying if the shear wave velocities were such that they would be acceptable to you people and used the fixed base.

It is certainly more straightforward and easier. We will reanalyze exactly where we are at.

MR. RINALDI: It sounds like you have all of the information. But if you have any question, I just want to present a suggestion. To make a decision about the soil, you might want to have the concurrence of the geoscience, the geotechnical persons on the Staff, which probably would have an input in determining that. I want to suggest, from the structural point of view, although I have not seen all of the results -- I was just given an outline -- it seems that you have all of the information and the limiting cases considered in your evaluation, so that the only other suggestion is that you might want to get an input from the geotechnical, geoscience person at that site, where you can just go the shortcut and take 4000 as an average weighted value.

MR. JENG: One important point --

MR. LANDERS: If you stay with what you have -- if you don't, then fine -- but if you are going to stay with what you have, can you give us an idea now of why you had dramatic changes in stiffness versus the old approach? Why is it that the lateral stiffness reduced and the rocking stiffness increased?

MR. RIZZO: The lateral stiffness is reduced primarily because of the layering of the claystone up near the top of the foundation. The vertical reduced primarily because the shear wave velocity of the Twin Mountains formation is a little bit lower than Glen Rose, and when the original analysis was done, it was assumed that the vertical is not influencing that depth. It does influence that depth, in fact. The rocking is the geometry. What you saw was the most dramatic effect in the aux building.

MR. LANDERS: Explain geometry to a layman.

MR. BURWELL: Can you use a slide and make some reference? I think it would be easier.

MR. RIZZO: Sure.

MR. BURWELL: This is Section DD of the auxiliary electrical building, an earlier slide.

[Slide.]

MR. RIZZO: I would like to go back to the previous slide, the plan view of that foundation. When we did the original FSAR analysis for this building, the mat, although a singular mat, crosses the entire length. It was treated or split to accommodate the structural model, which you recall from previous slides, is two sticks coming down.

[Slide.]

At that point, the construction model has a stick here and a stick here (indicating), and when the rock structure interaction parameters were considered, this was taken as a single mat, and this was taken as a single mat (indicating), even though it is one continuous mat across there.

So when the springs were calculated, they were calculated one here and one here (indicating), while, in fact, if you consider the entire mat, it is not linear. You do not have the two, because it is a cubic function, and therefore if you generate one stiffness with this direction, as opposed to two small ones, you get a much larger rocking stiffness.

MR. LANDERS: You had a slide up that showed the stick model that had two separate slabs, and did it not have springs in each slab?

MR. RIZZO: You are correct.

MR. LANDERS: So your model, in fact, --

MR. RIZZO: When I went to the model, I said we calculated a singular spring for the entire mat, and I said that we resolved it was consistent with the model.

MR. LANDERS: How did you resolve that?

MR. RIZZO: By shearing geometric compatibility and static. That, in fact, is where the big factor comes from on the one spring in the geometry calculation.

MR. JENG: The torsion, the stiffness, you used the entire mat? Do you separate the two models?

MR. RIZZO: When we do this analysis, we have a separate torsion spring as well.

MR. JENG: For the determination of the rocking and torsional spring for each of the mats shown there, did you use separate one-half dimension of the total mat?

MR. RIZZO: When we calculated the spring constants for this building, it was two steps. First, the spring constants were determined for the entire singular mat beneath that building.

MR. JENG: For what degree? For six degrees?

MR. RIZZO: Six degrees of freedom. When we applied it to the structural model, which is broken into two parts, we resolved this spring into two components, each one of those six springs into the two components. Geometric compatibility. The two verticals must equal the vertical. The rockings must satisfy the rocking, including the vertical components. Torsion must be satisfied by the horizontal springs.

MR. JENG: But between the two submats, you must have some point of comparing and determining, assuring compatibility.

MR. RIZZO: It is riding statics. Some of the verticals must be vertical.

MR. HOLLEY: At the risk of messing it up, Dave, what I think Paul has done is to calculate first the six springs on the basis of a single large mat. It is then said that if you had that single large mat, but each of these six springs was actually a pair of springs, so you had two located for the separate parts, what would the properties of those twelve springs have to be to be equivalent to the six? And to calculate that, you use simple statics and geometric compatibility on the assumption that whatever was occurring was the geometry of the large mat.

In other words, if you simply said, I'm going to take the six springs for the large mat and by statics alone, break them down into two sets. That's all they did.

MR. JENG: But it should not be the statics consideration. It should be that the behavior responds to the deformation, to judge whether compatibility has been attained. You are equating the two forces, that the sum equals the origin of the big one. But what about the behavior?

MR. RIZZO: That is a simplified way of saying it, David. You also have to assure the rocking spring, the overall rocking behavior of the foundation. I know I have two springs, how the two springs are affected by the verticals.

MR. JENG: Do they rotate at the same angle?

MR. RIZZO: Yes. You assure that kind of compatibility.

MR. JENG: What was the advantage of dividing the two sticks. Why couldn't you use the six springs or the large mat? What is wrong with that?

MR. RIZZO: Nothing is wrong with it. It is another approach to doing it. This is the one that was used in the FSAR.

MR. JENG: It is sort of unorthodox, and it is arbitrary, but I don't make judgments.

MR. RIZZO: We have to make certain judgments. At what point, do you change your FSAR, and at what point do you simply change analysis procedures? This is one of those borderline cases. We elected not to change this part of the FSAR. It would certainly be no different if we put a single mat in there with the same springs.

MR. JENG: The upper mass points.

MR. RIZZO: You get slightly different responses.

MR. JENG: The response is what we are interested in, to make sure they are consistent and compatible.

MR. RIZZO: If you want to be consistent with the FSAR, then you have to do this (indicating).

MR. JENG: I presume you have some explanation of how this is done.

MR. RIZZO: Yes.

MR. TRAMMELL: Let me ask a couple of questions. Is this over with?

Go ahead, Bob, you seem like you want to say something.

MR. CLOUD: I don't want to contribute to this. I want to come back to the issue of the fixed base. I can do that when you're finished.

MR. TRAMMELL: Let me ask a question. We have seen -- we have a response spectra meeting, and it looks like you want to change the response spectra, and there are some other things that have gone on in recent requests that make me think that I want to see what the entire program is, if it is a program, or these little piecemeal things.

We have been asked to approve the use of some recent edition of the ASME Codes on supports, Section NF. We have been asked to allow you the use of, I think it is N-397, as a code case, but I'm not sure. It has to do with combining modal responses or something. You know what that is, but I don't.

We have been asked to approve the use of Code Case 411, which has to do with damping piping, I believe, and now we have response spectra. These four things seem to be related to the same subject. If you're going to go back and redesign piping or conduits or cable in some cases, it would be of some value to you.

Is there anything else? Is there going to be a meeting on something else next week, or is this pretty much the end of the reassessment program?

MR. GEORGE: As far as what I call the prerequisites to this analysis, this is a response spectra, to my knowledge, coupled with the code cases. It will be what we will have the opportunity to use in any reanalysis, with your approval, of course, and we are proceeding with the reanalysis, of course, on our existing design basis parameters. That is the Stone & Webster reevaluation of piping.

MR. LANDERS: For example, is there any anticipation that you know of, Joe, to use higher damping for the cable trays, which is not a code situation?

MR. GEORGE: The program on Unit-1, I don't anticipate the additional damping there. That could be one that I don't have the answer to here today. The response spectra will impact, providing what comes through on response spectra we have talked about here today, it will indeed affect the loading on cable tray supports and on conduit supports and more importantly on embedded bolts that attach these to our steel reinforced concrete. I view this response spectra issue as an opportunity in any reanalysis to add a layer of insurance to the showing that this equipment is satisfactory and will do its job in most cases, and hopefully with a minimum of redoing the things.

MR. HOLLEY: I think the program that Marquette discussed last Friday for the cable trays envisioned -- or he actually mentioned some element tests, among others, and I can imagine that these might lead to a request for local damping changes.

MR. GEORGE: It possibly could. But as far as my being able to tell you positively one way or the other, I'm not in a position to do that today. We will be testing the conduits more than the trays.

MR. SCHEPPELE: I'm not sure whether they plan on esting the trays with regard to damping, but certainly then it would have to be defended.

MR. LANDERS: We understand that, but really what we're trying to do here is, faced with the ARS potential for that, is to look at all of the issues that would be impacted by that, and if, in fact, there is the anticipation to use higher damping values on the cable trays, it would be nice to know that up front.

MR. TRAMMELL: We want to get it all together, so we have a package here, so that we know collectively what we are faced with. We do not want to just pick this piece of the code out of here, because we kind of like that, and say, "Let's go back to the '74 code for that. That's kind of neat." And by the time you put it all together, you don't have the cohesion that we thought we had.

MR. CLOUD: Can we come back to the fixed base, because Don raised a question that would help you better understand exactly why we did this?

Could we see the soil profile again?

[Slide.]

It is kind of important, because it would have been easier for us, as Joe mentioned, to go -- to come in and ask for fixed base. But we wanted, if you will, to account for any potential questions that would subsequently come from you people, and as Don's question on how did we -- why did the stiffnesses change, clearly, you know -- clearly elaborate the reasons for us making the decision that we did, because whereas a couple of feet of claystone here and here and here would not make any difference, the placement of it is very important. As you see, it is -- the thick layer of claystone is right at the very top.

[Slide.]

This strongly affects -- this shows it even more clearly. The thickest layers of the claystone are right at the very top, which strongly affect the rocking and the other close-in properties.

And not shown on this -- and by the way, the middle one in this picture is exaggerated. It is very thin. It is only a couple of feet, and then it goes down for 100 feet of solid limestone, but then the entire thing is underlain with the other formation, the Spring Mountain formation, which has a strong effect when you consider it. So it is the placement of these different things as much as the volume of them, and we felt that if we do it the way that we had done it, then we will more properly account for the true physical behavior of the site. That's the reason we did it. Right, wrong, or indifferent, that's the reason we did it.

MR. RIZZO: The claystone was 2300 to 3500.

MR. JENG: This resulted in the change of the -- drastically in the vertical direction?

MR. RIZZO: The horizontals.

MR. JENG: Based on my experience of reviewing plants, I'm not concerned about the vertical direction; I'm very much concerned about the major change of the spring, which is the 80 percent contributing to the higher level of response in the horizontal action, Z. I will be concerned if you are proposing a procedure which would change the torsional springs and rocking, which in my understanding would lead to changes of 80 percent of the responses at the high level. I would like to know why such a change is reasonable, justifiable and supportable, and for that reason I am going to add the point that he reminded me. Assume you are going to continue to come up with the procedures, which you might as well, though, if you so believe that is the basis for your plan.

I would like to see any additional informations which are so-called observed behaviors, observing the response data of any plants as they are compared to the application. Not just saying that in 1983 somebody wrote an improvement on the computer of such and such and another guy wrote a refinement of the computer code, and putting these together, you say it is 1985 technology.

That is not what we are interested in. We are interested in what reality has taught us since 1975 which would make your procedure more supported, more believable. If you have such information, we would appreciate it. Maybe to try your effort to find if there is any other evidence.

MR. RIZZO: The best we have is Humboldt Bay, the performance that -- you know the results of that.

MR. JENG: Since Humboldt Bay, have you observed anything from a European source?

MR. SHAO: So far the methodology changes have been analysis. The actual observed behavior experiments. Do they have anything about actual incidents?

MR. RIZZO: We can certainly look in Europe. We know there is nothing else in the States except Humboldt Bay.

MR. JENG: If you have a 2300 psi interspersed in such a way, I consider that this is part one from the engineering standpoint for the structural analysis. I believe that is the case. But you have other judgments. Then I would yield to that.

MR. RIZZO: Our first judgment was to go fixed base. I would like to hear a reading from you, Don.

MR. LANDERS: In hindsight, it is going to be substantially easier for you to sell fixed-base to the Staff than the kind of analysis that you are involved in right now.

MR. HOLLEY: And we would never know if it would be the other way around if we had gone the other way.

MR. LANDERS: You could have walked in here with fixed-base and got hit with 900 questiosn the other way.

MR. ENOS: If you go with fixed-base, are you going to try to take credit for the Twin Mountain effect where it gives you such a drastic reduction in the vertical response?

MR. RIZZO: We don't take credit for anything if we go with fixed-base. It does not give me drastic changes. It just softens the vertical strain.

MR. ENOS: You have a real big reduction.

MR. RIZZO: That is damping, primarily, a big vertical damping correlation coming into play. I had the vertical geometric damping at 65 percent. That impacts on the vertical response. But look, fellows, if your attitude is fixed-base --

MR. CLOUD: We will reserve the option.

MR. LANDERS: I think one of the things that was said here that maybe should be repeated is that here are no geotechnical people here.

MR. SHAO: We had the option to look at fixed-base too.

MR. SCHEPPELE: Can you give us further guidance on things like this? I think you understand what we have tried to do in good faith in this particular matter. It is a situation which to a certain extent is judgment. Now, I would think that you should give us in some form some guidance on this, however, that you would suggest.

MR. SHAO: But today we are essentially exploring.

MR. CLOUD: I understand that.

MR. SCHEPPELE: We are not trying to have you commit one way or another, but we have a good dialogue of what can be considered. We heard the reason of what we did what we have done. But in the hierarchy that you have here with regard to manners in which you feel as though the licensing could be expedited, which really is the heart of the matter, I would think that if we could get your guidance from the viewpoint of the fixed base concept in some form, however you would ask us to do it, by written form or whatever, then I would think that that would be something that would expedite the whole situation.

We understand. We are not asking you for a set position today. We have tried to give you as much information as possible, which I know covers a broad range. That guidance that I can see on that point is very critical.

MR. SHAO: Dave expresses the opinion, but I also wanted to see if everyone agrees with the fixed-base too, from the soil people.

MR. CLOUD: There will be soil people who look at it.

MR. SCHEPPELE: Do you have any feel for the timing it might take to get --

MR. SHAO: I think I would like to talk about other implications -- I would like to talk about other implications so that you are aware when you make the submittal how are we going to review it. The minute you open this box, we are going to review the whole thing. We are going to review the spectra. I think Dave has questions about the modeling, the past modeling. The whole issue has to be reviewed. It is not just everything is right and we are going to do this.

MR. SCHEPPELE: I assume you don't go back to ground accelerations.

MR. JENG: But what spectra should be the one in 1.60, or the Newmark spectra, which I understand you reasoned in.

MR. JAN: Let me add the Comanche Peak project, the ground response spectra are essentially based on the Newmark paper, and then when we said horizontal, it is Reg Guide 1.60, because Reg Guide 1.60 comes out of -- it is like the original paper. And for the vertical, just somewhat different, but the difference is rather small. We do not consider it as a really significant effect, so we are not choosing one part of it and leaving the other part out.

MR. SHAO: Suppose you have the whole package here. This part, you want to use the latest knowledge, but the other part, you also want to use the latest knowledge. That is a question that would come up you are to answer and the Staff to answer. The whole thing. You say everything is closed. The minute you open, you open the whole box. It is not just opening a portion that you want to open.

MR. HOLLEY: Operationally you feel it would be easier, in essence.

MR. SHAO: Suppose they wanted to open the ground acceleration, too.

MR. TRAMMELL: Look at load combinations, see how modern that is.

MR. SHAO: It can also be under Staff control.

MR. TRAMMELL: 1.9 load factor.

VOICE: Are you going to commit yourself to Standard Review Plan, 1981 revision all together? In other words, are you going to reanalyze the structures, for example, for the -- using the new seismic codes, or just leave them the way they are?

MR. SCHEPPELE: You mean with regard to the response spectra we have shown here.

VOICE: Yes.

MR. SCHEPPELE: From the point of view of looking at the loadings, yes.

VOICE: There is a new revision of Standard Review Plans, July 1. Are you going to resubmit or revise the FSAR according to the new release? Are you going to use the analysis of containment using 1983, for example, issue of ASME, the Code revision 2? At what point do you want to go with this -- to what extent do you want to go to this modernization of your analysis or FSAR? Where do you want to stop?

MR. SHAO: You have to think out all of the implications before you ask for a change on one part. They are related. It is not just isolated.

MR. SCHEPPELE: If you try to get a change in this criteria, in effect you are opening all aspects of licensing.

MR. SHAO: You may open all aspects.

MR. TRAMMELL: Let me ask you a question on timing, Joe. How soon would you need approval of something like this to be of value to you? The clock is running and you are making changes. I guess you are making them in the basement. That's where the changes seem to be minimal here. Is that right? Are you working the problem in the low level of the structure for now, on cable trays or conduit repairs or whatever you are doing? There is work going on. I heard you say that.

MR. GEORGE: Yes.

MR. TRAMMELL: Are you on hold now with respect to this issue, with modifications to conduits or cable trays?

MR. GEORGE: No. Any support work under way in the way of piping support will start with the reevaluation in redoing any core support stability that is in issue, and that does not really get into the loading of the supports so much. That work will be ongoing in another week or so.

MR. CLOUD: The basic plan, Charley, on the reanalysis for the piping is to initiate the work on the current basis, and then if some piping or some support should turn out to require attention, then those would be set aside, and then when the new spectra come --

MR. TRAMMELL: So you would have to do that. How soon would you need this approval to be of value? The clock is running here. Time is very much of the essence.

MR. SHAO: Existing spectra.

MR. TRAMMELL: If it is going to be of value, it has to be of value fairly soon, it seems to me. How soon would you expect the Staff approval, other than as soon as possible?

MR. SHAO: You have some questions.

MR. TERAO: My question is relating to seismic qualifications.

MR. SHAO: Most of the question is at the foundation level.

MR. TERAO: Based on what you are seeing with the response spectra, what do you think the extent of the impact may be for the seismic qualification? Are you going to do reevaluation? At this point we have almost finished our review.

MR. CLOUD: The answer there is that we would hope that this work would have no negative impact on equipment qualification.

MR. SHAO: But not on the curve I saw.

MR. LANDERS: They have already stated that they will look at that.

MR. SHAO: He says no impact.

MR. LANDERS: They are hoping no impact, but earlier we have on the record that in fact they are going to take these new amplified response spectra and look across the board at all of the equipment.

MR. SHAO: He should know how much work is involved with the seismic qualification. You have to reopen that issue.

MR. CLOUD: Certainly we have to address that issue. If these spectra have negative implications for any of the equipment in the plant, it will obviously be necessary to address that.

MR. ENOS: I have a question where you show the original spectra and then the new spectra. Would you put one of those slides up for the horizontal?

[Slide]

You said earlier that you were doing plus or minus 10 percent and then an additional 10 percent on your broadening. Was that also done for the original curves?

MR. RIZZO: The original plot up there, the solid line used the property variation of 2K plus or minus 10 percent on the two sides.

MR. JAN: The answer to your question is yes.

MR. ENOS: Now, the piping that Stone & Webster is using is using the original response spectra, and this includes the 10 percent plus or minus, correct?

MR. CLOUD: It would be that solid line.

MR. ENOS: Now, did they have to address the 15 percent?

MR. CLOUD: That is the existing design basis, the solid line.

MR. ENOS: But you do not have to license it. The plant is a 1985 plant. It is not a 1973 plant.

MR. SHAO: You cannot use part of the '85 and the others 1975. The same question that he has. You cannot say one part is '85 and the other --

MR. ENOS: Is the piping that Stone & Webster is going to be doing, is it going to be okay to use that spectra or do they have to increase?

MR. LANDERS: The current Stone & Webster analysis is using the FSAR commitments. It is not an open issue at this point with respect to what Stone & Webster is doing.

MR. SHAO: But the point is they may use this.

MR. LANDERS: If this is approved and if the Applicant uses it and if Stone & Webster use it, that is another issue. Currently Stone & Webster is complying with licensing.

MR. SHAO: It is different, the piping and damping. The spectra gets into other things. The damping is more cleancut. If you want to increase damping values, it only affects piping, but with spectra, you have the structures, you have the -- I just want to say it shows the whole picture very carefully before you come in with the proposal.

MR. JENG: Can you qualify one point for me? Earlier you mentioned right now the basic direction for the engineering is to go ahead and use the old spectra and to see if that can be qualified properly. Now, in the case of an exceedance or difficulty in this effort, you would automatically shift to a bunch of -- a list to be handled by the spectra or after you have tried modification with reasonable easiness to exhaust all of the possible reasons, and then after you have some left that are unresolved, you go and use this one, or automatically shift to this one.

MR. CLOUD: The latter. It automatically shifts completely.

MR. JENG: So it could involve exntensive uses.

MR. CLOUD: It would be the basis for the qualification of the plant. The reason for starting now is purely for expediency of getting the effort moving.

MR. GEORGE: It is possible, back to Charley's question on timing, that we could go through the whole revalidation of the plant with the old spectra and never use this even if we made the submittal.

MR. TRAMMELL: I was thinking that this is a problem subject to operations research, typical problem. The clock is running, expenses are such and such for this and that, and there has got to be a point in time where Staff approval of this is of no value. I would think that timeline must be very short.

MR. LANDERS: I have another technical concern I would like to address, and really Dick's question led me to it. It would appear to me, at least for the building that you have presented, that your broadening in your new approach will, in fact, be less than the FSAR.

MR. RIZZO: Yes, overall broadening.

MR. LANDERKS: That is going to be a critical issue, in my opinion, and somehow or other you have got to address that so that the Staff is convinced that what you are doing is acceptable. And it is building-dependent, as you pointed out. Some buildings will be very much less, and some will be slightly less. And as I look at the slides you put up there, a little more broadening puts you outside of the original spectra, and therefore requires some evaluation, and having seen that and recognizing this difference, it leads one to recognize that there may be some concerns here.

MR. JENG: The broadening, is it dependent? Or is one of the results of this use --

MR JAN: Stiffness.

MR. JENG: If you were to use the simple fixed-base, this may not be the case anymore.

MR. RIZZO: If we go to the simple fixed-base, ther is no variation.

MR. JENG: You are saying the outcome would be about the same --

MR. SHAO: It would have broadening --

MR. RIZZO: Peak broadening but no variation.

MR HOLLEY: You have pointed out, you and your colleagues, a number of the things that come up when you open the box. Would you say a few words or outline a few words as to how much less open the box is if you go fixed-base?

MR. SHAO: The box is open. There can be all kinds of questions on different things.

MR. HOLLEY: But a lot of questions would go away, like the peak broadening.

MR. SHAO: It's like if somebody questions -- there's no end to it.

MR. SCHEPPELE: I think there has to be some understanding of what box is open. On the part of the Applicant, I think he misunderstands, and it is part of our job to try to give him an assessment of this.

MR. SHAO: The box does not even know. Suppose all sorts of questions come from external sources?

MR. SCHEPPELE: Are you saying there is no answer?

MR. SHAO: I don't know the answer. It would be a pretty messy problem later on. Plus there is the possibility that there are all kinds of questions that, even without the Staff's control, are possible the minute you open the box.

MR. BURWELL: From my point of view, I think you need to be very careful about the impact of taking this course of action on, shall we say, the analysis of record, the design of record. Where do you intend to apply it, and where do you not?

You need to be very clear on that interface. From what Larry is saying, I think that once you start a course, it will be very difficult to say, well, we will apply it to this design of record and not to the structure. For example, we will apply it to piping, but not structural and so on. I think you'd had better think very carefully.

MR. GEORGE: We would be required to be consistent with the application. It is a prerequisite that many of the designs in the plant, any structural building supports or whatever, we recognize that. We would have to be consistent.

MR. SHAO: What I'm worried about is, I think you could do all of this, but your question, your methodology in certain areas --

MR. CLOUD: If I could sum up the situation, the way it looks to me at this time, first I think the meeting has been immensely valuable to all of us.

Second, the box that you refer to would be opened at the time the submittal were made. So the situation that we find ourselves in is that we need to reevaluate our position to decide either to make no submittal, to make a submittal on the basis that we have described to you, or to make a submittal on the basis of a fixed base model, which we will do.

MR. BURWELL: And we have work to determine that.

MR. SHAO: The fixed base -- I think you should look at all of the possible implications before you make a submittal.

MR. CLOUD: That is to decide whether to make one.

MR. TRAMMELL: And your submittal should define precisely what you are looking for, and I would think you might take a little extra trouble to say it does not apply to this, this, and that, and define these limits, so that when the Staff starts asking you questions, you can say, "Hey, that is beyond the scope of my request, and I did not intend to include that."

It would help us a lot. The Staff will run over you.

MR. LANDERS: Lines 5 through 8, Section 2.2.1.

MR. TRAMMELL: Be quite specific in what you are asking for. And then you can say that we're asking questions outside the scope.

MR. CLOUD: We will go further. It is true that we will ask for the reasons that you elaborated, Charlie, that we will ask for an expedited approval, and we will give you the time that we would hope you would be able to respond.

MR. TRAMMELL: Obviously the better you define it, the quicker we can review it.

MR. CLOUD: Fine.

MR. LIPINSKI: It may work the other way, too. You can confine the submittal to certain aspects, but in the opinion of the Staff, it may not be sufficient. You may find, for example, that the revision has to go further beyond what you describe.

MR. TRAMMELL: That is the other shoe. If it turns out that we cannot approve it, that is of equal value.

MR. LANDERS: That is the importance of that kind of a submittal. At that point, the Applicant can say, "I'm going to withdraw my submittal. If it's going to broaden it, I'm going to withdraw it."

MR. TRAMMELL: You need a yes or a no; do you not need a maybe.

MR. MIZUNO: It is not sufficient just to define the lines that you want to have open. You have to provide a basis for saying why certain other things which potentially, from a logical standpoint, are linked, but you do not wish to know why these are excluded.

MR. SHAO: That is the same thing I said. A lot of things are linked together. If you could change one part, the question is why the other part doesn't change.

MR. JENG: To the extent that you propose that these proposed changes are A, B, C, D, you should address whether such a proposal extent would affect consideration of the changes to require a CP modification or whatever. That issue should be tied in, too.

MR. CLOUD: Thank you very much, gentlemen, and we will look forward to seeing you the next time.

[Laughter.]

[Whereupon, at 12:13 o'clock, p.m., the meeting was adjourned.]

CERTIFICATE OF OFFICIAL REPORTER

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

Name of Proceeding: Meeting on Recalculation of Seismic Response Spectra: Comanche Peak

Docket No.:

Place: Bethesda, Maryland

Date: Tuesday, June 18, 1985

were held as herein appears and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission.

(Signature) Barbara Whitlock

(Typed Name of Reporter) Barbara Whitlock

Ann Riley & Associates, Ltd.

RE-ANALYSIS
OF
ROCK-STRUCTURE INTERACTION

COMANCHE PEAK STEAM ELECTRIC PLANT
SPRING 1985

<u>OBJECTIVE</u>: TO ASSESS THE EXCESS SEISMIC MARGIN IN THE IN-STRUCTURE FLOOR RESPONSE SPECTRA CONSIDERING:

- 1985 VERSUS 1974 TECHNOLOGY

- AS-BUILT CONDITIONS (MINOR CHANGES AND REFINEMENTS)

ORDER OF PRESENTATION

- BRIEF REVIEW OF BASIC SEISMIC DESIGN CRITERIA

- BRIEF REVIEW OF SITE FOUNDATION CONDITIONS

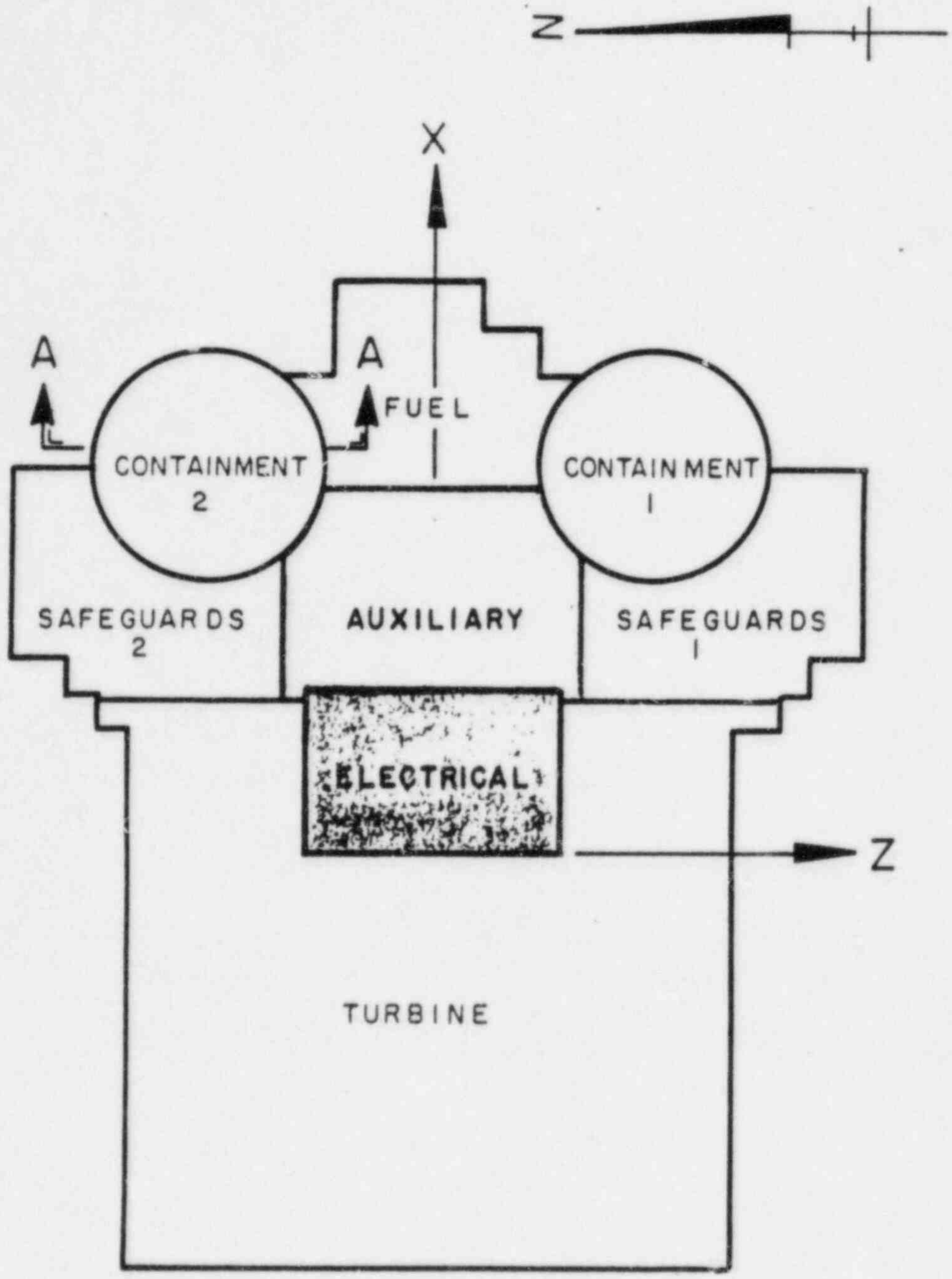
- MAJOR STEPS OF RE-ANALYSIS

- EXAMPLE RESULTS (AUXILIARY BUILDING)

BASIC SEISMIC DESIGN CRITERIA
(FSAR)

ITEM	VALUE/DEFINITION
SSE	0.12G
1/2 SSE (OBE)	0.06G
RESPONSE SPECTRA	
• HORZ.	R.G. 1.60
• VERT.	NEWMARK, ET AL., 1973
STRUCTURAL DAMPING	R.G. 1.61
ARTIFICIAL TIME HISTORY (FREE FIELD)	
• HORZ.	ENVELOPES DESIGN SPECTRA
• VERT.	ENVELOPES DESIGN SPECTRA
• DURATION	10 SECONDS
CONTROL MOTION LOCATION	FOUNDATION ELEVATION
RSI APPROACH	LUMPED PARAMETER (SUB-STRUCTURING)

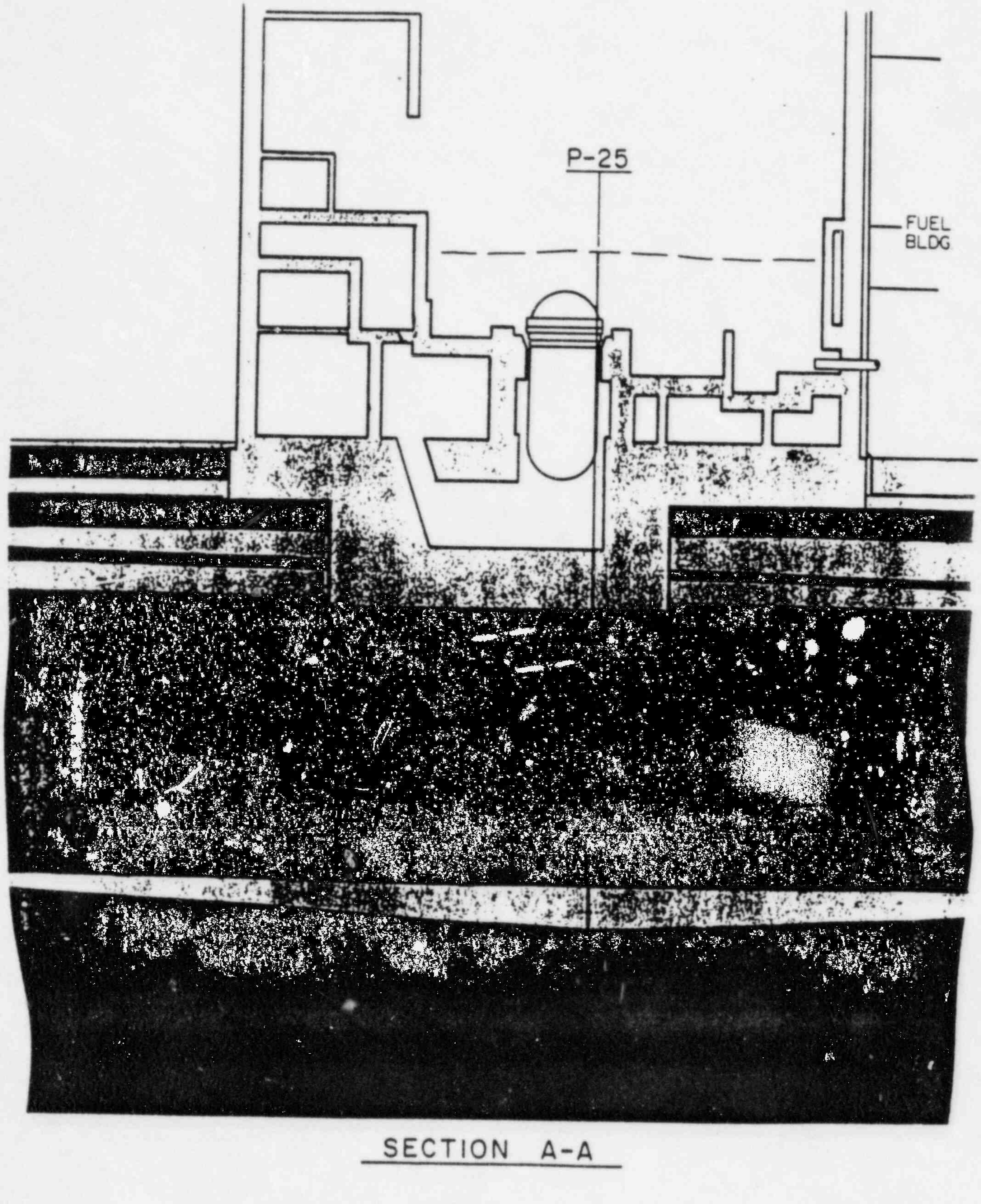
NOTE: FOR THE 1985 RSI RE-ANALYSIS, NO CHANGES TO THE ABOVE HAVE BEEN INTRODUCED TO DATE.



KEY PLAN

SCALE

200 0 200 FT.



SECTION A-A

TYPICAL ROCK PROFILE

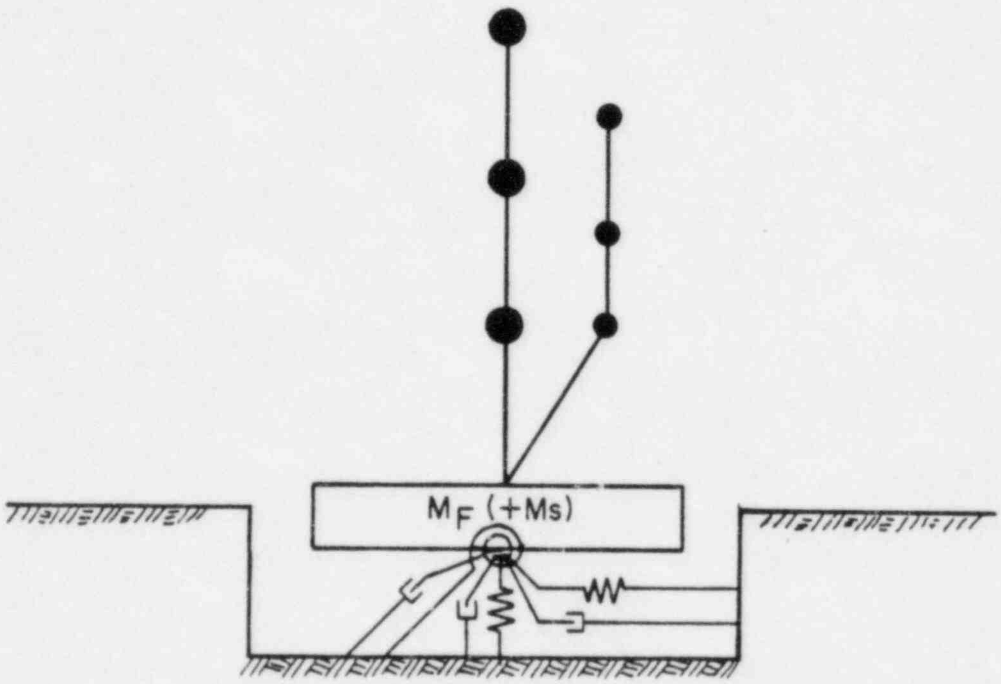
EXC SLIDE

EXC SLIDE

Rock
Slide

ROCK

SLIDE



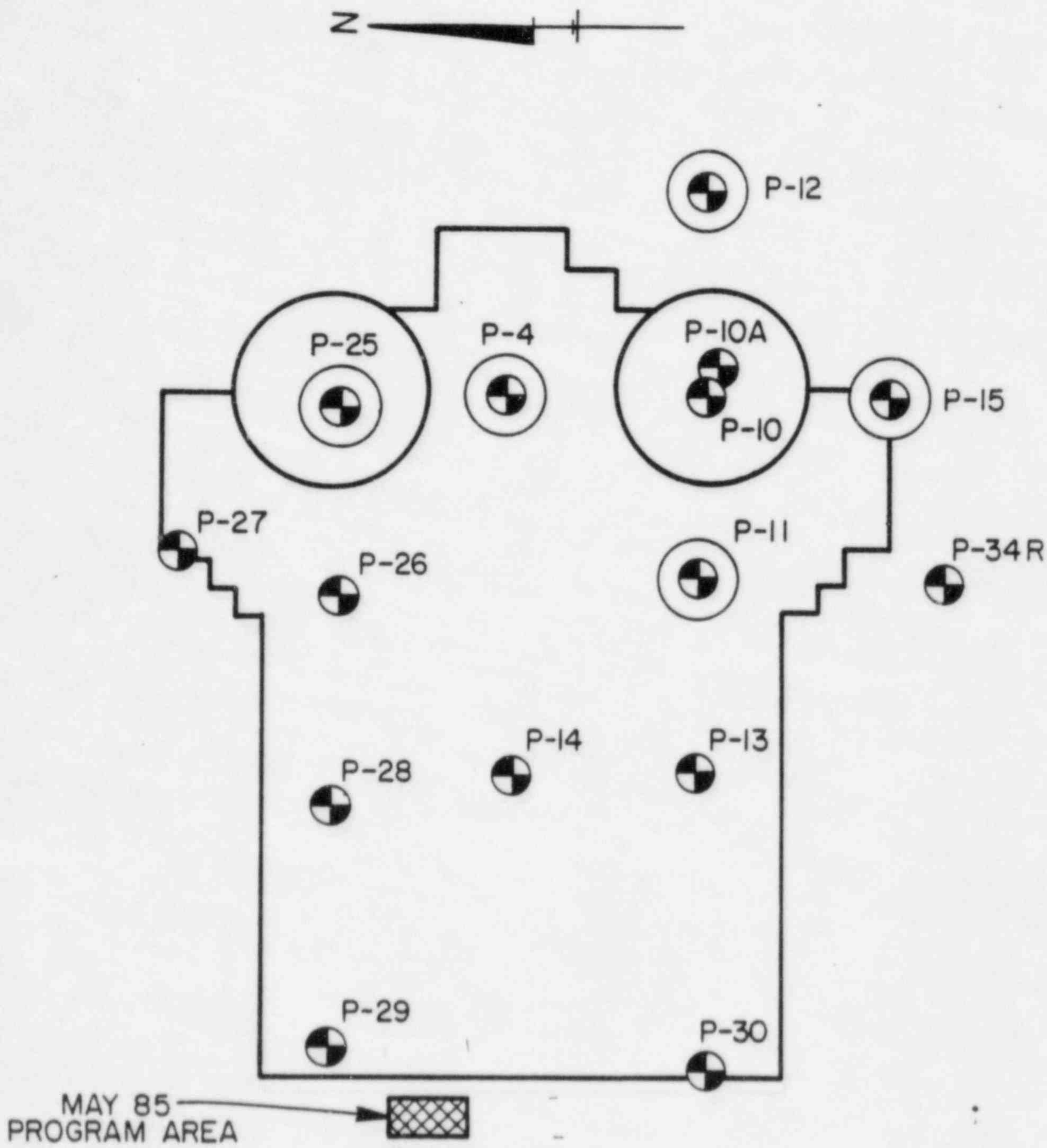
GENERIC SIMPLIFIED RSI MODEL

COMPARISON
FSAR VERSUS RSI RE-ANALYSIS
ROCK STRUCTURE INTERACTION

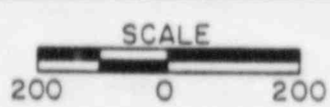
ITEM	FSAR	RE-ANALYSIS
(1) SOIL MASS	INCLUDED	EXCLUDED
(2) STIFFNESS	UNIFORM MODULUS VALUE ADOPTED	LAYERED SYSTEM ANALYSIS
(3) DAMPING		
• TRANSLATION	10% (HYSTERETIC)	GEOMETRIC DAMPING (VISCOUS) + MAT'L DAMPING (HYSTERETIC)
• ROTATION	5% (HYSTERETIC)	GEOMETRIC DAMPING (VISCOUS) + MAT'L DAMPING (HYSTERETIC)
(4) EMBEDMENT	INCLUDED	INCLUDED WITH UPDATED INFORMATION
(5) VARIATION IN STIFFNESS		
• LOWER BOUND	K/4	65% TO 150% (BASED ON VARIATION OF INPUT PARAMETERS)
• BEST ESTIMATE	K	
• UPPER BOUND	2K	

MAJOR STEPS
FOR
RSI RE-ANALYSIS

STEP	DESCRIPTION
(1)	DEFINE RSI ANALYSIS PROFILE AND DYNAMIC ROCK PROPERTIES
(2)	DEFINE FOUNDATION GEOMETRY
(3)	OBTAIN STIFFNESS & DAMPING FOR 6 MODES (RIGID MATS ON ELASTIC LAYERED SYSTEM)
(4)	CORRECT FOR EMBEDMENT
(5)	DISTRIBUTE SPRINGS COMPATIBLE WITH STRUCTURAL MODEL
(6)	PERFORM MODAL SUPERPOSITION ANALYSIS WITH ATH • 6 DOF • 3 DIRECTIONAL INPUT MOTION (SRSS) • MODAL DAMPING • VARY ROCK PROPERTIES AND EMBEDMENT EFFECTS • PEAK BROADEN
(7)	COMPARE "OLD" AND "NEW" RSI PARAMETERS AND FLOOR RESPONSE SPECTRA


N
P-12
P-25
P-4
P-10A
P-10
P-15
P-27
P-26
P-11
P-34R
P-14
P-13
P-28
P-29
P-30
MAY 85
PROGRAM AREA

BORING PLAN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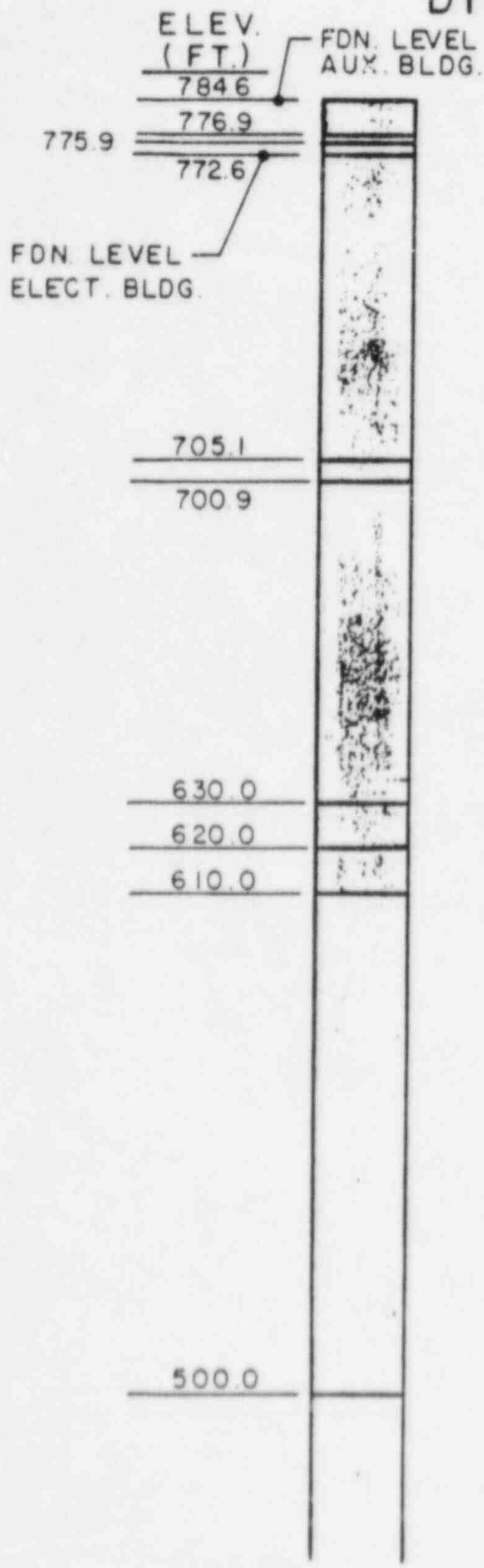
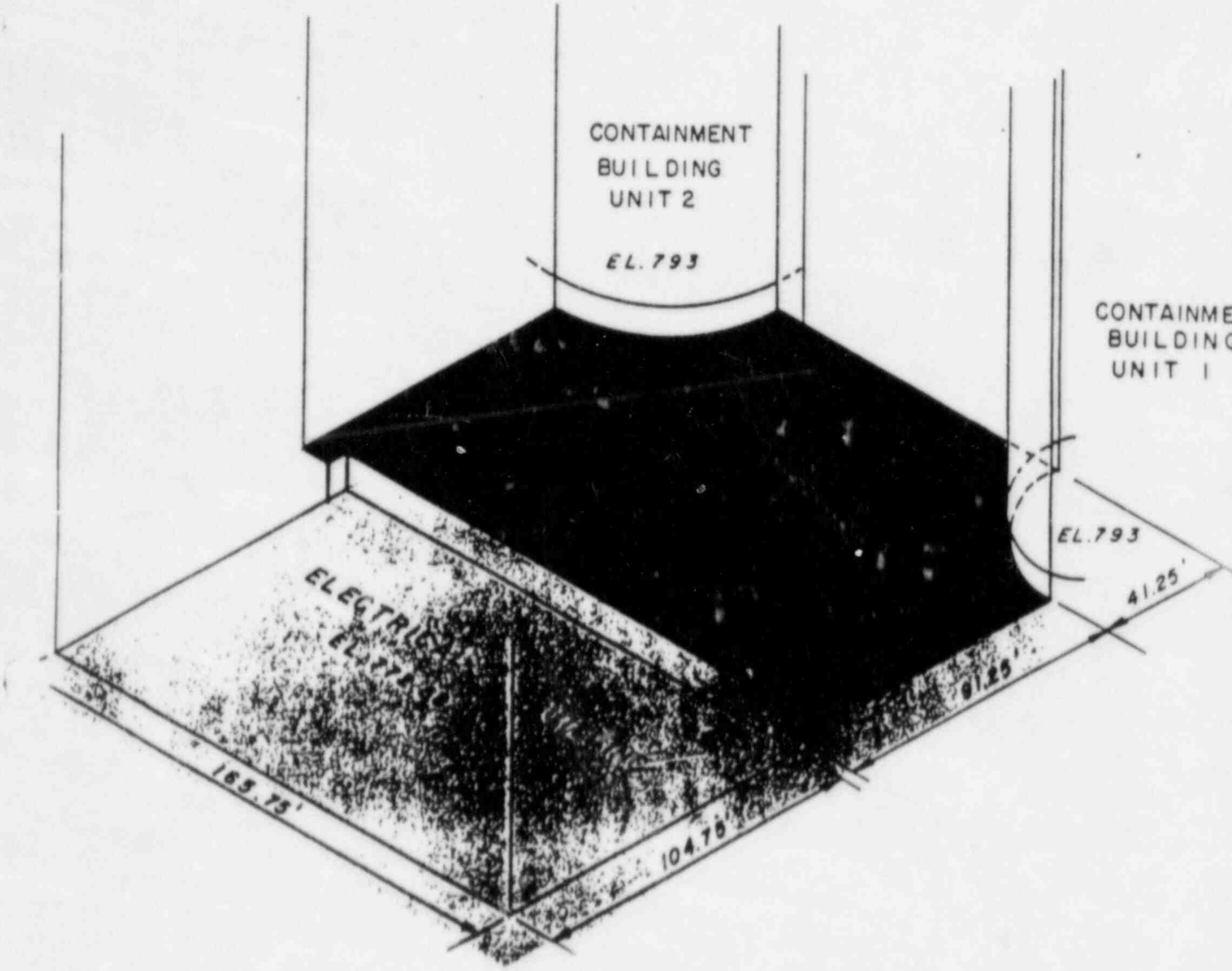
AUXILIARY/ELECTRICAL BUILDING ANALYSIS PROFILE AND DYNAMIC ROCK PROPERTIES



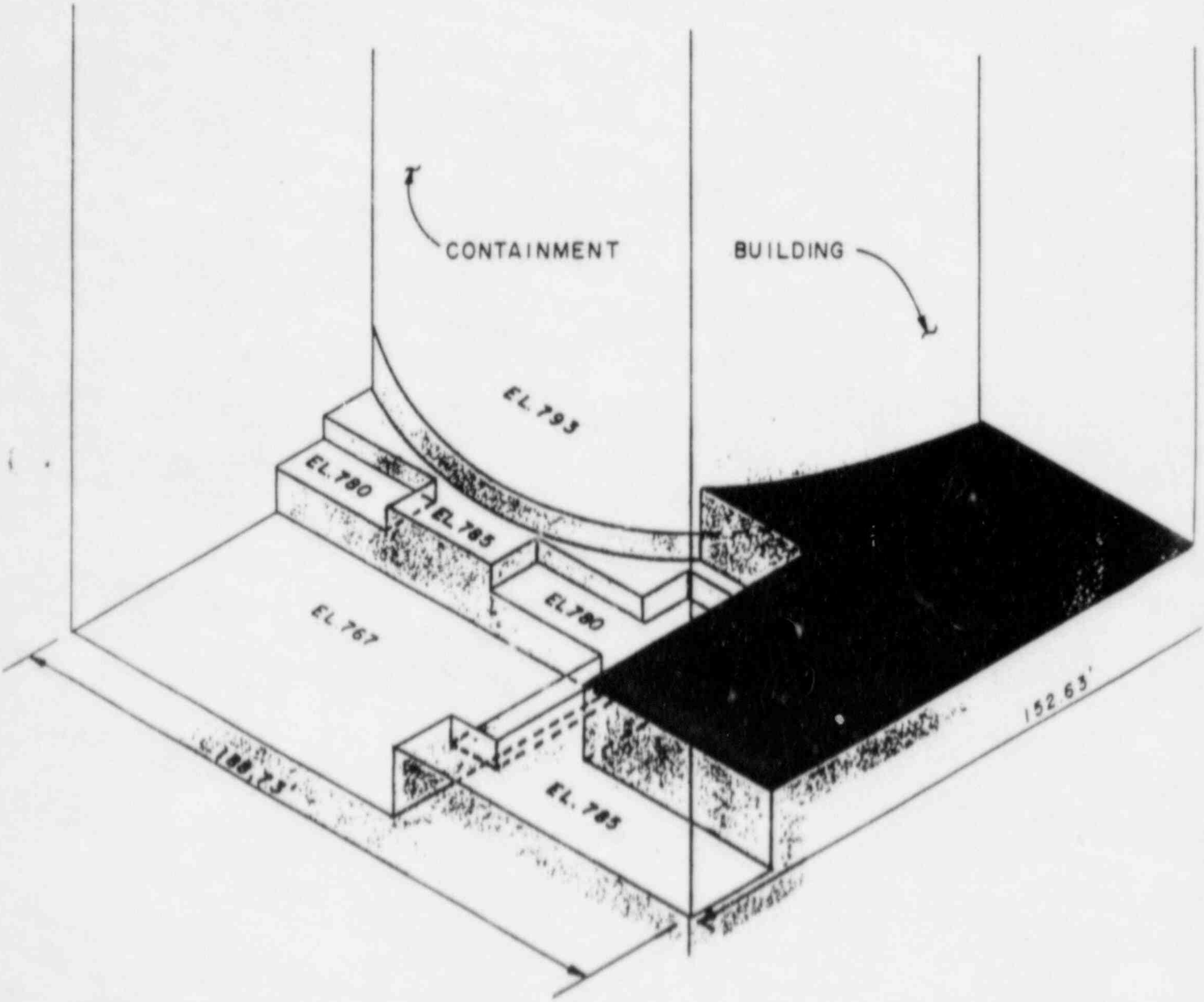
ROCK TYPE	G (10^5 psi)	V	$(lb/ft^{2}$
CLAYSTONE	1.6	0.40	135
LIMESTONE	8.0	0.30	150
CLAYSTONE	1.6	0.40	135
LIMESTONE	12.0	0.27	155
CLAYSTONE	1.6	0.40	135
LIMESTONE	12.0	0.27	155
CLAYSTONE	1.6	0.40	135
LIMESTONE	12	0.27	155
TWIN MOUNTAINS FORMATION	3.0	0.32	135

MAJOR STEPS
FOR
RSI RE-ANALYSIS

STEP	DESCRIPTION
(1)	DEFINE RSI ANALYSIS PROFILE AND DYNAMIC ROCK PROPERTIES
(2)	DEFINE FOUNDATION GEOMETRY
(3)	OBTAIN STIFFNESS & DAMPING FOR 6 MODES (RIGID MATS ON ELASTIC LAYERED SYSTEM)
(4)	CORRECT FOR EMBEDMENT
(5)	DISTRIBUTE SPRINGS COMPATIBLE WITH STRUCTURAL MODEL
(6)	PERFORM MODAL SUPERPOSITION ANALYSIS WITH ATH • 6 DOF • 3 DIRECTIONAL INPUT MOTION (SRSS) • MODAL DAMPING • VARY ROCK PROPERTIES AND EMBEDMENT EFFECTS • PEAK BROADEN
(7)	COMPARE "OLD" AND "NEW" RSI PARAMETERS AND FLOOR RESPONSE SPECTRA



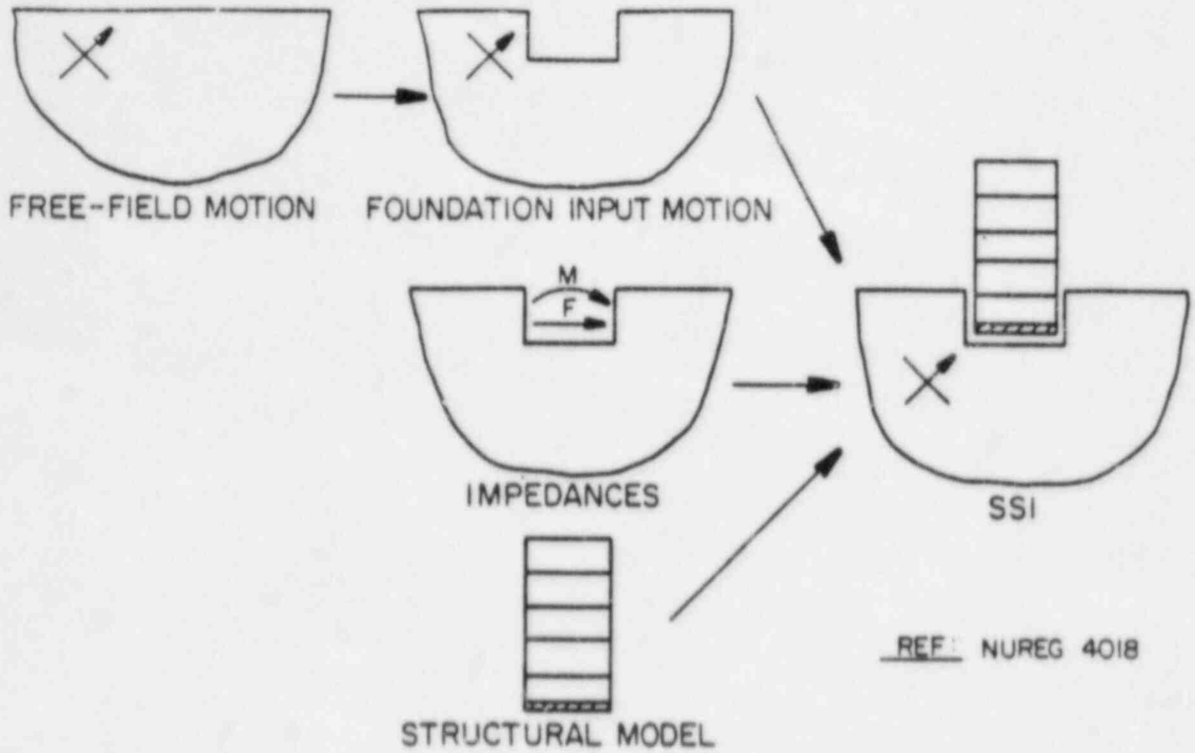
AUXILIARY / ELECTRICAL BUILDING



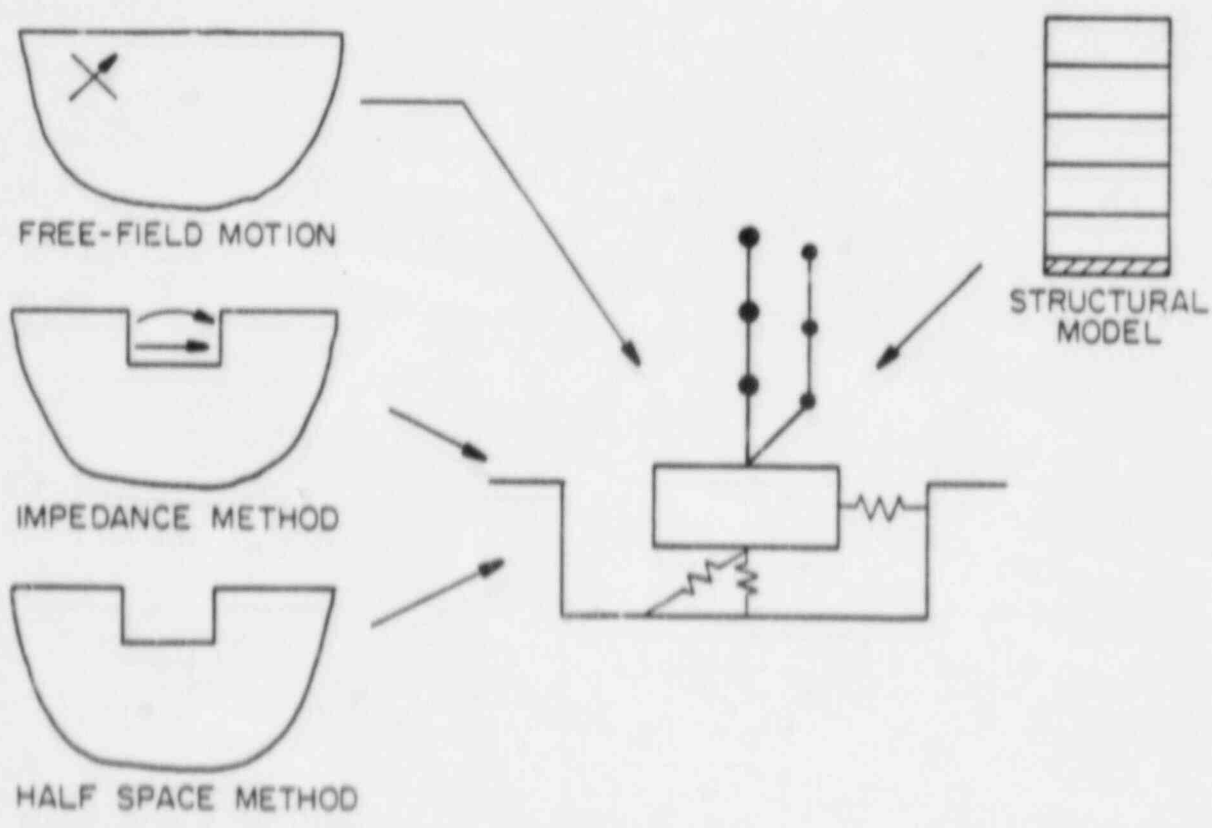
SAFEGUARDS (UNIT 1) BUILDING FOUNDATION

MAJOR STEPS
FOR
RSI RE-ANALYSIS

STEP	DESCRIPTION
(1)	DEFINE RSI ANALYSIS PROFILE AND DYNAMIC ROCK PROPERTIES
(2)	DEFINE FOUNDATION GEOMETRY
(3)	OBTAIN STIFFNESS & DAMPING FOR 6 MODES (RIGID MATS ON ELASTIC LAYERED SYSTEM)
(4)	CORRECT FOR EMBEDMENT
(5)	DISTRIBUTE SPRINGS COMPATIBLE WITH STRUCTURAL MODEL
(6)	PERFORM MODAL SUPERPOSITION ANALYSIS WITH ATH • 6 DOF • 3 DIRECTIONAL INPUT MOTION (SRSS) • MODAL DAMPING • VARY ROCK PROPERTIES AND EMBEDMENT EFFECTS • PEAK BROADEN
(7)	COMPARE "OLD" AND "NEW" RSI PARAMETERS AND FLOOR RESPONSE SPECTRA



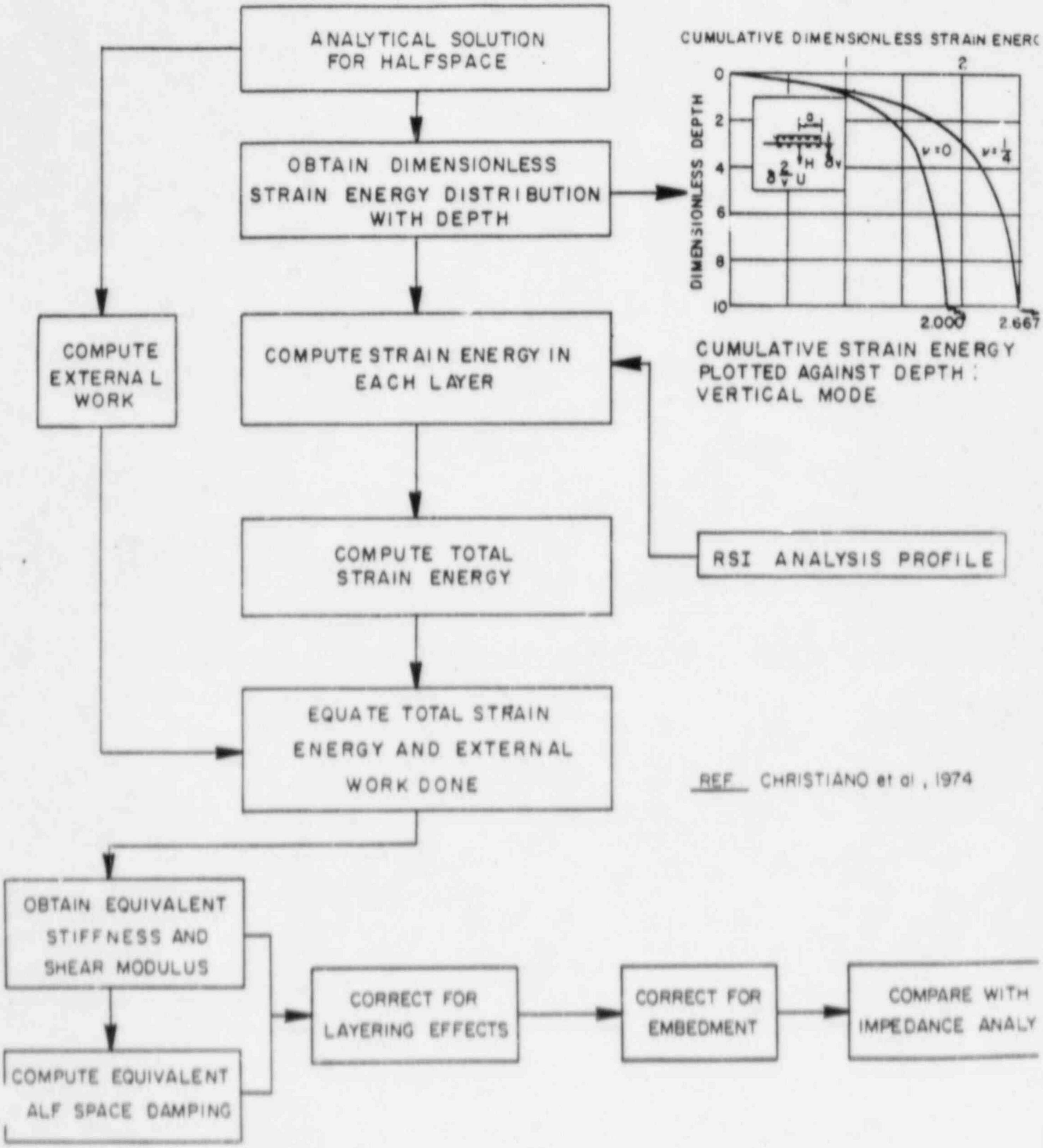
TYPICAL SUBSTRUCTURE APPROACH



CPSES APPROACH

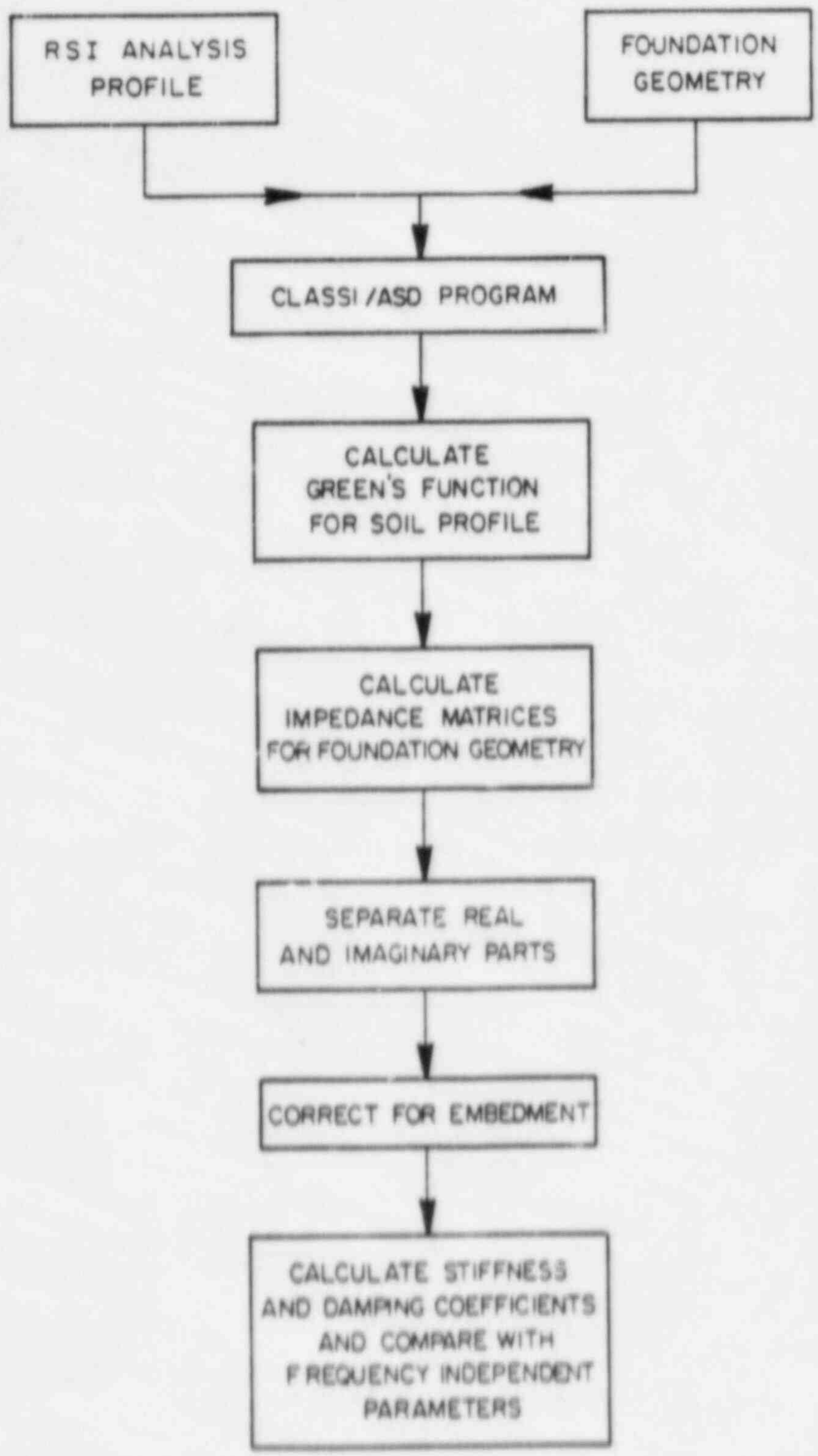
LAYERED SYSTEM ANALYSIS

(FREQUENCY INDEPENDENT)

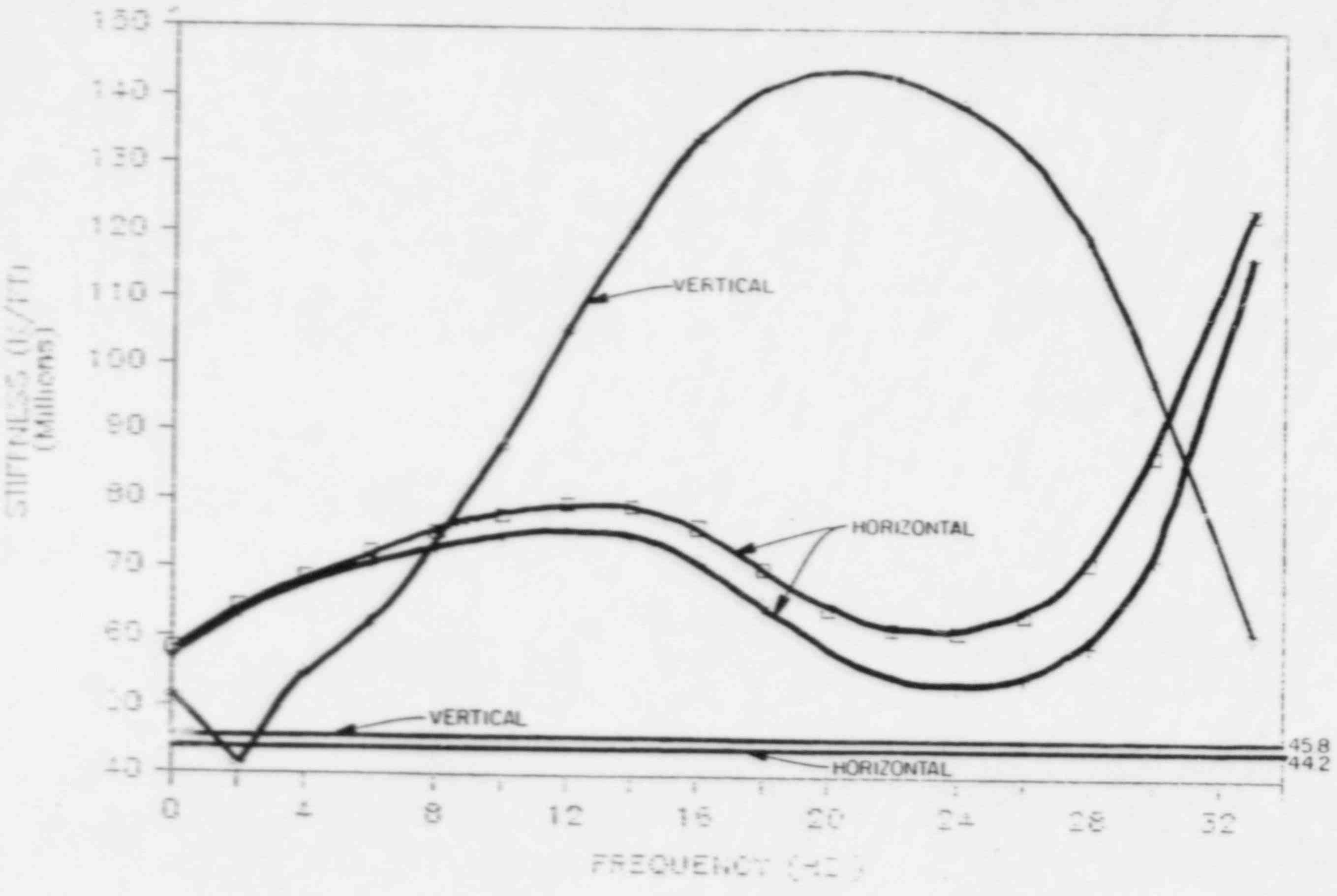


LAYERED SYSTEM ANALYSIS

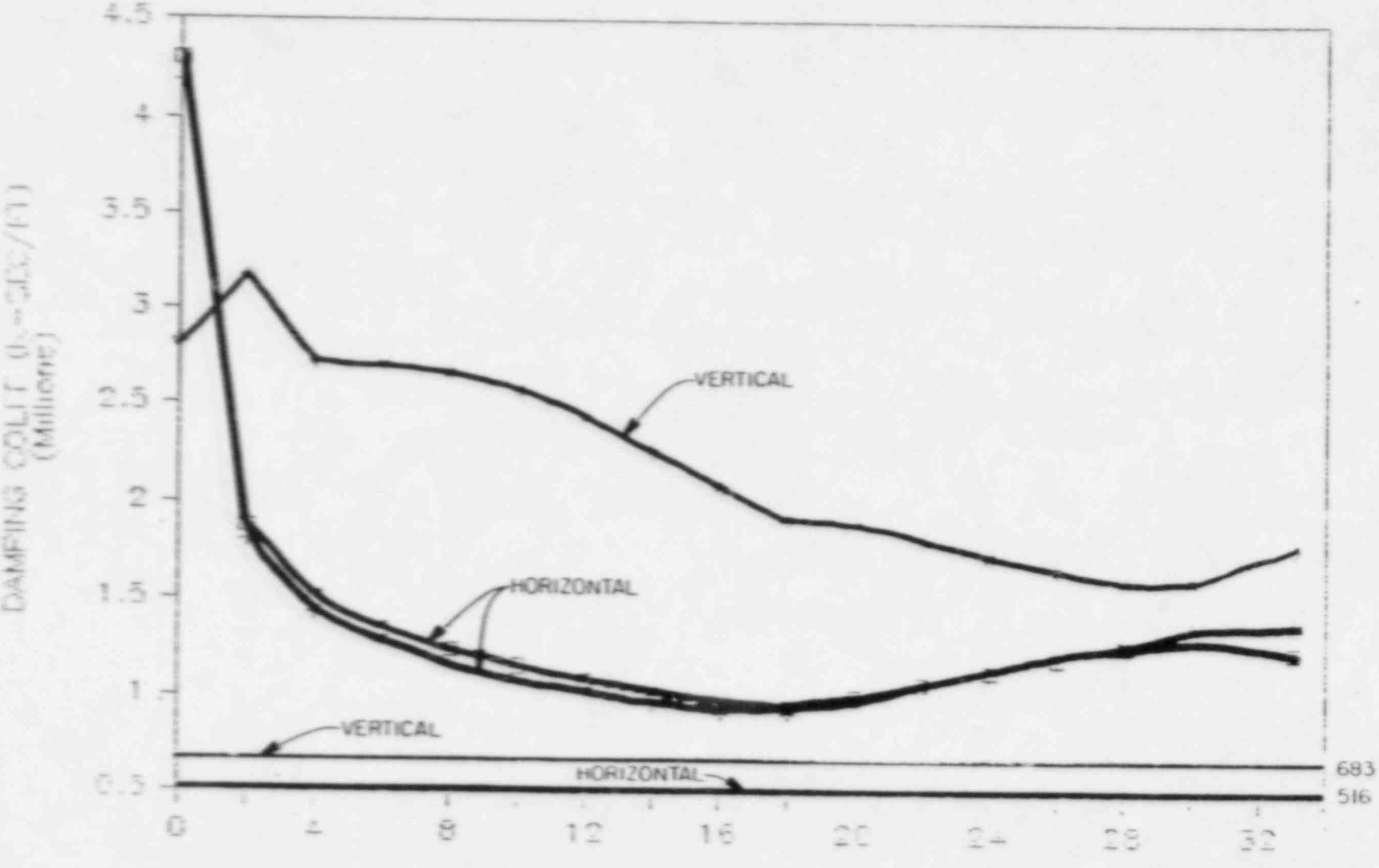
(FREQUENCY DEPENDENT)



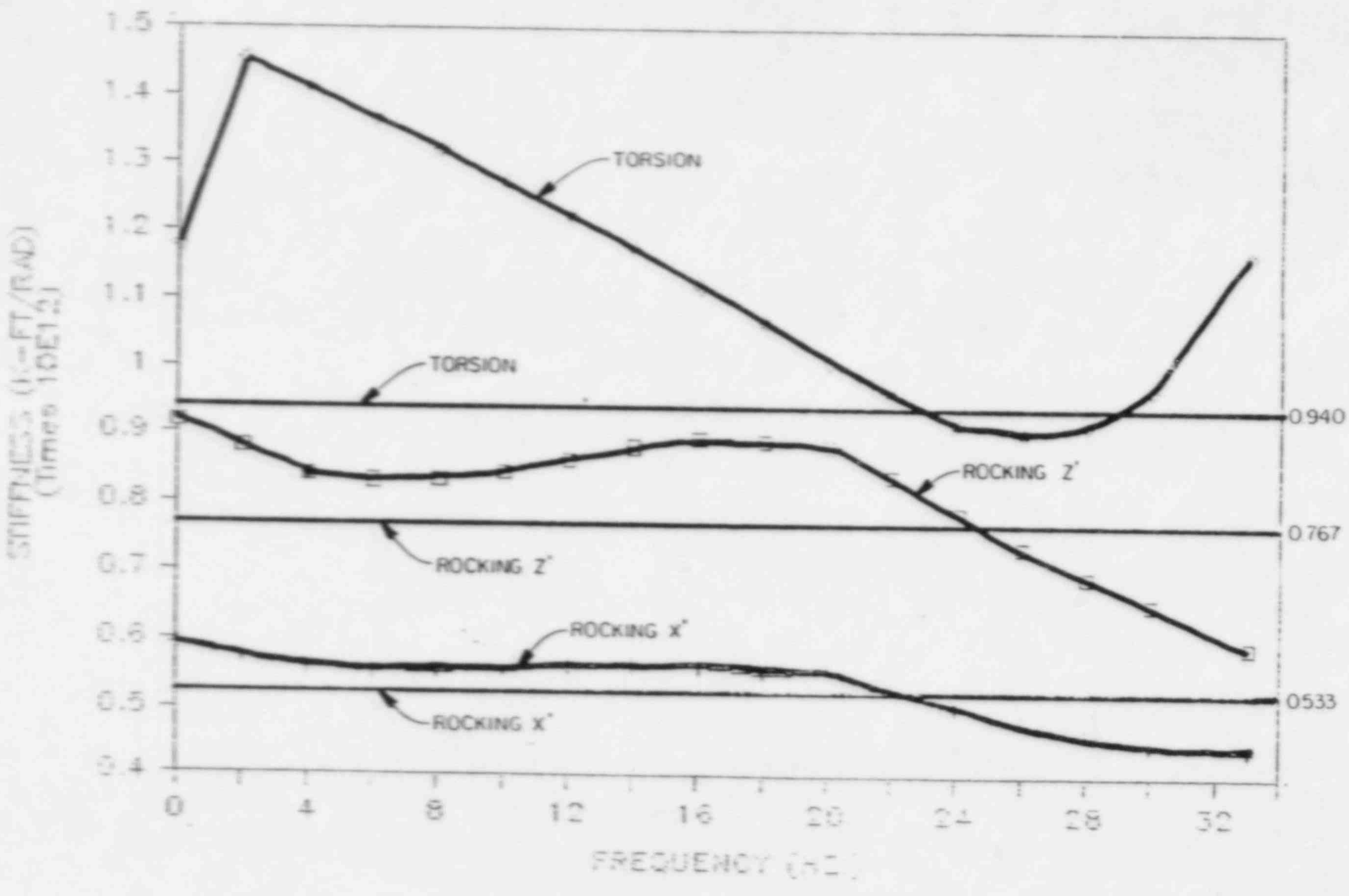
AUX/ELEC. KX , KY & KZ



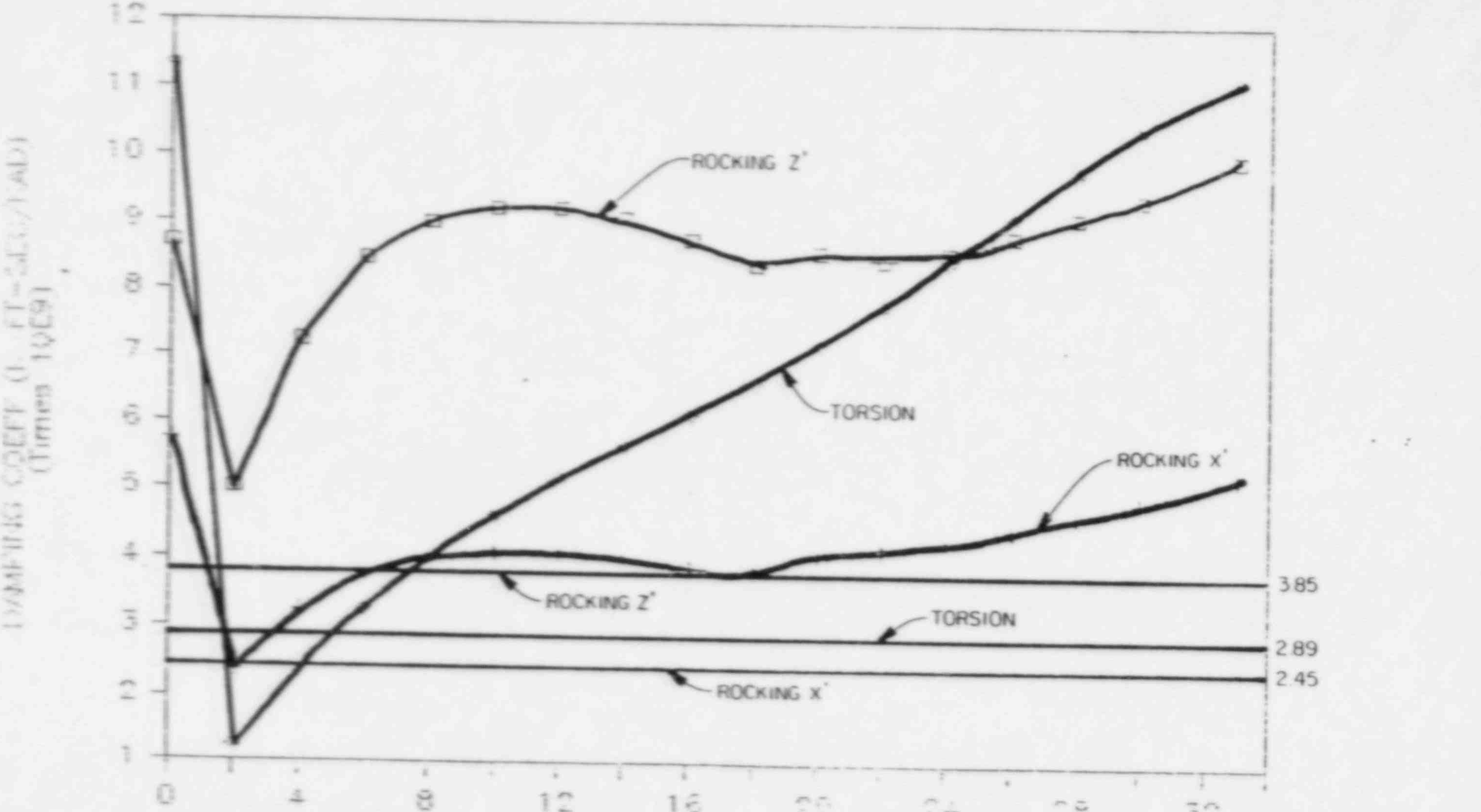
AUX/ELEC. CX , C & CZ



AU /ELEC. KR , P. & PE



AU /ELEC. CRX, CP & CPE



MAJOR STEPS
FOR
RSI RE-ANALYSIS

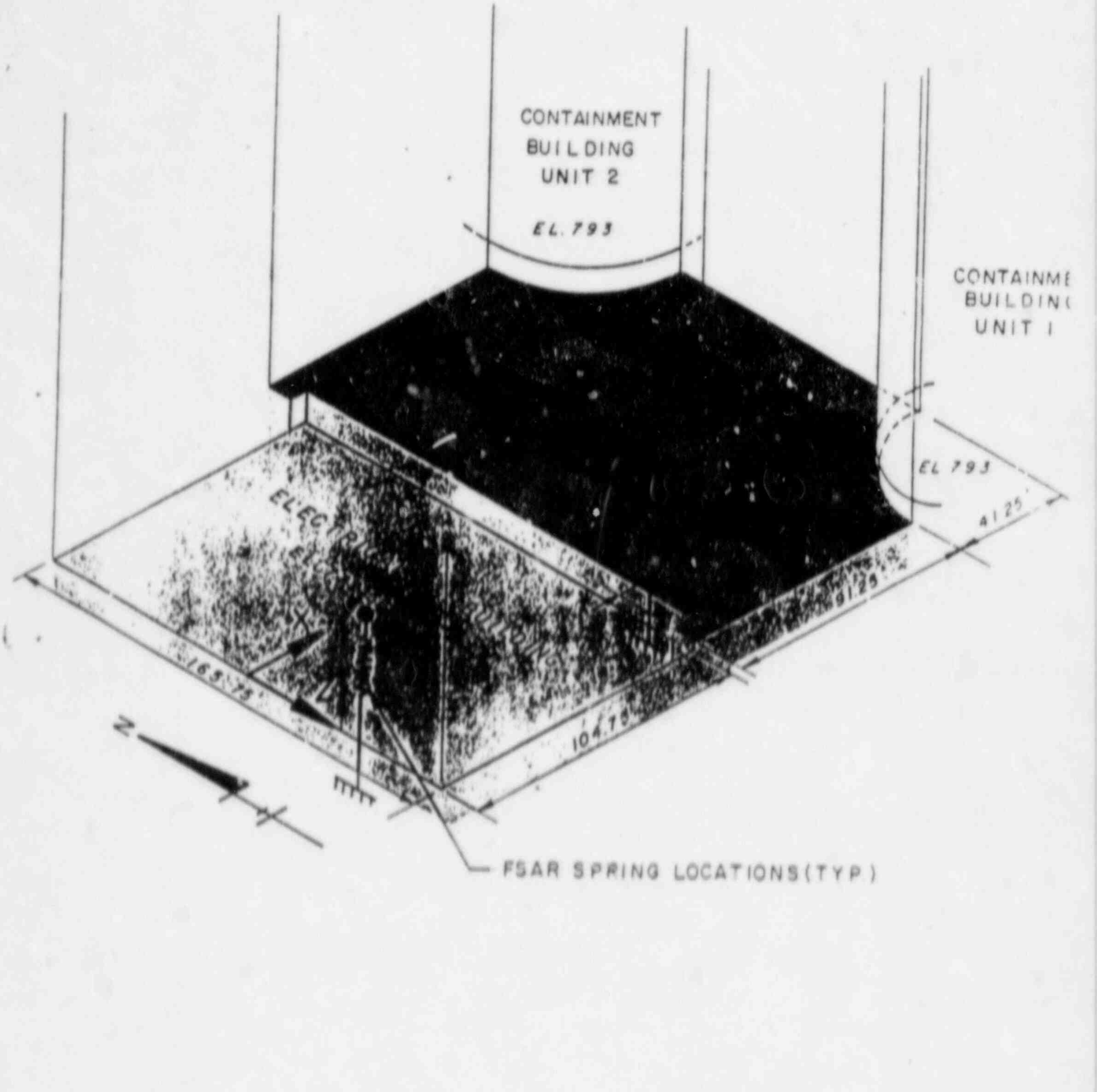
STEP	DESCRIPTION
(1)	DEFINE RSI ANALYSIS PROFILE AND DYNAMIC ROCK PROPERTIES
(2)	DEFINE FOUNDATION GEOMETRY
(3)	OBTAIN STIFFNESS & DAMPING FOR 6 MODES (RIGID MATS ON ELASTIC LAYERED SYSTEM)
(4)	CORRECT FOR EMBEDMENT
(5)	DISTRIBUTE SPRINGS COMPATIBLE WITH STRUCTURAL MODEL
(6)	PERFORM MODAL SUPERPOSITION ANALYSIS WITH ATH • 6 DOF • 3 DIRECTIONAL INPUT MOTION (SRSS) • MODAL DAMPING • VARY ROCK PROPERTIES AND EMBEDMENT EFFECTS • PEAK BROADEN
(7)	COMPARE "OLD" AND "NEW" RSI PARAMETERS AND FLOOR RESPONSE SPECTRA

EMBEDMENT COEFFICIENTS
AUXILIARY/ELECTRICAL BUILDING

MODE	$CF = K_{EMB}/K_{NON-EMB}$				$C_{EMB}/C_{NON-EMB}$
	CHRISTIANO ET AL. (1974)	NOVAK ET AL. (1973)	GAZETAS (1982)	BEST ESTIMATE	
VERT.	1.10	1.09	1.09	1.09	1.21
HORZ.	1.20	1.15	1.11	1.16	1.54
ROCKING (Z)	1.13	1.10	1.20	1.15	1.49
ROCKING (X)	1.15	1.12	1.24	1.17	1.56
TORSION	1.25	1.26	1.30	1.27	1.92

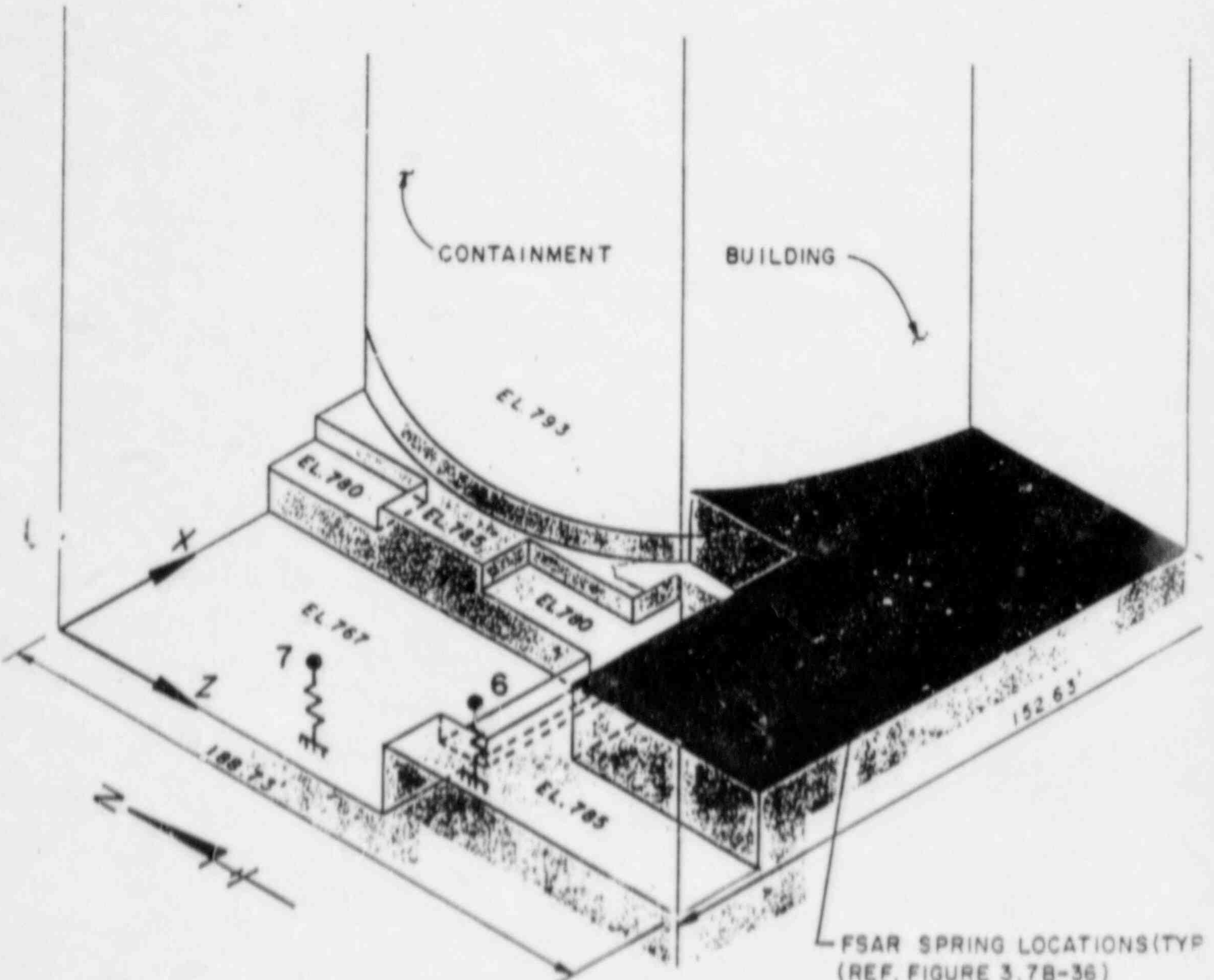
MAJOR STEPS
FOR
RSI RE-ANALYSIS

STEP	DESCRIPTION
(1)	DEFINE RSI ANALYSIS PROFILE AND DYNAMIC ROCK PROPERTIES
(2)	DEFINE FOUNDATION GEOMETRY
(3)	OBTAIN STIFFNESS & DAMPING FOR 6 MODES (RIGID MATS ON ELASTIC LAYERED SYSTEM)
(4)	CORRECT FOR EMBEDMENT
(5)	DISTRIBUTE SPRINGS COMPATIBLE WITH STRUCTURAL MODEL
(6)	PERFORM MODAL SUPERPOSITION ANALYSIS WITH ATH • 6 DOF • 3 Directional Input Motion (SRSS) • Modal Damping • Vary Rock Properties and Embedment Effects • Peak Broaden
(7)	COMPARE "OLD" AND "NEW" RSI PARAMETERS AND FLOOR RESPONSE SPECTRA



AUXILIARY / ELECTRICAL BUILDING

SPRING NODE	X	Y	Z
5	92.22	806.5	149.62
6	53.93	785.0	90.71
7	30.50	767.5	47.62



NOTE:

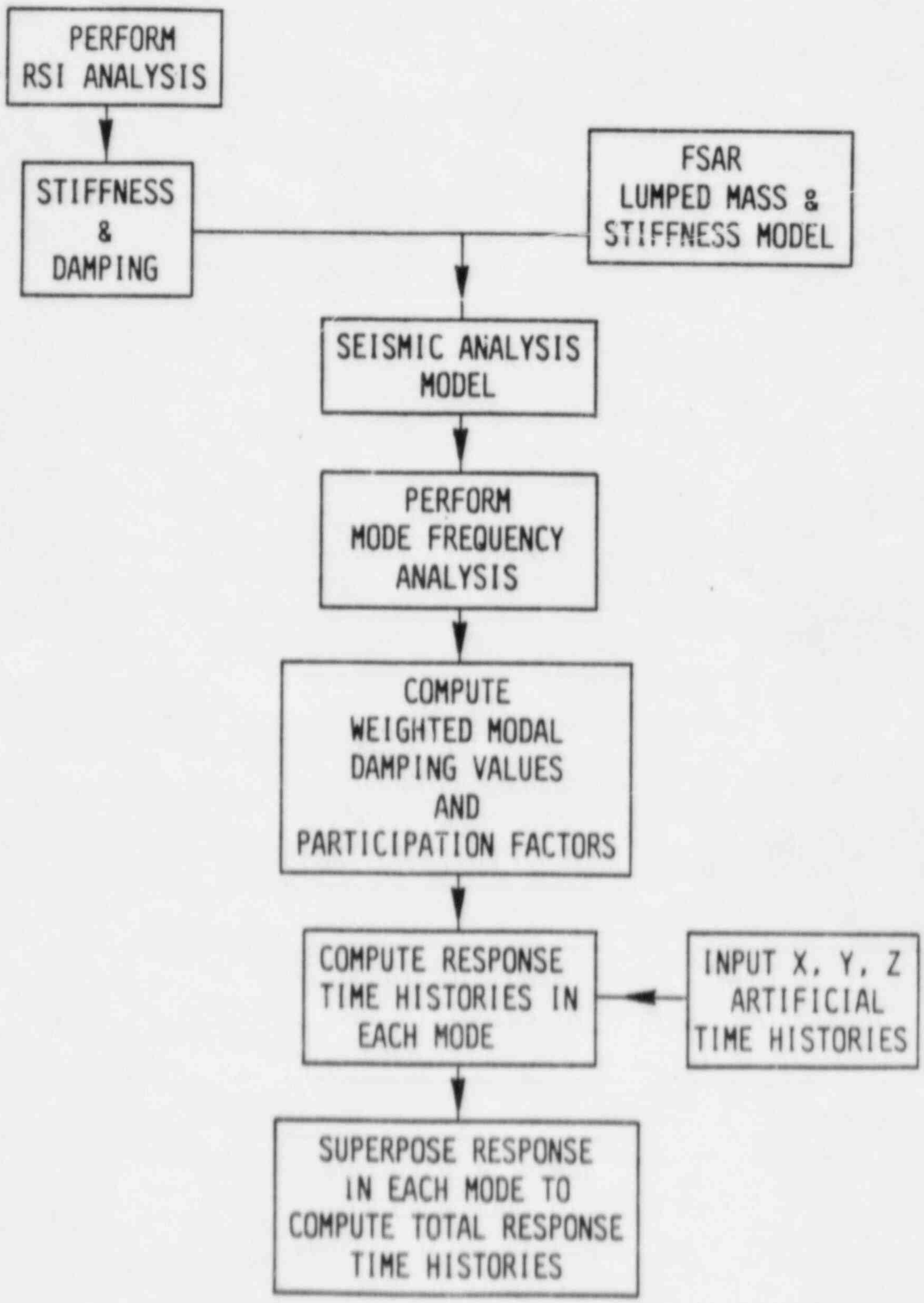
ELEVATIONS SHOWN ARE APPROXIMATE AND REPRESENT BOTTOM OF MAT.

SAFEGUARDS BUILDING FOUNDATION

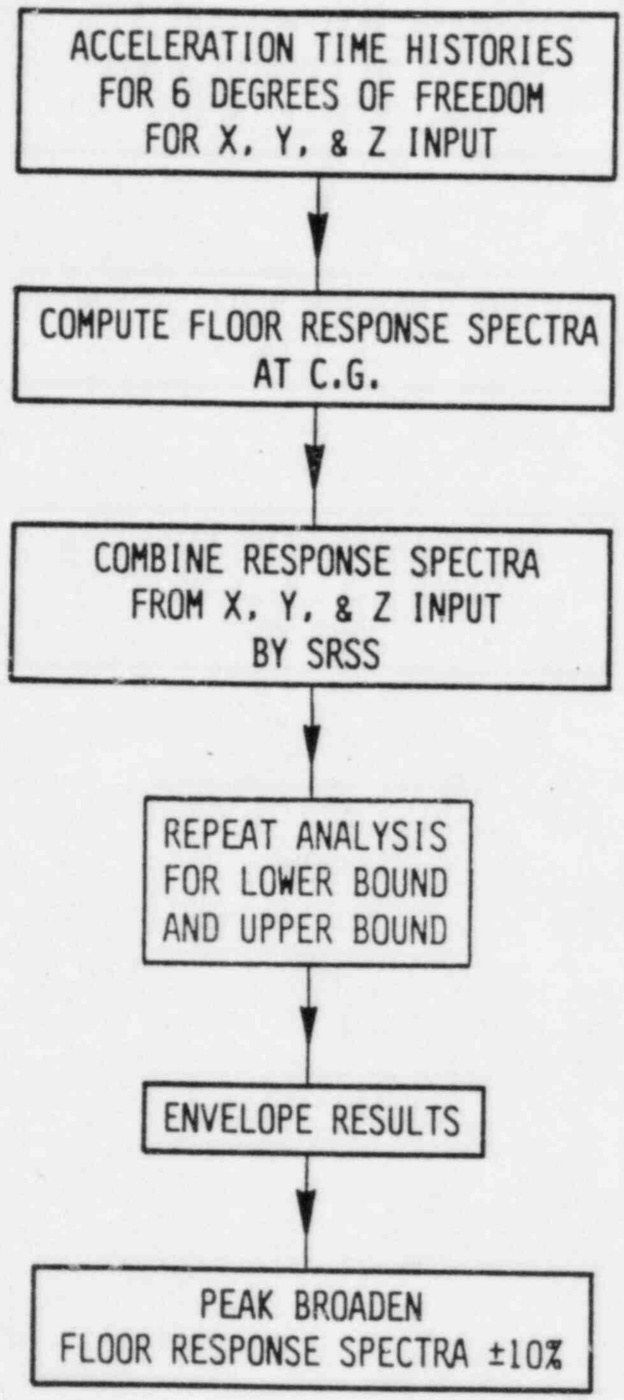
MAJOR STEPS
FOR
RSI RE-ANALYSIS

STEP	DESCRIPTION
(1)	DEFINE RSI ANALYSIS PROFILE AND DYNAMIC ROCK PROPERTIES
(2)	DEFINE FOUNDATION GEOMETRY
(3)	OBTAIN STIFFNESS & DAMPING FOR 6 MODES (RIGID MATS ON ELASTIC LAYERED SYSTEM)
(4)	CORRECT FOR EMBEDMENT
(5)	DISTRIBUTE SPRINGS COMPATIBLE WITH STRUCTURAL MODEL
(6)	PERFORM MODAL SUPERPOSITION ANALYSIS WITH ATH • 6 DOF • 3 DIRECTIONAL INPUT MOTION (SRSS) • MODAL DAMPING • VARY ROCK PROPERTIES AND EMBEDMENT EFFECTS • PEAK BROADEN
(7)	COMPARE "OLD" AND "NEW" RSI PARAMETERS AND FLOOR RESPONSE SPECTRA

MODAL SUPERPOSITION ANALYSIS



OUTPUT


ACCELERATION TIME HISTORIES FOR 6 DEGREES OF FREEDOM FOR X, Y, & Z INPUT
COMPUTE FLOOR RESPONSE SPECTRA AT C.G.
COMBINE RESPONSE SPECTRA FROM X, Y, & Z INPUT BY SRSS
REPEAT ANALYSIS FOR LOWER BOUND AND UPPER BOUND
ENVELOPE RESULTS
PEAK BROADEN FLOOR RESPONSE SPECTRA ±10%

TREATMENT OF MODAL DAMPING

FSAR

$$D_i = \frac{\sum_j E_{ij} D_j}{\sum_j E_{ij}}$$

REF: WHITMAN, 1969

RE-ANALYSIS

$$D_i = \frac{\sum_j E_{ij} \left(\frac{\omega_i}{\omega_j}\beta_j + D_j\right)}{\sum_j E_{ij}}$$

REF: ROESSET ET. A
1972

D_i = WEIGHTED DAMPING FOR MODE i
D_j = HYSTERETIC DAMPING FOR COMPONENT j
E_{ij} = MODAL ENERGY STORED IN COMPONENT j IN MODE i

ω_i = FREQUENCY OF MODE i
ω_j = FUNDAMENTAL FREQUENCY OF RSI COMPONENT j
β_j = VISCOUS DAMPING FOR RSI COMPONENT j

MAJOR STEPS
FOR
RSI RE-ANALYSIS

STEP	DESCRIPTION
(1)	DEFINE RSI ANALYSIS PROFILE AND DYNAMIC ROCK PROPERTIES
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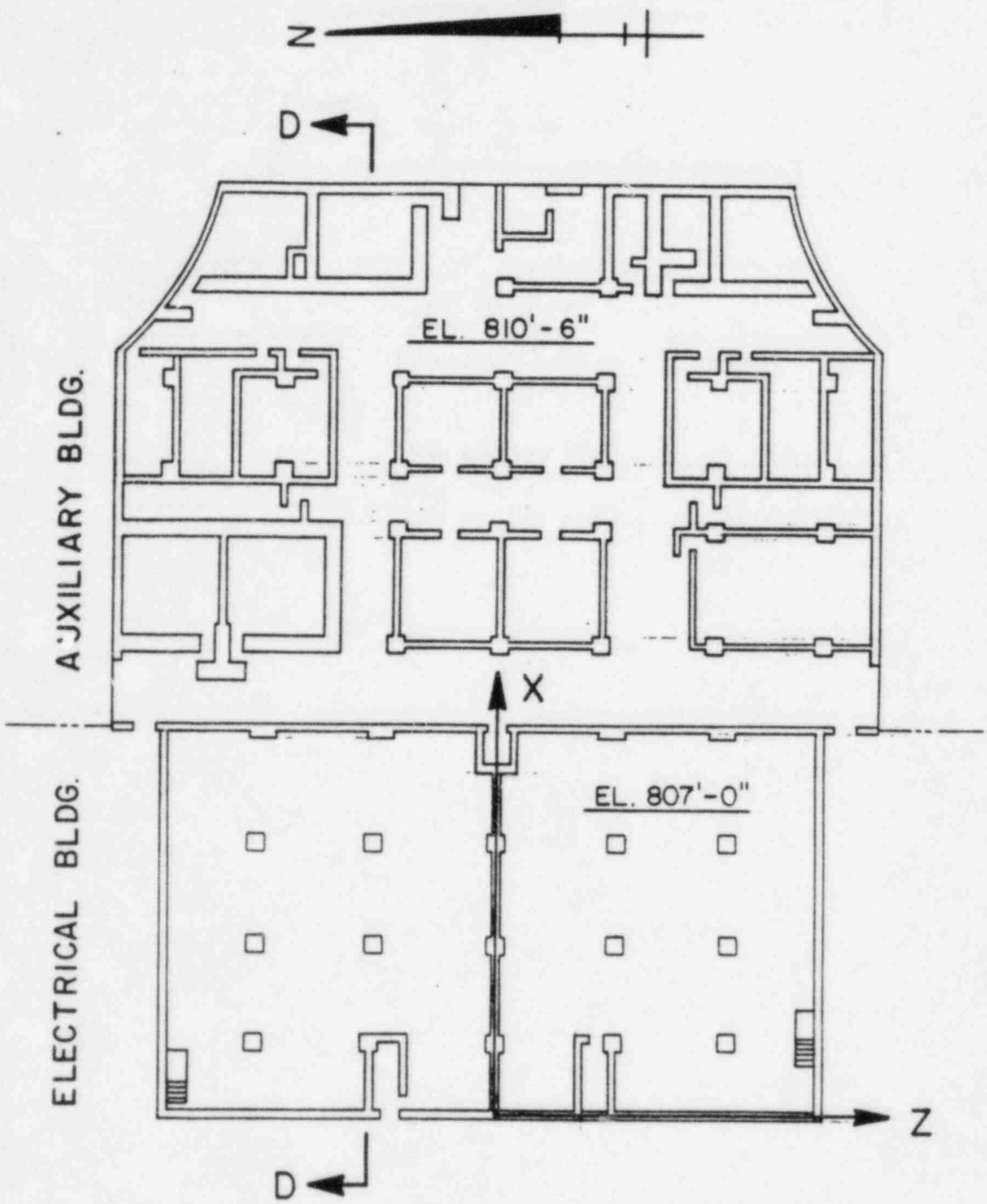
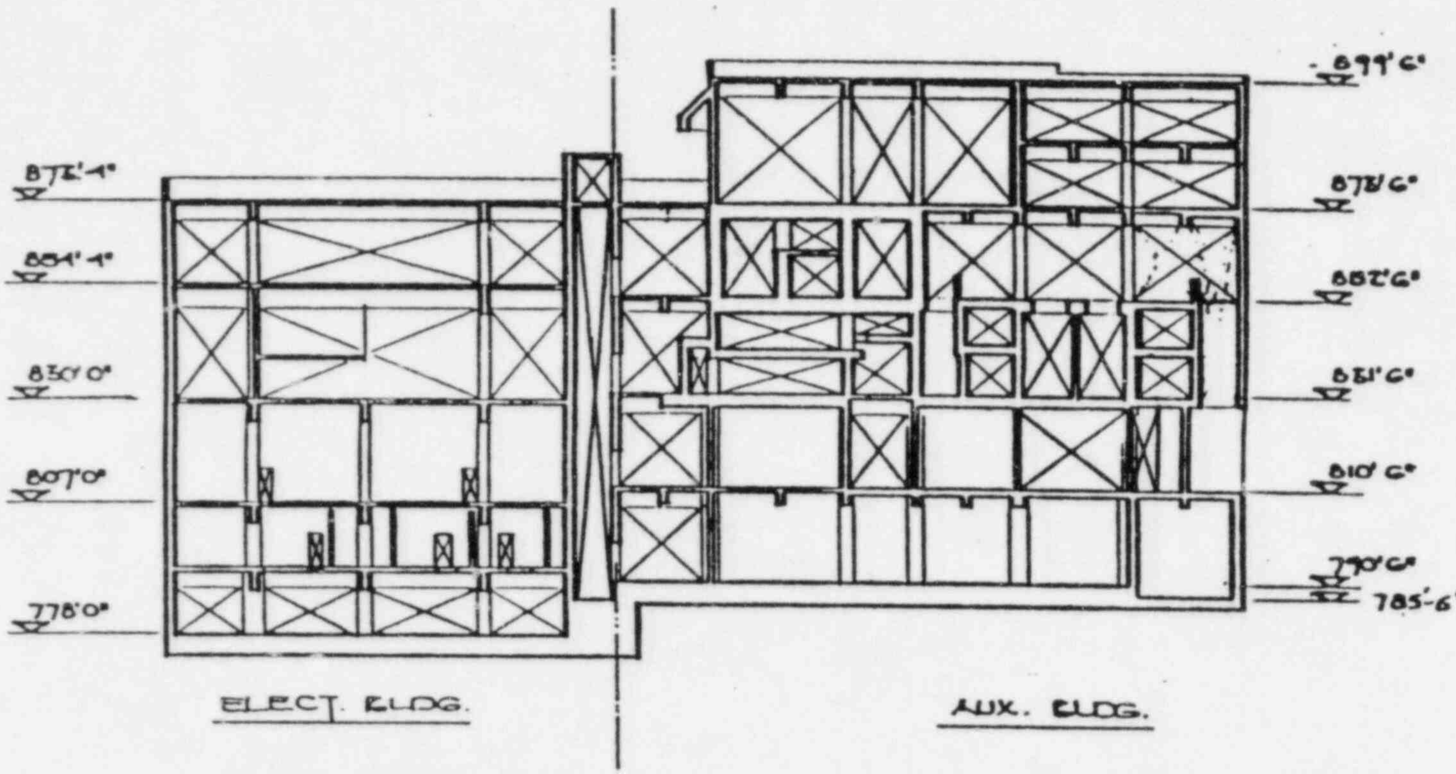


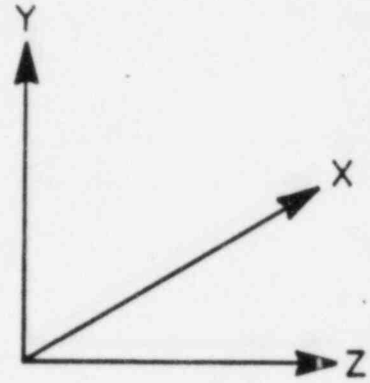
PLAN EL. 810'-6" & 807'-0"

AUXILIARY / ELECTRICAL BUILDING

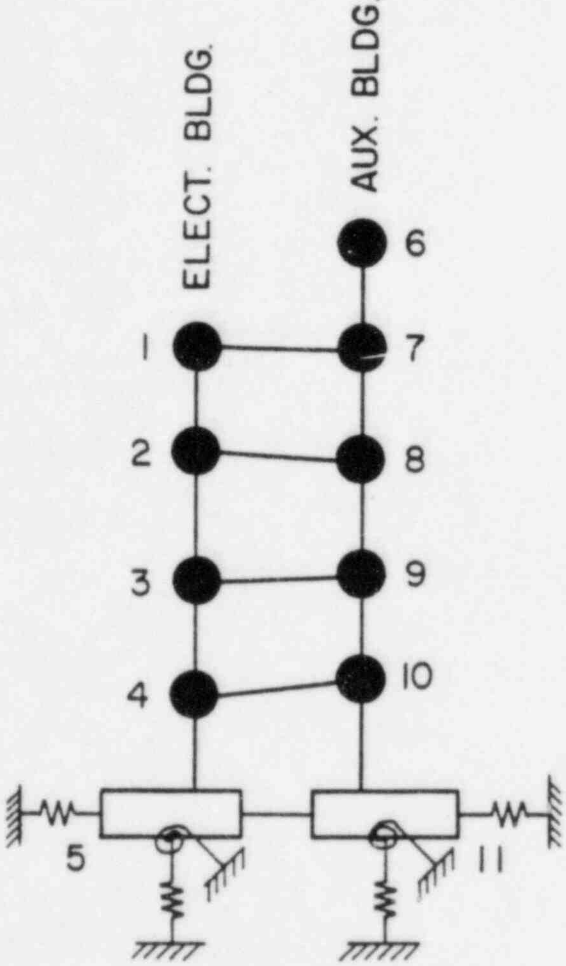


SECTION D-D

AUXILIARY / ELECTRICAL BUILDING



COORDINATE SYSTEM



SEISMIC MODEL

AUXILIARY / ELECTRICAL BUILDING

AUXILIARY/ELECTRICAL BUILDING
FOUNDATION SPRING CONSTANTS
RSI RE-ANALYSIS

MODE	LOWER BOUND	BEST ESTIMATE	UPPER BOUND
VERTICAL $\times 10^{8}$ KIP/FT.	.35	.46	0.60
HORIZONTAL $\times 10^{8}$ KIP/FT.	.32	.44	0.59
ROCKING ABOUT X AXIS $\times 10^{12}$ KIP-FT/RAD.	.38	.52	0.72
ROCKING ABOUT Z AXIS $\times 10^{12}$ KIP-FT/RAD.	.57	.77	1.04
TORSION ABOUT Y AXIS $\times 10^{12}$ KIP-FT/RAD.	.71	.94	1.24

1. ALL VALUES ACCOUNT FOR LAYERING AND EMBEDMENT EFFECTS.

COMPARISON
FSAR VERSUS RSI RE-ANALYSIS
AUXILIARY BUILDING
FOUNDATION SPRING CONSTANTS

MODE	BEST ESTIMATE FSAR	BEST ESTIMATE RECOMMENDED
VERTICAL $X\ 10^8$ KIP/FT.	.49	.26
HORIZONTAL ALONG X AXIS $X\ 10^8$ KIP/FT.	.49	.14
HORIZONTAL ALONG Z AXIS $X\ 10^8$ KIP-FT	.47	.14
ROCKING ABOUT X AXIS $X\ 10^{12}$ KIP-FT/RAD.	.15	.30
ROCKING ABOUT Z AXIS $X\ 10^{12}$ KIP-FT/RAD.	.08	.25
TORSION ABOUT Y AXIS $X\ 10^{12}$ KIP-FT/RAD	.21	.21

COMPARISON
FSAR VERSUS RSI RE-ANALYSIS
ELECTRICAL BUILDING
FOUNDATION SPRING CONSTANTS

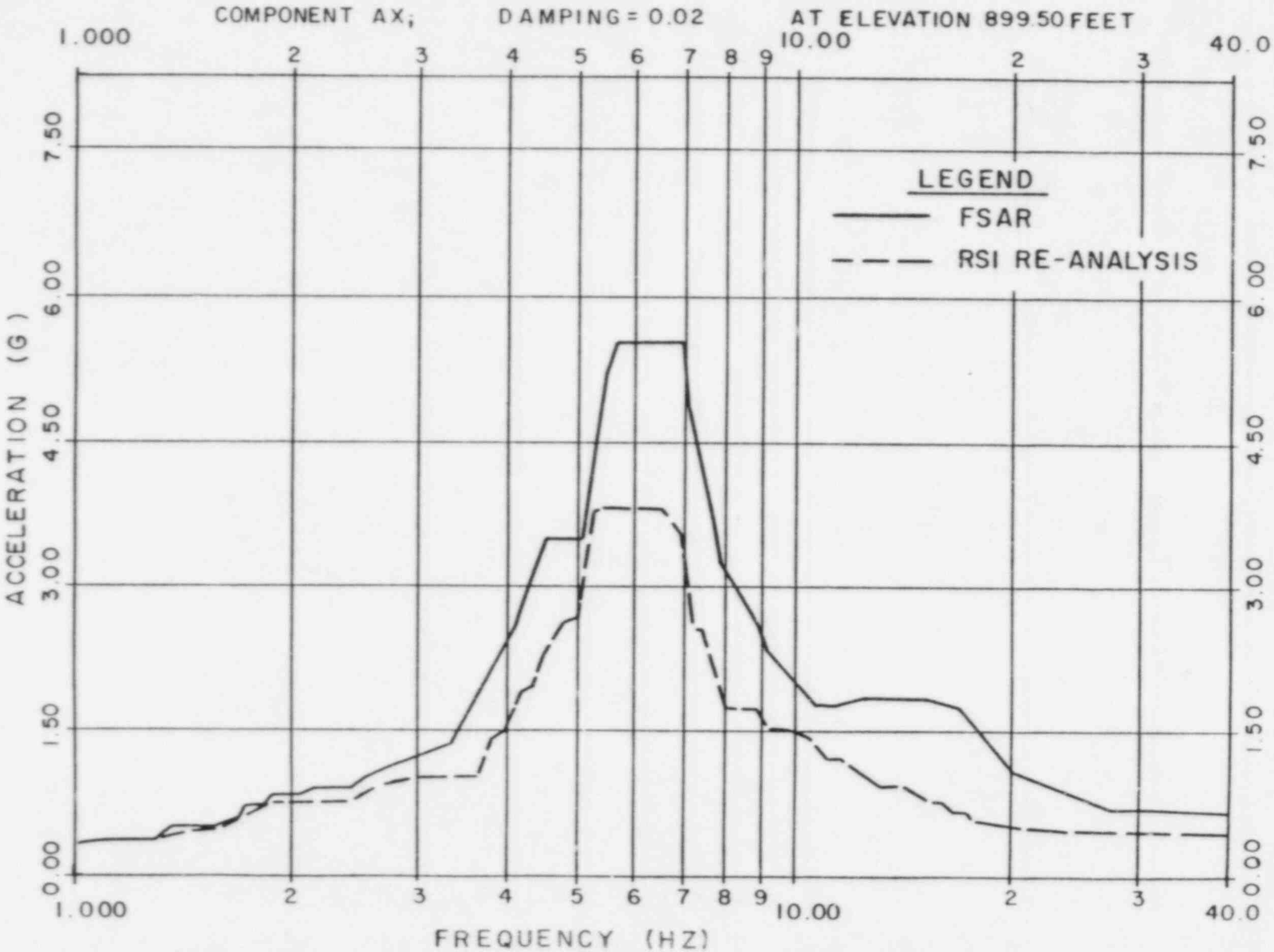
MODE	BEST ESTIMATE FSAR	BEST ESTIMATE RECOMMENDED
VERTICAL $X\ 10^8$ KIP/FT.	.39	.20
HORIZONTAL ALONG X AXIS $X\ 10^8$ KIP/FT.	.48	.30
HORIZONTAL ALONG Z AXIS $X\ 10^8$ KIP-FT	.50	.30
ROCKING ABOUT X AXIS $X\ 10^{12}$ KIP-FT/RAD.	.09	.22
ROCKING ABOUT Z AXIS $X\ 10^{12}$ KIP-FT/RAD.	.03	.36
TORSION ABOUT Y AXIS $X\ 10^{12}$ KIP-FT/RAD	.12	.53

AUXILIARY/ELECTRICAL BUILDING
FOUNDATION DAMPING VALUES
RSI RE-ANALYSIS

MODE	GEOMETRIC DAMPING (VISCOUS) %	MATERIAL DAMPING (HYSTERETIC) %
VERTICAL	65	2
HORIZONTAL	50	2
ROCKING ABOUT X	26	2
ROCKING ABOUT Z	31	2
TORSION	22	2

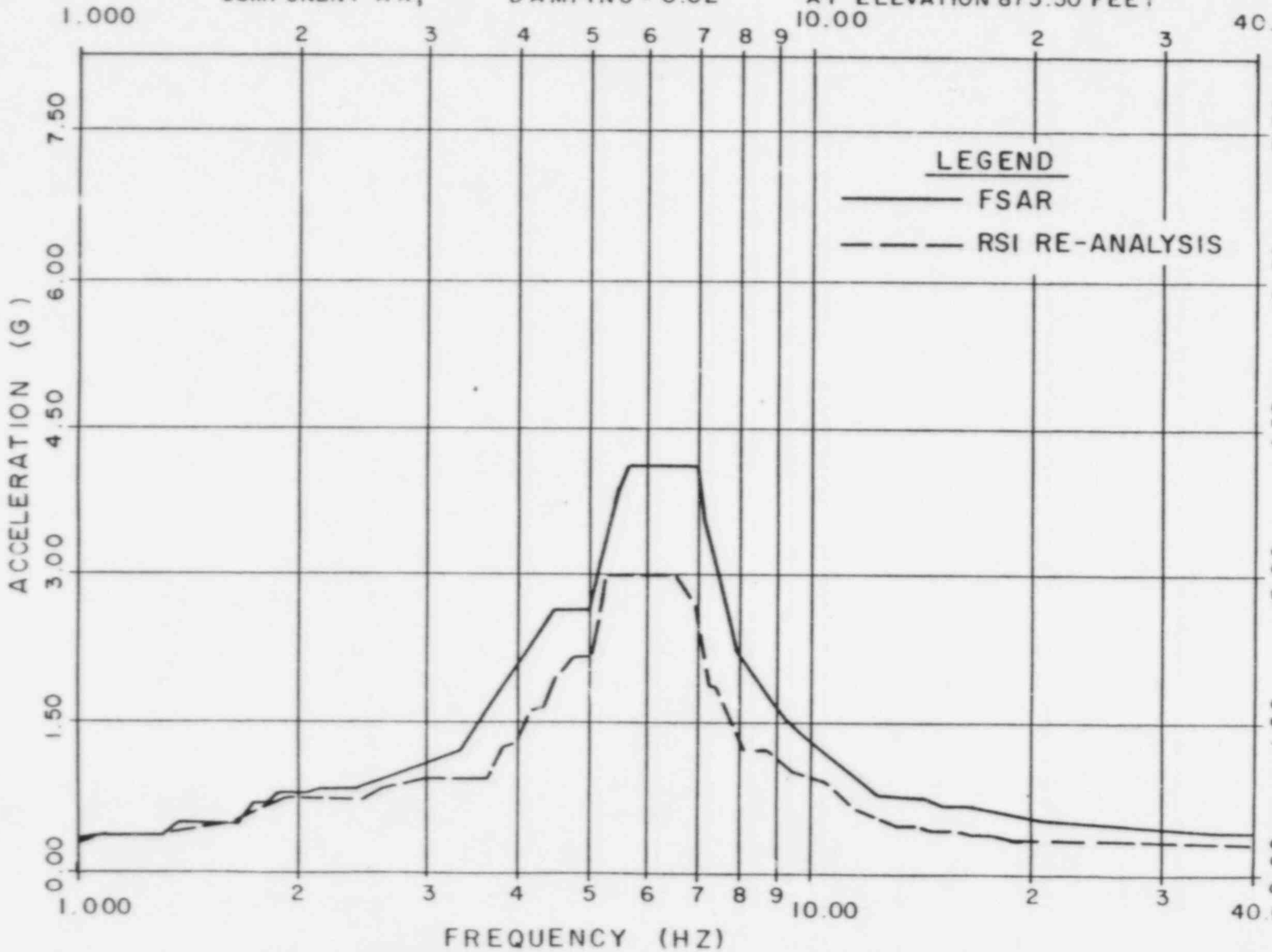
1. ALL VALUES ACCOUNT FOR LAYERING AND EMBEDMENT EFFECTS.
2. GEOMETRIC DAMPING VALUES DEFINED AT RIGID-BODY INTERACTION FREQUENCIES.

AUXILIARY BUILDING
FLOOR RESPONSE SPECTRA
FSAR vs RSI RE-ANALYSIS



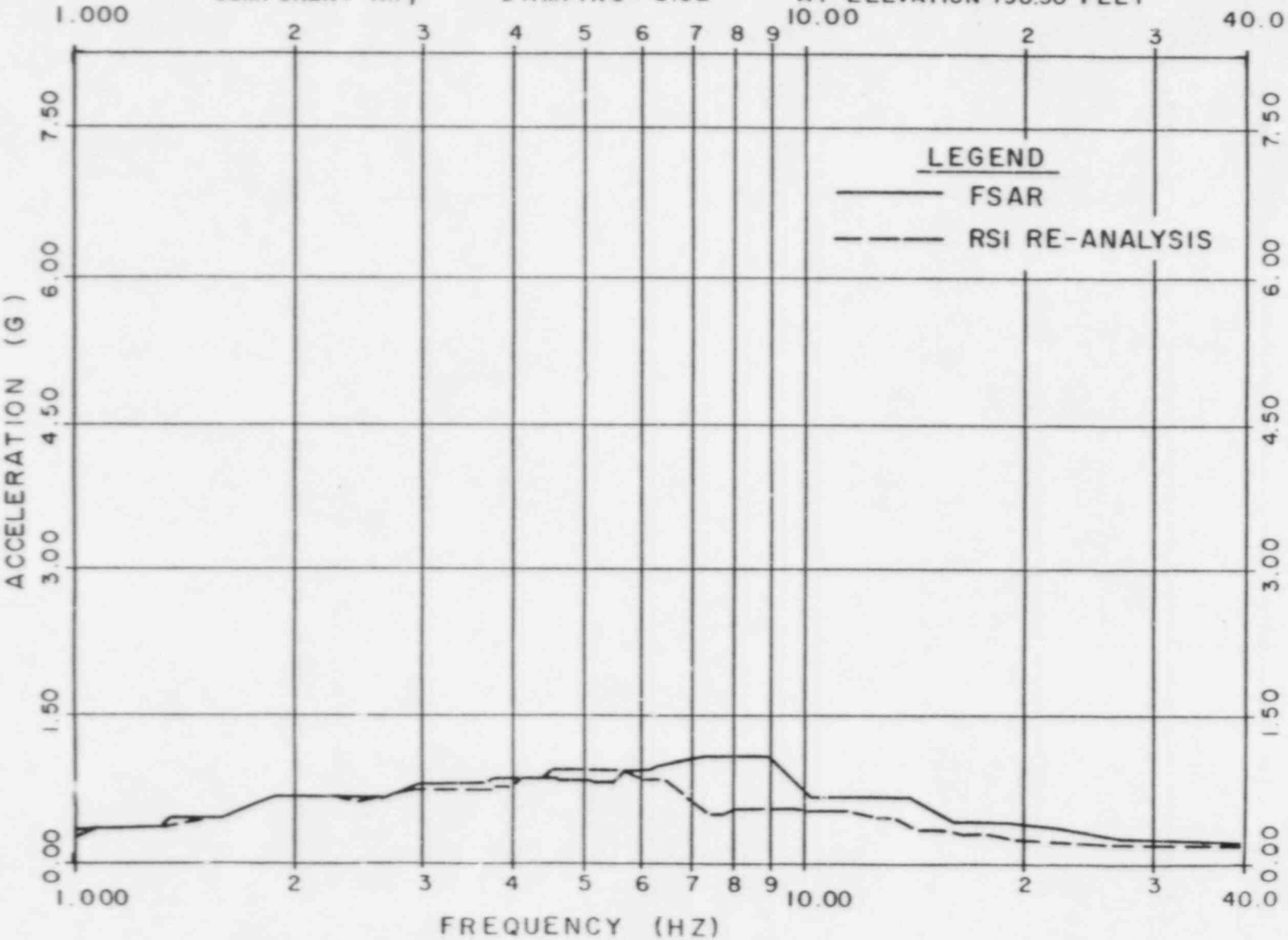
AUXILIARY BUILDING
FLOOR RESPONSE SPECTRA
FSAR vs RSI RE-ANALYSIS

COMPONENT AX; DAMPING = 0.02 AT ELEVATION 873.50 FEET



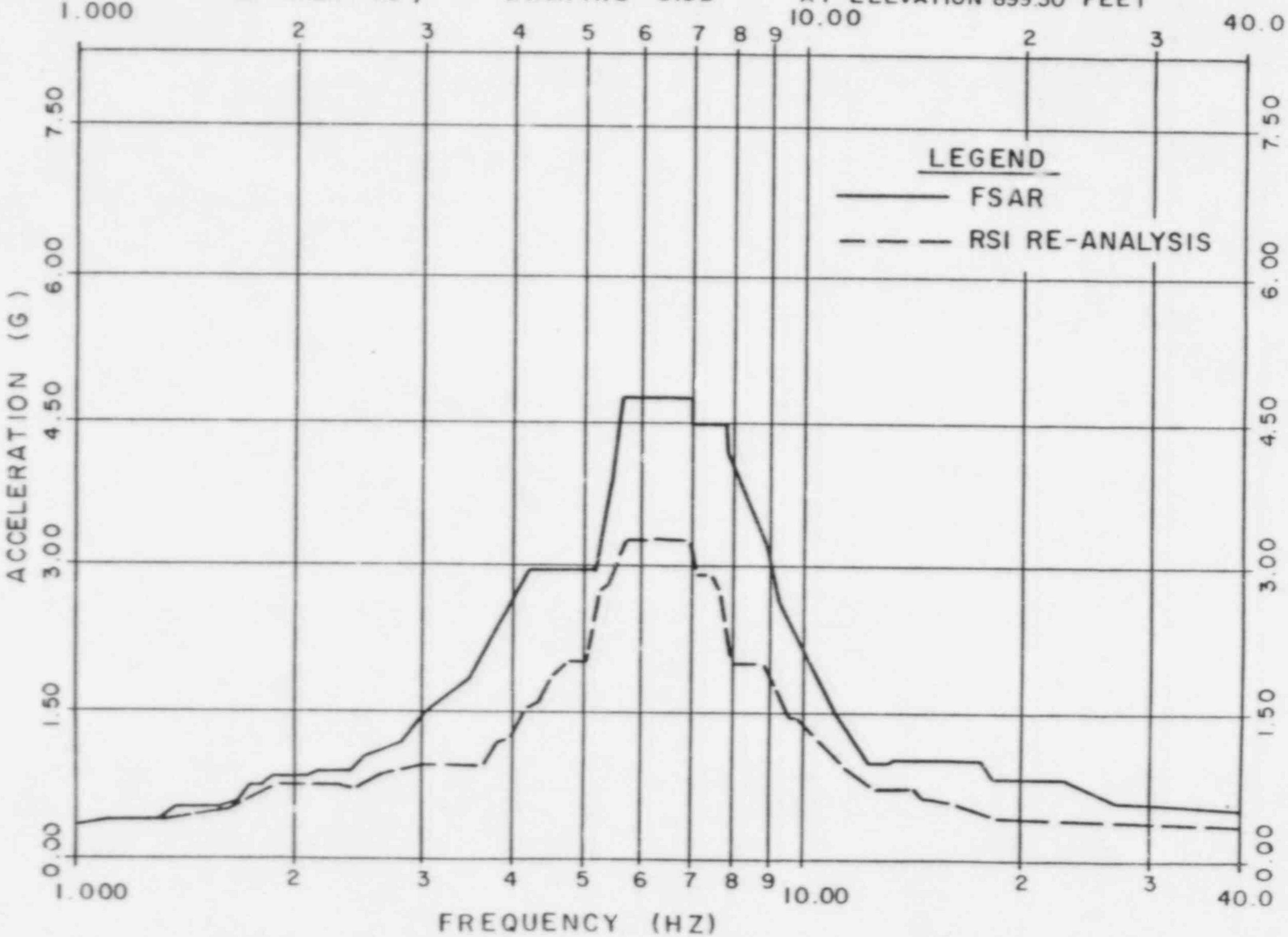
AUXILIARY BUILDING
FLOOR RESPONSE SPECTRA
FSAR vs RSI RE-ANALYSIS

COMPONENT AX; DAMPING = 0.02 AT ELEVATION 790.50 FEET



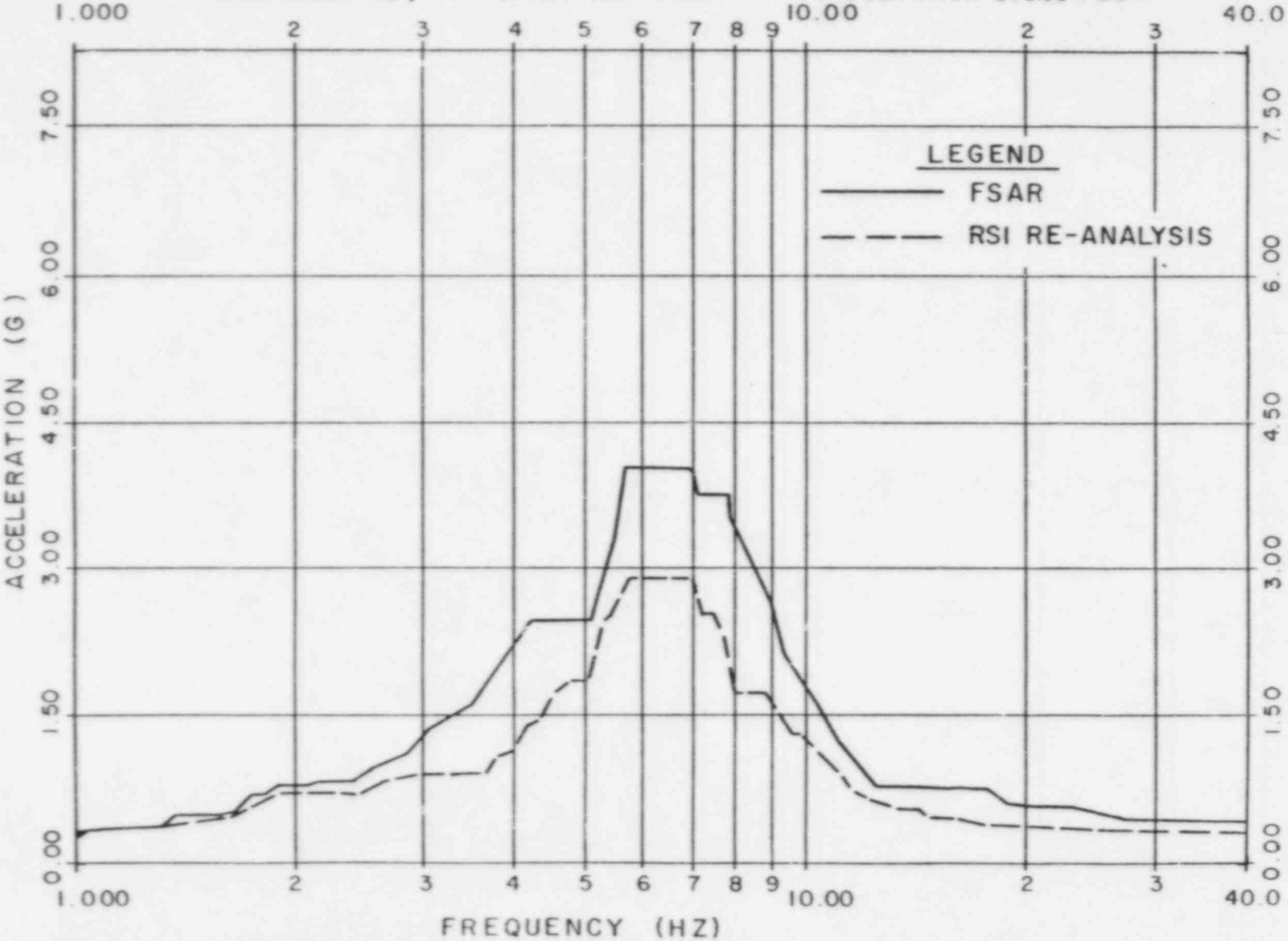
AUXILIARY BUILDING
FLOOR RESPONSE SPECTRA
FSAR vs RSI RE-ANALYSIS

COMPONENT AZ ; DAMPING = 0.02 AT ELEVATION 899.50 FEET

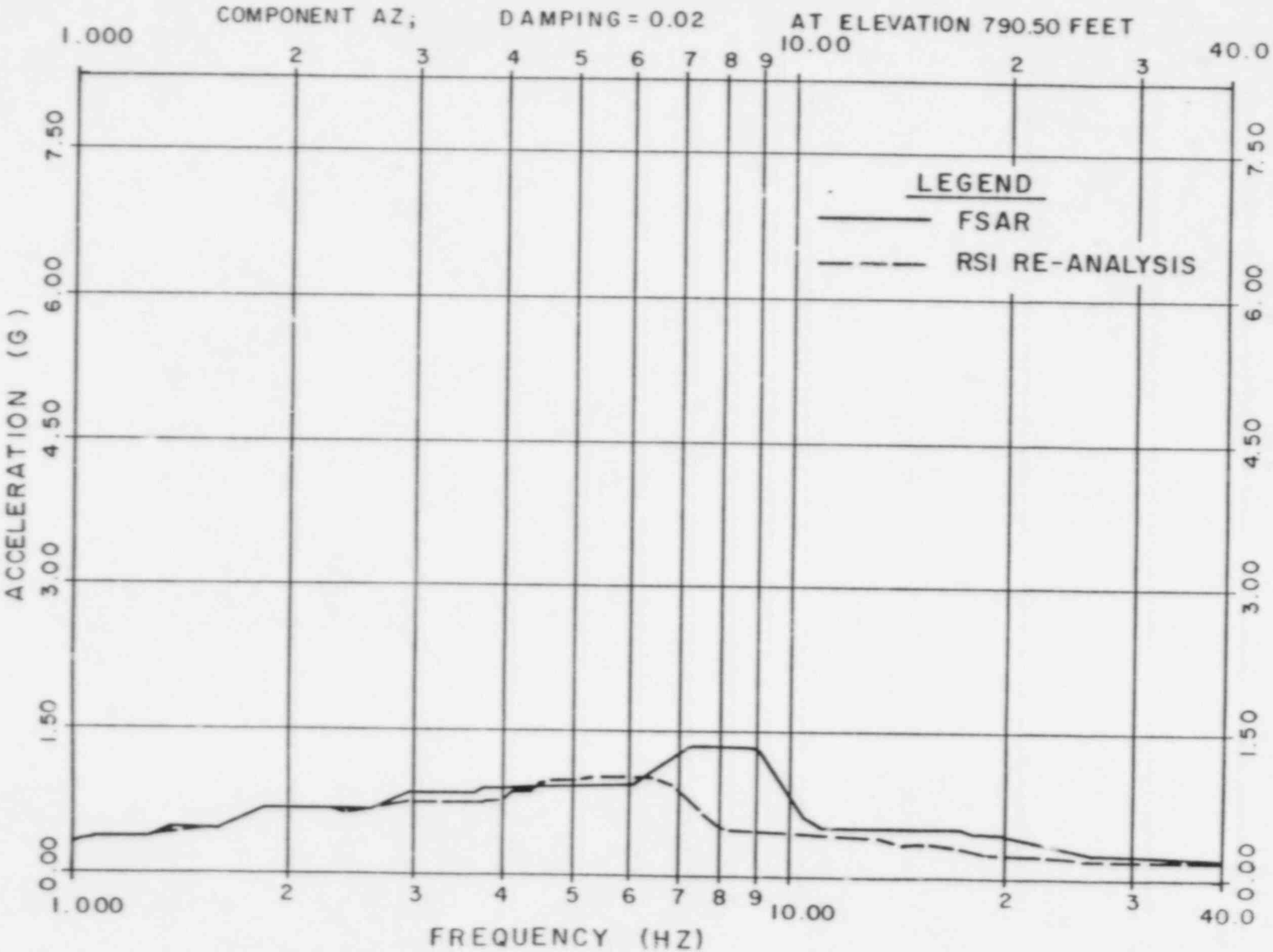


AUXILIARY BUILDING
FLOOR RESPONSE SPECTRA
FSAR vs RSI RE-ANALYSIS

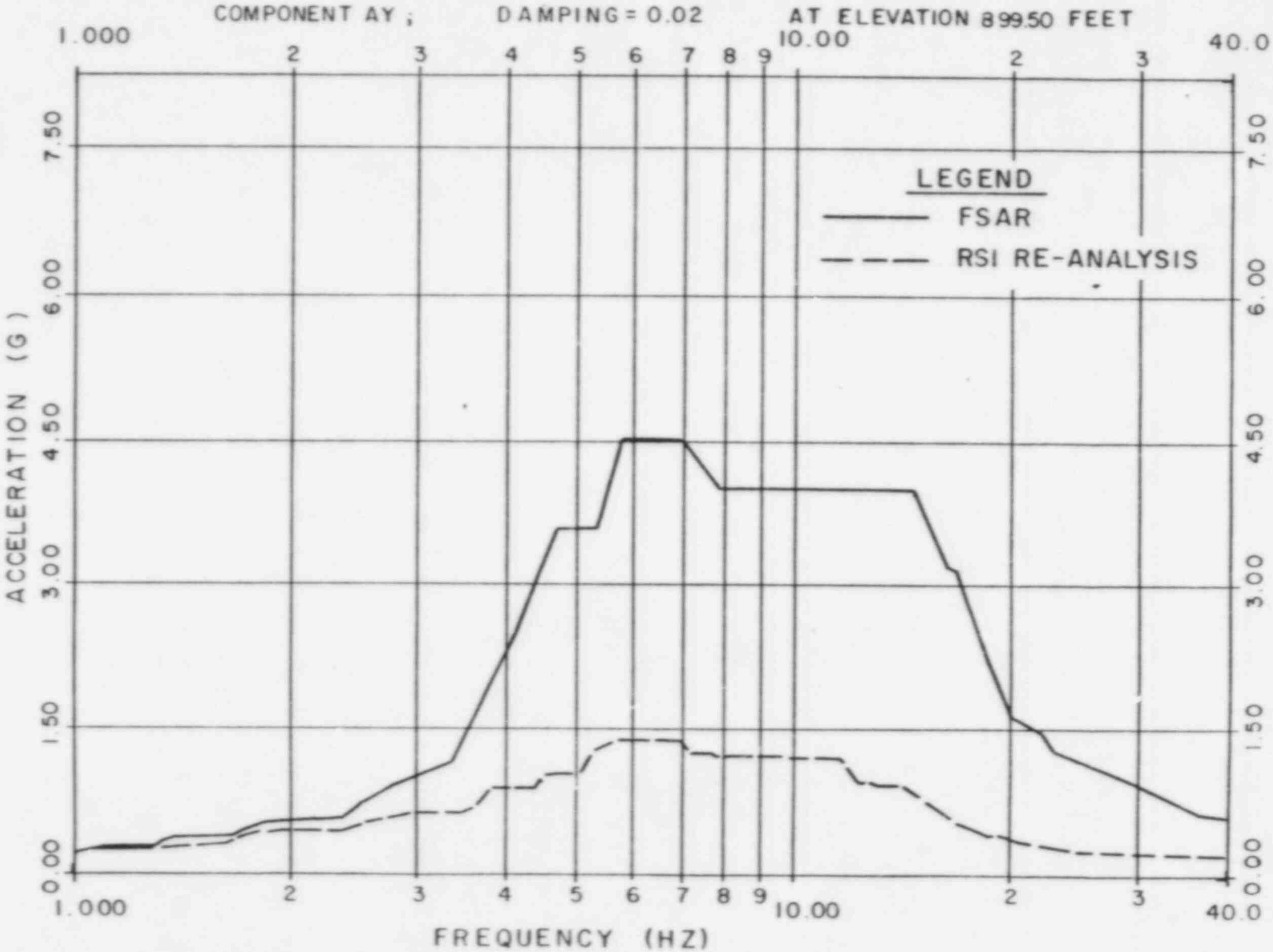
COMPONENT AZ ; DAMPING = 0.02 AT ELEVATION 873.50 FEET



AUXILIARY BUILDING
FLOOR RESPONSE SPECTRA
FSAR vs RSI RE-ANALYSIS

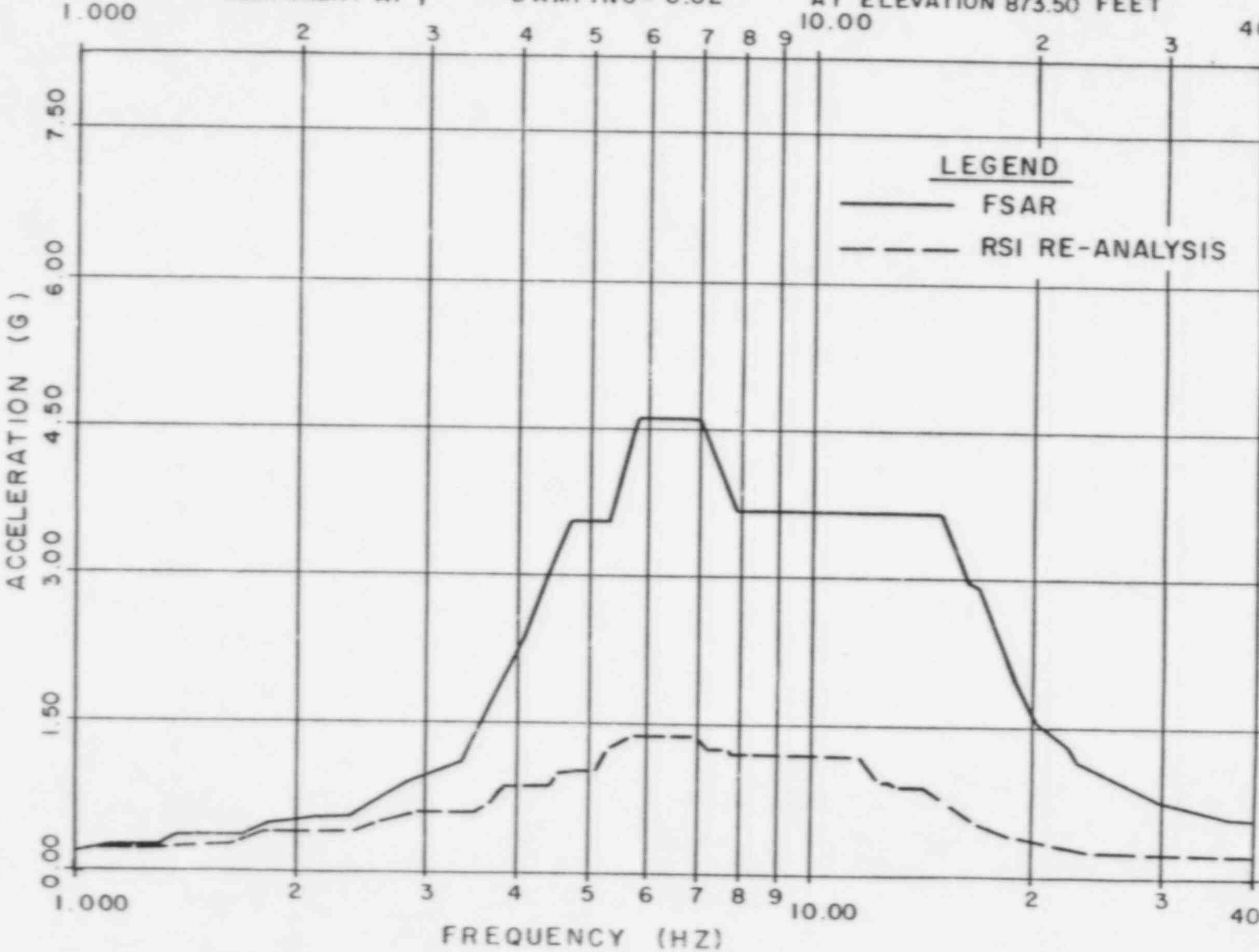


AUXILIARY BUILDING
FLOOR RESPONSE SPECTRA
FSAR vs RSI RE-ANALYSIS



AUXILIARY BUILDING
FLOOR RESPONSE SPECTRA
FSAR vs RSI RE-ANALYSIS

COMPONENT AY ; DAMPING = 0.02 AT ELEVATION 873.50 FEET



AUXILIARY BUILDING
FLOOR RESPONSE SPECTRA
FSAR vs RSI RE-ANALYSIS

COMPONENT AY ; DAMPING = 0.02 AT ELEVATION 79050 FEET