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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of	) Docket No. 72-22
	) ASLPB No. 97-732-02-ISFSI
PRIVATE FUEL STORAGE L.L.C.	)
	) DEPOSITION OF:
	)
(Private Fuel Storage Facility)	) **DR. MOHSIN R. KHAN**
	)
	)
	) (Utah Contention L/QQ)

Tuesday, March 5, 2002 - 12:10 p.m.

Location: Office of Parsons, Behle & Latimer
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Salt Lake City, Utah

Reporter: Vicky McDaniel
Notary Public in and for the State of Utah

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NUCLEAR REGULATORY COMMISSION

Docket No. ______ Official Exh. No. PP

In the matter of PFS

Staff ______ IDENTIFIED ✓

Applicant ✓ RECEIVED ✓

Intervenor ______ REJECTED ______

Other ______ WITHDRAWN ______

DATE 4/30/02 Witness ______

Clerk pmp

Q. When you say a correct solution --
A. For the input parameters that you use.
Q. I guess it means they gave you the same solution?
A. That's right, for the parameters that you use.
Q. And suppose you input the wrong parameter in the SAP -- in both codes, for example.
A. Then you will have both wrong results, sure. But for same, identical input, both give identical solution. For those parameters, it's benchmark.
Q. So if the input's wrong, the output's wrong on both of them?
A. Exactly.
Q. Garbage in, garbage out?
A. Exactly, sure.
Q. Now, in paragraph 62 you describe ANSYS as a, I believe another general purpose program?
A. Yes.
Q. I take it by use of the word "other" that SAP2000 is also a general purpose structural analysis program?
A. Yes.
Q. And what do you mean by a general purpose code?

drop the cask and it's 5 percent damping. How far should that cask be going back up?

A. I mean, I don't know how much it will bounce back, but --

Q. Can you calculate, if you know the damping is 5 percent, you drop a cask from 10 inches and the damping is 5 percent, can you tell me -- can you calculate how much the cask will bounce back up?

A. I'm sure, given all the programs, one could find. But to me is, again, when you are dropping this cask, there is no -- there is no damping associated to the cask when it touches the surface. At that time energy start dissipating, and the stiffness of the restraining object is the one that's absorbing most of the energy, okay? It is not the damping.

So if you are assuming that the damping is a significant contributor, you have to quantify it. You're taking two components which are resisting the motion. We don't know what the damping is. All we know is, for an object that deforms significantly, depending on the energy level, you could assume in that direction. But in the upward direction you have no -- you have no stiffness, so what kind of damping you're going to have in the upward direction.

Q. I thought it was only damping that

dissipated the energy. Am I wrong there?
A. I believe that there are two mechanisms which absorbs energy, absorption of energy. Your spring is absorbing energy to reduce the motion. Okay? When you have pure sliding, your sliding is actually dissipating energy and reducing the motion. When you have zero friction you can slide a long distance. Okay? When you have -- so in a vertical direction your spring is providing similar kind of behavior as your friction is providing in an unanchored system when it's moving on a horizontal surface.
Q. So you're saying that when I drop something, it's not the damping that's dissipating the energy but it's the spring on the ground absorbing the energy?
A. A significant amount of energy is absorbed by the crushing of the springs that you have.
Q. Well, I take a spring, okay. Take a spring. I push it down. Doesn't the spring push back up at me?
A. That's your spring action, but that's not the damping action. You could take this thing and crush it, okay? It's not the damping that has stopped it. It is the stiffness at the start of the motion.
Q. But doesn't the spring force back up again, or forces the cask back up again?
A. The spring will force it back again.

Q. And there's basically some damping associated with the movement of the spring in that sense, but the spring doesn't go -- doesn't force the cask back up as high as it was before?

A. It's only based on a small amount of damping. We don't know what that will be. It depends on the level of energy that you have. It depends on level of stress you have in the system. If you have a zero stress, you will have no -- very small damping.

Q. In your model, okay -- what did you say about zero stress again, now, just a second ago? Can you read that back?

(The record was read as follows: "It's only based on a small amount of damping. We don't know what that will be. It depends on the level of energy that you have. It depends on level of stress you have in the system. If you have a zero stress, you will have no -- very small damping.")

A. See, the Reg Guide I believe 161 defines for various level of earthquake for the kind of structures that you have which are going through certain deformation what kind of damping you should have. So if your structure is going through a state of deformation that you expect it's going to have, you associate damping with those values. And that's why,

you know, if you have an anchored cask where you are going to see high level of stresses in the anchored board or a structural member, you use 4 to 5 percent damping. For low-level earthquake where your stress level in the component are smaller, you use low damping values. And that's the basis of damping.

Q. Are you familiar with the term "impact damping"?

A. Yes.

Q. What does that mean?

A. The damping that could be associated during an impact. And that's experimentally determined, by the way.

Q. And so you have the cask impacting the pad; there would be impact damping between the cask and the pad?

A. Yeah. And that would depend on the level of impact, type of impact. It's a function of the amplitude.

Q. Do you account for impact damping in your modeling?

A. There is some small amount of damping equal to what I reported in this calculation that's for every structural element that's associated.

Q. In your model does the spring element

dissipate any energy?

A. Every element is used to deform, and therefore it absorbs energy or interacts against the motion.

Q. It's appropriate to have the spring to absorb energy, then?

A. Sure. We use spring all the time.

Q. Going back to my example of the ball. If you drop the ball from a foot or ten inches, whatever the case may be, and if you have no damping, doesn't the ball bounce back as high as it was before?

A. It's a coefficient of restitution depending on how the ball is -- it also depends on the gravity is pulling, you know. Let's say we can jump 50 feet, but we will always come back to earth because the gravity's always pulling you down. So it has nothing to do with damping. You will always be on the ground.

Q. But if you have no damping and you drop the ball at a certain force, it will go back up the same distance that you drop it from?

A. Well, if you don't have the absorption of energy as it bounces, if you have a perfectly rigid surface, infinitely rigid surfaces, you could say the coefficient of restitution between the two is such that you have no dissipation of energy. But you still have

the gravitational forces acting against an object, and it will always try to bring it back to the earth.

Q. You mentioned something, restitution?

A. Coefficient of restitution.

Q. What's the coefficient of restitution?

A. I think it's the -- as the -- when you drop the ball, the ratio between the force impacted and the reactive force, it gives you, whether it's a perfectly rigid bounce or it's an elastic bounce.

Q. And if you have a perfectly elastic surface, what happens then?

A. Well, perfect elastic surface, it should bounce back. But there is no perfectly elastic surface. There is no such thing as perfectly elastic and there is no such thing as perfectly plastic. Everything on this earth deforms. Okay? So a ball will always go back to the ground after a certain bounce.

Q. Now, the coefficient of restitution, is that a function of damping or is that a function of something else in addition to damping?

A. It could be function of whole bunch of phenomena surrounding when the ball falls. Could be, if there's a high wind, that could stop it. If it's in a vacuum, you may have a different thing. Surrounding

does affect what happens to the ball.

Q. Can you measure the loss of energy by the percent of coefficient of restitution? In other words, if something goes down and it comes up only so high, it means it's lost a certain amount of energy, correct?

A. But see, the question is, which is the absorbing phenomenon? Is your energy being absorbed by the surface that deforms it, or is it something else? And I think it's anybody's guess. It could be the elastic surface is absorbing some of the -- as it crushes, it absorbs energy. So it could be a combination. I can't say for sure.

Q. Suppose I throw a ball. Give you another example. Suppose I throw a ball, horizontal motion. Suppose I throw a ball against a wall and it comes back a certain amount, okay? And it doesn't come back all the way. What absorbs some of the energy? Is it the spring or damping or what?

A. Like I said, it could be a combination. Could be anybody's guess. It could be air resistance, actually.

Q. What studies have you done with respect to impact damping percentage, coefficient of restitution?

A. We never -- we never relied upon impact damping values.

Q. So you didn't do any work on impact damping values?

A. In our judgment we felt that the duration of impacts were too short to include those damping, so we used simply pure stiffness values. For local element where it impacts, for that element it was purely elastic collision and no damping were allowed.

Q. So no damping?

A. For that element.

Q. So you didn't study impact damping or analyze it?

A. No.

Q. We've used a couple terms, okay, energy absorption and energy dissipation. Used it in connection with different elements -- damping, spring, etc. Could you define what you mean by energy dissipation, first of all?

A. That's a loss of energy.

Q. A loss of energy?

A. Yes, during friction phenomenon.

Q. During friction?

A. Yeah, loss.

Q. Excuse me?

A. During friction to surface.

Q. Can it be loss of energy other than

friction?

A. Sure.

Q. So it's a loss of energy from an object?

A. Yeah. You could have damping in the system, you could have a crushing in the system, you could have a permanent deformation in the system.

Q. And how do you define energy absorption?

A. Energy absorption?

Q. Yeah.

A. You apply force and something deforms, and it does not respond. It captures that energy and retains it. You have loss of energy. That's how you absorb the energy.

Q. Suppose I crush a Coke can, okay? Is that absorption or dissipation?

A. It's an absorption. This is absorption.

Q. Does a linear elastic spring dissipate energy, or does it only absorb energy?

A. Absorbs energy.

Q. It doesn't dissipate?

A. No, it does not dissipate. The damping associated with that elastic motion would dissipate energy. So a spring always when it is associated with a damper, that's why they call it spring damper element. A damper basically dissipates the energy

using the damping effect.

When you have an equation of motion you have three components to it, and they all are in equal degree. You have inertia, you have forces which are a function to velocity, and then you have forces which are a function to stiffness. When you add them together, that forms the equilibrium of the equation. And then you may also have in it frictional phenomena as an item, friction effect.

Q. One last question in this area. It's your position that 5 percent is too much, whether you view it as energy dissipation by damping or energy absorption by the spring. Is that correct?

A. That is my judgment.

Q. So it's not a matter of how you define it?

A. Yeah.

Q. You're claiming that there's no loss of energy that's sufficient -- equal to 5 percent?

A. Yeah, for this -- when you're doing this sliding and taking friction into consideration, using 5 percent -- equivalent to 5 percent damping for those gap elements is high.

Q. And for that you would include any energy absorption by the spring itself?

A. Yeah, because you are absorbing all the

energy through friction anyways, and I would use a very small damping.

Q. If you have vertical motion up and down, you're basically saying it's all through friction?

A. No. There's no friction when it's vertical motion up and down.

Q. Isn't that a part of the modeling here?

A. If you model as it as a 3-D model, then friction is dominating your phenomena. Okay? What is the most dominant phenomenon, okay? If your most dominant phenomenon is your sliding, then the friction is the one that's taking care of all the energy in the system.

(Recess from 4:33 to 4:45 p.m.)

Q. I if could turn to some of the results you have in your table in the report. First of all, I'd just like to look at Table 3. This is, Table 3 is the result of the third mathematical model where you've assumed motion in all three directions, X, Y, and Z?

A. Plus cask height, effect of cask height, whatever the structural properties are.

Q. Now, you have in here -- in this Table 3 you have a column called Stiffness for Non-Linear Elements, and we have the vertical stiffness column.

A. Yes.

A. We use stiffness values all the time, every time we analyze the structure. For an anchored cask it could be zero in the upward direction.

Q. So how many times have you picked a contact stiffness value for sliding analysis?

A. A program --

Q. How many times have you picked a contact stiffness value for sliding, for lift-off analysis?

A. For this case?

Q. No, just in general. How many times have you picked a contact stiffness analysis for purposes of analyzing sliding or tipping?

A. This is the case.

Q. This is the first case?

A. Yes.

Q. First time you've done it, correct?

A. That's right.

Q. Okay. Dr. Khan, you say in paragraph 70, I believe it is, "The Altran analysis did not take into account for the amplification due to soil structural interaction in the 2,000-year earthquake input time histories." Then you go on to say, therefore, the vertical input motions at the base of the cask should be higher. I'm confused what you're saying in that paragraph 70. I think you also have something in your

provide you this value you should use for the stiffness.

Q. I said, did you follow the guidance that ANSYS provides in determining what stiffness to use?

A. ANSYS never provided any guidance on sliding, how to calculate the stiffness for a sliding problem.

Q. Did you follow the guidance of ANSYS in terms of how to arrive at appropriate contact stiffness guide for the problem you were looking at?

A. They would never give you an answer.

Q. So there is no guidance from ANSYS?

A. I used their program.

Q. You didn't use any guidance from them in terms of how to develop the appropriate contact stiffness for the problem you were working?

A. They would never say for a sliding problem what contact --

Q. I'm not asking that. I'm just saying, you did not follow the guidance of ANSYS with respect to arriving at the proper contact stiffness?

MS. NAKAHARA: Asked and answered.

A. There is no guidance. All I can say is, there is no guidance from ANSYS how to solve a nonlinear sliding problem with large horizontal

motions.

Q. Okay. In paragraph 72 of your declaration, I believe you say that, in your opinion, "the only way to validate Holtec's analyses is for Holtec to benchmark its sliding displacements calculated by Holtec's non-linear mathematical model with actual shake table test data. This is common practice in the seismic performance field. I frequently perform shake table tests to benchmark mathematical models."

How would you go about doing a shake table test for the Holtec cask?

A. Well, you know, find a shake table, maybe in Japan or someplace. I'll have a prototype model, shake it and apply the ground motion that you see. And you'll benchmark your nonlinear solution with a sliding displacement, impact loads inside the casks, and then substantiate your model, that this is what you're getting from your analysis and from your testing for sliding, displacement, tipping, and whatnot. And then you could go and use a bigger cask, a different size, because at that time you have a basis, parametric basis for that model.

Q. You've mentioned Japan. Why do you mention Japan?

A. They have a bigger table.