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UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

OFFICE OF THE SECRETARY
RULEMAKINGS AND
ADJUDICATIONS STAFF

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)	<u>DR. MOHSIN R. KHAN</u>
Facility))	
)	
)	(Utah Contention L/QQ)

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

Location: Office of Parsons, Behle & Latimer
201 S. Main, Suite 1800
Salt Lake City, Utah

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

Docket No. _____ Official Ex. No. 88
 In the matter of _____
 Staff _____ IDENTIFIED
 Applicant RECEIVED
 Intervenor _____ REJECTED _____
 Other _____ WITHDRAWN _____
 DATE 5-7-02 Witness _____
 Clerk _____



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SECY-02
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1 analysis is part of your review of the cask stability,
2 your work in general --

3 A. Yes.

4 Q. -- element analysis. Finite element
5 analysis, is that a broad area in terms of a general
6 description --

7 A. Yes.

8 Q. -- of work? And I guess you could do finite
9 element analysis in many different types of components
10 and structures?

11 A. Yes.

12 Q. Is there any particular ones you would point
13 to here as being relevant, or not?

14 A. Not really.

15 Q. Not really? Is there any -- did you do
16 while you were at Altran any finite element analysis of
17 freestanding objects?

18 A. Not at -- let me see. Not at Altran but in
19 my previous jobs, yes.

20 Q. In your previous jobs, what --

21 A. Sliding analysis.

22 Q. Of what types of objects?

23 A. Just rigid bodies.

24 Q. Rigid bodies?

25 A. Yes.

1 Q. Can you tell me some examples of rigid
2 bodies that you've analyzed?

3 A. This, sliding.

4 Q. He's moving a cup, okay. Can you give me
5 some examples of some equipment or components, I take
6 it, you did sliding analysis on?

7 A. Yeah. We took some blocks, we took some
8 racks, did some studying of the sliding objects.

9 Q. What size blocks did you use?

10 A. With analysis it doesn't really matter.
11 It's just a parameter. It could be thousands of
12 pounds, it could be 50,000 pounds. It wasn't an actual
13 test, it's just a mathematical simulation.

14 Q. It wasn't what?

15 A. It was just a mathematical simulation, so
16 you can put in any input parameters and it would give
17 you a seismic sliding analysis.

18 Q. I guess my question: did you model -- using
19 finite element analysis, did you model a freestanding
20 object that could slide or tip?

21 A. That's right.

22 Q. You did?

23 A. Yes.

24 Q. Okay. My question is, what freestanding
25 object did you model?

1 A. The freestanding object that we did study
2 was Holtec high-density racks using ANSYS.

3 Q. Okay, that was the spent fuel racks for
4 Diablo Canyon?

5 A. Yes.

6 Q. And the spent fuel racks were freestanding?

7 A. Yes.

8 Q. And what time period was this?

9 A. I believe maybe '87, '88 time frame.

10 Q. In addition to doing these study analyses
11 for the freestanding spent fuel racks for Diablo
12 Canyon, what other freestanding objects have you
13 modeled?

14 A. I did not model specifically but studied
15 whole bunch of freestanding models when I was at PG&E.
16 And doing designs which are being submitted by various
17 vendors, including Holtec at that time, for cask design
18 in freestanding conditions.

19 Q. So you're referring to having reviewed
20 models involving sliding and freestanding objects done
21 by various vendors of casks. Is that what I understand
22 you to say?

23 A. That's right. That was also a part of it,
24 yes.

25 Q. Any other examples of models of freestanding

1 objects that you reviewed?

2 A. In the plant you have, you know, going into
3 control room, you have racks which are freestanding.
4 And you look at the anchorages, see how far they can
5 move.

6 Q. Did you do any finite element modeling of
7 such racks?

8 A. No.

9 Q. So am I correct that the only finite element
10 modeling of a freestanding object model that you did
11 yourself was your modeling of the Diablo Canyon spent
12 fuel racks?

13 A. The spent fuel racks. We were looking at
14 some blocks just sliding on the free surfaces. We did
15 those studies, rigid objects sliding.

16 Q. Was this part of your analysis of the spent
17 fuel?

18 A. No, it was separate. It was not part of
19 this.

20 Q. What was the purpose for the sliding of the
21 blocks?

22 A. Oh, it was just part of the studies. We
23 used to do studies, evaluations of abnormal conditions.

24 Q. Now, going back to your work for Altran, you
25 identify in the fourth bullet of your resume under your

1 entire available space in such a way that you can
2 maximize the fuel space.

3 Q. So it would be correct to say that in terms
4 of sliding, the racks were more restrictive than --
5 spent fuel racks; sliding with respect to spent fuel
6 racks is more restrictive than sliding with respect to
7 spent fuel casks on the pad; is that correct?

8 A. Oh, much more, much more, much more. And I
9 think that's the only way you can really stack up more
10 fuel into the pool.

11 Q. Is to use freestanding racks?

12 A. Or racks that can store more fuel.

13 Q. You indicated, and I take it that -- let's
14 just use Holtec for the spent fuel racks, even though
15 they may have gone through a transition at this point
16 in time, okay, for describing the spent fuel racks at
17 Diablo Canyon.

18 A. Yes.

19 Q. Holtec had designed those spent fuel racks,
20 and did they do a stability analysis or finite element
21 stability analysis with respect to the racks at that
22 point in time?

23 A. Holtec did -- yeah, nonlinear, they did do
24 nonlinear analysis. But again, this sliding
25 displacement is very limited. They were very limited

1 based on the available space inside the pool on either
2 side of that rack itself.

3 Q. Did you review the model that Holtec used to
4 do the stability analysis with respect to spent fuel
5 racks?

6 A. I saw the results, yes.

7 Q. You saw the --

8 A. Conclusions, yeah.

9 Q. Do you know what program Holtec used to do
10 that model?

11 A. No, I don't remember, but it was in-house
12 program.

13 Q. Can you compare that program for modeling
14 the spent fuel racks with the program that Holtec used
15 for modeling the spent fuel casks at PFS, do you know?

16 A. No, I don't know.

17 Q. Do you know what modifications, if any,
18 would need to be made to it?

19 A. I don't know.

20 Q. At Diablo Canyon with respect to spent fuel
21 racks, weren't the spent fuel racks also analyzed to
22 see whether or not they would tip over on the same
23 program? Let me rephrase the question. Do you know
24 whether a single spent fuel rack, single spent fuel
25 rack in isolation was analyzed to see whether it would

1 tip over using the model that Holtec had developed?

2 A. It could have been. But the pool, the --
3 when the cask is inside the pool, you have --

4 Q. You're talking about the racks?

5 A. The racks inside the pool has water
6 surrounding. So there's a lot of difference with
7 respect to the effect of damping for water or effect of
8 water affecting the rack and then vice versa. So there
9 was significant variation in terms of the effect of
10 surrounding water on the rack dynamics.

11 Q. You indicated that you had done some
12 analysis on your own to -- you modeled the spent fuel
13 racks yourself, I take it, at Diablo Canyon?

14 A. (Witness nods head.)

15 Q. And how did you model the spent fuel racks?

16 A. The way that we did at that time was, we
17 basically looked at the strength of rack itself. You
18 know, there were numbers coming from rack analyses in
19 terms of impact loads, and we were modeling locally the
20 racks itself at that time to see whether the rack was
21 starting to take all these impact loads coming out of
22 the rack dynamics.

23 Q. Did you model the potential for sliding or
24 tip-over of the racks?

25 A. There was -- we did one study with ANSYS

1 simply to look at interaction, you know, very simple
2 interaction between a stiffness constraint and how the
3 rack impacts, but that was the only part that we did.
4 We did not do in the greater detail as a rack vendor
5 would do, because they had more -- lot of design
6 parameter, a lot of analysis parameters than we did.
7 We didn't have that.

8 Q. And they had a more detailed program
9 specifically designed to analyze that?

10 A. That was for cask design, yes, of the rack
11 design.

12 Q. They had a more detailed program to analyze
13 the sliding and tip-over aspects?

14 A. Yeah, because you could put in all the
15 racks' parameters from whatever geometrical constraints
16 you had.

17 Q. I take it that with your analysis and with
18 the analysis that Holtec did, you agreed with the use
19 of the freestanding racks at Diablo Canyon, the spent
20 fuel racks?

21 A. It was litigated and I believe what they won
22 was a judgment, everybody bought into it.

23 Q. Well, I guess, you agreed yourself
24 personally or professionally? You agreed with the --

25 A. I agreed professionally that the racks were

1 sturdy enough to store the fuel. I may not agree or
2 disagree, I may not have known exact value of numerical
3 value. But the way I looked at this, there's a pool,
4 racks are not going to go anywhere, and there's very
5 little movement or their casks -- the racks are very
6 sturdy, and so we made our own independent judgment
7 that, yes, everything's all right, they are very
8 structural.

9 Q. So you agreed with the use of the
10 freestanding racks?

11 A. Yes.

12 Q. You indicated in your resume, I think, that
13 you provided expert testimony on the high density spent
14 fuel rack design. What type of testimony did you
15 provide and where?

16 A. It was I guess expert deposition that I was
17 supposed to provide to say that the rack itself
18 looked -- they were internal PG&E folks, and I provided
19 that at that time. But nobody really cross-questioned
20 me. It was just written statements provided by myself
21 on the integrity of the racks itself.

22 Q. When you say a written statement --

23 A. Yeah. It was testimony like this, but --

24 Q. Like what? Like a declaration?

25 A. Yeah, I think it was a declaration. But

1 nobody -- at that time I think we had -- I know there
2 were folks from outside, Mothers for Peace, who were on
3 the other side, and they had a whole bunch of
4 questions. We were in the same team trying to provide
5 the racks are okay. So that's where I provide my
6 testimony.

7 Q. At the -- let me ask this. At the licensing
8 board here, was it heard before the licensing board in
9 this case?

10 A. No, I don't think so.

11 Q. You don't think --

12 A. No.

13 Q. -- licensing board?

14 A. No.

15 Q. Do you know if there was any live testimony
16 in that case, people got up on the stand and were sworn
17 in?

18 A. No, I did not do that.

19 Q. You did not do that?

20 A. I did not do that.

21 Q. Do you know if anybody else did that on
22 behalf of PG&E in defense of the spent fuel racks?

23 A. Oh, I'm sure there were lot of people
24 involved at that time, lot of attorneys involved.
25 Dr. Singh might know more than I would.

1 Q. Structural analysis and structural dynamics
2 is a very broad category, right?

3 A. That's right.

4 Q. Anything that you would point out as being
5 most relevant?

6 A. They all form the basis of relevancy, but
7 not, you could say -- so I couldn't say one paper is
8 more applicable than all the others.

9 Q. Do any papers involve structural analysis or
10 seismic analysis of freestanding objects?

11 A. No.

12 Q. With respect to your presentations, you have
13 referred to one presentation really that we've
14 discussed. Other than the one that you referred to
15 previously, are there any presentations that you would
16 consider to be particularly relevant to the area of
17 your expected testimony here?

18 A. No.

19 Q. Do any of your presentations involve
20 structural seismic analysis of freestanding objects?

21 A. No.

22 MR. GAUKLER: Let's take a break.

23 (Recess from 1:30 to 1:50 p.m.)

24 Q. (BY MR. GAUKLER) With respect to several
25 matters we were talking about, Dr. Khan. First of all,

1 NRC that forms the design basis for a freestanding
2 object?

3 A. Do I have a --

4 Q. Any work that's been docketed with the NRC
5 that forms the design basis for a freestanding object?

6 A. No.

7 MR. GAUKLER: I'd like to have marked as
8 Exhibit 4 a Joint Declaration of Dr. Steven F.
9 Bartlett, Dr. Mohsin R. Khan, and Dr. Farhang Ostadan.

10 (Exhibit 4 marked.)

11 Q. (BY MR. GAUKLER) Do you recognize what's
12 been marked as Exhibit 4?

13 A. Yes.

14 Q. Is this the joint declaration that you
15 prepared or assisted in preparing?

16 A. Yes.

17 Q. And it's dated December 7th, 2001?

18 A. Yes.

19 Q. And if you turn back I think to the last
20 page of the document, is that your signature that
21 appears on the bottom of that page?

22 A. Yes.

23 Q. Now, is it correct that the paragraphs of
24 this document for which you are responsible or
25 completely or partially responsible are identified by

1 A. Yeah. These are large manuals and provides
2 how to use those.

3 Q. Did you review any other documents in the
4 preparation of this report?

5 A. No.

6 Q. In paragraph 10 of the declaration
7 identified as Exhibit 4. Go back to Exhibit 4, please.
8 In paragraph 10 you say that you have "extensive
9 experience designing and interpreting non-linear finite
10 element models to show the structure, systems, or
11 component performance under seismic forces." What do
12 you mean by non-linear in that sentence?

13 A. Well, I think things which are not anchored
14 down, you know, it's a -- give you an example, a relay,
15 okay. That has an open contact and closed contact, and
16 they're very sensitive to seismic motion. If they
17 close it in a seismic environment, you may shut down
18 the plant or you may have a trip. So we do all this
19 testing to ensure that systems and equipment perform
20 their intended safety function as they are going
21 through seismic motion.

22 Q. Are you saying that anything that's not
23 anchored is a nonlinear system? Are you saying
24 anything that's not anchored is a nonlinear system?

25 A. It depends on the analysis that you're

1 performing.

2 Q. What makes a system nonlinear as opposed to
3 linear?

4 A. A linear is if we have in a linear fashion,
5 and a nonlinear is at a given point it does not behave
6 in a linear fashion. So it may be sitting here, apply
7 small force, it's not doing anything. You apply
8 forces, it starts sliding. That's a nonlinear system.
9 So the behavior with respect to the load application is
10 not a linear function of code application.

11 Q. What components have you done nonlinear
12 analysis for?

13 A. I did a lot of testing.

14 Q. What type of components?

15 A. These are cabinets containing switch gears,
16 electrical items, mechanical items. You could have a
17 pump, for example, you know, running, and it has
18 clearances. So you want to make sure that when it's
19 going through a seismic excitation the shaft does not
20 bend enough to create unnecessary deformations so that
21 it could become a potential problem while it's going
22 through motion.

23 Q. And is this part of your work doing
24 equipment qualification with respect to -- for PG&E?

25 A. Yes.

1 Q. And what type of nonlinear behavior did you
2 model for these components?

3 A. We -- every time there was an issue that we
4 have a nonlinear problem, in general we try to test it.
5 Because we couldn't really analyze the nonlinear system
6 in a realistic way, so we went and shook it.

7 Q. Did you analyze sliding of these components?

8 A. Which component?

9 Q. These --

10 A. No, we anchored them, most of them.

11 Q. So these are not -- the nonlinear system or
12 the nonlinear type of phenomena that you were
13 evaluating was not sliding, then?

14 A. It was impact.

15 Q. Impact?

16 A. Impact.

17 Q. So it was not --

18 A. Yes, that's right.

19 Q. And what size, how large were these
20 components that you worked with, generally speaking?

21 A. It was very small to where they would fit in
22 the room, maybe a few thousand pounds.

23 Q. Couple thousand pounds?

24 A. Yeah.

25 Q. Like a cabinet?

1 A. Yeah. In nonlinearity it is relevant, mass,
2 how it is anchored and what kind of mounting
3 conditions. So mass --

4 Q. I was asking about the size. So irrelevant,
5 mass is irrelevant, do you think?

6 A. Well, it -- you know, if an earthquake
7 comes, it's going to move a 500-pound item the same way
8 it's going to move a 1,000-pound item or 2,000-pound
9 item. It all depends on how it is anchored to the
10 floor and what kind of boundary condition exists.

11 Q. In Exhibits 5 and 6 you're evaluating the
12 nonlinear behavior of the HI-STORM cask, correct?

13 A. Yes.

14 Q. And you're evaluating the sliding and
15 tipping potential of the HI-STORM cask?

16 A. (Witness nods head.)

17 Q. Prior to this case have you ever
18 evaluated -- undertaken a simulation and evaluated the
19 sliding and tipping for a dry cask storage system?

20 A. No.

21 Q. And I gather from what I understood your
22 testimony to be before, you've not analyzed the
23 potential for sliding or tipping of a freestanding
24 object, taking a freestanding object, model it and
25 analyze the potential for sliding and tipping of them?

1 A. Not the cask. Not the cask, but other
2 sliding analysis studies, yes, I have done.

3 Q. But you -- if we can go back. The only
4 thing I could gather of what you told me about were two
5 things. I want to make sure I'm correct on this. One,
6 you stated you had looked at or evaluated the
7 freestanding spent fuel racks --

8 A. That's right.

9 Q. -- for Diablo Canyon.

10 A. That's right.

11 Q. But then you got into and discussed that,
12 and you said you were focusing more on the structural
13 strength and not the sliding or tipping of those
14 elements.

15 A. Because they were not as critical.

16 Q. So your study there did not focus on sliding
17 and tipping?

18 A. No, they were not as critical.

19 Q. And the only other thing I heard you talk
20 about were evaluating some sliding blocks.

21 A. That's right.

22 Q. And I take it, this was kind of like almost
23 hypothetical blocks, correct?

24 A. Sure. You could call it, sure.

25 Q. You weren't modeling any real equipment or

1 components, correct?

2 A. That's right.

3 Q. And what contacts, stiffness, for example,
4 did you use in evaluating those sliding blocks? Do you
5 recall?

6 A. No, I do not recall.

7 Q. Other than those two instances, correct me
8 if I'm wrong, have you ever evaluated the potential for
9 sliding or tipping of a freestanding object?

10 A. That's correct.

11 Q. Those are the only two instances?

12 A. Yes.

13 Q. Going to paragraph 30, you talk about --
14 it's in Exhibit 4. You say, "During the course of my
15 work associated with dry cask storming projects for
16 Pacific Gas and Electric ('PGE'), NRC staff has not
17 granted a license for unanchored vertical casks at any
18 sites with peak ground accelerations greater than 0.4 g
19 due to the greater potential for sliding and tipping of
20 these casks containing irradiated fuel assemblies."

21 What is the basis for that statement?

22 A. I guess -- back in those days we were going
23 back to, I guess with various vendors and looking at
24 that time what cask has been licensed. And most of the
25 casks which had been licensed were I guess east of the

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

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

6 A. A program --

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

9 A. For this case?

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

13 A. This is the case.

14 Q. This is the first case?

15 A. Yes.

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

17 A. That's right.

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