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	UNITED STATES OF AMERICA 2003 JAN 29 P	YM 3: 14
	OFFICE OF THE SANDER REGULATORY COMMISSION RULEMAKING ADJUDICATIONS	ECRETAR' S AND S STAFF
Before	the Atomic Safety and Licensing Board	
In the Matter of	f) Docket No. 72-22) ASLPB No. 97-732-02-ISFSI	
PRIVATE FUEL STO L.L.C.	ORAGE)) TELEPHONE DEPOSITION OF:	
(Private Fuel St Facility)	torage) KRISHNA P. SINGH and) ALAN I. SOLER	
)) (Utah Contention L/QQ)	
	Salt Lake City, Utah	
Notary	Reporter: Vicky McDaniel y Public in and for the State of Utah	
	State Exhibit	's 120
	State Exhibit CitiCourt, LLC THE REPORTING GROUP 50 South Mai Salt Lake City,	'S 120 n, Suite 92 Utah 8414

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Krishna P.	Singh & A	lan I. Soler *	March 6, 2002

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	Singn/Soler deposition, 3/6/02 13	1.	
' 1	cohesiveness, and also checking that the input data was		A. (DR. SULER) I DELLEVE BY FOLE WAS AS A
2	correct, that the model followed accepted engineering	2	reviewer of the document, and of course I had some
\mathbf{T}_{3}	principles and that the results made sense.	3	discussions early on as to the procedure that we would
Ĭ	0 And Dr. Soler, what was your role with	4	follow.
	y. And DI. Dutty made may your role with	5	0 And Dr Singh, was your role with respect to
15	respect to this document: I in Solly, DL. Singh.		the drop tinewar analysis the same as your role in the
6	A. (DR. SINGH) My role is the same in every	0	the group tipover analysis the same as your fore in the
17	work that's done in the company in the areas where I	17	other PrS Holtec documents?
8	have direct expertise. I review the work, and the	8	A. (DR. SINGE) That is correct.
9	engineers who do the work, they can consult with me on	9	Q. Dr. Singh, you stated that you very seldomiy
10	different aspects of the solution. And I'm generally	10	do the direct analysis any more. Have you ever been
11	Camilian with the work days hereases of the interestion	111	the principal analyst for a HI-STORM cask to analyze
11	Idmitidi Will the work when because of the interaction,	112	the response of a HI-STADM cask to a seismic event?
12	DUT 1 don't do the work myself. And 1 very seldom	12	LITE TESPONSE OF A RE-STORY CASK OF A SETSMENT EVENT:
13	serve as a direct reviewer of the document.	13	A. (DK. SINGE) NO. I DAVE NOT DEED THE
14	Q. And the third document, Dr. Soler, do you	14	principal analyst for seismic analysis of Holtec's cask
15	have in front of you a Holtec document entitled	15	systems. In recent years I have not done direct
16	"Dynamic Response of Freestanding HI-STORM 100 Excited	16	analysis myself.
17	by 10 000-Voar Daturn Farthmiako at DFCM?	117	0. When was, approximately, the last time you
11/	by IV, VVV-ICAL RECUTH BALLIQUARE AL ELD :	110	have performed direct seismic analysis or been the
18	A. (DR. SULER) 165.	10	nave performed unreal sersant analysis of been the
19	Q. And are you the principal author for this	119	principal analysi:
20	document?	20	A. (DR. SINGH) Probably about ten years ago.
21	A. (DR. SOLER) Yes, I am.	21	Q. And Dr. Soler, do you recall in your
22	0. And Dr. Singh, what was your involvement	22	deposition in November I asked you questions about
22	with this document?	23	other cask stability analyses performed by Holtec for
23	A (DD SINCE) My involvement Me Natahara	24	other sites?
24	A. (UK. SINGE) BY INVERTED IN, MAKENALE	25	B (DD COLED) Yoc
25	do you like to be called Ms. of Mrs. ? How do you like	123	a. UR. DUELA, 193. Citicourt IIC
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ſ		SHEET 3 PAGE 17 Singh/Soler deposition, 3/6/02 17		PAGE 19 Singh/Soler deposition, 3/6/02 19
	1	A. (DR. SOLER) Yes.		that. were you principally involved in the analysis,
ź	2	Q. Did you use the same lump mass mathematical	Z	cask stability analysis:
7	3	model used for the PFS site in the Diablo Canyon	3	A. (DR. SULER) I was involved as a reviewer
	4	analysis?	4	and giving some guidance as to the methodology.
	5	A. (DR. SOLER) No. Let me qualify that to	5	Q. And approximately when was this analysis
	6	some extent. The report on the 10,000-year return	6	conducted?
	7	earthquake at PFS uses the same computer code that	7	A. (DR. SOLER) This analysis is still ongoing.
	8	we've used for Diablo Canyon.	8	Q. And do you recall what the zero period
	ġ	0. Is it correct that Holtec conducted a cask	9	acceleration for Tennessee Valley is?
	10	stability analysis for Entergy Northwest?	10	A. (DR. SOLER) I don't recall exactly.
	11	A. (DR. SOLER) Energy.	11	Q. And Dr. Singh, your involvement with is
	12	0. Oh. Energy, Sorry,	12	it accurate to characterize your involvement with the
	13	A. (DR. SOLER) Yes.	13	Diablo Canyon, the Energy Northwest, the Tennessee
	14	0. Were you involved in the principal analysis?	14	Valley cask stability analysis the same as your
	15	1 (DR. SOLER) I believe that I acted as a	15	involvement with PFS as a reviewer and consultant
	16	reviewer for that analysis.	16	available for technical consulting with your staff?
	17	0 And did that analysis use the same lump mass	17	A. (DR. SINGE) That is correct.
	18	mathematical model used in the PFS 2,000-year return?	18	0. Dr. Soler, have you conducted other cask
	10	I (DR SOLFR) The same mathematical model was	19	stability analysis for the HI-STORM 100 at other
	20	need There were obviously a different number of casks	20	locations than we've discussed that have a peak ground
	20	involved Dimensions of the pad were different.	21	acceleration of above 0.4 g's?
	22	When did you perform this analysis, or when	22	A. (DR. SOLER) Performed some scoping analysis
	22	was this analysis performed?	23	for Humboldt Bay, but that does not involve HI-STORM.
	21	a (DR SOLER) I can only hazard a guess here.	24	Let me correct that. Early in the game before there
	25	that roughly a year and, maybe year and a half.	25	was a choice by the utility, we did subject the
	25	CitiCourt. LIC		CitiCourt, LLC
		(801) 532-3441		(R01) 532-3441
		10071 336 3337		1002) 332 3442
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י ר	 	PAGE 18 Singh/Soler deposition, 3/6/02 18 O. Do you recall what the zero period	1	PAGE 20 Singh/Soler deposition, 3/6/02 20 EI-STORM to the same kind of scoping analysis.
	1 2	PAGE 18 Singh/Soler deposition, 3/6/02 18 Q. Do you recall what the zero period acceleration for Energy Northwest was?	1 2	PAGE 20 Singh/Soler deposition, 3/6/02 20 HI-STORM to the same kind of scoping analysis. A. (DR. SINGH) Can I supplement that answer?
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Private Fuel Storage Krishna P. Singh & Alan I. Soler * March 6, 2002

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and a posserily characterize it as one or the other.] dynamic system. That's as brief as I can yet.
Can't necessarily characterized to be the	2 Modify me if
V. And the bounding, which job	3 DR. SOLER: I think that's fine.
3 A. (DR. SOLER) An earthquake larger than welle	4 O. And Dr. Soler, you
4 be expected at either of the sites.	5 a (DR SOLER) I would say I would answer
5 O. But the bounding work, was that in the	
6 Diablo Canvon or Humboldt Bay cask stability analysis	b in the same manner.
7 or in the tonical Safety Analysis Report?	U. U. Solei, Il you can, can you decorrect new
o a (pp solFP) We did bounding work	8 your testimony will differ of supprement br. singh s
8 A. (DR. SUBER) he willity and some of the work	9 with respect to these areas?
9 specifically for the utility, and some of the work	10 A. (DR. SOLER) I would suspect that my
10 found its way into the submittal to the autorital to	11 testimony might be more direct to specific points of
11 Q. Submittal 1'm sorry. The submittal to	12 the report because I was actively involved in the
12 the NRC for Diablo Canyon or for the TSAR, or bound	12 mideree and review of most of them in addition to
13 A. (DR. SINGE) Both.	1) guidance and review of more direct
14 I (DR. SOLER) Yeah, although the submittal to	14 being a consultant. So I would have how and
15 the official submittal to the NRC on Diablo Canyon	15 knowledge of the details.
10 the official submitted of the	16 Q. And Dr. Singh, do you agree of do you want
16 deals only with anchored custor Dr. Singh, are you	17 to supplement how you believe your testimony will
11 U. (BI ND. MARAANAA) DL. Dinging are jou	18 coordinate or supplement Dr. Soler's testimony?
18 familiar with the document that's been marked as by w	19 A. (DR. SINGH) I think Dr. Soler described it
19 Exhibit 1 entitled "Joint Submittal of Online	20 mite succinctly.
20 Geotechnical Contention, Utah L and Utah W":	21 O Dr Soler, what expertise do you bring to
21 A. (DR. SINGH) Yes, I am.	122 this testimony that Dr. Singh does not have?
22 O. Dr. Singh, is it correct that you've been	22 this testimony that bi. Singh does not increasely
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25 named as a writess of the optention?	24 Q. Yes.
24 Contention, consortated concentration	25 A. (DR. SOLER) I have a direct knowledge of
25 A. (DK. SINGE) les, i Deriete d'actor	CitiCourt, LLC
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Singh/Soler deposition, 3/6/02 22	1 and the applications of the computer codes
1 0. Will you please review the contention and	i some of the applications of the tompeter
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Private Fuel Storage Krishna P. Singh & Alan I. Soler * March 6, 2002

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		SHEET 4 PAGE 25		PAGE 27
		Singh/Soler deposition, 3/6/02 25		Singh/Soler deposition, 3/6/02 2/
	1	had it was a general dynamic analysis textbook. I	1	same; the algorithm, the engine by which the program
-	. 2	took that code over the years and adapted it first for	2	solves the problem is different.
· · · ·	3	use in yet storage seismic analysis, and later on used	3	Q. And why did you use a different algorithm?
	Ĭ	it for dry storage seismic analysis.	4	A. (DR. SOLER) The 10,000-year earthquake was
		0 And when did you adapt it for		a beyond design basis earthquake. We fully expected
Andrea		Q. And when did you adapt it for not storage?		from our province recults at other plants that the
	0	approximately when did you adapt it for wet storage:		2 000 man combinishe would give up what I will loosely
	11	A. (DR. SOLER) I Delleve, but this is not	1 ¦	2,000-year earthquake would give us what I will loosely
	8	let me see if my resume will give me a clue, but I	N N	call small deformation results, in other words, that we
Colum	9	believe we're talking about 1979, '80, '81 time frame.	9	would not show extremely large rotations of the cask
	10	Q. And when did you adapt it for dry storage?	10	during the motion.
	111	A. (DR. SOLER) Probably in early 1992.	11	The code which you have labeled as a lumped
	12	0. In general, what type of adaptions did you	12	mass model is a small deformation code in that it does
	13	need to make so the code would work for dry storage?	13	not it's not capable without modification of
	14	1 (DR SOLER) Dry storage, actually we made	14	modeling the potential for a cask to execute a large
	15	no direct adentions or modifications to the code. We	15	rotation.
	11	developed each what I'll cell proprocesors that	16	The 10.000-year earthquake, being beyond the
	10	developed some what I'll call preprocessors that	117	design basis was a comping analysis and therefore it
	11/	enabled us to automatically generate the spring	10	uestyll pasts, was a scopilly analysis, and increase it
	18	constants that are used to simulate the contact	10	was guite likely to expect that we would experience
	19	phenomena around the periphery of the cask.	119	large rotations of the cask, and therefore we used a
	20	I'll qualify that a little bit. We did add	20	program that was capable of managing that kind of a
	21	some output statements to the code, enabling us to get	21	notion.
3.00	22	some information that was directly usable for reports,	22	Q. And what program did you use?
b	23	for instance, to be able to generate information to	23	A. (DR. SOLER) It's called Visual NASTRAN
	24	predict the maximum displacements of one or more casks.	24	Desktop. It used to be called Working Model, but there
	25	0. Is there a limit to the number of casks you	25	was a corporate takeover.
		CitiCourt, LLC	1	CitiCourt, LLC
		10011 500 0441		10043 800 9441
	1	(801) 532-3441	1	(801) 532-3441
	I	(801) 532-3441	<u> </u>	001) 532-3441
	L	(801) 532-3441 PAGE 26 Singh/Soler deposition, 3/6/02 26		PAGE 28 Singh/Soler deposition, 3/6/02 28
	۱ ۲ ,	(801) 532-3441 PAGE 26 Singh/Soler deposition, 3/6/02 26 can evaluate in your model2		PAGE 28 Singh/Soler deposition, 3/6/02 28
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Private Fuel Storage Krishna P. Singh & Alan I. Soler * March 6, 2002

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		Singh/Soler deposition, 3/6/02 29	1	Singh/Soler deposition, 5/6/02 51
	1	0 And was that for all revisions of the cask	1	Off the record.
	Ť		15	(Discussion off the record)
~~	2	stability analysis?	4	
Т	3	A. (DR. SOLER) Yes. We did not use Dynamo for	3	A. (DR. SOLER) Okay, now ask your question
	Ā	enwthing at Diable Canvon that has been submitted to	4	again.
	4	anything at blabto tanyon that has been submitted to	l c	O Is it fair to characterize your response in
	5	the NKC for their site license.		U. 15 It fail to characterize just respense in
	6	0. And did you use Visual MASTRAN?	6	the last deposition, or I guess in general that and had
	7	1 (DD SATED) Veg	17	compared portions of what I now know as Dynamo for wet
	1	A. (DK. SOMEK) TES.	l ò	storage to other poplinear codes?
	8	A. (DR. SINGE) NASTRAN.	0	Storage to other nonlinear codes:
	Q	A. (DR. SOLER) Yes. That's N, with an N,	9	A. (DR. SOLER) Well, I'm not sure what the NRC
- 1	10		110	has done independently, but as part of a number of
	10	NASTRAN, DOL MASTRAN.	11	nut done independencij, ode de part de in wet storsgo
	11	Q. I'm sorry. Thank you. And what model did	111	submissions for particular utilities in wet storage
	12	you use in the Energy Northwest cask stability	12	applications, we were of course asked questions by the
	12	you use in the intry horemote such stations	112	NRC staff reviewer, and previous to the submittal we
	13	analysis:		new star actions asked mentions by the stility
	14	A. (DR. SOLER) Dynamo.	14	were also sometimes asked questions by the dility
	15	0. And for Tennessee Valley?	115	reviewers before submittal. And if you take all of the
	10		116	submittals that we've made since when we started and
	10	A. (DR. SOLER) Dynamo.	117	there have not stored period there have been a whole
	17	Q. Approximately what range of zero period	11	through the wet storage period, there have been a more
	18	accelerations do you believe Dynamo is capable of	18	range of problems considered. And there of course is a
	10		19	validation report that's been issued with different
	17	processing:	20	classical problems both linear and poplinear Their
	20	A. (DR. SOLER) I would say, without having	20	Classical problems, both linear and honizheur. Incl
	21	pushed it. but I to the extent that zero period	21	"exact" solutions or their numerical solutions from
	22	accelerations imply a certain cask motion. I would not	22	other sources were compared with the results that we
	22	Acceletations imply a contain out a contain a mana	22	would get for the same problem.
	23	hazard a guess as to the upper limit on bynamo. I	23	would get for the same problem.
	24	would have to run it and check on the results. And II	24	So while you could not say that a particular
	25	those results remained in what I would call the small	25	wet storage submittal was completely modeled by another
		CitiCourt LLC		CitiCourt, LLC
- 1				(801) 532-3441
- 1		(801) 332-3441		(041) 032 0110
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(PAGE 30 Singh/Soler deposition, 3/6/02 30		PAGE 32 Singh/Soler deposition, 3/6/02 32
Ļ	1	PAGE 30 Singh/Soler deposition, 3/6/02 30	1	PAGE 32 Singh/Soler deposition, 3/6/02 32 program and compared with the results that we got,
<u> </u>	1	PAGE 30 Singh/Soler deposition, 3/6/02 30 rotation range, then I would accept the results from	1	PAGE 32 Singh/Soler deposition, 3/6/02 32 program and compared with the results that we got, marrians of the program were compared by testing the
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	1 2 3 4	PAGE 30 Singh/Soler deposition, 3/6/02 30 rotation range, then I would accept the results from Dynamo. However, the reason for not using Dynamo for the 10,000-year earthquake was simply at the outset I expected large rotations to validate the results from	1 2 3 4	PAGE 32 Singh/Soler deposition, 3/6/02 32 program and compared with the results that we got, portions of the program were compared by testing the problem that had been done in the literature, or, in one case, a finite element model using ANSYS that was
	1 2 3 4	PAGE 30 Singh/Soler deposition, 3/6/02 30 rotation range, then I would accept the results from Dynamo. However, the reason for not using Dynamo for the 10,000-year earthquake was simply at the outset I expected large rotations to validate the results from	1 2 3 4 5	PAGE 32 Singh/Soler deposition, 3/6/02 32 program and compared with the results that we got, portions of the program were compared by testing the problem that had been done in the literature, or, in one case, a finite element model using ANSYS that was made up by a utility to characterize all of the
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		- Krishna P. Singh & Alan	I. S	Soler * March 6, 2002
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		Singh/Soler deposition, 3/6/02 41		Singh/Soler deposition, 3/0/02 43
-	1	predicted displacements in the order of inches.	1	NASTRAN that allowed visual NASTRAN to accommodate
	12	And to confirm that ANSYS was giving us	2	potentially large rotations?
	3	reasonable results, we modeled the same thing on our	3	A. (DR. SOLER) Okay. Well, if you write the
	4	Dynamo program and got the same order of magnitude of	4	equations of motion of a system and restrict it to
	ŝ	displacements. We were not at that time trying to	5	small rotations, you can simplify the equations.
	ĥ	check the specific details that we had to put on the	6	In a nutshell, the Dynamo code does not
	Ť	client's racks against Dynamo. But we left those	7	alter the equilibrium equations step by step. It
-16	ģ	details off and just made a general check that our	8	assumes to always satisfy equilibrium based on the
	a	program was not predicting a guarter of an inch when	9	original configuration.
	10	average was not predicting five inches. We got a general	10	The Visual NASTRAN code was written from the
- 12	11	lowel of agreement there, and beyond that we used	111	outset to accommodate large motions, falling objects
	11	TEAL OL SALESTENC CULLE' THE FOLLOW CHER AS THE	12	that could tumble, turn over, bounce. Therefore, it
-20	12	ANSIS.	13	did not make internally any simplifications to the
	13	that way used a large earthquake Do you recall	14	equations that are presumably programmed at the site.
15	14	that you used a large earthquake. Bo you recarr	15	So if you attempt to take a code that is written for
	15	approximately what the zero period acceleration	16	small deflections and blindly just apply it and get a
	10	A. (DK. SULLK) RO. ND CAUKIED, Objection What project? The	117	result that would indicate large deflections, either
	11	MR. GAUNDER: ODJECTION. What project: The	18	your program will blow up on you or it will just give
- 20	18	one you're tarking about that uses Ausis:	119	you ridiculously large results that have no physical
	19	MD. NANANAKA: 165.	20	meaning, or it will simply give you wrong results that
	20	A. (DR. SOLEK) I do not recall what we used to	21	you may think there's a physical meaning to it. So you
	21	make that check. It was an informal check, what any	22	have to be careful to make sure that you don't pose to
	22	competent engineer would do when he's developing a hew	22	a code a problem that has a chance of going outside the
	23	nodel with a program that he's not used before on that	21	range of walidity of the code.
	24	particular application. So we just picked a time	25	And how can you ensure that the results for
\$	25	history that we had.	25	CitiCourt. LLC
		(1011, DLC)		(801) 532-3441
		[8UI] 332-3441		(002) 000 0000
-	•	1		
	·	PAGE 42		PAGE 44 Singh/Soler deposition, 3/6/02 44
	י 1	PAGE 42 Singh/Soler deposition, 3/6/02 42	1	PAGE 44 Singh/Soler deposition, 3/6/02 44
	' [1	PAGE 42Singh/Soler deposition, 3/6/0242Q.With respect to Dynamo, do you directly	1	PAGE 44 Singh/Soler deposition, 3/6/02 44 the PFS 2,000-year return period using Dynamo are
	1 2	PAGE 42 Singh/Soler deposition, 3/6/02 42 Q. With respect to Dynamo, do you directly apply ground acceleration time histories, or do you	1 2 3	PAGE 44 Singh/Soler deposition, 3/6/02 44 the PFS 2,000-year return period using Dynamo are accurate results?
	1 2 3	PAGE 42 Singh/Soler deposition, 3/6/02 42 Q. With respect to Dynamo, do you directly apply ground acceleration time histories, or do you have to make some modifications to the time histories?	1 2 3	PAGE 44 Singh/Soler deposition, 3/6/02 44 the PFS 2,000-year return period using Dynamo are accurate results? A. (DR. SOLER) If I take, say, the peak displacements that are predicted from any of the runs.
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	Singh/Soler deposition, 3/6/02 81		Singh/Soler deposition, 3/6/02 83
1	Q. (BY MS. NAKAHARA) Let's go back on the	1	really need to look at to give you that number 15
/2	record. Dr. Soler, what total vertical contact	2	Q. Is that the '97 report?
3	stiffness value did you use in the cask stability	3	A. (DR. SOLER) Yeah, probably 97-1631.
4	analysis?	4	MS. NAKAHARA: I need to do a better search,
5	A. (DR. SOLER) Total number, I think was 468	5	but I don't believe we ever got the '97 report.
6	times 108. That's the pounds per inch. That's the sum	6	MR. GAUKLER: Okay.
ĩ	of all the individual springs.	7	MS. NAKAHARA: We have two other earlier
ģ	MR GAUKLER: That was the total from all	8	versions of this report, none of the '97 that I could
ů	the	9	find. That was one of my problems looking at some of
10	MS NAKAHARA: 468? Off the record.	10	the references.
10	(Discussion off the record)	111	DR. SOLER: So I can't really give you that
11	(DISCUSSION OIL the record.)	112	answer.
12	A. (DR. SUMER) IL WAS & IILLE MOLE LUMA AND I	113	MS. NAKAHARA: So to the extent we don't
13	11 you take numbers from the actual math book. That s	114	have that report, we would like a copy of it.
14	the range, 450 plus times 100.	115	MR. GAUKLER: Dr. Khan had a reference to
15	Q. WIII YOU DITETTY EXPLAIN NOW YOU CALCULATED	16	it
16	that?	17	O /RY MS NAKAHARA) Will you explain how you
17	A. (DK. SOLER) OKAY, that number was	10	calculated in general the horizontal stiffness value?
18	calculated and this goes back to almost the	10	(DD CALED) Conorally encating what we
19	beginning of our analysis. It had nothing to do with	20	nemaling do is again the phenomena we're trying to
20	the earthquake. That number was calculated by taking	20	usually do is again, the phenomena we are drying or
21	the semi-infinite solution I referred to earlier this	21	simulate is what's called in the interaction w
22	morning and looking at the problem of if I just simply	22	stick-slip phenomena, meaning that nothing mappens
23	took the cask, which has an 11-foot diameter, placed it	23	until you slip, and therefore something suddenly
24	down on a pad of concrete, knowing the properties of	29	nappens after that and you jump up to the value o times
25	concrete in terms of the Young's modulus and the	25	CitiCourt UC
	CitiCourt, LLC		
	[801] 532-3441	1	(OVI) JJZ-J44I
_	PAGE 82		PAGE 84 Singh/Soler deposition 3/6/02 84
_	PAGE 82 Singh/Soler deposition, 3/6/02 82		PAGE 84 Singh/Soler deposition, 3/6/02 84
1	PAGE 82 Singh/Soler deposition, 3/6/02 82 radius, you can calculate a spring constant for that	1	PAGE 84 Singh/Soler deposition, 3/6/02 84 with a spring that has a very stiff spring constant so that it behaves like a linear spring up until the force
1 2	PAGE 82 Singh/Soler deposition, 3/6/02 82 radius, you can calculate a spring constant for that section of concrete. Then, since I was modeling 36	1 2 3	PAGE 84 Singh/Soler deposition, 3/6/02 84 with a spring that has a very stiff spring constant so that it behaves like a linear spring up until the force predicted in that spring is greater than the
1 2 3	PAGE 82 Singh/Soler deposition, 3/6/02 82 radius, you can calculate a spring constant for that section of concrete. Then, since I was modeling 36 springs around the periphery, which I felt was a	1 2 3	PAGE 84 Singh/Soler deposition, 3/6/02 84 with a spring that has a very stiff spring constant so that it behaves like a linear spring up until the force predicted in that spring is greater than the coefficient of friction times the normal force in the
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