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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REACTOR RESEARCH

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EXPERT PANEL WORKSHOP ON DEGRADATION OF CONCRETE IN SPENT NUCLEAR FUEL DRY CASK STORAGE SYSTEMS

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PUBLIC MEETING

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WEDNESDAY,

FEBRUARY 25, 2015

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The meeting was convened in the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Lance Rakovan and Christopher Jones, moderating.

PANEL MEMBERS PRESENT:

NEAL BERKE, Tourney Consulting Group

LAURENCE JACOBS, Georgia Institute of Technology

RANDY JAMES, Structural Integrity Associates

JOHN POPOVICS, University of Illinois

YUNPING XI, University of Colorado

NRC STAFF PARTICIPANTS:

LANCE RAKOVAN, NRC/EDO, Facilitator

CHRISTOPHER JONES, NRC/RES, Moderator

GREG OBERSON, NRC/RES, Materials Engineer

RICARDO TORRES, NRC/NMSS, Materials Engineer

BOB TRIPATHI, NRC/NMSS, Sr. Structural Engineer

AL CSONTOS, NRC/NMSS, Branch Chief

NRC CONTRACTOR PARTICIPANTS:

LEO CASERES, Southwest Research Institute (SWRI)

ASAD CHOWDHURY, Center for Nuclear Waste Regulatory Analyses (CNWRA)

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

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

(8:36 a.m.)

LANCE RAKOVAN: Okay, let's go ahead and convene. Good morning, everyone. I am not Sheila Ray. My name is Lance Rakovan, and I'll be stepping in for Sheila today to provide a little facilitation assistance, primarily laying some ground rules in the morning and then coming back for the public comment period later today.

The purpose of today's meeting is to enhance the existing technical bases related to dry cask storage systems, identify relevant knowledge and practices from non-nuclear concrete structures and identify potential information needs.

This is a Category III public meeting so public participation will be actively sought. Essentially we expect that the primary conversations will be happening at the table. But, then again, I will be back towards the end of the day to make sure that we go to the phone lines and for those in the room to make sure that we get some public comments, have some questions directed to our NRC staff, get some answers, et cetera.

Just to lay down a couple ground rules just to refresh, remember, we want to keep one speaker at a time. And if you could, silence electronic devices, make sure you identify yourselves when you make a comment. All this will aid in those on the phone being able to follow the conversations, know who's speaking, and also make sure that we can get a clean transcript.

We are transcribing today's meeting so, again, it helps if you can identify yourself at least the first few times that you're talking. But each time, if you, before you make a comment, if you could say who you are that would be great. Again, that helps people follow.

For those of you in the room, we are a safety organization so I always like to go through what the emergency exits are. Best way to do it is just to go back out the way that you came in and go to your left. There are some stairs that way. Restrooms are through the elevator lobby. Men is to the left, Women is to the right.

We have our agenda on Slide 32, for those of you on the phone lines. Essentially we'll be starting today with a bit of a recap and some introductions.

We then have four specific topics that we're looking to discuss today. That is, Inspection and Monitoring, Aging Management Programs, Time Limited

Aging Analyses and Remediation, Repair and Replacement.

Once we get through those we'll go ahead and open things up for our public comments and Q&A period, and then we'll do a quick recap and convene, hopefully, by 4:30 which is our time to end today.

I think that is all that I needed to go through this morning. Chris, did you want to go around the table and have folks introduce themselves again, to start out with or did you want to start with the recap?

MR. JONES: I think that's not a bad idea. Maybe, Neal, can you start again?

MR. BERKE: Yeah, Neal Berke with Tourney Consulting Group. And my primary background is in durability of corrosion of metals and durability of concrete.

MR. XI: Yunping Xi from the University of Colorado. My research primarily is in durability of concrete and also railroad concrete structures.

MR. JONES: Great.

MR. TRIPATHI: I'm Bob Tripathi, Senior Structural Engineer with NRC in the Division of Spent Fuel Management. I've been in the nuclear industry for almost 45 years so that probably says it all.

MR. JONES: Okay.

MR. TORRES: I'm Ricardo Torres. I'm a

Materials Engineer for the Division of Spent Fuel Management. And I work in NMSS here at the NRC, it's on the safety review of transportation, storage packages and ensure compliance with the code -- or federal regulations Part 71 and 72.

And I have been working on the safety review of specific licenses that are coming up for renewal. This way it's certificates of compliance for storage systems.

MR. JONES: All right. Maybe, Larry?

MR. JACOBS: Sure. Larry Jacobs. I'm a professor at Georgia Tech in Atlanta. And my background is in wave propagation and solids, non-destructive evaluation, those types of things.

MR. POPOVICS: I'm John Popovics with University of Illinois in Champaign-Urbana. My area of research is imaging, testing, sensing for infrastructure materials and also material degradation.

MR. JAMES: I'm Randy James with structural integrity, the Inter-Tech Division in San Diego. My background is structural engineering and assessment, so structures, performance-based assessments, degraded and otherwise, structures.

MR. JONES: Great. Maybe --

MR. CASERES: I'm Leo Caseres with Southwest Research Institute, senior engineer, working on concrete degradation and material degradation as well.

MR. CHOWDHURY: I am Asad Chowdhury from Center for Nuclear Waste Regulatory Analyses at Southwest Research Institute. I am a structural engineer. I work on many analysis projects, both licensing and renewal with a special emphasis on concrete structures.

MR. JONES: My name is Christopher Jones. I'm in the Office of Research at the U.S. NRC. So it's a bit of structural, geotech and seismic branch. So I guess, with that, let's maybe -- I'm just going to, quick minute, recap in what we did yesterday.

And the bulk of that was discussion of various concrete degradation mechanisms, their mechanics, the mechanisms, the identification of those mechanisms. I'm just going to sum up their treatment of several.

We talked a bit about prevention and mitigation strategies, ways to meet or head off these problems before they start or, you know, start a progression. And then at the end of the day we spent -- I called it an inadequate amount of time on inspection technique and technology. And so, with that in mind, I'd like to spend a little bit of time on that as we get started this morning to go back and just finish up a few things with that.

Then today we'll, as, you know, Lance pointed out, we've got sort of four topics to work our way through. I believe that there's a chance that we may move through some of this a little faster than we did yesterday. And I'm not going to rigidly hold us to the times that I have on the screen as much.

That has an implication for anybody on the phone. If you're going to call in for the public comment period later in the day you might want to dial in just a little bit early because we may find ourselves there. I'm just guessing that, you know, we have 3:30 on the agenda. It might be 3:00, maybe a little bit earlier. I don't know.

So, I guess with that, let me jump back to this cartoon that I made. And so we sort of had this concept working of the, I guess relative usefulness or relative benefit of certain inspection techniques. And so sort of the combined metric of their maturity and then the qualitative information that we would get out of a particular technique.

And so with that in mind, we have this list of inspection technique categories. And I felt like we didn't really cover the non-visual imaging very well. And so I wanted to pick up there -- UV imaging, radar-based imaging, microwave imaging, IR imaging, things like that.

So actually, as I hear noise on the phone, let me mention this too. If you're on the telephone and you have a mute button that would be great so we can, you know, not hear papers shuffling and phones ringing and that sort of thing, so.

So on the visual and non-visual imaging we -- I guess, maybe, let me ask this question. In the context of my slide on the other -- my figure on the other slide here, what -- how do we feel about some of these imaging techniques for concrete?

We know it's a heterogeneous material. It's kind of hard to push a wave through certainly compared to a more homogeneous metal for example. Maybe, would anybody care to share a comment there that we could sort of start our discussion?

MR. POPOVICS: This is John Popovics. I think that if you go back to the cartoon on 31 --

MR. JONES: Sure.

MR. POPOVICS: -- Slide 31. So we have a couple of boxes. I think that there are recent developments and research in application and development of technology which has moved a lot of these imaging techniques. From the upper left you have a box, meaning high information quality, low technological maturity.

And kind of inching towards the green box there's where we want to be. And I think, more specifically, in certain tasks, under certain tasks that we ask the equipment to do, some of them are already in the green box. That is, they can do certain jobs but finding certain kind of defects but not other defects.

So one example that I'll give is this ultrasonic array. You know, that --

MR. JONES: Mm-hmm. Sure, that's a good one.

MR. POPOVICS: -- they developed in Russia. That is kind of a large box, a footprint of arrays. And there are 40 point sensors. And you like push it against surface and then all the sensors talk to each other and develop a kind of image.

It's kind of a -- not quite a tomograph but it kind of creates cross-sectional image that kind of looks like a tomograph to find defects. And it's quite practical. And, I think, for some jobs, that is now in the green box. You get an image coming out and it's quite functional.

So, for instance, looking for voiding, I remember, Ricardo, you asked about voiding for impact echo. And I hesitated a bit because I thought it was not so easy. But voiding, for this tool, you know, is actually pretty good. You can see things in the cross-section, cross-sectional view, if the void's not too far from the surface and if there isn't a heavy steel reinforcing mat near the surface.

Because if there is then the machine is obsessed with the imaging, the reinforcing mat and it cannot see anything in the shadows or behind it. So I think there's lots of exciting potential coming for ultrasonic acoustic imaging. I, personally, am doing research. It's still solidly upper left, yellow box because it's my own developments and equipment. It's not commercially built.

But we're using ultrasonic tomography and then ultrasonic backscatter imaging to kind of characterize concrete distributed damage and defects internally. And I hope that that will also move to the green, upper-right green box in the years.

So I think there's a lot of excitement there. And I want to re-emphasize that, you know, I think Larry put it very nicely yesterday. I think that he wouldn't throw infrared thermography into the dustbin just yet. I think that could be exciting.

You know, with all the developments of the technology and the accessibility, it's better than ever with cost, investment to come in and the capabilities are coming in. I mean, there's quite a few of these kind of exciting imaging techniques. And you mentioned radar yesterday. I think it already is very mature. But I would put it more on the lower right.

MR. JACOBS: Low information --

MR. POPOVICS: Yes, yes.

MR. JACOBS: -- because of this application.

MR. POPOVICS: Right. If you want to find bars, it's great. And you have lots of commercially built equipment that, but if you want to find anything more complicated then it's -- runs into a limit.

MR. JONES: So, just to review, we mentioned the IR tomography. And that was sort of the appeal, I think your idea of the appeal was sort of this unique datum that we have with a relatively known heat load.

MR. POPOVICS: Yes.

MR. JONES: And that sort of gives kind of a unique --

MR. POPOVICS: Opportunity.

MR. JONES: -- opportunity to apply that technology.

MR. POPOVICS: Right.

MR. TORRES: Can I have a comment on IR thermography? If that were to be applied in one of these systems would it be more useful to do it on the inside and, you know, try to get a system that is able to make its way inside -- you know, kind of on the inside walls of the concrete wall or do it from the outside?

MR. POPOVICS: My thought was outside.

MR. JACOBS: My -- again, the advantage, from my perspective, is that you can do it from the outside, that you don't have to go on the inside, that it --

MR. POPOVICS: And you need that heat flux.

MR. JACOBS: And you have, again, a source. Again, I was thinking about it last night. And you know, it's going to be a really constant source so that might not be, you know, great. But I think it's certainly worth looking at.

I'll echo what John said about the array technology, you know, for anyone new, that there's a number that are sort of moving to the right. Again, and I, you know, go into the IR, if you look at the kinds of degradations we're looking for, they're complicated. They're going to be, you know, coupled. So we're going to need, from a monitoring or inspection perspective, techniques that are, again, complementary that have a lot of different things and can provide information that we can add together to sort of answer some of the coupled problems.

MR. POPOVICS: Now I'd like to confirm that I think, I didn't say that but complementary methods are useful imaging methods when we're --

MR. TORRES: Combined approach so your ultrasonic arrays with the IR imaging can be useful for kind of pressing those voids.

MR. POPOVICS: Yes, I think there's potential for it, but in one disadvantage of this ultrasonic array, it's still a physical contact person pushing it and holding it for five seconds and then moving it. And you only get information that's under that little footprint. So for a very large structure, you know, it's quite the effort.

MR. JACOBS: It will take time. It will. And you want an older type picture again, the medical ultrasound imaging of the fetus, right. It's the same technology, lots of rays. And then the thing with the technician does, you know, he or she sort of moves it and tries to get the best image. And that person knows what they're looking for. I mean, they know where it is and they know what they're looking for.

You have to do the same kind thing through the entire cask -- you know, from the outside and sort of get all the different images. And then know you are, as John said, you're wavelength limited. You're going to -- you won't get those clean, crisp images that you like right away. But it certainly -- it will take you down a road and it will give you, I think, information.

And I do believe that technology and maturity has, on that particular one, has moved from the yellow to the green.

MR. TRIPATHI: John, earlier you mentioned that this technology was developed in Russia --

MR. POPOVICS: Yes.

MR. TRIPATHI: -- the ultrasonic array.

MR. POPOVICS: Yes.

MR. TRIPATHI: Is it commercially readily available here in this country?

MR. POPOVICS: Oh, yes. Yes.

MR. TRIPATHI: And has it been used in these kind of applications?

MR. JACOBS: I don't think --

MR. POPOVICS: And so --

MR. JACOBS: I mean, nuclear waste --

MR. POPOVICS: No, I don't think in this one. They used in down in Florida.

MR. TRIPATHI: Florida?

MR. POPOVICS: Yes. So I, again, I --

MR. JACOBS: Where was it in Florida?

MR. POPOVICS: -- it's --

MR. JACOBS: What was the application?

MR. POPOVICS: It was their nuclear -- generic nuclear structures.

MR. JACOBS: Structures. Oh, that's -- the challenge there was the large size and heavy reinforcement. Can you find defects, so in a containment structure or a reactor, thick walled.

MR. POPOVICS: And, again, part of it is, you know, they've got to -- it's what they call shear wave. So there's not -- it's a little bit cleaner, right. It's a horizontally polarized shear wave.

And the folks, again, that John had spoken with and I spoke with there at the University of Minnesota -- and they sort of wrote their own software. You know, they said, okay, the software that was commercially available wasn't good enough. They wrote their own software with it, you know, Ph.D. students, in a couple years. And then, with that, the results, I think, really came out.

MR. JACOBS: Yeah, they kind of cracked open the --

MR. POPOVICS: Yeah.

MR. JACOBS: Well, it's a commercially available tool. I mean, it delivers a picture, and they wanted -- they did more with that.

MR. POPOVICS: They wanted more. And they did a wonderful job.

MR. JACOBS: And I wonder, were they part of the University of Florida study?

MR. POPOVICS: It think so. And I can give you their names and, you know, they would --

MR. TRIPATHI: When you said generic nuclear structure, what exactly do you mean? Like something --

MR. POPOVICS: Massive reinforced --

MR. TRIPATHI: -- related to containment?

MR. POPOVICS: Massive reinforced concrete elements. So this, about that thick --

MR. TRIPATHI: About three-foot, four-foot thick wall with massive rebar and --

MR. POPOVICS: -- with rebar front and back.

MR. TRIPATHI: And in --

MR. POPOVICS: Right. Exactly. So it was kind of, they had these mockup panels that, now I remember, at the University of Florida. I think it was funded by Oak Ridge or -- don't hold me to that. I don't remember. But Oak Ridge was involved somehow in consulting.

And these simulate, in general, massive structures that you would find at a nuclear power plant. And they invited, they evaluated different technologies to kind of image those. And I think they have a report.

MR. TRIPATHI: Yeah.

MR. POPOVICS: There's a report, and it might be an Oak Ridge report, about their results.

MR. TORRES: I think maybe Ryan wants to speak on it.

MR. POPOVICS: Yeah, sorry. Certainly.

MR. MEYER: Well, yeah. So this is Ryan Myer with Pacific Northwest National Laboratory. So, you know, maturity, I guess, is sort of a relative term. And so what I'm thinking about still is I'm hung up on sort of understanding more quantitatively what really you can detect.

Because before you can really understand whether or not you really need to look for another technique or whether you should apply them in combo, you know, it would be really useful to understand whether or not what you already have is actually sufficient or not.

And that's a complex question, I know, because it involves assessment of your structure for that. I mean, so, I guess really that and sort of understanding, you know, in terms of numbers, what, how these different techniques for concrete inspection can perform.

MR. POPOVICS: Well, I would just respond that, again, I said that we're moving into the green box but it depends on the job, right. If you're looking for a big void underneath, you know, that kind of dot or like in the wall, that imaging system is in the green box. It does the job.

But if you're looking for distributed damage, it is not in the green box. It's very task specific. So I don't know if I'm answering the question properly, but it's really task specific. And there is, I would say, that there is no one tool that you can go and it is solidly in the green box for every problem we and look for.

MR. MEYER: And I guess on top of that, I mean, from my perspective, I think in terms of guiding, you know, the development of new tools or whatever, I think actually understanding that would be very useful because, to me, you don't know for sure whether or not you actually need a new tool for a certain application or --

MR. POPOVICS: Sure.

MR. TRIPATHI: I can hardly hear you. Can you speak up a little?

MR. POPOVICS: Maybe the mic's not on.

MR. MEYER: Maybe this is not --

MR. TRIPATHI: Or maybe the microphone is not working.

MR. MEYER: Well, my comment was just more sort of just that, you know, it would be really useful to have a clear understanding of what you can and cannot do because I think that would guide whether or not you need to keep searching for new techniques or not and then sort of in the first place, if that makes sense.

MR. JACOBS: So from my perspective, and I think it's a wonderful question, I think we have to tie it back to the deterioration mechanisms conversation we had where you see, you know, one issue is just going from, you know, 60 years to 100 years to 200 years. I mean, that is going to be the driver. And that has to be the road map.

And, in my mind, that has to be one of the things that points us in the direction. We think this particular mechanism is going to be important freeze/thaw or, you know, ASR or something like that.

And I think those will develop, as John said, as a distributed damage. And I think that's -- again, if I'm betting, I'm saying let's go after techniques that are quantitative that would give you a -- information that you can use from a life-ing.

I'm sure we'll have this conversation when we talk about repair. You know, sort of taking us to the next level is, okay, now you know you have this, you know you have some kind of ASR damage. How does that affect or how does that impact the performance of the component. And then from there, obviously, how do you mitigate, either mitigate a repair or replace or whatever you're going to do.

So the monitoring techniques that are sort of now in the yellow, they're upper left yellow, I think we're going to have to pick -- pick, you know, look at the ones that we think if we want to move to the green, hey, that can physically do it.

I mean, just because we want it doesn't mean that we can do it and, but then re-answering the questions that are important for these degradation items. I think is, I think that -- personally, I think that's key.

MR. POPOVICS: So I guess, as a follow-up, I'd just like to as a random question. So what you're asking for is maybe it would be nice to have one of these color-coded diagram cartoons/space for each problem maybe. Like, if, oh, do you want to find distributed cracking here are the various tools where they lie on this graph maybe? Is that what you're --

MR. MEYER: Well, that would be a -- yeah, I mean, well, I mean, just speculating. Well, what would be really useful is to break down for each technique. We're kind of working on that. But at the same time, you know, whether I gather, at least, in the literature, is it seems to be as, you know, net quantitative information.

So if you've got these techniques for distributed damage for --- in some other form, you know once in a while, you'd probably be able to make some arguments based on physical principles. I mean, this is where we're at. I mean, that's just where we're at.

So, but I guess, you know, I would be thinking, you know, how do we sort of make progress on that front with concrete because --

MR. JACOBS: I think that's important. I mean, I think other materials have made more progress

--

MR. MEYER: Yes.

MR. JACOBS: -- on that than concrete. And I think there's a lot of reasons why it's not happening in concrete that's inherent to it. But I think this is a really good -- a conversation like this is a really good place to start.

And to tie the two together, to be able to say, okay, we're going to invest in the technique that we know is going to answer a question that's important for us. I think that -- you know, why invest in a technique that, it works but, gee, we already have enough images or it doesn't give us the kind of quantitative information that can be used to answer that, the structural question, for lack of a better term.

MR. JONES: So let me ask a sort of, maybe a dumb question, but so in the degradation mechanisms which we sort of had things that affect the microstructure, up to the microstructure that were sort of concrete issues. And then we had -- we lumped it all together. We called it corrosion. But then there are things that affect the bar, you know.

And it seems to me that things in the bar may be a little bit easier to detect than things in the matrix itself. I guess, for it -- it means that an accurate as that, one.

And then, two, what types of techniques do we use for each of those two kinds of situations? Does that two-step question make sense?

MR. JACOBS: I think that's reasonable. And I think your statement, I think the rebar will be much easier -- still not easy --

MR. JONES: Sure.

MR. JACOBS: -- but much easier than, you know, than the material. Again, I know from my lens or how I look at things, you know, going after the distributed type of damages, I look at -- and I know John and other people are doing some similar stuff -- we look at these, what you call an advance ultrasonic techniques -- a non-linear ultrasound which is not wavelength dependent.

That's the advantage of that. You're basically measuring the material nonlinearity in situ, so going much more after a strength measure as opposed to a stiffness measure. There are these, what are called, time reversal techniques.

Again, a lot of this is in, you know, just like the array technology, you know, is more on the processing, you know, getting a lot of acoustic information and putting that together.

There are what are called diffuse ultrasound, ultrasonic methods -- coda wave interferometry. These are all sort of ways to approach a problem using the same acoustic type signals and backing information.

MR. JONES: Mm-hmm.

MR. JACOBS: Those are clearly in the yellow, upper left and, you know, clearly. But they have the potential to answer these kinds of questions, these kinds of quantitative questions. And what I like about those techniques are concrete is a unique material. And these are techniques that are unique to concrete.

You wouldn't necessarily use these. People haven't developed these techniques because they haven't -- they're not good for metals, for aluminums and titaniums and titanium's too little, but that's beside the point. But they're not needed for that.

And I, personally, think that there's a lot of potential there. I think, you come back in a couple of years and, you know, just like that array technology, I think these techniques will move us over.

MR. TRIPATHI: Can I make a suggestion here? I didn't quite understand what you were asking, but I think -- no -- never mind, I'm behind you now. But I think, I'm guessing again, what you're asking is that, take those 14 degradation mechanisms for concrete and identify which block they belong to -- upper left, upper right, lower left or lower right.

And that would be something, some practical tool which we can use that, okay, for example, say, freeze/thaw or am I here, am I here -- that kind of thing. Is that what you're looking for?

MR. MEYER: I think that's certainly part of it. I mean, you do have to break it down versus distributed or voiding. Or, you know, as we said, different tools are better for different --

MR. TRIPATHI: Right.

MR. MEYER: -- aging, manifestations.

MR. TRIPATHI: So it will be out of place to ask the expert panel either individually or collectively, take those 14 degradation and at least identify, aha, this one belongs here. This one belongs here.

And if it's really bad, put them in the red block and so we don't waste time looking for achieving that mechanism. Do you see what I'm saying? Some practical tools.

MR. JACOBS: I understand. I would maybe

approach it a little differently. I love this cartoon, Chris. I think it's great. I think it really -- it's really --

MR. JONES: I should copyright this, you think?

MR. JACOBS: Yes, you're -- absolutely. You know, your question is slightly different. You're going to say, okay -- okay, I want to solve this problem. I want to find this. I want to determine this. I want to monitor this early on.

MR. TRIPATHI: Right.

MR. JACOBS: Now you're saying, okay, what tools are available and where are they.

MR. TRIPATHI: Exactly.

MR. JACOBS: Ryan's asking a slightly different question. He's much more getting on that -- I'm going say predictive side of things. You were saying, okay, when I design something so -- or when I want to know how long can this last I need a little more quantitative information.

I need things that I can put into some kind of, you know, whether it's a finite element model or some kind of a life-ing model that I can run scenarios. And you're much more -- I use the term, you're getting like a fingerprint of the component, the material at this instant in time.

Now that fingerprint can change. It will change over, you know, in the season -- you know, whether it's hot, whether it's cold, you know, where it is in its lifetime. And I think you were saying, okay, give me that material state kind of measurement.

MR. MEYER: Yeah, I mean, what I -- I guess what I'm getting at is the concept of POD for concrete --

MR. JACOBS: Yes, exactly.

MR. MEYER: -- and the aging effects, not just cracking. In this case, of course, you have the lamination site, void sites. The distributed cracking, however, you would quantify that, right. And I understand that's difficult. You can't do that overnight.

And so, but, you know, I think -- I know several of you are involved in ACI committees. And so, to me, I would think, you know, I mean, is there a way to make some progress on that front?

MR. POPOVICS: Well, I think there is. So, for instance, ACI Committee 228, which is a non-destructive testing committee, has two documents where basically -- I think what Bob was asking was was suggesting -- not in this kind of format.

MR. MEYER: Sure.

MR. POPOVICS: But, so they have tables in this Committee Document 228.2R, American Concrete Institute, where they'll say this problem -- these are recommended techniques. These are secondary techniques that could work and not so recommended.

MR. MEYER: Got you.

MR. POPOVICS: So there is this kind of document thinking developed already. ACI has also, has a structural health monitoring committee. So that's covering different territory because, by ACI's definition anyway, things like acoustic emission and sensing and so on doesn't fall into NDT.

NDT is a tool you tape to the structure and you take off. But it's just something is on there for the long-term. They don't call it NDT and so they have a different committee. And that committee, 444 is also coming out with a new document.

So I think there is a lot of existing information. And I know RILEM Committee's also have these kind of recommendations for Europe -- for --

MR. TRIPATHI: See, as a structural engineer, John, I'm more interested in the quality of the POD. I would rather have a high-information quality and then, after you establish that, then you can go into the qualification for a number or period of years.

MR. POPOVICS: Right.

MR. TRIPATHI: Is it good for 60 years or 300 years. But, fundamentally, it has to be a good quality information.

MR. POPOVICS: Exactly. And that's the kind of -- the basic information that's available now. It's been vetted by a committee and people. So I think there's that basic information available for that first step. But, you know, not POD kind of level.

MR. TRIPATHI: That's the reason I was suggesting there, let's take these 14 or whatever, 13, which we have identified so far plus some more --

MR. POPOVICS: Right.

MR. TRIPATHI: -- and at least put them in these four blocks wherever it belongs so we at least know are these good quality information for them.

But the maturity, maturity might take time. If it's not mature today it could matured five years down the road or ten years.

MR. POPOVICS: Right. So what I'm saying is that there isn't that information in this format, obviously, but there is that formation in more traditional format already that leads to, has already a good start, to kind of helping us put there.

Now if you want it in this format, I think there isn't anything available.

MR. TORRES: That could -- that's an excellent report, ACI 228.2R. But I think some of the information that we look for is what is this to, metal detection, you know, what's the probability of detecting that, that defect again.

I think part of that, and if we are to define, you know, what is high technological maturity, that needs to be tied, obviously, to a structure. And what's a significant defect for this system which is something that varies on a case by case basis.

So I think that the information is very useful but coming up with some sort of generalization specific to dry cask storage systems would be helpful in identifying, you know, what are those limits like.

MR. JACOBS: Chris, don't you have -- that next slide is the POD kind of slide.

MR. JONES: Yeah, well, I'm not sure.

MR. JACOBS: I think he's anticipated us, you know, even that being illogical, that being illogical.

MR. JONES: Okay. I want to -- did have one more question sort of the technology side of the coin and then we'll move into sort of the application of it. But so we have a box with 40 sensors in it and you press --

MR. JACOBS: Yes.

MR. JONES: So there's a guy that like holds the box and there's a guy that has the laptop. And so what I'm getting at is that the technician, their ability, or like there's an art to some of these techniques. And can anybody comment on sort of the --

MR. JACOBS: This, I'll talk about this particular one that both John and I are, I think are -- is going to put us to, you know, to a good place. And this one, the actual person who's holding it doesn't need any skill set at all.

MR. JONES: Mm-hmm, but kind of strong?

MR. JACOBS: Kind of strong. And you could, theoretically, automate this fairly easily. I mean, this is the one, you know, you could do it -- the issue becomes, it's what they call dry coupling. So, you know, what you would want -- John does a lot with something called air-coupled ultrasound which is a wonderful -- it's a non-contact where you can get a true scanning system.

And that would be, you know, and I'm not telling you what John does but he's -- he was also work, you know, to this kind of thing that you could scan across --

MR. JONES: Yes.

MR. JACOBS: -- that this. So the difficulty with this is that you have to touch, you know, literally touch it there. You know, you've got to make sure you get the signal. You know, the acquisition is, you know, micro-seconds so that doesn't -- and then you sort of take it and move it, and then take it and move it and then you get a lot of data.

I mean, you get, you know, then you can -- but you can do a lot of post-processes. Someone could be sitting off in a truck somewhere, you know, looking at it and saying, I'm going to go back and take a look. I see that.

And yet, I want to be clear, if you're looking for distributed damage this is not necessarily the way to do it because the information that it's giving is not -- it's limited by the size of the wavelength. And so, you know, but your question earlier yesterday about finding, you know, sort of the honeycomb or, you know, voids, you know, on that level -- you're all over this.

I mean, this will get it to you as long as it's not too --

MR. JONES: Yeah.

MR. JACOBS: -- it's not too far ahead. But there is the potential to take this same technology and make it non-contact because that's an important development for this particular application and a lot of other, you know, type applications like this.

And so that's going to take, you know, that's over in that low technical -- technological maturity.

MR. JONES: So something like that, is off on a bad direction with my box example.

MR. JACOBS: Yeah.

MR. JONES: But so there's, I guess, a technician calibration issue. There's like -- and we can interpret the same kind of signals. And like you even gave an example of the crack was there one time and it wasn't the next time. And --

MR. JACOBS: So to me, that's an inherent problem with the GPR because you're -- again, we're looking for mechanical changes, okay. And therefore, you know, radar or, you know, radar -- those waves are not mechanical waves.

What's nice about this technique is they're mechanical waves. So it's giving you mechanical information. So you don't need any kind of interpretation. You don't need -- there's not --

MR. JONES: You're looking at a quality material property, basically.

MR. JACOBS: Exactly. The IR is not going to give us this kind of mechanical impedances kind of thing. And so this is, in my mind, one of the main advantages of going in this particular direction.

But I agree with you. If you talk to -- in working with Georgia Department of Transportation or whatever, they get these GPR images, you know, similar kind of view. I don't -- great pictures, but what do I do with them? What -- you know, they don't really tell me enough.

And, you know, I've got to pay you to come in. I've got, you know, a consultant to come in and interpret it, who has a PhD. I don't think that that --

MR. JONES: Which is great work if you can get it, but --

MR. JACOBS: Yeah, that's good for the PhD.

MR. JONES: Okay, I think I -- I mean, I think we're getting at the issue there. So, okay, so now we're Tuesday morning -- I mean, Wednesday morning.

Inspection and Monitoring -- so we have this, I guess I see it as a sort of a challenge or a limitation. There's a, you know, we do our technique or whatever and there's some void size or crack or whatever defect below which we can't, you know, we're not sensitive to. So there's this kind of issue.

And then there's, along with that, what that implies is sort of the fact that these techniques will confirm the presence of an issue that do not -- they're the opposite which is to confirm the soundness or the absence of an issue. It just means you didn't see it.

So I don't know if this is -- this is kind of following on more where we were before. I guess, could we maybe -- could the experts kind of help us quantify the value of some of these. Like what is that floor, for example, is a question -- size or, you know, or are we going to be -- some sort of initiation or is it going to be fairly degraded by the time we start picking up some of these issues.

I guess that's kind of what would be useful. And if we could kind of talk in that direction.

MR. JACOBS: And, too, I think a lot of this is going to come back to the way the component is designed and how it's expected to perform. If you take the probability that the tech should approach and you take it to like an aircraft, they assume, you know, this is the smallest crack that they can find and then, therefore, they have to then assume that there's a crack smaller than that in the component and then how does that limit the life.

Now, that's relatively easy on a component that's, as I say is fatigue limited. You know how many fatigue cycles it has to go through, how many thousand fatigue cycles. I don't think these components are designed like that, okay.

They are, you know -- I don't want to say static. I mean, the load is, the thermal, you know, the radiation, all of that. But, and I know, let's say, if you're in a seismic zone, obviously you have to -- you know, it has to, you know, to perform, you know, getting shook around. I mean, you know --

MR. TRIPATHI: Vibration.

MR. JACOBS: Yeah, vibration. Yeah, you know what I mean, yeah. But I think the probability of the detection of a flaw of a single size, I don't necessarily think it's the right way to go for this particular application.

I think if we, you know, going back to our conversations yesterday, we were very much of a sort of distributed damage type things. You know, some kind of, you know, ingression or lots of, you know, lots of small defects of freeze/thaw or something like that.

And I think we have to find a way to quantify. You know, if we could quantify that from an in situ point of view how would a designer use that information. You know, it's almost like, okay, you know the concrete is not going to have the strength that you want. How is that going to affect the performance or that? Or you know the concrete is not going to have the stiffness that you want. How is that going to affect the performance?

I think it's -- you're going to have to have that approach a little more than this, okay, here's the crack. Here's the single macro-crack where, you know, I can find this delamination or this disbond or something like that.

MR. TRIPATHI: I think, Larry, you have an excellent point. You mentioned seismic. You know, that's one of the design basis phenomena which these casks are designed for.

Now once you detect a crack in the concrete --

MR. JACOBS: Mm-hmm.

MR. TRIPATHI: -- the seismic shear waves act differently for a cracked concrete than an uncracked concrete. So it all depends on what do you do with that information which you have detected.

You still have to go back to the drawing board or your original design and say, okay, here I have a cracked concrete. Compare the seismic amplification of the waves, whether they are, the seismic demand more or sometimes it's even less. Sometimes the uncracked concrete converts.

So it all varies. But once you find out what the problem -- and I'm talking about the second sub-bullet here -- techniques generally confirm the problem, not the soundness. The soundness -- I don't think any device will tell you how sound the concrete is.

You have to still go back and check your design, see that this cracked concrete is -- am I still sound and can I still function the way I used to function before the crack. You know, that part is separate from detecting problems.

MR. JAMES: This is Randy James. From a structural standpoint I have thoughts along the same lines. It just seems that we're asking, you know, how small a crack can it actually detect. And maybe we should be asking how big a crack can we tolerate in the structure first and then see if we have techniques that can find that size of a crack.

Because concrete structures can absorb a lot of damage and still function very well. So it -- and maybe we need to look at it slightly differently and kind of worry about what kind of damage are we really worried about for these structures and then find a technique that can, you know, move to find that kind of damage.

MR. TORRES: And that's where this -- how we handle that, the regulations through the QA program and the corrective action program where each licensee then, if you look at the criteria in ACI 349.3R, there's a 3-tiered criteria that it requires further review or further evaluation through additional testing.

And so, you know, we're trying to be as generic as to borrow some words from one of the members of the public yesterday. But at the same time, you know, we're -- knowing as much as possible about potentially the limits of detection on a generic and, you know, basis for we'll say vertical systems versus horizontal systems.

And that would be helpful in our review process for, especially when there is an issue. I mean, a licensee comes in and says we want to use this technique. We want to understand, you know, how well it's going to work for that specific defect.

MR. POPOVICS: Yeah, well, I'd like to agree with both comments. I think the approach that's taken --- we’ve had in the power industry for metal structures of finding one critical defect, one crack length -- it's just not appropriate for this because we have such a diversity of problems.

Now, as you said, if someone says, I need to find -- we have a crack that's four inches long, something. Then, okay, we can come together. We can kind of propose best methods, maybe using documents like Bob was suggesting that we develop.

But in concrete, you know, there's distributed crack information so it cannot be characterized by one single crack. It's really kind of a crack density in a certain volume -- totally a different problem.

And corrosion, you know, it's not a single crack. It's about how much bar is left or how much concrete that's balled up. So these metrics by which you quantify the damage are variable. So it's kind of hard to use this kind of POD for one kind of approach.

So I like what Randy saying about the, you know, now saying let's define which problems are critical and then kind of work backwards from there.

I think another issue that Larry mentioned is that it's fine to have a technique to be able to measure something and quantify it once we've defined it. But we have to make it practical for very large structures that we may not want to have close proximity to.

And that's -- I've been working very much on this kind of scanning air coupled method where we don't have to touch surface and it's almost robotic. It's the dream anyway. It's not ready now.

But to be able to scan and get information and especially using these kind of new advanced methods that are able to resolve sub-wavelength defects. Right now with conventional, like this ultrasonic impact echo and the ultrasonic array device, you are stuck with the wavelength imaging.

And if something is smaller than the wavelength you're not going to see it. That means you're not going to see things less than an inch -- just won't see it.

But like Larry's doing is non-linear ultrasonic -- that's sub-wavelength imaging. You can find distributed small defects. Now you're not measuring each one but you're getting a number. In this region the crack density is higher than in this region.

And I'm doing similar work but using linear aspects but, I mean, that's very exciting for me. But that's still solidly in the upper left yellow box.

MR. MEYER: Well, I guess I mostly agree with what was said, but I guess one minor disagreement is the fact that there is sort of some independence. And you're right. You should understand what your target is before you put a lot of effort in trying to characterize your technique because, I mean, you could be totally off base in that effort.

But it still would be helpful, I think, at this point, if it's not through some large effort, is to, again, maybe just based on some typical principal arguments, you know, what is the technical -- just, without that, at this point, since I don't think we do understand what the targets are for sure -- there's still this possibility that, you know, these techniques maybe are not able to detect what we need to. And so --

MR. JACOBS: I'll go back to comment, the Maine Yankee and the public -- I forget who, but the Yankees, the Three Yankees, right -- Three Yankees.

And, you know, if you look at the component it's a cylinder, right? You know, he's having their issues where the cut-offs are, you know, where they're accessing. And it's at the corner so, shocking, right.

You know, and they're at 45 degrees. Again, that -- in my, undergraduate class we'll be talking about why the cracks, you know, with concrete are at 45 degrees and under reinforcement. It's a great problem.

But I think what you want to know on that is how deep are the cracks. Are they getting in, are they allowing ingress to the rebar, let's say, to allow for corrosion for that. And that -- so that might be an instance where, okay, let's come up, let's have a technique that can size a single macro problem in this.

We see it there. We know, you know, tell me is it doing the thing, has it progressed so much, depth-wise, that you're touching rebar. And, again, I know, you've done some nice work on surface wave techniques. That's a question that I think we can answer and I think we can go after that as a way.

And then I think then we put the rest of them in this, you know, almost as you said, Bob, each problem must come with a way to do it, and where's that technology now.

MR. TRIPATHI: I think what I was leading more towards the second sub-bullet was that no matter what technique you use it will identify problems. But then you got to know, once you have a list of the problems, all right, let me take all these problems --

this damage, this damage.

And then still go back to do your original structural design and see if it's still adequate and is it still functioning the way it was supposed to function. If not, then you need to do something more. That's what I was -- the technique itself will not tell you whether the sound or not. You just have to identify the problems. That's where I was leading to.

MR. JONES: It seems like there's a, looks like for a given technique you can detect such a drop in strength or stiffness or get another technique and you can get a crack of such-and-such size.

You know, it's a measurement of what we do with that, one. But then also how do we match that up with the sensitivities of the -- like is this UT, XYZ UT technique, are we way more sensitive than we care about or are we way less sensitive than -- like that feeds back into my cartoon, I guess, on the quality of information.

Like is it -- are we getting something useful or is it -- or is it about right? Maybe it's right where we need to be. So I think we've got a few challenges and limitations over that here.

MR. TRIPATHI: And there is a fancy word these days for that kind of thing. It's called holistic. You've got to take as the picture, that all the damage put together, and still you have to make sure that your structure is still functioning the way it was.

MR. JONES: Yeah. Well let me -- this, my second major bullet is somewhat obvious and we've alluded to it. But there's -- these things have some access issues that are kind of tough to overcome. And so maybe we don't need to say much more than that.

But you have, you know, certain things below grade or certain things that are behind a door that you don't really want to open if you don't have to. And then sometimes there's as steel plate on your side of the concrete and you've got to shoot through that.

And so there's some significant challenges. I guess maybe that's all we need to say. But I don't if anybody has a comment. Maybe I shouldn't rest it that quickly, but that's an issue.

MR. JACOBS: I think size is also the --

MR. JONES: Yeah, size.

MR. JACOBS: You know, when you say access issues, I open that same thing. These things are big and they're, you know, you've got to --

MR. TORRES: So touching on that subject of accessibility, with regards to the rebar, if you will comment on how information about corrosion of the rebar, say by LPR or some other method -- how -- is that information useful when combined with other techniques by itself.

MR. JACOBS: I'll go back to something that John said early on that what's concrete is that it tells you things. It, you know, when it's distressed it gives you discoloration, this kind of stuff.

I think it's the same thing with the rebar. It's part of the system and that information is important. Its quality is also going to tell you something about the surrounding material and everything else.

MR. BERKE: Okay, well the real problem we run into with rebar is you're measuring the corrosion rate at one point in time. Tomorrow can be an order of magnitude less. Yesterday could have been an order of magnitude higher. You don't know. You have to -- it's one of these things you have to measure a few times under relatively same conditions and see what the trend is.

And if you do that you might be able to see something's happening before you can see the rust coming out on the surface. Clearly, if the rebar had enough corrosion on it that it was causing the concrete to crack and spall and delaminate, the techniques they have there are simple generic.

You'd either see visually on the surface or you'd be able to pick it up by the various techniques those guys are working on to pick up the laminations. And spalling you can see. The laminations they can detect.

And so, but it's -- before it gets to that point you have to measure a few times at different times to see what's going on. Because all you're measuring the day you're there, that's all you know about it.

MR. TORRES: I guess what I'm trying to get to is is it -- is that something that licensees should potentially consider? Or is it something that that staining will, you know, kind of will present itself before there's a major issue of corrosion?

MR. BERKE: Oh, no. Sometimes you've got staining and the major issues there.

(Simultaneous speaking)

MR. TRIPATHI: That's the point, but if right now --

MR. BERKE: So if I came by and measured today and then I came by, let's say, two years later and measured again and then came back two years later and measured again, I can see what's going on.

I can say, you know, the way it's rusting I'm going to have a problem. There's few more things are getting worse. And I might see that before I actually see the cracking. By the time I see rust stain coming through and cracks, you know, it's too late. I mean, you already have, right now you have so many other things.

MR. XI: Yeah. You can go to James' instrument, there are commercial ones, equipment available to measure the conversion potential. So here is also a company in Europe that sells like a small card -- you know, put this on the surface of the girders and now you can even, right around the card --- distribution of the corrosion potential.

But just like you said, so the corrosion potential changes -- I mean, you buy under the current, the current field. It will not tell you how much rust accumulated around rebar. And that's the most important information you need to know because the amount of rust will basically crack the concrete.

It will tell you the current activity, the corrosion, current distribution.

MR. BERKE: You basically have to integrate that over time. The only way to integrate it over time is to have a couple points over time.

MR. TORRES: Yes, but that information can be useful for, say, determining if there is a need to do, say, an opportunistic inspection or like actually to excavate and look.

MR. BERKE: Right. Yeah, and now currently, if you do the potential map that he's talking about, which is relatively easy to do, and you see large contours and areas that look -- that tells you, you know, you've got 10,000 square feet.

It might tell you where you need to take a core for the chlorine analysis and where you might have to make a corrosion right measurement which is a little bit more accurate. So it's very useful for that.

By it's only telling you what it's like today, when you're measuring it. So usually if it's corroding it doesn't stop corroding. So, yeah, that kind of gets in the way because, I mean, you don't know how long it's been doing that and, you know, how much cumulative damage you have.

In order to get the idea of cumulative damage you have to get it at a couple points in time. If you know your areas really well and you've got extremely high rate of corrosion then in time, even though you don't know how much cumulative, you know, you've got to -- there you might be maybe say, I'm going to have a problem here.

But that's not all, I mean, but that's

still, it could just be a one-time event something happened to that, so.

MR. XI: You know, it's like what Bob and Randy already mentioned. So you go to the field. You measure the -- let's say, you supposedly know all cracks and distribution using ultrasonics, infrared, whatever.

You still need to itemize -- let's say, there's a half-inch crack -- and what will be the impact of this crack on the seismic because you need that information to put into the final report, to analyze that, in fact, on the structure.

MR. TRIPATHI: Absolutely.

MR. XI: So how to process that is very difficult. But I did a lot of work like this. It's really difficult. And then I give the information to the federal -- guy so he can use it to do the earthquake, a missile attack or whatever.

MR. TRIPATHI: You mentioned about corrosion. I mean, rebar is in the very first start but the reason why we put is concrete is weak in tension --

MR. BERKE: Right.

MR. TRIPATHI: -- to take any tensile forces. So in spite of being corroded slightly, if you have not lost the bond between the rebar and the concrete it is still functioning as far as I'm concerned.

MR. BERKE: Oh, as a matter of fact --

(Simultaneous speaking)

MR. BERKE: You can lose a lot of rebar and still function.

MR. TRIPATHI: Right.

MR. BERKE: The problem with the rebar is not that the rebar's losing its strength, unless you really let the thing to go to -- you don't correct it for a long time.

The problem with the rebar is the corrosion products cause the concrete around it to crack and spall and delaminate. And that causes all the other problems for the --

MR. XI: I agree with you. There are other side effects.

MR. BERKE: The rebar, I mean, you can take that concrete off, clean the rebar off with a wire brush and pour new concrete and you're fine. It's not so much the rebar as much as the damage it causes to the concrete which has the potential property to spall.

MR. TRIPATHI: That's the reason why I said earlier that you have to take all these detection techniques. And once you have the sense of the structure you still have to go back and analyze it again to make sure that it is still functioning, that that is the bottom line.

MR. XI: Actually, people already proved a little bit of corrosion will improve the bond.

MR. BERKE: A little though.

(Simultaneous speaking)

MR. TRIPATHI: But it can get worse for a period of time. We talked about this.

(Simultaneous speaking)

MR. BERKE: That's exactly where it hits you at and it's going to crack off and spall off.

MR. CHOWDHURY: Okay, here we are discussing the steel encased inside concrete where it doesn't give us problem. The concrete encased inside steel --

MR. BERKE: Right.

MR. CHOWDHURY: -- that in the, until the other strategies interfered significantly because of the presence of metal, could you shed light on that?

MR. JACOBS: To your -- it's like you're looking at an image through a screen. You have to get -- again, let's say you have a circular steel plate around --

MR. CHOWDHURY: Yes.

MR. JACOBS: -- the concrete. You want to get at the concrete. I mean, that -- everything has to get in and out of that concrete --

MR. CHOWDHURY: That's right.

MR. JACOBS: -- out of that steel interface. And so that makes things much, much more difficult. It brings the level of detectability down and limits the kinds of things you can do.

This is where I, you know, in that case, can get inside, can go the other way or, you know, what questions -- obviously that steel ring is there for a reason and then, so hopefully it's doing, you know -- the quality of the concrete inside will be much better. Therefore you can do -- you don't need to do an image, from that particular --

MR. BERKE: Well, yeah, it detects steel casings which, you're familiar with for holding up bridges and stuff where you have a steel casing. You fill it up with concrete. Usually as long as you avoid the ASR type problems and the freeze/thaw type problems that concrete will be good for as long as there's any steel around.

The steel is a fantastic barrier. There's nothing that's going to get into that concrete that's going to hurt it. So if it's not there initially that concrete's going to be fine. Now if it heats up a lot and you get, you know, it's confined by the steel too.

So as long as the steel is designed to hold the concrete, you know, take care of any thermal changes in the concrete and the concrete doesn't have any deleterious things mixed into it, it's protecting the concrete. So you don't really need to worry about the concrete until the steel disappears.

MR. CHOWDHURY: So it is more a prevention?

MR. BERKE: Yeah, that's a good way of protecting concrete. Just stick a steel ring around it.

MR. POPOVICS: But I think there are some defects that could occur in the sandwich structure. For instance, consolidation, voiding, the concrete is not there.

MR. BERKE: Yeah, but those are all initial things, placing the concrete, doing things -- look, if the concrete's put in there right and you don't get any deleterious -- yeah.

MR. POPOVICS: Yeah, I know. But that is an issue that needs to be expected.

MR. CHOWDHURY: Yeah, yeah.

MR. POPOVICS: And so I agree with you about the protection. The issues related to concrete degradation go down when it's encased in there. But there still can be voiding. There can be corrosion on the inner side if the -- I know that these are normally -- steel, but there can be corrosion and voiding.

Now doing the non-destructive testing on those structures, it's harder because now you don't have the visual benefit and so it's all ultrasound or --

MR. CHOWDHURY: Okay.

MR. POPOVICS: -- other methods, really. And it's harder.

MR. CHOWDHURY: So that belongs where in the four categories -- that yellow, blue?

MR. POPOVICS: Oh, probably right now in the red.

MR. BERKE: Yeah.

MR. CHOWDHURY: In the red?

MR. POPOVICS: Yeah.

MR. BERKE: But that's where, you know, you put construction practices. I mean, you should be able to place concrete today that's high quality without getting voiding in it. I mean, and a lot --

MR. POPOVICS: I know you should.

MR. BERKE: I'm not -- no, but I mean, let's face it. You can do it in most, in many places. There's no reason why you can't. It's those times you've got to worry about that might have been -- but concrete today, if nothing else, you could make a soup.

You could make a soft consolidate and the steel casing's going to give it plenty of protection so it's not going to, the form pressure's not going to be a problem, so.

MR. POPOVICS: Yeah, but, you know, the difference between should and actual and --

MR. BERKE: Yeah, well, yeah --

MR. POPOVICS: Stuff happens.

MR. BERKE: That's where it's important to take care because I think in those places that are not accessible are going to be difficult to assess. That's where you got -- you have to use more care in making the -- making it in the first place, realizing that it's going to be hard to see what's going on after it's there.

So that's where, you know, that's where a little ounce of prevention is worth a pound of care.

MR. JONES: Certainly true. Let's -- I had this like kind of strategic monogram and I wanted to sort of bring us to the -- I see that I have a question in the observation column.

But could we -- I guess I want to introduce this notion of how can we be sort of strategic in the way we apply these? I think it would be foolish and, frankly, intractable to just walk around with the

40-sensor box and just start touching it. We need to have some sort of scheme for how we're going to do this monitoring.

We certainly have observed that certain techniques are better suited to monitoring than others, like acoustic monitoring, where it's false, is well suited to monitoring. It just is passive the whole time. But others are suited to sort of targeted in letting you know that -- or maybe you suspect that something is going on.

So as a first question that is in the wrong column, maybe good -- could we talk about examples for maybe the bridge industry or from paving industry or, you know, other fields where monitoring is an important component of ensuring the structure for its safety functions?

MR. XI: So I did a lot of work for the highway industry. So we put in sensors because yesterday I tried to convince you to take cores and say that's not a good idea.

But also I did, so we embedded concrete soil sensors in a concrete structure so you can measure the distribution of the concrete or the moisture. So you don't need to take a big core, just one small hole at different depths of the structure so you can get the temperature distribution.

MR. JONES: But could it even be cast in if you cold anticipate the --

MR. XI: That would be better. If you have a new dry cask and ask the manufacturer to embed soil sensors or moisture sensors at different depths, different location, then we could collect that information.

MR. JONES: Yeah.

MR. BERKE: Actually you don't actually embed the sensor. You usually put a tube in there that you use --

MR. XI: Oh, yeah.

MR. BERKE: You see what I'm saying? Because the sensor won't work when it's -- you destroy the sensor if you stick it in fresh concrete.

MR. XI: No, I actually it is a tube and then the sensor --

MR. BURKE: Yeah, and then you set the sensor in it. But you put the tubes in the locations that you want and that -- we do that all the time in our lab.

MR. XI: So all this can be done for the new structure.

MR. BERKE: Well, even on an old structure.

You --

MR. XI: Oh, I'm sorry, a grid.

MR. BERKE: -- just drill a small hole.

MR. XI: In the existing structure.

MR. BERKE: Drill a small hole.

MR. XI: So we don't like to drill.

MR. TRIPATHI: So we have a problem with the radiation, the actions --

MR. JONES: So in this case the strategy -- I'm trying to piece this together. So the strategy is to just put on the monitor for temperature, relative humidity, moisture, things like this as it goes along.

MR. CHOWDHURY: And those are categories. They're all --

MR. JONES: And that gives you a naturally temporal monitoring of how things are progressing, and that's sort of the strategy, I guess?

MR. XI: That would give you, let's see, the performance of coating. And we use even coatings on the surface of the bridges. And then you can see what's the resistance to penetration or water or chemicals, which one's better. So this is what we do on bridges.

And also, because you already heard from them that says it's difficult to detect the changes of a mechanical process, that the strengths, stiffness, you really have to talk a core. But it is relatively easier to measure the changes in the transport progress.

For example, some of the activity, we monitor the activity and all this stuff. In each new building the distribution of the temperature of the monitoring conditions, I can give to you right away, soil and activity.

And then the idea is to use the soil and activity when there's a transport process to calculate the degradation in the mechanical problems. Is the color cross, probably correlation.

So we develop all these models to do that.

MR. BERKE: Yeah. Yeah, we've done where we put pins in to do four probe -- four, one of four probe resistivity of the concrete. So it gives you an idea of both the moisture content and the resistivity of the concrete.

And you can put those in an area when you're casting it you just cast in four pins in various locations away from the bars. And you put them at different distances. And so you get an idea of how the concrete's drying out, you know, while they do it.

But it also tells you what the resistance of the concrete is. And then the resistance of the concrete is almost directly related to its strength.

MR. XI: Smoothness.

MR. BERKE: Smoothness.

MR. JONES: So, okay this is --

MR. BERKE: Well, and actually a relationship would be permeability in a prime state too. You can develop that but --

MR. JONES: Well, you can correlate anything, that's true, but.

MR. BERKE: No, but you can get a fairly big lot. I mean, the resistivity measurements or connectivity measurements are much more sensitive than your compression machine. But it correlates.

MR. JONES: So I guess -- so this is like another technology of sorts. I guess I'm trying to maybe move us ahead to a new idea and how would we sort of, you know, how that strategy of using this information that we get, like say resistivity.

We would, I'm assuming we would move in time. And then if we start to see a, you know, some sort of a drop then we could maybe take a more detailed look at something. And am I -- I don't mean to put words in your mouth. Is that --

MR. XI: But I want to mention this is the only -- let say, if you give me the temperature distribution we can only get the local properties at this point. It's not like Larry and John. So they can detect large area.

MR. JONES: Mm-hmm...

MR. BERKE: But those techniques can also, like the probe for potential mapping can be applied at locations that move along the surface.

MR. JONES: So probably we looked at detection, and we used the same words but applied them differently. If you randomly or quasi-randomly put these embedded sensors of any type you would have somewhat a way of better catching a problem that arose.

MR. JACOBS: And you could come up with a way to quantify it. And, again, I think the good thing about these components is they're cylinders, they're cans. And so it's not like getting, if you have hot spots or in the design. It's not like you have multiple high stress regions, that like that.

I mean, am I correct in saying that? And, again, you have it around the openings and things like that. Your question, are there examples from other industries of monitoring strategies, successful ones, sure.

You know, where, again, we talked about it yesterday. There is a component rotating and you're an aircraft manufacturer and you want to know the following variants. And you can tell that very easily because the dominant feature of that frequency is is --

MR. JONES: Yeah, starts to deviate a little bit.

MR. JACOBS: It tells you way, way sooner than when you need to know and so you just listen. There are not a lot other examples like that in structural systems that you can sort of before and after some kind of catastrophic event you could, obviously, do something before seismic or before a hurricane. And after you could, again, get some kind of monitoring from each that way. Can you -- but --

MR. JONES: Well I said I think there's a whole host of mature sensing technology available right now for concrete. The sensors, the DAQ, the communication, everything. It's there. And that you can measure -- things that a normally measured though are the environment.

It doesn't tell you what's going on, actually, with degradation or the damage that's in there. It just tells you environment and possibilities. So that can be useful information. So you can get temperatures and moisture contents, pH, chemical content.

You can get embedded LPR probes, embedded -- you know these are inside telling you about corrosion potential, not about -- not the corrosion about the bar or anything, but just the likelihood.

MR. POPOVICS: So I think there's a whole host of developed technology so but the question is what does it -- how much useful information does it provide?

Now in my opinion, it only goes so far. It tells you that this one is experiencing situations where there may be trouble. It doesn't tell you there's trouble, right?

So I would put these kind of technologies on the lower right yellow screen of your cartoon on 31. So I think that the information is for giving --

(Simultaneous speaking)

So if you're going to measure temperature, for example.

MR. JONES: -- guidance. Right. And -- but it does not tell you, actually what's happening in there. But it still can be useful as part of the larger scheme. And the technology is mature.

MR. POPOVICS: Yeah, it could tell that it's unlikely that something -- if anything else it bears healthiness and it can certainly tell you that it's unlikely that it's not going to --

MR. JONES: That's exactly, yeah.

MR. POPOVICS: Then that's actually very valuable information because if it's unlikely that it could be a very -- you don't have -- you know, it makes your inspection a lot --

MR. JONES: Well, it helps you kind of like a guide, yeah. But then, you need -- this is a -- you need a network of these things.

MR. POPOVICS: Yeah, right.

MR. JONES: So, and that way it's kind of opposite of some of our inspection technologies in that it, we're sort of confirming the absence of something. If we confirm that there's no moisture, for example, we're not --

MR. POPOVICS: So, right.

MR. JONES: But we can actually synergize between, you know, some of our metal measurements and --

MR. POPOVICS: So here's some of the problems associated with that technology. For this case, one is that you need a lot of sensors and you need a lot of networking. And you need a lot of wires.

Now if you go wireless then you have a data center issue that you need to think about someone can take. So these are kind of the issues that come up when you have a sensing system for sensitive structures. It doesn't mean it can't be solved but these are issues that you have to think about.

But I think, you know, if you're willing to invest in a significant sensoring kind of outfit and you've solved these problems with data management and what to do with all this data that you get, I would protect it properly. I think it's wise to kind of to do this kind of thing and to get information about it to guide your tests.

MR. TORRES: Ryan wants to get a comment in.

MR. MEYER: Well, I just was going to say, though, I mean, one obvious pitfall of this is that these embedded sensors are only applicable to new systems. And so for the systems that are out there --

MR. POPOVICS: Well, not always.

MR. MEYER: Okay.

MR. POPOVICS: But you can embed sensors in the system but it doesn't tell you what's going on and what's happened to date. It only tells you from that day you installed it. So if that's your point I totally agree with you. Right.

MR. MEYER: Well, and the other thing is, I mean, what's sort of -- I would draw a parallel to what is sometimes called online or continuous monitoring then in this case, and so here --

(simultaneous speaking)

MR. XI: We cannot hear you.

MR. MEYER: So I guess I'll use the term that is used many different ways in terms of online or continuous monitoring. And the concept of calibration which you can solve as opposed to redundancy but then also I guess the reliability of your sensors in that if you have -- you know, these sensors don't last forever and you have this out there for if you're thinking beyond a hundred years -- you know, the practicality of that.

MR. POPOVICS: Yes, that's an excellent point. You know, the lifespan of the sensors, I'd say one year. I'm very confident. Five years - you know, less confident. One hundred years, totally not confident. Well, of course.

MR. TORRES: I think for its value in monitoring, I would say extended storage.

MR. POPOVICS: Yes.

MR. TORRES: But from a practical perspective at this point inspection is probably more appropriate, especially because we have 2,100 plus systems out there. It's unlikely that we're going to be requesting any licensing to change to a design basis unless there's a volunteer licensee that wants to do that.

So this morning I think what we're trying to get to is to potentially figure out what inspection techniques are probably best on this system other than visual that would be useful about the conditions of the system, without altering the system itself.

MR. JACOBS: Okay. And I agree with your first statement that inspection is probably the, it's not the sensor. You know, the lifetime of the sensors is just going to be way too small.

And your second question, again, I think there's a, there will be a suite of -- and that's why I'm trying to -- I still don't have my arms around sort of what Bob, you know, sort of going that sort approach, as suite of techniques that, yeah.

MR. TORRES: And I think that's what Ryan, is helping us with --

MR. JACOBS: Yeah.

MR. TORRES: -- trying to figure out what, which of those techniques are appropriate.

MR. MEYER: Well, I -- so I'm sorry, but I'm going to circle back, I guess, a little bit here, the conversation earlier about the value of understanding the minimal detectable fault size. I mean, I completely agree with --

MR. TRIPATHI: Could you try that other microphone, see if it works better?

MR. MEYER: Well, does this -- can you hear me like this?

MR. TRIPATHI: Yes. Do that.

MR. MEYER: Okay, so I'm just kind of close enough to the microphone. So I wanted to mention, I completely agree with Randy's statement earlier that, absolutely, you should -- your performance evaluation should be based on what you can tolerate in a structure.

But, you know, again, sort of drawing the parallel to like metal materials, I think before we got to that state we were still characterizing performance in terms of what minimal detectable fault size. And that's at least a rough, sort of almost like a screening criteria so you can at least look and say, you know, someone's proposing this technique to look for this.

And you can kind of say that is or isn't feasible, roughly. Right away you can day, no, you can't use that here. Okay, try it. We'll see what we get. And then we'll have to dig in a little bit deeper and assess results.

So I think there is some value. Now maybe you shouldn't put a whole lot of effort into getting those characterizations because, again, they do have, I guess, a limit in terms of their value. But I think that's useful. Sorry.

MR. POPOVICS: Yeah, I'd just -- I'd like to take this opportunity to say I teach a class in non-destructive testing methods for civil structure in my university. And at the end of the class the graduate students have to come up with a table kind of like you described.

So it's a matrix of a problem, problem, problem, problem, problem, tool, tool, tool. And for each one they have to put Excellent, So-so or Poor. And then they have to footnote each one, like, okay, this is Excellent if the void's bigger than two inches.

And so -- so, and the reason I -- and I think I want to echo what you said. My statement to them in the beginning of the class is that I don't expect you to be an expert on NDT. I don't want you to think you're an expert.

But I want you to be able to be an engineer. And then when some vendor comes and says, oh, yeah, we can solve this problem you can pull out this table and say, I don't think so. And I think that's a very valuable tool which I try to give my students who will be engineers in the field.

And you said that. And I repeated it but it's a really useful tool to give this to your students.

MR. MEYER: It's a new assignment.

MR. POPOVICS: Yeah, it's a new assignment. I already did it. I mean, it's not for -- but, I think it's a very useful tool and I just wanted to mention that.

MR. XI: So I just want to reiterate, they gave me about 20 of these questions, so what is a critical size of the crack in the corners of the structure -- this actually is a quite difficult task.

The reason is because when you have a small crack, distributive cracks like a freeze/thaw like ASR and then we use damage mechanics, in models in the final element.

So something like the model developed by my colleagues is already a kind of ABAQUS. And then when the crack becomes bigger you have to use a fracture mechanics to analyze it. So you switch to another technique. So that's very difficult because in the current ACI code they don't use a fracture mechanics at all.

MR. JAMES: Yeah, I don't believe in fracture mechanics for concrete, frankly.

MR. XI: No, no. Yes. I agree with you.

Actually in April there will be a conference in ACI convention in Kansas so we will try to convince the shared committee to adopt the code based on the fracture mechanics.

MR. JONES: I guess a comment on that, you know, once you deviate from well-bonded concrete and rebar and it starts getting complicated in a hurry. You know, your model, what you need to capture can be dominated by details, you know, normally as the continuum models are.

I think that that may be one of the things that's been holding us back a little bit on that part of the problem. You know, exactly what we need to know because I think it's very dependent on the load, the type of deterioration, the location of that deterioration.

But anyway for what it's worth we can log that. I'm not in the transcript now. Let me ask this question though. Do we feel like our theoretical understanding of how these mechanisms progress can help us be strategic about the way we monitor the way we inspect, the way we maybe put embedded sensors, for example?

You know, if we think that these things are susceptible to ASR or DEF, you know, could we be kind of thoughtful about how we would, you know, look at setting a series of inspections or monitoring?

MR. POPOVICS: Absolutely, yes. This is John Popovics.

MR. JACOBS: Yes, I agree.

MR. JONES: Could we -- we can pick an example of, say corrosion. Could we sort of brainstorm what that could potentially look like if would be monitoring some environmental stimuli? So does anybody want to hazard a thought process here?

MR. BERKE: Yeah, well there are guidelines that I use to run, SHRP, which is Strategic Highway Research Program, so we're looking at bridge -- our vendors are bridge decks and predicting how it's going to progress in time.

And so that's certainly doable. The type of -- so knowing it's -- but once again you have to have a few times.

MR. JONES: Sure.

MR. BERKE: You have to have it. Things never really get better unless you change the environment so it could -- you could get an idea of which way things are going.

You can certainly model, you can certainly use tools to model that. And then you can say certain factors. I mean, the type of cracks you need, over a bar to have a problem are a lot smaller than what you need to cause structural problems.

So I mean, so knowing you can detect smaller crack sizes or how deep or how wide the crack is, that's a reinforcing problem. So maybe it gives you an idea and an environment because you could have a crack over the bar environment and it doesn't matter.

So you have to put all, you have to have a holistic approach to this. You just can't take, well, I've got a crack over the bar, the whole world's falling apart. You've got to look at what you're, what the world is around that crack.

But if you're in the middle of the desert you never see any rain, you don't get any chloride or you're indoors, that crack's not going do anything unless it gets to the point where it's too large from a structural point of view.

So I think, so if you put all that together you can model when you think you're going to see problems. You could also model -- you could also, knowing how the chloride has come in -- let's say you have chloride coming in the concrete, so knowing how that's coming in you can do actual models for when the corrosion might start and how it might recede.

So that gives the, so they know that there's a -- if they don't do anything, let things go along the way they're going, five years from now when they going to have enough corrosion on that bar to corrode the concrete and a couple years after that, I'm going to have a structural problem. Well, right around that time I'll start having structural problems because of that.

So you can prepare ahead of time or you can say I'm lucky to have, we got five more years left on my structure. And then somebody, you know, I don't fix it or I want it to last another 20 years so I'd better fix it so I don't have to fix it in five years and you look at it as a remedial.

It means they're fixing it today, cost effective, compared to waiting five years and fixing it then. So you have an -- or at least you could make an economic decision based on some sort of modeling and what was your weights that were measured. So that's a good way to go.

MR. JONES: So you're talking about some sort of modeling informed monitoring. So we sort of think that we might start to have corrosion -- excuse me, chlorides reaching the bar by X days and so then we know that about that time we would start to see the --

MR. BERKE: And corrosion's a special problem. If you do the measurements and you say you got a structural problem then you've got to fix it right away. If you do the measurements and say corrosion's occurring today then you've got to say how long this is going to take before I have something happen.

So that gives you time, you know, you can do something about it. If you have a structural problem, you'd better -- you've got to fix that right away. If you're going to address corrosion you can actually do some modeling, you can debate some thought processes.

MR. JONES: So, yeah, the thing is the structural string of events is the critical issue. But it's, unfortunately, it's out of reach right now.

MR. JACOBS: I think your statement that your -- it's the model independent of the measurement, that is the key component that you need to have some sense of how that corrosion will develop over time. Whether you're measuring it or not it's a predicted model. It's based on something. And then that informs your decision making on when to sort of sample.

MR. XI: Actually, it says for license renewal, the risk increase measured. So that's risk, dangerous when there's a corrosion problem. So the first one is the creation of a monitor on the chloride. And this will take, let's see, about 20, 25 years?

I made that non-count -- that's my experience on the bridges. So this first thing is actually very long. And then as corrosion starts the rows start to fill up the holes and everything in the bar-concrete interfacial zone. So this will take only a few years.

And then you have enough rows to crack hundred and that will take about two or three years and it will be gone. So wise to use the models to predict the performance and also the switch starters.

Another way, as I just mentioned, that the equipment they use, let's see, to measure the corrosion potential. So my suggestion is that you can ask them to measure the corrosion potential of the starter surface, scanning of the whole surface, and if there is a corrosion currently active, definitely no 40 years renewal because once the corrosion starts and the concrete will crack within five, maybe ten years, it cannot survive 40 years.

But if there's no corrosion currently detected, so it's still in the first stage it can run very long, especially for a dry cask. Because our highways deal with a lot of heavy traffic so it can stay there for about 20, 25 years.

MR. TORRES: And that was the question I

was trying to get an answer to, whether or not just visual inspection would be sufficient, considering that corrosion might require more testing through either GPR or half-cell potential, some of those. So then that's --

MR. XI: Well, the ultrasonics and the infrared, all this, it can detect cracks. But that's the only in the last stage of the corrosion process. So if any swelling in the last stage, it cannot survive for, let's see, five or ten years. So that's why for you 40 years renewal does not answer this.

MR. BERKE: On one condition. It won't survive if we do nothing. You could put a mitigation treatment in, I mean, so you take, you want a license, if you want to go on, I mean you have active corrosion going on. And within three, four years, you're -- I mean, you're going to see cracks, swelling, rust at the surface. That's not acceptable.

However, here's the various mitigation techniques that -- you come up with a mitigation technique that you're going to use that's going to stop that corrosion from proceeding.

MR. TORRES: So I know you have, for instance, you have modeling, corrosion and then what comes later -- mitigation.

MR. BERKE: You might mean --

MR. TORRES: I'm sorry, modeling.

MR. BERKE: That's right.

MR. TORRES: Not necessarily requiring some sort of field testing.

MR. BERKE: Well, I mean you definitely would do -- field testing is ideal if you could because there's nothing like actually having some initial data. I mean, at least to make sure that it's not an active corrosion when you start.

MR. XI: If we know the -- let's say if we know the moisture distribution, the corrosion, if you use initially if you use it -- you use that, we can figure out the principal that brought this -- the moisture, the facility, chloride, the facility. Using that the model can accurately predict what will happen in the next 20 years when the critical chloride comes on the rebar which will --- strength will be valuable. We can do that.

But without any measurements the prediction is not 100 percent reliable.

MR. BERKE: Okay, and visual, by the time you could see the rust coming through visually, it's already active corrosion. It's not -- you'll have, if the conditions stay like that it won't be more than a couple years before you'll have swelling and cracking.

MR. TRIPATHI: You know, you mentioned license renewal period 40 years. Once they issue a license renewal for 40 years it doesn't mean that nothing's going to be inspected for the next 40 years --

MR. BERKE: Exactly.

MR. TRIPATHI: -- when there are periodic inspections. And if something is missed today probably during the next inspection and somewhere it'll be year, some it will be five years, some --it will be detected.

And as soon as you -- it's detected -- if you put some measures to stop that deterioration. So it's not like once we issue a 40-years license that nothing's going to go down to 40 years, so that's nothing.

MR. JONES: So we'll actually get to that. And after our break here we have Aging Management Programs and sort of a --

MR. TRIPATHI: Right, you mentioned that a couple of time, so --

MR. JONES: Let me ask one more question before we go take a little break. But similar to my question yesterday on do we know enough about ASR screening to confidently screen out aggregates? Do we know enough about temporal monitoring and temporal training to make good decisions on when things are going to sort of hit these limits?

And it sounds like maybe corrosion is fairly well developed. But is ASR similarly developed? Is -- you know, freeze/thaw? So do we -- is the state of knowledge high enough that we can leverage these kinds of ideas to help us make decisions on safe operation?

MR. POPOVICS: I'd like to briefly address that. This is John Popovics. I think corrosion is kind of in a good position to make these kind of predictions because the -- you know what you're measuring. You’re measuring potentials, you're measuring currents and --

MR. JONES: Chloride.

MR. POPOVICS: -- chloride. And you know that you can measure them accurately and therefore, you have good data that you can now make a good predictive model.

The problem with something like ASR is, well, what do you measure?. Well, you can measure alkali contents. That may or may not indicate something. You can measure pH and moisture. It may or may not.

And there is no method, as far as I know, that can accurately determine, well, what's the extent of damage to date -- how much distributed cracking is there without the picture, you know, and the e-methods. So the -- and the same with freezing and thawing -- what do you measure. You know, how many cycles has it frozen, maybe?

You know, measuring temperature over time. Measuring saturation level. You can get a good idea but you don't know, actually, what's happened because you can't measure directly reliably this distributed damage.

MR. JACOBS: The second one, the yellow, I would say, you know, upper left.

MR. POPOVICS: Exactly, yeah. And so I think these predictive models are excellent when you have good data and reliable data. And I think corrosion is kind of more mature and developed than --

MR. JACOBS: Better for taking better positions.

MR. POPOVICS: -- than ASR freezing and thawing and others.

MR. BERKE: This is Neal Berke. Just a comment, just, I definitely agree with him. But that's why --- argues that why prevention is used for --

MR. POPOVICS: Sure.

MR. BERKE: -- ASR and freeze/thaw damage. Now we have -- we at least have tried putting embedded strain gages in concrete and we can see expansion due to ASR. We've done so and this and that. And these things are migrating strain gages. Bring the wire around, they should last for pretty much forever and it's --

MR. XI: This is a mechanical device.

MR. BERKE: It's a mechanical device but you still have to put a vibrating, you know, an activation source on it. But you can also use fiber optic with grates on -- you can do it that way too with the fraction grating. So, I mean, you can put it around the entire length of the part where you embedded it in there.

There's a strain change that's around. You could -- if the strain keeps increasing more than you would expect this model, well it's the thermal. It's hot. It gets to a certain point but then it keeps expanding. Other than that it might be ASRs occurring.

So there might be ways to get it like that but the typical ways, when we're designing 150 of these structures, we're saying, hey, we're going to --- out the aggregate, we're going to keep the pH in the concrete low and we're not going to worry about it because it's hard to measure it and know.

MR. JONES: To some degree that's the right answer but we've found a dozen situations where it may not have control over 2,000 some-odd.

MR. BERKE: There's things we can't model as far as when or how they're going to go. Those things you want to be -- those things you want to make sure you kind of use what's a prevention method.

You know you can't have ASR if you have an area that's susceptible to it and you don't have alkali.

MR. JAMES: This is Randy James. Kind of addressing most of these as far as strategy, I think -- I'm not sure how to pose this but maybe part of the strategy is you need to decide when you think you need to worry about the structure.

It's almost sounding like we're trying to inspect structures to try to find something that might happen with the structure and then predict when it might happen as opposed to just inspecting the structure until it's kind of clear that something is not going according to plan and then, you know, get into your AMPs and start doing more detailed assessments.

Try to find out what's really going on and then do predictions from there. So I think part of the strategy ought to be at what point are we concerned about the life of the structure. When do you kick in with more detailed assessments?

MR. JONES: So, sorry. I think that's a fair comment. So let's see you, through your visual inspections or however you get into your AMP, do you feel that the modeling and trending that we have is adequate?

You know, the other case, let's finish it bad is by the time we find it, you know, we're already too far down the road to get -- do you think that's accurate or?

MR. JAMES: Well, sometimes it seems that if you do some measurements and you find something that's going on maybe you can mitigate it for a while or delay it. But a lot of these diseases, so to speak, you can't be sure. They're going to happen at some point.

So when do you put it on life support, I guess, is a question. When do you want to try to get in and then do your predictions and measurements? And I guess it just depends on frequent visual inspections versus things that you can't get to see.

But that's sort of the way things work in the field now. People inspect structures. And they don't try to go in and find something that might go wrong. They inspect a structure to see if things are going to plan. And if something is telling them it's not going to plan then you start looking more in detail at what you should do about it.

MR. JONES: Your sense is that by the time we were to catch something it would probably not be so far advanced that it would be a --

MR. JAMES: Yeah, my sense is if you see something that you don't like there's still plenty of time. I think these concrete structures can sustain a lot of degradation and still perform functionally and structurally.

So I think there's -- once, even after you visually or otherwise find something that you don't really like or that's indication that something may be happening you have still plenty of time to do something about it or exception may be the corrosion or reinforcement that starts cracking off the cover layer that -

MR. BERKE: Well there you go. You won't lose the entire cask. You'll just have one section that needs to be replaced because it's unlikely if you hear of that, I mean, you could uniformly start working everywhere on it and start going.

Usually corruption like on a bridge doesn't corrode and 100 percent of the bridge has to go. You lose -- they'll wait until you have 10, 10 percent damage, then they'll fix it because at that point your cars are, you know, you're slowing down traffic and you're cars are getting on it.

So structurally it can stand output. The question is at some point you know that's going on, you're going to have to fix that. Because if you don't fix it then you have 100 percent of the bridge goes. And ideally it's less expensive to mitigate it and stop it than it is to pull out concrete and redo that.

MR. JONES: Sure. So let's take a 15-minute break. We'll be back here about 10:30. I think I'm on the right line of my schedule today.

(Whereupon, the foregoing matter went off the record at 10:15 a.m. and went back on the record at 10:35 a.m.)

MR. JONES: So we're resuming after our short break. Anybody on the phone? We'll plan to go from now until about noon Eastern Time. The topic of this little section will be Aging Management Program. But I do want to tie back to just the previous section and basically everything else before and sort of how an Aging Management Program fits into this whole picture.

And I want to start out with kind of where we left off and sort of a, maybe an exercise if you want to call it. I wanted to ask sort of a specific question and maybe the panelists could give, if you wouldn't mind, just responding individually just to kind of get sort of a poll feel.

And that question is is a visual inspection, these types of things, sounding, whatever, is that adequate to ensure continuous function? So if all we were doing was visual would we ever be in a situation where we were non-functional, I guess, for however we want to interpret that for a dry cask, this kind of stuff.

And this is a big question, I know, but I guess I'm just trying to get a sense. Just so maybe we'll start on this side just arbitrarily?

MR. XI: Can you repeat the question?

MR. JONES: Sure. So the question is, is this. Is visual inspection adequate to ensure continuous function of these dry casks systems? If that were maybe the only tool you could leverage, could we guarantee that they were functional continually?

MR. JACOBS: Could you -- and give me a time. Could you give us a time line? Are we looking at the short term or are we looking at the longer term?

MR. JONES: Well, I guess I wouldn't know anything about time, but let's say within the license period.

MR. JACOBS: Okay.

MR. JONES: So it's okay to know for the next forty years.

MR. JACOBS: Okay.

MR. XI: Okay.

MR. JONES: Is that a fair way to approach that?

MR. TORRES: Yes, I think part of is keeping in mind periodically the inspections will be performed. So, on this may be a more adequate time line would be every five years you do an inspection to ensure that that function is made -- those function are maintained for at least five years until you get to your next inspection.

MR. JONES: So maybe periodically it's important, maybe five years is too long, maybe it's too short? But let's say we're just doing some periodic visual inspection. Is that adequate?

MR. JACOBS: The only inspection you're doing is visual.

MR. XI: Yes.

MR. JONES: Okay.

MR. TRIPATHI: But it's only five years but if you detect, during the visual walkdown or what have you, some problem you do it immediately.

MR. JONES: Well, that's where we're going in our next section. But what I'm curious about is would we find ourselves in a situation where there's a lack of function, so.

MR. XI: Okay, so this depends on which (unintelligible) you are. For example, the corrosion, you could just look around the dry cask and you cannot tell. There's no sort of cracking due to corrosion. In that case the inspector can only make a recommendation and, yes, see, there's no problem.

But if you see like ASR like a freeze/thaw like with even then those are all those surface cracks. So you can tell immediately. And then the remaining ASR potential, all the future damage due to freeze/thaw, you cannot tell unless you have, you measure -- freeze/thaw measurement.

But in that case the visual inspection can tell you a lot. Let's see if ASR started, you cannot stop it. It doesn't matter what you do.

MR. JONES: Sure.

MR. XI: So in that case you have to do something further -- the recommendation or do some further measurement.

MR. JONES: So, Neal, would you respond to the --

MR. BERKE: Yeah, I think what would happen is, I mean, when you say visual, I mean, I don't think you're going to, you know, as long as you're doing it periodically you're unlikely to just get to the point where you look at it visually say, boy, this thing is going to fall apart right now, it's not even functional right.

It's probably still functioning. Okay, even with corrosion going on, maybe you can't see it. It's probably still functional. And even if you saw spalling or some spot, it's still probably going to do its job at that point. But it'll certainly tell you you need to -- if you should be inspecting more often or repairing, doing some sort of a repair mitigation.

So it's just a mess. So you're not going to, if you just use visual you might catch things at a point where it's more expensive to fix them. But I don't think you'll ever get, I mean to alarm, unless you wait out 20 years or something -- you know, as long as inspections occur and it's not too far apart you should be able to catch something before you lose function of the system and it becomes a safety issue.

But that's what's critical, how far your inspections are apart because if they're too far apart then something could happen in between the inspection time. As far as things like -- I think you can see freeze/thaw pretty easily on the surface because usually there's some scaling that happens with it even if there's no slight scaling about.

With ASR you'll see cracking on the surfaces. Some of these, as you can see, once again, the cask system might still be totally on a slab. It might still be totally functional at that point. But they're going certainly tell you that you have to do something. Yeah, so, I don't think you'll -- you're unlikely to miss having a disaster during just doing visual but if you see the visual stuff and you don't act you might have a problem. And sometimes when you see the visual stuff it'll be -- your options are going to be a lot less if you catch it visually rather than by some non-destructive technique beforehand.

MR. JONES: You were going to say?

MR. TORRES: Yeah, I just had a quick

follow-up question on your statement here. But you said if you wait 20 years it might be a different story.

MR. BERKE: Right.

MR. TORRES: So realizing that we said the cover, there might be chloride in there and so it might take you 25 years or so and --

MR. XI: To reach the --

MR. TORRES: To reach --

MR. XI: -- critical value at rebar?

MR. TORRES: Yeah, and considering the -- because actually it's during the initial license period, 20 years are mostly on the external surfaces of the system. You're not inspecting the internal. Does that change your assessment? If you did not perform any inspections in inside walls of your system for the first 20 years?

MR. JACOBS: In the first 20 years are up now.

MR. BERKE: They're up now.

MR. JACOBS: I'm trying to create the frame, the way you're framing the question.

MR. TORRES: Yeah, yeah. So it -- you're out 20 years in the license period?

MR. JACOBS: We're there now.

MR. TORRES: It's been operating and it's been inspected from the outside but it hasn't been inspected from the inside.

MR. JACOBS: The inside? Okay.

MR. TORRES: Does that change your answer?

MR. BERKE: Well, I mean if you're -- at this point you're doing a visual inspection of the inside, you'll clearly see what it looks at this point in time. And if it looks good that's good. And if it looks -- doesn't look good then you're going to have to make some sort of decision on whether you need to fix it or not. But that's just what it is right now. It doesn't -- I mean, you might have missed it already. It might be doing very poorly on the inside and you don't know it. But, so that's going to be your first inspection. So see what it looks like and then you'll make a decision.

MR. TORRES: Okay.

MR. BERKE: But it's unlikely if you look at it now and it doesn't -- it looks like it's pretty bad and it needs, might need some repair, you've got time to fix it unless it's starting somewhere, you know, Year 5 or something, and then it might be too late. So that's what basically, I think. You know, most cases if you looked at them visually at some point and reasonably not too far in the past from where we're looking at them now is okay.

Now the problem you run into with corrosion is corrosion might look pretty good. It might be going on right now. And in three years you can still have cracks and spall and concrete but your next inspection is at five years. You could very well miss that, okay. So that's the types of things that you kind of, that you miss by just doing a visual.

MR. JONES: Larry, will you --

MR. CHOWDHURY: Neal, let me ask you more directly the same question. Would this visual inspection be able to give indication there's a bigger problem that cannot be quantified by visual inspection but at least we can look for other methods?

MR. BERKE: Well, I mean definitely it can tell you if there's something -- I mean, visually, if you see something going on, something's going on. Now how bad it is, you might have to go to some sort of NDT technique or corrosion measuring, corrosion rates or seeing what chloride's are, something of that nature, or what the moisture contents are.

But, yes, certainly, if you see something visually going wrong, something's going wrong and how bad it is if you only have one point in time you might have to do some other techniques to get an idea of what the rate is. I mean, if I see something, I see a crack, I don't know if that crack happened yesterday and it's growing fast or it happened ten years ago and it never got any bigger. There's a big difference on your performance though so it's telling.

MR. TRIPATHI: Yes, very good point because there was some cosmetic damage observed at one of the nuclear power plants right after the, beyond the design basis earthquake, North Anna. So we don't know whether that cosmetic damage -- the cracks, the spalling -- occurred before the earthquake or it was there because of the earthquake. So you are right though. There may be some damage which is there already.

MR. BERKE: And has never progressed.

MR. TRIPATHI: Exactly.

MR. BERKE: So that's a totally different story than something that happened yesterday and is progressing very quickly.

MR. JONES: So, maybe, Larry, what are your thoughts on the --

MR. JACOBS: No, no. I was following up and I agree with a lot of, most of what was said. And I gave, in answer to your question, Asad, I already gave an answer yesterday talking about the matting for ASR. You're getting sort of these sort of matted cracks.

MR. CHOWDHURY: Yes.

MR. JACOBS: And it's a pattern that is very predictable. And you see that all of a sudden and you'll catch that by visual. Will it be too late? I don't -- probably not. But, I mean, that will give you information. Then going to your original question, Chris, only visual, I personally would like to get -- and I'm not quite sure what -- take advantage of the fact that you're going to be, you know, you're getting something in time now that is going to start the process for a much longer time. I'd like to get some way of quantifying state a little bit to maybe do that.

Now whether it's as simple as taking good photographs like we were saying, okay, do good photographic documentation that someone else can use later on. I'd like to say something like that. I don't know whether it's, you know, whether that's the thing but I'd like to add one thing to say, okay, let's sort of get at a status that we'll be happy in ten years or

20 years that we can look back and say, gee, I'm glad I had that information that I can use to help interpret in the future.

MR. JONES: And, John, I'll pose that to you as well.

MR. POPOVICS: Yeah, I mean, I don't have much to add to what's already been said except that I would say for concrete structures visual inspection is the first line of defense. It's essential. It must be done. But visual by itself, in my opinion, does not give you enough information to give a holistic, effective state of the -- condition state of that structure so that you could act appropriately in the appropriate time frame. I think it doesn't.

For instance, visual can say there's a crack there but it cannot tell you how deep is that crack, where does it go, what's its morphology, is it structurally significant or not. So we need more. But visual is essential for concrete. And you can't always see all exposed. Some concrete is clad so it gets --

MR. JONES: Yeah, and, Randy maybe it was the same thing that you said --

MR. TORRES: I think I bantered before the break and may have started this whole thing, so.

MR. JONES: Sure, yeah.

MR. TORRES: Yeah, my opinion is that -- the question was can you rely on visual inspection to identify issues before you lost structural or functional capability of the cask. And my answer's yes, I believe you can. But, obviously, if you do find something then you need to --

MR. JONES: Right.

MR. TORRES: -- you know, start a program to look more into it to see what's going on. I believe this is true because of the benign loading situation on these casks. They're just really just sitting on a pad. They're not active systems so, and I think the degradation mechanisms that we're talking about is going to take a long time to really develop far enough to cause serious issues with modern concrete. So that's why I think that we can rely on visual to identify issues.

There's also the issue of buried systems that you really can't do visuals on. So in those cases I think you need to rely on something besides visual, some kind of ground water or soil testing or something around those instead of visual for the buried systems.

MR. JONES: Well, I guess that gives us a near ideal segue into this question of frequency. So the ACI 349, that 3R document, proposes this -- proposes, offers this sort of inspection frequencies. And I'll grossly summarize that, but --

MR. JACOBS: Did you skip one slide?

MR. JONES: I did, yeah. So anybody on the phone, I'm on Slide 37 now.

MR. JACOBS: And the slide you skipped was sort of what we were talking about, right?

MR. JONES: It was. So -- and I intend to sort of circle back to that over there. But we have sort of this notion of inspection frequencies as sort of prescriptive and this notion that once a problem is detected that we should probably watch that a little bit more closely and maybe that's when some of these techniques come into play. We leverage them in a more targeted sense now.

Did I skip two? No, just this one. So anybody have a comment? We're on Slide 36 now. So I guess we have this notion about a lead system. I think this caused a little bit of consternation for the panel, I don't know, when we offered it previously. But the idea is that could we target a particular canister to sort of serve as a representative for the rest of the canisters or component for the rest of the components, et cetera. And so we posed a problem, posed the question, can this be done effectively, basically was the question that we've sort of come to.

Could, I guess, could a degradation ranking metric be determined? Could it be developed such that we could confidently take this sort of single canister and have a decent idea that we've captured the relative degradation phenomenon, et cetera? Could a composite metric be put together that sort of helps us identify a single component. So maybe several of you that offered basically metrics or processes, maybe we could, if somebody could maybe describe what they proposed or --

MR. JAMES: I'll be glad to start.

MR. JONES: Sure.

MR. JAMES: I think I proposed that if you have any cask that has seen some unusual circumstances over its life you should definitely look at that cask -- fire or flooding or some issue that's happened to these particular casks on that site. And then, other than that, I would propose looking at the cask with the longest time with the fuel stored. I know there was some questions about do the empty casks that are sitting on the site before they're loaded, would they age differently or have some effect on the overall life of the structure.

I guess I approach that as if that situation occurred I would expect that that cask would have been inspected before it was loaded if it was sitting on the site for any period of time before it was loaded. And at that inspection before it was loaded you would noticed anything unusual that would need some kind of disposition, I would say.

So if you did find something when it was loaded maybe that would put that cask into the first category, that it was an unusual situation, and you should look at it. If nothing was found then it seems to me that that cask being empty would not really affect the long-term degradation over a cask that's loaded in over temperature. So I think I ranked them as longest cask, loaded, and of those the one, if you're monitoring temperature, which I know we worked on this before. I would think it would be a good idea to kind of monitor temperatures in this cask.

Find the one that has consistently the highest temperature and use that as a lead cask. If you still don't have a good candidate from all that then take the one that has the wettest conditions since water really affects all the degradation mechanisms. And then finally, if you still don't have a good candidate, take the one that's had the biggest change in temperature over its life as kind of a metric to look at the one that's experiencing the most environmental differences.

MR. JONES: Looks like that would be sort of a flow chart of sorts to get you down to one or a few casks that would be --

MR. JAMES: Yeah.

MR. CHOWDHURY: So you are looking at that temperature instead of the age of the cask.

MR. JAMES: So age of the longest cask that has been the longest loaded cask.

MR. CHOWDHURY: Okay.

MR. JACOBS: That was your first criteria, correct? Yes.

MR. JAMES: Yeah, that's my --

MR. JACOBS: Of the normal ones.

MR. JAMES: Yes, of the normal ones, yeah.

MR. TRIPATHI: There could be a difference, though, that -- and if you know, in the good old days we had low burnup fuel. Nowadays we do have what we call high burnup fuel with high heat load. In the past there was low heat load. So there's a combination of different features. Just because I have one cask which has been loaded some 20 years ago and I've got another cask which is loaded just years ago but with different kind of fuel inside we're talking about different scenarios and different degradation mechanism which may have kicked in sooner because of other environmental features. So if you just rely on, okay, let's take a look at all the casks which are loaded 20 years ago you will miss something.

MR. JAMES: I agree. I assume the cask that was loaded recently with higher burnout fuel still needs the same temperature requirements, the same design basis on temperature limits that all the other casks do, the design too. But I see your point, yes.

MR. JACOBS: I think it's probably if you look at some of them, like let's say the ASR, the DEF, freeze/thaw, they're going to be very site-specific. Very, very, you know, you can really pick one at random and I think you can get that for that particular site. Look at the temperature, the thermal and the radiation, and these will be your, again, this is a less site-specific but I think you can grab one in a rational way and pick that one.

I think we're going to miss that approach, we'll miss any kind of what I would call QC/QA. Gee, this cask was improperly manufactured. In the construction, its honeycomb, whatever -- we'll miss that. But I think we can -- the detriment on that is so small. I don't think -- and that, using this visual approach will catch that. You just don't walk around. We're saying visual for everything and we'll catch that in that particular point.

MR. TORRES: And that should have been caught in the initial QA inspection.

MR. JACOBS: I agree. But even if we had missed it, again, I think I'm very comfortable with that particular one when you consider these are passive, when you consider how they're being passive type devices. As I said, the things that I'm most worried about, sort of long-term, the ASR, the radiation, the thermal. I mean, I think we're going to get something to start us in the short term in 5 years, 10 years, 20 years from now. And we'll have at least a basis or a benchmark that we can take them off.

MR. CHOWDHURY: Larry, somewhere you, I

believe, mentioned about random sampling.

MR. JACOBS: Yeah.

MR. CHOWDHURY: Would you expand on it a little bit?

MR. JACOBS: I'm a huge fan of that. I'm a big fan of there's going to be such a statistical variation sort of in the way it's loaded. And then there's going to be a statistical variation in the material itself. And then there's going to be statistical variation on what you sort of measure when you're measuring it, things like that.

So I would like to put some kind of probability or some kind of statistics in there in your selection. I appreciate Randy's idea of a flow chart. And I like that as a way to get started. And I think you'll probably add those candidate casks even to just simple Monte Carlo. You know, here's 100 of them that meet that. Spin the dial on this one. If this one comes out, pick it and go for it.

MR. TORRES: So it seems like your sample size you're proposing, looking at some systems that might have been outside with respect during say normal conditions or maybe have been subjected to something that would have caused accelerated degradation. I'd also look at potentially one, at least one, of those that haven't had those issues. It seems that your approach is more having the selection of the larger sample size, or the ones without degradation. Is that --

MR. JACOBS: Yeah, I think -- yes. Yes, but I do think if you have to say if there is a particular one that you are worried about, that you dropped it -- these are not, these are scenarios that didn't happen. But if there is something like that -- it had a fire or it had something like that you certainly would want to take extra careful attention to that.

But in the absence of that, I would say, based on the kinds of degradation mechanisms we're looking at, there should be -- I'm assuming they all came from the same, everything came from the same quarries. So they all have equal chance of having ASR if this kind of thing is going to have ASR. Then let's --

MR. BERKE: That's actually a question I get. These casks aren't inexpensive. Do they order ten of them at once to get delivered or do they order them as they need them?

MR. TRIPATHI: That depends. Some

licensees have, if they found a good deal, they'll order. And some of these empty casks are sitting there for years --

MR. BERKE: Okay.

MR. TRIPATHI: -- before they actually unload the spent fuel from the reactor and put it there, so.

MR. BERKE: Do some just get it as they need them?

MR. TRIPATHI: True.

MR. BERKE: Yeah, in that case they might be totally different.

MR. TRIPATHI: Not only that but at a given site don't assume that all the casks are same. There is one particular site, I won't name the name, but they've got five different kind of casks from five different vendors over a period of time, so.

MR. BERKE: That's what I was going to ask. So you have to look at each one.

(Simultaneous speaking)

MR. JACOBS: I was assuming that was not the case from what my --

MR. TRIPATHI: Some sites have vertical and horizontal. Some have only horizontal. Some have only vertical. So, I mean, there's a whole scenario of mix and match. So to identify a worst cask at a given site it's not that easy as being said.

MR. BERKE: Well, I think you could use Randy's approach on each -- but, again, each system or each one.

MR. JACOBS: On each system, yeah.

MR. BERKE: Now if you have ten of them, they all came in at ten different times, unfortunately, you might have to look at ten of them.

MR. JACOBS: Yeah.

MR. XI: Well, I have a different opinion. Are we putting answers I want to repeat. Let's say you just take ASR as an example. So while this cask can be 40 years old, if it's a good concrete nothing will happen. But another one only 20 years old, it is not a good aggregate. And now you have an ASR right away -- not right away. Let's say, after 20 years. So the age under normal condition, well, they will not matter. So the aggregate is the most important factor. I think, Larry, you alluded that the QA/QC is assuming it equal.

MR. JACOBS: Equal, exactly. Yes.

(Simultaneous speaking)

MR. BERKE: Let's assume that a certain time would affect what he's talking about.

MR. XI: Yes. So my suggestion is that you inspect every one of them every two years. This actually happened in the highway industry. So nationwide we'll only have a 2,400 dry casks.

MR. TORRES: Of --

(Simultaneous speaking)

MR. XI: Just in Colorado we have 2,000 bridges. So every single one of them being inspected required to be inspected every two years. And people did it. And why we inspect bridges, is the surface area is so big. So you use the cranes to go inside, go through, underneath everything. People did it.

MR. TORRES: When you say inspect it every two years --

MR. XI: Yes.

MR. TORRES: -- is it sufficient to do the external surfaces when you're --

MR. JACOBS: Exactly.

MR. XI: Yes.

MR. TORRES: Okay, so --

MR. JONES: That's normally, but it all needs --

MR. TORRES: Okay. Just to clarify we're not talking about inspections of the interior surfaces so --

MR. XI: No, for bridges you don't have anything internal. But we can take cores if you see any problems. So a lot of money has been spent on the bridge systems nationwide by different levels of government. And you may guess right in the regulation and the owners you have to inspect. This is not difficult. You just go around the dry cask, every one of them every two years, that's all.

MR. TRIPATHI: It's not a matter of being difficult. I think that on a bridge you have a 24/7 traffic going back and forth. These casks, as we all agreed, that these are passive systems sitting there. So the wear and tear is nowhere in comparison with the bridges. I mean, I hear what you're saying, that 4,000 bridges and they are inspecting them every two years.

MR. XI: Yeah, and those -- I'm talking about the cost to inspect a bridge the cost is very high. You have to --

MR. BERKE: It's not that those that are inspected --

MR. XI: -- detour the traffic. So the

cost to the private, to the agencies is very high. But to inspect just the very inspection of the dry cask to the owners -- compared to the bridges, this is nothing.

MR. JONES: Well, let me --

MR. XI: You send a guy there, going around --

MR. CSONTOS: Let me say a couple things on that. The requirement for two years on bridges is not a technical one. It is a legal one. It is a law, under the Congress --

MR. XI: Yes.

MR. CSONTOS: -- to the Federal Highway Administration. We've interfaced with the Federal Highway Administration on our concrete too. And what we found out is there's no technical reason why the two years was established. It was apparently a law, it was a setup to say you will do it every two years, okay. That's the reason, so far, what we've heard about the two-year inspection for bridges. So I just want to throw that out there for you, that that's what's -- what we were told.

MR. XI: Well, I know it provides a technical basis.

MR. CSONTOS: Well, I understand that.

I'm just saying that --

MR. JACOBS: What, for two years?

MR. CSONTOS: Two years. You could really come up, technically, say --

MR. XI: Yeah, I --

(Simultaneous speaking)

MR. CSONTOS: -- requirement. That's the technical basis.

MR. XI: No, they mentioned, five years, you may have some horrible damage.

MR. BERKE: I mean, I think that there's two years are there. There probably is political -- why it's two years. You're saying probably why they do it every year.

MR. CSONTOS: So when we interfaced with them they said that it was actually longer but two years was actually shortened from what the technical folks at the Federal Highway Administration. But it was because of a, you know, there was concern over things that were happening. And so they just shortened it. And that's typical. This happens in a lot of things. But I think that one of the things that we're looking at there is the function, like you said. But it's also not just visual. We can do this in a systematic way.

If you start seeing something you can go to Stage 2 or Tier II, okay. Think of it in those ways. It's not just five years. But if we see something in five years we can shorten or even make longer the frequency, okay. So it's just one of those things where we're starting off right now. We don't have cracking out there and so forth on some of the things that we've seen. And some places have repaired, okay. And I think you showed some of those pictures, right?

MR. JACOBS: Yeah, it's there.

MR. CSONTOS: Okay, so we've done some of those things. But it's a passive system and what we're saying is that at this point, as a start-off, a kick-off, is five years okay so that then we can start to assess whether we need to expand or contract that frequency. And are there -- what else we need to start looking at, not -- you know, visual's like the, I would say the front line. And then you have the reserves after that. What are those reserves, what is that front line -- all that's what we're asking about.

MR. BERKE: Well, I tend to agree with you. If you do the inspection at 20 years, when the renewal time is you have a detailed visual inspection. And if that, everything looks okay, five years is probably okay. You won't, functionally you won't lose anything. You might have to risk, say, you might have to spend a little bit more repairing something. But you're not going to have, you shouldn't have a disaster. I mean, you could but it's unlikely.

However, if at that point, at that 20-year relicensing inspection, you find out that maybe it's looking like something might be occurring, maybe five years is too long to wait on that particular cask for that inspection.

MR. CSONTOS: Correct.

MR. BERKE: Or maybe you have to do a little bit more detail work. If everything looks very good, I mean, I think anytime -- and that's with, even with the bridge guys, they inspect them every two years but the type of inspection they do is based on what type of rigging basically.

MR. CSONTOS: Right.

MR. BERKE: And they have a high rating they expect --

MR. CSONTOS: They have a whole risk-based, a model.

MR. BERKE: They've got a, right, 1 to 9 or something --

MR. CSONTOS: Right.

MR. BERKE: -- on the rating. If it's up in the 9-range it's kind of like, quick, walk through, goodbye. And if it's down in the 2 or 3-range they take all the traffic off of it.

MR. CSONTOS: Right.

MR. BERKE: So there is a system to it.

MR. CSONTOS: And just, also, just note that there is a requirement. It's tech spec requirement to inspect all these canisters -- the concrete outlet vents, okay. We have it because we need to have airflow going through.

So it's a warm source, so winters, critters like to get, you know, in there and things like that. I mean, yes, things happen. So there's a requirement that I guess it's every 40 -- you have to --

MR. TORRES: Maximum every 48 hours.

MR. CSONTOS: -- 48 hours.

(Simultaneous speaking)

MR. CSONTOS: Right, it's a --

(Simultaneous speaking)

MR. TORRES: -- daily inspection and you have the option of doing temperature monitoring.

MR. CSONTOS: Correct.

MR. TORRES: So it's not necessarily visual though.

MR. CSONTOS: Right. So it depends on which license but there is a feature in there to look at these vent ports, so.

MR. JACOBS: Just to reiterate the comparison with the bridges, the loading on a bridge is incredibly different than the loading on the --

MR. CSONTOS: Oh, yeah. The fatigue and everything else, right.

MR. JACOBS: The fatigue, just -- I think that's a driver for us here. I think we've really got to keep that front and center.

MR. CSONTOS: Yes, I agree.

MR. XI: But let me say, the loading conditions on the bridge decks are different from a dry cask. But on the cost it's pretty much similar. Because you'll see the heavy truck load actually are measured, the stream or variation on the columns of highway bridges. Actually on a heavy truck there's no changes. It's a similar stress. It's a daily temperature variation. It is a maximum load on the columns.

Same thing happens in the dry cask. But

given five-year inspection period. So let's say you can see there is nothing happening on the highway columns. And after three years I wonder myself, swelling due to corrosion. So that's why I put in writing my response. And that's what I want to repeat five years is too long. I mean, for a new cask that's fine. But it is already 20 years old or 40 years old, another 5 years you may see a lot of cracking and the --

MR. CSONTOS: Well, I guess I just want to think about that. I agree with -- I mean, I'm sure you can find things that are spalling off after or before five years. But will the function, they check on the bridge. You know, was it something that was a functional change in the bridge's capability to maintain its performance? That's what we're looking for. Because if we find spalling -- and we have. We found spalling. Three Mile Island has received a bunch of repairs. And that's in Idaho, okay.

MR. TRIPATHI: It's not in Idaho.

MR. CSONTOS: You're right. The thermal fatigue, you know, what we call it. Especially in Idaho, the temperature goes up, temperature goes down. It's a desert. And it's a very -- it fluctuates consistently through the year and through the day. But the thing is is that is it going to change the performance to the point where we need to change that frequency to make them prepare it or fix it before five years. Do you think -- that's kind of where I want to make sure it's performance based -- we're looking for performance based type of concerns.

MR. XI: Okay, now let me ask a question. There's a, supposed dry cask there. It's spalling everywhere on most all concrete cover top -- and this is a problem or not?

MR. CSONTOS: Well that's where they do -- what's the shielding requirement? There's tech specs on doing surveys.

MR. JONES: Okay, if you're going to guest speak identify yourself?

MR. CSONTOS: Okay, Al Csontos, Chief --

(Simultaneous speaking)

MR. JONES: So just identify yourself, right.

MR. CSONTOS: I see.

MR. SISLEY: The answer to the dose rate, it's system specific. I'm trying to remember what it is on VSC-24 -- 50 millirem on the top center line or something to that effect. I wanted to add that -- oh, Steve Sisley, Energy Solutions. In general most of these vertical systems require an annual visual, 100 percent of the casks. So every year you're looking at the entire outer surface of all of the casks.

MR. XI: Oh, okay.

MR. SISLEY: Every year.

MR. XI: So that is important.

MR. SISLEY: Yeah. And the five-year inspection is for the interior, the annulus of the cask which is a sheltered environment. Now in this initial license period the purpose of these inspections is not exactly to look for all these degradation mechanisms that we're looking at in the AMPs. But even though that's not the main purpose of the inspection, you still have that observation of the condition of the concrete or the steel liners or whatever. So I think it's important to frame this discussion around what we actually do. We do a lot of inspections of these casks, right.

MR. CSONTOS: Right. And that's where there the Idaho facility I was talking about, the Idaho ISFSI, that hasn't come before renewal, okay. But through the daily or couple days and the annual inspection, just to look at certain things, not for aging management, for these degradation elements. They found things and repaired them. Prior.

MR. TORRES: I just want to -- this is Ricardo Torres. I want to clarify, there is no regulatory requirement for inspections every year. This is system specific. We've had 20-plus years of licensing so there's a variety of inspection walk down periods. There is no specific requirement of shielding right next to a cask. We evaluate on the near cask locations one meter from the cask, but the regulation, we're looking at the site --

MR. JACOBS: At the concrete.

MR. CSONTOS: But those three criteria.

MR. TRIPATHI: But you said, Steve, that there are planned procedures in place. There are tech specs which requires them more frequent walk around. So it's not something like you don't do anything for five years.

MR. CSONTOS: Right. It's just not explicit -- this is Al Csontos. This is not explicitly for aging management. What we're saying is, for aging management of the degradation, I guess for the performance or what, you must do it five years. Okay, what's our progress.

MR. TORRES: Yes, I want to clarify that. What happened at TMI, there's an aging management plan that DoE put in place because of the issues that they had. Even before it came -- it hasn't even come in for renewal so there are walkdowns. There are issues identified. We inspected them.

MR. CSONTOS: Correct.

MR. TORRES: If we determine that there's an issue that requires further inspection then the licensee comes in and says we're going to inspect every five years. I believe that they came in for every five years. They have an aging management plan. It's not a program but it's essentially the same thing. So --

MR. TRIPATHI: Well I think your concerns are very valid but we have more frequent inspection than what is coming across.

MR. JONES: Yeah.

MR. CSONTOS: Generally speaking. It's not a requirement but this is why, important, it ties into this discussion because we want to understand exterior versus the interior of the overpack module. You know, what are initial suitable inspections. From what I gather here, it seems like it's very important to do a baseline inspection irrespective of what site it is, so.

MR. JONES: Okay.

MR. JACOBS: Just your bridge column analogy is not 100 percent because of the loading on --

MR. XI: No, no. I'm talking about the surface now.

MR. JACOBS: But I'm saying the loading on that particular bridge column can be very different, on the same bridge can be very variable based on its foundation conditions. And that is not the -- I don't have an analogy here that would make that particular requirement.

MR. JONES: So let's see here. To make, I guess, some varied opinion on the notion of a lead canister --

MR. TORRES: I just want to ask a follow-up question here. Considering the limited operating experience with interior inspections of these systems, is there anyone here that believes that the use of surogate inspections decides what -- meaning other sites with similar environmental conditions and similar sourcing of the concrete and, you know, same assigned criteria -- can they reference other sites' inspections? Is that valuable?

MR. POPOVICS: I think that kind of information would kind of build a database on the overall performance of that particular storage systems. Like, oh these systems that have problem and what environments or these systems, this corner is the issue. I mean, that's very valuable information that's helpful to everybody. But I would caution against saying, oh, this one in New Hampshire, I'm going to say this has the equivalent of Washington State. I think going beyond the statistics of overall performance for a particular design is a little bit risky.

MR. BERKE: Yeah, I think other than possibly getting too hot on the inside the things that are going to just lead degradation to the interior of the concrete aren't any different than the things that are going to cause the outside of the concrete to deteriorate. So if you don't have -- if the outside looks good it's a good -- you know, as your temperature values over the range haven't gotten too much of a dose of neutrons or gamma rays you should be fine inside, you know, by looking at it every five years. Should be okay because it's not a different concrete that's on the outside. And the outside, you know, I can't believe you'd get something occurring on, you know, other than it's a radiation type thing, how you'd get something on the inside that wouldn't manifest itself to the outside. Most of your, out of that environment, most of the things are coming in from the outside anyway so they might even give you a little bit before that.

But, so I think they're five years and opportunistic. I mean, if they're looking at that lead canister for any reason whatsoever, if you take a look at the inside of that concrete, when you got the chance, I mean, it's kind of a golden opportunity at those points if they're going in there for something else. But it probably will pay in those cases with the possible exception of what I talked about -- if you had some type of corrosion going on because of ultra-high temperature or something else or that it got cold and you've got other phase transformation. That can delay that formation but other than that, I mean, I mean those are different concrete degradation mechanisms.

MR. JONES: Maybe I misunderstood your question.

MR. TORRES: I think what I'm trying to get through is baseline inspections are critical.

MR. BERKE: Baseline should be at day one when you realize you should get that baseline.

MR. TORRES: But the potential of having one site say this other site has performed inspections and it's under this set of environmental conditions, same type of sourcing and same testing for aggregate activity and so on, design criteria, is there a concern in here that that approach is thinking --

MR. JAMES: I think you can use that information to guide what you do at your site very effectively and maybe reduce what you do at your site. But I don't think it would be a substitution for inspection here in the individual site.

MR. XI: Yes, I agree with Randy. I think -- I'll give you one example. That's a problem I had before. So if the two sites are side by side the concrete was supplied by the same Ready-Mix concrete company, same aggregate. But one site is fine, the other one, right away is transverse cracking every three feet. So what they said or I'll read them right here, from my lab which ran the test to find out way. So finally, you know what, we run the tests for the concrete with the drying shrinkage -- the automated shrinkage was the same. The only difference is that this one, the one that had cracked, the early rate of shrinking is high. So the automation is all about 1,000 psi. But this one, 700 -- not psi, microstrains. But this one could even at 100, so 700 microstrains happened in the first week. So basically the cement was different, but from the same plant. So that's why my recommendation is just every single one of them go through the same process. We cannot use same size, same environmental condition and same suppliers and it will not work.

MR. BERKE: Yeah, I tend to agree with that. But I think what Larry said made a lot of sense. I think you build up a database. And if you get, let's say, 500 of this cement type, 500 of this type and 500 of that type you might see a trend on which parts of these tend to show more damage. So one might have a problem here. Another one might have a problem somewhere else. So you'll see actually the perhaps design related problems that would pop up. It's kind of like if you have an automobile. Every one of them feels different but they all tend to show that they have a problem with their airbag system after a while, you start looking at the airbags as possibly something that's going to wrong.

MR. JONES: So that's a little bit of trend, so that's trending and making observations to be a useful tool. But that's a little bit different than appealing to that as a --

MR. BERKE: But it'll help them in the long term.

MR. JONES: Sure.

MR. BERKE: Because in the long term they'll have the database and then it will help them decide what they need to specifically look for in an inspection.

MR. JONES: No doubt helpful but I don't know that we can -- I think John's concern is, and Randy's, you shouldn't appeal to that as a reason why yours would be somehow in good shape. I'm speaking hypothetical, of course, but.

MR. BERKE: I think that would be more useful if there's a problem area in it that needs support. Doesn't mean you're necessarily better if you have less of them.

MR. JONES: So we've -- actually I didn't on this slide. That's on this slide number 37 if you're on the phone. Let's -- I want to talk about this notion of below grade so there's a page here, 349, 3Rr. Ten year for below grade, inspection frequency. And that seems to me to be kind of a tough problem, knowing what's going on on the earth side of things or if there's a deeper convection or something like this. Does anyone have a thought about below grade inspections or perhaps an experience from another industry, another field on?

MR. POPOVICS: Before we start I had a question about the definition of below grade. That's wasn't --

MR. JONES: Okay, that's fair.

MR. POPOVICS: -- kind of well-defined in the documents of 349.3R. What does it mean? I mean, is it completely below the top of the grades such that you will never see it? Or are you allowed to excavate soil and replace? So when we say below grade do we mean we are never moving any soil and we will never see anything? Or it's currently below grade but if necessary I can excavate and take a look?

MR. JONES: Or perhaps partially so or? Fair question. I don' know.

MR. CHOWDHURY: Isn't that the first part we never see opportunistic if somebody does some digging for some other reason and take advantage of the opportunity.

MR. TRIPATHI: Well, if somebody asked me what's below grade as opposed to above grade I would say that anything which is in contact with the soil is below grade. Anything above the grade level or the ISFSI pad level --

MR. CHOWDHURY: Yeah.

MR. TRIPATHI: -- that's all above grade.

MR. JONES: But now for the inspection process are we allowed to excavate to take a look visually or run some tests on the area that used to be below grade, but we excavated the soil, got access and then replaced. Is that out of the question?

MR. TORRES: So it's actually nice to -- some questions that I think we point to here --

(Simultaneous speaking)

MR. TORRES: I've really actually asked another question. That also ties to whether or not there needs to be other than ground water coming from monitoring over a structure -- if opportunistic inspections are sufficient. That's where I think we're looking for some feedback here. It is certainly an option for some of these systems or at least for the pad if it's important to safety. It would probably be the first structure to get affected by, say, the ground water or the soil. So I think we're looking for feedback from you all on this also.

MR. JONES: So I'm hearing that we need it by the way.

MR. POPOVICS: But for the purpose of this discussion let's assume that we're not going to excavate. Let's just say for now. This is John Popovics, by the way.

MR. TORRES: Yeah, and I think that if ground water comes through monitoring it's adequate. It's sufficient. I think that would be an adequate approach to just use our inspections and, but.

MR. POPOVICS: But looking at that conversely if we assume that we do not excavate is ground water sufficient?

MR. TORRES: Yes.

MR. POPOVICS: Okay, I just wanted to clarify that for the --

MR. CHOWDHURY: If we take that example of a concrete pad then on top of the pad we can see the sides and the --

MR. POPOVICS: Right, it's a shallow foundation pad/footing.

MR. CHOWDHURY: Yeah, sides and the bottom we cannot see. Those are by the ground. So, again, as we would say, we want to implement. Our current thinking is that top is above ground, as we can see. The sides and the bottom below grade.

MR. POPOVICS: But just because I don't know about these structures I imagine there are other sub-grade structures which are not simple pads, more foundational. Some of these containers are completely underground, right, and this is a totally different case. Right?

MR. TRIPATHI: Yes, there are underground, totally underground cask systems.

MR. POPOVICS: Are there any deeper foundations in some cases where you need some sort of piling or something or that all the pads, just kind of slabs on grade?

MR. TRIPATHI: Primarily thick slabs.

MR. POPOVICS: Thick slabs?

MR. TRIPATHI: Hardly any pilings. You know, they're --

MR. POPOVICS: Or walls.

MR. TRIPATHI: Maybe, well, one particular site had to use concrete, in situ concrete piles but that was just to strengthen the natural soil. But then when you come up to the sub-grade level with an engineer fill you just fill over the concrete pad itself. So, but I think your question was, John, different. Are there any storage systems which are totally underground?

MR. JONES: Sure, that's my --

MR. TRIPATHI: And there are. If you revisit my initial presentation back in December Slide 25, 28 and 29 clearly shows these things totally underground.

MR. POPOVICS: Right. I mean, and that's what I want to -- the purpose of the discussion.

MR. TRIPATHI: But you also said that the excavation is not something which we go back and ask the licensee that --

(Simultaneous speaking)

MR. TRIPATHI: Excavate and see what's going on.

MR. TORRES: Any excavation will potentially change design basis. We're avoiding that necessarily.

MR. POPOVICS: Yeah, so let's say for the purpose of the discussion now we are not excavating.

The separate structures are either thick slabs on grade or underground containers.

(Simultaneous speaking)

MR. DAVIS: Yeah, this is Marlone Davis, Division of Spent Fuel Management. Yes, they below the ground in bunkers, so to speak. And they all are able to be retrieved out from there to give you the visual.

(Simultaneous speaking)

MR. DAVIS: So the bunkers are concrete surrounding and then the canister being able to be retrieved, and that's below ground.

MR. JACOBS: And so just for my edification the justification for the ten-year versus the five-year is based on the ACI code as opposed to anything else?

MR. DAVIS: That is correct, yes.

MR. JONES: And is that grade? I don't know.

MR. JACOBS: No, that's just, yeah.

MR. TORRES: Well part of the reason, I think I'd also mention, is ISI as much.

(Simultaneous speaking)

MR. JONES: So I think, I guess, the other next question do you feel first of all the frequency is long but is a ten-year frequency or whatever we're doing, ground water monitoring or I guess we're not excavating now -- is that where we --

MR. TORRES: Okay, I was going to say if we could part from that premise where we're not doing excavation -- get over it -- just using opportunistic inspections. When we have ground water it comes through monitoring which might be quarterly or every six months. We have some criteria that we defined from -- we've given you based on what's in the gallery of pictures which is the same thing that's in Section 11, so Section 11 we'll be on.

There seemed to be some argument on whether we're sure that chloride concentration does not seem to be adequate direction. Also is there anything into the inspection report, that warrants activity through the corrective action program. We still think there was some confusion there. So knowing what we know or at least this limits what is wrong about our chemistry monitoring, is that still a safe assumption or not -- just not doing ten years? Just going to that and then after we see those indications of aggressive water then we decide we need to inspect?

MR. POPOVICS: This is John Popovics. I

mean, I would answer the same way when Chris asked about visual inspection alone. Is that sufficient to kind of ensure kind of confidence in condition? I'd answer this the same way. It's a very important metric. I think you should do it. Very valuable but by itself -- by itself -- I cannot tell you what's happening to -- really happening underground. It just says the potential, the environment is ripe for this but it doesn't say it's happening. So I think it would be a very valuable groundwater modeling where you are monitoring the right species. And yesterday we talked about maybe broadening the range of species, the ions that you look at. It's very valuable and certainly you should do it. But would I rely only on that to make decisions about the conditions of a bunker, let's say the concrete around the cans? I'd say it's not reliable. We need more information. But it can guide you. And it's, like visual, great information, maybe essential.

MR. BERKE: Neal Berke. I tend to agree with John. And one of the things you have, certainly the ground water, based on 349 and 201 in ACI will tell you and even ACI 365 will tell you what type of concrete you have to have based on how much salt, chloride, resistivity of the soil is. But you should actually have a type of concrete wall. So hopefully if you had some salt base in the soil you use a Type 5 cement or some sort of mitigation technique so you have some prevention there. You had enough sacrificial cover of concrete. Now those designs are typically based on maybe a 50-year life if you follow everything and you're not doing anything. You've got about 50 years within those subsequent conditions. But ground water will tell you if you've got a process where you're leaching calcium out of it or the ground water's getting worse conditions. It can certainly you that. It can't tell you if you have ASR going on down there. The ground water's not necessarily going to change at all. So it's not going to tell you that's going on. It's not going to tell you if you have salt that attacked inside your concrete because it won't necessarily leach any calcium. So if you have a process that's leaching calcium out it'll tell you that. If the ground water, for some reason, is getting more corrosive because you're next to some ocean or something where water -- because some of the patterns of the water or tides or something changes you've got -- it won't tell you that. It won't tell you what's necessarily going on. And if the water level's going up and down in the freeze zone and the concrete already gets some freezing it's not going to necessarily tell you you've got biological growth next to your concrete and it's acidic down there. So there's a lot of things you don't know. However, the general design, if they did everything right, you probably got close to 50 years anyway for the conditions at least you started off with.

Now you will be able to see from the top of the slab, you'll be able to see if there's freeze/thaw damage. You could probably see ASR occurring there, put a cap and so. And if it's ASR on the top of your pad it's probably occurring down below in the part of the pad you can't see. If it's occurring, if you have freeze/thaw damage there then it's probably occurring wherever the waterline is there, in that region where it would freeze there. So you can pick up some of that stuff.

Obviously if you see some sulfate attack you might be able to see that. So anything you can see from looking at the top of the pad will certainly -- if it's happening on the top of the pad it's most likely happening deeper. With the exception of freeze/thaw deep down it's probably happening everywhere else in that concrete. So that's a good indication. The ground water will tell you if things are getting worse and/or not changing, which is good. But it doesn't tell you everything that's going on.

MR. JONES: So the ground water is just going to be an environmental condition with the possible exception of leaching. If you're leaching --

MR. BERKE: Yeah, if you're leaching that's a --

MR. JONES: That's maybe a small thing about the concrete but it's basically just a --

MR. BERKE: Yeah. If you see the pH change in the ground water for some reason then you might worry that now, all of a sudden, the concrete down below is much more, the environment is much worse all of a sudden. So then you might have to do something more than just look at ground water.

MR. JAMES: So this is Randy again. I think my idea into that was what about trying to do some movement monitoring, put some monuments on top of your slab and just monitor the deformation or what's going on on top for these buried structures that you really can't see. I think, it seems to me that would give you some good information. If you're moving upwards or swelling something's not quite right. If there's settlement, you can see the slab is settling on you, that might be an indication to go look more at what's going on. And it's pretty easy to do. Put some -- movement in the slab.

MR. POPOVICS: So in addition to what -- so there are some methods that maybe could be applied in addition to complement ground water modeling and gross deformations. So resistivity might be kind of an easy test and another set. So that would tell you basically about conductivities, electrical resistivity and corrosion potential. Again, it's just the environment. But it could give you another sense beyond the ground water model.

And another thing is that there are some NDE methods for deep foundations that tell you gross properties of buried concrete elements. And based on the design of this concrete bunker that I saw these are kind of walls going down, a kind of sheer wall kind of thing that's embedded and encase the bunker. And a method like seismic echo or cross-hole sonic logging is a way which you can infer mechanical properties of the embedded concrete grossly in terms of thickness. Oh, wow, we are losing stiffness or we're losing sections halfway down.

Some of these are somewhat invasive in that you have to drill and embed a sensor tube next to it in water.

MR. JONES: Soil.

MR. POPOVICS: In soil. Experts say drill a sensor, a hypertube in water next to the soil, embed it and then you take measurements along there to kind of interrogate the structure. And it's a little bit rough. It's gross. But you can monitor over time and see changes in the mechanical properties of that wall. So there are some approaches that could translate from the deep foundation NDE field.

MR. TRIPATHI: Well when you say deep foundation, John, let me make it very clear that we are not talking about 700, 800 feet like we have for --

(Simultaneous speaking)

MR. TRIPATHI: We're talking about probably 50, more than 50 feet.

MR. POPOVICS: Well let me clarify. Deep foundation means anything that's not a slab on a grade. Anything that's sticking down into the soil. And what I saw on that bunker design, it's indeed a deep, a mini-deep foundation where you have concrete going into the ground and you want to know the quality of that concrete as you go down away from the surface. And so thank for clarifying that. I don't mean a pile that goes 100 meters down. But the technologies --

MR. TRIPATHI: Now you mentioned that the seismic, cross-bore holes and stuff, that's really done for a really deep foundation. But we don't have that situation.

(Simultaneous speaking)

MR. POPOVICS: Shallow is easier than deep so there's nothing limiting it. It doesn't need to be 100 meters to apply that technology.

MR. TRIPATHI: Luckily most of the sites we hit a good bedrock, solid bedrock within 40, 45 feet at the most.

MR. POPOVICS: That's pretty deep.

MR. TRIPATHI: Some even quicker.

MR. POPOVICS: Okay.

MR. TRIPATHI: But it's not like 700 feet down.

MR. POPOVICS: No, no.

MR. TRIPATHI: In some cases they use engineered soil as their initial soil after that peak, that foundation. So those are very rigid, strong foundations, concrete mass.

MR. JONES: So there might be some other tools rather than just ground water monitoring that can help us with this? I mean, let me just try to get us here to the proposed AMP. This is proposed anyway.

MR. TORRES: It's coming out of --

(Simultaneous speaking)

MR. JONES: So the AMP is much more than this but for the comfort of the panel basically we're talking about the middle phases where we're talking about monitoring, detection, corrective actions, things like this. So, and again, we've sort of already been getting into a lot of this material. But that includes visual degradation inspections. And maybe we're going to distinguish those from routine inspection, but visual degradation inspection and some frequency, ground water chemistry monitoring, radiation surveys and we, in the past have asked do we feel like this is adequate. And the results were maybe kind of diverse. And I want to just spend maybe the time we have left before lunch talking about what we think about this. Again, I'm going to the observation side. Pretty universally it was identified that these methods would not be sensitive to internal damage. Of course there's the question of how structurally significant that is but we're going to be insensitive to those. And then the initiation of anything we're probably not going to miss.

So maybe we could just talk about how this, the AMP looks and how it could be altered. And that's sort of my general question here if anyone would want to be bold and jump in.

MR. TORRES: Yeah, I think you guys have seen the AMP by now. It does rely on visual inspection for ACI 349.3R and it uses the ground water chemistry monitoring. It does not take into account motion sensors with surface or any other mitigation activity. I think we need to talk about these inspection intervals. And baseline inspections should be required. I think that's general agreement here. Survey inspections don't seem to be adequate and a five-year inspection interval for accessible areas seems to be adequate. That's the information I gave to you.

Ten-year seems to be something that potentially a licensee could come in with an approach where it uses multiple techniques to potentially support the technical basis for not doing any excavation. Right now we read stuff. There are inspections every ten years. So I think it seems to be -- I'd like to hear a little bit more on the below grade and see if that's something that everyone here thinks that, if we can have some sort of additional discussion on whether or not initial inspections should remain as something in the example AMP or concerning multiple techniques for the --

MR. JAMES: Are you saying that every ten years you expect excavation and visual inspection at the below grade, part of the below grade structure?

MR. TORRES: You would perform an excavation and look at the area potentially more susceptible to water and --

MR. JAMES: That seems adequate to me, I guess.

MR. BERKE: Yeah, I mean, I think as you look at the corners, that's going to be the place where you're going to have the most coming in because you can -- it's two-dimensional versus one-dimensional. So you don't have to excavate the entire pad. You find the corner that's got the most water, where the water -- if there's no difference where the water is you could pick a random corner. But if there's some you pick a corner and you look at that. But one of the things is if you're -- a lot of the damage you're going to see below grade, if you've got access to the top of the pad it's going to be on the top of the pad too.

MR. JACOBS: As well, yeah.

MR. BERKE: And so if you've got a sulfate problem in the soil you'll see it on your -- you'll see it near the -- basically you don't have to excavate or maybe you only have to go down a few inches of the soil, move it away and look at it. So you'll see that there. You'll see that provided you have one soil strata. The question is if you get your soil stratified, which I doubt you have with these things especially with the short, small ones. It should be all the same soil type. So you should be able to see a lot from the surface. And that and the ground water should tell you if you really need to excavate.

When you have to excavate the corner's the place to go. And you can see, you'll get a lot of information. And then you can use all the techniques, all the visual techniques and all the other techniques, all the non-destructive techniques.

MR. TRIPATHI: Or there could be a scenario where during the visual inspection you see the bad, I mean the differential settlement. You said they're like 200 feet long and they're 50 feet wide. And if you see one end going up and relative to the other you know that that corner has some problem with liquefaction or what have you.

MR. BERKE: Yeah, that gets out of my range of expertise. Let's call on Randy.

MR. JAMES: I thought that was going to -- I didn't realize you were going to excavate every ten years and physically look at it. So I don't know that there's a reason to monitor the movement of the slab, you know, monitor it.

MR. TORRES: Just one part of it too. So it's what are potential approaches.

MR. JACOBS: Do you think the excavation will cause events --

MR. BERKE: Events and is that a possibility?

MR. JACOBS: Yeah, and I'm wondering if -- I like Neal's statement that you can get a lot -- a lot of degradation mechanisms you can get from the top anyway. And, again, I'll echo what John said, that the highway industry, they're good at these gross ventures with these acoustic techniques.

I was -- these, you send a wave down, looking at it bounce back. And you can, it's a well-defined -- we know what's under there, these sort of pile integrity type measurements. I'm wondering if that approach is not a smarter approach, that you don't touch it. You don't scrape it and do that stuff. And then if surface, on the top, add, do the differential settlement or anything like that. And then, worst case scenario, if you see something, then excavate and go for it.

MR. TRIPATHI: Randy, I think probably there is a chance you misunderstood what Ricardo is trying to say.

MR. JAMES: There's always a good chance of that.

MR. TRIPATHI: It's not a requirement that every 10 years thou shalt do excavation.

MR. JAMES: Okay.

MR. TORRES: No, it's what's on the AMP right now is what we're discussing.

MR. JAMES: Okay.

MR. TORRES: If you're out of suitable frequency, it can be 20 years.

MR. TRIPATHI: We are seeking an opinion.

Is that ten years necessary or should it be more? Should it be less? I think that's what --

MR. POPOVICS: To be clear, this is for an excavation and a visual.

MR. TORRES: Yes.

MR. POPOVICS: When you say 10 years or 20 you're talking about excavation. Is that right, Ricardo?

MR. TORRES: Yes.

MR. TRIPATHI: Say that again?

MR. POPOVICS: Are you talking about an excavation at 10, 20 or other period?

MR. TRIPATHI: That's what I believe the AMP --

MR. POPOVICS: Okay.

MR. TRIPATHI: -- is suggesting.

MR. POPOVICS: I heard Ricardo say yes.

MR. TRIPATHI: Yes, it's not set like in hard rock that thou shall do every 10 years. But we are asking your opinion that are ten years' frequency okay or not.

MR. POPOVICS: I see.

MR. TRIPATHI: Should it be five years? Should it be 15 years?

MR. POPOVICS: Well I think the 349.3R document has, for instance in the five-year recommendation it also gives a lot of flexibility to the individual operator/owner to amend that under unusual environmental conditions or their own judgment. And I think that is appropriate here too.

So if you set it roughly ten years but leave it to the judgment of the operator, like if we have an unusual ground water situation, because we're monitoring it it should be sooner. Do you think the flexibility to apply it sooner?

MR. BERKE: Well I don't think they have any problem if they do it sooner, right?

MR. TRIPATHI: Oh, no.

MR. BERKE: It's doing it 20 years.

(Simultaneous speaking)

MR. TRIPATHI: On the previous slide it did say if the problem is detected they'll do it sooner.

MR. POPOVICS: Well with the possible exception that we might be -- that might be a bad idea to be excavating if you're asking for more.

MR. JAMES: So in lieu of the ten-year excavation it might be worthwhile to think about some of these other techniques that aren't quite so invasive. Or maybe a little step up from looking at settlement issues, if you notice any of that you might want to do it. But if you haven't noticed that you might still want to do whatever your magic is down there. Come up with some stiffness changes or something. And if that indicates something then maybe an excavation is required. But I --

MR. POPOVICS: Well I think that sounds like tiered approach which, like, whatever the first tier stuff. So that's ground water, modeling, visual on the top, access. Now the slab on grade, that tells you a lot about the whole slab. If it's a bunker it doesn't tell you so much. Settlement, unusual events and maybe some of these NDT methods that perhaps can be transitioned from the foundation to get you to Tier II.

MR. BERKE: Looking at these bunkers you might not have to inspect the ground at all. I mean, there's no reason at all why you're going to not fill this up with clean material.

MR. TRIPATHI: We don't call it a bunker. We call them a vault.

MR. BERKE: Well the vaults. Well why would you put anything but clean fill around it?

MR. JAMES: It's probably engineered --

MR. BERKE: And do something to keep that fill clean. You don't have to inspect them at all.

MR. POPOVICS: Yeah, but there are many probably in the ground right now.

MR. BERKE: No, these -- if you look at the picture here, they've got to excavate, you fill that up with dirt right behind this.

(Simultaneous speaking)

MR. BERKE: But ideally, anybody, you put something -- you know it's one thing, if you're putting something in the ground, Caltrans, FHWA -- all the reports tell you you put in clean fill. You don't throw junk around it.

MR. POPOVICS: And I think that's true. You could still have a potential migration from --

MR. BERKE: If you have enough of it and you could put a -- it's very simple to put a membrane around or a little thin sacrificial concrete wall around that.

MR. TRIPATHI: Those so-called bunkers are only 200 feet from the Pacific Ocean.

MR. BERKE: Yeah, so that's when you might actually put a -- if I was to design something like that

I might even put a mobile fill concrete fill in there and then put maybe a sacrificial concrete wall on top and that's supposed to keep stuff from getting to it.

MR. JONES: So I guess what we're trying to hit on with the notion of this AMP that, do we feel like this is a reasonable way to approach, with the knowledge that there's a tiered --

MR. XI: I have opinion.

MR. JONES: Sure.

MR. XI: Actually I think ten years is too long. Ten years is too long and it means a lot of things. Let's say you inspect for old structures. Let's say if it's already 40 years old and then you inspect in the 50 years and that's too long. For new structures ten years should be fine. And also, let's say for different role of settlement, you can do it on the surface.

Yeah, there are equipment so the people use it to detect the, even below grade, all the settlement on the concrete basement slabs. So there is commercial equipment, very easy to use. You get the like half-inch, one-tenth inch movements on that. So you can do that. But a lot of the things you cannot detect from the surface.

If you have a slab, let's say a 200 or 300 feet long, 100 feet wide, and what happened in the center, and whatever on the edge is totally different because in the center it does not have direct contact with the soil. So that's why I think, especially for the old structures you should do the inspection every five years and see the surface, if there's any crack or anything.

MR. TORRES: I think that at the periphery of the base.

MR. TRIPATHI: Yeah, yeah.

MR. JAMES: I think you just, you should realize there are risks when you do an excavation next to a structure like that. I mean, you've got heavy equipment, you're right next to it, and when you backfill you're putting pressure against that wall. You'll then have a situation where you don't have even rating. You now have a different --

(Simultaneous speaking)

MR. JACOBS: You're taking a stable, not loaded, and potentially making it unstable.

MR. TRIPATHI: And there are different dose requirements at the cask, as the site boundary. I mean, there are a lot of implications. I agree with you that before you start excavating around the periphery of the support pad which would be needed.

(Simultaneous speaking)

MR. JAMES: Excavation as a --

MR. TRIPATHI: Last resort?

MR. JAMES: -- a necessary thing when you identified something is going on and you really need to get in there and take a look.

MR. TRIPATHI: So you remove all of the surroundings or just part of that when you do the inspection?

MR. JONES: I'm sorry?

MR. JACOBS: Excavation.

MR. TRIPATHI: Excavation. Do you remove everything here, surrounding or just remove part of it?

MR. TORRES: It would be in a localized area.

(Simultaneous speaking)

MR. TRIPATHI: Localized?

MR. TORRES: Certainly. And there would have to be some technical basis for it.

MR. JACOBS: Okay, so it's just a corner or something like that.

MR. BERKE: The corner's going to be your worst location, all things equal. And probably, at least for a pad you could probably go in there with a shovel and move a little bit away from the corner to take a look at it and not bring in the heavy equipment and then put it back in.

MR. JACOBS: I was thinking more of these -- I'm not too worried about the pad, frankly.

(Simultaneous speaking)

MR. TRIPATHI: And then these systems are very engineered so well condition. So you're going to need the excavation. So what -- it would be hard to have an excavation if necessary but there may be some of this involved. So what is that expedition?

(Simultaneous speaking)

MR. JAMES: I'd just do it, if it's necessary, to get more information when you've identified a problem. Don't require it to be done every ten years.

MR. BERKE: I agree. You have to watch the surface condition though because the surface will tell you a lot of what's going on.

MR. JACOBS: That's if the surface tells you something that you don't understand or you don't --

MR. BERKE: That you're worried about, yeah.

MR. JACOBS: Then you do the excavation.

MR. BERKE: Right. Absolutely.

MR. JACOBS: But default is not the excavation.

MR. TRIPATHI: Oh, okay.

MR. POPOVICS: And I agree. But it would be nice to get more information to make that assessment to excavate rather than relying on ground water chemistry to pull up.

MR. JAMES: Yeah, before we've got another step we need to do some --

(Simultaneous speaking)

MR. TORRES: So follow-up to ground water chemistry monitoring, the acceptance criteria right now, it's 500 parts per million chloride. There seems to be some disagreement in that respect. Does the people in this room agree that that threshold is, should be lower or what is the general agreement here?

(Simultaneous speaking)

MR. POPOVICS: I think magnesium is going to go penetrate easier in the cement.

MR. BERKE: Pardon me. I certainly

wouldn't go less conservative than what ACI has.

MR. POPOVICS: Did you say you wouldn't?

MR. BERKE: I would not go less conservative than that.

MR. POPOVICS: Would not go less conservative.

MR. BERKE: I wouldn't raise it to thousand or anything. I mean, I'd keep it 500. I'd keep the sulfate at that, provided, of course, once again, you follow the designs for them because they -- I mean, people look, you've got this and they tell you what kind of concrete you're supposed to make.

If you didn't make that kind of concrete the chlorine might not be so bad because below 500 parts chloride you might not have enough threshold value to cause much of a problem, as long as the concrete doesn't carbonate. But the sulfate won't bad. You'll be at a higher sulfate content.

MR. TRIPATHI: Sulfate is at 60, right, part per million?

MR. BERKE: No, it's not.

MR. TORRES: Sulfate? It's 1,500.

MR. BERKE: 1,500.

MR. TRIPATHI: 1,500?

MR. BERKE: Yeah, it's higher, the sulfate.

MR. TORRES: Much higher.

MR. BERKE: It would be bad for -- if the pH for some reason drops then it wouldn't be bad from the corrosion of the seal point of view but we'll assume the pH isn't going to drop to that.

MR. TORRES: And again, realize that this is much, these measurements are taken from samples much lower than, the earth surface. That's something of locations and the surface.

MR. BERKE: Now do they get soil data when they place the stuff in the soil? So maybe you want to look at that historical soil data.

MR. JONES: So let's go get a sandwich or anything else you want. We'll meet back here at 1:00 p.m. Eastern time for anyone left out.

(Whereupon, the foregoing matter went off the record at 12:00 p.m. and went back on the record at 1:03 p.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

(1:03 PM)

MR. JONES: I hope everyone had a good lunch, good conversation, good food. Well, okay, food.

So we have, I guess, two sort of gross topics left. You know, major topics, left. Time limited aging analyses and remediation, repair and replacement.

By participation, no, it doesn't have to be this way, is that the time limited aging analysis discussion will be a little bit short. And so we may get into some of the repair and remediation topics a little early before the break at 2:15. Or we may not. TLAA may take a little time.

So anyway, we'll be a little bit flexible towards the end of our schedules here and maybe circle back to some things that if anyone wants to talk about, we can do that. I know that there's some issues with flights and weather so, you know, it might be beneficial to wrap up a little earlier for people. I don't know, but.

So time limited aging analyses. I guess the concept is, you know, could there be a degradation or a phenomenon that you could, through analysis and knowing your time period of license, you know, exclude from consideration. And so the obvious one that's come up in sort of thinking about this is radiation.

We know that the radiation loads are lower in the casks than they are in the plant itself. And so that, coupled with the fact that we've got some limits, although perhaps, you know, John raised some questions on what those limits are and how should we interpret them.

With those limits and the fact that the radiation level is a little lower, we can envision a situation where, you know, this could be a good candidate for time limited aging analysis, so.

I guess my question, my two questions, do we feel comfortable with that, I guess, is a general one. Do we need to more about any sort of coupling or do we think we know even the radiation itself well enough for these? So, we'll just start with that for now. Do we, you know, are we comfortable with the understanding of the phenomenon to use these limits? Things like that, so.

MR. Popovics: First, this is John Popovics. So, again I have concerns about the limits you have there that are taken from the 349.3R document. And that I because I think, and Yunping and I have agreed, that the units that are described there, with Gray and also the neutrons per meter squared, but in particular the first one of the flux numbers, I think that those units were not properly taken from the reference document.

MR. JONES: From the Hilsdorf documents?

(Simultaneous speaking)

MR. POPOVICS: Now whether they intentionally changed the units to lower it by two orders of magnitude and had some understanding of that, they didn't justify it in the document. And my concern is they just took that number and misappropriated the units.

Similarly the gray unit there in the document, it's in rads. In R. Ten to the ten. Now whether they made the conversion with an understanding that a technical basis is ten to ten Gray, I don't know. It's more likely they just took ten to the ten and misappropriated the units. I don't know.

So you have to be very cautious with these unit numbers and kind of put more thorough scrutiny of those numbers needs to be done, just and in general.

MR. JONES: Okay.

MR. CHOWDHURY: Also, I think yesterday there were some questions about the way they have been calculated. So that could also affect this limit.

MR. POPOVICS: Right, yeah. Because I think in the -- again, there's some units mix up potentially and also an understanding of the limits. So in the Hilsdorf document, that fluence number is established, from what I read from Hilsdorf, it's like the critical level, beyond which you are starting to potentially accumulate damage. Whereas in the 349 document, that number, although with units changed, is listed as a tolerable lifetime limit. And to me, those are not two --

MR. JONES: They're different concepts.

(Simultaneous speaking)

MR. JONES: Okay. So there's some concern about the limits perhaps?

MR. POPOVICS: Yeah. I think they need to be double checked and maybe what's there is right, because they have a basis for it.

MR. JONES: Yeah.

MR. POPOVICS: But they just didn't describe it in this document.

MR. XI: Yeah. Yesterday I already, you know, I also talked with John after meeting during the lunch break. So this image, does he even use N versus cm squared? So that will ten to the 13th. And then I put two figures in my answer. Let's see it went like this, all right?

I took this one, this is 10 to 14 -- 13 I think, 13 is being divided by 10,000. There will be no damage at all in structure.

MR. POPOVICS: It's a very low influence.

MR. XI: Yeah. A very low, very -- I think it's over conservative. But as a standard that was fine. And then a little bit discussion with a gentleman (phonetic), so the lifetime limit must be lower than the critical value.

MR. POPOVICS: Mm-hmm.

MR. XI: So, it is. You can compare that. Here it's obvious, about ten to the power 20. And, you know, most recent paper published by LePape and Larry mentioned yesterday -- actually I also put the figure in my answer. So they have physically the same trend. The same trend that, about the same critical value. So in that case, in my answer, I said the ACI lifetime limit is fine. Because it's very conservative. Very low value.

MR. TRIPATHI: When we say lifetime, what kind of life are we talking about here? 60, 100, 300?

MR. JONES: In the document, I'd --

MR. XI: Oh, okay.

MR. TRIPATHI: Lifetime?

MR. XI: Lifetime means --

(Simultaneous speaking)

MR. TRIPATHI: Cumulative.

MR. XI: Yeah, cumulative.

MR. JONES: Yes.

MR. XI: Yeah, because this is not intensity. Intensity is always divided by cm squared divided by seven or by day, depending on the time unit. So that's the intensity. But this is the cumulative.

MR. TRIPATHI: So this automatically, this here in 349.3R is on the conservative side?

MR. XI: Yeah, it's very conservative.

MR. TRIPATHI: And so we just tell the client or the applicant could do that.

MR. TRIPATHI: Yeah.

MR. POPOVICS: That's for the fluence, but the Gray --

MR. XI: Fluence.

MR. POPOVICS: The gray and the rad --

MR. XI: Right.

MR. POPOVICS -- has to be vetted more.

MR. XI: No, no. That's for the gamma ray.

MR. POPOVICS: Yeah.

MR. XI: So this totally different.

MR. POPOVICS: I know.

MR. XI: Yeah.

MR. POPOVICS: No. What I'm saying is that in this first document, it's ten to the ten rad that's listed there.

MR. XI: Oh, that's divided by 100 --

MR. POPOVICS: And here it's to 10 to the 10th gray. So --

MR. XI: But that's divided by 100 --

MR. POPOVICS: So --

MR. XI: -- by 50.

MR. POPOVICS: But did they do that on purpose because they have a technical basis or was it a mistake? These things need to be vetted.

MR. BERKE: Well, the papers I looked at

tend to think they probably add the gray from the neutron flux. And you kind of wonder if -- and I've see neutron fluxes that were that what ACI was saying was okay. And the grays were a little bit, the gray value was a little bit lower.

MR. XI: Okay.

MR. BERKE: So it could be this don't get that high gray value all by itself. I don't know. I'm not a nuclear guy, so it might be that it's perfectly okay.

MR. POPOVICS: It might be, but my point is that there's a lot -- to me it looks very suspicious.

MR. XI: Mm-hmm.

MR. POPOVICS: And it just needs to be vetted a little more so that we have confidence that these numbers are what, are based on the literature that that 349 document is reporting.

MR. JONES: So you mean, so there's some ongoing research on this topic, too, through the Office of Research and so. So to sum it up, we're --

MR. POPOVICS: Right. Yeah.

MR. JACOBS: I was speaking on this with Joe Wall. I don't know if Joe does some work in pressure vessels and what.

MR. WALL: Yeah, we've been looking at this issue in reactor cavities for about four years with Oak Ridge National Lab. We have a very good handle on, you know, on neutron flux and in concrete and, you know, basically what you're looking at is swelling of the aggregate.

MR. JACOBS: Sure.

MR. WALL: That forms the base limit of the silica. And we don't really see that occurring in most aggregates until after ten to the 19 neutrons per centimeter squared.

So there you've the value up on the screen is orders of magnitude, conservative. If you integrated the neutron flux over 300 years is less than that. You're not going to have a problem, even if it's more than that by several orders of magnitude.

MR. JACOBS: Mm-hmm.

MR. JONES: Can you identify yourself for the record?

MR. WALL: Oh. My name is Joe Wall and I'm from EPRI.

MR. TORRES: But I think you're still referring to the gamma dose.

MR. POPOVICS: I'm referring to both. I

think, I just, I think it's a worthwhile effort based on the experience we have in the room, or that you have in-house to kind of nail down these numbers and make sure that what that is reported in ACI 349 is correct and has the technical basis or is it a mistake. It could be a mistake. Both of those numbers.

MR. WALL: And --

MR. POPOVICS: That's all I'm saying. I'm not saying it is a mistake. I think, I'm a little suspicious and it's worthwhile to kind to of, you know, I think it could be clarified pretty quickly.

MR. TRIPATHI: Referring to your third reply, you mean, I think what you are saying here is it's 10 to the 8th for gamma, which is equivalent to 10 to the 10th rad, r-a-d.

MR. JACOBS: Oh.

MR. TRIPATHI: Now here we are talking about something different --10 to the 10th G, while your paper says 10 to 8th.

MR. XI: So this is, yeah, that's why, like John mentioned --

MR. JONES: Yeah.

MR. XI: -- they've messed up with the unit. ACI.

MR. TRIPATHI: ACI?

MR. XI: Yeah. I don't want to say they messed up, but --

MR. POPOVICS: Is that the Dan Nauss paper that we're --

(Simultaneous speaking)

MR. JONES: I think the issue has been broached that we need to look and make sure that these limits are correct and the --

MR. BERKE: The grays are usually calculated, if I'm not mistaken, off the neutron flux at the left side.

(Simultaneous speaking)

MR. POPOVICS: No, it's not a radiation --

MR. BERKE: Yeah, but.

MR POPOVICS: -- neutron --

MR. BERKE: Yeah, but I think one of the papers that I had actually did actually physically measure it. They calculated it based on the drop-offs. And that was the value for a much higher value of neutron.

So, and this was a paper done since Hilsdorf, so maybe it had their numbers. But they actually did testing and what they claimed is the neutron flux number to be way conservative.

So, if even you divide it by 300, it's nowhere near it. And really what was the problem was high temperature combined along with it. So as long as the temperature in the concrete stays below a certain point, it's not going to be a problem.

MR. JONES: So, if just assume that we can resolve this performance issue that there's a limit --

MR. WALL: Yeah, right.

MR. Jones: -- what it is.

MR. WALL: Yeah, I just want that assumption.

MR. JONES: And we -- yeah. No, I'm just trying to move this along here. But, you know, if we could move forward with that, you know, do we feel that the effects are well enough understood that, you know, like, for example, a lifetime limit. Does is matter if you accumulate that lifetime limit in a minute or 50 years, you know. I don't know. Not that that would happen in a great gasp, but I'm just floored that these lifetime limits are kind of a gross number.

And then, you know, is there any kind of coupling effect going on that needs, deserves, anymore study? Or do we --

MR. WALL: For gamma rays and temperature couples, it's impossible to keep track of it.

MR. JONES: Sure.

MR. WALL: That's really -- well, and also, I think it was mentioned yesterday about radiation assisted ASR.

MR. JONES: Mm-hmm.

MR. WALL: Radiation can accelerate ASR, plus a few things or two.

MR XI: That I want to make a comment because in that, the most recently published report, 7171 --

MR. JONES: Mm-hmm.

MR. XI: And we find out there is coupling under radiation, but if you read the fourth paper it's by a Japanese --

MR. JONES: Yes

MR. XI: Ichikawa. So they did a test on opal. So this is a well known --

MR. JONES: Reactive.

MR. XI: -- very reactive aggregate.

MR. JONES: Mm-hmm.

MR. XI: So, but they just want to prove the concept.

MR. JONES: Mm-hmm.
MR. XI: So, but for other regularly used aggregate, they need to put some more stuff.
MR. JONES: Well, yeah, there's a good comment. I think amorphization is documented in other types of crystal and silica. So, I mean, you know, maybe there could be some effect. I guess is what I'm -- I guess the question I'm trying to ask is, is this a significant thing that we should also be considering, in addition.
MR. JACOBS: Is the coupling significant? And I'd say yes, right, you know, with the thermal. And I think with the ASR, at least you look at.
MR. TORRES: So, John, did you look at the actual ACI reporting on the 3R or?
MR. POPOVICS: Yes.
MR. TORRES: Okay. Because I'm just taking a quick look here and I see 10 to the 10 rad.
MR. POPOVICS: That's my concern.
(Simultaneous speaking)
MR. WALL: Just to clarify, Hilsdorf is 10 to the 10 gray, not rad.
MR. POPOVICS: Oh, okay. Now I don't remember where the rad and the gray confusion is.

(Simultaneous speaking).

MR. WALL: That's fine. That's fine.

MR. POPOVICS: I remember I saw it in two different places and I was suspicious of that.

(Simultaneous speaking)

MR. TRIPATHI: 10 to the 10 rad is equivalent to 10 to the 8th gray, isn't it?

MR. POPOVICS: Right, yeah

MR. WALL: Mm-hmm.

MR. JONES: A hundred.

MR. TORRES: Yeah.

(Simultaneous speaking)

MR XI: So in that case, for the gamma, the value right.

MR. JONES: No, now I'll never get it right. Yeah.

MR. POPOVICS: You pulled it right out.

MR. XI: And just so you -- it's so conservative.

MR. POPOVICS: Yeah. I'm looking at Hilsdorf right now.

MR. WALL: It looks like 10 to the 20 neutrons.

MR. POPOVICS: The maximum dose for

pre-stress is 10 to the 11 rad here.

MR. JONES: So maximum is a different language than critical.

MR. POPOVICS: Yes. I'm sorry. I'm under pressure to find these numbers here.

MR. TORRES: We'll certainly take a look.

MR. JONES: Yeah, mm-hmm. Anyway, so I guess the final question on this is just a very generic one and that is, you know, do we feel like this is going to be a limiting issue for these casks? We know that the radiation loads are far lower than the operating experience in the bioshield wall.

MR. WALL: Right.

MR. JONES: And I don't mean to be leading in my question, but I'll ask the question. Do we feel like this is going to be a -- that's pretty limited?

MR. POPOVICS: I have a question and that is that the concrete, even though there may be a, inside the cask, there is this level of fluence. There is a steel liner. So the concrete will not feel that, probably at that level. Is that right?

MR. TORRES: We know that the fluences can get to these levels.

MR. POPOVICS: At the concrete's level.

MR. TORRES: Not fluences, I'm sorry. Gamma doses.

MR. POPOVICS: Gamma dose, yeah.

MR. TORRES: Can get to those levels past 100 years.

MR. POPOVICS: Okay.

MR. TORRES: So --

MR. POPOVICS: In the concrete?

MR. XI: Yeah.

MR. POPOVICS: Okay.

MR. TORRES: This is the, or for extended storage. This --

MR. JONES: So?

MR. TORRES: So extending, I guess, from -- so it's it's up to 300 years.

MR. BERKE: Yeah, but, you know, 300 times what they got there is still that number almost. We're not looking at -- if you're at 10 to the 8th and you need 10 to the 10, you know what I mean, right? You know, it's like 10 to the 6, you need 10 to the 10.

MR. XI: And the orders of magnitude are --

MR. BERKE: You know, 300 years isn't going to make it any bigger. So you're still not going to get to it.

MR. WALL: But also the activity of the fuel drops over time.

MR. BERKE: Exactly.

MR. JONES: Right.

(Simultaneous speaking)

MR. XI: As it ages, it drops. You're right.

MR. JONES: So it's not even 300 times. It's --

MR. BERKE: Yeah, exactly. It would be like maybe 50 times or 100 times.

MR. JONES: Yeah. So that remains. Is there a sense among the panel as to this is going to be a big issue and has that a sort of open-ended sense?

MR. BERKE: The only thing I saw is as long as you stay within your temperature ranges, that's fine.

MR. JONES: Mm-hmm.

MR. TORRES: All right. I saw your answer and it seems like you have 100 degrees. That's kind of --

MR. BERKE: 100 degrees centigrade where you're not supposed to be above 100 degrees centigrade here.

MR. TORRES: No but it's how you designed this has allowed us to go up to 149 actually?

MR. BERKE: Centigrade?

MR. TORRES: Yes, at the initial period, so.

MR. BERKE: Okay. But that's from, that's cumulative too. Yeah.

MR. POPOVICS: Is your 140 is the internal temperature at the container, the can, or is is the concrete temperature?

MR. TORRES: The concrete temperature.

MR. POPOVICS: Okay.

MR. BERKE: Oh, okay, because I thought originally we had a lower concrete temperature on that.

MR. TORRES: Well, our design basis --

MR. POPOVICS: Right.

MR. TORRES: -- guidance --

MR. POPOVICS: Right.

MR. TORRES: -- it actually exceeds.

MR. XI: But not for a long period of time.

MR. TRIPATHI: Initial period.

MR. XI: Initial --

(Simultaneous speaking)

MR. TORRES: I mean, maximum temperatures is --

MR. XI: Outside of 65, then we see it.

MR. BERKE: Yeah. The normal operating temperature over the 20 years is going to be much lower than that.

MR. TORRES: No. It's obviously not, you know, monotonic. It's depletes but it --

MR. BERKE: It's not? Because the, what they had in the thing we were looking at said it wasn't going to get that hot.

MR. TORRES: So, our design basis allows concrete temperatures to exceed those.

MR. BERKE: A short time.

MR. TORRES: A short time.

MR. BERKE: For a short time.

MR. TORRES: I mean, the loading stage is the -- so this is something to consider. It seems like --

MR BERKE: Yeah.

MR. TORRES: -- you're saying that over 100 degrees Celsius.

MR. BERKE: That's bad for corrosion, too, if we've got a rebar there.

MR. TORRES: I know because this TLAA limits --

MR. JONES: Then it drops to 10 to the 8th from 10 to the 10th for each particle.

MR. TORRES: You dropped an order of magnitude?

MR. BERKE: Yeah. They had, according to these guys up here, between 130 to 200 degrees C, it would drop. Actually, where they -- no, somebody else said that. Oh, they had damage to that, okay. Yeah, so, yeah, that's a smaller number at the higher temperatures.

MR. JONES: Okay. So it's more susceptible to damage if there's some --

MR. BERKE: If they're already hot. A concrete wall, the concrete in the wall, kind of, at those temperatures, isn't normally good for necessarily for regular concrete anyway.

MR. XI: Yeah, I agree with Neal. So the operating temperature is very warm, and it should be higher than the 65 degrees C. We actually did a lot of study sponsored by a Japanese company. They want us to study why -- this is actually a study -- it's not from ACI, originally from ASME Pressure Design Code.

Pressure Design Code. They want us to study to trace back and why this 100 degrees was decided. So we did, and the finding was that if you go higher than that for a long time it's no good for the concrete mobility.

MR. BERKE: Yeah, the high temperature might not be good for concrete at all. I don't think the radiation is necessarily the problem. But, I mean, it could have been here for a long period of time and it's a sharp gradient. You can probably sacrifice a little --

MR. CASERES: Well, additionally, it's also increasing the temperature of the concrete, so it is in addition to whatever it is the temperature of the cask.

MR. BERKE: Yeah. Yeah, it is. You'd have to see how fast the gradient drops off. It drops off. But, you know, you can probably lose a quarter inch of concrete on a lot, you know, without a problem in there.

MR. JONES: It just seems that the structural at that standpoint, you could --

MR. BERKE: The structural standpoint easily, because that's on the inside. But, I mean, I would think, but even from the point of radiation, it won't necessarily fall off at the speed they're weak, but it's not doing, it might be doing much. So I mean, it'll still act as a barrier but it won't, you know, but, you know, it's not necessarily going to come flying off or anything.

MR. JONES: Sure.

MR. TRIPATHI: What about from shielding point of view?

MR. BERKE: Well, the spacer is still in position, you know. It might not be, it doesn't have to be strong, I would gather, to be a shield. It just has to be in place. But some things that, where somebody might want to look at, but, you know, that would be if -- I don't if somebody back there did some work on that.

MR. TORRES: From what I gather from your response and what you mentioned here, for high temperatures exceeding, say, 100 degrees, this limit, might not necessarily be the most appropriate?

MR. BERKE: Yeah. The rad one would be a little lower, but the gray you could miss. It might be a little lower, but then again it's how long you're there. You know, or how much --

MR. JONES: Yes.

MR. BERKE: And that's just based on what this one Japanese paper said. So, I mean, that's prior to, you know.

MR. JONES: So some questions maybe then on this, but let me ask another, sort of, group of questions. Do we -- is there any other type of -- I don't know if you think we could address the TLAA. I thought of an ASR combination. Somebody mentioned it's not a degradation, but somebody mentioned fatigue is one that's commonly addressed this way. If you can spend a little extra cycles. But, just as an opening question, can anyone think of any idea that might be appropriate to approach? I think a mechanism might be appropriate to approach in a TLAA manner?

MR XI: Yesterday, I remember Neal mentioned about, you know, accelerated carbonation coupled with the radiation. A neutron radiation. So that's something that's actually quite important, because usually carbonating a very slow process is from carbon dioxide energy into concrete. Because this one, the carbonation is being initiated by the neutron radiation from the inside of concrete. So either carbonation is accelerated a lot and then you have early corrosion.

MR. BERKE: Yeah, well, I guess it wouldn't matter if, you know, if the temperature -- there's a certain temperature which limestone breaks down at.

MR. XI: Mm-hmm

MR. BERKE: And so this might be like a laser and that the very outside of the area it maybe gets hot enough to break it down. So that was something. Somebody would have to look into that.

MR. XI: Oh, you mean the effect to aggregate?

MR. BERKE: Yeah. Yeah, because that's what the limestone is the aggregate. There's nothing else that's going to break down and give you CO2 other than limestone aggregate. And I don't how many reactors have limestone. How many storage casks are using limestone.

MR. JONES: The source for the carbon dioxide is a carbonate, Neal?

MR. BERKE: Yeah. And then, of course, this larger aggregate is usually the limestone because the sand is still usually silicone.

MR. JONES: Mm-hmm.

MR. BERKE: Which is a -- and that's the

binder stuff is what you mostly have to worry about, so it might be a big deal that the major aggregate is --

MR. CASERES: How about does the acid hydrate in the cement? Would that be affected, too? Does it matter--

MR. POPOVICS: Yeah. Probably the portlandite cask might --

MR. BERKE: Yeah, but that's also going to make carbon dioxide if there's no seal, so when there's only one, the only place there's carbon dioxide would be, the limestone breaking down, that tends to be the larger aggregate, so it's not -- it would be worse if it was small aggregate, but that's usually sand. Silica. So it might not be -- it's something that maybe could occur, but the likelihood of what it's going to do. And once again, that would be at the inner surface far away from where the bars are. So once the cooler side might not be happening and then in essence the carbonate may be a little bit on the, you know, away from the bars. That's fine.

MR. XI: Does the --

MR. BERKE: It would help you on the high temperature corrosion though if the pH dropped to that.

MR. XI: The neutron was the low impact on the crystalline materials like limestone, like calcium hydroxide crystals. It has less impact on the CSH, because it's a amorphous structure.

MR. JONES: Mm-hmm.

MR. XI: Now there's the reason why there is accelerated carbonation, right. And because CSH crystals break down as the neutrons react, transfer.

MR. BERKE: Yeah, but you need the carbonate source. I mean, CHS breaks down. There's no carbonate there. It's got to be -- they have to be from limestone or something.

MR. XI: Mm-hmm.

MR. POPOVICS: And you're talking about this accelerated carbonation.

MR. XI: Yeah.

MR. POPOVICS: Right. But then there is also just regular thermal breakdown, yeah.

MR. BERKE: I think it's mainly a thermal breakdown technique. I mean, I think you get localized heating and that's what the gamma rays do. And then you got the heat from there normally and, but that's beneficial for corrosion.

Because if you're at a high pH and high

temperature, that's bad. So actually, it might prevent you from having corrosion. I mean, it would be much better to be at 12 at 100 degrees C -- pH than to be at 13.

So, it might actually be beneficial for all the wrong reasons, because you want a lower pH. You don't want to at high pH at low temperatures. You want it to be lower pH.

MR. POPOVICS: What temperature is that now that you're talking about when you say high?

MR BERKE: Above 80 degrees C.

MR. POPOVICS: So because of the thermodynamics product?

MR. BERKE: The thermodynamics, yeah. And that, like I say, that's why boilers don't operate at higher pH. So now you're talking 100 degrees C, you're definitely in the region where iron's passive at pH 13.

MR. POPOVICS: Mm-hmm.

MR. JAMES: So this is Randy James. I just had a comment about TLAA and ASR, you know. The macro factor of ASR. The thing that affects the structural performance is the swelling. volumetric swelling, and degradation of properties compressive strength and modulus.

So it would seem that you can use, you know, an analysis looking at a range of swelling rates in the concrete and get an idea of when, you know, what kind of ASR damage would really affect your structure in the long term. So, in that way, you could use TLAA to kind of project what the degradation mechanisms were that you're worried about.

One way to use TLAA to answer this question, I think, as far as a coupling with the radiation effects of radiation is enhancing ASR. Then you're -- that means you have an ASR problem and so you're looking at ASR.

And if you're really trying to get the expansion rate of the gel and the macro effects of that ASR from the concrete, so it doesn't seem to me it doesn't matter if the radiation is affecting it a lot or not, because you are monitoring exactly what the ASR is doing itself, however it got to that point.

So I think that you can use TLAA for modeling to address some of these issues.

MR. XI: So I want to just say a little bit more about ASR. So what do you see the ASR having in occurred in a hundred structures, now the next question is: What would be the remaining potential? As a prediction, ASR especially. You can look at the common ASTM modern-time testing methods there, but none of them can handle, can address this issue.

The truer Canadian standard you can consider by them and you can get, you may guess the future the remaining ASR potentials.

MR. JONES: Mm-hmm.

MR XI: That is actually important because I know people are working on Seabrook and the main problem is what will be the future exposure. It is very small. We don't need to worry about it. I mean, it is large then we need to do something about it.

We actually had some problems in the gravity dams, so sometimes the duration can stop after 30, 40 years, because the suppliers, our client may be exhausted.

MR. JONES: Mm-hmm.

MR. XI: So that's reducing -- I mean, in that case you really need to drill, get the chemical analysis to see how much alkali is in the system.

MR. TRIPATHI: Can you provide reference to these Canadian standards? Do you have them?

MR. XI: I can find them.

MR. TRIPATHI: Okay.

MR. JONES: Let me ask our friends the negative question. Are there any mechanisms that we feel like are not suitable for approaching with a time limit to aging analysis?

MR. XI: Not suitable.

MR. JONES: Are there any that would, you know, if you saw a so-called time limited aging analysis come to your desk for a certain mechanism, would you be, you know, concerned about the validity?

MR. POPOVICS: I guess any mechanism that's transient in nature was instigated by an event outside for the normal cyclic life, but, you know, an overload, an accident, you know, things like that.

MR. JONES: Sure.

MR. JACOBS: No, I tried. It's like, you can't really think of this as everything is going to be relatively consistent and that's what this works so well on, on a consistent, relatively consistent.

MR. TRIPATHI: Is the answer no?

MR. JONES: The answer is no.

MR. JAMES: To me, if you can characterize, you know, the structural properties that that degradation is affecting, you can certainly perform the TLAA to assess the long-term performance and the functionality of the structure.

MR. JONES: Mm-hmm.

MR. JAMES: The obvious question is can you, you know, how well can you characterize it and get the growth rates or the --

MR. JONES: Or the data reliable, so.

MR. JAMES: And so, typically, I think that can be approached by a probabilistic, you know, method. Take variation of the parameters and growth rates and how to establish, you know, a range of --

MR. JONES: Outcomes, yeah.

MR JAMES: And the issues.

MR. CHOWDHURY: So the timing effect of some of the parameters is going to be important to this --

MR. JAMES: Yeah. Because, I mean, it's, you know, it's hard to know what the growth rate is going to be out in the future. Whether it's going to increase or decrease, so you take a range of growth rates and project out in the future.

MR. CHOWDHURY: Surely. So you want to project probabilistic approach.

MR. JAMES: And obviously you can refine

that model as you go along and you get -- the more data you get, the narrower you can make the bands.

MR. CHOWDHURY: Yeah. I want to add something else. So we're just for visiting analysis on -- is not sufficient because the physical, the relation to law is very important. Yeah. We have to get a good handle on that. So like was mentioned this morning, you see the cracks on the surface and how to translate the crack density into the decline of stiffness in the structure. And that, in a worst case, not favorable that's for sure, but at least some reliable models in the final call and value along with statistical analysis.

MR. JONES: Mm-hmm.

MR. CHOWDHURY: So some mechanical models to consider they affect some reduction of sickness due to cracking or?

MR. JAMES: Yeah, yes.

MR. CHOWDHURY: But what I mean is that in your model, I see every aspect you need to try your best to get the reliable models. And then you can see the variations of model variables.

MR. TRIPATHI: Now there was talk about distributed damage. So those could be probably more than no reasonably.

MR. JONES?: I think you're just saying that the quality of your model is important in these aging analyses and, you know, not just varying parameters. You have to have a quality model to feed --.

MR. TRIPATHI: Yeah.

MR. JONES?: -- the parameters, too, I think is the point.

MR. TRIPATHI: John, I would like to follow up on something you said earlier.

MR. POPOVICS: Sure.

MR. TRIPATHI: You mentioned something about as long as you use Portland cement, you don't need to worry about, what was it? In reference to its ASR or?

MR. POPOVICS: I don't remember.

MR. TRIPATHI: You did mention Portland cement a few minutes ago.

MR. JONES: So that specific standard, I know, is -- so Portland cement is possible for ASR.

MR. POPOVICS: Oh, no, no. I know. You mean just five to ten minutes ago?

MR. TRIPATHI: Yeah, we were talking

about --

MR. POPOVICS: I'm talking about portlandite, which is a phase of the hydration product of cement, Portland cement. It's calcium hydroxide.

MR. TRIPATHI: Calcium hydroxide.

MR. POPOVICS: So I did not say -- if I did say Portland cement, it was a mistake.

MR. TRIPATHI: I thought I heard Portland cement. The reason I'm bringing this up is that some of the vendors, the three major vendors, two major vendors, have leased casks that overseas. And they may not be using Portland cement. That's the only reason I'm bringing it up.

MR. POPOVICS What are they using?

MR. TRIPATHI: And they are made in Japan, in India, and Spain.

MR. JONES: But they'll use a large --

MR TRIPATHI: South Korea.

MR. JONES: -- replacement rate with slag and --

MR. POPOVICS: Oh, yeah, but that's still Portland cement at the base.

MR. BERKE: That's basically why they're not going to calcium aluminate cements or calcium sulfate aluminate cements, which are not Portland. Usually it's Portland cement plus fly ash slag, so if you --

MR. TRIPATHI: Usually.

MR. BERKE: Usually. And that's why they still have Portland cement. Now there are other cements. If you're in the ceramic business, you go with calcium aluminate cements, because for all -- and they could be using those. But those have, so they can go through transformation phases that will --

MR. TRIPATHI: Yeah, with temperature.

MR. XI: All I'm saying is there are other countries which are also in business --

MR. BERKE: That also use Portland cement. The biggest Portland cement producer in the world is China.

MR. TRIPATHI: Not China.

MR. BERKE: China. Then India is right, India, if you -- so we actually use a small amount in the U.S.

MR. TRIPATHI: Really?

MR. BERKE: Compared to what they use.

MR. POPOVICS: But, on the other hand, you are right.

MR. BERKE: Yeah.

MR. POPOVICS: The European, for example, countries, tend to use higher replacement rates of Portland cement with slag than we do here.

MR. BERKE: They sell it there like that. I mean, Canada uses more than us.

MR. JONES: So I think these are kind of the main topics with TLAA.

MR. BERKE: Those are beneficial, by the way.

MR. JONES: You know, again, it's an hour and fifteen minutes, but I also kind of expected this, might has left us all. So I suggest we would do is start talking about repair and remediation, and then our take our break at the --

MR. BERKE: Sure.

MR. JONES -- the correct time wherever I have it on the schedule and then, you know, finish up whatever we need after that, so.

We spoke yesterday about prevention mitigation. So that's sort of in a similar theme as remediation, repair and replacement, but maybe a little bit further down the continuum if you want to think about it in those terms.

We can take some actions early in the life, but at some point we'll get to a place where we need to step in and do something a little bit more. And so that's, you know, the point of this little section of the discussion.

Incidentally, anyone on the phone, we're now on Slide 43, so. We observed, we have from numerous places, but from the previous responses, that corrective actions could take a lot of different forms. You could remove material and, you know, maybe patch up the section that had the freeze/thaw or partial demolish and replace some material or you could sure. You could totally replace a structure.

And it should be clear, this is fundamentally a licensee decision, but at the NRC we need to be able to evaluate the adequacy of any type of remediation, replacement or repair actions that are going on. And so that's, you now, that's NRC's position in this whole thing.

And so, one of the key questions I came to is how can we evaluate the central issue? How do we evaluate the effectiveness of a repair? And I, you know, have a couple of sub-bullets.

Is it a prescriptive approach or a

performance-based approach? Is there any experience from other industries evaluating the efficacy of repair activities, replacement activities, remediation activities?

MR. CHOWDHURY: There are some publications for GPR.

MR. JONES: So, compliance with a code or a method or something would be a way --

MR. CHOWDHURY: Yeah.

MR. JONES: -- demonstrating the effectiveness?

MR. JAMES: So, I think there's lots of experience in using performance-based analyses to look at repairs. I know in the dams when they get, need to be re-certified to higher-side hazards, for example, our intake powers, typically these intake powers of variable structures and, you know, they just can't meet the U.S. seismic hazards.

So they go in and repair them or enhance them. And so the way that's usually done is to develop miles of them and evaluate different methods and perform, you know, performance-based analyses, run U.S. quake record through it, and establish high performance under, you know, under the goal.

And those methods are used to confirm, you know, engineering designs and retrofit measures. So I don't see reason why we can't do that here.

MR. JONES: And analytical confirmation of the --

MR. JAMES: Of course, I'm an analyst, so.

MR. POPOVICS: But, you know, on the other hand, if you are doing a repair not to upgrade for a new time consideration, but because you have damage and you are chipping on and patching or replacing part of it, you want to know whether that patch was well bonded and solid and doing what it's supposed to do.

MR. JONES: Yeah.

MR. POPOVICS: I think experiments are really the only way to do that, you know.

MR. BERKE: Well, there's like there's a IC app. International Concrete Repair Institute has for concrete repairs anyway, but concrete mortar repairs has a whole set of guidelines.

And there, you know, there will be bond. There will be dimensional stability, as you're going to want to put a repair and a patch. And the repair shrinks and just separates off or there's concrete that zeroes all the way down with shrinkage, so you need to slow the shrinkage. There's strength. There's a whole stack of, a whole procedure you can follow for patch repair.

I thought yesterday about a method to look at topical treatments for embedded anodes. So, I mean, our methods that look at that protection on there are, you know, you have polarization drop. The 800 millivolts but you know, the polarization and various other standards to see if it's working.

So there are quite a way of doing it. A lot of that's been developed, you know, from the highway industry. This one here, I mean, they do a lot of repairs, obviously.

And then you've got to look at the root cause. To some extent, you want to know why you're repairing it.

MR. JONES: Mm-hmm.

MR. BERKE: You don't want to just cover up something and then it happens, you know, the same place again. So you have to watch that. But, yeah, there are guidelines on how to make repairs and there are several of ways of looking to see if you're, to determine if your repair works or not.

MR. TRIPATHI: So we're lucky we don't

have to worry about potholes and stuff like that. The patching is probably partially for cosmetic reasons.

MR. BERKE: Right.

MR. TRIPATHI: We don't care how --

MR. BERKE: Mm-hmm. How it looks.

MR. TRIPATHI: As long as it functions properly.

MR. BERKE: Oh, yeah. So this would -- they still want to make sure if you put a patch and you want the patch to stay there, you don't want the model to fall apart. You don't want it to expand like crazy and crack the concrete next to it. You don't want it to shrink a lot so that it pulls away and it's not protecting like it's supposed or actually causes enough stress to crack and, you know, pop out and so forth.

Yeah, but there's things out there for that. So it could be modeled with a little bit of work and you can confirm that they're working.

MR. CHOWDHURY: Yeah, quite a bit of experience around --

MR. BERKE: Yeah.

MR. CHOWDHURY: -- remediation when I spent interpreting.

MR. BERKE: Oh, yeah. It gets tricky in

this application, because, you know, you're not going to want to have people that are too long doing this, but.

MR. XI: Yeah. So, you know, like Neal mentioned about the shrinkage of the new patch and John mentioned about the pump, actually there is another thing I need to be careful is the redistribution of chloride.

In a re-patch, you have other load distribution where a low chloride contents and an the old structure got high, so there is a kind of a division grade.

Again, back to the highway industry, what we do is so along the edge of the patch, we put down a sacrificial salt protective system. So that can prevent the corrosion of steel bars right at the edge of the patch

MR. BERKE: Yeah.

MR. XI: Those are easy to apply to install. And those are used to run. You need to have a power supply.

MR. BERKE: Those are sacrificial anodes so you can spend --

MR. XI: Yes.

MR. BERKE: That's one of the --

(Simultaneous speaking)

MR. BERKE: -- see how well they cover an area around them. But the thing, but what's important to know is why you are patching. If you're patching -- I mean, there's no chloride here and you're patching because you had ASR damage in a certain localized area, you're not going to worry about corrosion.

MR. XI: Oh, yeah, you just --

(Simultaneous speaking)

MR. BERKE: So you ask about why, you know. Why the pH is something and you pull it out and not find out why it failed. So, you know, so you don't want to do more than you have to do. You don't want to do less than you should do.

So, I mean, so it's basically understanding at that point, we're removing concrete, if you're patching, so you can clearly see what was the problem. But the, as long as you address the root cause or at least know what's going on nearby, you might say, I only need ten more years on the canister and maybe, you know, you're going to have a problem for another ten years, you won't do the all thing, you know.

There's got to be a little bit of

engineering, you know. Of decision making, there. Not just, you know, you don't want to make a 100-year patch if you're only going to need insurance for five years.

MR. JONES: More on the time limiting concept.

MR. BERKE: Right.

MR. JONES: But let me ask sort of a follow-up question. I don't have any great cartoon. So, is there experience in evaluating the ongoing performance of a repaired structure of a composite -- some repair material, some original material, and these sorts of things, and can maybe we talk about that?

So my cartoon, I guess, you know, so it's degrading time in time, let's say in some form or capacity, and then we step in and make a repair and that increases that capacity and then it be considered degrading again. So what do you --

MR. BERKE: Well, your cartoon is actually good because there's all kinds of -- we kind of use a different scenario going up when we look at patching and, you know, should we start off low and go into damage propagation --

MR. JONES: Mm-hmm.

MR. BERKE: -- and then it takes off and hits a line. So you've got it kind of upside down than what we normally do. But that's okay.

And then you say, okay, you kind of got it -- okay, after you patch it, is the life less than what it was beforehand, so you can actually extend the patch? What do you apply the patch on that line? Coming up and down matters.

If you apply it right before the loss of required capacity, your patch might not be as effective. Or your repair. We won't even call it patch repair. It might see as effective as if you applied it earlier.

And you've got somewhat indicated there. You have a longer line out that nothing happens after you've patched it. And then it starts to come along the same way. So the rates can -- so there can be differences in the deterioration rate, of one that starts to deteriorate before.

MR. JONES: Mm-hmm.

MR. BERKE: Rarely do you get it back up to the initial condition, which is showing there. So, it's usually a little bit less than as brand new, but, you know, but it's been -- that's a good way of looking at them.

MR. JAMES: And then there's optimistic tail marked and it's come to me --

(Simultaneous speaking)

MR. BERKE: But all those things he's giving you -- and you kind of show us kind of the rate of what is going on, so that the slopes can change. The, you know, how long it takes for something to initiate change. So there's initiation things. They're slow.

MR. JONES: Mm-hmm.

MR, BERKE: Once they start, the rate picks up and that can change and then, you know. But typically it won't get as high as what you started at.

MR. JONES: So let me ask, it sounds like you've got some good experience. I mean, do we have, maybe I'll bring out the word competence, do we feel like we can evaluate these situations fairly well? The ongoing performance of a repaired structure.

MR. BERKE: Yeah. Part of that two-year inspection on the digs, they did that by accident.

MR. XI: You know, we have a project to evaluate the requirement here for patching materials.

MR. JONES: Mm-hmm.

MR. XI: Each of these were, for example, was CDOT Web site, and you can see a lot of materials specifically designed for repair. But my thing really is that you do not have to use those, because for highway industries are different.

MR. JONES: Right.

MR. XI: They want to open the floodgate as soon as possible, so that's why the setting time is important.

MR. JONES: Mm-hmm.

MR. XI: But at the same time, you may have a high shrinkage and things like that. So that's why for dry cask, you don't need a large amount of traffic. So you just wait for 28 days and for most trends, that will be fine.

MR. JONES: Mm-hmm.

MR. XI: So that's why my recommendation is that you should go to look, to search for the repair materials, you need to be careful. You don't have to use the materials designed for highways.

MR. JAMES: I think there's examples in the Corps of Engineers. You know, infrastructure, locks and dams, and they do repairs and concrete structures all the time and monitor how well a rock anchor is performing or grouted bars to, you know, help close a crack. So, I think this is definitely a lot.

MR. JONES: Okay.

MR. BERKE: Yeah, this is well understood. The main thing is this is just a selector to the right repair systems.

MR. CHOWDHURY: In the ASCE 41 that it says, I think, Seismic Evolution and Interpreting.

MR. TRIPATHI: Yeah, there is an ASCE standard of --

MR. CHOWDHURY: Yeah. But used to two variables. One for evolution, we show that in 41, and another, I that was 31. Now they combined these things and make them only 31.

MR. TRIPATHI: But there's new mention. There is an ACI --

MR. BERKE: ICRI.

MR. TRIPATHI -- repair manual.

MR. BERKE: Yeah, ICRI Repair Manual.

(Simultaneous speaking)

MR. BERKE: ACI and ICRI are together. I think that in as one of the references I sent in and it's quite, it's fairly complete. But what, you mean, and there is -- a lot of this was plain common sense.

We know what they're telling you to do, but it also has a lot of techniques in how you evaluate your structure after you repair it.

MR. JONES: Okay.

MR. BERKE: There's a whole section on that, you know, is your repair working. The visual is quite good for that. So you want to take a visual.

MR. TORRES: Can we reference some of those documents in the AMP? The Corrective Action section on -- just ask a better question. Was there a reference in that AMP that anyone here had seen I could -- would not be adequate for either monitoring trending or corrective actions? They're mostly ACI. I think it's five, six here and so on, so.

MR. JONES: So maybe your question is, what's the correct process of applying of the -- is there anything unique about these dry cask systems that would make those methods --

MR. JACOBS: No. You know, it's pretty --

MR. JONES: Mm-hmm.

MR. JACOBS: It is applicable in my opinion, yeah.

MR. JONES: In your view.

MR. JACOBS: They are applicable in my

opinion, yes.

MR. XI: The only special factor is the radiation. Other than that, it's the same, you know, initial conditions. So, I think I agree with Larry.

MR. JONES: Maybe somewhat higher temperature, too, but --

MR. TORRES: Yeah, but a combination obviously of high temperature and radiation.

MR. JONES: Okay. Well, we find ourselves in an interesting --

MR. BERKE: Dilemma?

MR. JONES: An interesting dilemma, or opportunity.

MR. BERKE: Opportunity?

MR. JONES: Yeah, opportunity. I guess I'm going to ask a general question. So we presented sort of a situation, you know, that we're faced with as an agency. Also as a country. And we have this fuel basically stored in these dry casks and many more casks will be filled. What's the -- would anybody want to issue a sort of summary statement of what they sort of embark in this process or, you know, an observation in general would be from this in the last sort of thing or in what just kind of a conclusion type statement, if that makes sense?

MR POPOVICS: I just want to say that I like the way that this was structured in that we had kind of two sets of questionnaires with telecon in between. It kind of helped us. I think it focuses the discussion. I thought it was very helpful and well done.

MR. JONES: Thanks.

MR. POPOVICS: Yeah.

MR. TRIPATHI: If I may ask you --

MR. JONES: Sure.

MR. TRIPATHI: -- do you have some -

MR. JONES: Sure. That would be --

MR. TRIPATHI: -- additional time. There's one design feature which we haven't had time to discuss. It is the hardened concrete.

I think I may have alluded in the past during one of my presentation that, you know, there is a design requirement to meet. I wouldn't say design requirement, but there is a phenomena called non-mechanistic tip over.

With these casks, and I included that my December presentation on Slide 46, that the pad has to be strong as well as flexible. It's kind of like an oxymoron. But that's what it is.

It needs to be strong to support the dead weight, which is going to sit there forever as far as we are concerned. Not only that, but if there is a non-mechanistic tip over the basket which has the fuel inside the cask, the canister, has to be able to take that up and down, up and down, in case of there is a non-mechanistic tip over.

If the pad is too rigid, too rigid, then it has a tendency to go back and forth. We don't really want that situation. And to achieve that, initially when the concrete is poured for the mat foundation to support that, we engineered the sub grade and bring the sub-grade modulus such a way that that pad will be flexible. Strong yet flexible.

Now, we had talked to here about 20 years, 40 years, 100 years. And that concrete which was 3,000 psi now, as I mentioned yesterday, may be 6,000 or 8,000. It has become a lot more rigid than it used to be 20 years ago.

MR. JONES: Mm-hmm.

MR. TRIPATHI: Are we still meeting that flexibility of the pad which was required initially after so many years? And if not, how do we go about testing that, being rectify the situation?

MR. POPOVICS: I think I would just -- this is John Popovics. You give an example where you tested early on for those designs for concrete resting strength of 3,000 psi, but then later in life it's 6,000 psi.

Well, usually, you know, ready-mix concrete comes in above the recommended, so that statistically it's not rejected. So your strengths will always be probably higher.

But I wouldn't expect an increase at double in strength, which you mentioned, any time after a month after casting. So, as I think most of us know, most of the strength development and potential is achieved within a month and you're not going to get --

MR. BERKE: Also, you're not going to get a fly ash content, right?

MR. POPOVICS: But even so, it's not -- I don't think it would quite be doubled.

MR. TRIPATHI: Well, I have some literature which is even more than doubled.

MR. POPOVICS: From 28 days to?

MR. TRIPATHI: In 20 years.

MR. POPOVICS: From what point to what

point?

MR. TRIPATHI: From 28-day strength to after 20 years.

MR. BERKE: Now is that 28-day design strength or 28-day actual?

MR. POPOVICS: It's actual.

MR. TRIPATHI: Design strength.

MR. BERKE: Oh, yeah. Well --

(Simultaneous speaking)

MR. BERKE: -- design strength, I mean, if you got 3,000 design strength, you've probably got 3,500 4,000 --

MR. POPOVICS: 5,000, sure, because the delivered concrete is going to aim high, so that statistically it's not going to be rejected.

MR. TRIPATHI: Regardless, but we still have the issue of the flexibility of the pad.

MR. POPOVICS: Well, I think maybe the problem is not that it's growing, creeping up over time. It's that it came in too strong for your design maybe.

MR. TRIPATHI: But the ground force becomes larger over time. I have stiffness of the pad.

MR. POPOVICS: Right.

MR. TRIPATHI: So when, a vertical cask is tipping over, the cask is expressing higher force then it can go up and down what based on the original state of stiffness of the pad.

MR. POPOVICS: I understand so that was the question but my issue is that your concrete pad is much stronger than your design anticipates, correct?

MR. TRIPATHI: Yes.

MR. POPOVICS: Regardless of how it got there. Whether the batch came in at a much higher strength or that it developed strength maybe over time because it had an extremely class F flash content or something. Is that correct?

MR. TRIPATHI: Yes.

MR. POPOVICS: Right. So you're asking there are methods to monitor in-place strength?

MR. TRIPATHI: Well, the cask has been designed for say deceleration up to even 40 g, okay? 40 g deceleration tipping over on the concrete. Coming back, tipping over.

I mean, we're not talking about here domino effects. That's a separate issue. But I'm talking about just a single cask, non-mechanistic tip over by human error. They're bringing it on a crawler, trying to put it on this to see that, and something goes wrong and it tips over.

MR. POPOVICS: Okay.

MR. TRIPATHI: When it tips over, we want to -- the end result or the end objective is protect the fuel, which is inside the basket. And the cask has been designed for 40 g deceleration. The cask itself.

MR POPOVICS: I understand.

MR. TRIPATHI: Okay. But what I'm talking about here is the bouncing effect that depends on the strength of the concrete --

MR. POPOVICS: Right.

MR. TRIPATHI: -- which is getting stronger and stronger.

MR. JAMES: A perfect example for a TLAA, right? You do an analysis and see if whatever strength you got is a problem or not.

MR. TRIPATHI: But suppose if you don't meet that? Then the solution is to what? Dig under the pad and do some more --

(Simultaneous speaking)

MR. JONES: -- the strength of concrete, I think there's no, you know, easy solution.

MR. JAMES: Put some kind of an impact limiter around the top of the cask or something like that. So when it tips over, it crushes up.

MR. POPOVICS: But might that -- but I still, I understand the issue. But the issue is that the mat pad is too strong or too stiff --

MR. TRIPATHI: Yes.

MR. POPOVICS: -- for your design.

MR. TRIPATHI: That's right.

MR. POPOVICS: Okay.

MR. TRIPATHI: Yes.

MR. POPOVICS: So then you would like to know what the in-place stiffness or the in-place strength is, right?

MR. TRIPATHI: Yes. Strength plus you need to maintain the flexibility of the pad.

MR. POPOVICS: Well, that's the geometry.

MR. TRIPATHI: By achieving the sub-grade modulus that's at a given, you know, engineer strength.

MR. POPOVICS: Yeah. So you're asking for a geophysical characterization of the site to make the foundation, right?

MR. TRIPATHI: What is the pad?

MR. POPOVICS: It's kind of like a layered system and you have thicknesses and stiffnesses of each, right? Is that right?

MR. TRIPATHI: Yeah.

MR. POPOVICS: Yeah. So there are these kind of methods to monitor strata. So they're geophysical and they've been applied to pavements, because pavements are layered systems with certain geometries and certain stiffnesses.

There are approaches for that. I don't know how reliable they could be for this kind of structure. So I'm not sure I'm answering your question, but.

MR. XI: No, I think you don't need to worry about it too much, because I tested 47-year-old concrete to compare with a 28 days, where they had complete rebar.

So where you're right, the strengths can double. But the stiffness --

MR. POPOVICS: The modulus?

MR. XI: Yes. The stiffness is a slope straddling the peak.

MR. POPOVICS: Okay.

MR. XI: So the slope actually increases are very little. The stiffness increases very little. What you need is the change of stiffness. So the good thing is that the stiffness increase very small amount for concrete.

(Simultaneous speaking)

MR. TRIPATHI: So what you're saying, the F prime C may double but that doesn't matter.

MR. XI: Yeah.

MR. TRIPATHI: The strength may go up.

MR. BERKE: Yeah. You need the relationship between your modulus and your strength. And that's usually much smaller, the modulus. So I don't know. Like, it might be a square root relationship or a power-type thing that's not been changed.

MR. JAMES: I think they're relying some on the compressive strength of the concrete to crush up a little bit as the cask tips over to absorb some of that energy and keep it from, you know, imposing high G levels on the cask or --

MR. JONES: So the strength does matter?

MR. JAMES: Yeah.

MR. TRIPATHI: They're only designed up to 40 G deceleration, so if it exceeds that, then we got --

MR. JAMES: The way I would approach that is to do a TLAA and decide if it's an issue or not if, you know, whatever strength of concrete you have. If it is an issue, then you deal with the consequence if there is a tip over.

MR. TRIPATHI: Okay.

MR. JAMES: Go in and it's probably not a fun thing to do, but take that canister out and process it however it needs to be processed and put in another cask.

MR. TRIPATHI: So you recommend a TLAA for now.

MR. JAMES: I would.

MR. CHOWDHURY: A TLAA and for tip over.

MR. JAMES: Too assist the --

MR. CHOWDHURY: Tip over.

MR. JAMES: -- possible consequences of a tip over as your slab ages.

MR. POPOVICS: But that depends on --

MR. JAMES: I'm sure there's a margin on the initial design, so you can -- your increases, strength, and modulus, there's some margin on that, so. You need to decide where that is, where you don't meet the design.

MR. POPOVICS: But if I understand correctly, that depends on that design parameters are layered thicknesses and layered stiffnesses and also strength, right? What are the design parameters?. You can have layers of sub-grade and mat, and is that right?

MR. JAMES: Yeah.

MR. POPOVICS: So you need a way to assess that data if you're going to have a TLAA. And really, the only reliable way is to pull cores and test them. Or pull sub samples and test them. I mean, there are -

MR. JAMES: I don't want to --

MR. POPOVICS: There are indeed methods that can be applied to seismic methods, because they characterize strata via physical methods for pavements. Their reliability is questionable and, you know, how good of an estimate do you need, I guess?

MR. TRIPATHI: If she goes to my slide 53 from the December, if you have it. Asad, if you are kind enough to pass that page 53.

MR. CHOWDHURY: Okay.

MR. TRIPATHI: -- Slide 53. I've shown the actual method which was used at one of the ISFSI site, which I visited almost eight years ago, and this is how they do the field plate bearing test to determine a single modulus of soil sub-grade reaction. But this is before you start pouring the concrete for the pad.

Now, what I'm talking about is 20 years down the road. I mean, you don't have that luxury of doing this kind of field plate test to measure the modulus.

MR. POPOVICS: Exactly, right, that's my point. So you would have to use an in situ NDT method, which tries to characterize the layer strata thicknesses. And if you also need strength, then you need a method to assess strength. And all of these are obtained in the most basic ways, pulling a sample of a core. Now, do you want to do that?

MR. TRIPATHI: No.

MR. POPOVICS: Are you allowed to do that? If not, then these kind of in situ NDT methods could be a way by which you could get this information needed to kind of monitor the progress over time. So this is -- yeah, I understand, this is a --

MR. BERKE: There it is.

MR. POPOVICS: -- a geo tech site test before any casting. But it doesn't necessarily tell you what's happening 20 years from now --

MR. BERKE: Seems like --

MR. POPOVICS: -- under the --

MR. BERKE: -- you know, when they designed the sub-grade and they designed the slab, they had a -- must've had a model of how much it's going to go. You just put all the new information in the bottom and test it.

MR. TRIPATHI: It's designed to take the 40 g deceleration --

MR. BERKE: Yeah, but this changed the modulus and the strength of the concrete. The sub-grade stays the same.

MR. POPOVICS: Exactly.

MR. BERKE: It doesn't say what it does.

MR. POPOVICS: That's my point.

MR. BERKE: Run the -- I mean, all you have to do is run your same model and see -- because you didn't drop a cask on one, you know?

MR. POPOVICS: But there's still a model that doesn't necessarily tell us the in situ conditions.

MR. BERKE: But the whole thing was designed as a model. They didn't drop a 40 g decelerator --

MR. POPOVICS: No, but concrete mixtures

can change, they can pretty much --

MR. BERKE: -- well, no, no, no, they take that into account. They take the original -- what their design strength was with everything that was there, they can calculate what the 40 g deceleration is for something of a certain weight falling on it, what it was modeled to do.

The only thing that changes is the concrete. Concrete gets stronger, the modulus goes up a little bit.

MR. POPOVICS: Exactly.

MR. BERKE: What's it look like?

MR. POPOVICS: My point is, what is that value to put in the model?

MR. BERKE: Correct.

MR. JAMES: The TLAA would tell you what strength and modulus you can tolerate --

MR. POPOVICS: Right.

MR. JAMES: -- to maintain the 40 g's.

MR. POPOVICS: Right.

MR. JAMES: And then you'd have to -- if it's something you got to go change --

MR. POPOVICS: Right.

(Simultaneous speaking)

MR. JAMES: -- take core samples of the slab, and you'll see what the actual --

MR. POPOVICS: And there are semi-destructive ways to assess strength in concrete based within penetration and, I think, fairly accurate, but ballpark ways to kind of set up the strength of --

MR. BERKE: I can't imagine a little four by eight cylinder core out of the slab so you guys can do a --

MR. TRIPATHI: Aren't you assuming here, Neal, that the sub-grade stays the same?

MR. BERKE: Well, if the sub-grade changes, it doesn't matter what your concrete did. Then everything is changed on you.

MR. POPOVICS: Well, if it's a stabilized -- if it's an engineered soil --

MR. BERKE: Yeah.

MR. POPOVICS: -- you'll get some change.

MR. BERKE: You're implying that the soil's okay, and that only my concrete does --

MR. TRIPATHI: The soil was okay, initially. I'm saying about for the long period of time, as the concrete hardens --

MR. BERKE: Oh.

MR. TRIPATHI: -- what guarantee is it that the sub-grade modulus is still the same after 20, 50, 100 years?

MR. BERKE: You're absolutely right, but then what's to say the concrete stays the same? What's the guarantee that the soil's there and you still don't have a block off? I mean, you can assume anything on that one.

MR. POPOVICS: Right, so don't assume, and measure it.

MR. BERKE: Yeah, you're assuming that the concrete -- you're assuming that, you know, that the concrete didn't change, when you designed in the soil would be --

MR. TRIPATHI: No, we know for sure the concrete will harden over a period of years.

MR. BERKE: -- yeah, and that's what you're concerned about?

MR. XI: You know, in the first 40 years, the concrete will get stronger a lot, a little bit stiffer, but after 40 -- let's say from 40 to 300 years, and because of the freeze/thaw, you know, all the later mechanisms, of course you have --

(Simultaneous speaking)

MR. TRIPATHI: The reason I'm bringing up this issue is that there has been realized issues at some of these businesses, which have been sitting out there on the support pad older than 20 years, and, you know, we get all kind of questions. Hey, what about hardened concrete? Am I still okay, or not? That's the reason I'm -- since you guys are the expert in the concrete --

MR. BERKE: Well that's what I was suggesting, if you assume the soil hasn't changed, you could do the concrete analysis and see if that's the problem. But you could say the concrete changed and the soil changed, you can run that scenario, and see if it's a problem.

But the problem is, what you're saying, is you're only writing the scenario because you think the concrete got stronger.

MR. TRIPATHI: Well, I'm not going to assume that the sub-grade modulus is still the same after 100 years. I didn't say that.

MR. CHOWDHURY: Normally, it is handled through evolution that the people working that there causes influences are still whether or not the cask can -- can it get force without affecting the safety function? The cask evaluation is done through evolution.

MR. BERKE: That's pretty interesting.

MR. TRIPATHI: The whole thing is to protect the fuel --

MR. CHOWDHURY: Yes.

MR. TRIPATHI: -- inside the canister.

MR. CHOWDHURY: The canister and the fuel basket. And normally, the deceleration force is quite conservative. Yeah, 40 g's probably a lot more than it could really seem.

MR. TRIPATHI: But the hardened concrete is that the solution is less than perfect, and it's okay.

MR. JAMES: The 40 g may change over time, too, yeah? As the fuel cools down, it may not -- it may can accept more than 40 g's before it breaks.

MR. TRIPATHI: No, fuel has nothing to do with it. It's the human error by -- the 40 g deceleration has nothing to do with the fuel temperature or what have you. Is that what you're implying?

MR. JAMES: I figured the 40 g came from some criteria about what the canister could withstand before it --

MR. TRIPATHI: The basket, yeah. The basket's plus nine --

MR. JAMES: -- and that didn't have anything to do with the amount of g the actual fuel bundle could withstand, huh? If the fuel bundle can withstand 80 g's, why is there a 40 g limitation on the canister?

MR. TRIPATHI: Let me see if I understand your question. What's the genesis of 40 g, is that what you're --

MR. POPOVICS: Yeah, I think that's --

MR. TRIPATHI: -- yeah, that is based on what the fuel with the balance --

MR. CHOWDHURY: Can take.

MR. TRIPATHI: -- the strength it can take.

MR. JAMES: So that may get larger over time, also, right? An older fuel bundle can probably withstand more deceleration than -- depends on a lot of what happens when the fuel cools down on it again? Hydrides can develop in the cladding and so forth, but.

MR. CHOWDHURY: The cladding stage goes up for the fuel cladding, with age?

MR. TRIPATHI: Actually, you'll get less.

MR. CHOWDHURY: Less?

MR. TRIPATHI: With age.

MR. CHOWDHURY: Less, probably, because it brittles. Brittle materials.

MR. JAMES: Yeah, we're here as concrete experts for a reason.

MR. CHOWDHURY: Yeah. No, brittle bundle mechanical problem is really brittle in fuel baskets.

MR. JAMES: I'm just saying, you know, you should look at the whole situation and -- with the changing on the demand side, you ought to look at the passing side, also.

MR. TRIPATHI: The short answer is that this can be something which is handled which can be handled by TLAA -- we've got to do that.

MR. JAMES: Yeah, I think so. So let's use a TLAA to decide if you need to do more, you know, and what more you need to do. If you need to go take measurements and --

MR. TRIPATHI: Speaking about your industry and transportation, are there any --

MR. XI: No, no, no, not my industry.

(Simultaneous speaking)

MR. TRIPATHI: Are there any requirements for the flexibility of the pavement, say, for example?

MR. XI: Well, everything else -- the concrete, pavement should be as stiff as possible.

MR. TRIPATHI: As stiff as possible.

MR. BERKE: Yeah, they look at pavement, if it's concrete, they look for structural strength, and they design it so -- they'll do it for fatigue purposes. So they've got a certain structural strength, and they know the kinetic load of the dead strength, you know, and it's not going to hit the fatigue limit.

MR. JONES: So why don't we go ahead and take our break here? It's 2:15, well, actually a little past 2:15. Let's go ahead and come back at 2:30, we'll kind of make some concluding comments, open up for the public comment period, and I think probably wrap up a little bit ahead of schedule, which may or may not be appreciated, depending on how your flights are working.

(Whereupon, the above-entitled matter went off the record at 2:17 p.m. and resumed at 2:36 p.m.)

MR. JONES: There we go. So we've had

most of two days of, you know, great discussion here. We've covered everything that I had planned for us to go through. We kind of -- a few little tasks left I think we can wrap up kind of soon.

I wanted to just make a couple of sort of, not exactly concluding, but end of the day kind of comments. We will -- we expect to produce a report of these activities.

And by we, I mean the two gentlemen from the Southwest Research Institute will be heading that effort, and we expect that sort of in the period of a few months. We don't have a specific deadline. That would be sort of a staff-level letter type report. This won't be a, you know, NUREG.

It won't specifically inform -- won't specifically imply a new regulatory position or anything, but just a, you know, again, developing this technical basis for the regulatory framework. The report will be publicly available for -- however, I do want to emphasize that it's not a consensus report where we're really trying to document the activities that are -- that have gone on.

You know, we're not asking the panelists to, you know, form some sort of consensus opinion through that -- through these efforts. So, I think we can look forward to that as a way of, you know, synthesizing some of this information that we've gone over through this process.

And hopefully, that'll be a useful document, both for NRC and also maybe for some of the folks in the room to kind of read through and see what the, again, outcomes of this are. Entirely separate note, there's a few feedback forms on the chair back by the sign in sheet. If you wouldn't mind filling one out, we'd appreciate it.

I apologize for the missing QR code on the back. I guess there was a box for the QR code reading that didn't work, but -- so, at this point, I think what we'll turn to is we'll bring on -- our participator, Lance, will open up the line for questions. Any public comments from the room, as well. So, Lance.

MR. RAKOVAN: Thank you, Chris. Let's go ahead and see if there's anyone here in the audience that might have any questions for the NRC staff. Again, this is an NRC public meeting, so we ask that the questions be addressed to NRC staff, or if you have any comments, as well, just to pause for a second. Please, sir, if you could come to the microphone and introduce yourself.

MR. PLANTE: Yeah, I'm Paul Plante from the Three Yankees. We want to make a few observations about -- as a licensee, and what our understanding of some of the processes are. And with respect for re-licensing, and TLAAs, if we have an analysis in our initial license application, when we go into license renewal, only those TLAAs that are in our initial application can be evaluated in our renewal application.

So we can't really go back and apply a TLAA process to something we haven't done, initially. So, that's my understanding of it, and please correct me if I'm incorrect on that. I'd also like to say that, you know, we talked the last two days about some methodologies that we might use for doing further analysis.

Certainly, I think Ricardo noted this, but I'm going to emphasize, that we cannot put these canisters into what we call unanalyzed conditions. Certainly, taking a core out of the middle of one of these VCCs -- we could do it on a pad. I think that can be done, but on a VCC, that would be a whole other animal altogether.

That's not a licensed configuration, so we would have to go through a fairly extensive process to evaluate that. Same thing with excavating a pad. The pads do have some analysis that go with them, particularly even in the low seismic areas that this pad is able to withstand certain seismic issues. And to excavate around the pad, and undermine what compacted fill and all of those other things would create unanalyzed conditions.

So, you know, it's just not one of those things that you could go and just say, all right, I'm going to go excavate around here, and get a handle on what's going on. So, I did want to bring up those two things. And then, just as a final note, I was involved in the -- at least the construction of the Maine Yankee VCCs, and the facility, and these are licensed components.

They have licensing drawings, they have engineering drawings, they have specs, they have travelers, we have construction travelers go with them. They had step-by-step what you have to do all the way through the process, what mixes need to be made by the concrete suppliers. We had QC and QA involved throughout the process.

So, I'm fairly confident to say that these were nuclear-grade safety class components when they were constructed. There was not -- I am not going to say every little aspect of it was addressed. I don't personally know whether there were AAR testing going on, or anything like that on the concrete mix, but I will say there was nuclear-grade quality applied to all of this through the process.

So, you know, you should -- and the same thing with even the construction of the facility, and putting these support pads down. We got to excavate the facility, put down engineered fill, compact that engineered fill, put our pad on grade, and then these canisters sit some two and a half feet off the grade on a concrete pad.

So, it's quite the process. It took us about three years to get the facility up and running, and we started building those VCCs and moving those all over to the pad. So, we did 60 canisters consecutively. We're not, you know, and that's kind of a peculiarity of a decommissioned plant.

They will build their casks in a large group all at once. I'm not -- I can't say that I can recall any decommissioned plant, anyway, that did not do it that way. So, you know, there's not a lot of variation. They're all -- use the same concrete supplier for that group of casks, and they're all constructed at the same time.

So, hopefully that information might be a little bit useful to you, and just want that -- put that out there. Thank you.

MR. TORRES: All right, thanks, Paul. With regards to your first question, you're absolutely correct. TLAAs, by rule, should be incorporated or referenced in their approved design basis. And we were talking here about -- we were loosely using the term TLAAs.

But, we realize that in regards to aging and degradation, new calculations and analysis may be used to support the exclusion of a certain degradation mechanism or effect from an AMP, or for justifying a specific inspection frequency, or excess criteria, whatever you call it.

So, we eventually added guidance in NUREG-1927 just clarifying this, that there might be additional calculations and analysis. Not technically TLAAs, but we will evaluate them just to the extent that they're applicable to give us reasonable assurance. With regards to your second comment, again, I appreciate that, and I wanted to get input here from the panel on below grade structures for that reason.

Right now, the AMP, I think, is ten years, but it -- there are many aspects of the AMP that make it clear that the criteria is -- any applicant can come in with an alternate criteria, and we will elaborate that, which is why I wanted to entice your discussion on what other NDT/NDE and what complementary methods could you use so that we don't have to put the pad in an unanalyzed condition.

So, I think the AMP is -- I think will be getting a lot of public comment on those AMPs in 1927, and I encourage everyone here to provide comment on the specifics. We will discuss them, and obviously take input from the panel here, and see how if maybe we need to modify or clarify the information in those AMPs.

MR. RAKOVAN: Okay. And just for reminder, if folks could introduce themselves when they speak so we know who's talking. Anyone else here in the room have a question or a comment at this time before we open up the phone lines? Please, sir, if you could come to the microphone and introduce yourself.

MR. SALIH: Ahmad Salih, Areva Transnuclear. One question about the NDTs. As you know, these dry storage, you know, they're considered radioactive in high temperature. Which NDT methods are more suitable in these environments? Also, I'd like to make a couple of comments. One on the 300 degrees Fahrenheit design basis for the concrete.

This is off normal short-term based on ambient temperature of about 117 to 125, so this is very extreme case. The other thing is, with respect to concrete strength, and the residual strength after 28 days, my experience and knowledge mainly for Portland cement, concrete, you get a residual strength increase of five to ten percent after 28 days.

I've never heard of, you know, increasing the strength by two times. Thanks.

MR. RAKOVAN: Do we have someone who can address the non-destructive testing question?

MR. JONES: Would either of our self-appointed NDE experts care to respond to that? You're not obligated to, but if you would like to.

MR. POPOVICS: So, your question was what NDT methods work in radioactive and high temperature environments? And, kind of the answer is, of course all of them work. The question is, are the sensors and your technology hardened against high temperature and radioactivity? And all of your hardware that's associated with that? The AQs, and the ICs, and things like that.

If you are outside of the containment area, the temperature and the radiation levels that would be expected are not enough to, you know, require hardening of the sensor. But if now, you're talking about sensoring that goes inside of the container, that's a different story, and you have to plan and design around sensors and technology that can withstand the respective radiation dose.

Not only the sensors, but all of the hardware associated with any cabling or anything. And that must be done to -- at every temperature in radiation.

MR. JACOBS: And there are sensors that can withstand radiation, you know, special PC electrics. If you're doing acoustics and then with the temperature, things, again, they're high temperature sensors. You can always go to -- these will never go to these temperatures, but buffer rods and things like that. I mean --

MR. RAKOVAN: Thank you, gentlemen. Theron, if we could go ahead and un-mute the phone lines. If there's anyone on the phone lines that would like to ask a question of NRC staff or make a comment at this time, if you could just say your name and I'll try to get to everyone. Theron, are we un-muted?

MR. LEWIS: My name is Marvin Lewis.

MR. RAKOVAN: Marv, go ahead, please.

MR. LEWIS: Okay, just a comment. You're talking about putting these casks containing vast amounts of radioactivity in contact with groundwater, aquifers, and what have you. I'd just like you to think about looking up Ozymandias, a poem by Percy Bysshe Shelly. In pulling it up and reading it, you might find it valuable. Thank you.

MR. TRIPATHI: Can you repeat what Marvin said?

MR. JONES: Let me see if I can turn it up a little bit.

MR. RAKOVAN: Marv, we had a difficult time hearing you. I'm going to see if I can get the microphones turned up in the room. Sorry to ask you to repeat it.

MR. LEWIS: Yes, I was saying, you might want to look up a poem by Percy Bysshe Shelly called

Ozymandias, and think about putting this tremendous load of radioactive poison, plutonium, various plutonium isotopes, in contact with groundwater, and aquifers, and soil. And sure enough, I know, oh, my goodness, you've done a wonderful job saying that it isn't going to open up.

Well, I assure you, the people in Japan, and Japanese did a wonderful job of saying, oh, it won't spill, it won't get out. It is getting out. That's all. Thank you.

MR. RAKOVAN: Thank you, Mr. Lewis. Anyone else on the phone lines have a question for our NRC staff or a comment at this time?

MR. HOFFMAN: This is Ace Hoffman.

MR. RAKOVAN: Please, go ahead, Mr. Hoffman.

MR. HOFFMAN: Thank you. Earlier, it was mentioned that the loads are going to be pretty different from an operating reactor, and I understand this is certainly true in many ways. But, the dry cask thing in San Onofre are very near railroad tracks, and near crashing waves.

And there will be an undercurrent of vibration that might need to be taken into account from a -- that would not necessarily be true of other places and that you might not have been thinking about.

Also, I want to make a strong note about the concrete guys were expressing the strength of the concrete in getting stronger, but perhaps more brittle, and the fuel is probably going to get more brittle, but -- and weaker. They're going in different directions over time, and the way these things go, what they -- where they're going to end up can be very delicate to predict.

And in a side note, there's -- it sounds like there's going to be a dozen different ways to store the fuel that are all going to be acceptable. And it seems unlikely that they're all going to be equally good. And then the last thing I wanted to point out is that I think it was an NRC person said that they had done and looked at why bridges were required to be inspected every two years.

And they discovered that there wasn't really any sound scientific reason for it, it was more of a political sort of thing, that they just kind of decided that. And I think that's not really the question. The question that you should've gone and asked and maybe you also did, but make sure that you do, is was two years sufficient?

And is it yielding good results? Maybe

that these casks need to be inspected a lot more frequently, considering that there's going to be 10,000 of them just to hold the fuel that we've already created. So, I think you're behind the eight ball to begin with. Thank you very much, and it's been a very interesting two days. Thank you.

MR. CSONTOS: Hi, Ace, this is Al Csontos. I was the one who commented. We visited the Federal Highway Administration, and we talked to their lead scientists and engineers on this topic. And, you know, they believe that their methodology, they have a risk-based methodology.

They have a very large computer code that looks into, oh, boy, they look into weather, they look into salt damage, they look into all the research that's been going on for decades, and they put it into a big old model. And it spits out probabilities, and such, and prioritization. And they felt they had a basis for going forward and inspecting.

And this is everything that they have told us. This is not, you know, what -- this is from our meeting with them. They felt they had a good handle on it, but Congress -- I think there was an issue with a bridge, and so therefore, Congress went ahead and just made the law for that. And then just -- and just said, look, you're just going to do it every two years, at minimum, so that was that.

What was your second question, Ace? You mentioned about, I think it was about looking more than a couple years? Or more than five years, was that it, Ace?

MR. TRIPATHI: Well, I think the other issue he talked about was the hardening of the concrete and simultaneously, weakening or brittleness of the fuel inside.

MR. HOFFMAN: Yeah, and I think you're the person that pointed it out, that these are going to be going in opposite directions from the ones, the concrete guys you were expecting.

MR. CSONTOS: Okay. But you were also mentioning something about having more inspections, or such? Can you --

MR. TRIPATHI: Every two years. I think that's what he was saying.

MR. CSONTOS: Was that what you were saying, Ace? Can you just reiterate what you were asking?

MR. HOFFMAN: Oh, just that with 10,000 dry casks, perhaps at least at the start, inspecting even as infrequently as two years might be way too insufficient --

MR. CSONTOS: Okay. Yeah, so --

MR. HOFFMAN: -- for all of the oddities during that time.

MR. CSONTOS: So that's part of what we call the extent of condition analysis, okay? When we do our initial examinations or when the licensees do their initial examinations, based on the results of their inspections, we will determine, and with actual licensing laws that are determined through their corrective action programs, whether they need to expand their inspections.

Once they start seeing things in the most bounding cases -- let's say, for example, we get this body here that's telling us temperature is a big player, environment's a big player, so what we go in through and we get a systematic process by which we look at one or two canisters, or in this case, it's the overpacks.

If we find that there are problems, then those -- then the subset of systems being inspected will grow. And if it is a, you know, if it is something generic that has happened to all the systems, yes, all those systems will be inspected at some point if there is the first cases of it being -- of finding any kind of degradation.

So, do you see how that logic goes? That you analyze the first ones, and then you look and you evaluate how much you could do more in the future. Like, what we call -- it's what we call technically is the extent of condition.

MR. HOFFMAN: Okay, but not sure what you mean by the first ones, because as one of the other gentlemen mentioned, the high burn-up fuel might be degrading a lot faster than the older, low burn-up fuel.

MR. CSONTOS: No, the only real difference between the high burn-up fuel -- and I was going to say something about that -- is really the temperature. It's the heat loads. And so the heat loads could be, you know, we have certain canisters that have high heat loads now, and with the high burn-up fuel, you may just have a hotter fuel -- or hot fuel.

But it's all capped at the same limit, so you may not have as much fuel in the canisters, because the fuel is hotter, but the fuel -- the temperature of the canister has to be capped at that 400 degrees. So, you may have less fuel in each canister, but the concrete sees that same temperature. Does that make sense?

MR. HOFFMAN: Yes, it does.

MR. CSONTOS: So that's where -- I'm not

sure if that really changes much, other than the max temperature that the concrete will see for many different canisters, with and without high burn-up fuel.

MR. HOFFMAN: It will probably see it for a lot longer with the high burn-up fuel, though.

MR. CSONTOS: Correct.

MR. HOFFMAN: That's going to be a factor. One more thing was, yesterday, I mentioned putting the canisters into an enclosed area, because somebody else had said -- one of the experts said that moisture is always a factor in the degradation. And I think you got some EPRI responding -- it was hard for me to hear, but as I understand it, you said that the room would get filled with caustic materials, sodas or something like that.

But that would be assuming that there was no cleansing of the air through a filter system. So, of course, that wasn't what I was assuming. I was just assuming that it would be blocked off from the standard day-to-day moisture and chemicals that were coming in. Just wanted to make that clear. Thank you.

MR. CSONTOS: Oh, okay, so you're just saying that the enclosure that you're talking about would have filters or something that just takes out the humidity or regulates the humidity and takes out all the other elements that could cause degradation?

MR. HOFFMAN: Exactly, yeah, that's all.

MR. CSONTOS: Okay. Thanks for the comment.

MR. HOFFMAN: Okay, thank you.

MR. RAKOVAN: Okay, any other additional comments on the phone line, or questions at this time?

MS. MAGDA: Marni Magda.

MR. RAKOVAN: Please, go ahead.

MS. MAGDA: I have only been able to listen sporadically to this two-day conference. I do apologize, I didn't know in time to change important other conflicts. So, I would love to have a transcript of the entire proceeding. I've listened in enough.

Since I am here near San Onofre, very, very concerned about the decision of the buried canisters, and I did get to hear that one -- actually, I'm trying to figure out, because you can't even visually inspect them, how often you'd have to look at them, whether excavating would make it worse.

I would just like to, you know, the experiment of this at San Onofre Bluffs, concrete, it is going to be just 500 feet from the ocean. We have welling up of water every year that wrecks our roads and our concrete, everything cracks. Nothing lasts for the 100 years that this has to last before we get it out of there, if we ever get it out of there.

I hope someone is going to stand up for challenging the system. We need to get the canisters off of Camp Pendleton Military Base into a system that is in a dry, away from people, and ocean, and fire, and everything you have mentioned that could go wrong at San Onofre.

It's an experiment. You've only had canisters for 25 years, and we can't -- no matter what any of you -- everyone is alluding to the things that could be a problem, and then you'll say, but, we'll test this. And it is horrifying to me that we've watched at Chernobyl, within 28 years, the whole overpack had to be changed at $1.4 billion.

And so I don't see any of you facing the honest truth of -- I heard Tom Palmisano say that the cement overpack at San Onofre is already crumbled and needed repair. Then later, he said he was talking about the National Laboratory cement overpack. Cement isn't going to last the time that these canisters need to last.

The canisters won't last the time that they need to last, and what we're creating is a system that's too heavy to move it, and we need to move the fuel now. So, I am just asking all of you to honorably stand up for what this country needs right now.

California military base at Camp Pendleton is the wrong interim storage military base. We need everyone's help to have the public understand that and make a change. What I've heard at this meeting so far has made me much more concerned, not less concerned, so I have my 90 year old aunt in emergency right now.

I can't listen to answers today, but I would expect some answers in writing, and please, please, stop trying to tell us everything's safe when it's an experiment. It's only 25 years old. We've got to watch this fuel for tens of thousands of years.

The taxpayer has to pay for all the costs. Help us do it right, and everyone being bold at what a real solution is, not these temporary ones. Holtec's casks are even more frightening than Areva's at San Onofre. Help us get it all moved. That military base is way too exposed to fire, earthquake, tsunami, terrorists, everything could go wrong, and you're just trying to tell us that it won't.

But it could go wrong, and that's a dead zone forever. So, please, please help us. Sorry I can't listen, I will write more letters. I can't even listen to your answer today because she's in the hospital, so just know how much I want you to seriously be as brave as some of the people were who stopped the steam generators and shut down the plant because of not being sure it was safe.

We can't mess with the radiation of nuclear. It is not like an earthquake or a fire. We won't recover from it, and thank you for listening. I have to go.

MR. RAKOVAN: Okay, thank you for those comments. Anyone else on the phone line have comments or questions at this time? Anyone here in the room or on the phone lines have any questions or comments at this time? Please, if you could reintroduce yourself.

MR. PLANTE: Yeah, this is Paul Plante again from the Three Yankees. I did want to go over a little bit about our inspection process. We have a -- in our FSAR, we're required to look at these canisters every year, and do an annual inspection.

That's a licensing commitment, so that's something we've been doing since they went into service. And also, looking at re-licensing, it's also applied across our system of canisters. All the users out there that use these canisters have the same FSAR, they have that same annual requirement.

Looking at re-licensing, our plan is to take those annual inspections and feed them into the re-licensing program. Now, the annual inspections that we do now are not a 349.3 annual inspections, which is where we're headed. I will say that at our three plants, we have been test driving that inspection process so that we're not caught at that point in time wondering, you know, what are we going to do now?

We want to kind of find out where those problems are ahead of time. That process requires that there be a person called responsible in charge engineer that has to have certain qualifications. We have two such engineers on the staff, and we review all those inspection results.

But in the long-term, we expect these annual inspections to feed into our re-licensing plan, and inform that process as we go forward, and hopefully identify which canisters ought to be the lead canisters, if you will, at each site, where we would do maybe more detailed inspections.

So, we don't have all those processes laid out right now, but, you know, I'm fairly confident that we'll be there when the time comes. And just wanted to elaborate on that process, at least at our utilities. Thank you.

MR. RAKOVAN: Further questions or comments, either here in the room or on the phone lines?

MR. DUNCAN: Andy Duncan from Savannah River.

MR. RAKOVAN: Please go ahead, Mr. Duncan.

MR. DUNCAN: I guess I would like to address the expert panel and just kind of echo my comments from yesterday, and maybe they were misunderstood. From my perspective, the worst thing you could do for carbonation rates is enclose the building and air condition it.

Because you put relative humidities -- and air conditioned air is somewhere between 40 and 60 percent, and that's the maximum rate of carbonation that goes into your concrete, which is great, as long as you keep it air conditioned for a millennia or so, you know, as -- for your storage life.

But if you ever decide to close it up and not air condition it anymore, then you've got something that's -- maybe has the cover compromised to the extent of 50 to 75 percent of the concrete cover is now fully carbonated, and no longer a protective barrier for the rebar. I thank you for your consideration.

MR. RAKOVAN: Okay, we have a question or comment in the room. Please, sir, if you could reintroduce yourself.

MR. SALIH: Ahmad Salih, Areva Transnuclear. Yesterday, the panel talked about performance based specification, and testing. We talked about shrinkage, chloride absorption. And the NUREG-1536 is very clear that you have to use the ACI 318 or 349.4 for design construction.

Is the NRC considering amending the NUREG-1536 to allow use of performance based specification? Thank you.

MR. TORRES: This is Ricardo Torres of the NRC. At this moment, I am not aware of discussions for amending 1536. Well, on a performance base. I don't know if you want to comment on this, Bob?

MR. TRIPATHI: I'm trying to understand your question here. Are you saying that if you follow the NUREG-1536, which is our acceptance criteria, are you okay, or are -- on top of that, you're required to use ACI 349.3R. Is that your question? The ACI 349.3R may not have been mentioned in 1536.

MR. SALIH: Yeah, I'm mainly talking about new systems and new construction. I'm not talking about existing systems. So, in NUREG-1536, when you design and build storage systems, you use ACI 318 and ACI 349 for construction.

Now, there are durability requirements in the code. For example, for air entrainment, and chloride, and so forth. The question that I have here is, we talked about a performance based specification yesterday, and the question here is, will the NRC allow use of performance base as opposed to plans with ACI codes?

MR. TRIPATHI: Yeah, the short answer to your question is that, you know, we don't update the 1536 in NUREG, like, every year. In the area where we issue ISG, what they call entering staff guidance.

So if there is enough evidence of incorporating all this new technology and new requirements, then we can issue an ISG, and then after certain years, we incorporate all of those ISG into the new revision of the NUREG. Does that more answer your question? Is that what you're looking for?

MR. RAKOVAN: Any further questions or comments, either here in the room, or on the phone lines, at this time?

MR. HOFFMAN: This is Ace Hoffman. I just wanted to mention that I appreciate that clarification from yesterday, and it does complicate things.

MR. RAKOVAN: Thank you, Mr. Hoffman. Pause one more time to see if there's any questions or comments. Chris, should we go ahead and move to closing at this time?

MR. JONES: I think so. I don't -- unless anybody has a last minute comment.

MR. RAKOVAN: Can you let folks know when the transcript will be available, and how they can find that?

MR. OBERSON: The transcript --

MR. RAKOVAN: Use the mic, man.

MR. OBERSON: This is Greg Oberson from the NRC Office of Research. I would say the transcript will be released no sooner than two weeks, but we'll make it publicly available on ADAMS. And anybody who's provided me with their contact information by email, Greg.oberson@nrc.gov, if you're interested in a transcript, I can directly email to you the notice of that when it's made available.

MR. RAKOVAN: Excellent, thank you. Chris, any parting words?

MR. JONES: Great. So, we've been -- again, better part of two days talking about the different issues relative -- related to the degradation, the chemical degradation of storage systems. I think we've covered a live breadth of areas, and that's somewhat reflected in the diversity of experience and expertise of the panelists.

I think that we've, you know, I was -- as I was thinking about it, there's, like -- well, heck. We had a objectives slide. I think that we've done a good job of enhancing the technical bases with a few of the, even the discussions we've had here over the past two days.

Furthermore, the other activities that have gone along with the phone calls and the written responses, I think, have contributed to that. I think that there's been, you know, a good drawing out of expertise from transportation, other, you know, concrete industries, bridges, and pavements and things like this.

And I think through all of that, we've found maybe some areas where practices are different a little bit. The frequency of inspection, of course, comes to mind immediately. We identify that as maybe a little different.

And so that, you know, leads us to some items that we can go back and look at, identify if that's something the NRC needs to act on, or if it's, you know, if it -- there's a reason why they're different. Furthermore, in addition, there's some potential information needs that I think have been drawn out, and maybe we need to look at a few additional mechanisms than what we had in the TIN Report.

And also, maybe look at those a little bit more closely than we did. I think, in particular, the discussion of some of the NDE techniques and sort of using those in a smart way, I think was pretty valuable that we can, you know, improve our understanding there.

So, I guess on behalf of the Office of Nuclear Materials, Safeguards and Security Office of Research, I'd like to thank the panelists for giving us the time. We realize it takes some effort to get out here, and we appreciate that. I do apologize for the weather, although I have no control over that, and the certain cancelling of flights that may have happened.

So, I can't do anything about it, but I feel for you there. So, I guess with that, we'll wrap up this activity. Again, I'll say thanks, and we appreciate it.

MR. POPOVICS: I have one question.

MR. JONES: Sure.

MR. POPOVICS: Will there be any further expectations of us in the expert panel regarding this effort?

MR. JONES: At this point, I don't -- would you like -- I'm not sure.

MR. OBERSON: I guess I would just say no, I think we can have a brief discussion on -- kind of offline after the meeting about any further -- need would be rather limited, I think.

MR. POPOVICS: Yeah, I understand.

MR. JONES: Yeah, I tend to agree. I would think that -- I would only give the caveat if, for some reason we wanted to change that, we would reserve the right to, but we don't have anything planned at this point, so. Yeah, I don't, you know, that's -- another comment?

MR. CSONTOS: No, I just, you know, as the end user of this product, okay, I just want to say thank you to the panel. It has been a good, lively discussion, and, you know, our job is not to make people feel safe, it is to make them safe, all right, and to ensure safety.

And so, talking about these degradation mechanisms, although it might be uncomfortable for some people to hear, it's important for us to talk about it so we can understand what it is that we need to go out there and make sure people inspect for, okay?

So, I want to thank you for all the work that you've done that as the end user, we will take this information to heart. Thanks.

MR. JONES: All right, I guess that'll do it.

(Whereupon, the meeting in the above-entitled matter was concluded at 3:17 p.m.)