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(202) 234-4433

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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NUSCALE SUBCOMMITTEE

+ + + + +

WEDNESDAY

JANUARY 19, 2022

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The Subcommittee met via Video Teleconference, at 2:00 p.m. EST, Walt Kirchner, Subcommittee Chairman, presiding.

COMMITTEE MEMBERS:

WALTER L. KIRCHNER, Chairman

VICKI BIER, Member

RONALD G. BALLINGER, Member

CHARLES H. BROWN, JR. Member

VESNA B. DIMITRIJEVIC, Member

GREGORY H. HALNON, Member

JOSE MARCH-LEUBA, Member

DAVID A. PETTI, Member

JOY L. REMPE, Member

ACRS CONSULTANT:

DENNIS BLEY

STEPHEN SCHULTZ

DESIGNATED FEDERAL OFFICIAL:

MICHAEL SNODDERLY

ALSO PRESENT:

JOSEPH COLACCINO, NRR

MICHAEL DUDEK, NRR

OMER ERBAY, NuScale

LIZ ENGLISH, NuScale

GIULIO LEON FLORES, NuScale

AMITAVA GHOSH, NRR

ATA ISTAR, NRR

FEHMIDA MESANIA, NuScale

DEMETRIUS MURRAY, NRR

RIM NAYAL, NuScale

BOB PETTIS, NRR

GETACHEW TESFAYE, NRR

EVREN ULKU, NuScale

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

2:00 p.m.

CHAIRMAN KIRCHNER: Okay, good afternoon, everyone. This meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, NuScale subcommittee meeting.

I am Walt Kirchner, Chair of this meeting. Assisting me, and joining me, is Ron Ballinger, from the Committee.

Members in attendance today are, in addition to Ron Ballinger, Vicki Bier, Charles Brown, Greg Halnon, Jose March-Leuba, David Petti, Joy Rempe. And consultants Dennis Bley and Stephen Schultz.

Have I missed anyone from the Committee? Please speak up if I have. Hearing none, okay, I'll proceed.

Mike Snodderly is the designated federal official for this meeting. The Subcommittee will review the Staff's evaluation of NuScale's licensing topical report, TR-0920-71621, building design and analysis methodology for safety-related structures. Today we have members of the NRC Staff and NuScale Power to brief the Subcommittee.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act, FACA.

The NRC implements FACA in accordance with its regulations found in Title 10 of the Code of Federal Regulations, Part 7.

The Committee can only speak through its published letter reports. We hold meetings to gather information and perform proprietary work that will support our deliberations at a full committee meeting.

The rules for participation in all ACRS meeting were announced in the Federal Register on June 13th, 2019. The ACRS section of the U.S. NRC public website provides our charter, bylaws, agendas, letter reports and full transcripts of all full and subcommittee meetings. Including slides presented therein. The agenda for this meeting was posted there.

Portions of this meeting can be closed, as needed, to protect proprietary information pursuant to 5 U.S.C. 552(b)(c)(4). As stated in the federal register notice and in the public meeting notice posted to the website, members of the public who desire to provide written or oral input to this subcommittee may do so, and should contact the designated federal official five days prior to the meeting, as practicable.

A phone bridge line has been open to allow members of the public to listen in on the presentations and Committee discussion. We have received no written comments or requests to make oral statements from the members of the public regarding today's meeting.

There will be an opportunity for public comment. And we have set aside 15 minutes, in the agenda, for comments from members of the public attending or listening to our meetings.

Written comments may also be forwarded to Mike Snodderly, the designated federal official.

A transcript of the open portions of the meeting is being kept. And it is requested that speakers identify themselves and speak with sufficient clarity and volume so that they can be readily heard. Additionally, participants should mute themselves when not speaking.

So let me reiterate that request. Please mute your phone or your computer when not speaking.

We'll now proceed with the meeting. And I will call first upon, do we have any NRC senior Staff who wish to make an introduction?

If not, we'll go directly then to the NuScale presentations. And we will begin with Fehmida Mesania from NuScale. Please proceed.

DR. MESANIA: Thank you very much. This is Fehmida Mesania from NuScale licensing engineer. Good morning and good afternoon to everyone.

On behalf of NuScale we would like to thank the Staff and the ACRS Committee for the opportunity to present our topical report on the building design and analysis methodology for safety-related structures.

Can everyone hear me okay?

CHAIRMAN KIRCHNER: Yes, Fehmida, that's excellent.

DR. MESANIA: Thank you. Liz, please next one. Thank you. My name, like I said, Fehmida Mesania, I'm a licensing engineer with NuScale. Along with my colleagues, we will present our topical report.

For this open session it -- are going to be myself and Evren Ulku who will be presenting a generic overview of the content of our topical report.

Next slide please. The proposed agenda for today's presentation will include a brief discussion of the process, and introduction of the timeline of events, followed by a technical generic discussion of the building design of the SC walls, reinforced concrete members, in-structure response spectra and effective stiffness modeling approach.

Next please. So the purpose of this presentation is to present the ACRS a technical content of our topical reports as outlined in the proposed agenda. And also provide a generic understanding of the building design and analysis methodology for the SC-1 and SC-2 safety related structures for the reinforced concrete and steel composite walls that are applicable for the NuScale SMR design.

Next slide please. So this slide provides a generic introduction of the timeline of the events moving out to today's meeting.

NuScale submitted a topical report on December 2020. NRC accepted for review and completed the audit. And REI, their review by October 2021.

So the plant specific did revise our topical report and submitted it as 1. And in November 2021 NRC issued its draft SER of the topical report.

Next please. Next slide please, Liz.

MS. ENGLISH: Are we on Slide 6?

DR. MESANIA: Yes.

MS. ENGLISH: Okay.

DR. MESANIA: Now we can move to Slide 7 please. Sorry.

MS. ENGLISH: Oh, okay. Got it.

DR. MESANIA: Okay, I think we are missing one. Maybe not. Would you mind going back to --

CHAIRMAN KIRCHNER: Fehmida, I think you need to go back to Number 6.

DR. MESANIA: Yes. Sorry, Liz. I'm looking at a different screen here. My apologies to everyone. So yes, I did miss a slide so sorry about that.

So yes, this slide where we want to just give an introduction of what the content of the topical report is. So the new reactor design recently have adopted a modular steel plate composite structure as one of the design features of the safety related structures.

Our report offers an advance building design and analyses methodology that will be used for our SC-1 and SC-2 structures. Our report defines the methodologies to account for the interaction of SC walls with traditionally constructed and reinforced concrete members, such as basemats, slabs and roofs.

In addition, this report implements the soil library methodology, as outlined in this topical report. And the information provided in this topical report would be used as part of our standard design approval application.

Are there any questions or comments so far?

MEMBER BROWN: Yes, we were really on Slide 6 so I'm not sure, this is Slide 7 that's showing, are we still behind the eight ball, Walt?

DR. MESANIA: We are currently on Slide 6. Are you able to see Slide 6?

MEMBER BROWN: Slide 7 is shown on the screen, that's why I asked the question. I don't know what anybody else is seeing.

CHAIRMAN KIRCHNER: We are seeing 6, Charlie.

MEMBER BROWN: All right, I'm happy. As long as, it's my laptop then. Sorry about that.

CHAIRMAN KIRCHNER: Okay.

DR. MESANIA: So, if there are no questions so far, I'm going to hand it over to Evren to present a generic overview of the technical content of the report.

DR. ULKU: So, thanks for that. Can everyone hear me okay?

CHAIRMAN KIRCHNER: Yes, Evren. Go ahead please.

DR. ULKU: Okay, thank you. Yes. Good

morning and good afternoon, everyone. Again, this is Evren Ulku.

I am the supervisor for the structural analysis at NuScale Power. I've been at NuScale for about four years now, and almost 13 years in the nuclear industry.

So the open session of the presentation today was intended to be a generic introduction for the closed session. I only do have about five slides to cover. And the order of slides we'll cover, is what you will see in the closed session.

So I do have two slides for SC walls, one slide for reinforced concrete and ISRS and design methodology and effective stiffness.

Please, if you can go to the next slide we can get started. Okay.

So in this first slide you see a cross-section of SC wall. And SC stands for steel-plate composite. And in this type of construction the concrete it sandwiched between two steel face plates. Reinforcement, or rebar in other words, like what we should see in reinforced concrete, is replaced by the steel face plates.

Again, reinforced concrete construction, heavier rebar density reinforce concrete members may bring some construction challenges due to congestion and crash of interfacing structural components. So these steel faceplates eliminate that. And they also replace the form work that would be used in traditional reinforce concrete construction.

We do have steel anchors, or referred to as steel-headed stud anchors, in the figure. Okay, was there a question from someone? Okay.

CHAIRMAN KIRCHNER: Please proceed.

DR. ULKU: Okay. So we do have stud anchors and they ensure composite behavior within the faceplates and the concrete.

There are tie bars between two faceplates. And sometimes there are tie plates. They promote structural integrity, they prevent the elimination of concrete. And finally, they serve as huge reinforcement when the design is complete.

You can see in the figure --

DR. BLEY: How does it work then for delamination? Just by keeping pressure on it?

DR. ULKU: Yes. And then, let's see, you see like for penetrations, again, in the figure, they can be, again, introduced in the design stages, or sometimes during construction stages. But again, they bring in the same advantages before the models are built.

Again, the embedded plates, they are in the, for commodity attachments. An additional commodity attachments can be introduced during construction. Or even during service, if there is a need.

Liz, if we can go to the next slide. Okay. And this slide is, again, SC wall related. We are looking now at potential advantages and disadvantages, or I would call maybe where we need to pay closer attention.

Again, the first bullet talks about the higher resistance against, like some of the design basis, blast or earthquakes. We do have higher ultimate strength with SC walls that comes in with the steel faceplates, which like provides significant contribution to that.

And as you see, there are considerable reduction in fabrication and erection times that is inherent with the module construction itself. This provides improvement in the wall construction schedule. And that translates like savings in the wall plant cost.

The module, whereas we plan to use, and we do have some figures in the closed session. They are smaller and lighter than previously used designs. And they are intended to be easy to transportable on the bed of a semi-truck. So we do have like weight and size restrictions on them that we are working on currently.

Now, the area is where we need to pay extra attention, or special attention. Again, the first is the connection reasons.

The connections, like anywhere between SC wall panels, like that might be horizontal where it joins. And like RC elements, reinforced concrete elements with the floors, basemats and the roofs. Like they may require some extra attention.

Again, these are potential areas where congestion or like where we need to develop the components.

DR. BLEY: Let me interrupt --

DR. ULKU: Another area --

DR. BLEY: -- again.

DR. ULKU: Sure.

DR. BLEY: It's Dennis Bley. A few years back another applicant came in using this approach. At that time the consensus standard was not in place for this kind of construction. There were some issues raised.

But can you give us a little background on the history of this approach and what's the longest, you know, application that's been in place? And not necessarily in the nuclear business but elsewhere.

DR. ULKU: So, let me rephrase the question. So again, there was another vendor and then at the time they had not, or there did not appear to be a standard for this type of construction. Was your question related, like, are you asking about --

DR. BLEY: Now, that was a statement.

DR. ULKU: -- developments or --

DR. BLEY: That was a statement.

DR. ULKU: Okay.

DR. BLEY: That at that time there was not a standard.

DR. ULKU: Okay.

DR. BLEY: The question is, what's the history of this kind of this construction throughout the world and what's the longest, the oldest example that's still a standard, that you know of?

DR. ULKU: I see. I think, yes, let me see. It did start in, I think, maybe Japan and those part of the world. And I think it goes back to maybe '80s or '90s.

And it started with commercial

construction. And we did have like some other composite members or, not necessarily fuels, but again, say concrete and fuel, fuel members. Like in hybrid construction I would call, in like different parts of the world that using it for tall buildings and whatnot.

And obviously, like for nuclear construction, again, like another vendor, like people that have, like, they started it and that wasn't a standard at the time. They used like other concrete cores, and whatnot, to come up with their own methodology and criteria documents to do that.

But in U.S., at least more recently, for example, that we were building like the tower that was built a few years ago that provided like significant cost savings and like construction schedule savings. That spot we build this, again, commercial construction, but again, it's standing a couple hundred feet tall.

DR. BLEY: Okay, but that's fairly recent. But you say this has been used in building construction as much as 30 years ago in Japan, is that correct?

DR. ULKU: Right.

DR. BLEY: Okay, thank you.

DR. ULKU: That is my thought. Yes.

MEMBER REMPE: Dennis, if I could ask for some clarification to the answer or are you done?

DR. BLEY: I'm done.

MEMBER REMPE: You mentioned it was for hybrid construction. What do you mean by that term? I'm sorry, I'm not an expert in this area.

DR. ULKU: When I said hybrid, for example, I meant that say, for example, you build a traditional or reinforced concrete buildings, that it may have some core elements, let's say. And then there was some members may have steel faceplates and they may have concrete in it.

So, it's not necessarily the same thing we talk today, but it is similar in the sense that it was built. And those are even like earlier than 30 years ago.

MEMBER REMPE: Okay, thank you.

CHAIRMAN KIRCHNER: I think Ron Ballinger, I think you had your hand up?

MEMBER BALLINGER: Yes. I would remind the members that we reviewed Reg Guide 1.243, or we had a chance to, and we decided not to, in August. And that document endorses the various codes and standards, N690-18 and AISC-360 something or other, I forget the exact details, which endorsed the use of these composite walls.

So we had a chance to, we looked at this in that Reg Guide, and its references are very extensive. And would provide members with the history and all kinds of information if they need to go and get it.

DR. BLEY: We didn't look at it, from what you said. What was the Reg Guide number, Ron?

MEMBER BALLINGER: 1.243.

DR. BLEY: Thank you.

DR. ULKU: Okay. And the last bullet on this part of the slide is, again, the issue of corrosion effects.

We did intend to use the SC walls below grade. And we do have, I think in additional slides on this one in the closed session, so we'll come back to this in the closed session a little bit more.

Liz, if we can go to the next slide. Now, this is on reinforced concrete. Again, even the SC walls introduce quite a few advantages over reinforced concrete. We are not trying to abandon reinforced concrete altogether. And we'll use reinforced concrete where it proves to be advantages.

For example, members in part, floor slabs, roof, basemats. They are pretty much all reinforced concrete. And again, this is believed to be advantages during construction.

And we plan to use, again, the latest addition of the nuclear code ACI 349 for reinforced concrete members.

Can you go to the next one? Yes. And this is like why we will present the, like how you extract the in-structure response spectra, ISRS. And for some models for the member design.

And this section we can deem as an add-on to our previous topical report on the -- like the analysis. So we do have like, again, detailed slides on how we are choosing some values, the building analysis and design.

And prior to, sort of methodology, we present, are consistent with the latest industry codes and standards.

Like here you see two criteria documents from ASCE on building analysis and design for nuclear structures. And one is the concrete code and the other one is the steel code for nuclear construction.

To go to the final slide, Liz. On effective stiffness. Okay.

So again, we'll go into quite a bit of

details on, like what we are doing for stiffness. So in this slide, this slide can define generically, like what is stiffness versus what is effective stiffness.

So stiffness, again, in simplest terms, is the resistance of deflection extent to which an object resists the formation, say, in response to an applied force.

And for structural wall members, again, like from geometric properties, geometric properties are the basic things that the stiffness depends on. But it also is dependent on like a lot of other factors. Say the reinforcement ratio, rebar from the foundation, the foundation rotation, the exit portion, the wall. It's a complex phenomena.

Concrete, again, on the other hand, is a non-linear material and it is going crack on the design loads. And we show like different cracking on the different set of flows like, again, for tension, for shear for example, like we may see different things.

And then we see concrete, absorb concrete. That stiffness of the member further changes, it reduces, and it becomes an even more complex phenomena itself.

So to make things simple, like when I say things I mean design because, again, ASCE or ACI did provide effective stiffness values that we can use. And these are given as a fraction of gross thickness.

Say for example, we would use 70 percent of the stiffness for columns and compression versus 50 percent of the columns intention for actual thickness.

And again, we see different reduction factors for different stiffness. Say for example we use half of the selection when we see cracking, but then we use capacity for shears. So it is different.

And we develop some methodologies where we match different significant values for different numbers. Again, like by using orthotropic material properties, using some layered elements and element layers to match the --- so we got quite a bit of details where we can start the slide.

And I think that's it on my end. The last slide is just acronyms, Liz. If there are any further questions I'd be happy to answer.

CHAIRMAN KIRCHNER: Well, Evren, this is Walt. You know, this is a very complicated topic we're presenting right now to the, in an open session to the general public.

Could you explain to the general public why they should not be concerned if one of these structural members has cracks?

DR. ULKU: Now, again, the reinforced concrete, we designed, we are designing members to the ultimate strength level. And at the ultimate strength level they are expected to crack.

So it is nothing to, like be scared of or it is nothing to worry. But we do need to take into account the reduction of stiffness due to crackings.

CHAIRMAN KIRCHNER: All right.

DR. ULKU: So, we are actually presenting, representing, the true material property by taking into account the effects of cracking.

CHAIRMAN KIRCHNER: Well, I would have gone further and said that the codes and standards that you referenced in your TR provide for this, and then provide design margin to compensate for these kinds of things, like cracking of the concrete. Isn't that correct?

DR. ULKU: That is correct. Yes.

CHAIRMAN KIRCHNER: Yes.

DR. ULKU: It is correct. Yes.

CHAIRMAN KIRCHNER: Okay.

MEMBER BROWN: This is Charlie, can I ask a question?

CHAIRMAN KIRCHNER: Go ahead, Charlie.

DR. ULKU: Sure.

MEMBER BROWN: Okay. Is this cracking, I'm not a concrete guy either, obviously, in the plants we had today, does the concrete, reinforced concrete container, are they understood to crack also?

DR. ULKU: Yes.

MEMBER BROWN: Under load? So this is not --

DR. ULKU: Yes.

MEMBER BROWN: -- it's not --

DR. ULKU: Again --

(Simultaneous speaking.)

MEMBER BROWN: I'm sorry, go ahead.

DR. ULKU: It is not different from the, again, existing plants or the new plants. This concept has been out there, again, for quite a while and has been considered in the, again, the standard review plans.

The only thing we are doing is maybe, again, like it is a more medium material but we are still assuming can go linear in the analyses. So by using, again, that red curve you see on the slide, like these are still sent to the linear on the linear aspect space.

But this is maybe a better representation of the actual state of conditions. But then again, the buildings are tested against the design margins.

But again, it is nothing new. It has been out there for quite a while. And, again, it includes the plant, existing plants.

MEMBER BROWN: Okay, thank you.

MEMBER BALLINGER: This is Ron Ballinger again. The steel plate composite walls have been used in the past for nuclear construction as well, am I right?

Only it has to have been, it had to have been approved on a case-by-case basis before 1.243 got updated.

DR. ULKU: Right. So, it is true, yes. Again, it was used on a case-by-case basis. The Applicant, I guess they used ACI, the concrete codes. And they changed, again, some aspects of the code or had to come up with their own approaches and methodologies for the design.

But right now, again, Reg Guide 1.243 is out there. The latest code, N690-18, Appendix N9 is out there. So we are making use of the latest and greatest standards.

CHAIRMAN KIRCHNER: Ron, this is Walt. If I remember correctly, we have several plants out there that use this SC walls for support of the reactor vessel and shield, isn't that correct?

MEMBER BALLINGER: Yes, I think that's true. I actually had a list but I can't, I've been feverishly trying to find it in my antiquated filing system. But I haven't been able to.

CHAIRMAN KIRCHNER: So I think there is experience, going back to Dennis's question, there is experience in the industry with variations on this steel plate composite, concrete wall construction.

DR. BLEY: What I was kind of interested in was the history of it. If you remember, back when we did that other design cert where this came up, there was a very strong and detailed disagreement among the staff that was brought to us and shown to us at that time. But again, that was before there was a standard.

Now, as the point Ron raised, we decline to review the Reg Guide 1.243. I kind of think most of us didn't realize that it included the steel wall, steel composite wall issue. And so questions at this time seem appropriate since we never really looked at this in detail after that first application that came in.

MEMBER BALLINGER: Well, the review memo

that was written specifically called out this type of construction.

DR. BLEY: Nevertheless, we never really talked it through.

MEMBER BALLINGER: Okay, I got it. We can always change our minds and review it.

DR. BLEY: I'm just glad to know where it is. And I've started reviewing it already.

MEMBER BALLINGER: Well, I sent you a copy.

CHAIRMAN KIRCHNER: Okay, Evren, does this complete the NuScale presentation for the open session?

DR. ULKU: That is correct. Yes.

CHAIRMAN KIRCHNER: Okay. Members, are there further questions at this juncture for NuScale?

Hearing none, then we'll turn to the Staff. And I believe that we will hear first from Demetrius Murray from NRR.

MR. MURRAY: This is Demetrius Murray with NRR. Can you hear me?

CHAIRMAN KIRCHNER: Yes, Demetrius. A little louder please, if you could.

MR. MURRAY: Is that better?

CHAIRMAN KIRCHNER: That's better.

MR. MURRAY: Okay. Thank you.

CHAIRMAN KIRCHNER: Go ahead.

MR. MURRAY: Good afternoon. I would like to thank the ACRS Subcommittee, NuScale and the general public for entertaining the NRC for our presentation of the safety evaluation of NuScale rebuild and design and analysis methodology for safety-related structures topical report.

In December of 2020 NuScale submitted Rev 0 of the building design topical report to the NRC. After acceptance of the topical report the NRC issued multiple requests for additional information to NuScale in May and August of 2021.

NuScale provided an answer to the NRC's REIs in June and September of the same year. NuScale issued Rev 1 of the topical report to the NRC on October 6th of 2021.

We are here today to discuss the Staff's advance safety evaluation of the topical report. The Staff review was Ata Istar, Dr. Amitava Ghosh and now retired Robert Pettis. I am the topical report project manager, Demetrius Murray, supported by senior project manager Getachew Tesfaye.

Before we transition to Ata, I would like to open the floor to NRC management. I would like to introduce Michael Dudek followed by Joseph Colaccino.

MR. DUDEK: Thanks, Demetrius. So on behalf of NRC management, Mr. Kirchner, I would like to thank the Committee for hearing us on this novel topical report that NuScale has proposed to us today.

I've listened intently to the NuScale's presentation regarding steel plate composite walls and reinforced concrete walls. And intensely read the SERs from the Staff.

And I found it very intriguing, so I'm very looking much forward to the presentation by the Staff today.

And thanks to both NuScale for the collaborative and efficient discussions that we've had, whether it's REIs or clarifications on this topic. I think it's been a very effective approach.

And thanks to Mr. Colaccino and his staff, Mr. Istar, Ghosh and Pettis for their collaboration and hard work on this SER, I think it really shows. And I'm really looking forward to the presentation today.

And now I'll turn it over to Mr. Colaccino for any technical opening discussion that he may have. But thanks to the Committee for hearing us today.

MR. COLACCINO: This is Joe Colaccino, I'm chief of the civil structure of Geotechnical Engineering Branch. And I thank Mike for that intro, he covered most of the stuff.

I would like to recognize Bob Pettis, who did retire last month. He was the lead for this project. I think he greatly supported all the technical decisions that were, that we made in the approximately one year review of this topical report.

Ata Istar is going to give the presentation today. Amit is going to be backup with any questions that you may have on his portion of the review.

I also want to note that prior to receiving this topical report the technical staff became aware of the efforts and research to endorse the code that you've been discussing. The N690-18 code that came up in the comments. I was actually really happy to hear about that.

Based on the timing of this application, and research efforts to publish a regulatory guide on this topic, the staff review team, led by Bob, coordinated NRR's review and issuance of the staff safety evaluation with the issuance of the research Reg Guide 1.243.

And I'd like to thank, specifically, the research staff for working with the staff in my branch. And acknowledge the applicant's support of that as well.

We asked another set of REIs, that you may have heard that Demetrius said, to understand, making sure that we were actually consistent. That what was presented in the NuScale topical was consistent with what the research staff was in the process of endorsing without actually having that report out. That was kind of like a unique effort our part that I felt.

Our coordination led to the staff's SEC reflecting the endorsement of the N690-18 code and ensuring that the information that the Staff was approving in the topical report was consistent with this Reg Guide.

I think this effort was kind of unique, and that's why I wanted to highlight it. And I appreciate the ACRS recognizing it. At least looking at that, understanding that they did not look at the, you did not request to look at that topical report. But I do want to acknowledge that the Staff was very aware that was going on and worked our efforts in concert.

With that, I'd like to now turn back, turn it over to Ata, unless there are any questions.

CHAIRMAN KIRCHNER: Thank you, Joe. Let's proceed.

MR. ISTAR: Good morning and good afternoon, everyone. This is Ata Istar. I'm the structural engineer. One of the members who have reviewed the topical report.

Before I go further I would like to recognize Bob Pettis one more time, that he was the lead for the review. And to the last day of his NRC employment he was contributing to the review of this topical report. He is going to be missed.

The agenda for this topical report is as follows. Introductions, regulatory bases, background and NuScale TR presented methodologies for each section, followed by the Staff review and evaluation, limitations and conditions and Staff conclusion.

Next slide please. NuScale Topical Report offers design and analysis methodologies to be used in the evaluation of Seismic Category I and II structures, applicable to the new generation of small modular reactors.

The Staff review included development of in-structure response spectra and design of structural members, determination of the effective stiffness of elements in ANSYS models, assessment of steel plate composites, walls and connections, assessment of reinforce concrete structures.

The development of in-structure response spectra and the design of structural members and the assessment of SC walls, such as steel plate composite, I'm just abbreviating, I may abbreviate time-to-time, walls and connections, NRC structures, conforms to the engineering principles and the applicable industry codes and standards.

The determination of effective stiffness values were performed analogically using the codes and standards to represent the composite members of SC and RC structures, and then was confirmed with the implementation of ANSYS models using solid shale, and shale elements.

Next slide please. The regulatory basis that we used during the review are 10 CFR 50, Appendix A, General Design Criteria 2 and 4. And 10 CFR 50, Appendix S.

Next slide please. The guidance document that we used during the review are Reg Guide 1.243, which this particular, and recently, should, Reg Guide, endorses the N690-18 code, AISC N690-18 code, Reg Guide 1.142, Reg Guide 1.199, Reg Guide 1.61 and

Reg Guide 1.122.

Next slide please. Section 3.7.2 and Section 3.8.4 of NuScale design specific review standards were also used during the review.

Next slide please. The code standards that we used are two AIC codes, two ACI codes and two ASCE codes.

They're like N690-18, which I stated earlier, which was endorsed by, recently issued Reg Guide 1.243. And AISC 360-16, ACI 349-13, ACI 318-08, ASCE 43-19, ASCE 4-16.

Next slide please. The NuScale TR presents a methodology for the design of analysis of seismic Category I and II structures. In the TR, Section 4.0, the development of in-structure response spectra and the design of structural members.

In Section 5.0 of the TR the determination of effective stiffness of members. In Section 6.0 and 7.0 of the TR, the assessment of steel plate composite walls and connections. And Section 8.0 of the TR, assessment of reinforcement concrete of the structures.

The TR also described the use of computer software codes, ANSYS, in determination of effective stiffness values. ANSYS is the general purpose commercial available finite element computer code that has been accepted by the engineering committee and used in the right of structural applications. Including linear and nonlinear static and dynamic analysis.

The Staff concluded that the ANSYS program discussed can be accepted for design and analysis of seismic Category I and II structures without further validation. Therefore the Staff did not review, nor the Applicant, demonstrate the acceptability of ANSYS computer code.

Next slide please. The methodology for the design and the analysis of SC wall is providing in AISC N690-18. Again, which was endorsed by Reg Guide 1.243.

This is the first TR for the staff review related to the design of steel plate composite walls in accordance with Appendix N9.0 AIC, AISC N690-18.

The NRR ESB staff also participated in the public comment resolution over the Reg Guide 1.243. NuScale, DSRS, acknowledges in 1994 edition of N690 in Section 3.8.4, but has not been endorsed.

Using the provisions from Appendix N9 and commentary in AISC N690-18, the Staff developed a systematic flowchart for guidance providing a sequential steps for the design and analysis of SC walls and connections. And the Staff used this flowchart during the review process of the TR.

N9, AISC N690 organized as follows. N9.1 section is related to design requirements. N9.2, related to the analysis requirements. N9.3, design of SC walls. N9.4, design of wall connections.

Next slide please. Section 4 of the TR presents a methodology to obtain the in-structure response spectra and the design of member forces in seismic Category I and II structures.

The process includes development of two ANSYS finite element models, seismic and static, representing a small module reactor. The model includes the reactor building, control building, radioactive waste building and surrounded by engineering, engineered backfill.

These models are referred as triple building model. And they're abbreviated as TRB. The TRB seismic model is used in conjunction with the soil library methodology presented in NRC approved report, NuScale TR 0118-58005, to determine the in-service response spectra and the member forces from the safety shutdown earthquakes.

The TRB model is used to determine the

member forces from seismic demands and in-structure response spectra. The TRB static model is used to determine the forces from non-seismic loads.

Different material models from soil library were used. Soil Type 11 represents soft soil profile. Soil Type 7 represents a rock soil profile. Soil Type 9 represents a hard rock soil profile.

Five seismic, certified seismic design response spectra is abbreviated CSRDS. Those are Capitola, Chi-Chi, El Centro, Izmit, and Yermo, seismic motions were used with soil Type 7 and 11, soft and rock respectively. And soil Type 9, hard rock, has been evaluated with certified seismic design response spectra with high frequency motion for Lucerne station.

Next slide please. Analysis start with the TRB seismic model with structural members having all cracked material properties subject to CSRDS motion.

When I say CSRDS, it represents CSRDS and high frequency CSRDS. Just, I'm trying to abbreviate the discussion.

The harmonic analysis is represented from each CSRDS motion and for each soil type soft, rock and hard rock. It is expected some members are cracked under the ASCE events.

An engineering investigation is performed to determined which ones are cracked. Then the stiffness and damping route used. All the cracked RC members where updated to effective stiffness and damping values as provided in ASCE and AIC standards.

New analysis using the seismic motions per, are performed with updated effective stiffness values and damping values. The damping values are consistent with the Reg Guide 1.61.

Next slide please. Member forces from non-seismic loads are determined from the TRB static model. And combined with the seismic matter forces at each timestamp.

In-plane stiffnesses are matched in both static and seismic models. Maximum demand to capacity ratio is determined and reinforcement is added as necessary. Analysis is presented for each soil type with appropriate CSRDS motions.

Determination of in-structure response spectra is generated at a given location of a structural member from the harmonic analysis with updated stiffnesses and damping properties. For each of the five CSRDS motion.

The peak of the in-structure response

spectra is brought in by plus or minus 15 percent, followed by Reg Guide 1.122 guidance to account for uncertainties in the structural frequency.

The average in-structure response spectra is calculated from the results obtained from each CSRDS motion. In-structure response spectras are enveloped for three soil types and for each seismic motion.

Finally, the in-structure response spectras are enveloped for three soil types. The Staff finds both approaches consistent with the NuScale DSRS Section 3.7.2.

Next slide please. Section 5.0 of the TR represents the modeling approaches using effective stiffness values for RC walls and slabs. And SC walls using the ANSYS finite element code.

As discussed in Section 4 of the TR, an effective stiffness values are determined using the ASCE 4-16 for RC walls and slabs, AISC N690-18 for SC walls.

As shown in the figure, a typical SC wall section comprised of concrete place between faceplates with tie bars and headed stud anchors. I will describe further about this SC wall in the other slides. In the following slides.

And elastic FE model of SC walls in section can be developed per section N9.2.3 of AISC N690-18. The Poisson's ratio to concrete is used if the section thicknesses and elastic models and densities are calibrated.

Next slide please. Two alternate methods were used in, to calibrate the effective stiffness and density values. Method 1, one layer system with two dummy layers for both RC and SC walls. Middle layer, effective properties from ASCE 4-16 and AISC N690-18.

Method 2, three layer system for SC walls only. Different material properties for middle and outer layers from ASCE 4-16 and AISC N690-18.

ANSYS finite element models were, are modeled, with SOLSH190 and SHELL181 elements. Generally, isotopic materials are used in the analysis of nuclear, at the nuclear industry.

However, in this case, orthotropic material properties represent the composite members for the walls and the slabs. Orthotropic materials properties are independently defined along the three orthogonal access.

Three Young's moduli, three shear moduli and three Poisson's ratios. Based on the review, the approaches to determine the orthotropic materials are acceptable.

Next slide please. ANSYS finite element model is a three-dimensional rectangular structure for where we find the implementation of effective stiffness values.

TR analysis includes five example problems to validate the use of proposed SOLSH190 and SHELL181 elements in the ANSYS model. The ANSYS model with SOLSH190 elements were used in both Methods 1 and 2 produced comparable results.

Results with SHELL181 element agree with the results of SOLSH190 elements. Although to calculate the frequency with SHELL181 elements are slightly lower.

ANSYS model with SOLSH190 represents connection regions better and preferred. Using the provisions from ASCE 4-16 and AISC N690-18, and the staff finds to those you determine the effective stiffness and density values conforms to NuScale DSRS Section 3.7.2 and 3.8.4. And Reg Guide 1.243.

Next slide please. In Section 6 of the TR described a design methodology for straight steel plate composite walls based on the requirements of Appendix N9 of AISC N690-18. And the applicable provision in AISC 360-16.

Where AISC N690-18 was recently endorsed, recently issued in endorsing Reg Guide 1, endorsed by Reg Guide 1.243.

As shown in Figure A, the typical RC wall composites structure is placed on all concrete between either carbon steel or stainless steel faceplates. Steel anchors assures composite behavior of faceplate and concrete. Ties between the faceplates provides structural integrity, prevents lamination of concrete core and serves as a shear reinforcement.

The SC walls can be connected to each other and anchored to the traditional constructed RC basemat, slabs and walls. The design is performed using the load resistant factors design per AISC N690-18.

The specification include the design requirements for interior, for interior section, interior region per section N9.1 and connection region per section N9.4.

Impactive and impulsive loads will be discussed further. Which were also performed, and designed per Section N9.1.6.

Analysis for all of the SC walls performed for interior regions, per Section N9.2.5 and connection region per Section N9.4.2. Using effective thicknesses in the finite element models requires strength in SC walls are determined. Design of SC walls, the available strengths, are determined per section N9.3.

Qualification of SC walls are performed based on the comparison of required strength against the available strength. Where the required strength has to be less than or equal to available strength.

And the corrosion effect will be discussed a little, right after this.

CHAIRMAN KIRCHNER: So, Istar, this --

MR. ISTAR: Yes.

CHAIRMAN KIRCHNER: -- is Walt Kirchner.

MR. ISTAR: Yes, sir.

CHAIRMAN KIRCHNER: This is a nice illustration in that field. And my experience in the field is a little different.

So you show an embedded plate for commodity attachments. Whether, it could be for pipe hangers, whatever.

What happens in the field if that wasn't designed and accounted for initially?

What I'm thinking of is, you're in the field and now you've already poured concrete, we had a question earlier about delamination. So you've already poured concrete and now you're welding on a plate that you're going to attach something to.

Does that have to be analyzed in the field?

MR. ISTAR: Yes. It's an additional load to the structure. But I don't think the intent of the SC walls to weld additional supports to support other structures. These are like exterior walls that is going to be placed for the reactor building, mostly.

And of course, if the applicant were to weld the support off of the faceplates, that needs to be accounted for. Because that's a localized --

CHAIRMAN KIRCHNER: Right.

MR. ISTAR: -- condition for that situation.

And in the design of SC equations associated with the buckling of those faceplates --

CHAIRMAN KIRCHNER: Yes.

MR. ISTAR: -- there's a lot of, a lot of thinking goes into that. And I don't believe in anyone who is using the SC walls would consider supporting anything without the analysis originally performed on this. Deviations will be very difficult to do.

CHAIRMAN KIRCHNER: Well the ideal world

this would be designed and accounted for, and we'll hear from NuScale. (Audio interference.) It might be welded on in a shop somewhere and all that would be accounted for.

But in the real construction world, as you know, often the pipe sleeve that is shown in this picture or the plate is not really in any of those and its alterations. Just --

MR. ISTAR: It -- yes, go ahead.

CHAIRMAN KIRCHNER: Are you assuming that we'll have an immaculate design that doesn't require any in-fields modifications and such?

I am just testing you to see what would happen in practice in the fields.

MR. ISTAR: Yes. I -- let me go back to whenever your statement was associated with the shop building.

I think Ulku in an earlier presentation he meant the SC walls and the anchors and tie bars and everything can be constructed and fabricated in a shop in smaller scales and they can be brought up to the site and placed and then the concrete will be poured. That's what he meant. I don't think he meant that --

(Simultaneous speaking.)

CHAIRMAN KIRCHNER: Well that's the ideal world.

MR. ISTAR: Yes.

CHAIRMAN KIRCHNER: Yes. That it's prefabricated and your design, that pipe sleeve is perfectly located until it --

MR. ISTAR: Yes.

CHAIRMAN KIRCHNER: Unfortunately, you install all the equipment and find out it's not where you need it and then you are into a mod, some kind of mod in the field.

MR. ISTAR: Yes. I mean these are again small modular reactors. I mean if you are to taking a big AP1000 shield wall kind of situation it's a big, very big structure, and these are much, much smaller than what those full scale reactor, I should say shield walls, and these are reactor building walls. I think the --

CHAIRMAN KIRCHNER: Well, the RXB, the RXB is a huge construction project. I can see how they could -- maybe in the closed session we can explore this further. I am very interested in connections.

MR. ISTAR: Yes.

CHAIRMAN KIRCHNER: But for something as large as the RXB if they are using steel plate concrete walls then these are going to be sections that are going to be connected, you're talking about a very large structure if they completed RXB.

MR. ISTAR: Yes. It's -- I mean it's not as large as the one that, as AP1000 I would think, you know. I forget the dimensions, but it's not as large, but it is large.

I mean these are for small modular reactors and it's, you know, it is -- I think if it's engineered properly everything should work accordingly, you know.

There is going to be a lot of thinking in how to do everything sequentially and for the connections and everything. It is -- it may get complicated, I agree with you.

It may get complicated with the use which side, you know, as I told earlier, it could be stainless steel or carbon steel.

Stainless steel may be used in some instance where the pool is and those things may need to be considered in depth.

CHAIRMAN KIRCHNER: Well I'll just assert now, and we can go into more detail in the closed session --

MR. ISTAR: I think so.

CHAIRMAN KIRCHNER: -- but I think the

RXB, the RXB is so big that it's not, it's going to have to be sections that are prefabricated.

The actual walls, if they are going to use this for any of the pool walls, are going to be much larger than you can move on a truck.

MR. ISTAR: Well I think they need to fit into a truck from a fabricating shop to bring it up into the site, you know. That's what I would think.

(Simultaneous speaking.)

DR. BLEY: Ata, may I interrupt a second?

MR. ISTAR: Yes.

DR. BLEY: If I could, Walt, I don't know if you saw any of the movies they did for AP1000 as they were building it, but they used a tractor kind of like the ones that haul the rockets out.

CHAIRMAN KIRCHNER: Yes. Yes, I saw those.

DR. BLEY: Yes. And I mean that's a massive piece they were bringing out, but they did have to bring it out, still, in massive pieces.

CHAIRMAN KIRCHNER: Yes.

MR. DUDEK: Mr. Kirchner, I would ask that the NRC Staff not pontificate or theorize about this. If we want additional details -- I mean I think we still have the specialist and NuScale on the phone and they may be able to provide some additional clarification on this.

CHAIRMAN KIRCHNER: No, we can explore this in the closed session. I know we're talking about here methodology and we're not talking about the detailed design of the NuScale plant.

MR. DUDEK: Okay.

CHAIRMAN KIRCHNER: So I will hold my question for the closed session.

MR. DUDEK: All right. Thank you, sir.

MR. ISTAR: Thank you. Going forward, I would like to elaborate a little bit more about the impactive and impulsive loads and effects of corrosion.

Impactive loads can be identified as tornado missiles, pipe whip, turbine missiles, and aircraft impacts.

Impulsive loads can be identified as jet impingement, blast pressure, and compartment pressurization.

The local and global effects are considered due to the impactive and impulsive loads. The effects of impactive and impulsive loads are considered in extreme environmental and abnormal load combinations concurrent with the other loads.

The impactive and impulsive loads used inelastic analysis and considered the limitations of the ductile ratio, ductility ratio, I'm sorry, ductility ratio, and the principle strain of faceplate in the TR.

However, the limitations for rotational capacity was not considered in the TR as provided in Reg Guide 1.243. I will elaborate more about this in the staffing relation part of it.

The effects of corrosion, the small modular reactor designs may also consider the possibility of plant license extensions up to 80 years.

In-service inspections and repair or below grade exterior SC walls would be impractical for the duration of an extended licensing period and there are no provisions for the corrosion effects in AISC N690-18 and Reg Guide 1.243.

However, in Section 5, Section B3.13 of AISC 360-16 has the general requirement that states structural components shall be designed to tolerate corrosion or shall be protected against corrosion.

Again, I will elaborate further about this resolution for this in the staffing relation part. Next slide, please.

This particular slide shows a generic straight SC wall. The materials you are presented in the TR applies to straight SC wall to the requirements of Appendix 9 of AISC N690 and its commentary.

As it can be seen from the figure, the SC walls are divided into interior region and connection region. Force transfer between the SC walls, the wall from the composite sections between faceplates and concrete and over to the connection region.

Connection region is designated as straight along the edge of two intercepting structural elements, for example slabs, walls, and basemat. There were force transfer between the connected elements.

The connection region distance is considered to be less than or equal to three times the wall thickness per N912 of AISC N690-18.

The elements in the finite element models can be either a thick shell or three-dimensional solid elements per N921 of AISC N690-18.

As discussed earlier, SOLSH190 and SHELL181 ANSYS elements may be used in the development of finite element mathematical model of SC walls. Next slide, please.

As discussed earlier, limitations for

impactive and impulsive loads of ductility ratio and the principle strain of a plate, faceplate, were considered in the TR.

The displacement ductility ratio controls the failure limit state due to the formation of flexural and shear cracks in the concrete. The principle strain limit controls the failure limit state on the faceplates at the tension site.

And as stated earlier, the rotational capacity of yield hinge was not considered in the TR as provided in Reg Guide 1.243. The figure is from paper by Dr. Amit Varma.

Using the test results from the paper the value of rotational capacity can be estimated. Where the results is comparable with the rotational capacity limit in AIC-349, which is in commentary RF-34.

However, as stated in commentary N916B of AISC 690-18, the plastic hinge rotational capacity need not to be checked if the displacement ductility ratio is kept under the identified limitation for flexural control section.

Based on this review the Staff concluded that consideration of limitation of ductility ratio and principle strain of faceplate for the effect of impactive and impulsive loads are acceptable since the

TR complies with the commentary N916B of AISC N690-18.

Effects of corrosion, as discussed earlier, the exterior below grade faceplates of SC walls shall be protected from corrosive environment.

The following graded approach is described in the TR, the application of tar epoxy coating on the exterior below grade faceplate using a controlled low strength material or employing a shotcrete cementitious material on the exterior below grade faceplate, as well as using backfill materials with controlled pH and chloride limits.

Based on the review of this site specific graded approach the Staff found it is acceptable by meeting the requirements of Section B.3.13 of AISC 360-16.

As a conclusion, meeting the provision of AISC N690-18 and AISC N360-16 ensures that Seismic Category I and II SC walls will perform their intended safety function.

The Staff determined that design methodology presented in the TR for the SC wall is acceptable and is consistent with the acceptance criteria of NuScale DSRS Section 384 and the requirements in AISC N690-18 and AISC 360-16. Next slide, please.

In Section 7.0 of the TR presents the design methodology of the SC connections that complies with the requirements of AISC N690-18, AISC 360-16, and ACI 349-13.

Basically, the connection is an assembly of connectors. Connectors are -- there are numerous connectors in there. I will give some examples, steel-headed stud anchors, anchor ruts, tie bars, couplers, welds, bolts, and post-tensioning bars and shear lugs, which I will show you in the next slide some of those connectors in the next slide in a figure.

The connectors participate in the force transfer mechanisms for tension, compression, in/out-of-plane shear, and out-of-plane flexure.

The connections available strength for each demand types are calculated using the applicable force transfer mechanisms and the available strength for its contributing connectors.

The available strength for connectors are determined per section N9.4.3 of AISC N690-18. I can give some examples which the available strength of these are calculated based on the different codes and standards.

For example, for steel-headed stud anchors the available strength is determined based on the AISC 360-16, Section I.8.3. For anchor ruts available strength can be determined from AISC 349 Appendix D.

There is a user note in Section N.6 and N9.4.1 of N690-18. It refers to AISC Steel Guide 32 for additional guidance. Although AISC Design Guide 32 is not a regulatory document the Staff reviewed the AISC Design Guide 32 illustrations for type of connections and applicable force transfer mechanisms for transferring forces between SE connections.

The AISC Design Guide 32 discusses a behavior and design of SC walls subject to the various individual and combined seismic and non-seismic force demands and connection types, regions, force transfer mechanisms, connections philosophy, required strength, available strength, connection detailing, design of SC walls and connections, and demand types.

This is a valuable design guide that will help for any designers to use during a renewal application. Next slide, please.

The figure on the left depicts the typical SC wall connection to the basemat with demands. In Appendix N9.4 of N690-18 the design requirements of various types of connections are provided, which are basically six types.

Spliced between the SC wall sections, spliced between the SC wall and RC wall sections connections, intersection of SC walls, connections at the intersection of SC with RC walls, anchors of SC walls to the RC basemat, and connection to the RC walls to RC slabs.

The connections are designed for the demand types of tensile force demand, which I showed in the figure on the left, compression forces, forced demands, in-plane shear demands, auto plane shear demands, auto plane flexural demands.

The figure on the right, force transfer mechanism for tensile force demand. The AC faceplate to the baseplate welded resisted tensile demand on the SC wall.

Then the force in the baseplate transfer into the basemat concrete and anchor rut welded to the baseplate. These are the connectors and these are each one needs to be independently designed in NOIs, of course.

Each one has associated welding for these. That's how for this tension demand how the force transfers into the basement goes in.

The connections are a design in full strength. That the full strength connection design flows develop the expected strength of the weaker of the two connected parts. Next slide, please.

The Staff determines that design methodology for the SC connections are based on the provisions in AISC N690-18, AISC 360-16, and ACI 349-13, Appendix D.

The Staff found the methodology is consistent with the acceptance criteria in NuScale Design Specific Review Guide Section 3.8.4. Next slide, please.

Section 8.0 of the TR provides a methodology for the design of seismic Category I and II structures in accordance with ACI 349-13, the applicable section in ACI 318-18, and Reg Guide 1.142.

The design of RC structures can be performed using either the match dependent and element-based approach in which the stress results are obtained per unit of element of the finite element model, in section cut-based approach in which the stress results are obtained in a member cross section of a finite element model.

The TR refers to a technical paper titled "Integrated Seismic Analysis and Design of Shear Wall Structures" dated in 2008 which says the element and section cut approaches, the paper concludes that section cut approach has significant savings in RC design compared to the element-based approach.

Based on the review Staff agreed with the conclusion and confirmed the consistency with Section 911 of ACI 349-13.

Lateral and gravity load-resisting systems. I will discuss this in the next slide in a figure. TR describes the required strength and the required strengths are determined from the finite element models for slabs/basemats, columns, and T-beams.

The TR provides a figure with detailed discussions for identifying the critical location of section cuts for design.

Basically, the critical section cut locations for designs are determined from stress counters plus from horizontal and vertical amounts resulting from in- and out-of-plane actions and rectangular frame structures and basemats were used in determining the critical sections. Next slide, please.

The figure on the right provides lateral and gravity load-resisting systems. The structure elements are configured to resist the gravity and lateral loads that are comprised of vertical elements and horizontal elements.

Vertical elements extend between the foundation to the elevated floors as shear walls and columns. Horizontal element diaphragms consist of floor slabs and roof, including cords and collectors.

Here the collectors is shown on this picture. I will describe the cord force on the other figure. Cord is defined as boundary elements in structural diaphragms that resist in-plane moment or tension, tension of compression forces.

Collectors are tension and compression members that gather shear forces from diaphragms and deliver them to the vertical members.

The figure on the left provides critical section for section cut locations to determine in-plane shear and cord forces due to the seismic force in "Y" direction.

This is the seismic force in "Y" direction and the in-plane shears are these on both sides and out-of-plane moment and cord forces on both sides. At these critical locations the "P/M" interaction check using ACI 349-13 is required.

Again, the TR provides numerous figures and describes for identifying the critical locations of section cuts and design.

As an example, section cut locations to determines out-of-plane moment, demand due to the gravity and frame actions in "X" and "Y" directions. I am providing the titles or the figures that was provided in the TR.

Section cuts for one-way and two-way shear in basemat subject to the wall overturning, another example, section cut for out-of-plane bending in basement subject to the wall overturning. Next slide, please.

As stated earlier the critical section locations for rectangular structures and basemats were described in detail in the TR.

The appropriate lengths of critical sections are used to average the load to avoid unrealistic conservatism in the design.

The critical section lengths are determined using finite element stress results, but generally need not to be less than three times of the RC member thickness.

However, the design engineer also needs to justify the use of appropriate lengths at the identified critical location.

The design methodology for RC structures conforms to the conventional engineering principles by identifying section cuts and lengths from geometric configurations and design requirements of AISC 349-13, the applicable sections of ACI 318-08, and Reg Guide 1.142, and is consistent with the acceptance criteria of NuScale DSRS Section 3.8.4. Next slide, please.

Limitations and Conditions. Materials for this TR performed linear elastically during the seismic event. Nonlinear responses, liquefaction and the subgrade, liquefaction of a subgrade, and the significant cracking of structural components are not permitted.

ASCE 43-19, Limit State D is applicable for this TR, which as Limit State D defined as expected to formation is essentially elastic behavior and expected damages negligible under combined loading conditions. Next slide, please.

CHAIRMAN KIRCHNER: Ata, this is Walt again.

MR. ISTAR: Yes.

CHAIRMAN KIRCHNER: Can you go back to your limitations and conditions?

MR. ISTAR: Yes, sir.

CHAIRMAN KIRCHNER: Please. Well the first one I see is almost a generic statement that the materials perform in a linear elastic manner.

The second bullet really is to me -- when I read this it struck me this is going to be site specific and then you iterate on your design accordingly or you change your subgrade or you change your site location or something, it strikes me something like liquefaction of the subgrade would be a siting issue.

But if you had then obviously your, you know, non-linear response for the building and then I suppose -- I am just -- in practice for a methodology I get it, but how do you actually apply this?

MR. ISTAR: You know, the site, this is again it's a site specific issue, and based on the methodologies provided in the TR liquefaction of the subgrade is not expected or it's not going to happen.

If it happens, of course, which is not a good thing, and significant cracking of structure components are not supposed to be happening.

CHAIRMAN KIRCHNER: Well, see, the second part -- the first part is site specific. The second part is design specific.

MR. ISTAR: Correct. Correct.

CHAIRMAN KIRCHNER: And that one, okay, what you are saying is when you complete your design for your design basis safe shutdown earthquake you have to demonstrate that you do not have significant cracking.

MR. ISTAR: Yes.

DR. BLEY: Walt, this is Dr. --

CHAIRMAN KIRCHNER: And then reinforce or redesign until the structure that is in question doesn't significantly crack. Go ahead, Dennis.

DR. BLEY: Yes. This is just -- the way I see this is from the Staff this is just saying you can't use this Reg Guide if in fact you might have liquefaction, but then you have to do what you were just saying, which is maybe the Staff would be, they would have to look at some detailed analyses.

Staff, that's really my estimation of what you are trying to say. Tell me if I am right or wrong.

MR. ISTAR: I mean the report, liquefaction -- I can't -- I am having problems pronouncing this word.

MR. COLACCINO: Hey, Ata?

MR. ISTAR: Yes, sir?

MR. COLACCINO: Ata?

MR. ISTAR: Yes?

MR. COLACCINO: I think what was just said was exactly what we would do.

MR. ISTAR: Yes. Yes, sir. That's what I was going to repeat.

MR. COLACCINO: Okay. I thought that's where you were getting -- so you can avoid saying liquefaction.

MR. ISTAR: Yes. Yes. Thank you. Thank you, Joe.

MR. COLACCINO: That was Joe Colaccino, sorry.

MR. ISTAR: Yes. Thank you.

MEMBER REMPE: Walt?

CHAIRMAN KIRCHNER: Go ahead, Joy.

MEMBER REMPE: Well maybe Dennis's response is also the answer to my question, but when I look at the SE as well as the words on the slide I was wondering I mean during all seismic events or seismic events down to a certain frequency or is it that if you look at all of the design basis events and they don't perform elastically then you've got to use something else or is -- what would that something else be?

I just was wondering down to what frequency of seismic events, but maybe, again, Dennis's response also clarifies that.

I was just kind of puzzled I think with

the same kind of thing you are thinking about, too, is what happens if it doesn't. Yes, I -- does that make sense what I am trying to ask or is it --

MR. ISTAR: Yes, it makes sense, but, again, I think I am going to repeat myself. The TR liquefaction of subgrade is not allowed based on the methodologies provided in this TR. That's --

MEMBER REMPE: But I am not talking about the second bullet, I'm talking about the first one. What if during --

MR. ISTAR: Oh, okay, for --

MEMBER REMPE: Yes, down to what frequency of seismic events? Every seismic event? Beyond design basis earthquakes? Design basis earthquakes?

MR. ISTAR: Well, that's a good question. The CSDRS is performed and whatever the applicable CSDRS, there are five of them, as I elaborated earlier, and which they should, the structure will be within the elastic limits using those CSDRS motions.

CHAIRMAN KIRCHNER: So, Ata, what I took, picked up from that, when you actually go to build a plant at a specific site, kind of related to Joy's question, then what you are going to do and practice is get agreement, the applicant is going to get agreement with the NRC about what the safe shutdown earthquake is, what the spectra is, and so on for that site.

MR. ISTAR: Correct.

CHAIRMAN KIRCHNER: And then the applicant will do his or her detailed analyses to demonstrate that it's linear. Obviously, they would demonstrate also that there is not liquefaction, et cetera.

So it seems to me it's an iterative thing. What was done in the TR was to pick five -- what did they do again, five spectra?

MR. ISTAR: Yes, sir.

CHAIRMAN KIRCHNER: Five spectra and bound it and three soil types and bound that. So, Joy, I think they enveloped a credible range of seismic inputs wherein the TR and the methodology would be valid.

MEMBER REMPE: And then if it's not they'll just go to a different site or something like that is what you're saying, and so it will go even to beyond design basis events?

MR. ISTAR: Well, I don't want to speak for the applicant. If they don't -- you know, those are major earthquakes that it was, you know, they covered quite a bit of range in their response inspector.

If the site were not to be enveloped by those they have to redesign the structure as the methodology has provided in this topical report.

MEMBER REMPE: Okay. That makes sense. I just -- I thought it was -- I wasn't quite sure what it meant that way. Thank you.

MR. ISTAR: Yes. You know, another limitation that maybe we should have had in this list, whatever the CSDRS is listed in this topical report, but I think -- well, anyway. Okay. Any other questions?

Next slide, please. In conclusion, the methodologies presented in the NuScale TR are acceptable to perform the building design analysis for seismic Category I and II structures safety-related RC and SC structures other than the containment.

The methodologies follow implementation of the requirements of AIC 349-13, AISC N690-18, Appendix 9, endorsed by Reg Guide 1.243.

The methodologies are also consistent with the applicable regulatory requirements of acceptance criteria in NRC NuScale DSRS Sections 3.7.2 and 3.8.4. That concludes my presentation. I can take any other questions that you may have. Thank you.

CHAIRMAN KIRCHNER: Ata, this is Walt

again.

MR. ISTAR: Okay.

CHAIRMAN KIRCHNER: Let me start with your first bullet. Basically, you say that this methodology is acceptable for building design and analysis for Cat I and II's safety-related RC and SC structures.

Then you go on to say "other than containment." Now basically is that because there is another Reg Guide for a conventional containment that you would use as a guidance?

MR. ISTAR: Yes. And as RC walls are not pressure rated walls and, therefore --

(Simultaneous speaking.)

CHAIRMAN KIRCHNER: Okay, so that's the distinction.

MR. ISTAR: That's the distinction on any containment wall or pressure retaining structures.

CHAIRMAN KIRCHNER: Right.

MR. ISTAR: And that's where the difference comes in. There is a trend to get the RC walls into ASME code, and which I am part of that, and then there is a lot of discussions why is it, as you know ASME is considering all of the pressurized components, not the -- and there are a lot of members questioning whether this should be within the Division 2 of Section 3 of ASME.

So I don't know what the resolution is going to be. Some members think that is doable, some members think that's not doable. I don't know what are the NRC's positions at this point and --

(Simultaneous speaking.)

CHAIRMAN KIRCHNER: I was just thinking. I asked that because, you know, the underlying methodology relying on ANSYS and the other methodology that you previously reviewed and we reviewed that was submitted on soil structure libraries, these are kind of generic things.

The codes that are referenced here from both the steel and the concrete codes and the standards are basically kind of generic. That's why I asked the question other than containment, but the main thing is that the containment is a pressure boundary.

MR. ISTAR: Correct, pressure rated.

CHAIRMAN KIRCHNER: Okay. Thank you.

MR. ISTAR: You're welcome. Thank you.

CHAIRMAN KIRCHNER: Members, further questions?

Not hearing any, any comments, Members, at this point? We'll have another opportunity in a little bit in a closed session to pursue further questions if you don't have any right now.

Okay. With that, then, Mike Snodderly, I think we should turn and provide the public an opportunity to comment.

MR. SNODDERLY: Yes. Any member of the public may unmute their phone and make a comment if they would like. Ms. Fields, are you on?

CHAIRMAN KIRCHNER: I'll repeat the offer again. Any member of the public wish to make a comment please identify yourself and make your comment.

MEMBER REMPE: Mike and Walt, do they have to press *6 in order to unmute themselves or is it open for everybody right now?

MR. SNODDERLY: You're right, Member Rempe. Please press *6 to unmute yourselves.

CHAIRMAN KIRCHNER: Okay.

MR. SNODDERLY: I think we're okay, Walt. I have been watching my email and Sarah wasn't on at the beginning of the meeting and she didn't -- sometimes if she has trouble connecting she'll send me an email and I didn't get anything, so I think we've given them a sufficient opportunity.

CHAIRMAN KIRCHNER: Okay.

MR. SNODDERLY: Thanks.

CHAIRMAN KIRCHNER: And any other Member of NuScale or Staff wish to make a comment in an open session this would be fine. While you are thinking of a comment what I will do is we'll take a break here shortly.

I think we're coming up on the scheduled break time at 3:45. So if there are no further comments we will take a break from now until 4 o'clock p.m. Eastern Standard Time.

MEMBER BALLINGER: Walt, we have a separate invitation for the closed session, right?

MR. SNODDERLY: That's correct.

CHAIRMAN KIRCHNER: Yes. Yes.

MR. SNODDERLY: This meeting will end and those that have a need to know will go to the closed session and every Member should have an invitation to that.

If you don't send me an email and I will make sure we get you on. But the closed session has been activated, so you can go whenever you feel --

CHAIRMAN KIRCHNER: Okay.

MR. SNODDERLY: And as Member Kirchner said we would, in accordance with the schedule we'll start at 4 o'clock.

CHAIRMAN KIRCHNER: On the closed session.

MR. SNODDERLY: Yes.

CHAIRMAN KIRCHNER: So this will complete the open session involving the public of this subcommittee meeting. Thank you, everyone.

MR. SNODDERLY: And I would ask the transcriber to also go to the closed session.

CHAIRMAN KIRCHNER: Thank you, Mike.

MR. SNODDERLY: Okay.

CHAIRMAN KIRCHNER: Okay. With that this open session is closed, and we will return in a closed session, and you have an invitation for that, at 4 o'clock Eastern Time. Thank you.

(Whereupon, the above-entitled matter went off the record at 3:43 p.m.)

January 12, 2022 Docket No. 99902078

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2738

SUBJECT: NuScale Power, LLC Submittal of Presentation Materials Entitled “ACRS Subcommittee Meeting: NuScale Building Design and Analysis Methodology for Safety-Related Structures (Open Session),” PM-111761, Revision 0

The purpose of this submittal is to provide presentation materials to the NRC for use during the upcoming Advisory Committee on Reactor Safeguards (ACRS) Subcommittee Meeting on January 19, 2022. The materials support NuScale’s presentation of the topical report "NuScale Building Design and Analysis Methodology for Safety-Related Structures," TR-0920-71621, Revision 1.

The enclosure to this letter is the nonproprietary presentation entitled “ACRS Subcommittee Meeting: NuScale Building Design and Analysis Methodology for Safety-Related Structures (Open Session),” PM-111761, Revision 0.

This letter makes no regulatory commitments and no revisions to any existing regulatory commitments.

If you have any questions, please contact Liz English at 541-452-7333 or at EEnglish@nuscalepower.com.

Sincerely,

Mark W. Shaver

Mark W. Shaver
Manager, Licensing
NuScale Power, LLC

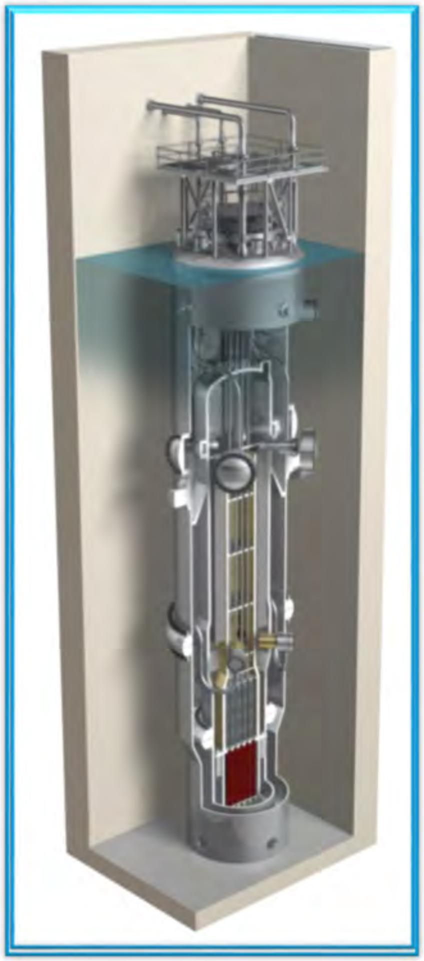
Distribution: Michael Dudek, NRC
Getachew Tesfaye, NRC
Bruce Bavol, NRC

Enclosure: “ACRS Subcommittee Meeting: NuScale Building Design and Analysis Methodology for Safety-Related Structures (Open Session),” PM-111761, Revision 0

Enclosure:

"ACRS Subcommittee Meeting: NuScale Building Design and Analysis Methodology for Safety-Related Structures (Open Session)," PM-111761, Revision 0

ACRS Subcommittee Meeting



NuScale Building Design and Analysis Methodology for Safety-Related Structures

January 19, 2022

(Open Session)

Presenters

Fehmida Mesania, Ph.D., P.E.
Licensing Engineer

Evren Ulku, Ph.D., P.E.
Supervisor, Civil Structural

Agenda

- Purpose
- Introduction
  - Steel-plate composite (SC) Walls
  - Reinforced concrete (RC) members
  - In-structure response spectra (ISRS)
  - Effective stiffness modeling approach

Purpose

- Present technical content of topical report TR-0920-71621
- Provide a general understanding of building design and analysis methodology for seismic Category I and II nuclear safety-related reinforced concrete (RC) and steel-plate composite (SC) structures applicable to NuScale design

Introduction – Timeline

- NuScale submitted topical report TR-0920-71621, Revision 0, “Building Design and Analysis Methodology for Safety-Related Structures,” – December, 2020 (ADAMS Accession No. ML20353A404)
- NRC accepted the topical report for review – February, 2021
- NRC completed detailed technical review via RAIs -9833, -9834 and -9860, October, 2021
- NuScale issued topical report Revision 1 - October, 2021(ADAMS Accession No. ML21279A336)
- NRC issued draft Safety Evaluation Report (SER) - November, 2021

Introduction – Topical Report

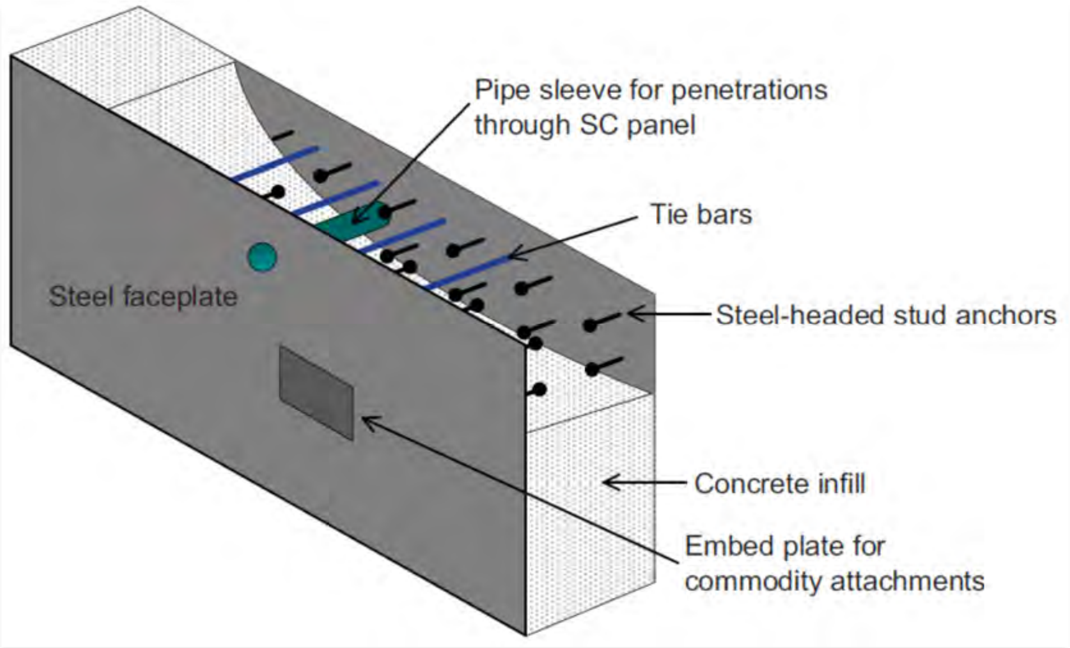
- Topical report presents a design methodology implementing new industry standards for nuclear facilities
- Applicable to new generation SMR designs
- Complies with reinforced concrete and SC walls requirements
- Defines design methodologies to account for the interaction of SC walls with traditionally constructed RC members such as basemats, slabs, and roofs
- Implements the soil library methodology for complex structures as per NuScale topical report, “Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis”, TR-0118-58005-P-A, Revision 2
- Topical report information will be used as part of SDAA submittal

Introduction - Building Design

Evren Ulku, Ph.D., P.E.
Supervisor, Civil Structural

Steel-Composite Walls

- Steel-Plate Composite Walls
  - Steel faceplates with concrete core
  - Anchors to ensure composite behavior
  - Ties to ensure integrity



SC Walls – Insight

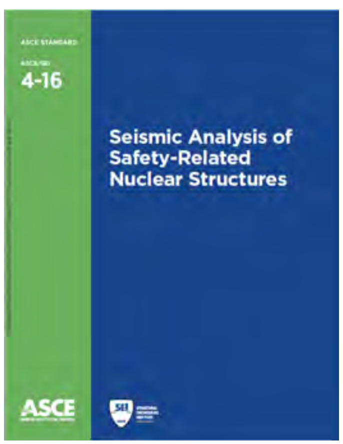
- Advantages
  - ✓ Higher resistance to blast and earthquake, higher ultimate strength
  - ✓ Modular construction➔ reduction in fabrication and erection time
    - Use of several common module layouts repeated throughout elevation
    - Smaller, lighter modules that are more easily transportable
- Areas requiring special attention
  - ➢ Connection with reinforced concrete (RC) elements (i.e., basemat and floors)
  - ➢ Requires below grade mitigation of corrosion effects

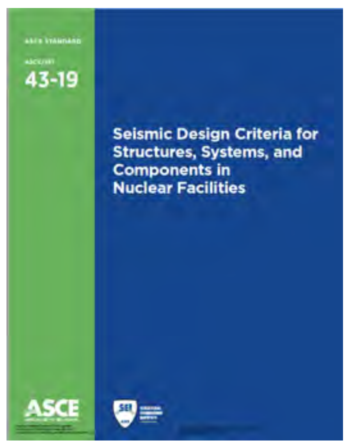
Reinforced Concrete

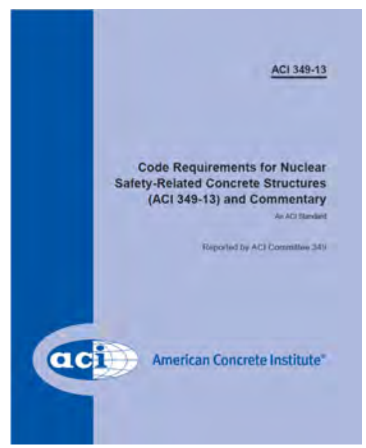
- RC design methodology is based on the requirements of American Concrete Institute, ACI 349-13 *"Code Requirements for Nuclear Safety-Related Concrete Structures"* and ACI 318-08 *"Building Code Requirements for Structural Concrete."*
- RC members include:
  - Basemat
  - Floor slabs
  - Roof slab

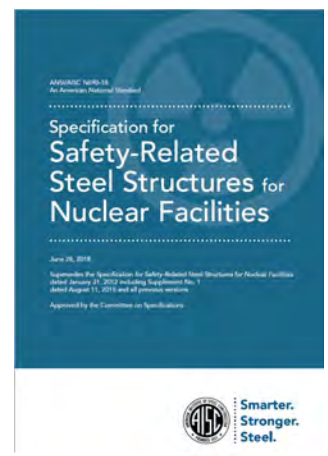
ISRS & Design Methodology

- Implements NuScale Topical Report “Improvements in Frequency Domain Soil-Structure-Fluid Interaction Analysis,” (TR-0118-58005-P-A, Rev 2), to obtain ISRS for subsystem design and member forces for design of Seismic Category I/II structures, systems, and components (SSC)
- Provides analytical models for complex structures with damping values and stiffness properties based on the actual stress state of members under the most critical seismic load combination
- Consistent with latest safety-related codes and standards:



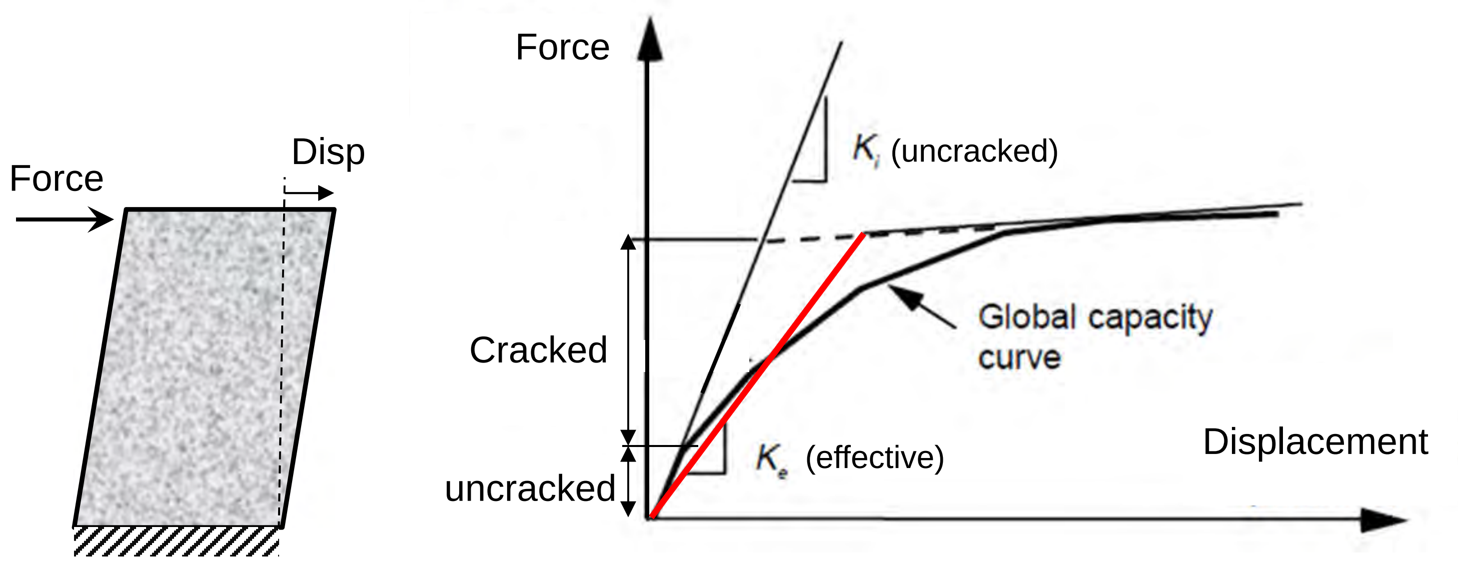






Effective Stiffness

- Describes modeling approach to represent effective stiffness for RC wall/slab members and for SC walls for Seismic Category I/II structures
- Effective stiffness values are taken from codes and standards



Acronyms

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ISRS	In-structure Response Spectra
NRC	Nuclear Regulatory Commission
RAI	Request for Additional Information
RC	Reinforced Concrete
SC	Steel-plate Composite
SDAA	Standard Design Approval Application
SMR	Small Modular Reactor
SER	Safety Evaluation Report
SSC	Structures, Systems and Components

Portland Office
6650 SW Redwood Lane,
Suite 210
Portland, OR 97224
971.371.1592

Corvallis Office
1100 NE Circle Blvd., Suite 200
Corvallis, OR 97330
541.360.0500

Rockville Office
11333 Woodglen Ave., Suite 205
Rockville, MD 20852
301.770.0472

Richland Office
1933 Jadwin Ave., Suite 130
Richland, WA 99354
541.360.0500

Charlotte Office
2815 Coliseum Centre Drive,
Suite 230
Charlotte, NC 28217
980.349.4804

http://www.nuscalepower.com
Twitter: @NuScale_Power

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Staff Presentation to the ACRS Sub-Committee

NuScale Topical Report
Building Design and Analysis Methodology for Safety-Related Structures
(TR-0920-71621, Revision 1)

JANUARY 19, 2022

Topical Report Review Chronology

- NuScale submitted topical report TR-0920-71621, Revision 0, "Building Design and Analysis Methodology for Safety-Related Structures," on December 18, 2020
- NRC issued RAIs -9833, -9834 on May 06, 2021. and RAI 9860 on August 06, 2021
- NuScale provided responses to RAI 933 and 9834 on June 05, 2021 and RAI 9860 on September 05, 2021. The Staff found the responses acceptable.
- NuScale issued topical report Revision 1 of on October 06, 2021, that incorporated the RAI responses
- NRC issued the advanced Safety Evaluation Report on November 30, 2021

NRC Staff

Reviewers:

- Ata Istar, Structural Engineer, NRR/DEX/ESEB
- Amitava Ghosh, Ph.D., Geotechnical Engineer, NRR/DEX/ESEB
- Robert Pettis, P.E. (Retired) Sr. Reactor Engineer, NRR/DEX/ESEB

Project Managers:

- Demetrius Murray, TR Project Manager, NRR/DNRL/NRLB
- Getachew Tesfaye, Sr. Project Manager, NRR/DNRL/NRLB

Agenda

- Introduction
- Regulatory Bases
- Background
- NuScale TR Presented Methodologies
- Staff Review and Evaluation
- Limitations and Conditions
- Staff Conclusions

Introduction

NuScale Topical Report (TR) offers design and analysis methodologies to be used in the evaluation of Seismic Category I and II structures, applicable to the new generation of small modular reactors (SMRs).

Regulatory Bases

NRC Regulations

- **10 CFR Part 50, Appendix A, GDC 2:** SSCs important to safety must be designed to withstand the effects of natural phenomena such as earthquakes.
- **10 CFR Part 50, Appendix A, GDC 4:** SSCs important to safety must be designed to accommodate the effects of environmental conditions associated with normal operation, maintenance, testing, and postulated accidents.
- **10 CFR Part 50, Appendix S:** Safety functions of SSCs subject to earthquake ground motion must be assured through design, testing, or qualification methods, and that the evaluation must consider soil-structure interaction effects.

Guidance Documents

- **RG 1.243**, "Safety-Related Steel Structures and SC Walls for Other Than Reactor Vessels and Containments," recently endorsed ANSI/AISC N690-18 (hereinafter referred as N690-18).
- **RG 1.142** “Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)”
- **RG 1.199** “Anchoring Components and Structural Supports in Concrete”
- **RG 1.61** “Damping Values for Seismic Design of Nuclear Power Plants”
- **RG 1.122** “Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components”

Guidance Documents- cont.

- NRC NuScale, “Design-Specific Review Standards (DSRSs)”
  - **Section 3.7.2**, “Seismic System Analysis,”
  - **Section 3.8.4**, “Other Seismic Category I Structures.”

Codes/Standards

- **ANSI/AISC N690-18**, “Specification for Safety-Related Steel Structures for Nuclear Facilities.”
- **ANSI/AISC 360-16**, “American National Standards Institute/American Institute of Steel Construction.“
- **ACI 349-13**, "Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary.”
- **ACI 318-08**, “American Concrete Institute, “Building Code Requirements for Structural Concrete and Commentary.”
- **ASCE 43-19**, “Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities.”
- **ASCE 4-16**, “Seismic Analysis of Safety-Related Nuclear Structures and Commentary.”

Background

The NuScale TR presents methodologies of the design and analysis of seismic Category I and II structures:

- In-structure response spectra (ISRS) and design of structural members (**TR Section 4.0**).
- Effective stiffness of members (**TR Section 5.0**).
- Steel-Plate composite (SC) walls and connections (**TR Sections 6.0 and 7.0**).
- Reinforced concrete (RC) structures (**TR Section 8.0**).

Background – cont.

- The methodology for the design and analysis of SC walls is in accordance with N690-18, endorsed in RG 1.243.
- The methodology for the design and analysis of RC structures is in accordance with ACI 349-13, endorsed in RG 1.142, "Safety-Related Concrete Structures for Nuclear Power Plants (Other than Reactor Vessels and Containments)."

TR Section 4.0: Determination of ISRS and Design of Structural Members

- ANSYS Triple Building (TRB) models includes Reactor Building, Control Building, Radioactive Waste Building.
  - TRB Seismic Model: determines member forces and ISRS.
  - TRB Static Model: determines member forces from non-seismic load combinations.
- Three Soil Libraries were considered:
  - Type 11 (soft soil), Type 7 (rock), Type 9 (hard rock).
- Five certified seismic design response spectra (CSDRS) for soil types 7 and 11: Capitola, Chi-Chi, El Centro, Izmit, and Yermo.
- One CSDRS-high frequency (CSDRS-HF) for Soil type 9: Lucerne.

TR Section 4.0: Determination of ISRS and Design of Structural Members

- Check walls and slabs for cracking in in-plane shear and in-plane bending.
- All cracked RC members: assign effective stiffness and damping per ASCE/SEI 4-16 and ASCE/SEI 43-19.
- All cracked SC members: assign effective stiffness per N690-18 and damping per ASCE/SEI 43-19.
- New analysis using CSDRS and CSDRS-HF is performed with updated stiffness and damping values .
- Damping values are consistent with RG 1.61.

TR Section 4.0: Determination of ISRS and Design of Structural Members - cont.

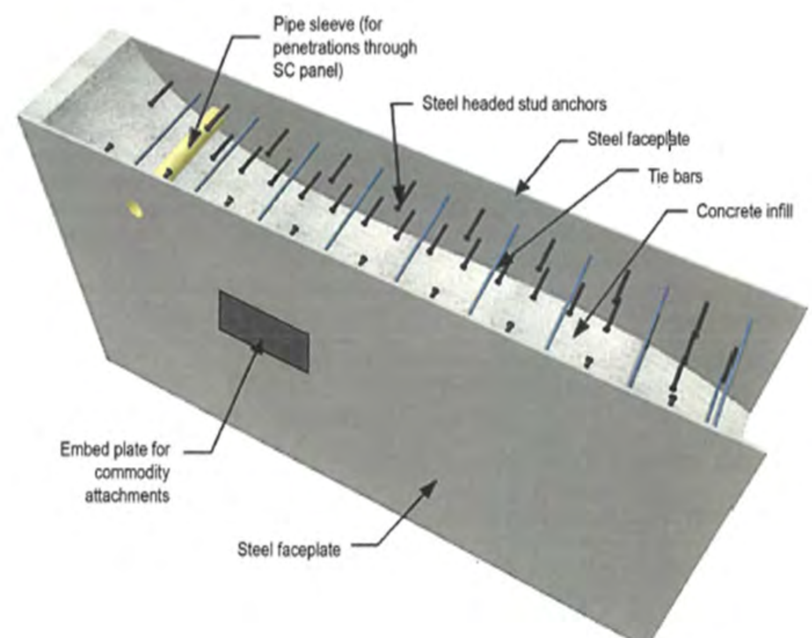
- **Determination of Member Forces**
  - Combine member forces from TRB Seismic and TRB Static at each time step.
  - In-plane stiffnesses matched in both models (seismic and static).
  - Add reinforcement if Demand to Capacity (DCR) > 1.0.
  - Envelope reinforcement and determine controlling DCR for each member.
  - Re-perform analysis for each soil type with appropriate CSDRS or CSDRS-HF. to determine final reinforcement.
- **Determination of ISRS**
  - Determine ISRS at required locations as algebraic sum of time histories.
  - Determine average ISRS and broaden peak by ±15% for uncertainties (per RG 1.122)
  - Repeat for each soil type with appropriate CSDRS or CSDRS-HF.
  - Envelope ISRS .
- Staff finds both approaches consistent with DSRS Section 3.7.2.

TR Section 5.0: Determination of Effective Stiffness

- **Effective stiffness**
  - RC walls and slabs modeled using factors given in Table 3-2 of ASCE/SEI 4-16.
  - SC walls modeled using Section N9.2.2 of N690-18.

- **Sec. N9.2.3 of N690-18 for SC walls:**

  An elastic FE model of SC section geometric and material properties
  - Poisson's ratio of concrete
  - Section thickness and elastic moduli through calibration to match
  - Density through calibration



From AISC Steel Design Guide 32

TR Section 5.0: Effective Stiffness Staff Review and Evaluation

- Two alternate methodologies of Effective Stiffness and Density
  - **Method 1:** A single orthotropic material with dummy outer layers (zero density and insignificant moduli) for both RC and SC walls.
    - Middle layer effective elastic properties from ASCE 4-16 and N690-18
  - **Method 2:**
    - Different material properties for middle and outer layers from ASCE 4-16 and N690-18 for SC walls only.
- Implemented solid-shell element SOLSH190 and shell element SHELL181 in ANSYS.
- Orthotropic material properties (3 Young's moduli, 3 shear moduli, and 3 Poisson's ratios) are used.
- The approaches to determine these properties are acceptable.

TR Section 5.0: Effective Stiffness Staff Review and Evaluation - cont.

- TR includes five Implementation examples to illustrate and validate the use of the proposed methodologies using ANSYS.
- Models with SOLSH190 using both Methods 1 and 2 produce similar results.
- SHELL181 results agree with SOLSH190 results although calculated frequencies with SHELL181 are slightly lower.
- SOLSH190 better represents connection region and preferred.
- SHELL181 can represent open spans accurately.
- Staff finds methodologies used conforms to NuScale DSRS Sections 3.7.2 and 3.8.4, and RG 1.243.

TR Section 6.0: Design of SC Walls

- Design methodology for SC walls complies with the requirements of AISC N690-18, Appendix N9, and AISC 360-16.

- Specification requirements:

  Design

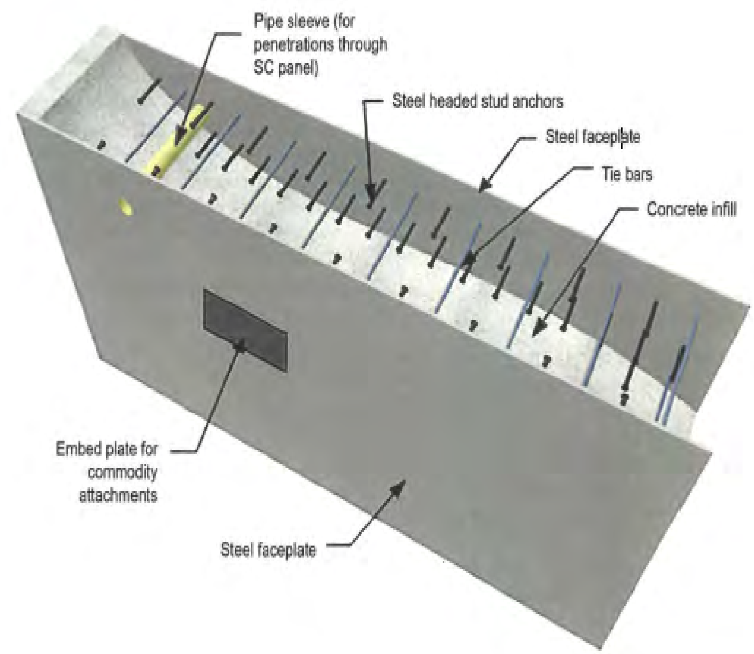
  Impactive and Impulsive Loads

  Analysis - Required Strength

  Design of SC walls - Available Strength

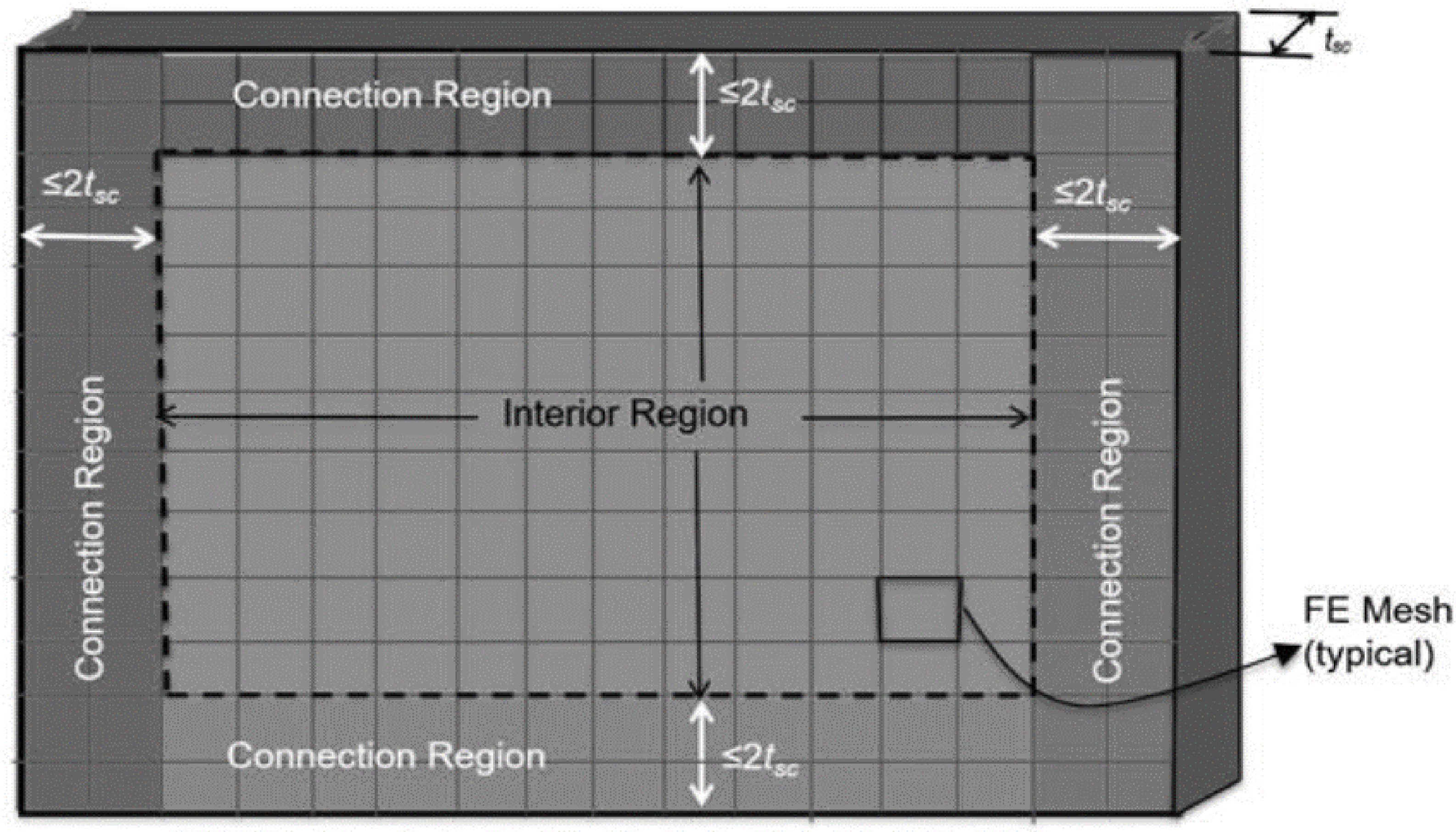
  - Required Strength ≤ Available Strength

  Corrosion Effects



From AISC Steel Design Guide 32

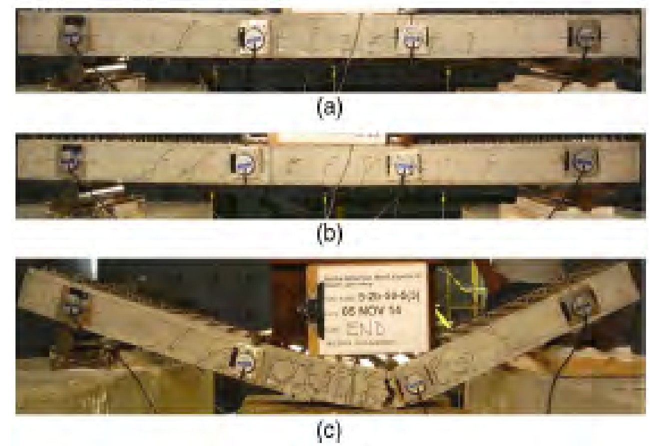
TR Section 6.0: Design of SC Walls – cont.



From N690-18, Appendix N9, Commentary

TR Section 6.0: Design of SC Walls Staff Review and Evaluation

- Rotational capacity of any yield hinge less than or equal to 0.07 radian (4°) was not considered as a limit under impactive and impulsive loads as it was provided in RG 1.243 as one of the three limitation for flexural-control.



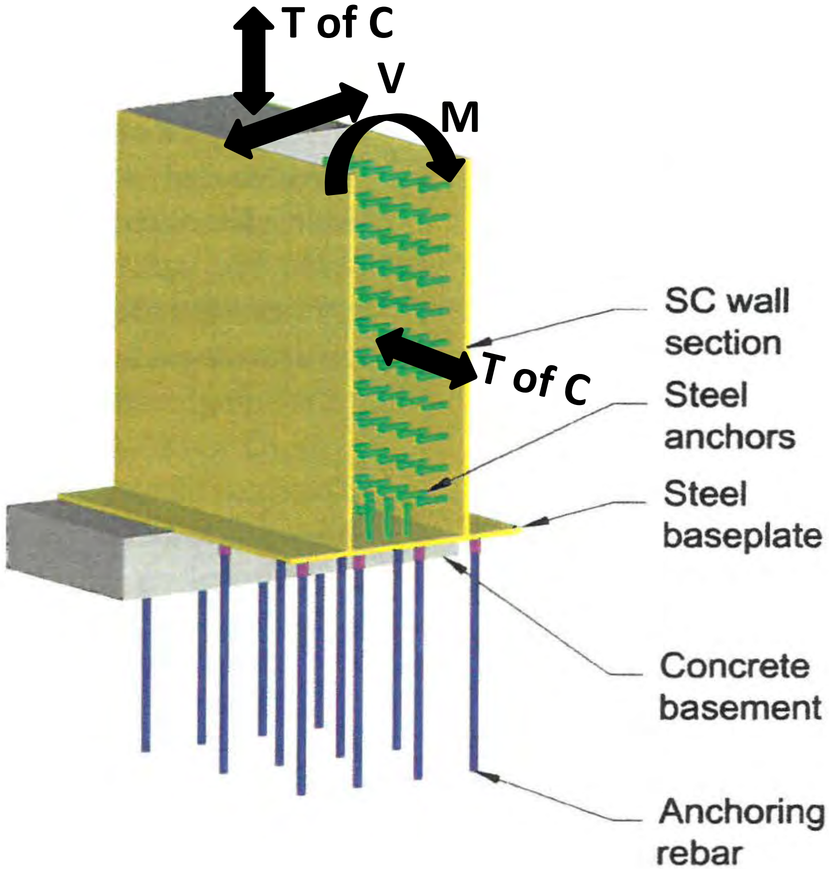
Paper by Dr. Varma, et al.

- Effects of corrosion of below-grade exterior sections of SC walls was not addressed.
- Methodology for the SC wall connection is acceptable and consistent with NuScale DSRS 3.8.4, and N690-18 and AISC 360-16 as endorsed by 1.243.

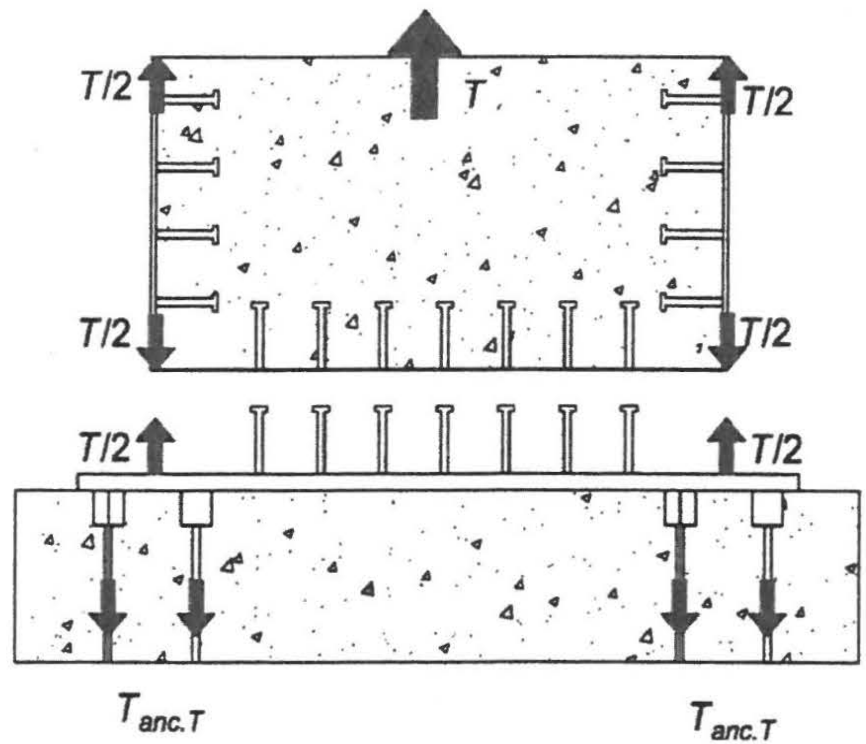
TR Section 7.0: Design of SC Wall Connections

- The methodology presented complies with the requirements of N690-18 and AISC 360-16, and ACI 349-13.
- The methodology presented the development of available strength for each demand type using the appropriate force transfer mechanism (FTM).
- Connectors participate in the FTMs for tension, compression, in/out-of-plane shear, and out-of-plane flexure.
- User Note in Section N9.4.1 of N690-18 refers to the use of AISC Steel Design Guide 32 which presents numerous figures of connection types and FTMs implementing the provisions of N690-18, Appendix N9.

TR Section 7.0: Design of SC Wall Connections – cont.



Typical SC wall connection to basemat with demands



Force Transfer Mechanism (FTM) for Tensile Demand

From AISC Steel Design Guide 32

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Protecting People and the Environment

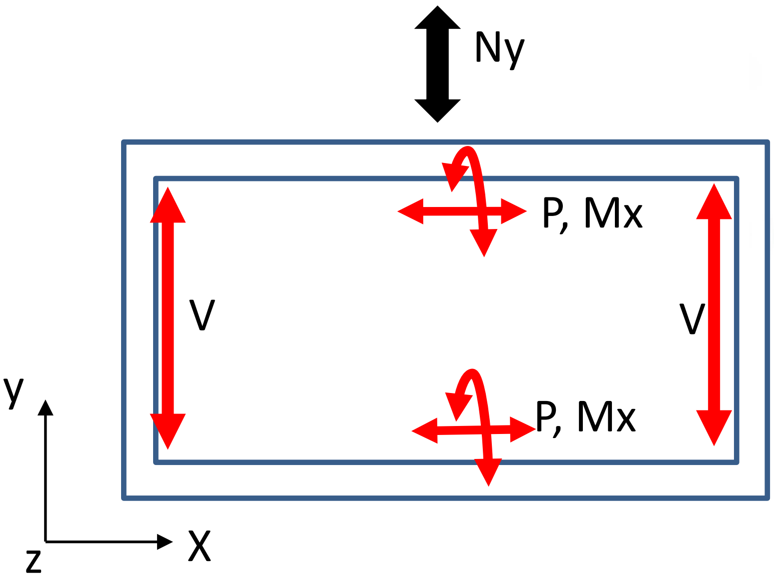
TR Section 7.0: Design of SC Wall Connections Staff Review and Evaluation

- Methodology for the SC wall connection is acceptable and consistent with NuScale DSRS 3.8.4, and AISC N690-18 as endorsed by 1.243 and AISC 360-16, and ACI 349-13 as endorsed by RGs 1.199, and 1.142.

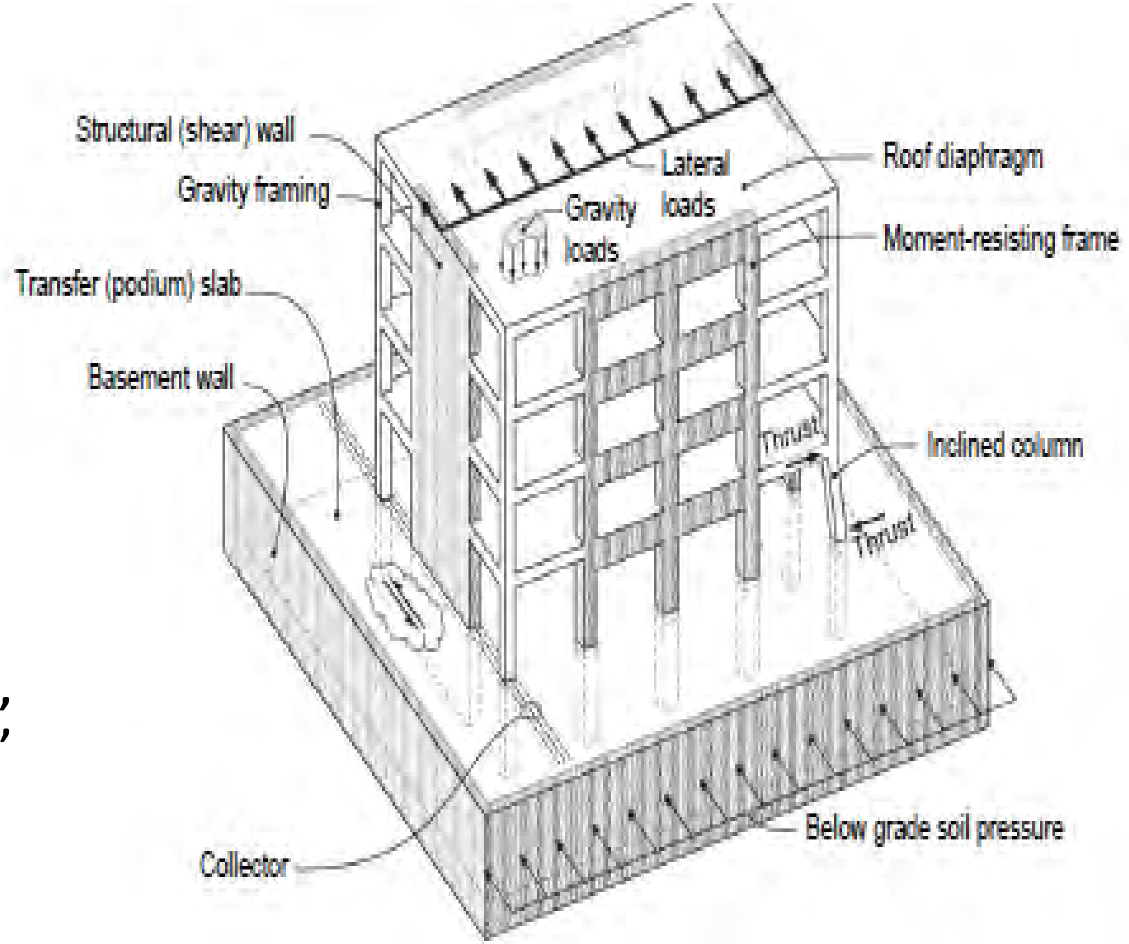
TR Section 8.0: Design of RC Structures

- Design Requirements for RC seismic Category I and II structures are based on ACI 349-13 and the applicable Section in ACI 318-08.
- Section Cut-Based Methodology: was used in which stress results are obtained in member cross sections of RC seismic Category I and II structures.
- Lateral and Gravity Load-Resisting Systems.
- Required Strengths for design of slabs/basemats, columns, T-beams form FEA.
- Critical location where the largest demand is expected for design.

TR Section 8.0: Design of RC Structures – cont.



Critical locations of section-cuts, demand due seismic force in "y" direction



Lateral and Gravity Load-Resisting Systems

From the NIST guide

TR Section 8.0: Design of RC Structures
Staff Review and Evaluation

- Section Cut-Based Methodology
  - Determining the section cut length.
- The design methodology for the RC structures conforms to conventional engineering principles for identifying section cuts and lengths.
- The methodology is consistent with the applicable sections of the ACI codes and the acceptance criteria in NuScale DSRS, Section 3.8.4.

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Limitations and Conditions

- Materials perform linear elastically during seismic events.
- Nonlinear response, e.g., liquefaction of the subgrade and significant cracking of structural components, are not permitted (ASCE 43-19, Limit State D).

Staff Conclusions

- The methodologies presented in the NuScale TR are acceptable to perform building design and analysis for seismic Category I and II nuclear safety-related RC and SC structures other than containment.
- The methodologies follow implementation of the requirements of ACI 349-13 and AISC N690-18, Appendix N9, endorsed by RG 1.243.
- The methodologies are also consistent with the applicable regulatory requirements of acceptance criteria in NRC NuScale DSRS Sections 3.7.2 and 3.8.4.

Thank You for Your Attention

Any Questions?

Full Name	User Actio	Timestamp
Snodderly, Michael	Joined	1/19/2022, 1:29:07 PM
Burkhart, Larry	Joined bef	1/19/2022, 1:29:07 PM
Dashiell, Thomas	Joined bef	1/19/2022, 1:29:07 PM
Murray, Demetrius	Joined	1/19/2022, 1:29:43 PM
Rim Nayal (Guest)	Joined	1/19/2022, 1:34:20 PM
Mark Chitty (NuScale Licensing) (Guest)	Joined	1/19/2022, 1:34:32 PM
Walton, Shandeth	Joined	1/19/2022, 1:36:44 PM
Istar, Ata	Joined	1/19/2022, 1:38:02 PM
Court Reporter (Guest)	Joined	1/19/2022, 1:38:02 PM
Dennis Bley (Guest)	Joined	1/19/2022, 1:39:53 PM
Fehmida Mesania - NuScale Power (Guest)	Joined	1/19/2022, 1:40:28 PM
Liz English (Guest)	Joined	1/19/2022, 1:40:50 PM
Liz English (Guest)	Left	1/19/2022, 1:47:45 PM
Liz English (Guest)	Joined	1/19/2022, 1:47:50 PM
Giulio Flores (Guest)	Joined	1/19/2022, 1:40:55 PM
Giulio Flores (Guest)	Left	1/19/2022, 1:41:41 PM
Giulio Flores (Guest)	Joined	1/19/2022, 1:41:48 PM
Rempe, Joy	Joined	1/19/2022, 1:41:38 PM
Fehmida Mesania - NuScale Power (Guest)	Joined	1/19/2022, 1:43:43 PM
Peter Subaiya (NuScale) (Guest)	Joined	1/19/2022, 1:45:04 PM
Ghosh, Amitava	Joined	1/19/2022, 1:45:58 PM
Bier, Vicki	Joined	1/19/2022, 1:46:19 PM
Kevin Lynn (Guest)	Joined	1/19/2022, 1:47:56 PM
Brown, Charles	Joined	1/19/2022, 1:48:01 PM
Omer Erbay (Guest)	Joined	1/19/2022, 1:48:19 PM
Antonescu, Christina	Joined	1/19/2022, 1:49:05 PM
Ronald G Ballinger	Joined	1/19/2022, 1:49:27 PM
Kirchner, Walter	Joined	1/19/2022, 1:50:46 PM
Colaccino, Joseph	Joined	1/19/2022, 1:52:13 PM
Skov, Tammy	Joined	1/19/2022, 1:52:45 PM
Dave Petti (Guest)	Joined	1/19/2022, 1:53:03 PM
Schultz, Stephen	Joined	1/19/2022, 1:53:15 PM
Halnon, Gregory	Joined	1/19/2022, 1:54:22 PM
Jose March-Leuba (Guest)	Joined	1/19/2022, 1:55:38 PM
Evren Ulku (NuScale) (Guest)	Joined	1/19/2022, 1:56:30 PM
Nourbakhsh, Hossein	Joined	1/19/2022, 1:56:39 PM
Tammy Morin	Joined	1/19/2022, 1:56:55 PM
Moore, Scott	Joined	1/19/2022, 1:58:00 PM
Bavol, Bruce	Joined	1/19/2022, 1:58:41 PM
Schichlein, Lisa (GE Power Portfolio)	Joined	1/19/2022, 1:59:16 PM
Josh Parker (NuScale Power) (Guest)	Joined	1/19/2022, 1:59:30 PM
Dudek, Michael	Joined	1/19/2022, 2:01:32 PM