International Code Council

ICC IS-3DACT Committee Minutes – Meeting #9

June 7, 2024 – 10:00 AM PDT

1. Welcome and opening remarks

Staff Secretariat, Melissa Sanchez called the meeting to order at 10:04 am PDT and welcomed all committee members, invited parties, and ICC staff. Ms. Sanchez announced that Mr. David Langefeld and Mr. Eric Kreiger have been appointed to the board and are voting members.

Ms. Sanchez then went on to note the committee must adhere to the ICC Code of Ethics, which states that those participating in ICC activity must adhere to the highest ethical conduct, with the purpose of the protection of the health, safety and welfare of the public by creating safe buildings and communities. In addition, Section 5.1.10 in Council Policy #7 is in effect and any committee member with a conflict of interest must withdraw from participating in discussion or vote on the matter in which they have an undisclosed interest. Lastly, Council Policy #50 outlines ICC Antitrust guidelines, which indicates the committee meetings are not intended for discussion of pricing and marketing topics.

2. Quorum and Attendance

Ms. Sanchez called the roll of the IS-3DACT with the following members registering attendance. Ms. Sanchez noted there was enough for a quorum.

	2024 IS-3DACT COMMITTEE MEETING							
NAME	**#3 12/15/23**	**#4 1/12/24**	**#5 2/9/24**	**#6 3/15/24**	**#7 4/19/24**	**#8 5/10/24**	**#9 6/7/24**	**#10 7/12/24**
Jared Brewe [A]	X	X	-	X	X	X	X	
Gabriel Carrera [D]	X	-	X	X	X	X	X	
Bora Gencturk [C]	X	X	X	X	X	X	X	
Rory Hamaoka [H]		X	X	X	-	X	X	
Werner Hellmer[H]	X	-	X	X	X	X	-	
Maryam Hojati [D]		-	X	X	X	-	X	
Berok Khoshnevis [D]	X	X	-	-	X	X	-	
Jeff Martin [A]	X	X	-	X	X	-	X	
Doug Mayer [H]	X	X	X	-	X	X	X	
Paul Messplay [H]	X	-	X	X	X	X	-	
Adil Tamimi [D]		X	-	X	X	X	X	
Bing Tian [A]	X	X	X	X	X	X	X	
David Langefeld [B]						X	X	
Eric Kreiger [C]							-	
TOTAL	10/13	9/13	8/12	10/12	11/12	11/13	10/14	

Interested parties in attendance included Abdul Peerzada (Quikcrete), Daniel Galvez Moreno (ICON), Robert Devine (Wiss, Janney, Elstner Associates), Stephan Mansour (ASTM), Mahmut Ekenel (ACI), Muhammed Shakeel Akhtar (Parsons), Rex Donahey (ACI)

3. Approval of Agenda

Chair Mr. Bora Gencturk asked for a motion of approval for the agenda. Mr. Jeff Martin motioned and Mr. David Langefeld seconded. The agenda was unanimously approved.

4. Approval of Previous Meeting Minutes

Mr. Gencturk asked for a motion of approval for the previous meeting minutes. Mr. Rory Hamaoka motioned and Mr. Jared Brewe seconded. The previous meeting minutes were unanimously approved.

5. Update on Work Groups

Mr. Gencturk summarized the last meeting whereby Chapter 3 was finalized, and a vote was called. Chapter 3 was approved by the majority, with one negative vote from Mr. Gabriel Carrera. Mr. Carrera has since sent his suggestions and comments on Chapter 3. Mr. Gencturk suggested to hold off voting on these comments until Chapter 3 goes to the public for comments. Once all comments are gathered then the committee will vote only once more on the changes.

a. Materials Work Group (Bing Tian)
Mr. Bing Tian commented that the Materials Working Group received comments and input from ICON for Chapter 5. Mr. Gencturk recommended that the committee go over Chapter 5 before going over Chapter 4. Mr. Langefeld then presented Chapter 5 to the committee.

The first section presented was Section 501 – Required Field Prequalification Testing. For Section 501.1 Mr. Langefeld explained that this section was to allow a producer to use Section 406, which is based on AC509 with some revisions, as prequalification. Mr. Martin asked what type of revisions to AC509 were being considered. Mr. Langefeld answered that the biggest revisions w~~h~~ere on what needed to be shown on the report. Mr. Abdul Peerzada asked what the testing requirements were in Section 406. Mr. Gencturk said this will be discussed in the Chapter 4 discussion. Mr. Gencturk then asked the committee if they agreed that Section 406 can be used as a replacement to Section 501 for prequalification testing. Mr. Langefeld added that there would still be testing on the construction site, but this Section was meant to show that a printer and material can achieve results that will get a team to a construction site. Mr. Brewe suggested to change the formatting and make an exception as other ICC Standards have done. Mr. Langefeld edited 501.1 to include an Exception paragraph that stated that "Field prequalification of 3D-ACT wall specimens according to Section 501 is not required where structural strength is established in accordance with Section 406." Ms. Maryam Hojati pointed out that Section 405, which was being referenced, was about the connections and that Section 406 was about structural testing. Mr. Mahmut Ekenel asked if Section 406 and Section 501 were exchangeable. Mr. Gencturk answered that the language implies this is true.

Moving on to Section 501.2 – Material Source and Storage Requirements. Mr. Brewe asked if this section was referring to the materials used for prequalification testing or if it was generally applicable to all situations. Mr. Tian replied that it should apply to all situations and suggested that this section should be repeated in the QC section as well. Mr. Gencturk asked to clarify what was meant by the phrase "ready-mix concrete standard practice". Mr. Carrera also had the same question in the chat. Mr. Gencturk suggested to add in a reference document. Mr. Peerzada asked in the chat to confirm if Section 501 was stating that the structural performance in the lab precludes the material performance in the field. Mr. Langefeld answered that Chapter 3 was on the material in the lab, with no printing. Chapter 5 was meant to test the printed material and compare the two as well as to establish an f_r and other properties used for design. Mr. Robert

Devine asked in the chat if Section 501 was meant to be prior to the design process or prior to the construction process. Mr. Brewe commented this was a like ready-mix scenario where field test records demonstrate what can be established with the raw materials. Mr. Langefeld and Mr. Tian agreed. –With regard~~s~~ to the phrase "materials sourced for the field prequalification shall be consistent with those used in the laboratory", Mr. Devine commented in the chat that ACI 301 was a bit more lenient and that field strength records allowed for "similar" materials. In response, Mr. Langefeld asked the committee if there was a preference for language about consistency of materials and would "similar" materials work. Mr. Tian replied that producers will still need to go through the procedures of Chapter 3 for any replacement material. Mr. Devine responded that his question referred to suppliers wanting to use local aggregates or swap different Type II cements – , ~~w~~Would they need to do the prequalification testing of Chapter 3 again for alternates~~.~~? He reasoned that because this material was newer that using the word "consistent" was fine and that it was a good idea to do prequalification testing with any new changes.

Mr. Langefeld next moved on to 501.3 – Test Print Specimens. Mr. Tian asked what the minimum width and height of the layer was. Mr. Langefeld responded that it was probably going to be proprietary. Mr. Tian responded that there needed to be a minimum dimension or a range. Mr. Langefeld requested to table this comment and come back to it. Mr. Tian agreed. Mr. Brewe asked if it needed to be stated that the interior wythes are in contact. Mr. Langefeld agreed and made a note to add in this dimension. Ms. Hojati asked where the number of 16/17 layers came from. Mr. Langefeld replied that it was to ensure that there was enough material to make a beam for the flexural test. Ms. Hojati asked if this number was based on the experiments from ICON. Mr. Langefeld replied that it came from the discussion of doing some type of flexural testing to establish the flexural bond strength between layers. Mr. Gencturk commented that this number came from trying to establish enough layers to make a specimen for flexural testing. Mr. Tian ~~chimed in to say~~ said that while this is coming from the experience of ICON, ~~they wanted to hear~~input from all producers that have had experience would be appreciated.

The discussion moved on to 501.4 – Printing Process. Mr. Tian commented that there should not be a set time between layers because some systems, such as 2K systems, set very fast and that they should just be required to satisfy the installation of the mock-up wall. Mr. Gencturk asked what the intention of the 45 minutes was. Mr. Langefeld replied that the intention was two-fold – 1) for consistency and 2) the print path wouldn't be 30 seconds. Mr. Gencturk thought establishing a time was good but did not know what time. Mr. Peerzada commented that he did not find 45 minutes realistic to print a mock-up wall. He believed that there should be a maximum interlayer time. Mr. Tian agreed and said that it would take 13 hours to finish the wall for 17 layers if each layer took 45 minutes. It would not be practical especially considering weather conditions and the difference between systems. Mr. Gencturk asked if this was to be printed outdoors. Mr. Tian confirmed this test was for outdoors. Mr. Gencturk suggested to change the language from a specific time to the maximum time that is intended for printing in the field between layers and it shall be a minimum of what the actual field implementation or field construction will require between layers. Mr. Langefeld commented that this language presented a challenge because if the floor plan changed then this test would have to be repeated. Mr. Gencturk responded that the longest time between different

floor plans should be taken. Mr. Daniel Galvez Moreno commented that the 45-minute interval time was not wasted time since other testing could be done during the time between layers. He also commented that the test took less than 13 hours for ICON because the first few and the last few layers were printed quicker than the middle layers. Mr. Peerzada commented that the 45-minute layer time did not make sense for continuous mixing systems and that the time should be less than the maximum layer time specified by the manufacturer. Mr. Devine asked in the chat why the language of AC509 was not being used as it specifies that the maximum allowable print delay should be tested. Mr. Doug Mayer commented that it seemed that 501.4 was trying to simulate a print delay which was different than a print stop. He suggested to test both situations by specifying at a certain layer to do a maximum print delay and then do a couple of layers at normal print speed before doing a full print stop at another set of layers. Mr. Tian added that the overnight night stop is meant to test the cold joint while the print delay is meant to test the interlayer bond strength and that these two requirements should be separated. Mr. Gencturk summarized that most of these comments were saying the same thing and suggested the language for the print delay be changed to "The time between layer extrusions shall be the maximum interlayer print time that will be used in construction."

Mr. Gencturk ~~then~~ asked ~~about~~ if there were any comments ~~about~~ regarding the overnight print stop. Mr. Brewe asked ~~if~~ whether someone would have to establish a print stop if they did not want one. Mr. Gencturk replied that he had the same thought and suggested inserting the phrase "if an overnight print stop is intended during construction". Mr. Langefeld asked what would happen if there was an unintended overnight print stop during construction. Mr. Gencturk replied that the print would need to be broken and re-built again. Mr. Brewe agreed. Mr. Devine typed in the chat to make the language mandatory and then make an exception. Ms. Hojati asked why specifically were layers 7 and 8 the intended layers for an overnight stop. Mr. Devine commented in the chat that the middle of 16 layers is between layer 8 and 9 (assuming layer 1 is just for leveling). Mr. Lengefeld replied that when the flexural test is performed it is in the middle of the specimen. Ms. Hojati asked why not change the language to mid-height of the mock-up wall because the layer number could be different for different systems. Mr. Tian agreed with Ms. Hojati and added that sometimes a layer is 1-in for one system and 2-in for another. Mr. Gencturk responded that the thickness of the layer does not matter since the mock-up wall will be 16 layers and that use of term "mid-height" is not clear enough. Mr. Peerzada commented that 7/8 layer might change if the height of the specimen were to be specified in Section 501.3. Mr. Gencturk agreed with Mr. Devine's comments about the exception and said that the number of layers versus height of the specimen can be decided later.

In the interest of time, Mr. Gencturk moved the discussion forward to the next paragraph of Section 501.4. He commented that "as closely as possible" was a vague term and suggested to remove it as well as change "resemble" to "replicate" to be specific. Mr. Langefeld commented that the intention was for people to be reasonable but acknowledged that replicating the field conditions was hard. Mr. Gencturk asked what were the field conditions that were being replicated. Mr. Langefeld responded that in the previous draft it was written that the mock-up wall was to be printed alongside the projects citing concern with the wind, humidity, and temperature. He commented that

this was to establish a prequalification that considered that the print was not indoors and was subjected to relative humidity, wind, and temperature changes. Mr. Mayer suggested in the comments to use the phrase "shall be consistent" with field conditions. Mr. Gencturk commented that the term "consistent" can be interpreted differently. Mr. Devine asked in the chat if this implied that the prequalification testing was to be redone every time a project site changed, not just for mix changes. Mr. Langefeld responded that this was not the intent. He suggested to write the phrase in the negative form "shall not be climate controlled". Mr. Gencturk said this was one option but pointed out that while the batching could be done in a climate-controlled-environment, the printing might not. He suggested to write the phrase as "material printing shall not be in a climate-controlled environment". Ms. Hojati asked about including language that referred to using admixtures like retarders or accelerators for any changes in climate conditions. Mr. Brewe asked whether establishing a protocol for printing in adverse climate conditions prohibits the use of a climate-controlled chamber. Mr. Langefeld said this was a good point. Mr. Brewe suggested to use the word "anticipated" climate conditions. Mr. Gencturk suggested to add the phrase "material batching, delivery, and printing shall take into consideration relative temperature and humidity conditions anticipated in the construction." Ms. Hojati agreed with this language. Mr. Langefeld suggested to ~~kick~~ defer this issue to the ~~licensed design~~building official and include it as part of the submittal documents. Mr. Gencturk disagreed with this suggestion, stating the intent of ~~because the whole point of~~ the standard was to ~~avoid this~~reduce burden on the building official.

Moving on to the next paragraph Mr. Gencturk suggested to remove "as close as practicably possible".

For Section 501.5 – Print Logs, Mr. Brewe asked if the print logs were just for the prequalification testing. Mr. Langefeld confirmed that it was just for the prequalification testing. Mr. Carrera commented that the phrase "and available upon request" should be removed and instead put "shall be maintained and submitted".

Moving on to Section 501.6 – Testing, Mr. Brewe commented that some of the wording like "complete these tests expeditiously" is not needed, while other wordings such as "within 5 minutes" should reference an ASTM standard instead. Mr. Gencturk agreed with Mr. Brewe. Mr. Langefeld replied that there was not a standard that applied to 3D printed material and the specified durations were taken from a standard on sampling concrete in the field. Mr. Gencturk said this was resolved in the discussion for Chapter 3 and that Section 501.6.1 should reference Chapter 3.

Moving on to Section 501.6.2 – Hardened Properties, Mr. Gencturk said to leave details, such as compression cylinder test set up~~how to cap~~ or ~~failure should be in the middle of the~~ location of specimen failure, to the ASTM standard. Mr Brewe asked if two mock-up wall specimens were specified. Mr. Langefeld confirmed this was the case. Mr. Brewe asked if there was a minimum number of acceptable results. Mr. Gencturk added to this question and asked if there was an acceptance criteria for a minimum strength with this requirement. Mr. Tian had the same question. He added that the interlayer tensile bond strength is the more critical parameter. He asked Mr. Brewe if there was a need for the interlayer flexural bond strength for structural design and/or structural considerations.

Mr. Brewe said that it might be possible to correlate the two in a similar manner to the split tensile strength test with concrete as described in ACI 318. Mr. Peerzada asked how applicable ~~was~~ ASTM E518 is. He said there was no direction specified in Section 501.6.2.2. Mr. Tian agreed. Mr. Peerzada said that he did not think it was a good test for 3D printed systems and mentioned that it is~~was~~ not in Chapter 3 either. Mr. Tian agreed and suggested to remove the section. Mr. Brewe commented that if the flexural requirement is removed there is~~would be~~ no need for a mock-up wall and only a few layers would need to be printed for the tensile test. Mr. Ekenel commented that this test was included in AC509 as a comparison test between the lab and the jobsite during the qualification testing. Mr. Brewe said the ~~difference with~~intent of this section was to ~~get~~determine a value for structural design to avoid the test~~ing~~ requirements from AC509 (in Chapter 4). He said the interlayer flexural bond strength test is~~was~~ only found in Section 501. Mr. Ekenel commented that this is~~was~~ a big deviation from AC509 and came back to a previous question about the reversibility of this section with Section 406. Mr. Gencturk commented that the intention of 501 is~~was~~ to establish some ~~criteria, some~~ physical ~~hardened~~definitive criteria, rather than ~~perform~~ comparison testing. Mr. Gencturk suggested to add in the text that the data of interest was not the strength but the failure mode, which should not be interlayer failure. Mr. Ekenel countered that ASTM E518 is for masonry and the failure was usually in the mortar where the joints were. He did not know if the same applied to 3D printing and offered that perhaps ASTM E518 ~~was~~ is not the right type of test for this. Mr. Devine typed in the chat that in ICON's experience the failure always occurred at the interlayers. In the interest of time Mr. Gencturk tabled the discussion for the next meeting.

Mr. Gencturk turned the discussion to the compressive test requirement and asked if it was for a cut-out from the mock-up wall or cast from the printer. Mr. Langefeld said it was from the printer nozzle. Mr. Gencturk suggested to specify a deviation limit from Chapter 3. Mr. Tian asked if the requirement for cut-out compressive strength testing was included. Mr. Langefeld said ~~there~~ it was not. Mr. Tian suggested then to include a cut-out compression test requirement because of the discrepancy between a cast sample and printed sample. Mr. Galvez Moreno said there was a discrepancy, but the direction of the cut-out determines whether interface failure occurs. He mentioned that in ICON's experience the samples that were cut-out perpendicular to the print direction did not exhibit interface failure, but other directions there was interface failure occurs. Mr. Peerzada asked if ICON did cubes or cylinders in the lab to compare with the cut-outs. Mr. Galvez Moreno replied that the cut-outs were compared to cylinders. Mr. Peerzada clarified his question to ask if the cut-outs were cubes or cylinders. Mr. Galvez Moreno responded that they were cubes. Mr. Peerzada asked if there was a difference in compressive strength. Mr. Galvez Moreno said on average there was not, but a bigger data set was needed to make this claim. Mr. Gencturk asked if the committee would like to do cut out tests for compression. Mr. Galvez Moreno commented on the difficulty of cutting out perfect cubes from the mock-up wall. Mr. Gencturk said imperfect cubes would okay because there would be a deviation specified, such as 500 psi, that will be account~~ed for~~ for it. Mr. Gencturk concluded that cut-out compressive testing needed to be included somewhere in the Section.

At this time the discussion on Chapter 5 was stopped due to time. It was concluded that a Materials working group meeting would be held before the next committee meeting to discuss the unresolved issues as well as the rest of Chapter 5.

b. Structural Work Group (Jared Brewe)
Mr. Brewe started the discussion on Chapter 4 by starting with Section 406 – Alternative Structural Design and Testing Provisions. Mr. Brewe explained that this section was based off full scale destructive structural testing protocols of AC509. Mr. Gencturk commented that Section 406 was mainly on testing and asked where in Chapter 4 were the design recommendations. Mr. Brewe said the rest of the Chapter 4 was focused on design criteria. He showed Section 406 first because it was referenced in Chapter 5 and had been discussed already in the meeting. Mr. Devine asked if there were other requirements, such as reinforcement detailing, in the other Chapter 4 sections that would need to be satisfied before doing the testing in Section 406. Mr. Brewe replied by showing Section 403.1 which stated that structural elements shall meet the minimum detailing requirements of Section 403, the connection requirements of Section 405, and either the engineering requirements of Section 404 or structural testing criteria of Section 406. Mr. Langefeld suggested that it would be helpful to have a Structures working group meeting to go over Chapter 4. Mr. Brewe agreed.

Mr. Brewe then went on to give an overview of the rest of Chapter 4. Section 401 was about the general criteria that applied to structural design, while Section 402 was about the design loads. Section 403 was on Detailing Requirements, and it applied to all systems. Mr. Brewe pointed out that Section 403.1.1 was the minimum reinforcement primarily related to shrinkage and temperature changes. He said ~~a lot of these~~many of the requirements were based on a traditional planar wall system and focused on vertically plumb elements ~~that don't have a lot of changes~~with limited changes in cross-sectional areas other than ~~except~~ for openings. For Section 403.1.4 on the Minimum Concrete Cover, Mr. Brewe commented the table was pulled out of ACI 318 with only information applicable to 3D printed wall systems included. Mr. Brewe then let the committee read/scroll through the rest of the subsections of Section 403. Mr. Brewe asked whether the coordination between ACI and ICC will change the scope of Chapter 4. Mr. Gencturk responded that there ~~was~~ is nothing formalized yet between ACI and ICC and thus Chapter 4 should continue with the intended scope. Mr. Gencturk asked if Chapter 4 was ready for a vote. Mr. Brewe said Chapter 4 was not ready.

6. Additional Discussion of Initial Draft

Mr. Carrera asked if balloting offline was an option. Mr. Gencturk replied that it ~~was~~ is an option provided the document ~~was~~ is ready. Mr. Brewe asked if there was a balloting system or if it ~~was~~ is a manual process. Mr. Gencturk replied that it was probably a manual process. Ms. Sanchez said she will look into if there is an automatic balloting system.

7. Next Meeting

The next meeting is set for July 12, 2024, at 10am PDT.

8. New Business

To finalize Chapters 4 and 5.

9. Action Items & Summary

The action items from the meeting were summarized as follows:

Materials working group to meet~~ing~~ in next two week and circulate the documents to the entire committee at least 1 week before next committee meeting.	*Mr. Tian*
Structures working group to meet~~ing~~ in next two week and circulate the documents to the entire committee at least 1 week before next committee meeting.	*Mr. Brewe*

With no other questions or comments before the committee Mr. Gencturk moved to adjourn the meeting. Mr. Brewe motioned for adjourning and Mr. Tian seconded the motion. The meeting adjourned at 12:03 pm PDT.