



International Code Council

ICC IS-3DACT Committee Minutes – Meeting #10

July 12, 2024 – 10:00 AM PDT

1. Welcome and opening remarks

Staff Co-Secretariat, Aileen Vandenberg called the meeting to order at 10:00 am PT and welcomed all committee members, invited parties, and ICC staff.

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

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

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

3. Approval of Agenda

Chair Mr. Bora Gencturk asked for a motion of approval for the agenda. Mr. Paul Messplay motioned and Mr. Jared Brewe 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. Brewe motioned and Mr. Bing Tian seconded. The previous meeting minutes were unanimously approved.

5. Update on Work Groups

a. Materials Work Group (Bing Tian)

Mr. Gencturk shared the latest version of Chapter 5. He explained the intent of the meeting was to go over the chapter and then possibly vote on it.

Mr. Gencturk presented the revised title of Chapter 5 – 3D Printing Material and Structural Field Prequalification – Testing Methods, Performance Requirements and Final Acceptance. He said the reason was to connect Chapter 5 to Chapter 3 and Chapter 4. Mr. Gencturk explained that Chapter 5 was meant to address the printing system, whereby the first section was meant to be done in a setting outside the construction site and the second section was meant to be done in the field prior to, or during, the construction phase.

Mr. Gencturk then begin the discussion on Chapter 5 with the first section, Section 501 – Required Field Prequalification Testing. Mr. Gencturk read out loud Section 501.1 and started the discussion on the third paragraph which addressed climatic and geographic condition variations. He commented that more specification was needed on the definition of climatic variation and the requirements. He suggested that language that places the responsibility on the design professional be removed. He pointed out a sentence in Section 502.4 as an example that stated, “This shall be done once a week or when there are changes in temperature by more than 20°F or in humidity by more than 20% or where materials or water-to-binder or water-to-powder ratio have changed more than by 5%.” Mr. Gencturk then asked for input from the committee.

Mr. Tian suggested to change climatic and geographic condition variation to “Climatic Zones” as in the USA there are already established climatic zones. Mr. Gencturk replied that the standard that establishes these climatic zones would need to be referenced. Mr. Tian agreed. Mr. Werner Hellmer commented that seasonal changes were important to consider for environmental conditions. Mr. Gencturk responded that climatic zones do not consider seasonal changes where the difference in temperature between seasons in the same climatic zone could be greater than 20°F and suggested that instead to just specify the temperature and humidity change. Mr. Hellmer replied that the phrase environmental conditions should consider both temporal and ambient conditions. Mr. Gencturk then changed the phrase “Climatic and geographic condition” to “Variation in environmental conditions”. Mr. David Langefeld suggested to use ACI’s definition of hot and cold weather. He also commented that a temperature difference of 20°F could mean testing would have to be done multiple times a day if the temperature difference is greater than this, which he pointed out was costly. Mr. Gencturk responded that 20°F was up to discussion. Mr. Daniel Galvez Moreno asked the question of what the variation was based on, such as the average temperature of the day, and what was the length of the variation, from morning to afternoon or for X number of days. Mr. Abdul Peerzada commented that there was an equation in ACI where the mix temperature needed to be regulated to account for the amount of variations. Mr. Galvez Moreno responded that finding the temperature of 3D printed materials was difficult. Mr. Gencturk agreed. Mr. Robert Devine commented that if it was $\pm 20^\circ\text{F}$ from an average temperature of 65°F this would cover all but hot and cold weather placements. Mr.

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Gencturk agreed and edited the document to include $\pm 20^{\circ}\text{F}$ and $\pm 20\%$ in humidity from the average daily temperature and relative humidity. Mr. Mahmut Ekenel expressed concern that the document was venturing into code language rather than standard language and suggested that this section should be removed. Mr. Gencturk responded that it is not uncommon for standards to specify environmental conditions when the outcome of the test relies on the environmental conditions. Mr. Ekenel understood and suggested to specify a temperature and humidity range, and if environmental conditions fall outside of this range, more testing should be done. Mr. Gencturk replied that a range was previously discussed, but it was decided that specifying a range will not work because mock-up wall tests are not necessarily printed in an environmental controlled chamber. Mr. Hellmer added that the idea of variation in environmental conditions was added to prevent a producer from doing the prequalification testing in ideal environmental conditions and then in the field print in extreme hot or cold weather conditions. Ms. Maryam Hojati agreed with Mr. Ekenel and commented that an exact number will bring more confusion. Mr. Peerzada mentioned that the NRMCA-PCA nomograph (Figure 4.1.4 of the ACI 305Rr-20 Guide to Hot Weather Concreting) provides a graphic method of estimating the loss of surface moisture for various weather conditions. He also typed in the chat the definition of cold weather concreting from ACI, which states "The conditions of cold weather concreting exist when the air temperature has fallen to or is expected to fall below 40°F (4°C) during the protection period." Mr. Robert Devine added that ACI 301 Section 4.2.2.5(b) states "Unless otherwise specified, temperature of concrete as delivered shall not exceed 95°F ". Mr. Galvez Moreno commented that at ICON they have hot and cold weather printing strategies which align with ACI's definition of hot and cold weather. Mr. Gencturk suggested to allow a producer to do prequalification testing in any temperature and specify a range of temperature and humidity based on the testing temperature based on the nomograph.

In the interest of time, Mr. Gencturk moved the discussion forward to the next Section 501.2 – Material Source and Storage Requirements. Mr. Brewe pointed out the word "consistent" and suggested the previous section could follow the relaxed language of this section by stating the conditions shall be consistent in the qualification testing. Mr. Gencturk commented that while there was still disagreement about how specific the environmental conditions should be, he agreed with Mr. Brewe.

Moving on to Section 501.3 – Prequalification Elements, Mr. Gencturk read Mr. Eric Kreiger's comment that the dimensions should be height rather than layer dimensions because the strength requirement will be based on the vertical build rate (loading rate) and the stiffness requirement will be based on the unbraced vertical and horizontal dimensions and the build rate. Mr. Jeff Martin asked whether the width and height mattered if the bond strength was the important parameter. Mr. Tian replied that he believed the width mattered but was unsure about the height. Mr. Langefeld commented that the interlayer bond strength would be determined from the double bead portions (in Figure 501.3) and thus a minimum double bead width specification makes sense with regards to ASTM C1583. The single bead width would be for the overall flexural bond strength and thus could be based on the geometry of the producer. Mr. Tian asked if the flexural bond strength test was needed in addition to the interlayer bond strength. Mr. Galvez Moreno replied that both are done because AC509 requires the flexural bond strength (ASTM E518). Mr. Langefeld commented that the maximum height of 1-in was

too tight. Mr. Gencturk suggested to change it to 2-in and Mr. Tian agreed. Mr. Galvez Moreno suggested to base the height on the number of beads instead of a fixed dimension. Mr. Peerzada commented that if there was a maximum height of 2-in, the anisotropic effect would be missed. Mr. Gencturk commented that the cut needed a certain number of layers and that is why there was a limit on the maximum height of the bead. Mr. Langefeld suggested not to include a minimum width or maximum height and instead refer to the size requirements of the ASTM standards. Mr. Galvez Moreno agreed. Mr. Gencturk agreed and edited the last sentence of 501.3 to “The bead dimensions shall be such that the cut dimensions of the samples comply with the requirements of the subsequent tests specified in this section.”

For 501.4 Mr. Gencturk commented that the phrase “typical interlayer print time” was too vague. Mr. Tian explained the phrase typical interlayer print time was used to reduce the amount of time the mock-up wall print would take. Mr. Robert Devine commented that from a structural point of view they would want to design to the minimum interlayer bond strength, which means the mock-up wall should be printed at the maximum interlayer time that doesn’t constitute a cold-joint. Mr. Gencturk pointed out that the overnight stop between layers 7 and 8 was where the ASTM C1583 testing would be done. Mr. Devine pointed out that if a bonding agent was applied to the cold joint, this might change where the minimum interlayer bond strength was. He said there that it would be difficult to tell which case would have a smaller interlayer bond strength – a cold joint with a bonding agent applied or a 2-hour delay joint with no bonding agent Mr. Gencturk suggested to add the phrase “and layers 6 and 9 shall be printed using the maximum interlayer print time”. Mr. Langefeld expressed concern that this would not work with ASTM E518. Mr. Devine countered that it would work provided the layers that were allowed to break were measured and the stress calculated wherever it broke. Mr. Galvez Moreno asked about the sequence of printing. Mr. Devine said that layers one through six would be printed at typical interlayer print times, then between layers 6 and 7 the maximum interlayer print time, then between 7 and 8 a cold joint, then between layers 8 and 9 the maximum interlayer print time, and finally layers 9 -16 typical interlayer print time. He suggested a figure might be beneficial for understanding the sequence. Mr. Gencturk agreed and also suggested to have a figure to show the cut locations in elevation view.

Mr. Gencturk paused here and called for a 5-minute break.

Continuing with Section 501.4, Mr. Brewe asked if the cold joint print stop had to be overnight for a firm 8 hours. Mr. Tian agreed and suggested the wording say, “a cold joint shall be incorporated between layers 7 and 8.” Mr. Gencturk suggested to write “a print stop exceeding the final set time according to ASTM C403.” Mr. Tian commented that ASTM C403 does not work for mortar; that would be ASTM C807. Mr. Galvez Moreno commented that ASTM C403 would work for mortar because the concrete is sieved for the test. Mr. Langefeld asked if the final setting time was a required test in Chapter 3. Mr. Peerzada replied that there was no setting time test in Chapter 3 because the Materials working group decided it was a redundant test. He added that the setting time test was a relative test and the results for ASTM C403 would not necessarily match the results of ASTM C807. Mr. Galvez Moreno added that for 2K systems and other accelerated systems that ASTM C403 would not apply because the mix stiffens too quickly. Mr. Gencturk asked what to put then for final setting time. Mr. Galvez Moreno

said that the Materials Working Group identified 24 hours as the final set time. Mr. Langefeld suggested to keep it at 8 hours since this would be the time between the end of one workday to the next. Mr. Gencturk agreed and just removed the word overnight from the sentence. Mr. Devine commented in the chat to specify that the maximum interlayer print time for layers 6 and 9 should be without any additional interlayer augmentation such as a bond agent. Mr. Gencturk agreed and added this into the text.

Mr. Langefeld brought up the numbers of the layers might be wrong since there were 16 layers above the first layer. Mr. Gencturk said that this would make the middle between layers 8 and 9. Mr. Peerzada said it did not matter about the middle layers if the bond strength was coming from ASTM E518 and added he believed this test should not be in the standard because it did not apply the loading uniformly and artificially applied the loading in the center forcing the failure to be in the center. Mr. Langefeld countered that was the point of the test. Mr. Devine wrote in the chat that ASTM C1583 would likely give a lower conservative bond for the flexural tension strength and that in Chapter 4 a minimum bond strength of 75 psi will be required. Mr. Peerzada said ASTM E518 is a large and expensive test and questioned again its place in this standard. Mr. Brewe mentioned that the flexural tensile strength was an important structural parameter to know. Mr. Tian asked if the structural parameter was the flexural performance or the interlayer bond strength. Mr. Brewe said ASTM E518 test gives the modulus of rupture which was the flexural tensile strength needed to determine out-of-plane bending in walls. Mr. Galvez Moreno commented that this test also determined material properties as it correlated to the slump of the material. Mr. Gencturk agreed that ASTM E518 was a valid test and should be kept in the standard.

On to Section 501.5 – Print Logs, Mr. Langefeld suggested to make it one sentence with a comprehensive list of items needed such as batching information, admixture dosages, layer print times, and print ambient environmental conditions.

For Section 501.6.1 – Fresh Properties, Mr. Gencturk commented the sentence was a little unclear. He added the text “and tests shall be repeated on samples collected at all three times.” Ms. Maryam Hojati asked why samples were collected at the nozzle. Mr. Peerzada replied to account for effects of the pump on the properties of the mix such as air content.

For Section 501.6.1.1 – Workability, Mr. Galvez Moreno asked what the dimensions or the weight of the steel plate were. Mr. Gencturk suggested to leave a comment about it to come back to.

For Section 501.6.2.1 – Compressive Strength, Mr. Langefeld requested that cylinders of dimensions 3” x 6” be considered because casting cubes in the field is difficult. Mr. Gencturk mentioned that 3” x 6” cylinders were not included in the laboratory tests in Chapter 3 because ASTM C39 does not include this size of cylinder. Mr. Galvez Moreno mentioned that ASTM C192 gives a method to make this size and suggested to include this specimen size in Chapter 3. Mr. Tian suggested to make it simple by using ASTM C109 for mortar and for concrete ASTM C39. Mr. Gabriel Carrera agreed with Mr. Tian that a technical basis had not been provided for using 3” x 6” cylinders on 3D printed mortar. Mr. Galvez Moreno expressed concern about the difficulty of doing ASTM C109

in the field and that technicians have more knowledge in making cylinders rather than cubes. Mr. Langefeld suggested to add modifications to the ASTM standards to adjust for the 3" x 6" cylinders. Mr. Gencturk asked for the type of modifications. Mr. Langefeld and Mr. Galvez Moreno said they would put together a paragraph on including 3" x 6" cylinders.

For the second paragraph Mr. Gencturk suggested to add ASTM C39 for cored concrete specimens. Mr. Langefeld said a core could not capture the different orientations. Mr. Gencturk suggested to make the samples 6" x 6" or 4" x 4" cubes for concrete. Mr. Langefeld commented that the current print area would not be large enough to accommodate such large cut-outs since specimens for the ASTM C1583 test were also coming from the double bead portion of the print.

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)

There was no discussion on Chapter 4.

6. Additional Discussion of Initial Draft

Mr. Gencturk expressed the intended goal for the next meeting was to vote on Chapter 5 and then move on to Chapter 4.

7. Next Meeting

The next meeting is set for August 9, 2024, at 10am PDT.

8. New Business

There was no new business.

9. Action Items & Summary

The action items from the meeting were summarized as follows:

<i>Materials working group to meet in next two week and circulate the documents to the entire committee at least 1 week before next committee meeting.</i>	<i>Mr. Tian</i>
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With no other questions or comments before the committee Mr. Gencturk moved to adjourn the meeting. Mr. Martin motioned for adjourning and Mr. Tian seconded the motion. The meeting adjourned at 12:00 pm PDT.