ABC-UTC 2022 In-Depth Web Training: Non-Proprietary Ultra-High-Performance Concrete (UHPC)		
#	**Questions**	**Responses**
	Module 1: Non-Proprietary / Open-Source Mix Design	
1	What are the prospects of using larger graded sand particles in UHPC in order to reduce the cost?	It is possible to use larger sand particles depending on the desired specifications, the quality of the sand, and consideration for optimizing the mix gradation. There has been some work at other institutions with mixes that include larger aggregates and achieve compressive strengths in excess of 18,000 psi.
2	Regarding FRP fibers, what are the tested substitutes to the steel fibers typically found in UHPC?	Some synthetic fibers have been tested for use in UHPC, but have not necessarily been shown to be potential direct substitutes for steel fibers. The following reference to work at Iowa State University is a good example: https://abc-utc.fiu.edu/wp-content/uploads/sites/52/2022/03/non-proprietary_UHPC_mix_design_for_ABC_applications_w_cvr-Revised.pdf
3	Could UHPC be poured in low temperatures with cold weather conditions? Are there any specific protection or heating requirements needed?	UHPC can be cast in cold weather conditions, but the strength gain will be affected. It is important to keep the UHPC from freezing, and it is beneficial to keep the constituents warm. An accelerator can be used to ensure adequate strength gain.
4	Do these non-proprietary mixes need to be mixed with high-shear mixers like commercial UHPC? Are ready-mix trucks effective?	So far our work has primarily used high shear mixers. We have had success with standard mortar mixers and it is possible to mix in a rotating drum mixer, but the mixing time is increased. We have not specifically investigated ready-mix trucks at this point, but other researchers have done so and indicate it is possible with increased mixing time.

5	Does the non-proprietary mix design need to be modified for locally found materials?	Yes. At a minimum the HRWR (High-Range Water Reducer) dosages will need to be adjusted, but there may also need to be adjustments for different aggregates and cement/supplementary cementitious materials combinations. Trial batches are very important.
6	Has anyone tested UHPC containing graphene fibers in lieu of steel fibers to achieve high tensile strength?	I am not aware of any work in this area.
7	Are there quality control issues with suppliers that have limited experience with UHPC?	There can be quality control issues in this area. Most commercial suppliers are very good and have excellent quality control. It takes some level of skill and experience to consistently get UHPC performance, especially with non-proprietary mixtures. Accurately weighing out the constituents is important. Proper training is needed for QC/QA (Quality Control / Quality Assurance) testing. Unfortunately, not a lot of field implementation has been done with locally developed mixtures.
	Questions during Module 1	
8	Is it possible to make the UHPC mix without oven drying the sand?	Yes, it is possible, but it is difficult to maintain consistency. Also, careful consideration of aggregate moisture must be made.
9	Have you seen any issues related to variability in the constituent materials, specifically the silica fume or slag cement?	Yes. There can be variations between specific shipments of silica fume and slag cement that lead to variations in UHPC performance.
10	Slide 17: Why was the AASHTO Direct Tension Standard T397 used in lieu of the Prism test, ASTM C1609?	The direct tension test provides a better representation of true tension behavior compared to the prism test without an inverse analysis. The AASHTO T397 test is the only direct tension test that is currently standardized and is recommended as the best option. Many labs are not yet equipped to run that test, but more research is needed in the area of correlating direct tension test results with prism results.

11	Slide 55: Did the steel fiber content affect the RCPT (Rapid Chloride Permeability Test) results?	Yes. The reported results are from samples without steel fibers, as the steel fibers invalidated the results of initial tests that included steel fibers.
12	Were all the test mixes heat cured?	No. Some mixes were heat cured to examine effectiveness of heat curing and to accelerate comparison of specific variables. The majority of test mixes used ambient temperature curing in lime water. Similar strengths were achieved without heat curing, but at a later age.
13	Can glass/FRP fiber be used instead of steel fiber?	These types of fibers can be used, but will affect performance in one way or another.
14	To my understanding, the modified A&A model (Andreasen and Andersen particle packing model) can yield the relative proportions of the available constituents based on their particle size distribution. Are the relative proportions then measured in units of volume or units of mass while measuring the samples for mixing?	We consider the mix designs in terms of relative proportions and then convert to an absolute volume, cubic yard basis for mixing. Mix constituents are then measured in terms of mass/weight for a specific volume mix.
15	While using the aggregates in the oven dry state, is the absorption capacity of the aggregate considered while calculating the net amount of water to be added to the mix? Also, is the w/b (water/binder) ratio adjusted accordingly?	No adjustment was made for the water absorbed in the aggregates during mixing either for mixing or w/b (water/binder) calculation. It is likely that the actual w/b is less than what was reported in this presentation.
16	Other than the optimization curves such as modified A&A model (Andreasen and Andersen particle packing model), what is a good way to simulate the packing of the binders or (binders + fine aggregate) before making the mix in the lab?	Our research found the optimization curves to be an effective method, but discrete element models and other particle packing models can also be used.
17	Although literature refers to the use of quartz sand or silica sand, that might end up increasing the UHPC price. What other sources of sand or sand types can be used as a replacement of quartz sand? Is there any property of the sand that needs to be measured to finalize the sand type to be used in the mix?	ABC-UTC researchers at FIU utilized a limestone powder as a partial replacement for the quartz sand and showed improvement in compressive strength. It is not unusual for reactive supplementary cementitious materials to be used as an effective part of the aggregate portion. The primary consideration is the particle size distribution, but the impact of the specific material on compressive strength should be considered.