ABC-UTC July 2021 Research Seminar: Behavior and Strength of UHPC in Shear		
#	**Questions**	
	Mix Design	
1	Are any specialized curing requirements used for your non-proprietary UHPC mix, e.g., steam curing?	The University of Washington (UW) used a lime bath to cure specimens and did not study curing requirements further. The University of Oklahoma included steam curing in their portion of the project.
2	Do you anticipate any change in strength when materials are differently sourced?	UW did not see any change in strength for differently sourced materials.
3	Have you considered the fiber orientation in the study? If yes, do you have any results of the shear stress versus fiber orientation?	UW did not consider fiber orientation in the study. This would be a difficult parameter to control but might be worth looking into in the future.
4	Were different sands examined relative to shear strength of the UHPC?	The sand from local UW materials was less fine than the sand from local University of Oklahoma materials, but the strength results for the UHPC remained the same for both.
5	Can you discuss UHPC in the plastic state, i.e., the addition sequence in batching, length of mixing, workability retention, etc.?	Qualitative data on these parameters was not obtained, but many observations about the mixing and workability of UHPC were recorded. UHPC was very sensitive to mixing and requires a high energy mixer. Admixtures are essential in creating a workable mix. Too much will cause fibers to sink, not enough will create a material that is impossible to work with.
	Strength/Testing	
6	Can you comment on effects to bursting zone performance for UHPC? Also, can you comment on the applied zone length?	This was unfortunately outside the scope of the project at UW.
7	Can you discuss cracking and shear in UHPC?	Cracking and shear in pure UHPC was one of the main focuses of the study. The results can be found in the presentation slides.

8	What is the difference in the cracking strength of the UHPC between pure shear loading and pure tension loading?	Not enough UHPC specimens were tested in pure shear to obtain a definitive answer for this question, but the two strengths proved to be well correlated.
9	Have you tested any shear key types in your research? Have you considered the Virginia Adjacent Member Connection (VAMC) in your studies?	This was unfortunately outside the scope of the project at UW.
10	Though the seminar is to highlight the UHPC's behavior and strength in shear, please shed some light on its comparative ductility.	Ductility was not studied in the project at UW but observations from testing suggested that ductility is related to fiber content. This parameter is worth studying more in the future.
11	Has a design method for shear been proposed based on the research? Will it be the same as for conventional concrete?	A design method for shear has not been proposed based on the research. This project included the first pure shear UHPC tests of its kind so it was the potentional first step in developing a method.
12	Can shear reinforcing be eliminated if UHPC is used on a case-by-case basis?	No definite conclusion was made about shear reinforcing from this project, but based on the findings we suspect that shear reinforcing can be reduced.
	Cost	
13	What is the cost per cubic yard of your UHPC?	The cost of UHPC varies greatly based on whether it is proprietary or not, the fiber content, and other ingredients used. The UHPC we used was roughly $1500 per cubic yard.
14	Can you list all the suppliers for UHPC? How can you overcome the private sector dictating mix design when they use trade secrets?	LafargeHolcim's UHPC product Ductal® is one of the most well known proprietary mixes. Another commonly used mix is Cor-Tuf UHPC® but there are many other mixes from smaller suppliers. It is hard to say if non-proprietary mixes will ever be as reliable and replicable as those available from the private sector, but with more research we can continue improving non-proprietary mixes over time.

	Questions during Seminar	
15	It would be interesting to see how many times you can bring the sample to the shear stress seen in Crack Localization (then remove the load), before failure would occur at this reduced load. Can you comment on this?	This was not studied in the project, but it would be possible to perform using the UW Panel Element Tester and would tell us a lot about the behavior of UHPC. Perhaps the next study can include it!
16	You mentioned that the Modulus of Elasticity (Ec) is higher for proprietary than non-proprietary mixes. Assuming this is due to material differences, is it possible to isolate these differences and then work toward improving the non-proprietary materials to the proprietary material level?	That definitely is a goal of studying non-proprietary mixes to improve their performance! With more tests, different variables can be isolated.
17	In slide 49, do you think there is enough data to construct a relationship? I believe relating shear strength to tensile strength is advantageous.	I do not think there was enough data from the UW tests to construct a relationship, but it works as a starting place for future studies.
18	Please explain how shear strength as you determine it from plate testing relates to shear strength in a prestressed I-beam?	Prestressing was not taken into account in this study. However, prestressing can be simulated using the UW Panel Element Tester so that could be studied in the future.
19	On slide 52, is the UHPC shear estimation based on the flexural beam test?	Yes, the tensile strength of UHPC was found using the results from the flexural beam tests, assuming plastic behavior.
20	Why use more than 2% fiber if you do not need it in real products such as I-beams, box beams, etc.?	The UW portion of the project did not use more than 2% fibers. The results from UW and the University of Oklahoma showed that increasing beyond 2% fibers is likely not practical or efficient.
21	Can you have design recommendations without considering actual prestressed concrete products?	No design recommendations were developed from the study since many parameters, such as prestressing, were not considered. Additionally, there were not enough results from the study to draw these kinds of conclusions.
22	The University of Michigan and MDOT developed a non-proprietary UHPC mix and deployed it for closure pours of precast deck elements. We noted similar issues on mix sensitivity, notably the silica fume source can affect water demand. See El-Tawil report on UHPC.	Great to hear that you had similar results!! I suspected that silica fume had a large impact on the UHPC since it is so fine.

23	Is any consideration being given to similar shear testing using different fiber sizes (diameters)?	There have been similar panel tests on FRC (fiber-reinforced concrete) at the University of Toronto with varied fiber sizes and materials by Vecchio. This variable was not included in our project.
24	It seems that curing is very influential on shear. How did you cure the panels?	At UW, we used a lime bath to cure all of the specimens. The University of Oklahoma used steam curing, and the other schools in the project may have used other methods of curing as well.
25	Why was 60-day curing used for your tests?	The Structural Engineering Lab at UW was shut down for a period of time due to the pandemic. This prolonged the curing of some of my specimens. In order to keep things consistent, I decided to go with 60-day curing for all specimens.
26	Was the rebar bond/development behavior investigated in the testing?	It was not investigated at UW, but other schools involved in the project looked into this parameter.
27	I would be interested in hearing more about the bond behavior. Can you give the title of the articles where this was discussed?	A couple of resources on bond strength of UHPC are: https://www.fhwa.dot.gov/publications/research/infrastructure/structures/hpc/14089/14089.pdf https://www.extension.iastate.edu/registration/events/UHPCPapers/UHPC_ID88.pdf
28	In Houston, Texas DOT did a repair of corroded steel girder ends using UHPC encasement. The TxDOT presentation is available at: https://static.tti.tamu.edu/conferences/tsc20/presentations/bridges/fan.pdf.	Thank you for sharing this resource!!
29	Your slide for UHPC uses showed casting around a (damaged) steel I-beam with studs for attachment. Is this just an idea, or has it been investigated? I ask since there are minimum element thickness values for shear stud attachment, and most webs are too thin for that.	This was not investigated in our project. Please see the following source for information on a real-life UHPC encasement: https://static.tti.tamu.edu/conferences/tsc20/presentations/bridges/fan.pdf

30	For the rehabilitation application shown on slide 18, how do you form the proposed rehab section and encase with UHPC in the field?	Please see the following source for information on a real-life UHPC encasement: https://static.tti.tamu.edu/conferences/tsc20/presentations/bridges/fan.pdf
31	Since fibers are the most expensive element in UHPC, do you foresee the possibilty that a beam could be cast with different amounts of fiber in different regions of the beam where different stresses are found?	This would be difficult to implement practically. I do think studying fiber content further (percentage, material, shape, size) could help to decrease the total cost of UHPC.
32	How do your research recommendations compare to the existing shear formula in the code (format wise) in compression field theory?	Current shear code provisions were not a focus of this study. Many more shear tests will need to be performed on UHPC to obtain enough data to get to that point.
33	Why not use plastic fiber in the UHPC?	This is definitely an option! Just not one of the variables we chose to focus on in this study.
34	In Michigan, the DOT has found the cost of non-proprietary UHPC to be about $900 per cubic yard.	Thank you for sharing!! This is less expensive than what we estimated for our mix design (~$1500 per cubic yard).
35	What do you expect the crack control design to be for a typical concrete versus UHPC?	This was not within the scope of our project. There have been similar panel tests on FRC (fiber-reinforced concrete) at the University of Toronto with a focus on crack control by Vecchio.