Event ID: 3264063

Event Started: 7/11/2017 12:47:47 PM ET

Ladies and gentlemen, thank you for standing by. Welcome to the FHWA ultra high performance concrete for prefabricated bridge element connections. This is listen only mode. I would like to turn this over to your host, Andy Foden.

Thank you. Welcome to the FHWA series on ultra high performance concrete for prefabricated bridge element connections. I'm Andy Foden with WSP USA. I serve as the national bridge evaluation manager. I will be a moderator for today's session. With me in the background is Tim Luttrell, my cohost with Leidos. Today's webinar is the fifth in a series of webinars that FHWA will be conducting between now and August 2017. The purpose of the webinar is to provide interest for private entities for the uses and benefits and lessons learned.

Before I go any further, I have two administrative items to highlight. First, for those of you calling in, please mute your speakers. If you wish to obtain a certificate for professional development hours, we will provide an opportunity at the end of the webinar to type in your name and email address to a PDH registration pod. We will leave the line open for a few minutes to facilitate the entry of names and email addresses. We will be sure to send out certificates for all of those who request one through this facility.

At this time, we will administer the first audience poll. Would like each of you to select answers to the following two questions. Okay, I will leave that up.

The focus of this webinar titled ultra high performance concrete for prefabricated connections. It is providing an overview of why and how Delaware DOT and Georgia DOT adopted UHPC technology as part of their accelerated bridge construction practice. Information will be provided about why UHPC was chosen for connections and full implementation along with the challenges, lessons learned, and ideas for future direction.

Today's webinar will last 90 minutes. The first 60 minutes are allocated to speakers in the last 30 minutes will be open for questions and answers. If during the presentation you think of a question, type it into the chat area on the left-hand side of the screen. At the end of the presentation, the speakers along with the guest panel will answer as many of the questions in the chat box as time allows. Ultimately, you may also type in questions at the end of the presentation. It will also be available online within a few weeks along with recordings and transcripts. We will notify all attendees when these are available online through email.

Now, turning to today's presentation team, we have three expert presenters on hand. They are Mark Leonard, Mary Benton, and Dexter Whaley. Mark Leonard is a structural engineer on the FHWA resource center structures technical service team. Mark provides technical assistance, training, and review services in the areas of highway structure design, maintenance, preservation and inspection. He began his employment with FHWA in 2012 and has 28 years of experience as a structures engineer for Colorado Department of Transportation, including 12 years as a state bridge engineer. Mark is a registered professional engineer in the state of Colorado and is a graduate of the University of Notre Dame with a Bachelor of Science in Civil Engineering. Mark is also the FHWA EDC UHPC and innovation deployment team leader.

Our second speaker, Barry Benton, is a state bridge engineer for Delaware. Barry has 25 years of experience in the bridge section, most of it managing bridge replacement and rehabilitation projects in Delaware. As a state engineer since 2012, Barry has continually looked for ways to better the process for maintaining the state inventory of bridges. He is actively involved in bringing innovative design, materials and construction methods and procurement processes to improve the quality of bridge projects in Delaware. He and his staff are constantly striving to update bridge details, reduce construction time, manage costs, and reduce future maintenance.

Our other speaker is Dexter Whaley. He's a state bridge design group manager for the Georgia Department of Transportation. Dexter has been with GDOT for 11 years. He has designed many bridges ranging from grade separations across interstate highways to water crossings across Lake Linear. In addition to bridge design, Dexter is responsible for the review of structural supports for traffic signs and signals and implementation of the latest AASHTO specifications for them. I am now going to turn it over to Mark Leonard to begin the presentation.

Thank you, Andy. Thank you everybody for attending the webinar today. I want to say a few words about Every Day Counts. Today's webinar was made possible by FHWA’s Every Day Counts Initiative. As a part of the initiative, FHWA has been keeping track of the use of all ultra high performance concrete for connecting prefabricated bridge elements. In the January 2015, there were 12 transportation agencies that used ultra high performance concrete for connecting prefabricated bridge element. In January 2017, that has gone up to 21 agencies. So over that period of two years, nine additional agencies used ultra high performance concrete to connect prefabricated ridge elements for the first time. In January 2015, in the United States, there were about 49 projects that had been completed that had used ultra high performance concrete for connecting prefabricated bridge elements. In January of this year, there were 95 projects, so almost twice as many projects within a period of two years.

Through our webinars, we have been trying to bring you information from some of these agencies in the country that have used ultra high performance concrete. So taking a look at it, this webinar series has six webinars, and in March, the presentations were just by FHWA, but in

April, we heard from the New York State DOT and the Iowa DOT. In the May webinar, there was a presentation on the Hennepin County Minnesota Franklin Avenue bridge project. Last month, there were presentations on the New York State I-81 project near Syracuse. Today we will hear from the Delaware and Georgia DOTs. I am so pleased that Dexter and Barry could join us today and let us know about how ultra high performance concrete is being used in Delaware and Georgia.

Next month, which will be the last webinar in the series, we will hear about the New Jersey Pulaski Skyway project, which is a very large project that is using ultra high performance concrete in the rehabilitation of the skyway. We are recording these webinars, so if you missed any of the previous webinars, or if you're going to miss the next one, or if you want to read or revisit any information, you can access the recordings by going to this website. The addresses are given there on the slide. Instead of writing it down, you can do an Internet search on FHWA EDC UHPC. Also, on the file share you can see a document that also gives you the links to the information we have available online. With that, I hope you find today's webinar interesting and informative and I will turn it back to Andy so we can get started. Thank you.

Thanks, Mark. For our second group of poll questions, I would like you to tell us about your UHPC experience. As you do that, a couple of quick reminders. Please type your questions in the chat pod so we can answer them at the end of the presentation during the Q and A period. Also, remember to stick around until the end so you can receive the PDH certificate. Let's give it a few more moments. Okay. I'm now going to turn it over to Barry to do his presentation.

Thank you very much, Andy. My name is Barry Benton, I'm the state bridge engineer for the Delaware DOT. I'm here to tell you about the experience that Delaware has had with UHPC. We are a very small state, and there are probably some local agencies and other states that are thinking about using UHPC or starting to use it and we have been at it for a couple of years. It has become part of our regular bridge program. To take you through this, Delaware's secretary of transportation, Jennifer Cohan, has a platform of employing innovation to help better serve our customers. We have support at the highest level to pursue innovative ways to build bridges. Delaware DOT began considering it in 2014. Up to that point we had no expense with UHPC. We went there with Ben Beerman and Ben Graybeal and they got us excited about it. We brought it back and we started implementing it. What I will show you today is the process that we used. We started with some smaller projects. Then we went up and used it in more advanced applications and were successful in implementing it.

In October of 2015, we had a joint workshop with FHWA and DelDOT and we invited the contractors into the conference to tell them what our plan was for accelerated bridge construction and the use of UHPC so they could get on board and learn more about it as well. DelDOT is committed to building quality bridges faster and better. We have more traffic in the northern part

of the state and they're expecting shorter closures and they want a quality bridge. UHPC has turned out to be a huge part of the program. You know we are serious about it because we actually have a logo. So, once you have a logo, I think that makes you official.

A number of locations identified as good candidates for ABC were roads with long detours, ones in which the critical path of the total project was the bridge; if we had interchange work and the bridge was a critical path, we implemented ABC to get the bridges off the critical path. The types of bridges that we identified for using it were mostly precast bridge elements that we want to join together with UHPC. That includes bridge deck replacements, and we have a lot of those from the interstate era—there a lot of bridges with decks that are deteriorated. Adjacent box beam bridges are a common structure for us—some people call them adjacent slabs. But we always get cracking in the cast-in-place deck over, but we found the solution to that with the UHPC. Next beams, that particularly in the northeast, are something that is that is taking, off. It is something basically like a double T beam like you see in garages. Superstructure replacements using modular units, and that would be the steel beams with the precast deck on it. We even have one project where we will do a deck overlay using UHPC, and that is coming up this year and I will highlight that.

DelDOT's first UHPC connection experience was actually without UHPC. It was a bridge 2-195A on Western Railroad Avenue over Isaac Branch in a small town. We came up with the design with all precast, and it was NEXT beams on top of precast abutments. We had a small construction window over the summer. There are a lot of school bus routes that went over the bridge and the detour was significant. We were trying to replace the existing bridge in a period of about two months. This is the detail of what the bridge looks like. The design was being done around 2012. For this type of design, they were calling at that time for UHPC connections between NEXT beams, but we really didn't have any knowledge about UHPC, or very little. It was not a product that was made in the United States at the time. We ended up changing it out and using a grout instead of UHPC mix. We used a high-strength grout thinking that would do the same thing. The beams were all designed individually so we weren't counting on the connection to distribute load but it was something we wanted to join the pieces together.

You can see this from the October 2013 inventory inspection. It ended up being a beautiful bridge. We got it done on time, we were able to construct the abutment, construct the superstructure, and then we put a membrane on top of the NEXT beam and then put a hot mix overlay on top of that. Again this is with grout, without UHPC. What you will see is shortly after we built that and put it into service, we started getting water coming through the joints. We ended up with a heavy water flow, and you can see the picture on the right, and the picture on the left you see the heavy effervescence at the shear joint. Again this bridge that is only two years old and it is looking like it's already in need of some maintenance before we get into serious issues.

Some of the lessons that we learn from this is that high-strength grout is not equivalent to UHPC. Although we did save some money by not using UHPC, we lost that in maintenance. We went back out and milled off the hot mix and put on a nova chip surface, which was a more waterproof surface, to help keep water out of it. It is probably going to be something that we will be chasing throughout the life of the bridge. The surface that we put on there seems to be working better but for sure it will come back. The first use of next beams was a great experience. They went together great and they are wide beams. They had really quick construction. But we knew we needed to find out a little bit more about UHPC and start implementing that into the design.

This brings us to our first real UHPC connection experience. Once again, this was a very small bridge, this was bridge 3-558. It was a low ADT road, it was an adjacent box beam bridge. The reason this was chosen primarily was because, when we went to the Every Day Counts summit in 2014, we had an opportunity to take some of our young designers. That is because that was held in Washington DC, which was very close to our office. And so we took them over for the day, and they got to hear Ben Beerman and Ben Graybeal talk. Our one designer, Scott Walsh, got excited about it. He said hey, I want to try this on my adjacent box beam bridge. We always have problems with cracking, let me see how this goes. The final plans were done—and he got them all done in one day. We put it out to bid within months of the Every Day Counts summit and then it was constructed in fall of 2015.

It was a great opportunity for us to try UHPC in a low-profile job and for a federal contractor to get his hands on it, and for us to see what the results would look like. Here is the detail. This is the type of bridge I'm talking about. It is adjacent box beam. You can see tie rods go across and shear connectors are on here. This whole bridge has a lot of details that we put in to try to stop the cracking, and we still usually get them. What the UHPC detail did, it allowed us to really simplify them. We got rid of the tie rods, we got rid of the shear connectors. All we ended up with was a slightly larger shear key, with some bar reinforcement coming out the side of the beans, and then some UHPC to tie it all together.

One of our concerns was how our pre-casters would be able to do this because they had forms that we didn't know if they would have the bars stick out through the shear key. It ended up that the pre-casters really didn't have a problem. They come up with a solution in which they put in a threaded insert inside the form and then we were able to thread the bars in and have them sticking out. You can see on the right-hand side, there is a picture of the shear key. It is very clean. The bars are alternating from one side to the other so they are not in conflict. They just have to overlap by 4 inches.

Here's a picture of the UHPC being installed. Again, this was a new use of it for us. This was our first use in the state. Our contractor had never used, it and he was trying to put it in the same way

he would normally put grout in. UHPC is a self-leveling mixture. The supplier was required to be onsite, the representative was. He was suggesting strongly that they would go ahead and top form it and use buckets and be able to pour it through the buckets, and that it would flow all the way down. The contractor was still bent on doing it his way because that's the way he had always done, and he was fighting gravity and the flow of the UHPC down the camber of the beam. Meanwhile, the supplier went ahead and started the other joints doing it his way. I think there were nine joints on the bridge and the supplier got seven done in the same time that the contractor got two. I give him some commendation for not giving up.

But we learned lessons from this. First of all, this was the end deck. We put a concrete deck on top and we were working with Ben Beerman and Ben was telling us we didn't need to do concrete deck on it, but since it was our first use, we continue with that. You can see we got no cracking through the deck at all. The UHPC worked beautifully. It was a great first experience for us.

Some of the lessons that we learn from this were first of all, to listen to the UHPC supplier. The contractor, it was his first job and he didn't want to totally give in and listen to them, and the UHPC suppliers, they know what they are doing. They have dealt with this for a long time. The cast-in-place deck was overkill. We are glad we did it but you will see later that we are not going to use that. We did find out that UHPC is expensive. We knew that we would pay a lot early on, and I'll go over numbers, but it's something we're willing to pay for now so that it is able to be incorporated into the program later. The end result though is exactly what we wanted. The box beams were little bit more expensive because of the change in the form, but they worked well.

The next use that we had was with NEXT beams. This project was also already in design so we were able to incorporate it rapidly. This was a similar type of project to the one that we had just done and 2013 that did not use UHPC. Here we used a thin epoxy overlay over top of the NEXT beams. Again it was a low ADT road, and there was a temporary bypass. The speed of construction wasn't necessarily as big of an issue. It was more that we wanted a durable bridge and a maintenance-free bridge for a harsh environment. This bridge was out on the coastal area in tidal wetlands, and during storm events, it would be in the water. We thought it was a good chance to use UHPC to learn more about it (it was a different contractor) and to see how it would go forward.

Here's the detail. This looks similar to the detail that we used on the other bridge, the first one that I talked about without the UHPC. The only difference was the connections were all high performance. You can see this beautiful coastal Delaware here, Prime Hook Beach, that's actually a wildlife refuge. Here are the beams being set. Here are pictures underneath. In the first one of the left, you can see the joint my very simple. You have alternating bars coming out of the NEXT beams, they are headed bars, there's not a lot of our reinforcement in those joints. Then

on the right, you can see the forming that the contractor did. The stuff is more fluid than concrete, and forms need to be watertight. He used a system of support from underneath to make sure he had them watertight. It worked out really well. This contractor did listen to the supplier all throughout. Here's a picture of the UHPC going in the joints and some pictures of it being mixed. You can see the gold fibers. From the price of it originally I thought it was real gold, but it's just steel fibers, and they are very fine. Here they are placing it.

You can see they do the top forming at the end, but they place the bulk of the UHPC with the joint open, and when they get near the top, they put the top form on, and then pour the UHPC and then it is ground off. You see the big concrete block on the right; those were used to hold the top form on, and it helped level the camber differences between the beams. Here is the final surface. From the final surface you can see—this is after it has been ground—the bridges ready to receive the thin epoxy overlay. Final result, once again, a very beautiful bridge out in the setting. The final product was exactly what we wanted.

Some of the lessons that we learned. This is UHPC project number two for us. We listen to the supplier, the contractor did listen to the supplier. We were adamant about that. He made sure that the forms were tight and we had no problems with leakage. The price of UHPC was still expensive. On this particular job, the mixer was too small for the job and it was batch time while they were pouring it. You can see we actually had cold joints in a couple of spots because they had to wait so long for the UHPC to come in and it sets up quickly. The beams had camber differences that we would use of the weights to balance some of those. Again, the end result was exactly what we wanted. We really are setting the stage for a bigger project. We felt like we were ready for the next step, which was for us, the big time. That is this job.

This was our first UHPC connection with precast deck slabs. This was on I-95 northbound over SR-1. These are two extremely high-volume roadways. This was a very visible project. We did a time-lapse video of it. We went to the public and let them know what we were doing to cut the time down. The bridge was done in half the time because it was vital to get this constructed as quickly as we could. What we used was precast slabs, the existing deck was removed. Then we use the PPC overlay on top of that. Again, phased construction done in half the time. It was completed in 32 days. UHPC and precast labs gave us a quality product and cut time drastically. For us, that is a model for future deck replacements.

Here are the details for the bridge. You can see this was not an easy deck to tackle for the first one. It was fairly high skew, and we had a number of different spans. We ended up not removing the joints here, just the configuration of the bridge. We looked at removing joints but we did not. We essentially had four spans and high skew, two phases. Very complex job. The details that we settled on for the precast deck included two types of connections. The one that you will see on the bottom right is a hidden pocket detail. That is for over top of one set of beams where we did

not have slabs joining together, and we ended up using ports that we would pour the UHPC down into, but the pocket was down below the deck. The other one on the left-hand side is actually where two panels meet up. All of our joints were running longitudinally down the bridge were on top of beams. You can see the shear studs in there, and they were kept low enough that they would be below the bar reinforcement coming across the deck. That we could make sure we didn't have any conflict, and with UHPC you can do that. Without it, the shear studs have to be higher into the deck, but with UHPC you're allowed to keep your shear studs low, which helps in the detailing and ease of construction.

Here are pictures of what it looked like with the deck panels on and getting prepared for the UHPC pour. Once again, you can see all the joints are top formed. That is because it does flow downhill. Here's a picture of our mixers. For this one we ended up with larger mixers, there was a lot more quantity. We had problems with one of the mixers going down very early, so one of the things we definitely learned is that you need multiple mixers, and it's a good thing we had them so we could continue with the poor even though one was down so they could get it back running again. Just in pictures showing the preparation. Again you can see the shear studs in here. You can see it would've been difficult to try to detail any type of connection where the shear studs were up and would be in conflict with the reinforcement in the deck, so we were able to keep them low. You can see the angles that the slabs were resting on. There they are placing the slabs. We had to lift with a crane. Because of the joint size you have some play with regard to be up to fit the pieces together.

Here they are pouring the UHPC. This was a larger pour here, so instead of a wheelbarrow you're talking about a buggy that is automated, and they had these troughs they would pour into to get it in. As he got close to the top, they would do the top forming. The final product, after grinding, then you can see the PPC placement over top of it. We did the PPC overlay, and it was thin, only about an inch, but it allowed us to make up for difference between the slabs, any irregularities that they had due to fabrication challenges and things like that. Here's the final product. You can see it's a great looking product. You can see the pictures underneath—one of the joints there with the longitudinal joint on top of the beams.

Some of the lessons that we learn from this were listen to the supplier. That's a common theme. Forms must be tight. UHPC, again, is expensive. Backup mixer is a must. We had tolerances and lead-time issues on the precast, but we were able to work through them. We had some bar conflicts at the joints. There were a lot of bars where the slabs and the joints came in. The leveling screws would help. We had to overlay on this job, and we needed it, but on future jobs we’re going to go to leveling screws so we can go to the precise elevation we need and then maybe just grind and open to traffic.

Those are the three projects that have been completed. We have a couple waiting in the wings right now. This one is another bridge on a high-volume roadway, over a high-volume roadway. This is over US 13 and it will be a complete closure. This bridge is about 600 feet long. We will try to do it in six weeks. It is going to be very similar to the detail that we used on the other bridge—that is precast panels. The difference here is that we will have no overlay riding surface. So we will settle it with leveling screws, pour the UHPC up a little high, and then grind the surface and open to traffic. That one starts in September of this year. Another one we have that is been awarded and will start in August is a total precast bridge. This is a lower volume roadway, but it is our first entirely precast bridge with UHPC. We will have precast abutments on piles using some of the SHRP2 details. Then we will use adjacent box beams, which is similar to the first use. The difference there is that instead of a cast-in-place concrete overlay, we will use UHPC overlay on this. We applied for and received an AID grant from the FHWA to do this. We're excited to see how this comes out. There's the detail of the adjacent box beam. Very similar. Another one that we have coming up, this is SR 141 over I-95. These are two very high-volume roadways. This is a whole interchange replacement, and the bridges were on the critical path, and we put ABC in to get the bridges off the critical path. In this one we will use prefabricated modular superstructure units and we will use UHPC for the connections. We are also using precast piers. This is the type of superstructure that we use. At this point, we are feeling comfortable with our UHPC connections and use on different projects.

There's another one in design right now, this is bridge 1-251. It is a fairly high-volume roadway with a long detour. We will do a deck replacement on this one with very similar details to the first two that you saw. We hope to keep improving them every time with lessons learned. There's the details with the hidden pocket in the open joint over the beams.

I want to get into the numbers and what they have meant for DelDOT. The UHPC cost—we were told to expect somewhere between $5000 and $6000 per cubic yard. We saw quite a bit higher in the first use of it, and we expected that. On bridge 558, the first one, we had $425 per cubic foot, which I think is about $11,000 per cubic yard. It was about half that for the next one on Prime Hook Road, and for the one after that, we were right in the middle. We are settling in around about $300 a cubic foot. We hope those prices continue go down as UHPC becomes more prevalent in our state. We still feel like it is a worthwhile investment because of the benefits that we are getting from it.

Real quick, I had some costs for the prestressed beams. We were worried they would go up a lot, changing the details. We did see some increased cost. It wasn't that significant, and once again, we expect as the pre-casters start adapting to the details those prices will go down. Let's look at the numbers to replace the deck. I compared what we did on the I-95 job, and it cost us quite a bit of money per square foot. It is $140 per square foot on that job. That was not all UHPC that was precast panels, that was working 24 hours a day 7 days a week in a tough environment.

When I compared to a traditional concrete deck replacement without those time constraints and without using precast panels and UHPC, it was around $54 per square foot. So when I look at that and say well, had we done it traditionally, it would only have cost me about $1 million for the deck instead of $2.6 million. So I spent $1.6 million more to get this deck done quickly. But that is more than justified through the user cost. The MOT costs were about $8000 per day, our user cost was about $18,000 per day, for a total of $26,000 every day we were out there—and that was just from taking a lane to do the construction. So we estimate we saved around 94 days versus conventional construction, which is about $2.4 million. So I spent a little more to get it done, but in the end, I did not have those kinds of issues on I-95 in northern Delaware—because when we start closing down lanes, it is total chaos up there. So it was well worth it.

Some of the other things—I talked early on about what we have done in our deployment of UHPC. I talked about the fact that we had an ABC workshop with FHWA, we partnered with them, and Ben Beerman came in. We had some of the neighboring states, Pennsylvania and New York, they came down and actually presented on some of their experiences with it. They brought contractors with them to talk to our contractors and explain their experience with UHPC, and I think that really help to get our contracting community on board. Also, on our first job with UHPC, our materials and research section could not break the cylinders, so they ended up having to spend some money to send them away, so we bought some equipment that we needed that was necessary so we could break the cylinders here. We tried UHPC on test projects before using it on a high profile job. The first couple of jobs we used it on, nobody would have known that we were using it to learn from. So it was valuable to us. It was invaluable for the construction inspectors and for the contractors.

We also hosted a UHPC connections workshop. That was for in-house staff and for consultants and our contractors. We hosted a SHRP2 toolkit workshop. This was for the in-house staff and the consultants and contractors. We continue to use ABC and UHPC on projects where it makes sense. I was just reviewing a set of plans today that came across my desk that had UHPC connecting NEXT beams, and it is a project that has to be done quickly. It is nice, that it has become ingrained into our system now, and we are using it where it makes sense. We continue to improve the details. Every project that we do, we are trying to learn from it and see what we can do to further advance it within our state. One thing that is really important, we are always seeking more training for our designers, contractors, and inspectors. And we would like to share with other states, too. As we learn, we want to share with everybody else. We like to learn from other folks, too.

That was the end of my presentation. I would say one more thing with regard to UHPC: we do have a special provision that is a generic spec that we use, that we put into our projects, and we are in the process of incorporating that into our standard specs. It will not make it in this year, but I'm hopeful that it will make it in the following year. With that, that is what I have.

Thank you very much, Barry. I want to remind everyone if you have questions you can post those on the left side of your screen in the chat pod. We will have a Q&A after the next presentation. With that, I would like to bring on Dexter Whaley from Georgia DOT.

Thank you, Andy, Ben. My name is Dexter Whaley, I'm with the Georgia Department of Transportation in the bridge office. This is our first UHPC project that I will talk to you about. It was state Route 211 over Beech Creek. To give you an idea, it is – our main office in Atlanta– it is about an hour northeast. The overview, this was an existing bridge that was about 50 years old and it had a sufficiency rating of about 50. We replaced it with a single span bridge and we made it 40 foot gutter to gutter. We wanted to use UHPC for the joint connections. The other thing is that we wanted to use full depth precast deck panels. We also wanted to only have a 60 day road closure. In Georgia, a road closure of 60 days for bridge replacement is unheard of. This was going to be a big experiment for us. Here's a picture of the original road. You can see there that it is on regular H piles. The bridge was posted, and again the bridge was over 50 years old, it was out of date and wore out. The bridge carries about 3500 cars a day. When it was initially let, the contractor was able to go out and clear and grub the right-of-way. He installed a work bridge. So, the actual closure of the bridge took place on June 1, even though he was already out there working on site for a month or so beforehand. The actual demolition took about four days to complete.

You'll notice that in this presentation, we are really concerned about the 60 days and the use of the UHPC, trying to make sure it works and will allow us to shorten our bridge construction time. Again, here is a picture of the end vents, and them driving piles. We used 3500 psi 24-hour accelerated concrete. To put both ends in place and it took them seven days. These days again our normal 8-10 hour working days; no 24-hour workdays, even though that’s what we wanted them to do. They chose to work just a normal workday. Our beams were 72 inch bulb tees. One of the shortcuts or we allowed them to use was steel diaphragms. They made those off-site and brought them in and bolted them in place and they were good to go. Once the beams in the diaphragms were put in, they were ready to start doing the formwork to prepare to set the panels. As you see here, it took two days.

Here's a picture of the full depth panels. They were precast off-site using 4500 psi concrete. They were approximately 8-3/4 inches deep, and we used number five reinforcing bars, both transverse and longitudinal, on 6-inch spacing to make it easier for the fabricator to be consistent in their formwork. Depending on the size of the panel, this may be overkill as far as the spacing. You could probably spread it out a little bit, but we would like to make this panel in the future a standard panel so we can use this panel and it is the same rebar spacing throughout. In this case, our panels, depending on where they were located, were 8-feet wide by 20-1/2 feet long. Here's the typical joint. This is a transverse joint. This went transverse to the bridge. We kept a small

opening on the top with a 2 inch opening there. This allowed us to have a 5 inch bar lap for our longitudinal reinforcing. The reason we can only needed 5 inch lap is because of the UHPC. The UHPC allows us to use number five bar to reach the development within 5 inches. That is a good benefit of why we would use UHPC: it creates a smaller joint and allows you to use a short development length for the bars.

A shear connection is similar to the transverse joint. We had a number five bar coming out of the top of the beam. Normally our stirrups would come out of the top of our beam and we'd bend them and pull them over into our deck for our shear connections. Here, we took a number five bar and we put a loop in it, and we only needed to have 4 inches of the bar going into the UHPC. The total haunch area there was all filled with UHPC. We had to have a minimum depth of 2 inches on either of the flange sides.

Here we are replacing the panels. You can see this is similar to what Barry was showing. We have the crane come in, and they lifted the panels up and set them in place. You can see in the picture we have the lifting rings and we actually have leveling bolts. Leveling bolts allowed us to set the panels and get it to the cross slope that we wanted with a normal crown of 2%. It was very easy for us to set the panels and they were stable once we let them from the crane. The panels themselves, because they were stored on-site, they could take the crane, pick one up and bring it back in about 20 minutes. It took two days to set the panels. We had 34 panels total that we set here on this bridge.

Here's our mixers that we used. This is similar to what Barry was showing. We had two mixers on site, and this allowed us to have a continuous poor. It takes about 30 minutes to mix a batch of UHPC to be poured. So with the two mixers we were able to get a batch out every 15 minutes. We had the Lafarge personnel on site and they did the testing. They were on hand to give us pointers—they told us what we needed to do better, what we didn't need. It was good to have them on site to answer questions. It took us two days to actually pour the UHPC.

This is showing the components of the UHPC. There was one back of the ductile cement mix. It was a bulk bag that you see in the top. Then we had full bags of the steel fibers. The fibers here are brass coated, that's why they look gold here. They are very sharp so you would need to be very careful when you're dealing with these fibers. The safety gear requirement is Tyvek suits, respirators, and gloves. Gloves really don't help too much with the steel fibers, but as you can see, one of the guys chose not to wear their Tyvek suit, but they did have respirators in one had a dust mask on. I would prefer that they wear respirators, but that was up to the contractor and his employees out there. Also, you have the plasticizer that is a Lafarge product. You put water and ice into your mix there. The water and the plasticizer all have to be weighed out precisely. It is not "add 5 gallons of water and call it a day." We had to add to the mix, you had to have 130 pounds of water at that need to be weighed out precisely. We had a digital scale on-site and they

weighed it out and put the water into the mix. On this particular day, this was the first of July, we were having a 90 degree day there, so when we first started mixing it up we were putting about 90% ice into the mix with just a little bit of water. The mix itself generates heat, and it melted the ice, so we were good to go on that. One comment: as well as to have multiple mixers, you should have a backup digital scale when you're adding these mixes, because if your scale goes down, you can't measure precisely, and that can create a problem for you. This is actually how the Lafarge people—they were doing the testing for us—they made our cylinders and they were responsible for getting the cylinders broke. Our lab cannot break the UHPC cylinders because UHPC cylinders, their minimum strength is 21 psi for the break, and our lab could not break those. The Lafarge personnel would test each batch that came out and they would give us the okay on whether we could pour or not. This picture shows them setting up the slump test. This is a 3 inch cone, and they measured it to see what kind of flow it has. On that disc—that's a 10 inch disk—so when they do the test, they want the UHPC to stay on the disk between 9 and 10 inches. If it runs off, it is to loose and the batch is wasted.

Here we are replacing the UHPC. Originally we had a trough made to go into the joint but our joint being only 2 inches wide, the UHPC didn't want to flow into it as well. So we were using a crane and bucket. Actually when they turned the bucket over into the joint, they could open up the bucket and it would fall right into the joint pretty nicely. Then we ended up finishing up on the right-hand side. That was a night; because of the heat we decide to pour at night. That was the second side of the bridge.

In order to ensure you have good closure on the joints, you need to—when you're doing the form work—you need to have a little over pour on your joints so you have some area for air bubbles to go into and you can grind any excess off. In order to maintain pressure, we used buckets and maintained head pressure. So as you fill up a joint, you would cover it up with plywood, so have a hole and then fill the bucket out, and that would gradually drain down and fill in the joints. You'd watch your buckets and you kept them full, and then when the joint was filled, the UHPC would actually start flowing back into the bucket. Then you know you can move the bucket and move further down the joint.

The form works like we used here need to be watertight. Our contractor chose to use wood here, and he was able to build a platform on the beams for a nice walkway. He used 2 x 6 Tapcon into the flange of the beam and plywood to make his formwork. We wanted them to think about other alternatives, so they were suggesting maybe we would use steel next time. That way we could leave it in place possibly. The formwork putting it up and taking it down took us eight days, so trying to do a project in a limited window, eight days is a lot of time to spend on just putting up wood and taking it back down.

Here we have removed our formwork from the UHPC pour and they're forming up the end walls. They have the end walls going and they are starting to backfill for the approach slabs. All of this is some of the finishing work. This part of the project took nine days to do both ends. Our finishing touches for the project was, we ended up paved over the connective paving. We ground the bridge and then we grooved the bridge. Then we did the final grading on each side, and then we did the striping, and this took about three days.

Overall, we completed this bridge and 59 days which for us was great. It took us 59 days, that's two months, and otherwise it would've taken nine months to do. We would've had to have a detour bridge on site or the detour in this case, it would be off-site, going 60 days. So the neighbors and the people in the area were very happy about this. We chose not to put an overlay on the bridge. We left it open. Looking at the picture you can tell that this bridge pretty much looks just like any other normal cast-in-place deck. This bridge open almost a year now. We have been out there several times and there is no cracking or leaking, all the joints are nice and tight. We are very pleased with how this bridge has turned out.

Some advantages of UHPC… It allowed us to use precast components. In this case we used full depth precast deck panels. We wanted to use precast indents. This will allow you to use precast components and put this together like Legos. It allows you to have stronger connections. They gave us shorter developments on the rebar and allowed us to have smaller joints, which is what you want to try to avoid.

Our lessons learned: You need experience using UHPC. You need to read up about it, and have your contractor be willing to listen to the supplier. You need to have someone with experience on site. We also learned for our transvers joints that we need to have a larger joint opening at the top. We were trying to contain it to make it as small as possible, but 2 inches was too small, so we modified that connection and now we are allowing them to have a 6-inch opening. It takes a little more grout, but it allows us to go faster and poor quicker.

The cost versus benefit: The cost for our UHPC was about $2500 per cubic yard. This included renting the equipment, the mixers, material itself, and having the Lafarge people on site. The benefit is for us, we had a bridge open in 59 days. The public was happy with it. It was good PR for the department, and so cost versus benefit, for a normal bridge, this would have cost us 90-$100 per square foot. With the use of UHPC, it probably cost us maybe $130-$140 per square foot. The cost was about $200,000 more using the UHPC.

Our tolerances—our fabricator for our panels—was not very accurate on how they measured the panels. They didn't test them or check for squareness. So the panels were a little off, but because we had the joints, we were able to work that out. Overall, it says here we would like to have a 30 day road closure. For us on this project, it took us 42 days of actual bridgework. There were

other drainage and other stuff like that on the project as well, but actual bridgework was 42 days. We think we can do a bridge in 30 days.

Future projects: We're going to go full steam with UHPC. We probably have four projects in design now. We have two projects that are full depth precast panels that we will use. We have another project that is a deck bulb tee. We are going to have precast deck beams on the site and it will be set up at the correct elevation equal to what is projected. We will put the deck on the beams out there in the field. Then we will leave a joint there and then we will set the beam on the deck onto the final bend. They will use UHPC to close the longitudinal joints and that will be our next project that we will have coming up soon I believe. Here's my contact information. I will try to answer any questions that you have. And you can contact me here. That wraps me up. Back to you, Andy.

Thank you very much, Dexter. We will now have an additional poll before getting into the Q&A. The poll will help us understand the type of guidance that you need on UHPC connection and implementation and how this webinar today may help you overcome those challenges.

I am now going to kickoff the Q&A session. The questions during today's sessions will be answered by the presenters, Mark Leonard, Barry Benton, and Dexter Whaley. You will also be joined by additional panelist, Dr. Ben Graybeal. A few words about Ben. Ben Graybeal is the team leader for the bridge engineering research and FHWA office of it structure research and a prolific researchers and research program managers. He has a wealth of experience in UHPC having been a leader in the UHPC community since FHWA began research on the topic back in 2001. I will leave the poll up while we do our Q&A.

Our first question was from Paul and it had to do with slide 42 from Barry's presentation. What about UHPC allows for such low shear studs? Where is guidance that permits low shear studs to be found? I will ask Ben Graybeal to respond to that question.

Sure, so the guidance on the shorter shear studs comes out of research that we conducted, but the actual guidance is listed in the technote which is found in the download pod. This is federal highway publication HRT-14-084. It tells you about design and construction of the UHPC connection. What you are talking about in the question there is the connection between the deck panel and the supporting girders. UHPC can carry a significant amount of tensile strength, or tensile stress, and also shear stress. There is a way to design that connection between the deck panels and the supporting girders so that the studs are shorter and that eliminates the conflict when you're setting down the panels. We probably don't have 10 minutes to describe the details right now but I think that is a good start.

Thank you, Ben. The next question is from Ohio DOT. With the overlay, how will you deal with the mix being so fluid? Will you get a good riding surface? Go screaming blue chickens. Barry can you respond?

Yeah, I would like to address the Ohio DOT and Mr. Tim Keller for his shot at my alma mater, the University of Delaware. They are the fighting blue hens, Tim, not the screaming blue chickens. It's a good thing he can't talk right now because I'm going to make fun of the buckeyes. Your guy is a nut. So, with that, I have Jason Hastings who is my bridge design engineer with me, and I'm going to ask Jason to go ahead and address those questions. It was a concern.

Yes, so we worked with the UHPC provider, and they are coming up with a slightly different mix so it is not quite as fluid as the normal UHPC that is used for joints.

We are also doing a test pour on it. Because we have a 4% slope, and the supplier was not concerned with having to do it on a 4 % superelevation, but we are trying to do a test poor to see if we can work that out before going on the bridge.

Ben, do you have anything to add?

From a materials template, what is done is the UHPC supplier would do something like add a thickening agent so the UHPC—although it has a similar mix design—it wouldn't flow and be self-leveling under its own weight. Basically it would only flow when vibrated. It becomes a fix and drop it grout.

Our next question is from Glenn. Slide 56, from Barry's presentation, where lifecycle cost considered.

Barry?

For that, we did not consider lifecycle cost because we considered the precast deck and the cast-in-place decks have the same service life. We did not consider that when evaluating and comparing the two types of decks.

Okay. Our next question from the New Jersey Department of Transportation. For the NEXT beam superstructure, are there provisions for future deck replacement or partial deck replacement if needed. Barry?

We do not have provisions for a deck replacement. The deck is the integral part of the beam. We do take measures to make sure that we're not going to have infiltration of chlorides into it

whether it is putting a thin epoxy overlay on it or protecting it with in overlay of some sort, plus we use very impermeable concrete or low permeability concrete itself. If we ever got a serious concern with the deck portion of the next beam, it would be an entire superstructure replacement.

Thank you. Our next question is from Kyle. For the overlay, do you have to pay closer attention to environmental conditions, for example, evaporation rate? Barry, do you want to address that one?

I was going to boot that one to Ben. [Laughter]

I'll be happy to give it a stab. So, with UHPC, the idea is usually to keep the water in that you put in when you were mix it, so you don't want to let the water evaporate out. As was described when Dexter was talking, it's important to put the right amount of water in. You don't want too much or too little. In an overlay, you have a very large surface area, so you could have a lot of water evaporating out. You do have to pay close attention. Often what is done, is some sort of curing agent sealer is sprayed on the UHPC after it has been leveled. That is followed up with plastic that is laid down on top of the UHPC until enough of the curing has happened that the UHPC has gained significant mechanical properties. The plastic has to stay there and it has to be held in place so it doesn't blow away. It would stop the evaporation and it might stay there for a couple of days.

Right, and we have seen that on the overlay that was done in Iowa. Our next question is for Dexter. Were there any issues with the bottom lip on the panels of the joint getting chipped or broken during erection and transportation?

Actually, when they first were casting these at the plant, they use plywood form works, and when they tried to remove the plywood, they were breaking off the bottom lips. So we went out and looked at them and they suggested they would use Styrofoam formwork. At that point they were able to use Styrofoam, spray it off with a pressure washer, and we didn't have an issue with the lips breaking. Even when they were transporting them to the site and setting them and stacking them out there in the yard, they didn't break. If they did break, the purpose of them was to use as form works, so if they did happen to break, they would use more UHPC to close in the area. It wasn't really an issue if they did break. But we didn't have an issue using the Styrofoam as a formwork.

Okay. Our next question is from Paul. This is for Dexter. On slide 66, how did the longitudinal joint compare; i.e., how did the longitudinal joint detail compared to the transverse detail.

For the transverse detail, we were trying to keep the joint opening as small as possible. So we went with the 2 inch opening in the top, but the interior of the joint was actually 6 inches to

allow a 5 inch lap of rebar. For the longitudinal joint, we had a 6-inch opening on top of that and we still had a 5 inch overlap on the bars going across. So we were thinking that the longitudinal joint wouldn't be an issue riding on it, whereas with the transfers joint you might get maybe a bump or road noise going over it. But it didn't really happen. Once we ground the bridge and said it was smooth, you don't hear it or see the joint. But as I mentioned, in the future, we will allow that transverse joint detail to stay the same except for the top lip, which will be opened up to 6 inches as well.

Thank you, Dexter. Our next question is from Frederick. Do you need to grind the UHPC joint if you have an asphalt overlay. Barry, I will let you provide input.

For us, we would say yes. If you have any kind of unevenness, it will probably show through your asphalt over time. For us, I would say if I were to use asphalt overlay, I would definitely grind it.

Ben, do you have anything else to add?

Sometimes with UHPC you end up with a very weak almost a sort of bubbly surface right underneath the formwork for the connection. If you have that, you would want to take that away. That wouldn't be a good surface or a good thing to embed within the bridge under the asphalt.

Thanks. Okay. Our next question is from Kyle. How do you address changes that are suggested by the UHPC supplier during construction? And we will throw that to Dexter first.

In our case, our contractor had not ever seen UHPC. He didn't want anything to do with it, but we required him to use it. When the people from Lafarge came out and talk to him, he had to do a lot of changing and so, if there was an issue, I couldn't tell the contractor—because this was a means and method—I couldn't tell him how to pour his UHPC. The person he hired to tell him how to do it, I would talk to him and the supplier, the Lafarge person, would talk to the contractor and convince him that this is the way we've been do it, and this is the way you should do it to make it easier on yourselves. That is how we approached it. I can stop them, but I can't tell them you need to do it this way. I can't tell them how to do; but I can keep them from doing it, but I can't tell them how. So I left it up to the Lafarge personnel on our case.

I would like to add to that. As an example from the Pulaski Skyway, which we will talk about in our next webinar. In that case the contractor had insisted that he wanted to pump the UHPC into place and that was his means and method. The supplier suggested against it and the owner suggested against it, the designer suggested against it, but the contractor was insistent on it. That's the way he wants to do it. He had moderate success doing it and eventually found out it was easier to do it the way the material supplier had suggested. But it is very difficult to tell

someone they can't do it unless it is specifically mentioned in the specifications or prohibited. Barry, do you have anything else to add?

No, we are similar. For us, we rely on the supplier to make recommendations.

Okay. Our next question is for Dexter. This is from Michael. Dexter, are you speaking of beams and deck precast together?

No, when I mentioned the deck beams, they were not precast together. It was precast beams, and they will be set at elevation in the field. Then the deck would be placed and cast in place as normal deck. Then with the joint blocked out so they can separate each beam with a deck attached to the beam and they could set that into place. So it is not a precast deck and beam, is just a precast beam with a cast in place deck on top. I think that's what he is asking about.

Hopefully, we have answered your question, Michael. If not, please feel free to retype it into the chat pod. Our next question is from Eric. Is there an example of the design of the UHPC joint available? I will have Mark respond.

Yes, Eric, the FHWA guidelines for the design and construction of these ultra high performance concrete connections is given by the October 2014 technote. You will find that publication in the file share pod. It is not on the screen right now but we can bring it up later. If you get a hold of that on the FHWA website, again we referred to that earlier when we were talking about shear studs. To your question, yes there are examples of the connection concept in that tech note. But more importantly in the technote is the design information, the information for design the splices and the development links you need to make those connections. Right now, we are looking at updating that technote between now and sometime next year. We hope to update the examples and information that is in there.

I brought that file share pod back up on everyone's screen, so you should be able to see that pod where you can download the document that Mark was talking about.

Our next question is from Phil. What was the timing of the Georgia project versus the Delaware project? Is the big difference in cost is due to location or timing? DelDOT cost was about $300 per cubic foot versus Georgia's cost of 100 per cubic foot. Barry, your response?

I don't think it was timing. I think it is location. I was checking out Dexter's square foot cost for his bridge and I was wishing we had that. He referenced $90 to $100 per square foot for his bridge, and we were between 20 and $50-$300 per square foot. I think we tend to have higher cost in this area in the northeast. The cost tend to be higher than in the south. So it’s location probably more than timing.

Yes, I agree with that. The $100 per square foot is normal for the standard bridge. For the UHPC bridge, it was about $140 a square foot. For us, a factor is that we didn't have around-the-clock work. Our guys were working in normal schedule, so we didn't have extra labor costs in our project. We didn't get the accelerated bridge construction around-the-clock technique that we wanted them to use. That would keep the cost lower, as well.

This is Mark. I will add to that as well. We've been doing these workshops, ultra high performance concrete workshops across the country, and we're hearing about states and the cost that they are getting on the projects, and we noticed that there is a wide variation of cost between states and even between projects. One thing that I keep in mind about these costs is it is not just the cost of the material you're seeing there, of course; the cost that one particular state gets is depending on what they are including in the work for the pay item for the UHPC. Also, with these jobs where it is a first project in the state, the cost are reflecting the contractor's risk and potentially unfamiliarity with the material. Just from what we have seen in Delaware, in the difference between projects, was strongly different prices.

I would like to add a little bit as well. One factor that I see is huge as a contributor to unit cost is the volume of material. Your cost per mobilization, in getting the mixers on site and training and all the fixed costs regardless of the volume that you're going to have, regardless of whether you doing 2 cubic yards or 200 cubic yards. The smaller the job, the more your cost will be. The risk is a big factor for newer projects. If you're doing it for the first in the state, the contractors want to protect themselves against the risk and they will build that into cost. If you're doing it on a schedule where you have penalties and disincentives for not being done on schedule, there's a risk associated with that. Again the contractor will build that into his schedule, or if there are 24 hour crews. Finally, as Barry mentioned, location, being from New Jersey, we have one of the highest costs per square foot of bridges regardless of whether it is a traditional bridge or a UHPC precast bridge.

Our next question is for Mark. What should the capacity of the balance be?

I didn't understand what your question was. If you would retype that into the chat pod, we will bring that up again. And see if we can answer your question. You asked what the capacity of the balance should be. I don't know what that means. So if you could retype the question, we will try to answer that. Thank you.

Our next question is from Stephen. How difficult is it to find a UHPC provider? Are guidelines and materials available for contractors to perform independently to bring costs down, allowing contractors to become experts in the methods rather than relying on expert provider oversight of less experienced contractors? I will defer the question to Ben.

Is Ben still with us? Are you muted?

Here I am. So how difficult is it to find the UHPC provider? There is one large supplier that has a commercially available UHPC, and the next question we will get to will ask about Lafarge. Lafarge is that supplier. They have done most of the projects in the US that use UHPC for the connections. They are not the only supplier out there. There are other companies that have similar products, they are just not as large and as prevalent. Then there are nonproprietary mixes that have been developed. What we are talking about here is a concrete mix design, and you can develop mix designs, you can look at the literature, you can develop the things that UHPC class material will do. Now that material has to be robust enough to work in your application, so just having your local university develop a mix design doesn't mean that can be directly transferred to your contractor on your site and have them have success. The mix design does have to be robust. In terms of how this happens in a project, if the state writes a performance spec, and they say we want to use deck panels and the connections for the panels should have these properties, that can effectively be a performance spec and then the contractor can come back and propose a propriety or nonproprietary material. There are contractors now that are developing UHPC-class materials so that they can be a prime or a sub on a project and propose their own UHPC. That certainly can be done, but obviously there is effort involved. It is not just a "spend an afternoon with your local concrete guy and have him whip something up." There is effort.

Yeah, I will add to that as well. From doing different workshops with the states, from Michigan, I spent quite a bit of time and effort developing nonproprietary mix designs. As well as South Carolina, but South Carolina had a project where they had Clemson University developing a nonproprietary mix, and they put that in there spec. Alongside of the proprietary product, and they told the contractor that you can bid using either the nonproprietary mix design from Clemson or you can use the proprietary mix, and every single contractor bid on it with the proprietary mix. This goes back to the risk. They are taking the risk, the unknowns, out of the mix design, and who is going to be responsible if there is an issue with the mix design developed by the University. That is something to think about.

We have answered I think the other question in regard to the manufacturers other than Lafarge already. I don't see any other questions in the chat pod. If anyone has any last minute questions, we have just a few more minutes.

Okay, I will put our final poll question up. The chat pod is still open if you have a last-minute question. We will conclude today's webinar with a reminder regarding the next webinar. Pulaski skyways from an owner's perspective. We have an exciting lineup from New Jersey DOT and the project manager and also the resident engineer to talk about the largest UHPC prefabricated bridge element project in North America and the lessons learned from that project. Also, I want to put a slide up with additional information from Every Day Counts and where you can get

additional information. I also want to remind you the recording of this webinar will be available on the FHWA UHPC website. Are there any additional questions that came in?

Nelson was asking could they get a copy of the list of barriers and challenges. I am thinking that with the recording, you should be able to get the answers to the chat pod or I should say our polling questions but I have to check that. I'm not certain. Right now, I'm thinking that if you come in later after we have this webinar recording posted, you should be able to see the answers to those polling questions. However, I do have to verify that. I see somebody else, Larry, is typing in something.

While he is typing the question, I will go through some additional resources available. I thought we had a slide with UHPC contacts. There it is. If everybody is finished with the poll, I will open up the final pod, which is PDH registration, so please provide your full name and email address in the chat pod and we will make sure that everybody gets a PDH certificate for attendance. That concludes the formal portion of today's webinar. Thank you for attending. The PDH registration window will be open for a few minutes. Type your name and email address and we will get to the PDH. Once you're done providing that information, you may disconnect. Thank you very much for attending. Thank you very much for the speakers and panelists for your participation.

Thank you, Andy. Good job. We have another question here saying, can you put the downloads pod backup and again, what I will do is direct you to the recordings of the webinar and it will take us a week or two to get the recording up but in the recording, all the pods will be available to you including the download pod. There's a possibility that Andy could bring up the download pod or I guess the correct name is the file share pod before we go today.

I just noticed there are a few people that put their names and emails in the chat pod. For the PDH registration, you need to put that into the other PDH registration pod. That's the big pod in the center of your screen. Put your name and email in that chat pod, make sure you put it in the PDH registration.

With that, we can conclude the webinar and we will leave the registration screen up. We can say goodbye for now.

Yes, that is it. Thank you very much and have a great day.

[Event concluded]