UDOT Keeping Utah Moving

UDOT's Experience with UHPC

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Presentation Outline

- Project Overview
- Design Phase Decisions
- Lessons Learned
  - Owner Perspective
  - Contractor Perspective

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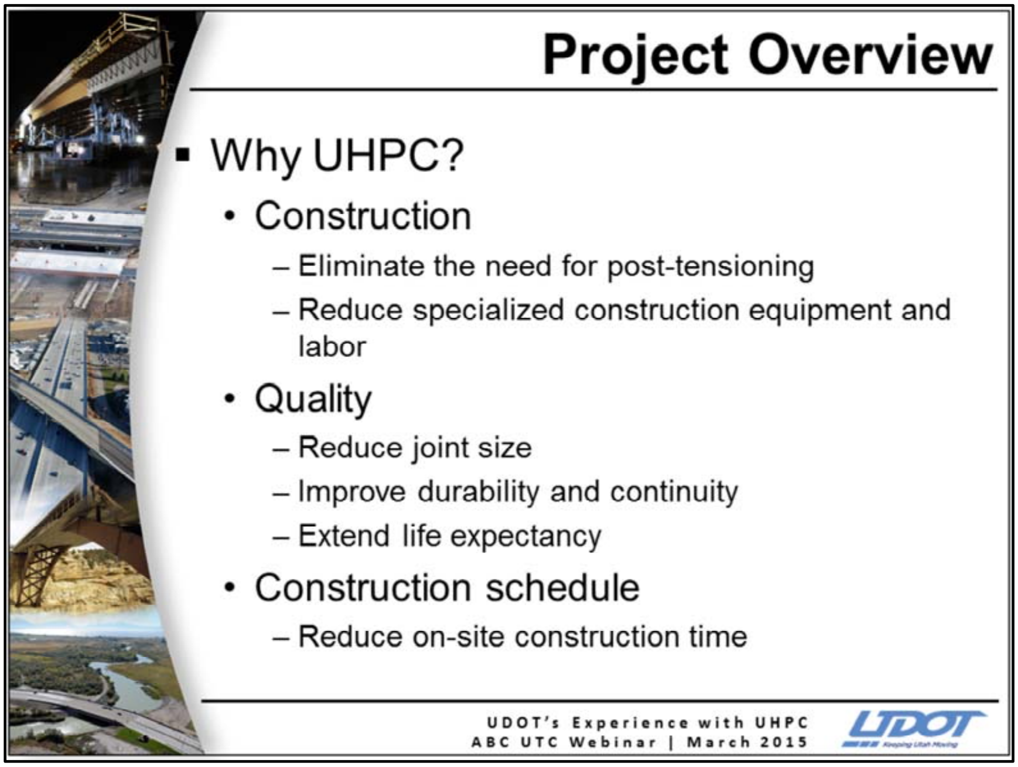
The project included the replacement of structurally deficient deck for a bridge that carries US-6 over the D&RGW railroad. The existing bridge consisted of a three-span configuration (65' – 110'- 55') with a cast-in-place concrete deck and steel girder superstructure. The bridge carries one median lane and two thru-traffic lanes. The bridge was originally contructed in 1978.

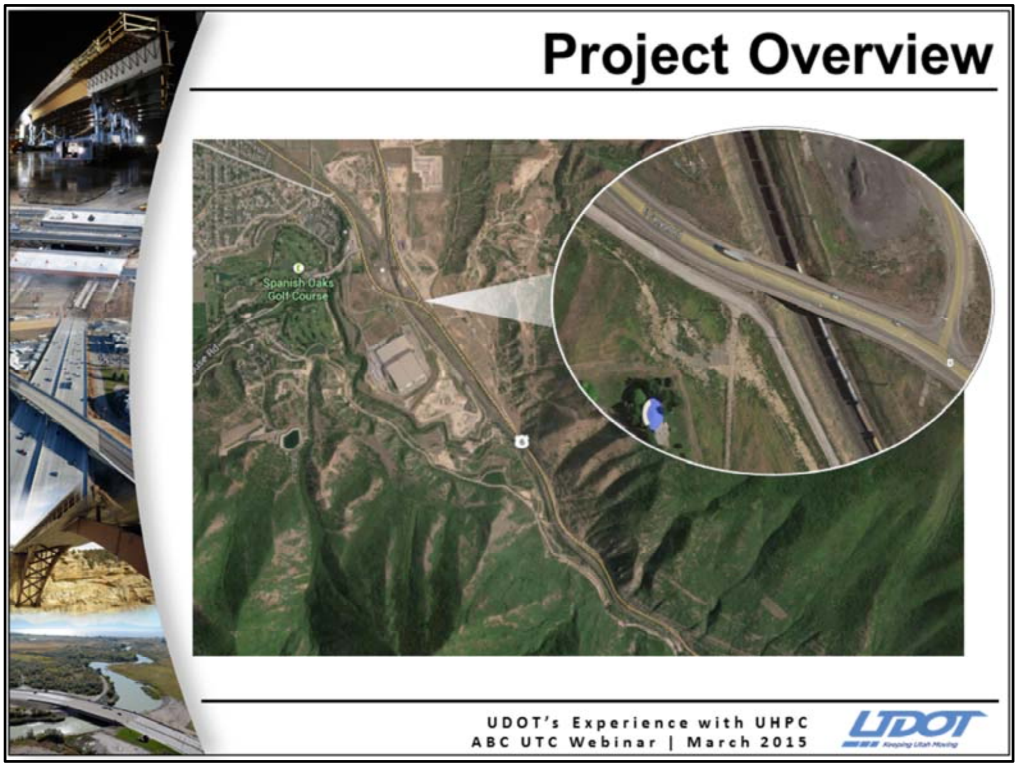


Conventional Post tensioning challenging with geometrics (skew/super-elevation) and traffic impacts.

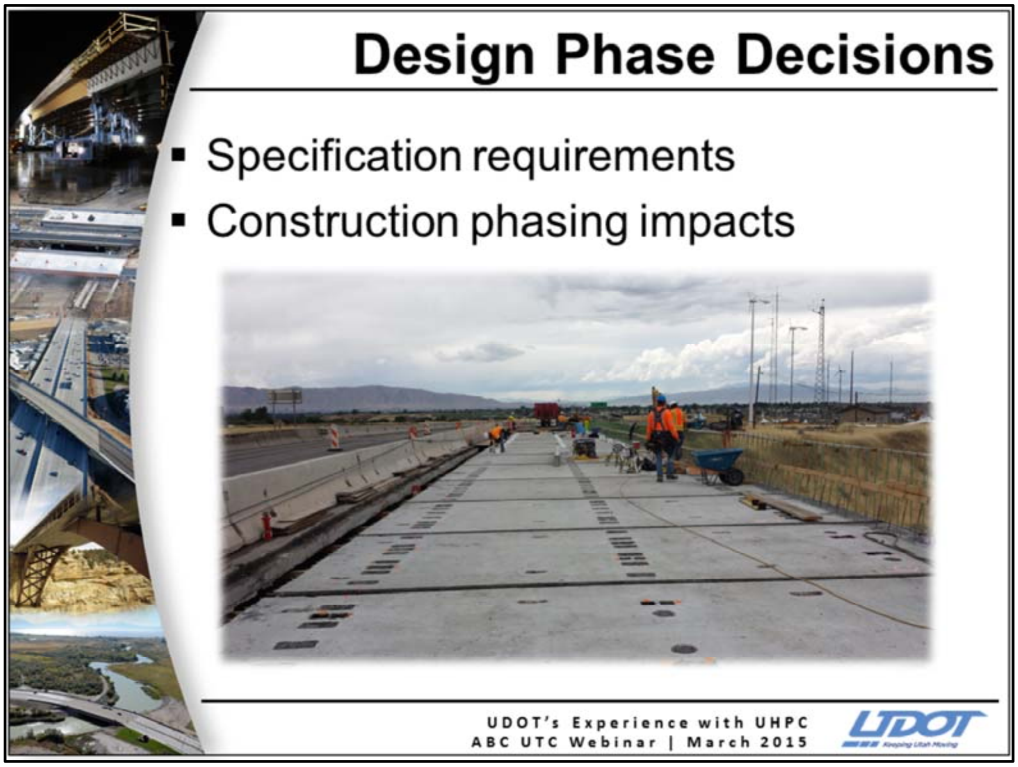
The deck replacement for this 3-span bridge consisted of:

- New Full-Depth Precast Panels for the deck and approach slabs
- CIP Parapets
- Field Cast Transverse and Longitudinal Joints using UHPC
- Use of UHPC for the girder haunches and shear stud blockouts
- Approximately 70 cy of UHPC

There were design challenges resulting from the bridge having a skew of approximately 46 degrees and having a reverse super-elevation due to its location at the intersection of two reverse horizontal curves.

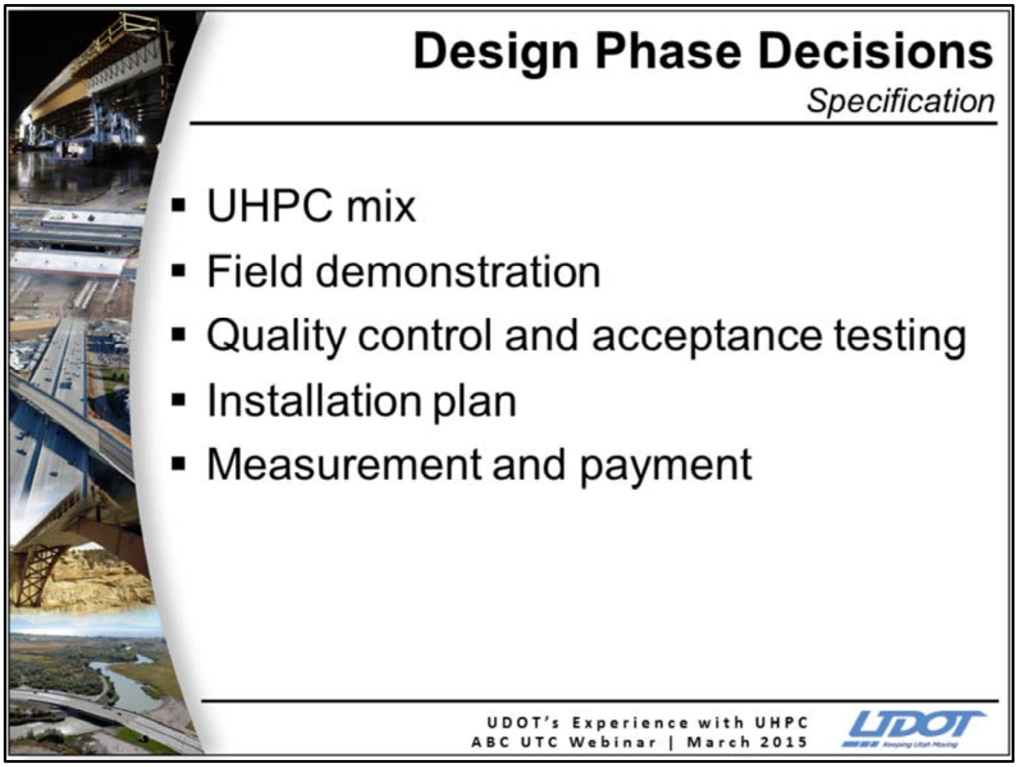


Not only is bridge over the railroad, but it is located at the mouth of Spanish Fork Canyon. The bridge provides connectivity to I-15 for recreational vehicles, commuters, and commerce. Some of the challenges with construction in this area can be attributed to the high winds coming out of the canyon (winds such that there is a wind farm located across the road).



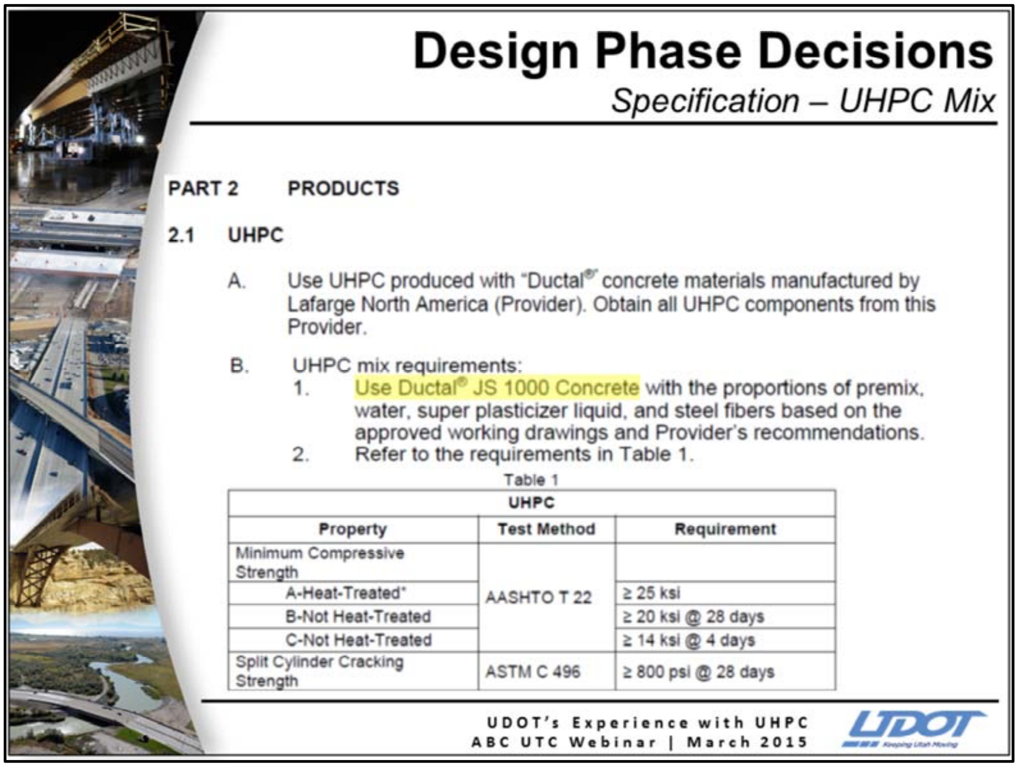
Focus will be on some of the decisions we needed to make during the design phase with respect to:

- Defining the specification requirements of the UHPC
- Determining the impacts of the phased construction since the bridge had to remain open to traffic at all times



Several questions we needed to answer with respect to the specification:

- How did we want to specify the material requirements for the UHPC?
- Did we want to add the extra time and costs associated with a field demonstration before in-place production? Would it be beneficial?
- What criteria should we use for QC and acceptance testing?
- What submittals did we want specific to the product?
- How were we going to measure and pay for the UHPC (cy, linear ft, other)?



First off, we needed to make a determination on the requirements of the UHPC mix itself

- Performance Based or Prescriptive
- Since our state had no experience with batching, producing, or testing the UHPC, we opted to go prescriptive

However, in addition to specifying the manufacturer and explicit mix, we did specify properties that the UHPC needed to meet and a requirement to provide test results to confirm compliance. Although there is some redundancy in this approach, we wanted to establish a basis for future projects, so we would have all the testing data available.

Secondly, we needed to make a determination on how we would handle quality control and acceptance during production and placement on-site

- Required the contractor submit QC procedures
- Established minimum sampling and testing requirements
- Provided an allowance for verification testing at our discretion

Ultimately, we decided to require a field demo. (Photos above were taken during the field demo.) We wanted for all parties involved in the various aspects of the work to have an opportunity to work with the material in advance of actually placing on the structure. We saw this as providing benefits to both quality and safety by allowing for everyone to get familiar with the process without traffic or time restrictions. The intent was to have this be as realistic as possible to the actual placement.

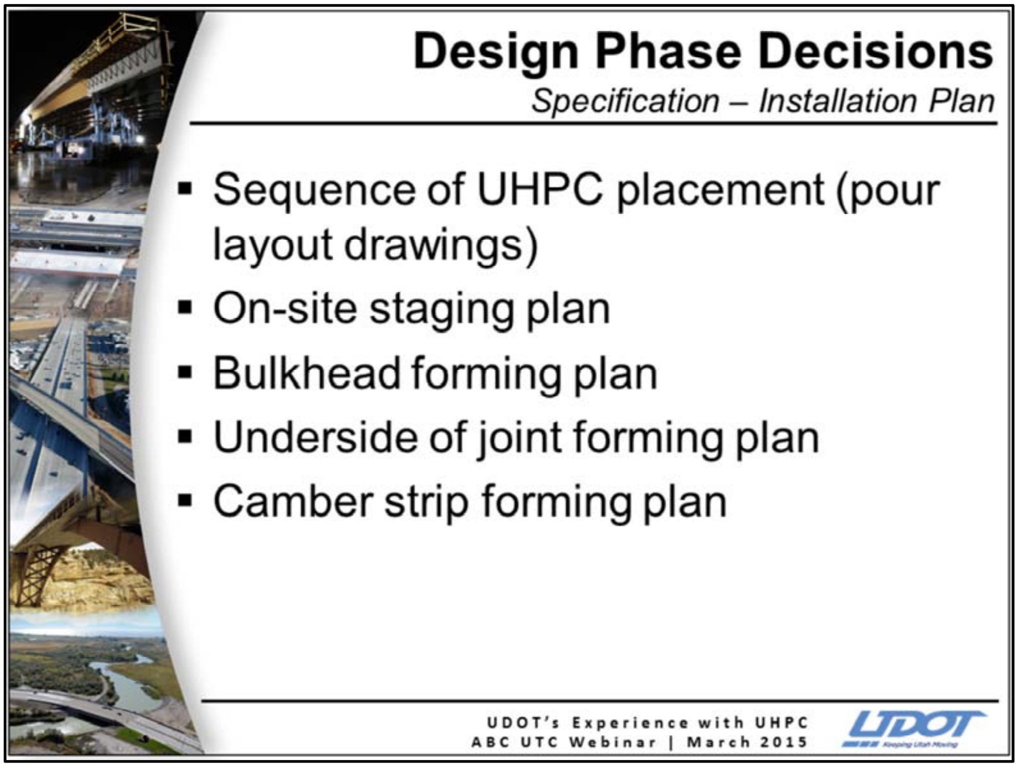
The criteria we established for the field demonstration included:

- Creating a mock-up to replicate the joint between precast panels
  - Match precast concrete panel depths to actual
  - Width, measured perpendicular to the joint 1.5’ min
  - Length, measured along the joint, 5’ min
- Replicate field conditions for preparation of surfaces and installation
- Use same personnel and similar equipment
- Produce and place a minimum of three batches to demonstrate continuous batching, placing, curing, and finishing of the field cast joints
- Demonstrate quality control procedures for sampling and testing. The minimum required testing to be done at the field demonstration included:
  - Slump flow
  - Compressive strength test (4 sets of three 3x6 cylinders)
    - First set tested at 4 days, Second set tested at 28 days
    - Third set was heat-treated and tested
    - 4th set Department verification testing
    - Steel bond test (pull-out test)
    - Check chloride ion permeability

- 30 days before UHPC placement on bridge. Stipulated to allow time before full production for any modifications to processes or adjustments resulting from testing issues/results.

During the on-site placement the requirements for quality control included:

- Technical rep on site at all times
- Slump flow for each batch
- Compressive strength test with 4 sets of cylinders for each production shift (a production shift was defined as material batched or tested by same personnel, cannot exceed 10 hours)



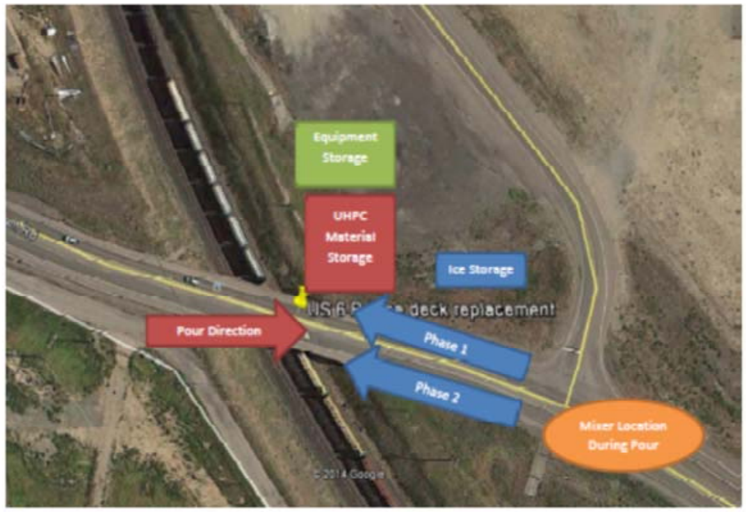
One of the contractor submittals we required was an installation plan. Working with limited time, being located over a railroad, and unfamiliarity with the material, we wanted to have an upfront understanding of how the Contractor was planning the work. We wanted to help ensure there was a contingency plan in place and the details had been thought through as well as having our inspectors familiar with the planned processes.

Some components of the installation plan included (see slide):

The sequence of UHPC placement was intended to control the quantity of UHPC placed in each pour by up-front planning of how each pour would be isolated. That way if there was a problem with a particular batch or there were formwork leaks it could be limited and controlled.

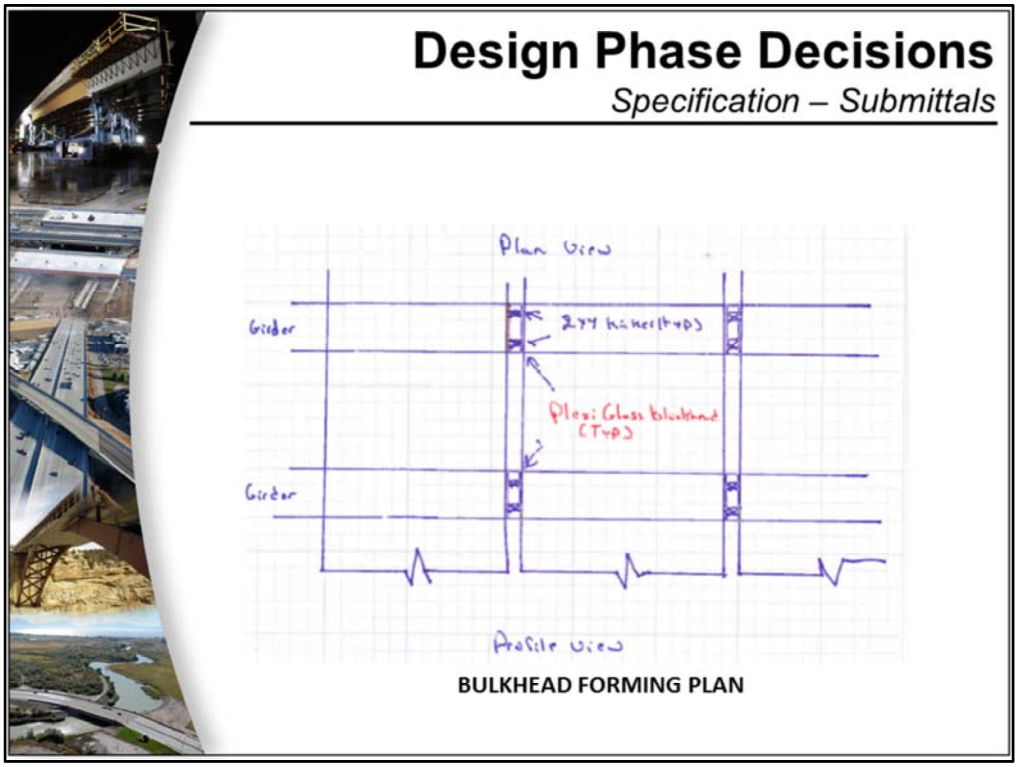
Design Phase Decisions

Specification – Submittals

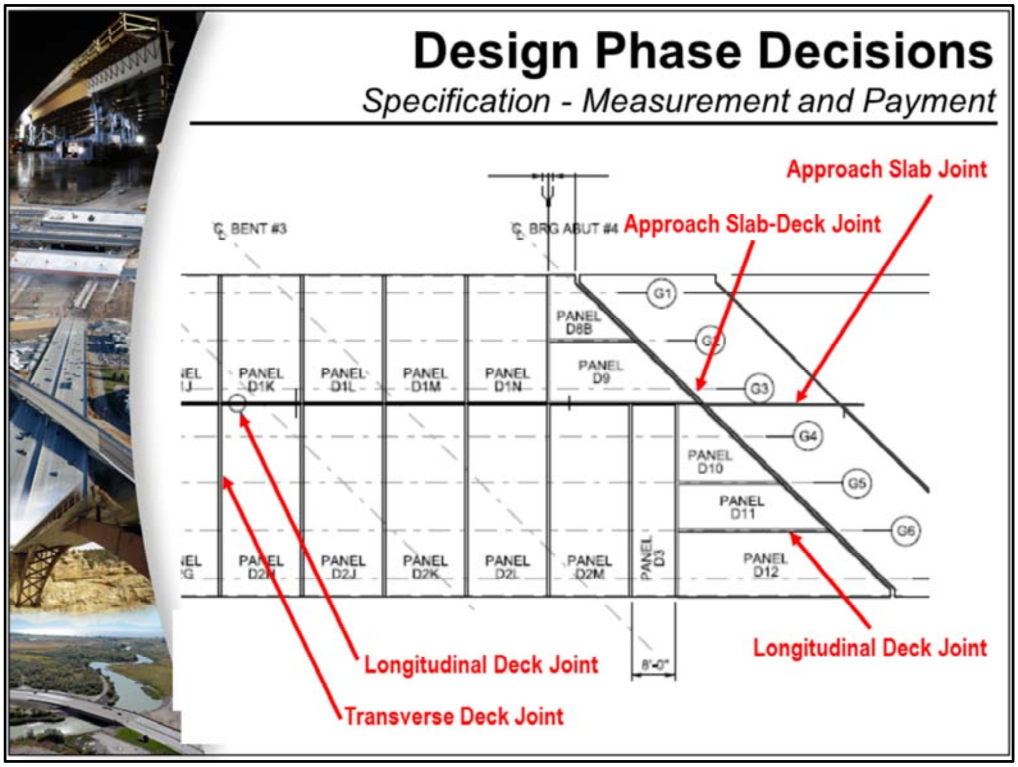


ON-SITE STAGING PLAN

On-site staging plan

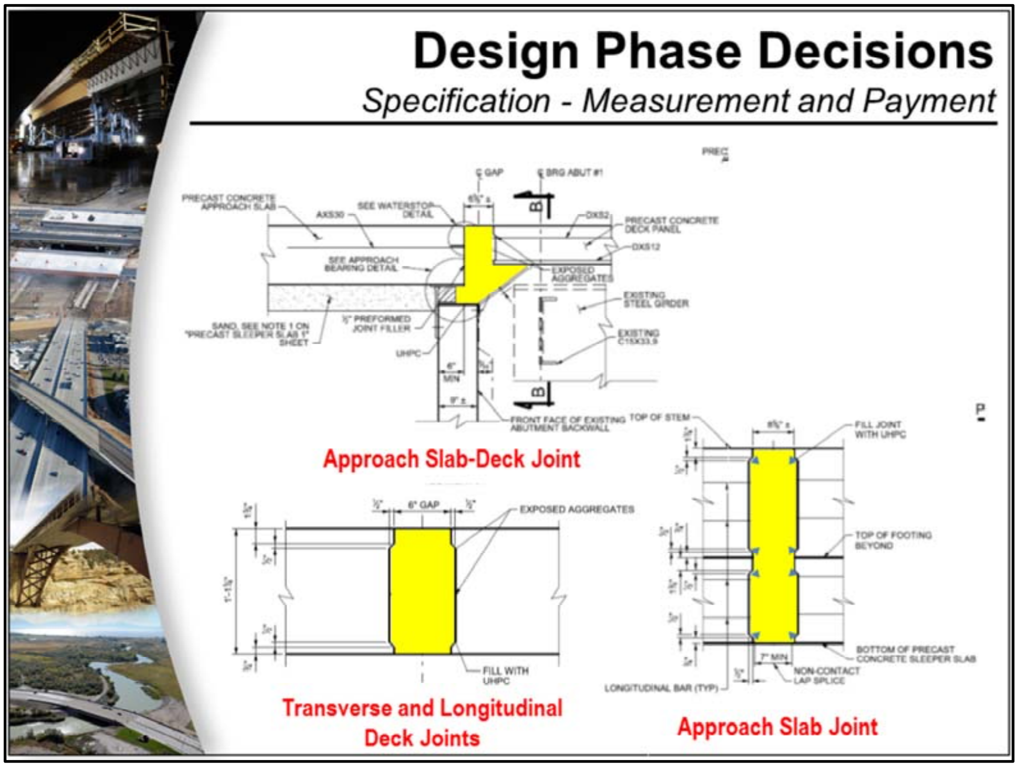


Bulkhead forming plan – Shows how the contractor planned to isolate pours.

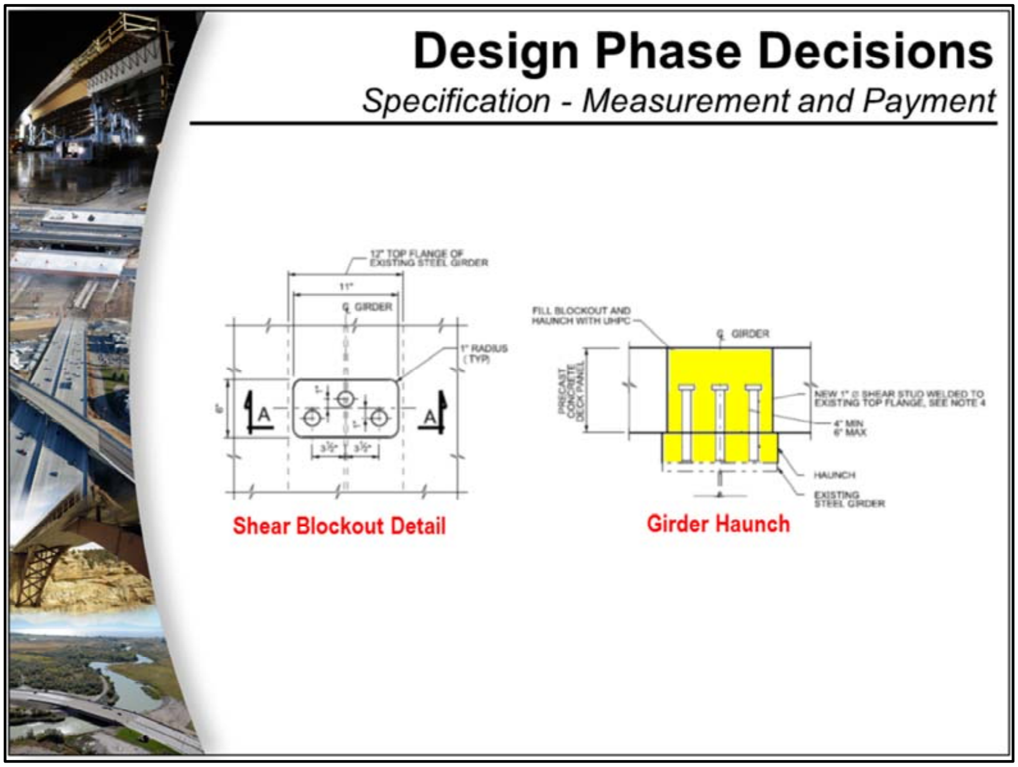


As a result of the geometrics of the structure and the panel layout to accommodate the phased construction, we wound up with a variety of joints.

i.e. Longitudinal (between girders, over girders, and within approach slab)



This shows an example of three of the joints in section. Note all the different areas.

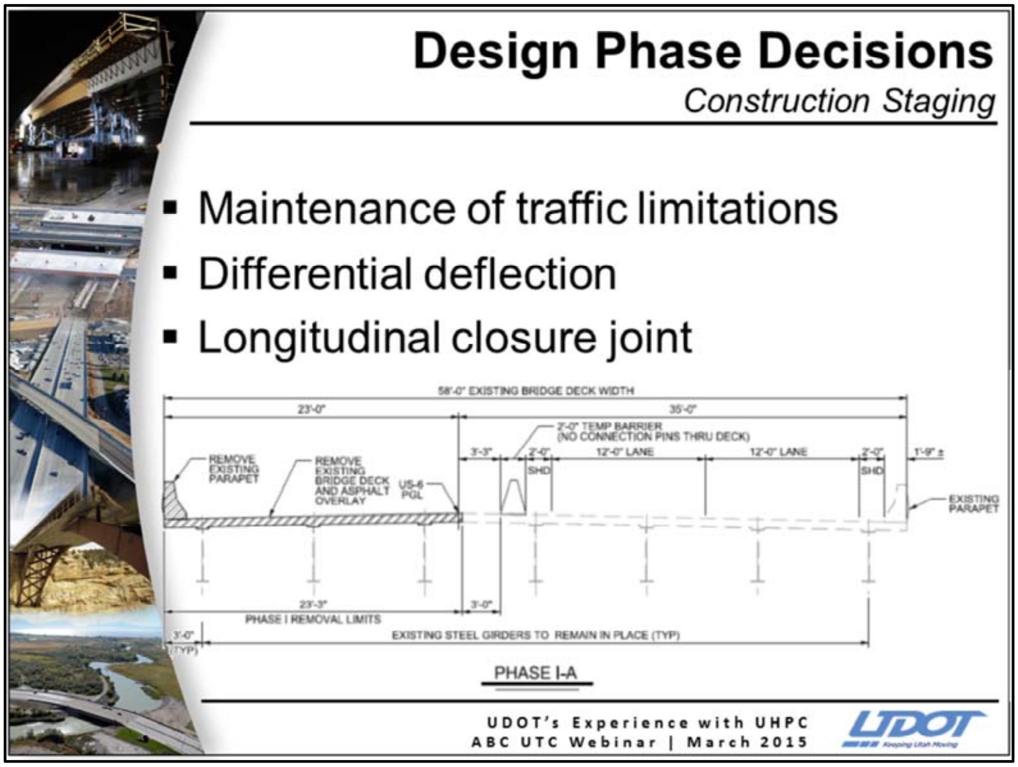


This is yet another joint (over the girder).

Tightness of forms, location of bulkheads, potential for waste and blowouts are factors in amount of UHPC that gets batched. All are within Contractor's control. Did not want to have to have contention in the field to quantify if there was waste in the mixer or buggies, leaks, or blowouts.

So instead of measuring and paying by the cy, we wound up with multiple pay items, one for each type of joint, which were measured per linear foot along the finished surface at centerline of the joint incidental to that item was the overfilling, grinding, grooving, and sealing the joints

Pictures of actual longitudinal and transverse deck joints.



Because of maintenance of traffic limitations, the structure work was performed in two phases. During Phase I, which occurred before Labor Day, two lanes of traffic had to remain open. During Phase II, after Labor Day, we were able to reduce to one-way, one-lane signalized traffic.

Phase I was 40% of the deck width (therefore less UHPC than Phase II) allowing Contractor additional time to get processes and placement working with less UHPC.

As a result of the phased construction and the need to pour the longitudinal deck closure joint under live load, concern was raised by Lafarge, during construction, with respect to how the non-contact splice would perform. Was mitigation required for differential deflection?
Because of the RR crossing beneath, no opportunity to support girders from below

We wound up modeling the affect of the live load with respect to anticipated deflection. In order to get initial set on the UHPC we looked at:
1) Feasiblity of a 24 hour closure (detour for all vehicles) – Not Feasible
2) Detour all trucks over 10,000 lb for 24 hours (maintaining phase 2 traffic control)
3) Adding a phase 3 with one-way, one-lane signalized traffic (open to all vehicles) – allows vehicles to be moved as far as possible for the longitudinal joint

Wound up implementing option 2.

Theoretical deflection of less than 2 mm.

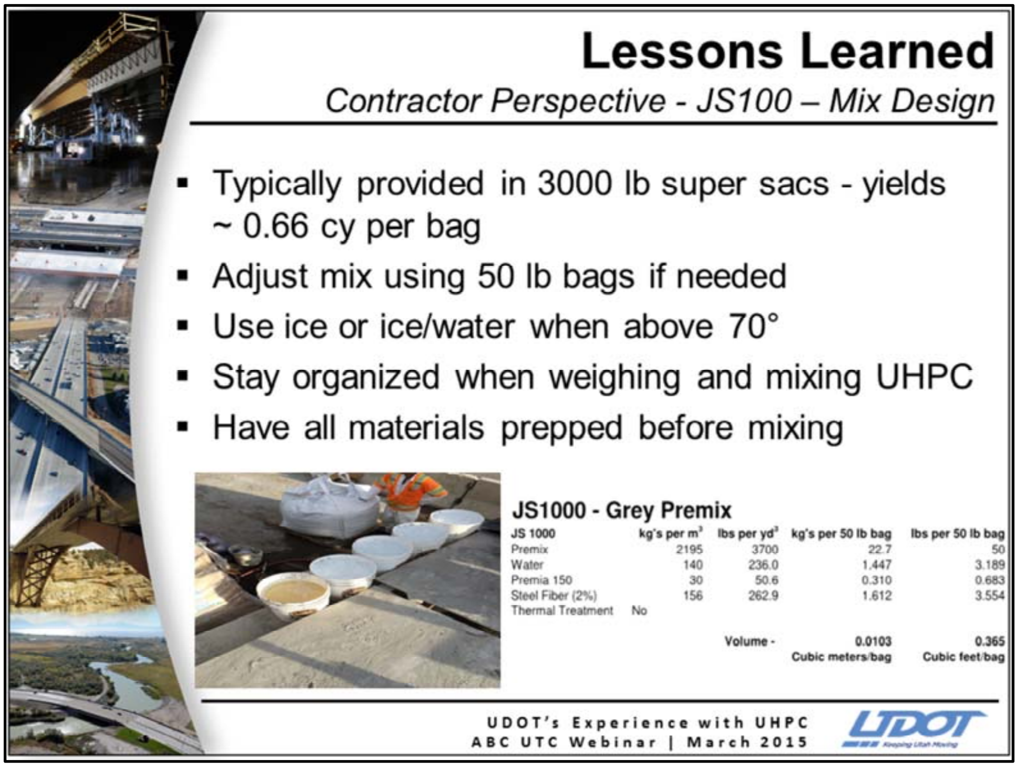
The third challenge with the phased construction wound up being the width of the longitudinal closure pour joint.

The joint width, per design was six inches like all of the deck joints. However due to the existing girder locations and tolerances within fabrication of the panels themselves, it was not always possible to maintain the six inch gap. The photo above shows how the gap varied along the length of the joint.

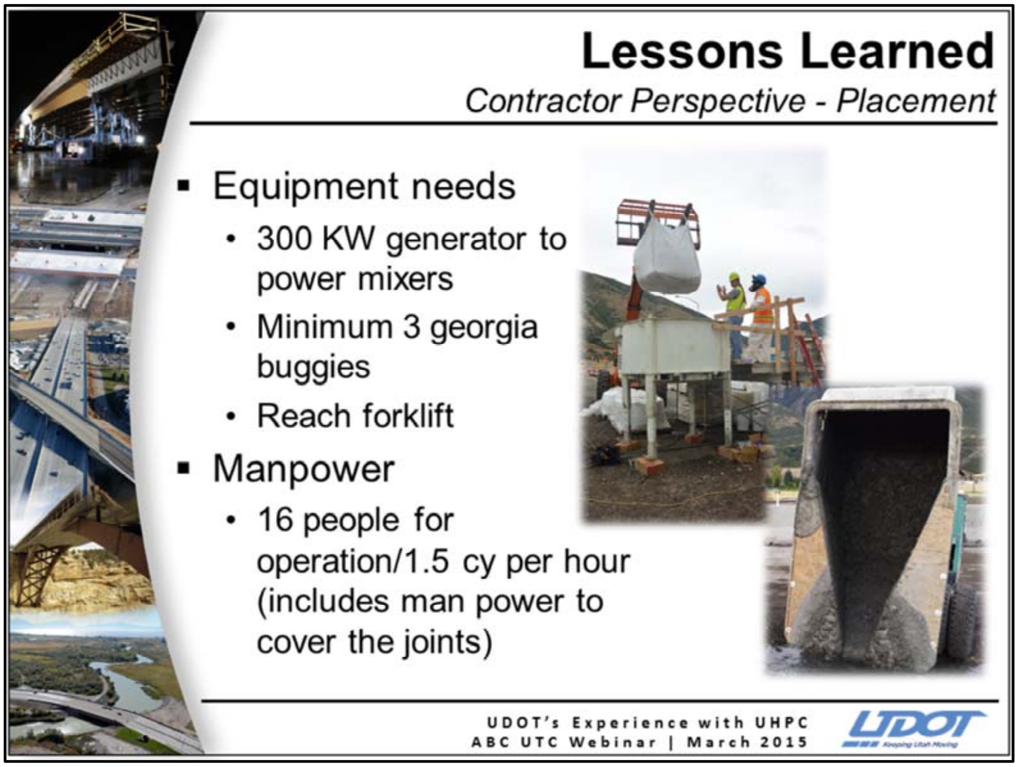
Longitudinal deck joint after being filled with UHPC.

What did we learn and what would we do next time?

- Beneficial to develop a performance based mix design with owner-performed testing and acceptance (We were heavily reliant on the technical representatives from Lafarge.)
- Found the field demonstration valuable and would continue to require
- There was a lot of complexity with the joints between the deck and abutment. They were difficult to form and with the skew, they were very long and difficult to block off to isolate pours. It would be beneficial to simplify as much as possible.
- During design, when laying out the panels, consider locations to block off pours to easily isolate the pours during construction.
- If a longitudinal closure joint is needed
    - Size the width of the joint to handle the build-up of construction tolerances
    - Consider the potential affects of differential deflection under liveload

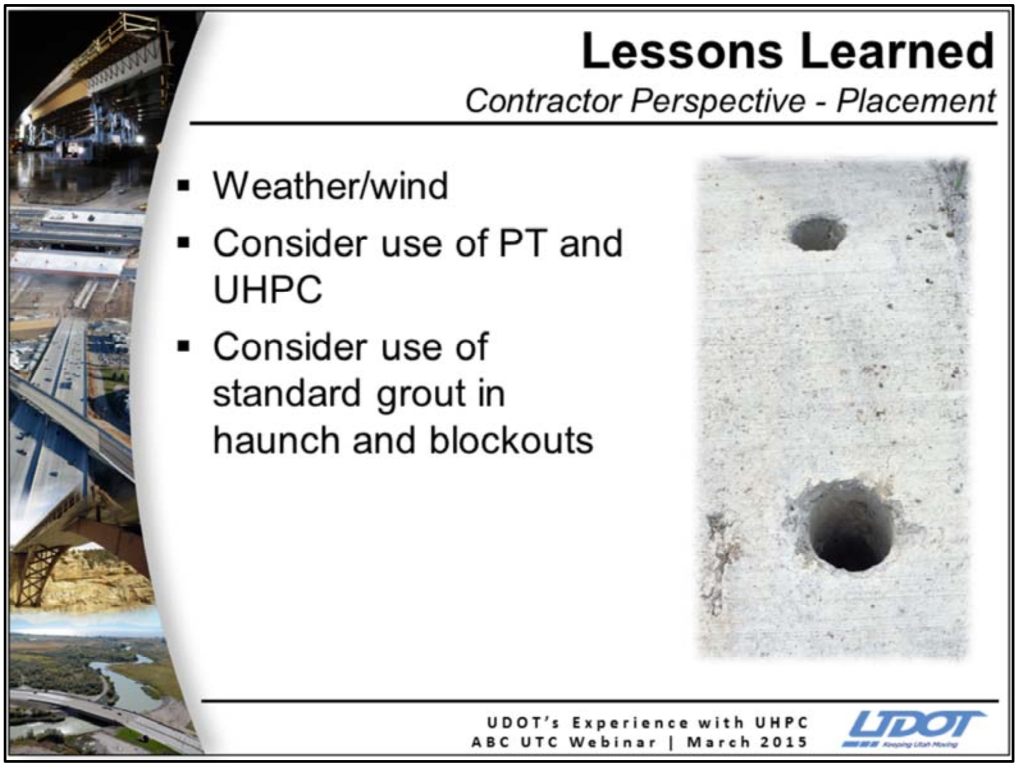


- UHPC is typically provided in 3000# super sacs, which yield about .66Cy per bag
- The 50# bags are used to dry up or adjust the mix if needed
- Above 70 degrees Fahrenheit the water will be replaced with ice by weight, and a water ice mix will be used
- Will want to stay organized, when weighing and mixing UHPC, and have all you're materials prepped and ready before mixing



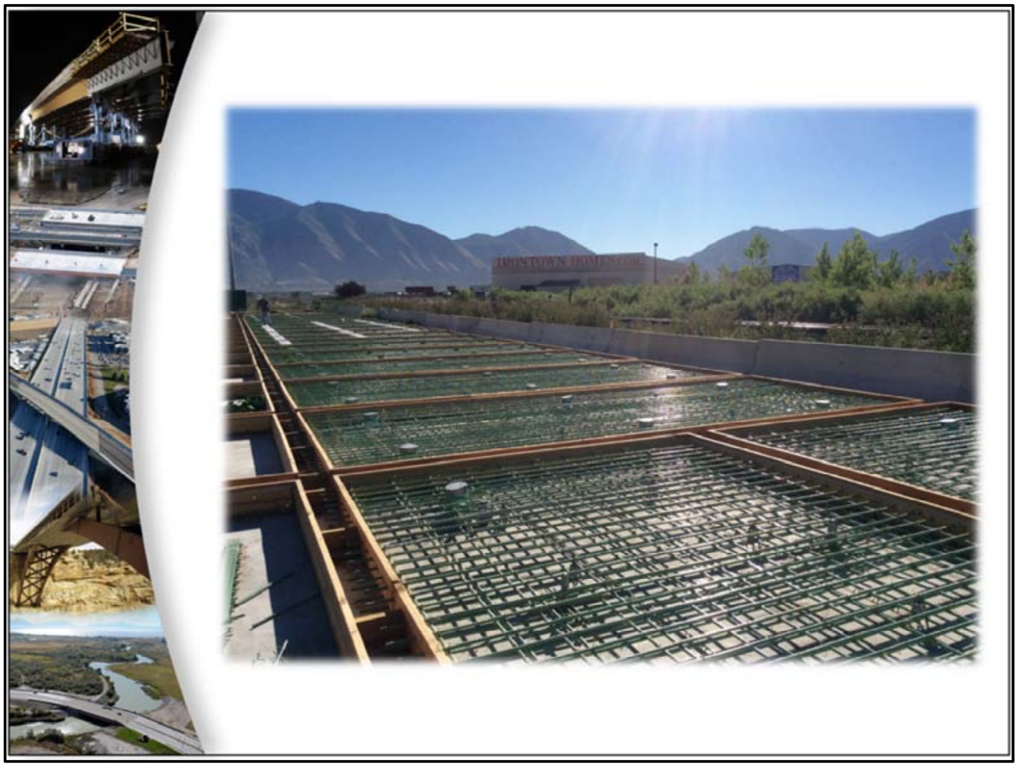
- Equipment needs- 300 KW generator to power mixers, Minimum 3 georgia buggies, Reach forklift.
- Manpower – will need around 16 people for the operation to get around 2.5 CY per hour. This includes man power to cover the joints

- Leaks - A lot of prep need to be taken to prevent leaks. They are very difficult to stop.
- Block off location for pours – It is recommended to isolate section of the UHPC so that the pour volume is smaller, that way if a problem occurs it can be kept to a minimum. Cannot have cold joints in UHPC that is way the block off is important. This should be thought of during design, where the locations should be. Deck to approach joint design made it very difficult to isolate the joint, so when pouring UHPC it had to be a large are to pour. The leak on Phase 1, had the volume of 3 panel tied together.
- Phasing, of pours and cold joints – Need to limit the size of the pour sections, we placed bulkheads on every other panel. This was good for the majority of the project, the deck to approach joint needs to be its own section.



- Weather /wind – The material for curing is sensitive to temperature, might not get the 14 KSI in 4 days. The material is thick and the wind tended to blow the material around during pours, made a big mess.
- Look at use of PT and UHPC in combination – Might be able to PT longitudinally along the deck and use UHPC in the pour between phase 1 to 2. PT would be roughly 80 to 100K UHPC roughly 300K
- Look at using Regular grout in haunch and block outs- Use a combination of Regular high strength grout and UHPC. Regular high strength grout material is about $1000/CY VS UHPC $4000/CY. This is just in material buy; the labor would also be less for high

Full Depth deck panels were match-cast near the bridge site.



Slideshow

Slideshow

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Thank you
Questions?