CLARE COUNTY ROAD COMMISSION

Dewayne Rogers
Managing Director
manager@clarecrc.com
989-971-3525

Mostetler Road

Built in 1930

Recon. In 1960

Span 24 feet

Rating 4

Poor Condition

Existing Steel Beams

Concrete Deck

Gravel Covered


May 2022

July 2022


BACK
IN
TIME

May 17, 2017

Journey begins

Thank you St. Clair County

Ultra-High Performance Concrete Connections for Prefabricated Bridge Elements

U.S. Department of Transportation
Federal Highway Administration

Workshop Agenda

May 17, 2017 **Horatio Earle Learning Center – 7575 Crowner Dr., Dimondale, MI 48821**

	Topic	Duration (Minutes)	Start	End
1	Welcome and Introductions	20	8:00 AM	8:20 AM
2	FHWA Every Day Counts Overview	20	8:20 AM	8:40 AM
3	Introduction to UHPC	60	8:40 AM	9:40 AM
	Break	15	9:40 AM	9:55 AM
4	Bridge Construction Using Prefabricated Bridge Elements	20	9:55 AM	10:15 AM
5	UHPC Connections: Structural Design	45	10:15 AM	11:00 AM
	UHPC Connections: Construction, Inspection, and Testing	30	11:00 AM	11:30 AM
	Lunch	60	11:30 AM	12:30 PM
6	UHPC Connections: Construction, Inspection, and Testing (cont'd)	30	12:30 PM	1:00 PM
7	UHPC Connections: Special Provisions	30	1:00 PM	1:30 PM
8	Examples of Recent Projects with UHPC Connections	45	1:30 PM	2:15 PM
	Break	15	2:15 PM	2:30 PM
9	UHPC: Emerging Concepts Beyond Connections	45	2:30 PM	3:15 PM
10	Michigan DOT Implementation of UHPC: Upcoming Project Plans / Interactive Discussion	55	3:15 PM	4:10 PM
11	Wrap-Up	5	4:10 PM	4:15 PM

Field Application of Nonproprietary Ultra-High-Performance Concrete

Experiences gained and lessons learned

by Sherif El-Tawil, Yuh-Shiou Tai, and John A. Belcher II

Ultra-high-performance concrete (UHPC) achieves a compressive strength of at least 150 MPa (21,700 psi) and it has self-consolidating properties. UHPC comprises component materials with particle sizes and distributions carefully selected to maximize packing density[1,2] (constituent particles arranged as compactly as possible), which is the reason for the extremely high mechanical and durability properties of the material. Another key feature of UHPC is that it is reinforced with a small percentage by volume (typically 1 to 2%) of short steel fibers, which enhance the material's tensile behavior and energy dissipation.[3,4]

The Federal Highway Administration (FHWA) and multiple state Departments of Transportation (DOTs) have exhibited strong interest in UHPC and its application in bridges. For example, the third round of the Every Day Counts (EDC-3) report included a chapter on UHPC connections for prefabricated bridge elements.[5] The fourth round of the program, EDC-4, is also expected to include that general topic.

The use of UHPC as a field-cast material is not new, but most experience in Europe and the United States has been gained with proprietary materials,[6] particularly for field-cast connections as outlined in Reference 7. A common thread in UHPC applications is that the required volume of material is not large, primarily because proprietary UHPC is expensive. UHPC must be purchased from specific suppliers, and the contractors that work with it must be specially trained, certified, and supervised, further increasing the unit cost. In a 2016 Michigan Department of Transportation (MDOT) project that required 8 yd^3 (6 m^3) of UHPC, the unit cost for the proprietary UHPC material was estimated at \$2500/yd^3 (\$3300/m^3). Another \$3700/yd^3 (\$5000/m^3) was spent on the specialized construction and technical services required by the supplier, although this cost is expected to drop substantially as the quantity of material increases and more experience is gained with the product.

Researchers at the University of Michigan, Ann Arbor, MI, developed a family of nonproprietary UHPC mixtures[1,2] that can be made from off-the-shelf products and do not require onerous placement or special curing processes. The resulting material has similar performance characteristics but is substantially less expensive than proprietary UHPC mixtures. This article describes experience gained with a nonproprietary UHPC mixture optimized for field applications.

Development of Nonproprietary UHPC Mixtures

Component selection

The nonproprietary UHPC mixture was produced using Type I ordinary portland cement (OPC), ground-granulated blast-furnace slag (GGBS or slag cement), silica fume, two types of silica sand, and short steel fibers. To ensure workability, a high-range water-reducing admixture (HRWRA or superplasticizer) was used. Optimum packing density of the particles was based on the material gradations as discussed in previous studies.[1,2] Four variants of the mixtures described in References 1 and 2 were considered good candidates for field application. The experimental variables were the amount of HRWRA and fiber length. The mixture proportions by weight are shown in Table 1.

White Type I portland cement was used in the initial development of UHPC[7] due to its low tricalcium aluminate (C_3A) content and high combined content of di- and tricalcium silicate (C_2S and C_3S), resulting in exceptional performance in the fresh and hardened states. However, white cement is expensive (currently, about \$275/ton). Research in References 1 and 2 has shown that Type I OPC, which is much cheaper (at \$150/ton), can be successfully used. In general, the selected cement must have a C_3A content lower than 8% and a relatively low Blaine fineness to reduce water demand during hydration. Many suppliers in the United States can meet this requirement.

Table 2:
Mechanical properties of laboratory and field batches

Mixture no. or ID	Spread, mm (in.)	Compressive strength, MPa (psi)				Tensile strength, MPa (psi)	Strain at peak tensile stress, %
		7-day	14-day	28-day	56-day		
1	214 (8.4)	121.3 (17,600)	149.1 (21,600)	175.7 (25,500)	196.2 (28,500)	12.9 (1900)	0.41
2	215 (8.5)	118.2 (17,100)	147.8 (21,400)	169.2 (24,500)	187.4 (27,200)	11.1 (1600)	0.17
3	235 (9.3)	118.8 (17,200)	143.5 (20,800)	159.0 (23,100)	176.4 (25,600)	9.5 (1400)	0.18
4	238 (9.4)	113.4 (16,500)	137.1 (19,900)	151.9 (22,100)	—*	9.6 (1400)	0.14
Field	238 (9.4)	108.9 (15,800)	127.0 (18,400)	148.1 (21,500)	—*	8.3 (1200)	0.13

*Specimens not tested. Not enough were made due to an oversight

After mixing was completed, the rheology of the UHPC mixture was assessed by measuring spread. The spread test method was based on ASTM C1437, "Standard Test Method for Flow of Hydraulic Cement Mortar," with one modification—the fresh UHPC was allowed to spread freely on a plexiglass plate instead of being dropped on a flow table as specified in the standard. When the mixture stopped spreading, the diameter of the spread was measured. Based on previous experience and research documented in References 1 and 2, a mixture was considered appropriate for use if its spread ranged from 175 to 300 mm (7 to 12 in.).

The compressive strength was obtained from cubes tested per ASTM C109/C109M, "Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)," while tensile strength was obtained using coupons tested per AASHTO T 132, "Standard Method of Test for Tensile Strength of Hydraulic Cement Mortars." Table 2 summarizes the properties of the four trial mixtures.

Table 2 clearly shows beneficial effects of the longer steel fibers, as Mixture 1 (with 19 mm fibers) exhibited a larger strain at peak tensile stress and a larger peak tensile strength than the mixtures with 13 mm fibers. For example, the peak tensile strength was 12.9 MPa (1900 psi) for Mixture 1 versus 9.5 MPa (1400 psi) for Mixture 3. The longer fibers also led to a slightly higher compressive strength than the shorter fibers. For example, the compressive strength at 28 days for Mixture 1 was 175.7 MPa (25,500 psi) versus 169.2 MPa (24,600 psi) for Mixture 2.

The 28-day compressive strength decreased with increasing amount of HRWRA. For example, the 28-day strength was 169.2 MPa (24,600 psi) for Mixture 2 and 151.9 MPa (22,100 psi) for Mixture 4, representing a 10% drop (Table 2). This was also true for tensile strength. The effects of using slag cement were also evident, as the strength kept rising substantially beyond 28 days. The 56-day compressive strength was 17 to 20 MPa (2500 to 3000 psi) higher. Comparing all the results, Mixture 3 provided a good compromise between flowability and strength, and it was selected for the field placement.

Field Application of UHPC

The bridge repair project was located on Kilgore Road over the Pine River (Structure No. 10091), Kenockee Township, MI, shown in Fig. 1(a). The bridge is 13.6 m (44.7 ft) long and 6.5 m (21.4 ft) wide (Fig. 1(b)). The repair effort entailed replacing the joints connecting the reinforced concrete beams with UHPC (Fig. 2).

Fig. 1: Bridge repair site: (a) location in Michigan; and (b) aerial view

However, the material is expected to continue to gain substantial strength at later ages due to the use of slag cement. Lab tests showed that the 56-day compressive strength was 17 to 20 MPa (2500 to 3000 psi) higher than the 28-day strength. The 150 MPa value is somewhat arbitrary. For example, the FHWA recommends that UHPC is defined using a minimum strength of 145 MPa (21,000 psi) at 28 days, a criterion that the field mixture meets.

Although the cost of nonproprietary UHPC is much less than proprietary UHPC, it is still relatively high compared to regular concrete. It is expected that this cost will come down as increasing demand drives up production of steel fibers and reduces their cost, or as lower-priced imported fibers become available in the United States. Given its great strength, durability, and other exceptional properties, it is expected that UHPC will play a key role in building the next generation infrastructure—one that is significantly more robust, resilient, and sustainable than in the past.

Acknowledgments

This research was funded by MDOT. The authors would like to acknowledge the ideas and intellectual contributions of D. Juntunen and S. Kahl of the Field Services Research Administration at MDOT.

Disclaimer

The opinions stated in this paper are the authors' and not necessarily those of MDOT or the individuals mentioned.

References

1. El-Tawil, S.; Alkaysi, M.; Naaman, A.E.; Hansen, W.; and Liu, Z., "Development, Characterization and Applications of a Non Proprietary Ultra-High-Performance Concrete for Highway Bridges," *Report No. RC-1637*, Michigan Department of Transportation, Lansing, MI, 2016, 199 pp.

2. Alkaysi, M., and El-Tawil, S., "Effects of Variations in the Mix Constituents of Ultra-High-Performance Concrete (UHPC) on Cost and Performance," *Materials and Structures*, V. 49, No. 10, Oct. 2016, pp. 4185-4200.

3. Wille, K.; Naaman, A.E.; El-Tawil, S.; and Parra-Montesinos, G.J., "Ultra-High-Performance Concrete and Fiber Reinforced Concrete: Achieving Strength and Ductility without Heat Curing," *Materials and Structures*, V. 45, No. 3, Mar. 2012, pp. 309-324.

4. Russell, H.G., and Graybeal, B.A., "Ultra-High-Performance Concrete: A State-of-the-Art Report for the Bridge Community," *FHWA-HRT-13-060*, Federal Highway Administration, McLean, VA, June 2013, 171 pp.

5. "Every Day Counts: An Innovation Partnership with States, EDC-3 Final Report," *FHWA-17-CAI-005*, Federal Highway Administration, McLean, VA, May 2017, pp. 50-53, www.fhwa.dot.gov/innovation/everydaycounts/reports/edc3_final/.

6. Hansen, L.P., and Jensen, B.C., "A New Building System Using Joints of Ultra-High-Strength Fibre Reinforced Concrete," *Innovation in Concrete Structures: Design and Construction*, R.K. Dhir and M.R. Jones, eds., Thomas Telford, London, UK, 1999, pp. 543-552.

7. Graybeal, B., "Design and Construction of Field-Cast UHPC Connections," *FHWA-HRT-14-084*, Federal Highway Administration, McLean, VA, Oct. 2014, 36 pp.

8. Yazıcı, H.; Yardımcı, M.Y.; Yiğiter, H.; Aydın, S.; and Türkel, S., "Mechanical Properties of Reactive Powder Concrete Containing High Volumes of Ground-Granulated Blast-Furnace Slag," *Cement and Concrete Composites*, V. 32, No. 8, Sept. 2010, pp. 639-648.

Note: Additional information on the ASTM and AASHTO standards discussed in this article can be found at **www.astm.org** and **www.transportation.org**, respectively.

Selected for reader interest by the editors.

Sherif El-Tawil is a Professor of civil and environmental engineering at the University of Michigan, Ann Arbor, MI. He has had a long-sustained interest in the development of nonproprietary UHPC and characterization of its short- and long-term properties. El-Tawil is particularly interested in the effects of extreme loading on structural systems and how UHPC, with its unique properties, can be used to mitigate those effects. He is a licensed professional engineer in Michigan.

Yuh-Shiou Tai is a Professor in the Civil Engineering Department at the ROC Military Academy, Taiwan, ROC. He has been a Visiting Research Scientist at the University of Michigan since 2013. His research interests include interfacial bonding properties between steel fiber and the cementitious material; and experimental testing, analysis, and modeling of UHPC under quasi-static and high strain rate loading.

John A. Belcher II has been with the Michigan Department of Transportation (MDOT) for 16 years, during which he served as the Concrete Construction Engineer. He is currently the Bridge Construction Engineer for MDOT.

UHPC JOINT REPAIRS

STEEL BEAM END REPAIR USING UHPC

STEEL TUB GIRDER; PRECAST PANELS; UHPC JOINT

LIMITED PRODUCTION
EXCESSIVE LABOR

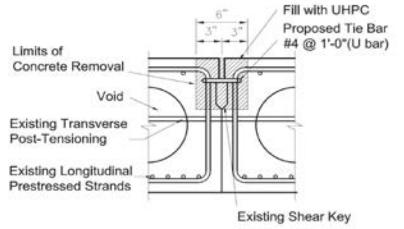
Design and Construction of UHPC-Based Bridge Preservation and Repair Solutions

PUBLICATION NO. FHWA-HRT-22-065

MAY 2022

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296



Source: FHWA.

B. Details of the repair.

Figure 5. Illustrations. UHPC connection repair used on the Martin Downs Boulevard Bridges.

Figure 6. Photo. Installation of UHPC on one of the Martin Downs Boulevard Bridges.

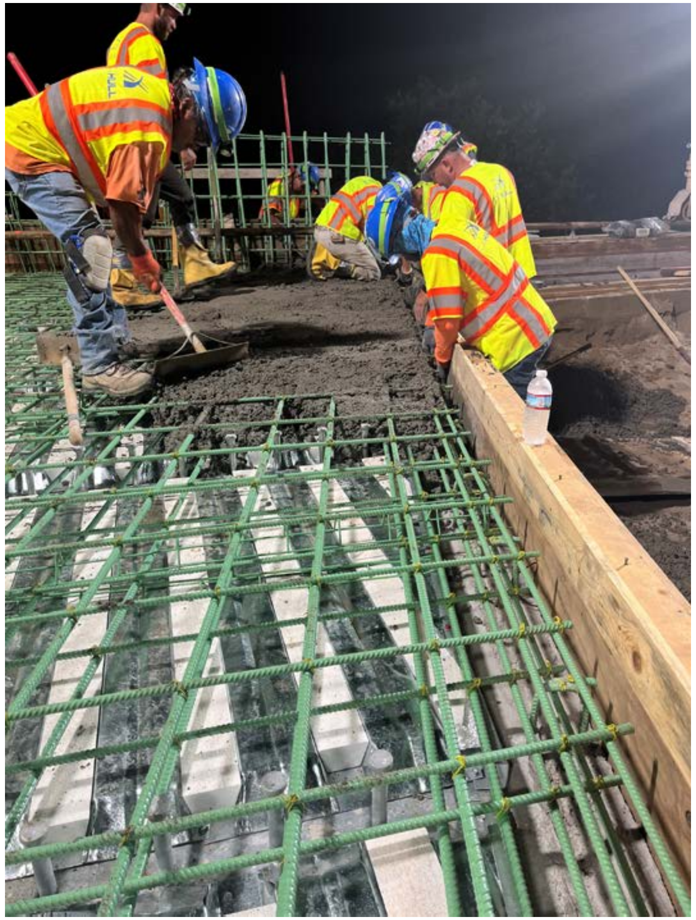
Figure 7. Photo. Installation of UHPC connection repair project on the Kilgore Road Bridge over Pine River in Kenockee Township, MI.

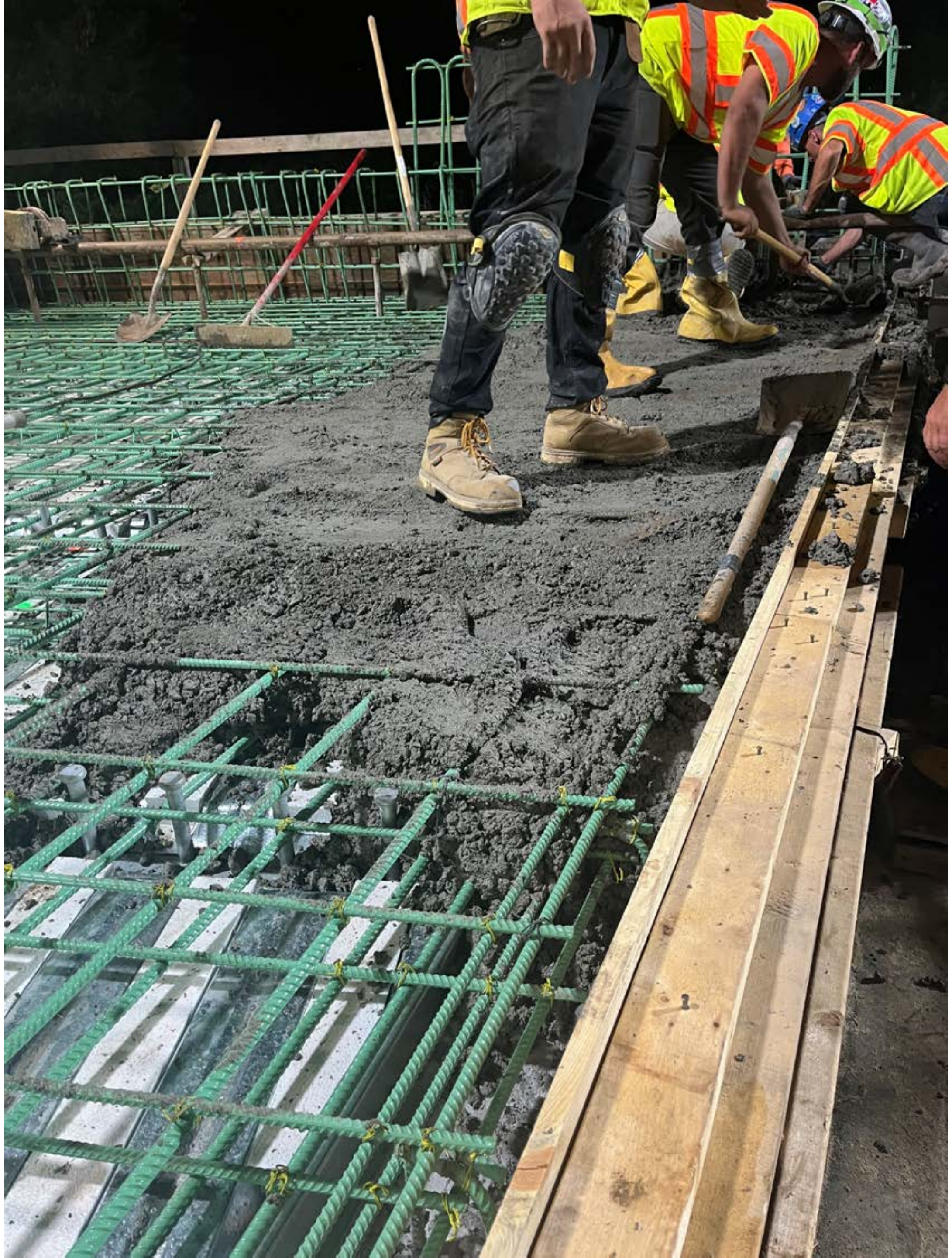
SEISMIC RETROFIT

Bridge structures built before the establishment of modern seismic bridge design and detailing provisions often require upgrading or retrofitting to enhance their seismic performance. Commonly, the reinforced concrete columns of these structures require the most attention, given that the columns are typically the primary lateral load-resisting elements in the structures. Traditionally, structural steel, fiber-reinforced polymer (FRP), or bulky reinforced concrete jackets have been employed to upgrade the strength and ductility of seismically deficient bridge columns. UHPC provides an alternative column-strengthening or -jacketing solution to these traditional methods. Laboratory research has demonstrated that UHPC can restore bridge column capacity with deficient reinforcing bar lap splices located in bridge column plastic hinge zones (Dagenais, Massicotte, and Boucher-Proulx 2018).

In 2014, the British Columbia Ministry of Transportation used UHPC jackets to encase and confine the hinge zones of pier columns on Mission Bridge in Mission, British Columbia, Canada. Built in 1973, the bridge was found to have multiple seismic vulnerabilities. As such, the bridge had previously used FRP wraps to retrofit the plastic hinge zones. One such seismic vulnerability was the threat of lateral spreading in specific pier locations. While ground improvements in the form of deep compaction piles mitigated the issue at most pier locations, a single pier required additional strengthening. For this location, a UHPC jacket was selected because it would provide an aesthetically pleasing and cost-effective retrofit solution compared with other alternatives. The construction procedure included removing the existing FRP wraps, after which the column concrete surfaces were roughened and steel rods were installed to anchor the UHPC to the surface of the columns. Steel stirrups were added around the column

ROSS
00-521-3367





Common Issues With Conventional Construction

- Concrete out of spec; Air/Slump
- Concrete trucks take too long to the site
- Bidwell issues
- Wind/Temperature/Evaporation
- Unexpected Rain
- Pump Truck issues
- Workmanship
- Labor/Night Conditions/Long Hours
- Late Nights/Long Hours
- Extended Periods of Construction Time
- Traffic Detours/Lane Closures/Delays

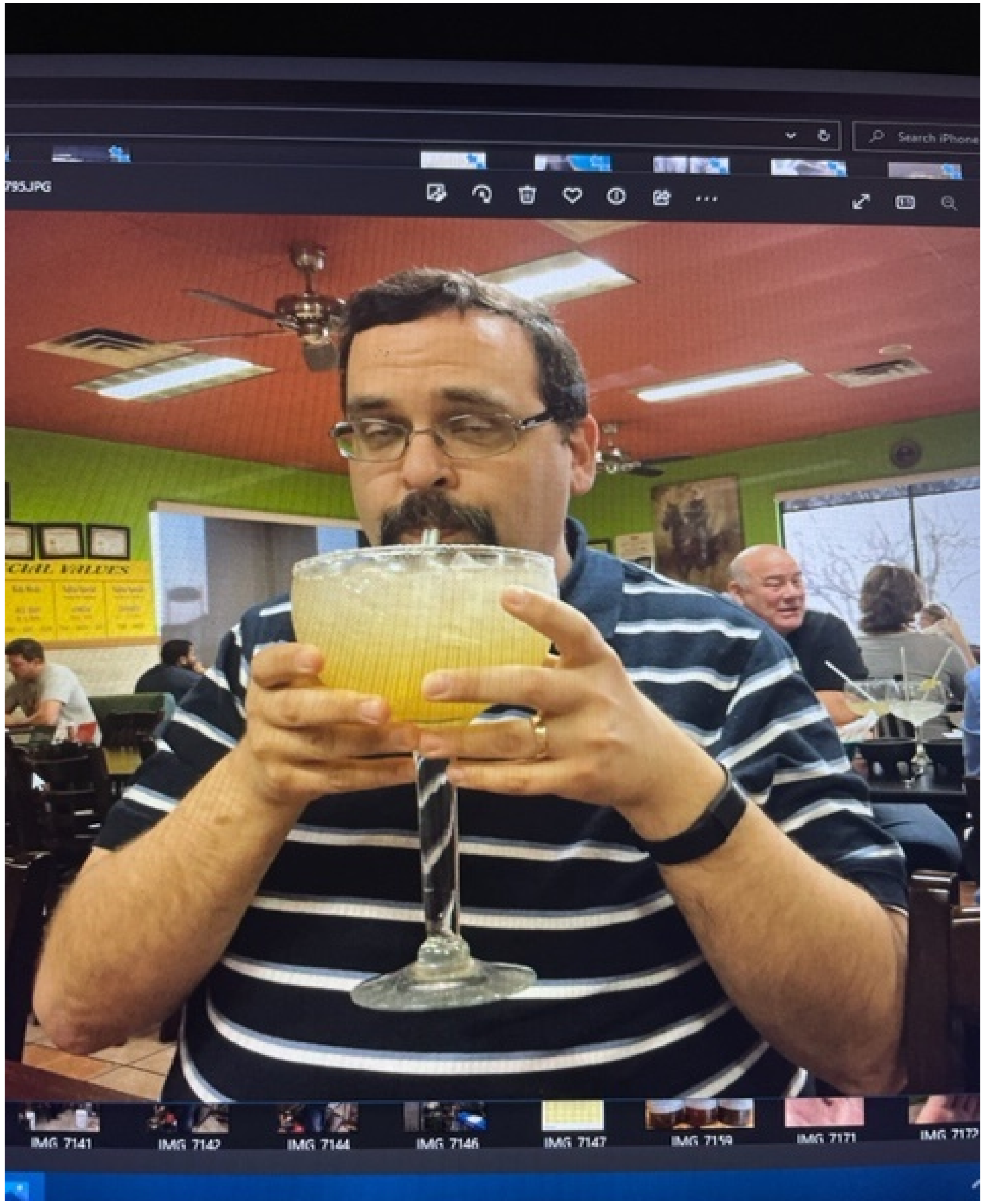
How Many People Have Had These Issues Or Similar Issues?


30
MPH
30
MPH


PETTIT
PARK

- Insufficient Life Expectancy
- Labor Costs
- Material Costs
- Traffic Delay Costs
- Temporary Fix
- **BUDGET**

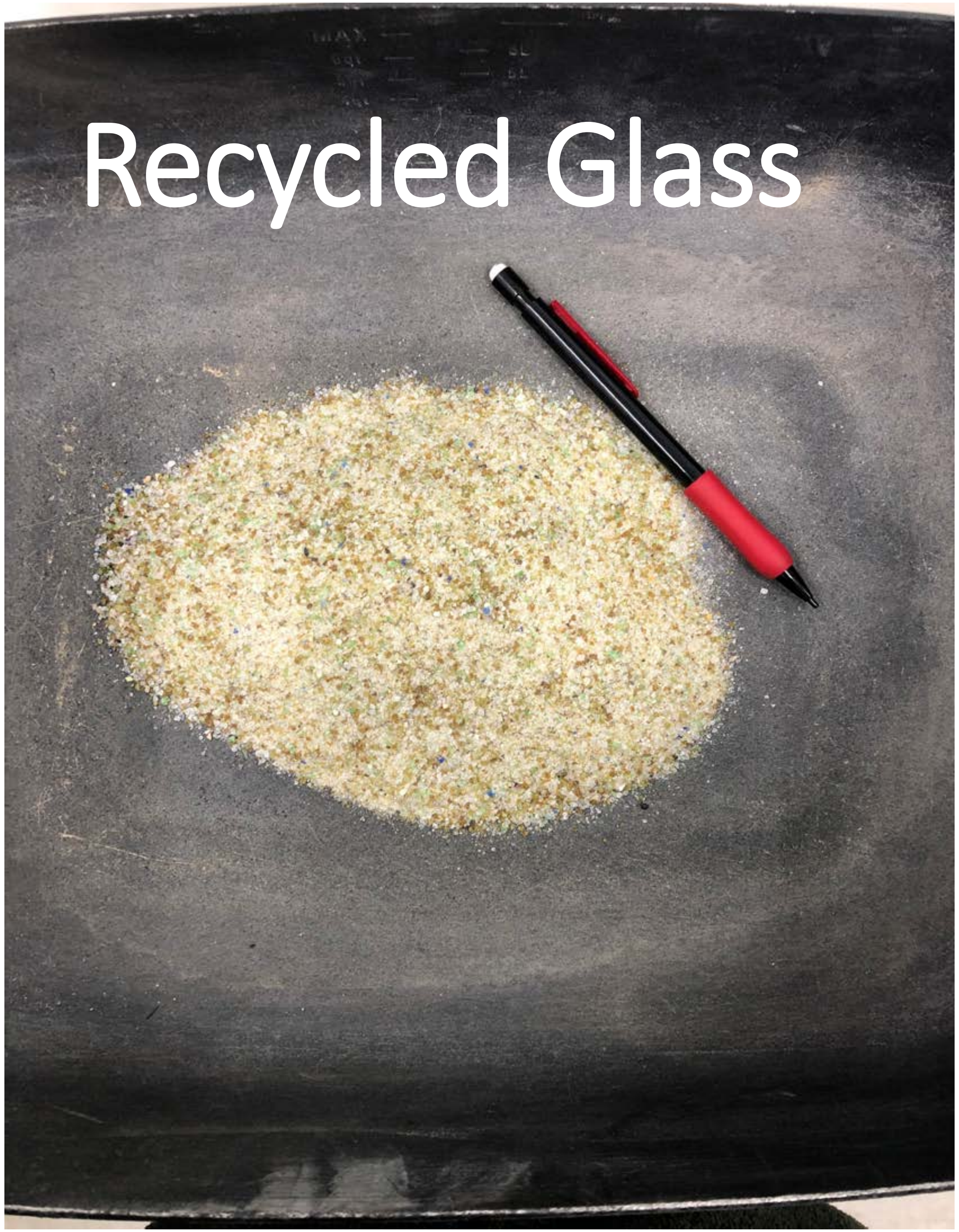
Water Break




SKT
WEIGHT LIMIT
20 T
37 T
73 T
Bridge looking w
1763

GRS Abutments





Recycled Glass

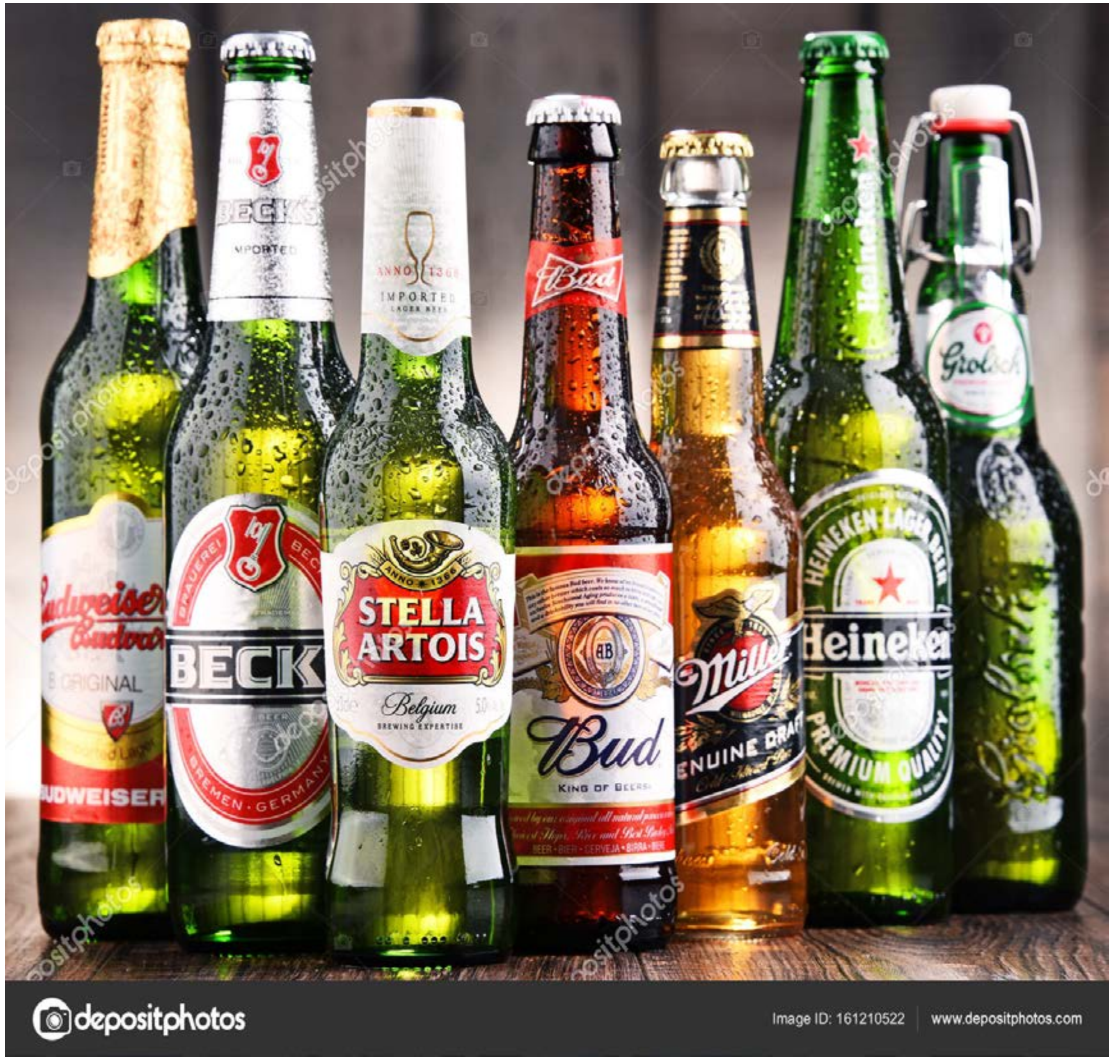
Fun Fact:

100 Beer Bottles/40 lbs of Crushed Glass

4 Tons of Crushed Glass = 8,000 lbs

8,000/40 = 200 X 100

Approximately 20,000 Beer Bottles



Fun Fact #2:

Clare County Produced the Bottles in 2.5 Days*

*This Fact May Be Exaggerated



- Prior to Bridge Construction the Real Work was Being Done
- Work Started in January of 2022
- Steel Tub Girders from Valmont Steel
- Innovations due to Limited Building Capacity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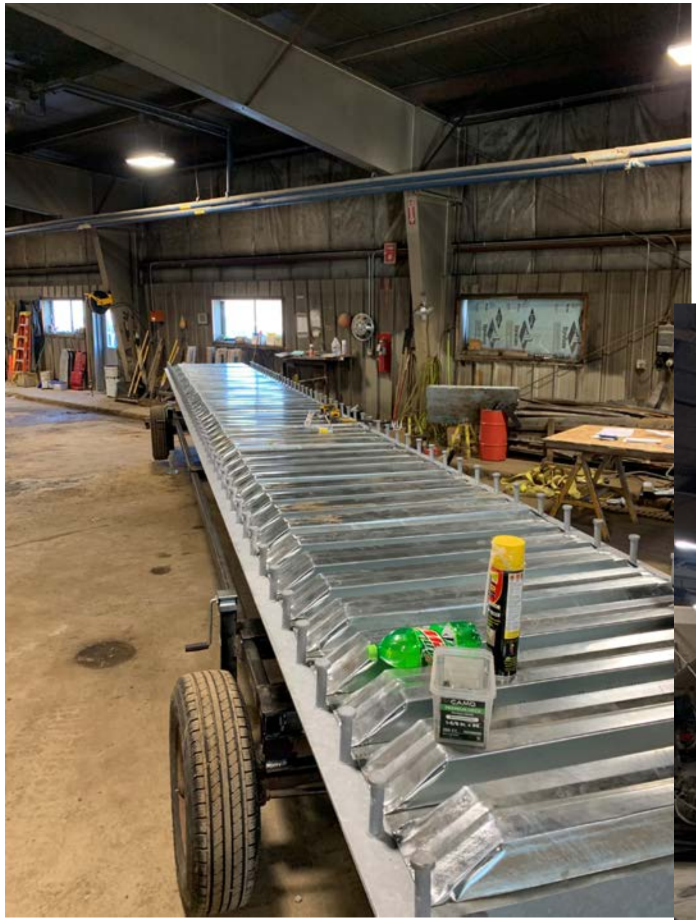
5209794-1
9-202
INSP

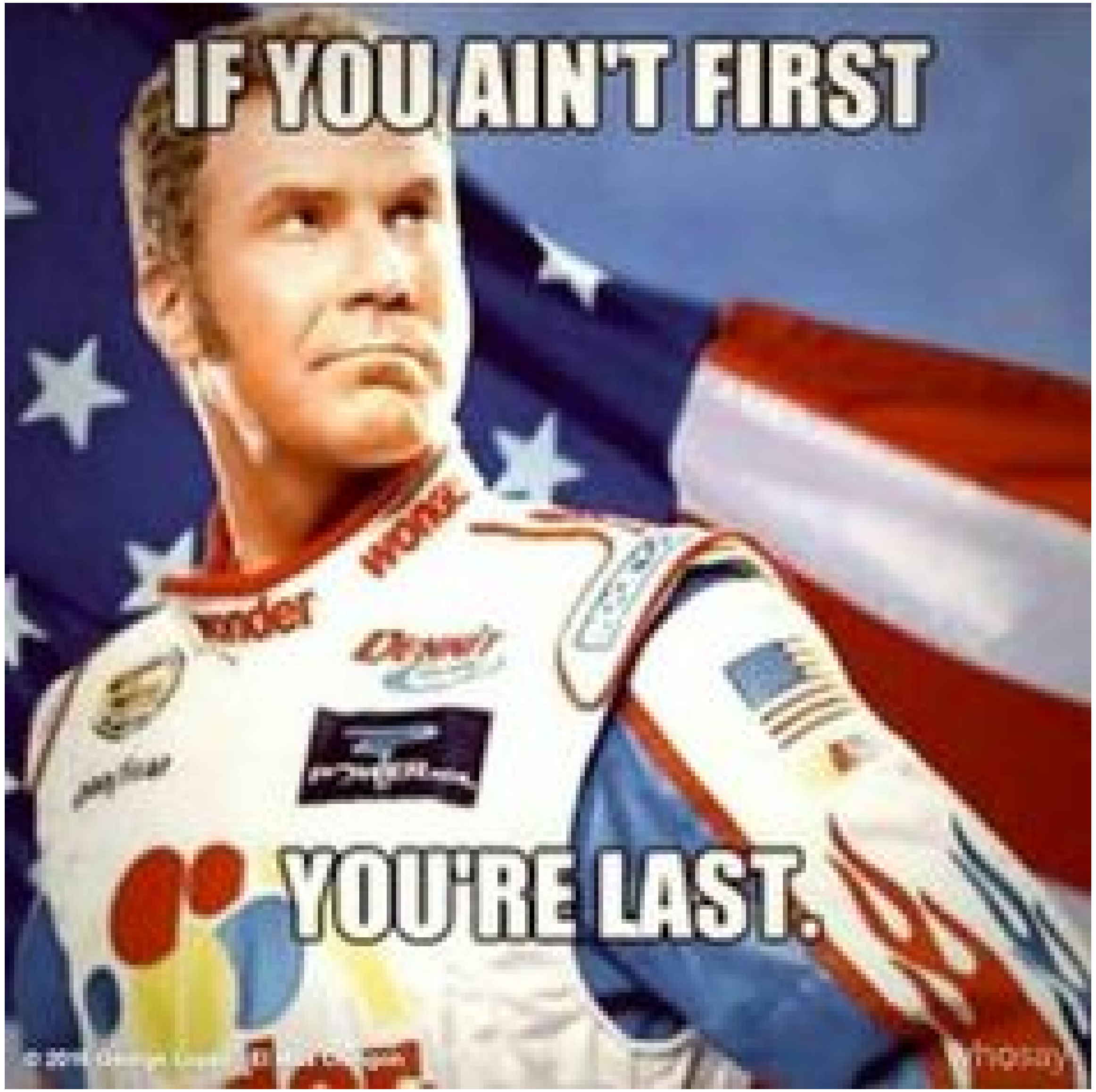


Steel Tub Girders Formed

3 CYD of UHPC Per Beam

6 Beams Total

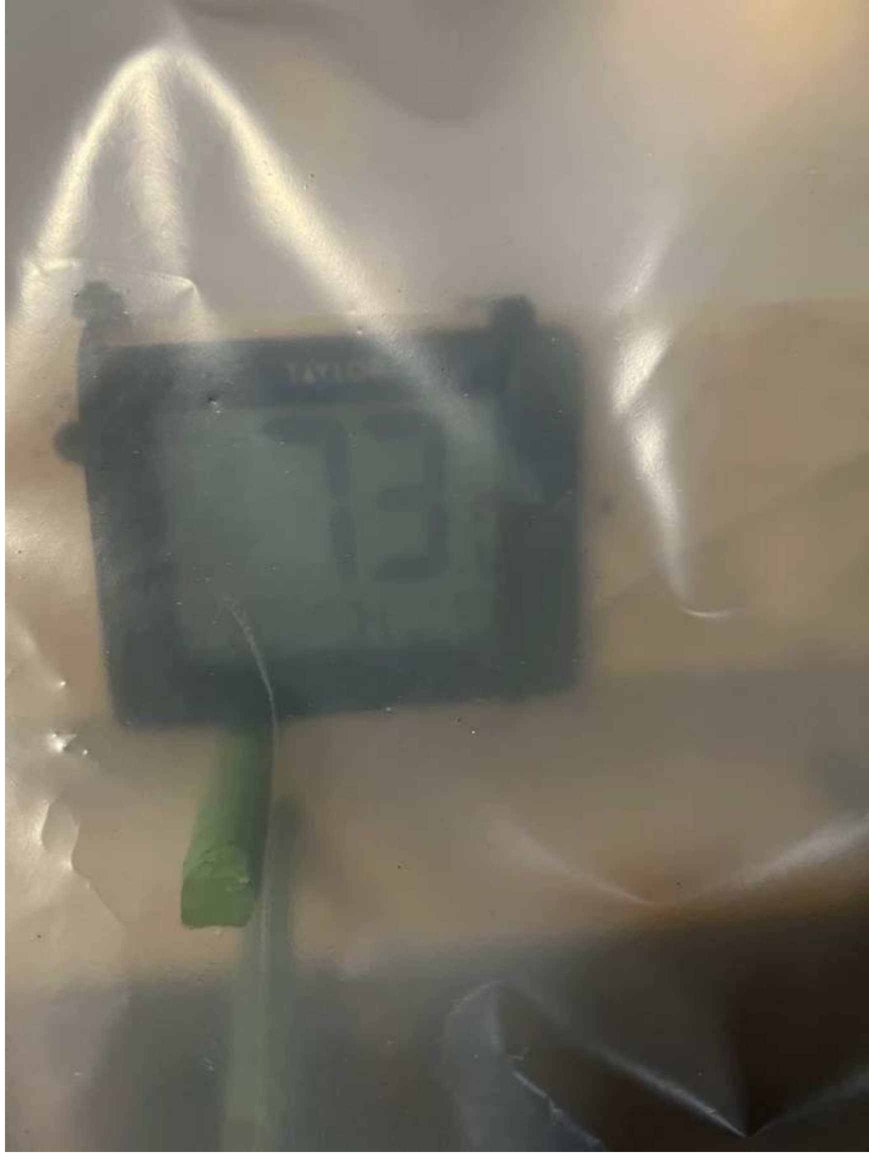
Moment of Truth




ERIOR CRETE

Me Hoping The UHPC Mixes Properly


RATED SHEATHING
48/24
SIZED FOR SPACING
EXPOSURE 1
THICKNESS 0.688




VOLVO
CAT


Actually, Midland County


607
D-1800



Supplier:	Superior Materials
Mix Identification:	88526.00 - UHPC - 13.9 Sack
Mix Design Strength (psi):	24000 at age 28 days
Project Required Strength (psi):	24000
Design Bulk Density (pcf):	153.2
Design Water Cement Ratio (lb/lb):	0.20

Material	Source	Amount (per yd³)	Moisture
Cement 1 (lb)	Portland Type I	653	N/A
Cement 2 (lb)	GGBFS Grade 100	653	N/A
Fine Agg 1 (lb)	Silica Fume - ELkem 900W	327	
Fine Agg 2 (lb)	Fine Sand 1 - F75	395	
Fine Agg 3 (lb)	Fine Sand 2 - F12	1580	
Admix (oz)	Sika HRWR	550	N/A
Water (lb)	Potable	264	N/A

Sample Details

Date Sampled:	Mar 3, 2022	**Sampled By:**	James R. Brown
Date Received:	Mar 7, 2022		
General Location:	Placement #3		
Sample Location:	See General Location		
Sample No.:			
Ticket No.:		**Truck No.:**	
Weather:	Interior Placement		
Yield. (ft³):		**Rel. Yield. (ft³):**	

Specification:

		Measured	Specified
Slump (in):	**ASTM C 143**	9.5	7.00 – 12.00
Slump w/ plasticizer (in):			
Air Temp (°F):		65	
Concrete Temp (°F):	**ASTM C 1064**	64	
Air Content (%)	**ASTM C 231**	3.4	
Bulk Density (pcf):	**ASTM C 138**		153.2

Batch Size (yd³):	3.0	**Time Batched:**	10:22
Yd³ Placed:		**Time Sampled:**	11:09
Time Unloaded:	11:30	**Time in Truck (mins):**	68

Compressive Strength of Hydraulic Cement Mortar Cubes ASTM C 109

Specimen ID	Date Tested	Age (Days)	Width (in)	Length (in)	Maximum Load (lbf)	Fracture Type / Remarks	Compressive Strength (psi)
22-3060-1\1	03/10/22	7	2.00	2.00	104310	3	26080
22-3060-1\2	03/10/22	7	2.00	2.00	102660	3	25670
22-3060-1\3	03/10/22	7	2.00	2.00	101740	3	25440
22-3060-1\4	03/31/22	28					

ST. CLAIR COUNTY ROAD COMMISSION

SPECIAL PROVISION
FOR
Conc, Ultra High Performance

a. Description. This work consists of using Ultra High Performance Concrete (UHPC) for pre casting of deck panels. All work must be in accordance with the standard specifications, except as modified herein.

b. Materials. The concrete mixture must contain the following materials per cubic yard. Below is a description for one bridge panel or 3.2 cyd batch:

Material			Weight [lb]
Cement Blend			
	Portland Type I		2089
	Slag Cement		2089
Silica Sand			
	Fine Sand[1]		1261
	Coarse Sand[2]		5046
Silica Fume			1043
Water			845
High Range Water Reducer[3,4]			125
Steel Fibers[5]			636
Defoamer[6]			2

[1]US Silica F75 / Short Mountain Silica Fine Sand
[2]US Silica F12 / Short Mountain Silica 3070 Sand (Coarse)
[3]Sika ViscoCrete-2100
[4]High range water reducer is applied at the rate of 21.6 oz/cwt
[5]The steel fibers are 1.5% by volume.
[6]Eucon Air Out

Steel fibers – Steel fibers must be straight with a smooth surface and conform to ASTM A820, Type I fibers. They must have a diameter of 0.008 in and length between 0.5 in and 0.75 in, both with a ±5% tolerance, and a minimum tensile strength of 410 ksi.

High Range Water Reducer – use Sika ViscoCrete-2100. No substitutions are permitted without written approval of the Engineer.

c. Equipment. Mixers with 5.0 cyd minimum capacity must be used. Pumping UHPC is not permitted.

d. Pre-Pour Meeting. Prior to the initial placement of the UHPC, the Contractor must arrange for an onsite meeting with the Engineer. The objective of the meeting will be to clearly outline the procedures for mixing, transporting, finishing and curing of the UHPC.

e. Construction.

1. **Storage.** Assure the proper storage of constituent materials, fibers, and additives as required by the manufacturer's specifications in order to protect materials against exposure to moisture and loss of physical and mechanical properties.

2. **Temperature Limitations.** Do not place concrete at ambient air temperatures below 40 degrees F, nor above 90 degrees F. The top surface of the concrete must be covered with insulating blankets, having a minimum R Value as specified in Table 706-1 of the Standard Specifications for Construction, when the air temperature is below 60 degrees F. Insulating blankets must meet the requirements of subsection 903.07.C of the Standard Specifications for Construction. Leave insulating blankets in place for a minimum 7 calendar days.

3. **Mixing Protocol.** The following mixing protocol must be followed:

   A. Mix silica fume and all silica sand together for at least 25 minutes.

   B. Add type I cement and slag cement. Mix together for at least another 25 minutes. Do not allow material to cake on the side of the mixer.

   C. Add water and HRWR gradually to the mixture and mix until mixture becomes fluid, approximately 20 minutes. If the air temperature during the time of pour exceeds 80 degrees F, provide enough ice to lower the water temperature to approximately 50 degrees F. Combination of ice and water shall not exceed batch weights described in Section b. table.

   D. Perform the slump flow test according to subsection e.5 of this special provision. If the slump flow is between 7 and 12 inches, add the steel fibers into the mix. Do not incorporate any UHPC into the project with slump flow outside the stated range. Fibers shall not be added until the on board flow meter in the redi-mix truck indicates +/- 1100.

   E. Add steel fibers to truck and mix for at least 20 minutes.

4. **Forms.** The forms must be water tight and coated to prevent absorption of water. The formwork must be resistant to the hydraulic pressure of the mix.

5. **Quality Control.** Submit a copy of all quality control records to the Engineer within 48 hours after the date of concrete placement covered by the record.

   Use a flow table to measure the slump flow for each batch of UHPC. Conduct the slump flow test in accordance with ASTM C230/C230M without compacting and without moving or impacting the base plate. Record the slump flow for each batch in the QC records. The slump flow must be within the range of 7 to 12 in. Do not incorporate UHPC into the project with slump flow outside the stated range.

6. **Compression Testing Requirements.** Make three sets of compressive strength test samples for each day of placement. Each set consists of three 2x2 inch cubes. All test samples must be cured using the same method of curing as outlined in the quality control plan. The compressive strength tests must be conducted on a minimum of three 2x2 inch cube samples according to ASTM C109. Other samples can be cast and tested with prior approval of the Engineer.

7. **Curing.** Do not apply curing compound. The concrete surfaces must be continuously cured with wet burlap per subsection 706.03.N.1.b, except that the wet burlap must be applied immediately after casting.

Clare County Road Commission Seeks Higher Performance at Lower Cost with Open-Recipe UHPC Formula

by Monica Schultes

The Kilgore Road Bridge Restoration Project in Kenockee, Mich., was one of the earliest field applications of a nonproprietary ultra-high-performance concrete (UHPC) in the United States. That early demonstration project in St. Clair County garnered national attention for its innovative use of open-recipe UHPC. With the successful completion of this project, the material has been used on several other similar projects.

Dewayne Rogers, managing director of the Clare County Road Commission (CCRC), was aware of the benefits of UHPC from his previous position in St. Clair County, and he was determined that Clare County, which is located in the center of Michigan's Lower Peninsula, would make use of the innovative construction material despite its reputation for being expensive and difficult to handle. He learned that the University of Michigan and the Michigan Department of Transportation (MDOT) were exploring how to translate the proven performance of proprietary UHPC to everyday use. An open recipe for UHPC was developed by Sherif El-Tawil, a University of Michigan professor of civil and environmental engineering, at the request of MDOT. That formula is now available to anyone interested in using it.[1,2]

Rogers was quick to use the open-recipe concept to produce robust concrete for maintenance purposes. "It was a challenge to raise our game and think creatively about our assets in the long term," he says.

In addition to proving the inherent strength and durability of nonproprietary UHPC, the research team wanted to study the material's impact on long-term maintenance. "UHPC is still more expensive than regular concrete, but if you consider the effect over the lifetime of a bridge, then the cost becomes very competitive," says Rogers. He adds, "There are substantial hidden cost savings. The extremely high strength of UHPC can result in a massive reduction in structural component weight, which reduces handling, transportation, and foundation costs. These savings add up and make the overall cost of UHPC structures competitive."

"UHPC is still more expensive than regular concrete, but if you consider the effect over the lifetime of a bridge, then the cost becomes very competitive."

Similar to projects across the United States that used proprietary UHPC mixtures, CCRC used the generic UHPC for closure pours between standard precast concrete elements. Rogers has also begun to precast concrete bridge elements using the open-recipe UHPC.

Mixture Workability

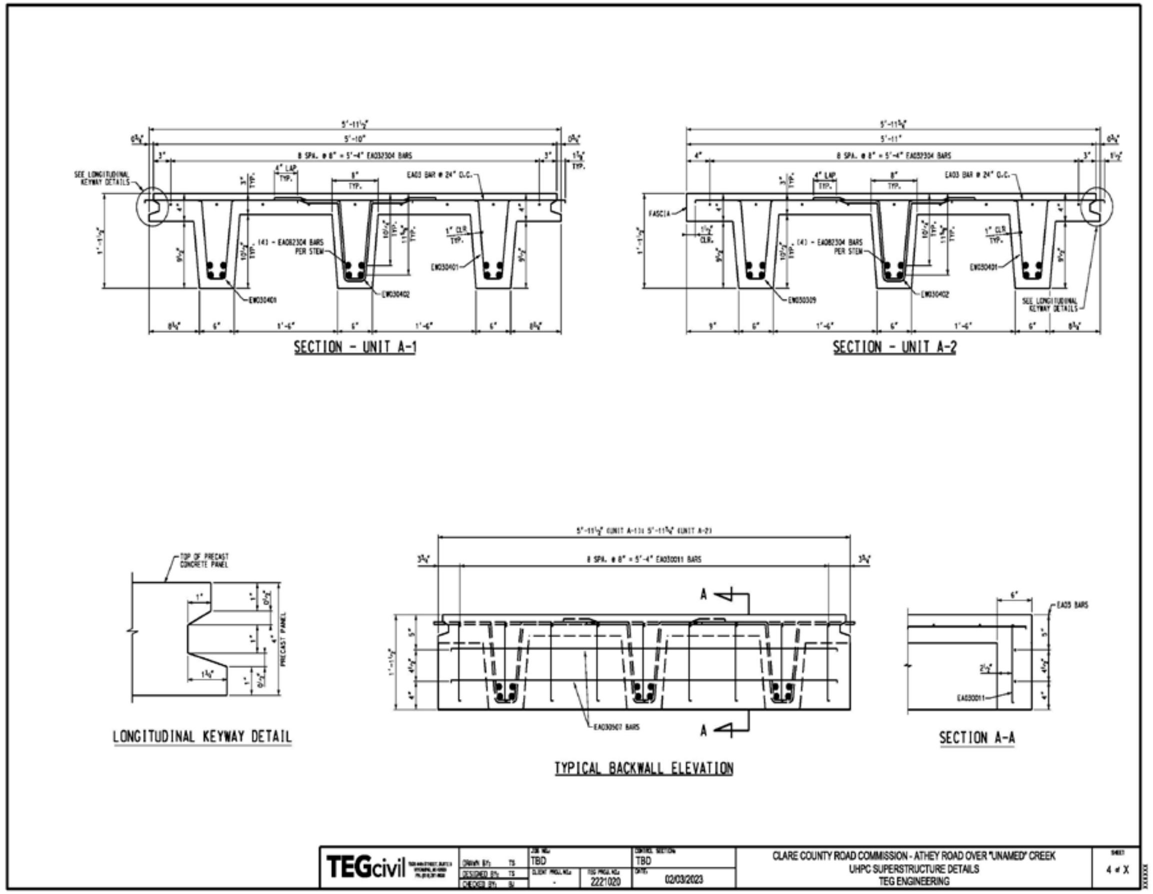
After extensive testing to prove the open-recipe UHPC performance characteristics, the University of Michigan research team focused on the workability of the concrete. Even with the cost savings, concrete production in the field needed to be streamlined and the workability of the generic UHPC would determine its ultimate success.

In the laboratory, the team had performed testing with a small drum mixer that replicated a concrete ready-mix truck. That method was then scaled up for field testing. "You have to change your mindset away from conventional concrete," states Rogers. "Conventional concrete has been around forever, and you have to vibrate and finish it. Neither are required for UHPC. You can put away your trowel."

The research team identified critical steps when preparing open-recipe UHPC. Careful consideration must be given to the mixing sequence, mixing time, mixing

Developed at the University of Michigan, the open-recipe ultra-high-performance concrete (UHPC) was carefully batched in small amounts on site (left) for deck closure pours for the Kilgore Road Bridge Restoration Project in Kenockee, Mich. This demonstration project was one of the earliest field applications of a nonproprietary UHPC in the United States. UHPC is placed in the closure joint after being batched with the light blue mixer visible in the background (center). The protruding all-thread rods visible in the photo on the right support the bottom formwork to prevent leakage during placement of the UHPC in the closure joints. All Photos: Clare County Road Commission.

What Is Next?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LONGITUDINAL KEYWAY DETAIL
TYPICAL BACKWALL ELEVATION
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CLARE COUNTY ROAD COMMISSION - ATHEY ROAD OVER "UNAMED" CREEK
UHPC SUPERSTRUCTURE DETAILS
TEG ENGINEERING

UHPC Triple Tee

Cost Saving Analysis

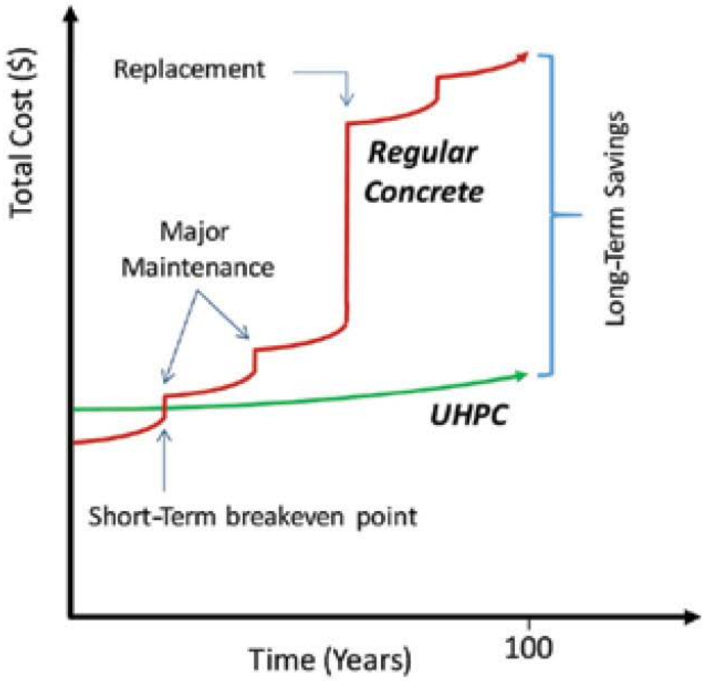


Fig. 5: Schematic diagram of life-cycle cost of UHPC and regular concrete

- Other Bridge Maintenance Topics
  - Drainage
  - Joint Sealing
  - Expansion Joint Cleaning
  - Deck Cleaning
  - Clearing Brush
  - Deck Waterproofing
    - Crafco UltraSeal
    - Epoxy Overlay
  - Large Culvert Replacement
  - Joint Repairs
  - Deck Patching

Standing Water On The Bridge

Saw And Re-Seal Existing Joints; Caulk or Rubber

Remove Dirt; Check Joint for Leaks

Remove Dirt and Debris from Bridge Deck

Clear Trees and Brush Around Bridge

Waterproofing With Crafco UltraSeal
Remove Existing HMA, Clean Concrete

Have The Right Tools!!!

Placing Hot Rubber and Fabric

More Rubber With Bit Board

New Asphalt Surface

Epoxy Coating or Transpo T-18

Aluminum Arch Culvert

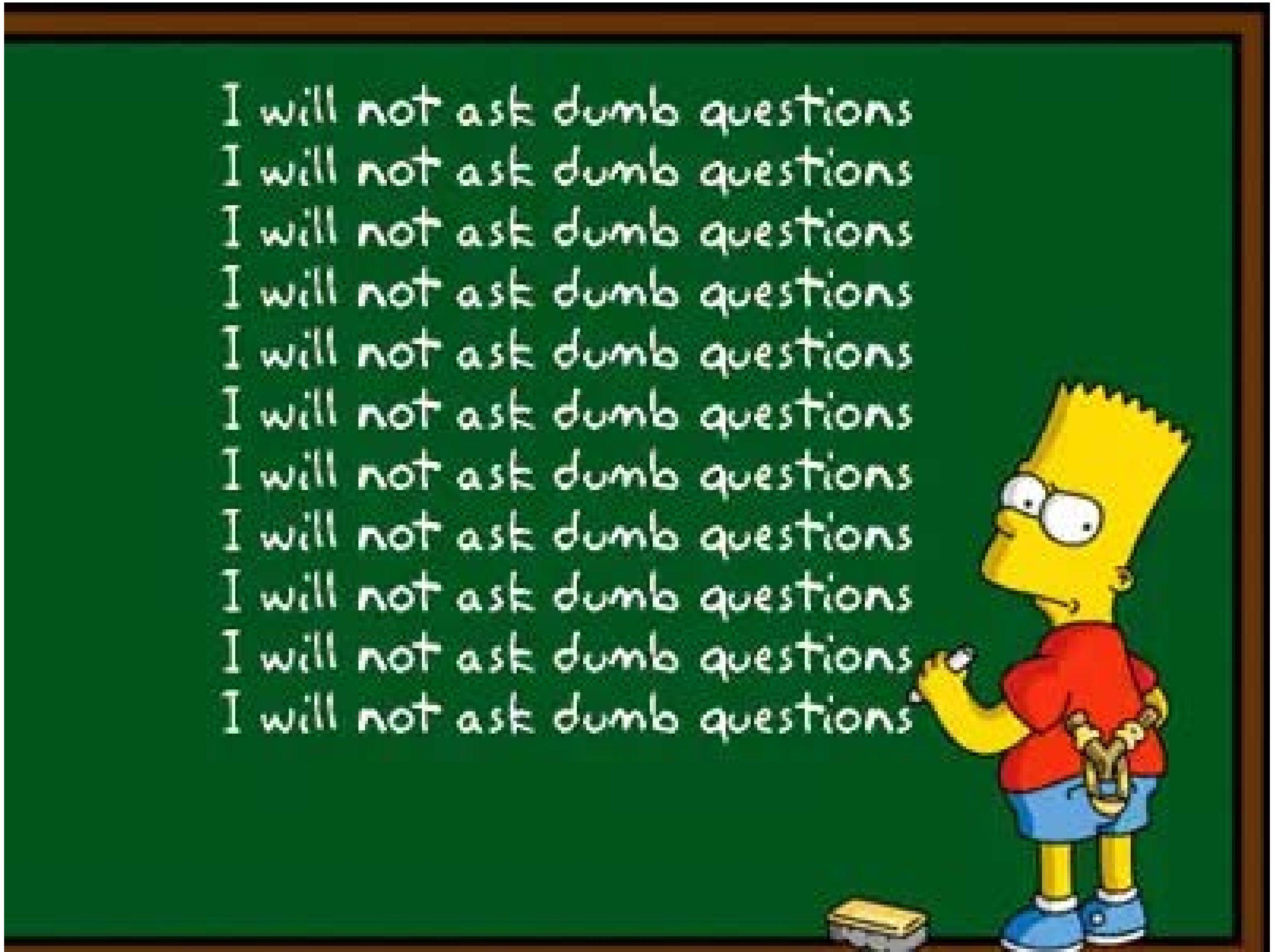
Aluminum Arch Culvert

Longitudinal Joint Repair with UHPC

Deck Patching and Repair


bleecakes
Check please !

Questions?



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