Link Slab with UHPC Ready-Mix Delivery

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CITY of BOSTON  Jacobs
Project Location

[Image of an aerial view of an urban area with labeled streets including Boylston St, Cambria St, Dalton St, Mass Turnpike, and Railroad.]

[Logo of the Massachusetts Department of Transportation (massDOT) and the U.S. Department of Transportation Federal Highway Administration.]
Dalton Street Bridge

- Bridge carries Dalton Street over East/Westbound Roadways of the Mass Turnpike, MBTA Commuter Rail/Amtrak and Cambria Street in Boston MA
- Four Simple Span Steel Stringer bridge
- Existing Bridge Construction – 1964 – Design Truck Load HS-20
- Limited staging areas – Stage construction required
Proposed Bridge Plan

Location of Ready-Mix UHPC Link Slabs
Concrete Deck Placement
Why UHPC Link Slabs
UHPC Link Slabs

- Limited link slab width
  - 20,000 psi compressive strength required
- Durable closure pour material
- No modification to beams (removal of studs) required
- Detail – New York State DOT
What is UHPC

- Cementitious composite material
- Compressive strength > 20.0 ksi
- Steel Fibers
- Pre- and post-cracking tensile strength > 0.72 ksi

<table>
<thead>
<tr>
<th>Condition</th>
<th>Requirement</th>
<th>ASTM Standard</th>
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<tbody>
<tr>
<td>Heat Treated*</td>
<td>&gt;25ksi</td>
<td>ASTM C39</td>
</tr>
<tr>
<td>Not Heat Treated**</td>
<td>&gt;20ksi</td>
<td>ASTM C39</td>
</tr>
<tr>
<td>Not Heat Treated – 3 day**</td>
<td>&gt;12ksi</td>
<td>ASTM C39</td>
</tr>
<tr>
<td>Prism Flexural Tensile Toughness</td>
<td>$l_{30} &gt; 48$</td>
<td>ASTM C1018 (10” span)</td>
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<tr>
<td>Long Term Shrinkage</td>
<td>&lt; 766 microstrain</td>
<td>ASTM C157 (initial reading)</td>
</tr>
<tr>
<td>Chloride Ion Penetrability</td>
<td>&lt; 766 coulombs</td>
<td>ASTM C1202</td>
</tr>
<tr>
<td>Chloride Ion Penetrability</td>
<td>&lt; 0.07 oz/ft3</td>
<td>AASHTO T259 (1/5” depth)</td>
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<tr>
<td>Scaling Resistance</td>
<td>$y &lt; 3$</td>
<td>ASTM C672</td>
</tr>
<tr>
<td>Abrasion Resistance</td>
<td>&lt; 0.025 oz. lost</td>
<td>ASTM C944 (2x wt., ground surface)</td>
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<tr>
<td>Freeze-Thaw Resistance</td>
<td>RDM &gt; 96%</td>
<td>ASTM C666A (600 cycles)</td>
</tr>
<tr>
<td>Alkali-Silica Reaction</td>
<td>Innocuous</td>
<td>ASTM C1260 (tested for 28 days)</td>
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ITEM 999.01: ULTRA HIGH PERFORMANCE CONCRETE LINK SLAB  SF

The work under this item shall conform to the applicable provisions of Section 901 of the Standard Specifications, and the following:

DESCRIPTION

The work for Item 999.01 includes all work required to construct the ultra-high-performance concrete (UHPC) link slab as shown on the drawings. Including but not limited to the following: reinforcement, concrete materials, mixture design, placement procedures, and finishes for UHPC above a deboned zone located at Pier 2. All labor, equipment, and materials required to complete the work as shown on the drawings and as described in this section are included under this item.

QUALITY ASSURANCE

Quality assurance for all cast-in-place concrete work shall be in accordance with Section 995 of the Standard Specifications.

SUBMITTALS

The Contractor shall submit to the Engineer for approval the following:

- Proposed UHPC product data and material specifications.
- Steel reinforcement shop drawings.
- Sheet gasket material data sheets and specifications.
- Detailed sequence of construction for the link slab.
- Material testing reports and certificates.
- Field quality testing and inspection reports.
- Installation Drawings for the UHPC Link Slab.

MATERIAL

Sand

Sand used shall be in accordance with Section M2 of the Standard Specifications.

The sand shall be commercial quality dry blast sand. 95% of the sand shall pass the #8 sieve, and 95% shall be retained on the #50 sieve. The container shall include the following information: The name of the manufacturer, the brand name of the product, the date of manufacture.

Water

UHPC Spec
**UHPC – COR-TUF**

**THE ONLY LICENSED PRODUCER OF COR-TUF UHPC IN THE UNITED STATES AND THE WORLD.**

**MEETING ALL OF YOUR UHPC NEEDS**

**DESCRIPTION**

Cor-Tuf CT25 UHPC is a class of concrete that is exceptionally strong and durable. Originally developed by the U.S. Army Corps of Engineers, it combines form and function with strength and resiliency.

Cor-Tuf CT25 has 10 times the compressive strength of traditional concrete and an estimated longevity of more than 100 years, versus 15-25 years for traditional concrete. It has been shown to withstand more than 1,200 freeze-thaw cycles with no damage whatsoever, while traditional concrete starts to deteriorate after only 28 cycles. Cor-Tuf UHPC is also impervious to water and resistant to other harsh environmental conditions. These qualities make Cor-Tuf ideal for traditional uses of concrete, such as bridge construction and repair, as well as new applications of concrete, such as contemporary designs that require thinner components or complex shapes. The exceptional durability of Cor-Tuf UHPC delivers a total life-cycle cost that is lower than traditional concrete, while delivering added benefits of safety, resiliency, and energy efficiency.

**APPLICATIONS**

Cor-Tuf CT25 is our standard material formulation and can be used in a wide range of applications including pre- and post-tensioned structural component construction, prestressed panels, field-cast structural connections, wear surface overlays, marine installations, injection and extusion techniques, tilt-up construction, blast and corrosion resistance, cast in place joints and many others. CT25 is a highly versatile mix that can be used as a direct replacement for standard concrete and is compatible with all industry standard production techniques ranging from large scale pre-cast facilities down to small cast in place applications.

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**PRODUCT DATA SHEET CT25**

**Constituents, Packaging and Yield:**

1. **Pastes:** proprietary pre-portioned constituents, local marble sawdust and Portland cement per QC manual.
   - 60 lb (27 kg) bag, 27 bags per pallet per pallet (2 pallets per pallet)
   - 1 pallet weighs approx. 1.3 ton (yard)
   - 1 pallet weighs approx. 2 cubic yards
2. **Additives:** sand and cement, blended separately, available upon request or use your own.
3. **Liquid Admixtures:** high-range water reducer, corrosion inhibitor.
   - 1 gal (3.8 L) Ibs
   - 0.5 gal (1.8 L) lbs
   - 0.25 gal (0.9 L) lbs
4. **Steel Fibers:** 0.003 in (0.06 mm) x 0.05 in (1.3 mm) long. Steel strength 50,000 psi (350 MPa) (not included as pre-mix)
5. **Water:** to be provided by contractor in accordance with QC manual.

**Storage:**

All materials should be stored in a dry environment, under cover to prevent moisture accumulation and dimensional shrinkage. Ideal storage temperatures range from 60 to 80°F (15 to 27°C). Materials should be stored for up to six months in the original unopened packaging.

**Preparation:**

Surfaces to be in contact with CT25 should not be pre-wetted or pre-soaked with water. Stone, gravel, sand and other coarse-textured contaminants should be pre-wetted and pre-soaked as necessary. CT25 should be placed as soon as possible without unnecessary delays.

**Batching:**

The batching of CT25 or any other Cor-Tuf UHPC product shall be done in accordance with Cor-Tuf published QC and batching protocols. Cor-Tuf requires all batching of CT25 be done only by trained and certified personnel. All batching shall be performed, weighed, and sequenced in accordance with Cor-Tuf batching protocols per field conditions. Material management is a key factor in the batching of CT25 and is based on volumetric measurement at the time of mixing. Follow all procedures for decomposing and recording batch moisture content prior to mixing per batching protocols.

CT25 is highly versatile and can be batched in a variety of batching solutions ranging from high yield industrial applications down to single yard solutions however, high shear mixes are recommended to properly batch CT25. Consult Cor-Tuf UHPC prior to batching to evaluate any proposed batching equipment.

**Finishing:**

Due to the variability of CT25, please consult with Cor-Tuf's technical division when finishing is required.
Ready-Mix UHPC

- First project using Ready-Mix UHPC delivery by Boston Sand and Gravel and Cor-Tuf

- Ready-Mix UHPC – Quality Control at Plant instead of in the field

- Several test batches of UHPC were prepared to validate the UHPC preparation and mix design

- SPS working with Boston Sand and Gravel and Cor-Tuf produced and delivered the Ready-Mix UHPC in trucks as opposed to in small mixers at the site

- Ready-Mix UHPC allowed for the entirety of the link slabs to be poured from a single batch
UHPC Design Properties
- Concrete Strength @ 4 days=12,000 psi
- Concrete Strength @ 28 days=20,000 psi

UHPC Test Results – Field from Truck
- Concrete Strength @ 4 days=16,400 psi
- Concrete Strength @ 7 days=19,200 psi
- Concrete Strength @ 28 days=21,000 psi
UHPC Link Slab Construction

Loading Mixer – UHPC at Plant
UHPC Link Slab Construction

Placing UHPC
UHPC Link Slabs

Placing UHPC
UHPC Link Slabs

Placing UHPC
UHPC Link Slabs

Finishing UHPC
UHPC Link Slabs

Finishing UHPC
UHPC Link Slabs

Finished Roadway Link Slab
UHPC Link Slabs

Link Slab Protection

Link Slab Heating

Link Slab Curing
UHPC Link Slabs

Link Slab before Grinding

Finishing the Link Slab

Grinder Vacuum
Grooving Deck

Grooving of the Bridge Deck
How can Ready-Mix UHPC be used

- UHPC Overlays of Deteriorated Concrete Bridge Decks
- Link Slabs
- Beam Closure pours
- Encasement of Deteriorated Steel Beam Ends
- Encasement of Deteriorated Concrete Substructures
- Strengthening of Concrete Substructures
Acknowledgements

- City Of Boston
- SPS
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- Cor-Tuf
- Massachusetts Department of Transportation
- New York Department of Transportation
- Jacobs Engineering Group
Questions