ABOUT COR-TUF
INTRODUCTION TO COR-TUF UHPC
PRODUCT APPLICATIONS AND COMPARISONS
PRODUCT DEMOSTRATION VIDEOS

WHAT IS ULTRA HIGH PERFORMANCE CONCRETE

PRESENTATION AGENDA
What is UHPC

Federal Highway Administration

- Defined by Federal Highway Publication FHWA HRT-13-060
- Published in June 2013
What is UHPC

Federal Highway Administration

- UHPC is a cementitious composite material composed of an optimized gradation of granular constituents, a water-to-cementitious materials ratio of less than 0.25, and a high percentage of discontinuous internal fiber reinforcement.

- The mechanical properties of UHPC include compressive strengths greater than 21.7 KSI (150 MPa)

- Sustained post-cracking tensile strength greater than 0.72 KSI (5 MPa)
What is UHPC

- Mixture of
  - Supplementary Cementitious Materials
  - Superplasticizers
  - Fiber Reinforcement

- Utilizes the particle packing theory to decrease interstitial void spaces to the absolute minimal size possible.

Originally presented by Ben Graybeal (FHWA) on 6/18/16 at the 1st International Interactive Symposium on UHPC
What is UHPC

• ACI 239 – Ultra-High-Performance Concrete

• Concrete, ultra-high performance – concrete that has a minimum specified compressive strength of 150 MPA (22,000 psi) with specified durability, tensile ductility and toughness requirements; fibers are generally included to achieve specified requirements.
About Cor-Tuf

- Company founded by Douglas Darling in 2016

- Product was originally developed for defense applications by the Army Corps of Engineers. Concrete needed to be tough and light weight.

- 10 times the compressive strength of conventional concrete and an estimated longevity of more than 100 years.
Cor-Tuf exceeds FHWA / ACI UHPC definitions through the following typical material properties:

- Compressive Strength
  - ASTM C 39
  - 73°F/100% RH
  - at 1 day: 9,050 psi
  - at 3 days: 11,140 psi
  - at 14 days: 20,780 psi
  - at 28 days: 22,920 psi
  - at 56 days: 24,770 psi

- Controlled Curing
  - 73°F/50% RH
  - 28 days (28 days Dry): -0.033%

- Chloride Penetrability
  - ASTM C 1202 AASHTO T277
  - 73°F Limewater
  - 190°F water 5 days; 190°F air 2
  - 28 days: >100 (Negligible)
  - 28 days: >100 (Negligible)

- First-Peak Strength
  - ASTM C 1609
  - 73°F/Limewater
  - 28 days: 1,811 psi

- Residual Strength (L/600)
  - ASTM C 1609
  - 73°F/Limewater
  - 28 days: 1,653 psi

- Residual Strength (L/500)
  - ASTM C 1609
  - 73°F/Limewater
  - 28 days: 940 psi

- Abrasion Resistance, Ave Loss
  - ASTM C 944
  - 73°F/Limewater
  - 58 days: 0.016 oz

*All data has been verified by independent laboratory CTL Group. Project #059330 Client: Cor-Tuf UHPC
What availability options exist for UHPC?

- Proprietary versions – Cor-Tuf, Ductal etc..
- Non-Proprietary version
- Non-Proprietary versions of UHPC are still under development. FHWA-HRT-13-100

Originally presented by Ben Graybeal (FHWA) on 6/18/16 at the 1st International Interactive Symposium on UHPC
How is Cor-Tuf packaged?

- Individual 50 Lb. bags
- 1-yard super sacks
  - Can be mixed with or without fiber, sand and cement (complete mix)
- Full pneumatic tanker
About Cor-Tuf

Fiber Reinforcement

- Steel fiber is used for reinforcement
- 13 mm x .20mm
- Minimum tensile strength of 2.6 N/mm² is required
Introduction to Cor-Tuf UHPC

US Army Core of Engineers Testing Facility at Treat Island

- Statement from US Army Corps of Engineers –

- Cor-Tuf 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, resiliency.

- It also has the ability to be prepared and poured in mass quantities via conventional means and methods common to the concrete industry.

Originally presented by Ben Graybeal (FHWA) on 6/18/16 at the 1st International Interactive Symposium on UHPC
Introduction to Cor-Tuf UHPC

UHPC Permeability

- ASTM C1556 – 11
- Chloride Ion Diffusion Coefficient
  - $2 \times 10^{-11} \text{ m}^2/\text{s}$ for conventional concrete
  - $2 \times 10^{-12} \text{ m}^2/\text{s}$ for HPC
  - $2 \times 10^{-13} \text{ m}^2/\text{s}$ for UHPC
- Less than 100 coulombs of permeability versus 1800 in regular concrete
Introduction to Cor-Tuf UHPC

UHPC Durability

- Can withstand more than 1,000 freeze/thaw cycles with no damage versus 27 for traditional concrete.
- Particle packing principle reduces void spaces to prevent penetration by water and other chemicals.

Originally presented by Ben Graybeal (FHWA) on 6/18/16 at the 1st International Interactive Symposium on UHPC.
Introduction to Cor-Tuf UHPC

• Typical values range between 18 and 35 KSI
  • Cor-Tuf has demonstrated consistent values in excess of 28,000 PSI

• UHPC typically exhibits 10x the compressive strength of conventional concrete

Originally presented by Ben Graybeal (FHWA) on 6/18/16 at the 1st International Interactive Symposium on UHPC
Introduction to Cor-Tuf UHPC

UHPC Flexure Standards

- C1609/C1609M

- Test Method for Flexural Performance of Fiber-Reinforced Concrete (Using Beam with Third-Point Loading)

- NOT ASTM C78 - Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
Introduction to Cor-Tuf UHPC

UHPC Flexure Standards

• Recent development of “Direct Tension Test” (Pull Up Test) with FHWA - Ben Graybeal, Ph.D., University of Florida - Kyle Riding Ph.D. and University of Alabama – Sriram R. Aaleti Ph.D.
Introduction to Cor-Tuf UHPC

- Cor-Tuf can be mixed using a variety of industry standard means and methods.
  - Small stationary field mixers
  - Large central batching facilities
  - Skid-steer Auger Bucket

- Cor-Tuf can be pumped using conventional concrete pumping solutions.
  - Cleans using only water

- Can be transported and placed using Tucker-built or ready-mix trucks
Introduction to Cor-Tuf UHPC

Benefits of Cor-Tuf UHPC

- Precast pouring of larger and longer structural components
- Reduced structural design criteria in reinforcing components
- Compatible with extrusion and extraction techniques
- Compatible with pre- and post-tensioning
- Can be used to create precast beams and deck panel
- Can link slabs between adjacent spans
- Precast parapets and side barriers
- Can be used in Tilt-up construction
- Cast in place joints between precast beams, deck panels and stud pockets
How Cor-Tuf UHPC Replaces Traditional Concrete

<table>
<thead>
<tr>
<th>Strength</th>
<th>Durability</th>
<th>Impermeable</th>
<th>Ductile</th>
<th>Versatile</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 times the compressive strength of conventional concrete, achieves half strength in 5-7 days</td>
<td>Can withstand more than 1,000 freeze/thaw cycles with no damage versus 27 for traditional concrete</td>
<td>Less than 100 coulombs of permeability versus 1800 in regular concrete</td>
<td>Has a demonstrated tensile strength in excess of 1,800 psi versus 600-800 of standard concrete</td>
<td>Hardens according to mix design variability and can be handled in as little as 8 hours</td>
</tr>
</tbody>
</table>
Blast and Impact Resistant – Originally developed by the US Army Corps of Engineers, Cor-Tuf is an ideal defense material.

Superior Adhesive – Unlike standard concrete, no special surface preparation is required to use Cor-Tuf.

Lighter Weight – Panels are 25-33% thinner than those of equivalent size made with conventional concrete.

Chemical Resistance – Due to its impermeability Cor-Tuf is highly resistant to salt and chemical penetration.

Longer Lifespan – Cor-Tuf has much longer useful lifespan in excess of 100 years versus 15-25 for traditional concrete.
Additional Benefits

• Off-site manufacturing
• Accelerated Bridge Construction via critical path savings
• Elimination of primary and/or secondary reinforcement
• Retrofit and modification projects
• Architectural design implications
• Structures exposed to harsh elements
• Accent the vertical and horizontal shear values
Cost Savings with Cor-Tuf UHPC

- Lower lifecycle cost
- Expediently reduces overall structural maintenance
- Expedites critical path method (CPM)
- Less material required for projects
- Lower gross weight reduces support and footing requirements
- Faster construction
- Reduced maintenance requirements
- Pumpable, cleans from equipment with only water
Aerial view of the VDOT crew pouring the bridge panel connections
Pre-tensioned piling being removed from its form during Florida Dot tests at Dura Stress Inc.
Cor-Tuf designated batch plant at Dura-Stress Inc. – Leesburg, Florida
Cor-Tuf being poured via ready mix truck during H-piling casting at Dura Stress Inc.
Pre-tensioned H-piling after casting at Dura Stress Inc.
Cor-Tuf UHPC beam prepared for transportation to the Turner-Fairbank Highway Testing facility - FHWA
Cor-Tuf UHPC security planters prepared for DOD / LBM Research Associates
Installation of 18"x18"x100' square piling in Leware Construction Yard, Leesburg FL.

Piling showed 100% integrity throughout installation.
Product Demonstration Videos

- Cor-Tuf Piling Lifecycle
- Cor-Tuf UHPC H-Piling Production
References

• UHPC 101, An Introduction to Ultra-High-Performance Concrete
  • Written and presented by Ben Graybeal, Ph.D., P.E.

• Ballistic Penetration Test Results For Ductal® And Ultra-High-Performance Concrete Samples
  • Written by Tom F. Thornhill, William D. Reinhart
  • Sandia Report Sand 2010-2222 Unlimited Release Printed March 2010

• Federal Highway Administration – Ultra-High-Performance Concrete

• Cor-Tuf
  • https://cor-tuf.com/