Ultra-High-Performance Concrete (UHPC) Based Repair/Upgrade Solutions

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CYLINDER ON LEFT IS UHPC. ON RIGHT IS CONVENTIONAL CONCRETE. CONDITION AFTER SIMULATING BEING 400 FT., BELOW OCEAN WATER 10 MINUTES – NSC 30 MINUTES - UHPC
UHPC for Repair
Best use of UHPC perhaps is in retrofit and upgrading existing deficient structural members
TYPICAL DAMAGE OF COLUMNS DUE TO CORROSION
Use of UHPC for Repair
In Europe
UHPC for Damaged Beam
Venetian Causeway Bridge - Miami
### Load-Displacement 15 feet deck

**Graph:**
- **Axes:**
  - Y-axis: Load (Kips) from 0 to 120
  - X-axis: Displacement (in) from 0 to 10

**Graph Lines:**
- **Red Line:** Retrofitted Deck
- **Green Line:** Deck With Damage
- **Blue Line:** Deck without Damage

**Legend:**
- Retrofitted Deck
- Deck With Damage
- Deck without Damage

**Table:**

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Maximum load based on Moment-Curvature analysis (kips)</th>
<th>Maximum Load based on Finite Element Model (Kips)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deck Without Damage</td>
<td>85</td>
<td>85</td>
</tr>
<tr>
<td>Deck With Damage</td>
<td>37.7</td>
<td>38</td>
</tr>
</tbody>
</table>
Specimen was subjected to three million cycle of loading before conducting ultimate load test
Load vs Cycles

Cycle No. 8000

Cycle No. 150000
UHPC can also be used to repair beam elements
With damage

Shell 0.75

Shell 0.75+nail

Shell 0.75+ Dense nail

Shell 1.5

Shell 2
TEST RESULTS

Control Test Specimen

Graph showing load (kips) vs. displacement (in) for Shell 0.75 and Shell 2, with a control test specimen.
Retrofitting Columns Using UHPC
TYPICAL DAMAGE OF COLUMNS DUE TO CORROSION IN MIAMI
CONCEPT OF REPAIR METHOD

Advantage:

➢ Flowability
➢ Short tension development length
➢ Early gain strength and capacity improvement
➢ Durability
➢ Good bond between fresh UHPC and concrete substrate
➢ Low permeability
➢ Low amount of cast in place
REPAIR PROCESS

➢ Surface preparation

➢ Batching repair
DISCUSSION ON EXPERIMENTS

UNIT 8: Column Repair (UHPC 2% fiber)
Symmetric repair

UNIT 9: Column Repair (UHPC 4% fiber)
Symmetric repair

UNIT 10: Column & footing repair (UHPC 2% fiber)
Symmetric repair

UNIT 10: Column & footing repair (UHPC 4% fiber)
Symmetric repair
Test Specimens
Moment Curvature

Moment Curvature Graph

- Moment (Kips-in)
- Curvature (1/in)

NC
UHPC

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UHPC to Repair Timber Piles
Samples in place
Shotcrete Using UHPC
Equipment – Air Compressor
Equipment – Pneumatic Nozzle
Use of UHPC in Conjunction with Pneumatic Spray Application and Robotic for Repair and Strengthening of Culverts- Phase I
Repairing Pipes and Culverts
Shotcrete Robot- Will be Ready In six months

- 3 to 5 feet culverts, Fully autonomous
UHPC Connection for precast Elements
Proposed Connection Detail

- Cap Beam
- Splice Region
- Prefabricate Column
- UHPC

Detail 1
Also Tested Series of Circular Columns
UHPC Connection for Concrete Filled Steel Tubes
Proposed CFT Connection

Stage 1
- A recess is constructed in the precast element.
- Internal and external dowels are embedded.

Stage 2
- CFT is placed inside the recess
- Shear studs used on CFT tube

Stage 3
- Recess filled with UHPC
- Normal Strength Concrete filled in CFT
Results

Minimal damage observed in UHPC Step

Buckling of tube
Results
High Rise Building Design Using UHPC
42 STORY PROTOTYPE BUILDING

I SHAPE & C SHAPE SHEAR WALL

GRAVITY COLUMN
UHPC Details for SDCL System
Alternative UHPC Connection
Prefabricated Barrier System
Connection of Barrier to Slab
Innovative Approaches to Use UHPC

UHPC Formwork Using 3D Print
Process of 3D Printing
BASIC SOLUTIONS FOR USE OF ULTRA-HIGH PERFORMANCE CONCRETE (UHPC) IN ADDITIVE CONSTRUCTION

Sponsored by US Army Corps

Atorod Azizinamini (PI)
Kingsley Lau (co-PI)
Select recent publications related to UHPC and based on research projects, supervised as PI by Dr. Azizinamini


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We do look for industrial partners to take our UHPC based solutions into market

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