FHWA BRIDGE ENGINEERING RESEARCH

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ALKALI-SILICA REACTION TEST
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Bridge Engineering Research
Turner-Fairbank Highway Research Center

U.S. Department of Transportation
Federal Highway Administration
Marrying UHPC, 0.7” strands, and refined cross sections to deliver the future of pretensioned girders
ULTRAGIRDER Concept

F.I.B.-102, Concrete Girder

Conventional concrete

(66) 0.6-in. strands

Span = 200 ft

UHPC

Span = 300 ft

UltraGirder

FIB 102
0.6” Strands
4’-1”
3’-3”
8”
8’-6”

FIB 102
0.7” Strands
4’-1”
3’-3”
8”
8’-6”

FIB 102 - 6” Web
0.7” Strands
4’-1”
3’-3”
6”
8’-6”

FIB 120 - 6” Web
0.7” Strands
3’-3”
3’-9”
6”
10’
UltraGirder Project Experimental Program

Modified PCEF-39 and PCEF-47 sections

- Girders reinforced with 0.7 in. diameter strands prestressed to 59.5 kips
- Total prestressing force in section up to 1,547 kips
UltraGirder
Engineering New Solutions…

**UltraGirder concepts can facilitate:**

- Longer Spans
- Shallower Girders
- Lighter Girders
- Reduced End Zone Concerns
- More Durable Solutions
- Increased Competition
Interested in the innovation?

FHWA/TFHRC welcomes partners who want to work with us to bring these innovations into practice.

ULTRAGRDER

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A Novel Advancement in Steel Joining Technology
Homopolar Generator Welding

Why?

• How long to completely weld a 3” thick, 30” wide steel plate with conventional submerged arc welding?

~ 30 hours

• What if you could do it in fractions of a second?
How does it work?

... Convert Kinetic Energy into Electric Current ...

Homopolar Generator Welding
How does it work?

¼ scale HPG and forging fixture built for SBIR.

Starting with 6 x 1 inch welds

HPGW = resistance heating + forging
The real deal…

** Video copyrighted KAI, LLC. **

Homopolar Generator Welding
FHWA Evaluation of HPG Welds

- ASTM A709 HPS 70W plate
- Evaluating reduced section tension, side bends, and CVN energy
- Evaluated two welds so far
HPG Weld Testing: Reduced Section Tension

PASS!
Fractured in base metal, strength exceeds AASHTO/AWS D1.5 requirement

Homopolar Generator Welding
HPG Weld Testing: Side Bend Tests

**PASS! No Defects**

Homopolar Generator Welding
HPG Weld Testing: Charpy V-Notch

A work in progress...

Base metal L-T direction results
ASTM A709 HPS 70W requirements are 25 ft-lbf @ -10 °F for non-fracture critical members or 35 ft-lbf @ -10 °F for fracture critical members

Weld results (green squares)
AASHTO/AWS D1.5 requires 25 ft-lbf @ -10 °F for temperature zones I and II
HPG Weld Testing: Charpy V-Notch

Broken CVN left side (50x)  V-notch  Broken CVN right side (50x)

Hypothesis: the forging pressure is too low

Homopolar Generator Welding
Next Steps…

Process optimization still on-going

Low impact resistance can likely be mitigated

Maybe more to report next year
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Homopolar Generator Welding
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A Better, Quicker and More Reliable Method to Assess ASR Susceptibility
Current ASR Tests Originate from 1948

- Meilenz, Green and Benton (ACI 1947)
- Sprague, Hun et al. (ACI 1948)
- 1-N Sodium Hydroxide 80°C
- Measured Mortar Bar Expansion
Current ASR Tests Methods

Aggregates
  - ASTM C 289 - poor reliability
  - Petrography - useful tool but depends on skill

Mortar
  - ASTM C 227 - leaching
  - ASTM C 1260 - overly severe

Concrete
  - ASTM C 1293 - long testing period, leaching, unsuitable for the eval. of job mix
FHWA/TFHRC ASR Aggregate Test – Pure Chemistry

- Mill Report
- Mix Design
- 5g Aggregate
- 21 Days
• Studied Chemistry of ASR Gels
• ASR gel has no unique composition
• Chemical composition of gels affect structure which affects expansion
• Raman Spectroscopy helped identify what chemical parameters are important in a test
# Comparison of Accelerated ASR Tests

<table>
<thead>
<tr>
<th>ASR TESTS</th>
<th>Aggressive Environment</th>
<th>Possibility to test job mix</th>
<th>Realistic concrete pore solution</th>
<th>Testing period</th>
<th>Mirror field performance</th>
<th>Testing Efficiency</th>
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<tr>
<td>ASTM 1260</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Medium</td>
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<tr>
<td>ASTM 1293</td>
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<td>TFHRC Chemical Test</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>High</td>
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</tbody>
</table>
Correlation with Physical Expansion (TFHRC Test)

- **Expansion**
- **False Negative**
- **False Positive**

**ASR Aggregate Testing**

**Exposure Block Expansion, %**

**Reactivity Index**

- No Expansion
- Expansion
- False Positive

**Graph Attributes**
- Color Coding: AL, SP, SX, RH, SU
- Data Points: Blue, Orange, Green
TFHRC Rapid Chemical ASR Test

- The test can accurately detect highly and non reactive coarse aggregates
- Intermediate reactive aggregates are more challenging
- Comparison of lab test results with known field block expansion shows good correlation.
- We are looking for field cases and block farm data to further populate the calibration charts.
Calibration of TFHRC ASR Test

Field Cases, block farms, or structures

- Aggregate samples 500g.
- Cement samples 50g or mill certificate
- Mix Design
- Expansion Data (New and Historical)
Interested in the innovation?

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**ASR TEST METHOD**
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