Innovative Use of Ultra-High Performance Concrete for Rapid Bridge Construction
Author and Presenter:

Philip Murray, M.Eng., P.Eng.
Senior Vice President, Hatch

Co-Authors:

Biljana Rajlic, P.Eng.
Senior Vice President, Hatch

Robert Burak, P.Eng.
President, Canadian Precast Prestressed Concrete Institute (CPCI)
Challenges:

• First grade separated interchange in Northwestern Ontario
• Across the busiest highway
• Short construction season
• Resource constrained
• Harsh climate and De-icing chemical
• Aesthetics to match nearby scenery
Solutions:

• Prefabricated components
• Less on-site working days
• Best use of available resources
• High strength and durability concrete
• Very slender profile with enhanced quality
Modular Construction

“Bridge-out-of-a-box”
## Previous Projects

<table>
<thead>
<tr>
<th>Name of Structure</th>
<th>Year</th>
<th>Spans (m)</th>
<th>Precast Components</th>
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Modular Construction

Pre-fabricated components
Modular Construction

32 Prestressed Box Girders
Modular Construction

30 sidewalk/parapet wall panels
Modular Construction

2 Ballast walls and Abutment caps
Modular Construction

20 slope paving panels
Modular Construction

16 approach slab panels
Modular Construction

An inverted-T shape UHPC pier cap
Modular Construction

3 UHPC pier column shells
Modular Construction

Components assembled
Modular Construction

Field-cast UHPC joints
UHPC

- Ultra-High Performance Concrete (UHPC)
- Cement matrix with internal fibres
UHPC

- Compressive strength up to 200 MPa
- Tensile strength up to 10 MPa
UHPC

- High strength
- Ductility
- Durability
- Fluidity – Self-consolidating
UHPC Joints

- Shear key between girders
UHPC Joints

- Continuity joint over pier
UHPC Joints

- Abutment cap joints
UHPC Joints

- Approach slab panel joints
UHPC Joints

- Sidewalk/parapet wall panel joints
Pier Columns with UHPC Shells

- Construction – Stay-in-place form with reinforced concrete infill
- Durability – Low porosity protective shell
- Aesthetics – Octagonal flaring geometry
UHPC Pier Cap

UHPFRC CAST-IN-PLACE JOINT

UHPFRC PRECAST PIER CAP

PRECAST BOX GIRDER

PRECAST BOX GIRDER

PRECAST COLUMN WITH PRECAST UHPFRC SHELL
UHPC Pier Cap

- Conventional pier cap design

- Hodder embedded pier cap design
UHPC Pier Cap

- Inverted-T shaped pier cap
- Prestressed and precast with UHPC
UHPC Pier Cap

- Finished pier cap with columns
UHPC Pier Cap

- Finished pier cap with columns
Highlights:

- On-site working days is 80% of conventional method
- Erect each girder in 15 minutes
- Less formwork and associated safety issue
- Effective use of UHPC and precast resources
- Unique design of pier cap and joint
- Stay-in-place pier column form
- Minimized impact on the traffic
- Enhanced quality, durability and aesthetics
Typical Highway Bridges
Typical Highway Bridges

Hodder Ave. Underpass

Source: Google

Source: Lafarge

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# Slenderness

<table>
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<tr>
<th>Examples</th>
<th>Elevation</th>
<th>Span-to-depth ratio</th>
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<tbody>
<tr>
<td>Hodder Ave. Underpass, Thunder Bay, Ontario (Photo: Lafarge)</td>
<td><img src="image1.png" alt="Image" /></td>
<td>29.1</td>
</tr>
<tr>
<td>A bridge over Highway, Ontario (Photo: Hatch)</td>
<td><img src="image2.png" alt="Image" /></td>
<td>Approx. 14.0</td>
</tr>
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<td>Doane Road Underpass over Highway 404, Queensville, Ontario</td>
<td><img src="image3.png" alt="Image" /></td>
<td>18.3</td>
</tr>
<tr>
<td>Queensville Side Road Underpass over Highway 404, Queensville, Ontario</td>
<td><img src="image4.png" alt="Image" /></td>
<td>19.1</td>
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Transparency

- Traditional highway bridges
Transparency

- Scenario of innovation
Transparency

- Hodder Ave. Underpass
Transparency

- Hodder Ave. Underpass
Awards and Publications

- PCI Harry H. Edwards Industry Advancement Award
- PCI Design Award (Main Span 76–150 Feet)
- Ontario Concrete Awards – Structural Design Innovation Award
- Ontario Concrete Awards – Material Development and Innovation Award
- “Hodder Avenue Underpass - A Modular Construction Approach and a Unique UHPC Pier Cap Design” – 9th International Conference on Short and Medium Span Bridges
- “Building a Better Bridge with UHPC” – Construction Canada Magazine
Hodder Ave. Underpass

- Expedites construction on site, optimizes resources
- Highly adaptable solution
- Can be fabricated by any precast company, assembled by any contractor at any location
- Precast/Prestressed Concrete Institute (PCI): Could be solution to all deficient bridges in North America
- Ministry of Transportation of Ontario (MTO): Plan to use it for a number of planned highway bridges
Hodder Ave. Underpass