Development of Prefabricated Concrete Bridge Railings: Phase I Testing and Results

Terry Wipf
Ashley Ecklund
Sri Sritharan

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Phase I

- Develop and test prefabricated concrete (precast) barriers for ABC applications
- Design barriers for MASH Test Level 4
- Evaluate performance using quasi-static loads
Outline

- Objective
- Design
- Connection Details
- Testing
- Results
Objective

• Develop prefabricated concrete bridge barriers with dependable connections
• Give considerations to
  ▫ Minimal damage to deck
  ▫ Constructability
  ▫ Easy repair
  ▫ Durability
  ▫ Cost
Design Approach

- Test Level 4
  - Design load = 54 kips
- Failure mode
  - Capacity protect barrier and deck
  - Force yielding to develop in the connections
FHWA Standard 42-in F-Shaped Barrier

GRADE 40 REINFORCING STEEL
3600 PSI CONCRETE

4 #7 LONGIT. BARS

4 #8 LONGIT. BARS

#5 @ 4 3/8" C-C
3 #4 LONGIT. BARS (TOP)
2"

1/4"
3 #5 LONGIT. BARS (BOTTOM)
#4 @ 9 1/2" C-C
1"

TEST INSTALLATION OVERHANG = 36"

#5 @ 4 3/8" C-C

#4 @ 9 1/2" C-C

#5 VERT. BARS @ 8" C-C

#3 LONGIT. BARS 4 TOTAL

#5 LONGIT. BARS 6 TOTAL

#4 LONGIT. BARS (TOP)
Barrier-to-Deck Connection - PBI - Precast Barrier with Inclined bar connection
PBI - Precast Barrier with Inclined bar connection

STAINLESS STEEL BAR WITH THREADED END AND BAR SPLICER CONNECTION

GENERAL NOTES:

1. DESIGN STRESSES FOR THE FOLLOWING MATERIALS ARE TO BE IN ACCORDANCE WITH AASHTO/LRFD BRIDGE DESIGN.
2. REINFORCING STEEL IN ACCORDANCE WITH SECTION, GRADE 60.
3. CONCRETE IN ACCORDANCE WITH SECTION 5, 5000 PSI CONCRETE STRENGTH.
4. 1" CONCRETE COVER FOR REINFORCING STEEL.
5. FOLLOWING SPECIAL REINFORCEMENT WILL BE PROVIDED:
   a. FOUR THREADED BARS
   b. 16 THREADED J8 BARS
   c. THREE BAR SPLICERS, VARIOUS LENGTH
   d. PROVIDE ONE UNIT OF THE BARRIER AND TWELVE 4½" CYLINDERS.
Barrier-to-Deck Connection - PBU - Precast Barrier with U-bar connection

In situ Grouting

In situ Grouting
PBU - Precast Barrier with U-bar connection
Barrier-to-Barrier Connection

Longitudinal reinforcement

Transverse reinforcement
Full-scale Testing

- Use two 12-ft long precast barriers
- Model both PBI and PBU
  - Test them individually
- Establish the Barrier-to barrier connection
  - Test the entire unit with application of loads at multiple places
Prefabrication
Barrier-to-Barrier Connection
Deck Construction
Deck Construction
Deck Construction
Assembly of Barrier

PBI

PBU
Assembly of Barriers
Test Set-up
Test Sequence
## Summary of Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Maximum Load</th>
<th>Maximum Displacement</th>
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<tbody>
<tr>
<td><strong>PBI Middle (Test 1)</strong></td>
<td>Push = 54 kips</td>
<td>0.81 inches</td>
</tr>
<tr>
<td><strong>Target</strong>: 54 kips</td>
<td>Pull = 2 kips</td>
<td>Final resting position = 0.26 inches</td>
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<tr>
<td><strong>PBU Middle (Test 2)</strong></td>
<td>Push = 36 kips</td>
<td>0.80 inches</td>
</tr>
<tr>
<td><strong>Target</strong>: 54 kips</td>
<td>Pull = 4 kips</td>
<td>Final resting position = 0.3 inches</td>
</tr>
<tr>
<td><strong>Center – Attached (Test 3)</strong></td>
<td>Push = 60 kips</td>
<td>0.56 inches</td>
</tr>
<tr>
<td><strong>Target</strong>: 54 kips</td>
<td></td>
<td>Final resting position = 0.17 inches</td>
</tr>
<tr>
<td><strong>Off Center, PBI (Test 4)</strong></td>
<td>Push = 81 kips</td>
<td>Loaded until 1.5 inches</td>
</tr>
<tr>
<td><strong>Target</strong>: Failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>End of PBI (Test 5)</strong></td>
<td>Push = 30 kips</td>
<td>4.85 inches</td>
</tr>
<tr>
<td><strong>Target</strong>: Failure</td>
<td>Pull = 22 kips</td>
<td>When pulled, loading beam 51 inches</td>
</tr>
<tr>
<td><strong>End of PBU (Test 6)</strong></td>
<td>Push = 24.8 kips</td>
<td>6.0 inches</td>
</tr>
<tr>
<td><strong>Target</strong>: Failure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Summary of Tests
Test 1 - Inclined Connection (PBI)

[Graphs showing load vs. top barrier displacement and center of load]
Deflection Components

![Graph showing deflection components](image)
PBI - Strain in Connection Rebar
Strain in Deck Reinforcement
Test 2 - U-bar Connection (PBU)
U-bar Deck Connection Strain

![Graph showing U-bar deck connection strain with different loads (6 kips, 12 kips, 18 kips, 24 kips, 30 kips, 36 kips) and the center of load location.](image-url)
Strain in Deck Reinforcement

![Graph showing strain in deck reinforcement for different load conditions.](image-url)
Splitting Crack in the Deck
On YouTube: Precast Barrier Test Video - Jan 2017
https://youtu.be/up6sMEeqfaU
Test 3 - Barrier to Barrier Connection
Strain in Connection Rebar

![Diagram showing strain in connection rebar with different load scenarios and barrier location measurements.](image)
Barrier to Barrier Connection Strain
Test 4 - Off-Center Barrier to Barrier Connection
Progression of Damage
End of Test
Demolition
Conclusions

- Use of precast barrier for ABC projects is very feasible
- Barrier-to-deck connections
  - PBI – performed as expected and remained elastic under design load
  - PBU – failed prematurely, but the detail can be improved
- Performance of Barrier-to-barrier connection was satisfactory
- All connections are fairly easy to accomplish in the field; PBI will facilitate easy replacement
- All connections are required to be verified under dynamic loads.
Next Steps - Phase II
Evaluation and Full Scale Testing of Concrete Fabricated Bridge Rails under Dynamic Loading

• Lead Agency and Contact:
  Brian Worrel
  Iowa Department of Transportation
  brian.worrel@iowadot.us
  Phone: 515-239-1471

• FHWA Technical Liaison(s):
  Benjamin Beerman
  Benjamin.Beerman@dot.gov
  Phone: 404-422-7209

• Committed Partners: FL, IA, NC, NJ, OH, OR, TX
• Solicitation Expires: July 7, 2017
• Commitments Required $600,000.00
• Commitments Received $420,000.00

More details: http://www.pooledfund.org/Details/Solicitation/1436