Rehabilitation of Longitudinal Joints in Double-Tee Girder Bridges

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Funding Agencies and Collaborators

- South Dakota Department of Transportation.
- Mountain Plains Consortium (MPC) - University Transportation Center (UTC).
Current longitudinal joint detailing

- **Background**

- **Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders**
The current longitudinal joint detail for connecting adjacent double-tee bridge girders exhibits poor serviceability and strength performance.
Ultra-High Performance Concrete

➢ Fiber-reinforced cementitious concrete
➢ Made with very fine aggregates in size of dust
➢ Usually with 2% volumetric steel fibers
➢ Better durability than concrete
➢ More than 22,000 psi (150 MPa) compressive strength
➢ Significantly higher tensile strength and strain capacity

Courtesy: Dr. Graybeal of FHWA
Summary of Activities

✓ 20 Rehabilitation Joint Detailing Alternatives.
✓ Testing of 13 Large-Scale Beams.
✓ Detailed Finite Element Analysis.
✓ Testing of 40-ft Conventional Double-Tee Bridge.
✓ Rehabilitation of the Conventional DT Bridge.
✓ Testing of Rehabilitated Bridge.
✓ Recommendations.
Test Specimen and Setup

Two Double-Tee Girders
40-ft Long, approx. 8-ft wide

W14x257 Column
HSS 12x6x1/2 Brace
Test Specimen
Load Cell
Testing Procedure

1. Fatigue testing of conventional DT – 250k cycles.
2. Monotonic testing of conventional DT to crack the joint.
3. Fatigue II testing of rehabilitated DT – 500k cycles.
4. Fatigue I testing of rehabilitated DT – 100k cycles.
5. Ultimate testing of rehabilitated DT to failure.
Instrumentation

➢ 34 Strain Gauges

➢ 14 LVDTs

➢ 4 String POTs

➢ 4 Load Cells

➢ 146-kip Actuator
Proposed Testing Plan

Pocket Detailing: UHPC filled pockets reinforced with steel bars.

Continuous Detailing: LMC filled joint reinforced with wire-mesh.
Rehab after initial 200k Fatigue Testing

Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
Rehab after initial 200k Fatigue Testing

Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
Joint Pour w/ UHPC & LMC

Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
Prior to Testing LMC Cracking

Girder A

LMC Joint

Girder B

Bridge Underneath
Fatigue Testing Video
Fatigue Results

No stiffness degradation after 0.5 million cycles of AASHTO Fatigue II and 100k cycles of AASHTO Fatigue I.
Ultimate Testing Video

South Dakota State University

Lohr Structures Laboratory

Rehabilitation of Longitudinal Joints of Double-Tee Bridges

Project: SD2014-20

Strength Test Date: February 24, 2017

Full-Scale 40-ft Long Double-Tee Bridge
Cracks and Failure Mode

Girder A
Rehabilitated Joints at Girder Failure

Minor cracks at the edge of Pocket and Continuous joints at girder failure.
Ultimate Test Results

Girder A — Girder B ◇ First Cracking △ Peak Load × Failure

Rehabilitated Specimen

Peak Load
P = 113.9 kips

Girder Cracking
P = 53.8 kips

Strength I LS

Service I LS

Midspan Deflection, Δ (in.)

Actuator Load, P (kips)

Actuator Load, P (kN)
Ultimate Test Results

Rehabilitated Specimen

Actuator Load, P (kips)

Strain, \( \mu \varepsilon \) (microstrain)

Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
Evaluation

Rehabilitated Detailing

New Constr. Continuous Detailing (Konrad, 2014)

Conventional Detailing

Fatigue II, P = 21 kips

Fatigue I, P = 42 kips

Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
Evaluation

Rehabilitated Detailing

New Constr. Continuous Detailing (Konrad, 2014)

Conventional Detailing

Rehabilitated Detailing

New Constr. Continuous Detailing (Konrad, 2014)

Conventional Detailing

Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders
Evaluation

Cost estimate for: 40-ft long by 30.6-ft wide double-tee girder bridge having 8 girders and 7 long. Joints.

- Pocket joint rehabilitation cost is 28% of that of replacement.
- Continuous joint rehabilitation cost is 57% of that of replacement.

<table>
<thead>
<tr>
<th>Rehabilitation vs. Replacement Cost for 40-ft Double-Tee Bridges</th>
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<tr>
<td><strong>Type</strong></td>
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<td>Replacement</td>
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<td>Rehabilitation</td>
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Conclusions

➢ Both pocket and continuous rehabilitation methods are viable solutions to rehabilitate Double-Tee bridges. Only UHPC should be used for field applications.

➢ The pocket joint rehabilitation method is the most cost effective solution.
Rehabilitation of Double-Tee Bridges

Sponsors:
South Dakota Department of Transportation and Mountain-Plains Consortium (MPC) – University Transportation Center (UTC)
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Year: 2015-2017

Personnel:
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https://sites.google.com/people.unr.edu/mostafa-tazarv/research/rehab-of-dt-bridges
Recommendations

Rehabilitation of Longitudinal Joints in Double-Tee Bridge Girders

Section A – Shear key Detailing

Section B - Pocket Joint Detailing
Recommendations

➢ Preparation

1. 1-in. Saw-cut around perimeters.

2. Hammer-chip at 45 degree slope, 20 degrees between pockets:
   a. 30-lb chippers for first 2.5 inches.
   b. 15-lb chippers around reinforcement.

3. Hydro-demolition shall be permitted as an alternative.

4. Joint surface shall be sand-blasted and pre-wetted for 24 hours prior to pouring.

5. Formwork shall be water tight and installed from top of bridge.
Recommendations

Pocket Detailing

1. UHPC filled square pockets with minimum side dimensions of 18 inches. Spacing shall not exceed 5 ft c/c.
2. UHPC filled continuous key with a minimum width of 5.5 inches.
3. Pockets reinforced with four Gr. 60 No. 4 bars each direction. Continuous key reinforced with two Gr. 60 No. 4 longitudinal bars.
4. Minimum lap-splice of 3 inches between pocket reinforcement and exposed wires.