Madrid Stone Arch Rehabilitation

Presenter
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DEAD LOAD CHANGES
When initially installed the red “cross-hair” was zeroed in the center grid. Each tick-mark is 1 millimeter and the photo on the right shows the progression of separation from 2006 – 2008.
Public meeting 8/19/08

• More than 150 people turned out
• Bridge qualifies to be on the National Register of Historic Places
• Community concerns caused by the bridge closure:
  – severing of the community
  – lengthening emergency response time
  – increasing commuter cost
  – negatively impacting business
• No temporary bridge to be put in (cost $2 mil)
Project Objectives

- Restore the structural integrity of the bridge and highway section and its appurtenances
- To improve safety and reduce accidents
- Improve the drainage deficiencies
- Provide adequate pedestrian facilities
Bridge Rehabilitation Alternatives

- Concrete Lining (Concrete under Stone)
- Rock Bolt Reinforcing
- ARCHTEC Reinforcing
- Bridge within a Bridge
- Saddle (Concrete over Stone)
Concrete Lining
Rock Bolt Reinforcing
ARCHTEC Reinforcing
ARCHTEC Reinforcing

Before

After
Bridge within a Bridge

TYPICAL SECTION AT MID-SPAN
Saddle (Concrete over Stone)
Preferred Alternative
Saddle (Concrete over Stone)

Over Arch

Over Pier
Modeling

- Two-dimensional frame model (half of arch width)
- Line elements in STAAD
- Pinned supports at pier footing level
- Modeled one span only

Live load used HS-25 truck load (moving)
1. Place temporary shoring system under spans 1, 2, and 3.

2. Remove fill over arches in spans 1, 2, and partial of 3.

3. Construct concrete footing on piers 1 and 2.

4. Construct concrete saddle over spans 1 and 2.

5. Construct end wall at Becon Abut.

6. Construct concrete saddle over spans 3 and 4.

7. Construct concrete footing piers 3 and 4.

8. Remove fill over abutments in rest of span 3, span 4, and partial of 5.


Suggested construction sequence (similar for remaining spans)
## Comparison of Schedules

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<th>Accelerated Schedule</th>
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<td>March 2009</td>
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<td>Letting</td>
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<td>April 30, 2009</td>
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<td>Construction Complete</td>
<td>December 2011</td>
<td>Bridge Dec 2009</td>
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ACTUAL BRIDGE OPENING NOV. 27, 2009
– Shuttle Bus in Contract for 7 days/week
– Extended Hours for Bluegrass Festival

Pedestrian Accommodations
Bridge Construction

- Construct access to the river (causeway)
- Re-point masonry and replace missing stone
- Construct shoring system under arches
- Remove all fill from the structure
- Construct new concrete arches and spandrel walls
- Fill center with CLSM
- Form and pour new concrete deck
- Install curbing, sidewalks and bridge rail
Cofferdam/Causeway Construction

• Completed cofferdam/causeway with riverweed area mitigation in-place
Relocation of Water/Sanitary Lines

• Hanging of temporary lines from causeway surface
Removal of Deck and Initial Fill

- Hoe-ramming blacktop surface
Construct Shoring System

• Completed shoring system through 5 spans
Removal of Remaining Fill

- Fill being moved onto tarps on bottom of arch with compressed air and shovels
Pour Footers

• Footer reinforcement over a pier
Pour Footers

• Arch saddle and spandrel wall bars need to be installed prior to footer pour
Pour Footers

- Footer pour using pumper truck
Pour Arch Saddles

- Arch saddle being poured with pumper truck
Pour Arch Saddles

- Completed arch saddles
Final Masonry Work

• Pointing the face of new built-up spandrel wall section prior to spandrel pour
Arch being filled Center with CLSM

• (Controlled low strength material)
Construct Deck Overhang Shoring

- Completed shoring system with deck forms, kickers and railing
Pour Deck

- Deck rebar being installed including railing anchors and utility hangers
Pour Deck

- Covering deck with wet burlap within 5 minutes of placement
Install Bridge Rail

- Bridge rail in process of being installed
Phase 2  Spans 6 through 9
Winter Concrete Provisions

- Spandrel wall pours covered with curing blankets for 7 days
Winter Concrete Provisions

• Heated bridge deck drying enclosure for spans 6-9
Problems/Issues Encountered

• Suppliers
  – Original shoring system supplier backed out of quote
  – Cost Slate Hill time (& money) to find new supplier and progress shop drawings

• Site Conditions
  – Shape of arches not as per drawings
  – Rock elevations varied
  – Condition of arches (spans 5,6,8) required Main Office assistance

• ‘Surprises’
  – 2 buried fuel tanks encountered on project in vicinity of bridge
Final Product

- Upstream fascia
Final Product

• Downstream fascia
Questions for PDH credit

• (1) In the structural model for the arch saddle, the supports at the footing level were modeled as
  – A. pinned
  – B. fixed
  – C. roller
  – D. sinking
Questions for PDH credit

• (2) What caused the stone arch barrels to begin to separate at the fascia?
  – A. Water getting behind spandrel walls
  – B. Eccentric loading caused by overhangs
  – C. Increasingly heavier loads
  – D. All of the above
Questions for PDH credit

• (3) Foam was used at the top of the stone spandrel walls (under the concrete slab overhang) to
  – A. Control shrinkage
  – B. Allow for differential temperature movements
  – C. Prevent loads from being transferred
  – D. Absorb impact from truck loadings