ABC and Innovative Bridge Construction for Minnesota Local Roads

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Innovative Bridge Construction for MN Local Roads

- HDR Engineering, Inc. prepared a Transportation Research Synthesis for the MnDOT Local Road Research Board (LRRB)
  - Document and compile ideas implemented from scanning tours
  - Interviewed County Engineers and Consultants

- Acknowledgments
  - LRRB
  - MnDOT
  - FHWA
  - Aitkin County
  - Blue Earth County
  - Polk County
  - Rock County
  - Steele County
  - Erickson Engineers
  - Short Elliot Hendrickson (SEH)
  - Yaggy Colby
Accelerated and Innovative Bridge Construction on MN Local Roads

• Minnesota’s local road system is the network of roads owned by the counties, cities, and townships (many are low-volume roads)
  – MnDOT does not own facilities, but administers funding and assists with contracting

• Techniques may not necessarily be new, but use on local roads and in MN is
  – Some previously used unsuccessfully in MN

• Many new techniques used in MN were identified on scanning tours
Minnesota Local Bridge Scanning Tour

• Initiated in 2006 by MnDOT office of State Aid for Local Transportation and MN Division of FHWA

• Purpose is to identify safe, durable and economical bridge types that can be constructed rapidly on the local system (low-volume roads)

• Team consists of county engineers, local consultants, and representatives from MnDOT and FHWA

• New York (2006); Washington (2007); Wisconsin (2009); Iowa (2012)
Typical Local Bridge Types

- Prestressed concrete I-girders with CIP deck
  - Span length, 90-150 ft.
  - 2012 Average Cost, $125/SF

- 3-span CIP slab bridge
  - Span length, 40-65 ft.
  - 2012 Average Cost, $120/SF

- Multiple lines of precast concrete box culverts
  - 12 ft. x 8 ft. precast typical cost, $700/LF
  - Difficult to compare directly with bridge cost due to grading and other costs for culvert construction
Innovative Local Bridge Types

- Side-by-Side Precast Box Beams on Sheetpile Abutments
  - Two techniques, can be used separately or in combination

- Mechanically-Stabilized Earth (MSE) Walls with Single-Line Pile Abutments

- Precast Inverted Tee Slab Span Bridges

- Large Precast Box Culverts and Three-Sided Structures

- Geosynthetic-Reinforced Soil (GRS) Abutments
Side-by-Side Precast Box Beams With Sheetpile Abutments

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Side-by-Side Precast Box Beams with Sheetpile Abutments

Blue Earth County Bridge 07547
Side-by-Side Precast Box Beams with Sheetpile Abutments

- Blue Earth County has constructed three of this bridge type

- Adjacent box beam superstructure bears on single row of piles in front of sheet pile abutment

- Two bridges have bituminous overlay and one has 5” composite CIP overlay
  - Details can be modified for higher ADT roadways

- Span up to 110 ft.

Blue Earth County Bridge 07547
Side-by-Side Precast Box Beams with Sheetpile Abutments

Blue Earth County Bridge 07547
Benefits

- Span length can clear streams without piers in waterway

- Accelerated Construction
  - Superstructure completed in one week (vs. 4-5 weeks for CIP slab, 2-3 weeks for precast beam/CIP deck)
  - No falsework required
  - Sheet pile abutment construction faster and lower cost than concrete abutment on piles

- Resistance to Approach Fill Loss
  - Sheet piles extend deeper than typical single-line pile abutment

- Shallow Structure Depth
  - Good replacement for timber or slab bridges without grade raise

Blue Earth County Bridge 07547
Limitations

• Learning Curve
  – Local contractors may struggle at first (grouting keyways, post tensioning)
  – County inspectors learn P/T procedures

• Cost per Square Foot
  – Approx. $180/SF (in MN) vs. $120/SF for CIP slab
  – Overall project cost can be lower due to shorter structure length
  – Cost should decrease with increased use

Blue Earth County Bridge 07547
Crash Tested Open Metal Railing

- **Blue Earth County**
  - Used with precast box beams
  - Bolted to outside face

- **Polk County**
  - Eliminates need for deck drains
  - Eases snow removal, minimizes drifting
  - Rapid construction
MSE Walls With Single-Line Pile Abutments

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MSE Walls With Single-Line Pile Abutments

Steele County Bridge 74551

ABC and Innovative Bridge Construction for MN Local Roads
MSE Walls With Single-Line Pile Abutments

Steele County Bridge 74551
MSE Walls With Single-Line Pile Abutments

- Steele County constructed in 2011
- Single span prestressed I-girder with CIP deck over DM&E railroad
- Embankments required 4-month surcharge
- MnDOT foundations unit monitoring piles – performing well
- MSE wall abutments are new in MN – previously used with two-line pile abutments
- Bridge length, 100-300 ft. depending on skew

Steele County Bridge 74551
Benefits

• Shorter Bridge
  – Bridge length 50% of 3-span I-girder alternative required for clearance

• Reduced Maintenance
  – No expansion joints

• MSE Walls Tolerant of Settlement
  – Also less settlement in compressible soils

• Lower Overall Cost
  – Approx. 25% lower than alternative 3-span bridge

Steele County Bridge 74551

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Limitations

• Increased Design Coordination
  – Not a common bridge type in MN
  – Documented successful use elsewhere to gain approval

• Geometric Control Sensitivity
  – Pile alignment is crucial
  – Include stringent requirements and more flexible details

• Standardization
  – In future, identify standards, requirements and limitations for use

Steele County Bridge 74551
Precast Inverted Tee Slab Spans
Precast Inverted Tee Slab Spans

Chisago County Bridge 13521

ABC and Innovative Bridge Construction for MN Local Roads
Precast Inverted Tee Slab Spans

- MnDOT developed system in 2005 based on similar section used in France

- First bridges built in 2005, and 11 have been built as of 2011
  - Continuous spans on Trunk Highway system

- Chisago and Scott Counties each constructed one bridge in 2012
  - Simple spans

- Span lengths, 20-65 ft.

Chisago County Bridge 13521
Precast Inverted Tee Slab Spans

TRANSVERSE SECTION

18" PRESTRESSED INVERTED-STOP BEAMS

39'-4"

36'-0" ROADWAY

1'-8"

6'-0"

12'-0"

12'-0"

6'-0"

1'-8"

LEVEL

SHOULDER

PROFILE GRADE

PROFILE GRADE

PROFILE GRADE

T.H. 28

(INPTH28)

36'

RIER,

(TYP.)

3035

2%
Benefits

- Alternative to Short Span CIP Slabs
  - No falsework required
  - Rapid construction; recently replaced two 3-span bridges in 4 weeks each

- Environmental
  - Reduce impact to area beneath bridge

- Shallow Structure Depth
  - Approximate 2 ft. deep

- Traffic & Worker Safety
  - Reduced construction time for staged work

*Chisago County Bridge 13521*
Limitations

- **Design Complexity**
  - More complex design than CIP slab
  - Learning curve

- **Larger Crane Required**
  - Lifts similar to prestressed beams
  - Larger crane required than for CIP concrete or timber slab

- **Fabricator Competition**
  - Currently only two fabricators have forms

- **Cost**
  - In 2010, approximately 10-15% higher than CIP concrete slabs
  - Decreasing with greater use
Lessons Learned

- MnDOT is currently using this bridge type very sparingly

- Experiencing unacceptable longitudinal cracking – mainly over webs, not due to differential movement between units
  - Cracking begins in first year, continues to worsen each year

- Details continue to change – no two have been built the same
  - Next step – fiber reinforced CIP

- University of Minnesota currently in 2nd phase of project to refine details

*Chisago County Bridge 13521*
Large Precast Box Culverts and Three-Sided Structures

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Large Precast Box Culverts

Aitkin County Bridge 01J31

ABC and Innovative Bridge Construction for MN Local Roads
Large Precast Box Culverts

• Aitkin County replaced existing bridge with 20 ft. x 8 ft. precast box culvert
  – MnDOT standard maximum span is 16 ft.

• County developed preference for single span structures when feasible
  – Minimize silting in of barrels

• Double and triple boxes not performing hydraulically as envisioned

Aitkin County Bridge 01J31
Large Precast Box Culverts (MnDOT Standard Detail)
Large Precast Box Culverts

- Constructability review did not identify issues
  - Confirmed by the fact that 8 contractors bid job

- Maintenance similar to typical precast box culverts
  - Less debris cleanout required

- Access and placement may be an issue with some sites
  - Larger crane required
  - Size and weight could be an issue with trucking

Aitkin County Bridge 01J31
Three-Sided Structures

*Morrison County Bridge 49J44*

ABC and Innovative Bridge Construction for MN Local Roads
Three-Sided Structures

- Increased use for local roads and MnDOT Trunk Highway System
- Precast without bottom slab
- Legs bear on CIP footings – typically on piles
- Typical spans of 28-42 ft.; max. of 60 ft. used in MN
- MnDOT provides footing design for one proprietary system, Contractor allowed to substitute with modified footing design
- Designed for 3-ft. min. soil cover at crown – typically have moment slab for rail impact loading
Three-Sided Structures

- Low-maintenance structure with natural stream bottom – DNR like natural bottom
- Scour susceptible sites may require pile footing, which increases cost
- Roadway barrier typically requires moment slab to resist impact load
- Cost typically higher than precast box culverts

Morrison County Bridge 49J44
GRS Abutments

Example of GRS Abutment (photo courtesy of FHWA)
GRS Abutments

- Rock County was awarded IBRD funds and will construct one bridge in Spring 2013
- Rapid and simplified construction
  - Approximately 3 days to construct abutment
  - No heavy equipment, specialized labor required
- FHWA recommends max. span length limit of 140 ft.
- Scour must be taken into consideration in design
- FHWA estimates cost savings of 25-60%

Rock County Bridge 67564
GRS Abutments

- FHWA and MnDOT implementing a monitoring plan due to 5.3% longitudinal grade
- FHWA likely to use this bridge as a showcase
  - Tentatively scheduled for April 16, 2013
  - 2-hour presentation on GRS abutments
  - Site visit to see construction
- For information regarding the GRS abutment showcase:
  
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For Additional Information

• For information regarding innovative local bridge construction in MN:
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  *Innovative Bridge Construction for Minnesota Local Roads
  TRS: http://www.lrrb.org/media/reports/TRS1203.pdf

• For information regarding local bridge scanning tours:
  *The Minnesota Local Bridge Scanning Tour, Aspire Magazine:
  http://aspirebridge.com/magazine/2010Fall/County_Fall10.pdf