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

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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

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MSE Walls With Single-Line Pile Abutments

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MSE Walls With Single-Line Pile Abutments

Steele County Bridge 74551

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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
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

Chisago County Bridge 13521
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-T BEAMS

ABC and Innovative Bridge Construction for MN Local Roads
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

Aitkin County Bridge 01J31

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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
Large Precast Box Culverts (MnDOT Standard Detail)

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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
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
Geosynthetic-Reinforced Soil (GRS) Abutments

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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%
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:

   Daniel Alzamora, PE
   FHWA Resource Center
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   Rock County Bridge 67564

ABC and Innovative Bridge Construction for MN Local Roads
For Additional Information

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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