Geosynthetic Reinforced Soil (GRS)
Integrated Bridge Systems (IBS)

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Adams et al. (2012), FHWA Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide
Motivations for GRS-IBS

• ‘Simple’ construction procedure
• Potential cost savings
• Reduce project duration, especially with other “ABC” techniques
• Eliminate the “bump at the end of the bridge”
## GRS-IBS vs. MSE

<table>
<thead>
<tr>
<th>Construction Materials</th>
<th>GRS-IBS</th>
<th>MSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freely draining aggregate, high strength reinforcement</td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Typical Reinforcement Spacing</th>
<th>GRS-IBS</th>
<th>MSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-in.</td>
<td></td>
<td>2 to 3 ft</td>
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</table>

<table>
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<tr>
<th>Analysis</th>
<th>GRS-IBS</th>
<th>MSE</th>
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<tbody>
<tr>
<td>Composite Material</td>
<td></td>
<td>Individual Tensile Forces</td>
</tr>
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</table>

<table>
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<tr>
<th>Typical Foundation</th>
<th>GRS-IBS</th>
<th>MSE</th>
</tr>
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<tbody>
<tr>
<td>N/A (GRS)</td>
<td></td>
<td>Piles</td>
</tr>
</tbody>
</table>

Spacing difference results in significantly different behavior and performance!
Adams et al. (2012), FHWA Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide
Rustic Road: Before
Rustic Road

• Just west of Columbia
• Crosses fork of Grindstone Creek
  – Prone to flash flooding
  – 2-year return period for bridge deck
• At city limit
  – County project with city participation
• Serves 10 residences
• Span length of 50 ft
• Height of about 14 ft
• Skew of 15 degrees
Limestone Foundation
Level First Row of Blocks
Vibratory Compaction of AASHTO #89 Stone (1/2” clean)
Placement of Reinforcement

Sure would be a lot easier without these Mizzou guys.
Repeat 14x = Completed Abutment
Precast tub girders
Prevent girders from floating away

Plates 3 ft below bottom of girders
Deviating from General Procedure

Clamped 2x4s to underlying reinforcement to prevent displacement of previous courses of block during compaction of current layer.
## Monitor for 19 Months

<table>
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<tr>
<th>Performance Metric</th>
<th>Monitored with…</th>
<th>Locations</th>
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<tr>
<td>External movement</td>
<td>Land Surveying</td>
<td>12 targets per abutment face</td>
</tr>
<tr>
<td></td>
<td>Settlement plates (vertical)</td>
<td>3 plates in north abutment (top, middle, bottom)</td>
</tr>
<tr>
<td></td>
<td>Inclinometer (horizontal)</td>
<td>One casing per abutment</td>
</tr>
<tr>
<td>Internal movement</td>
<td>Earth pressure cells</td>
<td>• Two cells at foundation • 4 cells below girders</td>
</tr>
<tr>
<td>Earth pressure</td>
<td>Piezometers</td>
<td>10 piezometers in north abutment</td>
</tr>
<tr>
<td>Pore pressure</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Survey Targets
Settlement Plates

3 plates in north abutment, installed in a vertical line in common casing

1 near bottom of abutment
1 near middle
1 near top
Earth Pressure Cells

6 cells in north abutment:

2 in base layer
4 near top – 1 beneath each girder
Vibrating Wire Piezometers

9 piezometers in north abutment:

3 near foundation,
4 in middle,
2 near top
Performance
Visual Observations: Cracks

Cracks observed after construction but prior to bridge opening. Crack gages indicated less than 3 mm of movement during subsequent 19 months.
Visual Observations: Cracks

Approximate Location of Wing Wall Cracks

Beam Seat

GRS Abutment
Type A Geotextile (4800 lbs/ft wide width tensile strength)

1:1 CUT SLOPE (PAY LIMIT)

Bearing Bed reinforcement
Type B Geotextile (2400 lbs/ft wide width tensile strength) (Typ.)

Limits of Concrete Encasement (Scour Protection)
Survey: <0.5 in. Movement at Face

Graph showing settlement over time with data points for Upper Settlement Plate, Survey Marker N-1, Survey Marker N-2, and Survey Marker N-3.
Inclinometers: <0.4” Horizontal Displacement
Earth Pressure Ground Temperature Cells

*DP = Daily Precipitation, in.
Piezometers

*DP = Daily Precipitation, in.
Piezometers: Response to one event

- 0.33” 24 Hour Rain Total 15 June
- 1” 24 Hour Rain Total 17 June

- Peak Value of 435 psf = 7.0 ft of Water above Piezometer (6/17/15 12:00pm)

- After 6 hours 230 psf = 3.7 ft of Water above Piezometer (6/17/15 6:00pm)

- 180 psf = 3 ft of Water Above Piezometer in 24 Hours (6/18/15 12:00pm)

- PZ-4 Peak Value of 210 psi = 3.4 feet of Head and Dissipates in 6 hours

*DP* = Daily Precipitation
Conclusions: Rustic Road

Performing as intended:

• Negligible external and internal displacements
• Backfill typically dry, drains quickly after precipitation events
• Cracks in facing blocks formed shortly after construction but did not expand
Conclusions: General

From MU interviews with contractors, agency personnel across the country:

- No significant performance issues have been reported for any GRS-IBS
- FHWA *Interim Implementation Manual* helpful, generally accurate
- Finding construction “rhythm” important
- Leveling facing blocks also critical
- Congested sites not good candidates
Conclusions: General (cont’d)

• Open-graded backfill with method spec easier than well-graded backfill with performance spec

• Agencies report cost of GRS-IBS decreases with experience

• Cost decrease hand-in-hand with construction learning curve
  – Especially for contractors who build either MSE or bridges, but not both
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Andy Boeckmann, Sam Runge & Erik Loehr, MU Civil Engineering

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https://library.modot.mo.gov/RDT/reports/TR201417/cmr16-019_reduced.pdf
Instrumentation and Monitoring of Rustic Road Geosynthetic Reinforced Soil (GRS) Integrated Bridge System (IBS)