Agenda GRS-IBS

• Introduction
• Key Materials
• Design Concepts
• Installation
What Is GRS-IBS?

- **GRS – Geosynthetic Reinforced Soil:**
  
  An engineered, well-compacted granular fill with closely spaced (<12”) layers of geosynthetic reinforcement

- **IBS – Integrated Bridge System**
  
  A fast, cost-effective method of bridge support, blending the roadway into the superstructure using GRS technology
History

• **GRS**
  
  • The U.S. Forest Service used geotextiles in the ’70s to construct wrapped face walls (i.e., burrito walls).
  
  • The Colorado DOT frictionally connected modular blocks as the facing component in the early ‘80s.

• **GRS-IBS**
  
  • FHWA refined this method for load-bearing applications (bridges) in 1995.
  
  • GRS-IBS was selected as an EDC initiative in 2010.
FHWA GRS-IBS Website

www.fhwa.dot.gov/everydaycounts/technology/grs_ibs/

GRS-IBS

Instead of conventional bridge support technology, Geosynthetic Reinforced Soil (GRS) Integrated Bridge System (IBS) technology uses alternating layers of compacted granular fill material and fabric sheets of geotextile reinforcement to provide support for the bridge. GRS also provides a smooth transition from the bridge onto the roadway, and alleviates the “bump at the bridge” problem caused by uneven settlement between the bridge and approaching roadway. The technology offers unique advantages in the construction of small bridges, including:

- Reduced construction time and cost, with costs reduced 25 to 60 percent from conventional construction methods.
- Easy to build with common equipment and materials; easy to maintain because of fewer parts.
- Flexible design that’s easily modified in the field for unforeseen site conditions, including unfavorable weather conditions.

Ancient Secrets, Modern Science: Geosynthetic Reinforced Soil (GRS) Integrated Bridge System (IBS)

The Federal Highway Administration’s “Bridge of the Future” initiative took a wise look at the past before soaring ahead to the future. The result was the Geosynthetic Reinforced Soil (GRS) Integrated Bridge System (IBS), which combined cutting-edge geosynthetics with ancient building secrets. This radically simple construction method can lower costs, slash construction time, improve durability, and increase worker safety.

GRS-IBS BROCHURE

Download Brochure
Printable/Foldable
Geosynthetic Reinforced Soil Integrated Bridge System Interim Implementation Guide
Published January 2011
Includes LRFD
Why Use GRS-IBS?

- Reduced construction time & costs (25 – 60%)
- Easy to build with common construction equipment; easy to maintain because of fewer parts
- Flexible design – easily field-modified for unforeseen site conditions, including utilities, obstructions, existing structures, variable soil conditions and weather
- Smooth transition from approach to bridge
Limitations to GRS-IBS

- Single span (currently ≤ 140 ft...)
- ≤ 30 ft...abutment height
- ≤ 4000 psf superstructure bearing pressure
  - Bridge DL + LL
- Deep scour depths
Section View of GRS IBS

- **Beam Seat**
  (Supported directly on bearing bed)

- **Jointless**
  (Continuous pavement)

- **Integrated Approach**
  (Geotextile wrapped layers at beams to form smooth transitions)

- **Facing Elements**
  (Frictionally connected top 3 courses with a rebar and grout)

- **Bearing Bed Reinforcement**
  (Load shedding layers spaced < 6 inches)

- **Scour Protection (Rip Rap)**
  (If crossing a water way)

- **GRS Abutment**
  (Reinforcement spacing < 12 inches)

- **Reinforced Soil Foundation**
  (Encapsulated with geotextile)
Components of a GRS: Facing Elements

• Segmental block/CMU block
  • Readily available
  • Inexpensive
  • Integral colors
  • Works easily with reinforcement

• Material requirements
  • Compressive strength $\geq 4000$ psi
  • Water absorption limit: 5%
  • Freeze thaw durability where required
Components of a GRS: Geosynthetic Reinforcement

- Geosynthetic reinforcement can include:
  - HDPE and PET Geogrids
  - PP or PET Woven Geotextiles

- Key Strength Requirements
  - Ultimate strength: $T_{\text{ult}} \geq 4800 \text{ lb./ft.}$
  - $T_{2\%} = \text{Strength at 2\% strain}$
Components of a GRS: Granular Backfill

- **Well Graded**
  - Graded aggregate base
  - $\Phi \geq 38$ degrees

- **Open Graded**
  - #57
  - #67
  - #89
  - $\Phi \geq 38$ degrees
Performance Demonstration
Performance Demonstration
Performance Demonstration
Basic Design Steps:
Determine Layout of GRS-IBS

- Define geometry of abutment face/wing walls
- Layout abutment with respect to superstructure
Basic Design Steps: Perform Site Evaluation

- Observe existing structures and roads
- Conduct a subsurface investigation
  - Evaluate soil properties for retained soil
  - Evaluate soil properties for reinforced backfill
- If a stream crossing - Evaluate hydraulic scour conditions
Basic Design Steps: Dimension of Reinforced Soil Foundation (RSF)

Determine Depth and Volume of Excavation

\[ B_{\text{total}} \geq 0.3H \]
Basic Design Steps:
Determine Layout of GRS-IBS

Estimate Reinforcement Layout

0.7H
Basic Design Steps: Determine Loads
Basic Design Steps:
Check External Stability Analysis (LRFD)

- **Direct Sliding**
  \[ \Phi_r = 1.0 \]

- **Bearing Capacity**
  \[ \Phi_{bc} = 0.65 \]

- **Global Stability**
  \[ \Phi_{gs} = 0.65 \]
Basic Design Steps: Internal Stability Analysis

• Ultimate capacity
  • Empirical method
    • Performance test
  • Analytical method
    • $\Phi_{\text{cap}}(q_n)/V_{\text{applied}} \geq 1.0$
Basic Design Steps: Internal Stability Analysis

- **Deformations**
  - **Vertical**
    - Performance test curve
    - Limit vertical strain to 0.5%
    - $D_v = \varepsilon_v H$
  - **Lateral**
    - $D_L = (2D_v/H)(b + a_b)$
Required Reinforcement Strength, $T_{req}$

- $T_{req}$ is the required tensile strength of an individual reinforcement layer and is a function of the sum of the horizontal stresses, the reinforcement spacing & backfill gradation (Equation 31)

- The geosynthetic strength (Lower of $T_{allow}$ or $T_{2\%}$) ≥ $T_{req}$
  - where $T_{allow} = T_f/3.5$ and $T_f$ is the ultimate geosynthetic tensile strength ($T_f \geq 4800$ lb/ft)
  - $T_{2\%}$, geosynthetic strength at 2% strain

- If necessary increase geosynthetic strength or decrease spacing to meet criteria
## Component of a GRS: Geosynthetic Reinforcement

<table>
<thead>
<tr>
<th>Mechanical Properties</th>
<th>Test Method</th>
<th>Unit</th>
<th>Minimum Average Roll Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength (at ultimate)</td>
<td>ASTM D4595</td>
<td>lbs/ft (kN/m)</td>
<td>4800 (70.0)</td>
</tr>
<tr>
<td>Tensile Strength (at 2% strain)</td>
<td>ASTM D4595</td>
<td>lbs/ft (kN/m)</td>
<td>980 (14.0)</td>
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<tr>
<td>Tensile Strength (at 5% strain)</td>
<td>ASTM D4595</td>
<td>lbs/ft (kN/m)</td>
<td>2400 (35.0)</td>
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<tr>
<td>Tensile Strength (at 10% strain)</td>
<td>ASTM D4595</td>
<td>lbs/ft (kN/m)</td>
<td>4800 (70.0)</td>
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<tr>
<td>Flow Rate</td>
<td>ASTM D4491</td>
<td>gal/min/ft² (l/min/m²)</td>
<td>30 (1222)</td>
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<tr>
<td>Permittivity</td>
<td>ASTM D4491</td>
<td>sec⁻¹</td>
<td>0.40</td>
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<tr>
<td>Apparent Opening Size (AOS)</td>
<td>ASTM D4751</td>
<td>U.S. Sieve (mm)</td>
<td>30 (0.60)</td>
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<tr>
<td>Pore Size 0.1%</td>
<td>ASTM D6767</td>
<td>microns</td>
<td>465</td>
</tr>
<tr>
<td>Pore Size 0.5%</td>
<td>ASTM D6767</td>
<td>microns</td>
<td>632</td>
</tr>
<tr>
<td>Factory Sewn Seam</td>
<td>ASTM D4884</td>
<td>lbs/ft (kN/m)</td>
<td>3000 (43.8)</td>
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<tr>
<td>UV Resistance (at 500 hours)</td>
<td>ASTM D4355</td>
<td>% strength retained</td>
<td>80</td>
</tr>
</tbody>
</table>

1 Based on Third Party Testing

### Physical Properties

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<tr>
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<th>Unit</th>
<th>Roll Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roll Dimensions (length x width)</td>
<td>ft (m)</td>
<td>15 x 300 (4.5 x 91)</td>
</tr>
<tr>
<td>Roll Area</td>
<td>yd² (m²)</td>
<td>500 (418)</td>
</tr>
</tbody>
</table>
Basic Design Steps: Finalize GRS-IBS

• Develop scaled drawings to include:
  • Reinforcement layout
  • Block layout
  • Extents of backfill
  • Other details specific to project
Basic Design Steps:
Finalize GRS-IBS
GRS-IBS Installation (Sunshine Hill Bridge): Original Bridge
GRS-IBS Installation (Sunshine Hill Bridge): Placement of RSF
GRS-IBS Installation (Sunshine Hill Bridge): Placement of GRS
GRS-IBS Installation (Sunshine Hill Bridge): Placement of GRS
GRS-IBS Installation (Sunshine Hill Bridge): Placement of Beam Seat/Beams
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GRS-IBS Installation (Sunshine Hill Bridge): Bridge Deck/Integrated Approach
GRS-IBS Installation (Sunshine Hill Bridge): Completed GRS-IBS
GRS-IBS Installation (Sunshine Hill Bridge): Completed GRS-IBS
FDOT Orange Avenue Case History
What about Alabama DOT?

• First GRS-IBS project installed in 2017 in Marshall County (Cochran Road over Turkey Creek)
  – This is a County Project
• Being evaluated by Auburn University team
• Sees them best utilized on moderate to low volume county road bridges
Summary

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  - Reduced construction time and cost, with costs reduced 25 to 60% from conventional construction methods
  
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  - Flexible design that’s easily modified in the field for unforeseen site conditions, including unfavorable weather conditions
For More Information

Guide Specifications, Details, Test Reports, etc. available upon request or at www.belgardcommercial.com

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