EDC

• Taking effective, proven and market-ready technologies and getting them into widespread use

www.fhwa.dot.gov/everydaycounts
Definitions

• **GRS - Geosynthetic Reinforced Soil**
  - An engineered fill of closely spaced (< 12” ) alternating layers of compacted granular fill material and geosynthetic reinforcement

• **IBS - Integrated Bridge System**
  - A fast, cost-effective method of bridge support that blends the roadway into the superstructure using GRS technology
Cross-Section of GRS-IBS

- **Beam Seat**
  (Supported Directly on Bearing Bed)

- **Jointless**
  (Continuous Pavement)

- **Integrated Approach**
  (Geotextile Wrapped Layers at Beams to Form Smooth Transition)

- **Facing Elements**
  (Frictionally Connected – Top Three Courses Pinned and Grouted)

- **Bearing Bed Reinforcement**
  (Load Shedding Layers Spaced at ≤ 6 in.)

- **Scour Protection (Rip Rap)**
  (If Crossing a Water Way)

- **GRS Abutment**
  (Reinforcement Spacing ≤ 12 in.)

- **Reinforced Soil Foundation**
  (Encapsulated with Geotextile)
Summary of Benefits

• Reduced construction cost (25 - 60%)
• Reduced construction time
• Construction less dependent on weather conditions
• Flexible design - easily field modified for unforeseen site conditions (e.g. obstructions, utilities, different site conditions)
• Easier to maintain (fewer bridge parts)
• QA/QC Advantages
Site Selection

- Single span (currently 140 ft)
- 30 ft abutment height
- Grade separation
- Water crossings with low scour potential
- Steel or concrete superstructures
- New or replacement structures
Composite Behavior

GRS

- Composite Structure
- Friction Connections
- Close Spacing
Performance Tests

Before

After
Performance Test

2400 lb/ft @ 8” Spacing

Before

After
6.8 ksf
(326 kPa)
18.1 ksf (867 kPa)
Performance Test Results

- FHWA pier
- Vegas mini pier
- Defiance mini pier
- GRS performance test
Vertical Deformation Continued

![Graph showing vertical deformation](image-url)

- **Vertical Strain (%)** vs.
- **Applied Vertical Load (ksf)**

- **Envelope**
- **Huber**
- **Vine**
- **Bowman**
- **Stever**
- **Glenburg**

Design of GRS-IBS
GENERAL NOTES
PURPOSE: These example plan sheets A through D were prepared to illustrate the typical contents of a set of drawings necessary for a GRS-IBS project. Presented in these plans are the assumptions for the bridge and GRS-IBS systems with typical wall heights (H) ranging from 10 to 24 feet. Two conditions were prepared for the quantity estimate Sheet II: "poor soil conditions" and "favorable soil conditions". INTENDED USE: These plans are not associated with a specific project. All dimensions and properties should be confirmed and/or revised by the Engineer of Record prior to use. Project specifications should be supplemented to prepare supplement this plan set.

DESIGN LOADS AND SOIL PROPERTIES
Combined load: Superstructure (SL = 90) 2 TSF maximum (service load, allowable stress design). Roadway live load surcharge: 250 psf uniform vertical

Road base unit weight = 140 psf, thickness = 34 inches

"Poor" Soil Conditions:
Retained backfill: Unit weight = 125 psf, friction angle = 34°, cohesion = 0 psf, (Cohesion > 200 psf assumed for temporary back slope cut conditions during construction.)

Reinforced fill: Unit weight = 115 psf, friction angle = 39°, cohesion = 0 psf

Foundation soil: Unit weight = 125 psf, friction angle = 25°, cohesion = 0 psf

"Favorable" Soil Conditions:
Retained backfill: Unit weight = 125 psf, friction angle = 40°, cohesion = 100 psf

Reinforced fill: Unit weight = 120 psf, friction angle = 42°, cohesion = 0 psf

Foundation soil: Unit weight = 125 psf, friction angle = 40°, cohesion = 100 psf

CONSTRUCTION SPECIFICATIONS
1. Site Layout/ Survey: Construct the base of the GRS abutment and wingwalls within 1.0 inch of the stated elevations. Construct the external GRS abutment and wingwalls to within ±0.5 inches of the specified state dimensions.

2. Excavation: Comply with Occupational Safety and Health Administration (OSHA) for all excavations.

3. Compaction: Compaction backfill to a minimum of 95 percent of the maximum dry density according to AASHTO T-99 and 95 percent of the maximum dry density according to AASHTO T-99. Only hand-operated compaction equipment is allowed within 3-feet of the wall face. Reinforcement extends directly beneath each layer of CMU blocks, every 40% of the full width of the block to the front face of the wall.

4. Geosynthetic Reinforcement Placement: Pull the geosynthetic taught to remove any wrinkles and lay flat prior to placing and compacting the backfill material. Splices should be staggered at least 24-inches apart and splices are not allowed in the bearing reinforcement zone. No equipment is allowed directly on the geosynthetic. Place a minimum 6-inch layer of granular fill prior to operating only rubber-tired equipment over the geosynthetic at speeds less than 5 miles per hour with no sudden braking or sharp turning.

5. RSF Construction: The RSF should be constructed in geosynthetic reinforced layers on all sides with minimum over-burden of 3.0 feet to prevent water input from the abutment wall. Gravel and/or RPS fill to the top of the RSF prior to final excavation, as this will serve as the leveling pad for the CMU blocks of the GRS abutment.

6. GS Wall Face Alignment: Check for level alignment of the CMU block row at least every other layer of the GRS abutment. Correct any alignment deviations greater than 0.25 inches.

7. Beam Seat Placement: Generally, the thickness of the beam seat is approximately 8 to 12 inches and consists of a minimum of two 4-inch lifts of wrapped-face GRS. Place pre-cast 4-inch thick foam board on the top of the bearing bed reinforcement butted against the back face of the CMU block. Wrap half-height or full height (depending on wall height and required clear space) solid CMU blocks on top of the foam board. Wrap two approximately 4-inch lifts across the beam seat. Before installing the final wrap, it may be necessary to grade the surface aggregate of the beam seat slightly high, to about 0.5 inches, to aid in seating the superstructure and to maximize contact with the bearing area.

8. Superstructure Placement: The crane used for the placement of the superstructure can be positioned on the GRS abutment provided the outrigger pads are sized for less than 4,000 psf near the face of the abutment wall. Greater loads could be supported with increasing distance from the abutment face if checked by the Engineer of Record. An additional layer of geosynthetic reinforcement can be placed between the beam seat and the concrete or steel beams to provide additional protection of the beam seat. Set beams square and level without dragging across the beam seat surface.

9. Integrated Approach Placement: Following the placement of the superstructure, geotextile reinforcement layers are placed along the back of the superstructure, built in maximum lift heights of 6-inches (maximum vertical spacing of reinforcement ≤ 6-inches). The top of the final wrap should be approximately 2-inches below the top of the superstructure to allow at least 2-inches of aggregate base cover over the geotextile to protect it from field mixing.

REINFORCING STEEL
Provide reinforcing steel conforming to ASTM A615, Grade 60.

CMU BLOCK
In colder climates, freeze-thaw test (ASTM C1262-10) should be conducted to assess the durability of the CMU and ensure it follows the standard specification (ASTM C1372). Additives can be used to reduce efflorescence at the facing of the blocks if they are located subject to de-icing chemicals.

Compressive strength = 4,000 psi minimum
Water absorption limit = 5%

Note: In many construction applications CMU blocks are placed with a ¼" mortar joint to create an in place nominal dimension of 8" x 8" x 16".

REINFORCED BACKFILL GRADATION
Reinforced Backfill Gradation = Geosynthetic Reinforced Soil Integrated Bridge System Interface Implementation Guide, Table 1 or Table 2. Consider GRS CMU minimal dimensions to be the same.

GEOSYNTHETIC REINFORCEMENT TENSILE PROPERTIES
Required ultimate tensile strength = 4,800 lb/ft (ASTM D 4959 (geotextiles) or ASTM D 6637 (geogrids))
Tensile strength at 2% strain = 1,370 lb/ft

POLYSTYRENE FOAM BOARD
Provide polystyrene foam board conforming to AASHTO M230, Type VI.
### GRS-IBS Poor Soil Condition Quantities Per Abutment

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<tr>
<th>HEIGHT (H)</th>
<th>ROAD BASE THICKNESS (IN)</th>
<th>GEOSYNTHETIC REINFORCEMENT (V2)</th>
<th>CMU BLOCK SOLID (EA)</th>
<th># REFAR</th>
<th>GRS BACKFILL (CUPS)</th>
<th>RSF FILL (CUPS)</th>
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### GRS-IBS ABBUTMENT Favorable Soil Condition Quantities Per Abutment

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**FOOTNOTES:**
- The estimated materials quantities correspond to the dimensions on the accompanying plans sheets. Deviation from the dimensions on the plan sheets will void the quantities.
- Foam board thickness is 4-inches (typ.).
- Wingwall length = B total + H + 3-feet.
- CMU block assumptions: solid blocks at the base of the GRS abutment from estimated scour elevation to 100-year flood event elevation (5-feet assumed): solid blocks in setback location to beam seat (1-row assumed): hollow blocks for remaining wall height and guardrail height: concrete-filled blocks assumed 3 rows below bearing pad and at the top of the wall of guardrail and at all corners: west wall coping at the top row of concrete CMU at abutment wall and wingwall: flush concrete fill in the CMU's at the top of the abutment wall under the beam seat below the clear zone. See Sheet C and D for illustrations of these details.
- Maximum vertical spacing of reinforcement = height of 1 CMU block (\(H_{max}\)) in reinforced backfill zone. Maximum vertical spacing of reinforcement ≤ 6-inches in bearing bed zone and integrated approach.
- No overlaps in geosynthetics measured for quantities.
- Design clear space (\(d_a\)) rounded up to the nearest 1.0 inch.
- Geosynthetic reinforcement quantity includes RSF and IBS geotextile quantities.

### ABBREVIATIONS:
- \(d_a\): Set back distance between back of facing element and beam seat
- \(H_{max}\): Height of CMU
- \(H_{RSF}\): Height of base of GRS abutment including the wall facing
- \(B\): Base length of reinforcement not including the wall face
- \(B_{br}\): Bearing width, beam seat
- \(L_{max}\): Length of geosynthetic reinforcement
- \(B_{cm}\): Base length of CMU
- \(B_{RSF}\): Width of RSF
- \(B_{total}\): Total width at base of GRS abutment including the wall facing
- \(L_{br}\): Length of bearing bed reinforcement
- \(L_{cm}\): Length of CMU
- \(L_{wingwall}\): Wingwall length.
- \(X_{RSF}\): Length of RSF in front of the abutment wall face
- \(H\): Wall height measured from top of RSF to top of beam seat
- \(H_{base}\): Height of CMU
- \(H_{max}\): Height of base of GRS abutment (equals height of super structure and pavement thickness)
- \(IBS\): Integrated Bridge System
- \(L_{abut}\): Abutment length
- \(L_{CMU}\): Length of CMU
- \(L_{wingwall}\): Wingwall length.

### GRS-IBS DESIGN DIMENSION QUANTITIES
NOTE:
1. Insert #4 rebar into the top 3 rows of CMU's and corner CMU's and fill with concrete.
2. Adjust length and angle of wingwalls for site specific conditions and quantities in Sheet 8 accordingly.
3. If RSF is not used beneath the wingwalls, then additional independent retaining wall calculations should be performed to determine the stability of the wingwalls.
4. Superelevation of the roadway is assumed to have a crest at the centerline of the roadway, which corresponds to the maximum design clear space (d).
5. No skew angle of the bridge to the stream channel is assumed.
6. No angular distortion between abutments is assumed.
7. Solid core CMU's placed up to the riprap height (5 feet typ.).
8. CMU blocks are staggered, including corners, so there are no vertical joints greater than 1 CMU block height.
9. Guardrail type and location to be designed by others in accordance with required safety standards.

FOOTNOTE:
1. Bench wingwall as necessary.
2. Wingwalls folded out for elevation view.
CONSTRUCTION
Youtube Video
User Perspective

Defiance County, Ohio
Open to Traffic:
47 days

Construction Costs:
80’x32’-$266,000 - 2005
Construction Costs:

28’x20’ - $68,000 - 2008
Construction Costs
28' x 20' - $88,000 - 2009
Construction Costs: 32’x10’-$51,000 - 2010
Construction Costs:
28’x20’-$70,000 - 2010
Construction Costs:
28’x20’-$65,000 - 2010
Construction Costs:
28’x32’ - $85,000 - 2010
Construction Costs:
36’x20’ - $71,000 - 2010
Construction Cost:
140’x40’-$620,000 - 2009
User Perspective

St. Lawrence County, NY
CR 12 - 40’x33’ - Material Cost $160,000
Construction costs $240,000
CR 24 - 47’x33’ - Material Cost $110,500
CR 31 - 56’x33’ - Material Cost $165,000
CR 35 - 67’x33’ - Material Cost $180,500
Construction Cost $310,000
CR 38 - 63’x32’ - Material Cost $175,000
User Perspective
Huston Township, Pennsylvania
User Perspective
Ottawa County, Oklahoma
User Perspective
National Park Service
Disney Bridge in Sequoia NP
PROGRESS TOWARD 2012 EDC
GRS IBD GOALS
2012 Deployment Goals

• December 2012:
  – 30 bridges have been designed and/or constructed using GRS-IBS on the NHS within 20 states
  – 75 bridges have been designed and/or constructed using GRS-IBS off the NHS
Total of 56 projects in 28 states at some stage of development from conceptual to construction.