MS-0460-0010

Use and Design Guidelines for Evaluating and Determining the Implementation of a Geosynthetically Reinforced Soil – Integrated Bridge System

(GRS-IBS)

OBJECTIVE

The purpose of this document is to provide municipalities with information and guidance towards having engineers evaluate the applicability of GRS-IBS for use on their local bridge projects.

INTRODUCTION

GRS technology consists of closely spaced layers of geosynthetic reinforcement and compacted granular fill material. GRS-IBS is a fast, cost-effective method of bridge support that blends the roadway into the superstructure. GRS-IBS includes a Reinforced Soil Foundation (RSF), a GRS abutment, and an Integrated Approach (IA).

I. PROCESS DESCRIPTION

Engineers must utilize the design and construction specifications provided as follows:

A. Federal Highway Administration:
   1. **FHWA-HRT-11-026:** "Geosynthetic Reinforced Soil Integrated Bridge Systems Implementation Guide."
   2. **FHWA-HRT-12-051:** "Sample Guide Specifications for Construction of Geosynthetic Reinforced Soil-Integrated Bridge Systems (GRS-IBS)."

B. Guidelines in this document provide additional information to FHWA-HRT-11-026 and FHWA-HRT-12-051. In instances where guidelines differ between the sources, this document takes precedence.

C. PennDOT current and applicable design standards, including, but not limited to PennDOT Publication 15M, Design Manual Part 4 on structures.

D. PennDOT standard drawings (PennDOT Publications 72M, 218M, and 219M).

II. GRS-IBS DESIGN GUIDELINES

(in accordance with: FHWA-HRT-11-026 and FHWA-HRT-12-051)

A. SITE LIMITATIONS

1. GRS-IBS is limited to bridges with simple span structures.
2. Skew angle for GRS-IBS bridges shall be according to PennDOT Publication 15M based on the limitations of the proposed superstructure type.
3. GRS-IBS is limited to span lengths up to 70 feet.

4. GRS-IBS is limited to bridges with GRS abutment heights up to 30 feet.
5. GRS-IBS is limited to sites with low scour potential.
6. GRS-IBS is limited to maximum stream velocities for all storm events, less than and including the 100 year storm event. Maximum allowable "through structure" stream velocities are:
    a. **≤ 7 fps**: Conventional GRS construction utilizing standard hollow Concrete Masonry Units (CMUs) with friction connection.
    b. **7-10 fps**: Complete concrete fill with rebar on standard hollow CMUs.
    c. **10-12 fps**: Large CMUs (24" x 24" x 72") with intermediate layers of geotextile wrap-faced at 8" intervals.
7. GRS-IBS is limited to sites with soil pH between 5 and 9.
8. Outlet pipes through the GRS-IBS are not permitted.

B. SITE EVALUATION

A site evaluation shall be performed in accordance with FHWA-HRT-11-026, Section 4.3.2.

C. SCOUR

1. **Scour Depth:**
    a. Footings are to be designed based on the total scour depth obtained from a scour design flood. The scour design flood is defined as a 100 year flood, the flood of record (if available), or the overtopping flood (if less than the 100 year flood), whichever results in the worst-case scour condition in accordance with PennDOT Publication 15M Section 7.2.2.
    b. The reinforced soil foundation shall be placed below this calculated depth in accordance with Hydraulic Engineering Circular 18 (HEC-18) – or- PennDOT Publication 15M Section 7.2.4.
2. **Scour Protection:**
    a. A properly designed scour countermeasure shall be placed to protect against local scour in accordance with FHWA-HRT-11-026, Section 4.3.3. Riprap protection shall be sized appropriately for the class of stone specified in accordance with PennDOT Publication 15M Section 7.2.5. It is recommended that CMU blocks which are solid be used at the bottom of the GRS wall for reinforcement, and CMU blocks of a different color can be used to indicate scour as per FHWA-HRT-11-026, Section 6.4.
    b. Potential for channel migration shall be evaluated. The effect of lateral channel movement on abutments may be mitigated by providing abutment setback or providing wingwalls that extend beyond the estimated channel migration distance. The RSF shall be protected from

scour. In all cases, wingwall height and length shall be constructed to adequately protect the reinforced fill from channel scour and undermining from surface drainage.

D. **BEAM SEAT:**

1. The maximum Service I Bearing Pressure on the GRS beam seat shall be limited to 4,000 lb/ft^2.
2. A cast in place or precast beam seat with a concrete end diaphragm is required for concrete girders, steel/timber superstructure elements, or other similar superstructures without backwall support.
3. When the use of a superstructure type warrants a beam seat, the superstructure must be properly anchored to the beam seat to prevent lateral movement or uplift of the superstructure.

NP-0050

Geosynthetically Reinforced Soil – Integrated Bridge System

(GRS-IBS)

I. **DESCRIPTION** – This work consists of designing and constructing an Integrated Bridge System (IBS) using Geosynthetically Reinforced Soil (GRS) technology on a Reinforced Soil Foundation (RSF).

II. **MATERIAL** (in accordance with: FHWA-HRT-11-026 and FHWA-HRT-12-051). Materials must be obtained from a manufacturer listed in Bulletin 15 (unless otherwise noted) for projects with state or Federal funding and conforming to the following requirements:

A. FACING ELEMENTS

1. **Concrete Masonry Unit (CMU):** PennDOT Publication 408, Section 713, and conforming to the following requirements:
    a. Concrete strength of 3000 psi minimum. No additional payment will be made for higher strength concrete.
    b. Water absorption limit $\leq$ 5%.
    c. Freeze thaw testing in accordance with ASTM C1262-10.
    d. "Standard CMUs", hollow or solid as required, with nominal dimensions of 8" x 8" x 16".
2. **Large CMU Unit:** PennDOT Publication 408, Section 714, and conforming to the following requirements:
    a. Solid block with nominal dimensions of 24" x 24" x 72". Consideration shall be given to the design/installation of necessary temperature and shrinkage reinforcement and any additional reinforcement or lifting devices necessary for handling the large CMU units.
    b. Concrete strength of 3000 psi minimum. No additional payment will be made for higher strength concrete.
3. **Existing Abutments:** GRS structures can be constructed behind existing bridge abutments, subject to PennDOT approval. In these cases, the existing bridge abutments effectively become part of the facing element of the GRS structure. The GRS shall be wrapped-faced using geotextile fabric against the existing abutment in accordance with FHWA-HRT-11-026, Section 7.3.3.
4. **Other Facing Elements:** Other facing materials may be used with District Bridge Engineer approval.

B. BACKFILL MATERIAL:

1. All backfill material shall consist of sound, crushed, durable particles, fragments of stone gravel free from organic matter or other deleterious material, with a minimum friction angle of 38 degrees.
    a. **Reinforced Soil Foundation (RSF) Backfill**: PennDOT 2A coarse aggregate. All backfill aggregates must be Type A. (PennDOT Publication 408, Section 703.2)
    b. **GRS Abutment Backfill**: AASHTO #8 is the preferred abutment backfill. Backfill may also consist of coarse aggregate conforming to AASHTO #8, #57, #67, or a combination thereof. All backfill aggregates must be Type A. (PennDOT Publication 408, Section 703.2)
    c. **Integrated Approach Backfill**: PennDOT 2A coarse aggregate (PennDOT Publication 408, Section 703.2) -or- Driving Surface Aggregate (DSA). (PennDOT Pub 447, MS-0450-0004)

C. **GEOSYNTHETICS (Geotextiles)**

1. **Geosynthetic Reinforcement in Abutment, Reinforced Soil Foundation and Integrated Approach**: Biaxial geotextiles with a minimum Ultimate Tensile Strength = 4,800 lb/ft or as required by design.
    a. Woven geotextile strength shall be as determined by ASTM D 4595. Geotextile reinforcement tensile strength at 2 percent strain shall be greater than the calculated required reinforcement strength in the direction perpendicular to the abutment wall face as outlined in FHWA-HRT-11-026, Section 4.3.7.

D. **Class A Cement Concrete**: Class A cement concrete for use in hollow block wall fill and cast in place coping. (PennDOT Publication 408, Section 704.1)

E. **Reinforcement Bars**: Deformed rebar of a size and spacing as required by design, epoxy coated or galvanized in accordance with PennDOT Publication 408, Section 1002.

F. **Aluminum Flashing**: Flashing, such as 4" x 1.5" aluminum fascia or equivalent, may be used to serve as a drip edge under the superstructure to shed potentially corrosive fluids off the dry cast block and to prevent animals from burrowing into the abutment. (Note: Flashing is not Bulletin 15 approved)

G. **Preformed Cellular Polystyrene**: Preformed Cellular Polystyrene Geotextiles shall conform to PennDOT Publication 408, Section 516.2 and ASTM C578. In addition, it should have expanded polystyrene filler or equivalent, having a compressive strength >10 psi. Total thickness of the foam board shall be 4 inches or greater depending on the abutment height.

H. **Asphaltic (bitumen) Coating**: An asphaltic coating shall be shop installed on the concrete beam ends where it will be embedded between the GRS abutment and the wing wall to seal the embedded concrete.

J. **Scour Countermeasures:** Rock Lining as defined in PennDOT Publication 408, Section 850. Rip-rap scour countermeasures shall be sized according to Hydraulic Engineering Circular 23 (HEC-23). Rip-rap size as required by design and as shown on the project drawings.

III. **CONSTRUCTION** (in accordance with: FHWA-HRT-11-026 (Chapter 7), and FHWA-HRT-12-051, Section 3)

A. **Equipment**: Use equipment that produces the completed GRS-IBS and maintain all equipment in a satisfactory operating condition as specified in PennDOT Publication 408, Section 108.05(c).

1. **Compaction Equipment:** Rollers and other compaction equipment as described in PennDOT Publication 408, Section 108.05(c) 3.d, 3.g, 3.h, and 4.

B. **Excavation**: Construct embankments and/or cut existing grade to the bottom of footing elevations. Excavate and backfill foundation areas as specified in PennDOT Publication 408 Section 204.3 and compact using a mechanical tamper or vibratory compactor. If unsuitable foundation material is encountered, remove all unsuitable material at least 12" or as specified or directed below the bottom of the RSF elevation and backfill with compacted No. 2A Coarse Aggregate as specified or directed. No additional payment shall be made if rock is encountered during excavation.

C. **Compaction of Backfill** (RSF, Abutment, and Integrated Approach): Hand-operated compaction equipment as specified above is required within 3 ft of the front of the abutment wall face.

1. **Compaction of Open-Graded Backfill in Abutment**: Compact to non-movement or no appreciable displacement with compaction equipment specified above and assess with visual inspection (minimum of 4 vibratory passes per lift). Abutment backfill is to be placed at a maximum compacted depth of 4 inches per lift.
2. **Compaction of Well-Graded Backfill in Reinforced Soil Foundation and Integrated Approach**: Compact well-graded backfill to not less than 100% of the determined dry-weight density. Dry-weight density for material in place in the field will be determined, in accordance with Pennsylvania Testing Method (PTM) No. 106, Method B. In-place density or compaction will be determined, in accordance with PTM No. 402 where directed. At the time of compaction, maintain the material's moisture content not more than 2 percentage points above optimum moisture for that material. Backfill is to be placed and compacted in lifts shallow enough to achieve 100% compaction, not to exceed 8 inches (loose) in a single lift.

D. **GRS Abutment Facing**

1. All CMU block walls shall be constructed with a vertical face.

2. **Reinforcement of Facing-wall/Wing-wall Corners for Flows ≤7 fps Maximum Stream Velocity:**
    a. The top three courses of Standard CMU block shall be filled with Class A cement concrete (PennDOT Publication 408, Section 704) with one #4 epoxy coated reinforcement bar of sufficient length to engage all three courses of block, embedded with a minimum of 2" cover, and provided with a cast in place cap in accordance with FHWA-HRT-11-026, Section 7.7.7.
    b. All courses of hollow CMU blocks on the facing-wall/wing-wall corners shall be filled as described in Section 2.a above. This shall include a minimum of 3 block columns comprised of the corner unit, and one unit on each side of the corner unit.
3. **Reinforcement of Facing-wall/Wing-wall for Flows of 7-10 fps Maximum Stream Velocity:**
    a. All courses of hollow Standard CMU blocks on the facing-wall and wing-walls shall be filled with Class A cement concrete (PennDOT Publication 408, Section 704), #4 epoxy coated reinforcement bars of sufficient length to engage all courses of block, and embedded with a minimum of 2" cover and provided with a cast in place cap in accordance with FHWA-HRT-11-026, Section 7.7.7.
4. **Construction of Facing-wall/Wing-wall for Flows of 10-12 fps Maximum Stream Velocity:**
    a. Large CMUs (24" x 24" x 72") shall be used. In addition to horizontal geotextile layers between blocks, two additional intermediate layers of geotextile shall be used behind each block, wrap-faced against the GRS wall so that geotextile spacing is at 8" intervals.

E. **Site Drainage**

All GRS structures shall include consideration for surface drainage both during and after construction in accordance with FHWA-HRT-11-026, Section 7.1,1 and Section 8.2.

IV. **MEASUREMENT AND PAYMENT** – Lump Sum. Includes all excavation required for GRS-IBS placement, the Reinforced Soil Foundation (RSF), the GRS abutments, the integrated approach, geotextile, backfill material, CMUs, and scour protection. Does not include the beam seat (when required), superstructure, removal of the existing structure as defined in the contract drawings, temporary support and excavation systems if required, dewatering and other erosion and sedimentation control measures, stream diversion, maintenance and protection of traffic, or approach roadway items.