Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS)

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Module Information

- Module number: 4
- Title: Performance Monitoring, GRS-IBS Maintenance, Quality Control and Quality Assurance
- Presentation duration: 45 minutes
- Level of audience: Professionals with knowledge in civil engineering

Acronyms

AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Standard for Testing Materials
CMU	Concrete Masonry Unit
EDC	Every Day Counts
EDM	Electronic Distance Measurement
FHWA	Federal Highway Administration
GRS	Geosynthetic Reinforced Soil
IBS	Integrated Bridge System
MSE	Mechanically Stabilized Earth
QA	Quality Assurance
QC	Quality Control

Introduction

- EDC is designed to identify and deploy innovation aimed at shortening project delivery, enhancing the safety of our roadways, and protecting the environment.
- These goals are worth pursuing for their own sake, but in challenging times, it is imperative to pursue better, faster, and smarter ways of doing business.

Introduction

- Teams from the FHWA work with the local state and industry partners to deploy the initiatives of EDC and to develop performance measures to gauge their success.
- GRS-IBS uses alternating layers of compacted granular fill material and fabric sheets of geotextile reinforcement to provide support for the bridge.

Introduction

- This technology provides an economical solution to accelerated bridge construction.
- Is easy to build and maintain with common labor, equipment, and materials.
- Has a flexible design that is easily modified in the field for unforeseen site conditions.
- Has significant value when employed for small single-span structures.

Definitions

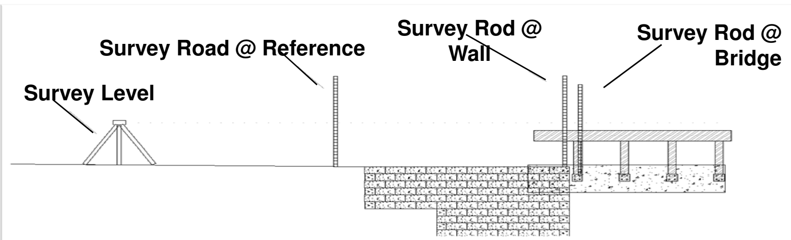
- MSE – a soil constructed with tensile reinforcing members (steel or geosynthetic) to increase the strength and load-bearing capacity.
- GRS – an engineered fill of closely spaced alternating layers of geosynthetic reinforcement and compacted granular fill material.
- IBS – a fast and cost-effective method of bridge support that blends the roadway into the superstructure using GRS technology.

Objectives

- Performance Monitoring and Maintenance
- Quality Control and Quality Assurance

Performance Monitoring

- Three important aspects to be monitored:
  1. Settlement
  2. Lateral Deformation
  3. Thermal Cycles



Settlement Monitoring

- Two common methods are used in practice:
  1. Standard Survey Level and Rod System
  2. Electronic Distance Measurement (EDM) Survey

Settlement Monitoring

- 1) Standard survey level and rod system
  i. Measured at 4 locations (each corner of the bridge)
  ii. Wall settlement recorded by the rod of the top off the CMU facing block adjacent to the superstructure
  iii. Superstructure settlement measured with the rod off a guard rail hanger bolt
  iv. Precision: +/- .005 ft.

Settlement Monitoring

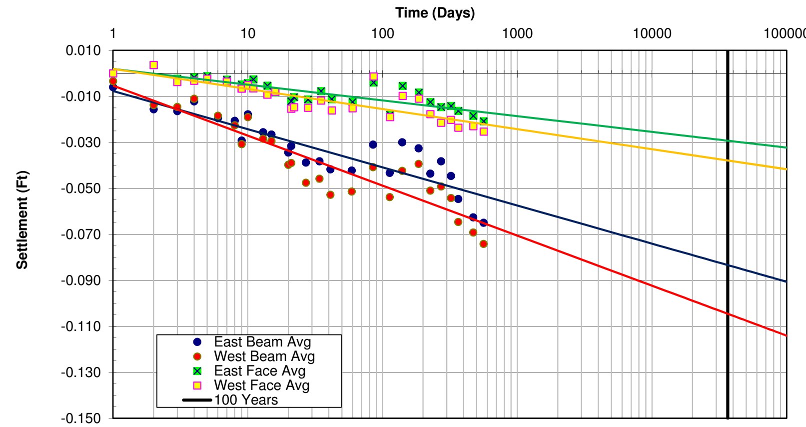
- 2)Electronic distance measurement (EDM) survey
  i. The total station is referenced off of a permanent pole embedded beneath the frost line
  ii. Targets placed on the abutment wall face and the bridge beam are then used to measure movement relative to the permanent pole
  iii. Install the permanent pole prior to placement of the superstructure
  iv. Precision: ± 0.005 ft

Settlement Monitoring

- In both methods, settlement is recorded for both the abutment face wall and the superstructure.
- The difference between the settlement measured on the abutment face wall and the superstructure is the vertical deformation within the GRS mass alone.
- This value can be divided by the height of the abutment face wall to compute the vertical strain within the GRS mass.

Settlement Monitoring

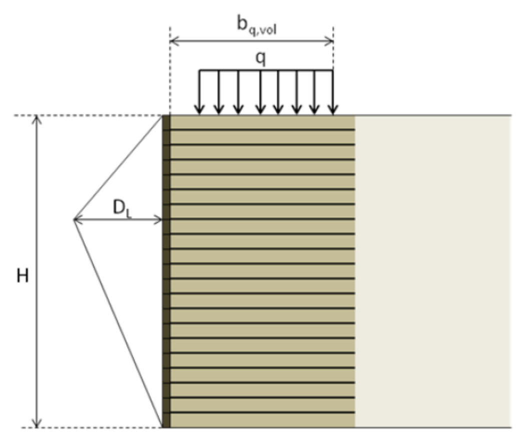
- To predict long-term settlement, plot settlement vs. time curve in log-scale and fit.



Lateral Deformation

- Estimated
  i. Theoretically assuming no loss in volume
- Measured
  i. Not frequently measured on bridges
  ii. Can use EDM, Slope inclinometer, etc.
- Lateral strain limited to 1% (of bearing area + setback)

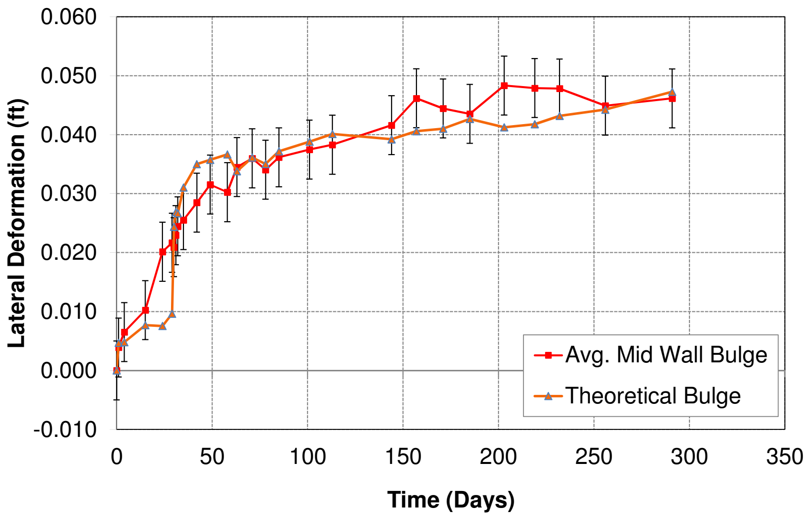
Lateral Deformation



$$\Delta V_{top} = b_{q,vol} L D_v = \Delta V_{face} = \frac{1}{2} H L D_L$$

$$\varepsilon_L = \frac{D_L}{b_{q,vol}} = \frac{2D_v}{H} = 2\varepsilon_v$$

Lateral Deformation

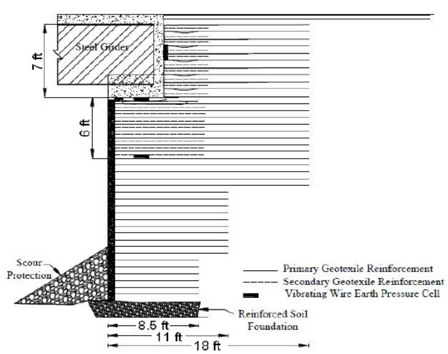


Thermal Cycles

- Compatible with thermal cycles
- Integrated transition behind the beam ends
- The wrapped face of the integrated approach:
  - Confines the soil
  - Prevents soil sloughing behind the beam ends
  - Limits development of excess pressures behind the beams

Thermal Cycles

- To measure lateral pressure behind beam end, place vibrating wire vertical pressure cells behind the beam end and connect to a data logger.



Maintenance

- Minimal maintenance because of fewer parts (e.g., no approach slab, parapet walls, bridge bearings, or joint details).
- Common materials = general maintenance similar to that of conventional bridge system.

Maintenance

- Duties might include:

1. Sealing of a pavement crack.
2. Stabilization of drainage ditches to prevent erosion.
3. Removal of vegetation growth from the wall face (unless part of design).
4. Sealing of any gaps in the facing large enough to allow for a loss of fill.

Quality Control and Quality Assurance

- QC consists of implementation, measurement, and enforcement of sound construction practices and field inspection procedures to ensure construction quality.
- QA is necessary to ensure the finished product meets specifications through inspection, testing, and final acceptance.

QA&QC (Cont.) - Role of the Contractor

- Since GRS is a nonproprietary generic wall system, the contractor building the wall can be responsible for developing and maintaining a QA/QC plan for project quality. Prequalification should be a necessary requirement for this type of construction.

QA&QC (Cont.) - Testing

1)Laboratory Testing

a) Gradation and moisture-density tests (e.g., Proctor compaction test) will be required for field monitoring of the backfill material.
b) The classification tests and moisture-density tests should follow AASHTO standards for aggregate sampling and testing.
c) Large-scale direct shear tests or triaxial tests are the most effective methods for determining the friction angle for coarse-grained backfill aggregates.

2) Field Testing

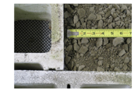
a) Fill placement and compaction is the predominant construction activity that needs to be monitored in a GRS-IBS project. Field density tests should be performed on each layer. The field test method should be applicable to the aggregate type that is used for the backfill material.

QA&QC (Cont.) - Construction Inspection

- Thorough inspection before and during construction will ensure the GRS structure is built in accordance to the plans and guidelines. Inspection requires an understanding of GRS design and methodology. Familiarity and understanding of the drawings is necessary. It is important to have firsthand knowledge of the GRS construction processes. A properly implemented field inspection program provides an opportunity to take corrective action during the construction process.

QA&QC (Cont.) - Materials

- Once materials are delivered to the site, they should be inspected for compliance with the guidelines and project specifications. Materials should be visually inspected for quality, damage, and defects.
- Backfill: In addition to the quarry material certificate showing the gradation of the aggregate, a visual inspection should be performed to verify maximum grain size, amount of fines and grain shape (angular or rounded), excess fines, moisture content, and durability.



- Facing block: The facing block should be inspected for integrity, consistency, and dimension tolerances. Confirm that sufficient quantities and proper block type (e.g., solid block, corners, and face block) are present onsite and ready for use.
- Geosynthetic reinforcement: Verify that the specified type and strength of geosynthetic is correct along with the required roll dimensions.

QA&QC (Cont.) - Equipment

- Compaction of the backfill in a GRS wall or abutment is a critical construction activity. It should be confirmed that the compaction equipment onsite is compatible with the selected backfill material.
- Verify that the required hand tools are onsite for spreading and grading aggregate, maintaining the facing alignment, and sweeping the top of the CMU facing block.

Conclusions

- GRS-IBS performance monitoring has three main aspects to be considered:

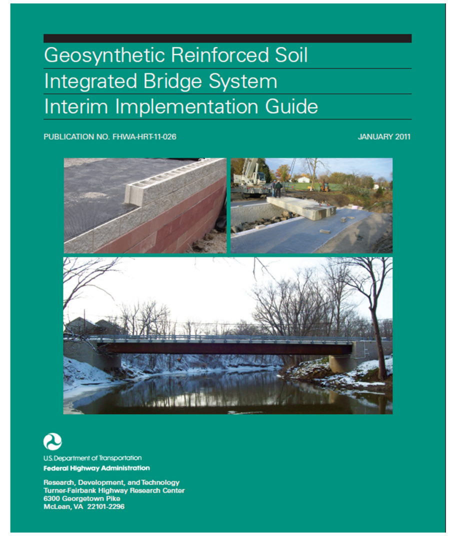
1. Settlement
2. Lateral Deformation
3. Thermal Cycles

- The vertical deformation within the GRS mass alone will be the difference between the settlement measured on the abutment face wall and the superstructure.
- Lateral Deformation (considering a “no loss in volume” assumption) will be twice that vertical deformation.
- The GRS-IBS is compatible with thermal cycles.
- Maintenance will be minimal because of fewer parts; the commonality in materials means general maintenance similar to that of a conventional bridge system.
- QA & QC measures will be taken (as with any project).
- However, since the GRS is a nonproprietary generic wall system, the contractor building the wall can be responsible for developing and maintaining a QA/QC plan for project quality. Prequalification should be a necessary requirement for this type of construction.

Acknowledgements

- Benjamin Colucci, PhD, JD, PE
- Michael Adams, PE
- Jennifer Nicks, PE
- Daniel Alzamora, PE
- Alvin Gutierrez, PE
- Transportation Technology Transfer Center Staff

Reference



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