TECHSUMMARY January 2020
State Project No. 30000981 / LTRC Project No. 13-5GT

Monitoring of In-Service Geosynthetic Reinforced Soil (GRS) Bridge Abutments in Louisiana

INTRODUCTION

Geosynthetic reinforced soil technology (GRS) was first used in the United States in the 1970s to build a GRS wall to support logging roads in steep mountain terrain. The GRS has a variety of applications in civil engineering such as walls, bridge piers, and bridge abutments. Over the last few years, the use of GRS for bridge abutments has received considerable attention. Geosynthetic Reinforced Soil Integrated Bridge System (GRS-IBS) is the coined name for a GRS wall and bridge system that was developed as part of the “Bridge of the Future” initiative by FHWA.

The GRS-IBS consists of three components: reinforced soil foundation (RSF), GRS abutment, and integrated approach. The RSF is built from compacted granular aggregate wrapped with geosynthetic, which is placed under the GRS abutment to provide more support and increase the bearing capacity. The GRS abutment is composed of compacted backfill and layers of geosynthetic reinforcement. The integrated approach is also constructed with GRS to transition to the bridge.

Figure 1
The GRS-IBS at Maree Michel Bridge

In 2010, GRS-IBS was made an Every Day Counts (EDC) initiative. Many of bridges in the U.S. have structural deficiencies, with the vast majority single span bridges no more than 90 ft. in length. Currently the demand for repair and future construction of bridges does not align with government budgets. Therefore, a new efficient system is required so that more bridges can be rehabilitated and constructed at low cost. GRS-IBS is a possible solution for this dilemma.

The GRS-IBS is proficient alternative for low-volume, single span bridges. It can be built in less time and over a variety of foundation soil conditions with common equipment and materials. The GRS-IBS is more cost-effective than traditional bridge construction. The cost of GRS-IBS bridge is 25-30% less than cost of standard pile cap abutments on deep foundations with 2:1 slopes for off-system bridges. The savings is due to the simplicity and flexibility of the design, speed of construction, use of readily available materials/ equipment, elimination deep foundation and other constructions associated with the approach way to the bridge, and lower maintenance costs.

OBJECTIVES

1. Monitor the short-term and long-term performance of in-service GRS-IBS abutment at Maree Michel Bridge in Louisiana (see Figure 1).
2. Verify the design parameters for GRS-IBS abutment, mainly stresses, strains, and deformations involved in both external and internal stability analyses.
3. Perform a comprehensive FE parametric study to investigate the effects of different design parameters on the behavior of GRS-IBS.

METHODOLOGY

To realize the potential benefits of using GRS-IBS abutments in Louisiana, DOTD built GRS-IBS abutments for the Creek and Maree Michel bridges in Louisiana to examine the performance of GRS-IBS abutments with respect to local materials and soil conditions. In order to monitor the performance of in-service GRS-IBS abutments, various types of instrumentations were installed in the south abutment of the Maree Michel Bridge. The primary measurements were: vertical and horizontal deformations near the front wall, settlements due to the RSF and the GRS-IBS backfill, distribution of stresses within GRS-IBS abutment and below RSF, and distribution of strains along geosynthetics. Additionally, the pore water pressure and temperature were monitored by piezometers and thermocouples. Six different types of instrumentations were used to monitor the GRS-IBS abutment: Shape Acceleration Array (SAA), horizontal and vertical earth

LTRC Report 614

Read online summary or final report:
www.ltrc.lsu.edu/publications.html

PRINCIPAL INVESTIGATOR:
Murad Abu-Farsakh, Ph.D., P.E.
Professor, Research

LTRC CONTACT:
Tyson Rupnow, Ph.D., P.E.
225.767.9124

FUNDING:
SPR: TT-Fed/TT-Reg

Louisiana Transportation Research Center

4101 Gourrier Ave
Baton Rouge, LA 70808-4443

www.ltrc.lsu.edu

pressure cells, strain gauges, piezometers, and thermocouples. A survey was also conducted at the bridge surface upon the completion of construction. Measurements from instrumentations provide valuable information to evaluate the design procedure and performance of GRS-IBS bridges.

The FHWA design of GRS-IBS abutments was verified based on the collected data from the instrumentation measurements. Furthermore, the long-term monitoring provides the measurements needed to examine the performance, durability and long-term stability of the GRS-IBS abutments constructed over Louisiana subsurface soil, under the live traffic load condition. In general, the overall performance of the GRS-IBS was within acceptable tolerance in terms of measured strains, stresses, settlements, and deformations.

CONCLUSIONS

- The satisfactory performance of the GRS-IBS abutment at Maree Michel Bridge helps gain more confidence in implementing the GRS-IBS technology.
- The deformation measurements of abutment indicate that the maximum total settlements across the GRS abutment were significantly less than the FHWA recommendations.
- The maximum lateral deformation of the GRS-IBS wall face was less than 1% of the bearing width, as recommended by the FHWA.
- The measured lateral pressure on the wall face was negligible and much less than the Rankine lateral earth pressure.
- The maximum geotextile strains were less than 2% as specified in the FHWA manual.
- The locus of maximum reinforcement strains shows that the failure envelope is most likely a combination of punching shear failure envelope (at top) and Rankine failure envelope (at bottom).
- FE parametric study showed that span length, reinforcement stiffness, and reinforcement spacing are the most significant parameters contributing to the performance of GRS-IBS.

RECOMMENDATIONS

- Based on the satisfactory field performance of the GRS-IBS at Maree Michel Bridge, it is highly recommended that DOTD design engineers to start implementing the GRS-IBS technology in the design of new bridge abutments in Louisiana.
- It is recommended to consider verifying the findings of finite element parametric study, such as the effects of length of reinforcement, reinforcement stiffness/spacing, and secondary reinforcement on the performance of GRS-IBS.
- Consider an experimental study to evaluate the combined effects of reinforcement spacing and reinforcement stiffness to optimize the performance of GRS-IBS abutments and to develop and implement the composite concept in the design of GRS-IBS abutments.

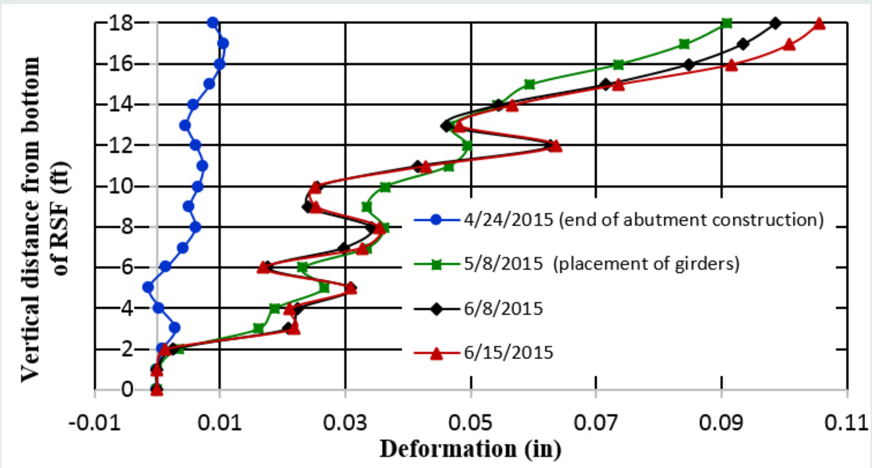

Figure 2. Lateral movements of the abutment close to facing wall

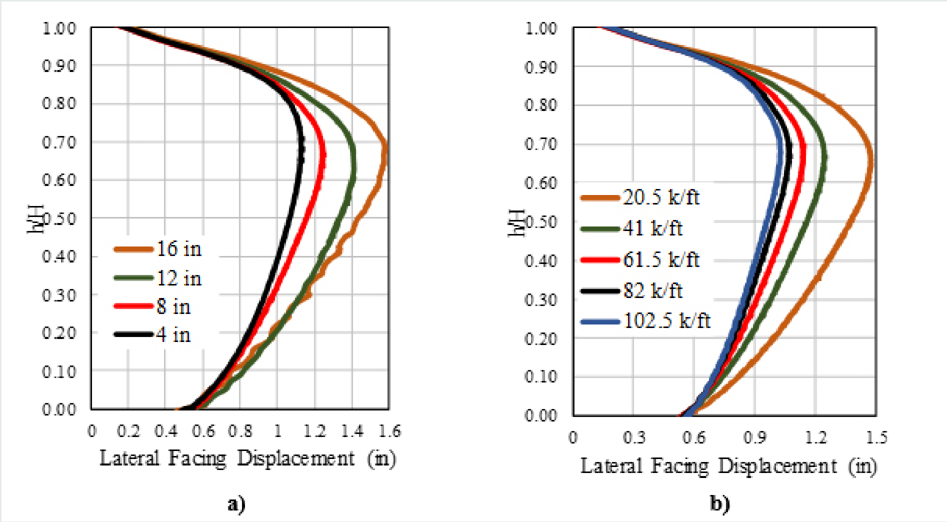

Figure 3. Effect of reinforcement a) spacing; b) stiffness on the lateral facing displacement