RESEARCH
PROJECT CAPSULE [13-5GT]

September 2014

TECHNOLOGY TRANSFER PROGRAM

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

JUST THE FACTS:

Start Date:
October 1, 2014

Duration:
24 months

End Date:
September 30, 2016

Funding:
SPR: TT-Fed/TT-Reg

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Sponsored jointly by the Louisiana Department of Transportation and Development and Louisiana State University

POINTS OF INTEREST:

Problem Addressed / Objective of Research / Methodology Used Implementation Potential

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PROBLEM

Over the decades, geosynthetic reinforced soil (GRS), a soil mass reinforced by layers of geosynthetics has been widely used successfully in a variety of earth structures such as mechanically stabilized earth (MSE) retaining walls, embankments, slopes, and shallow foundations. The application of the GRS technology to bridge-supporting structures, particularly for bridge abutments, recently has been gaining popularity due to its proven advantages over the traditional bridge abutments involving reinforced concrete pile foundations (Adams et al., 1999; Wu et al., 2001; Abu-Hejleh et al., 2002; We et al., 2006; Warren et al., 2011; Vennapusa et al., 2012).

A typical GRS bridge abutment consists of three primary components: the reinforced soil foundation (RSF), the abutment, and the integrated approach. The RSF is constructed with granular materials compacted and wrapped with a geotextile. The RSF adds extra bearing capacity to the GRS abutment. The GRS abutment is composed of alternating layers of compacted backfill and geosynthetic reinforcements. The spacing between the geosynthetic reinforcements is closer for the zone immediately underneath the bridge to provide bearing support for the bridge. The approach is also constructed with GRS to transition to the bridge.

When used for bridge abutments, the GRS has many notable benefits compared to traditional abutments (Helwany et al., 2003) including: simple and fast construction techniques with the elimination of heavy construction equipment and use of less construction area; savings in construction cost with 25 to 60 percent less than the traditional construction method; and the ability to tolerate large differential settlements, thus alleviating the "bridge bumps" often experienced at the ends of a bridge resting on a pile-supported abutment.

The design methods and construction techniques for GRS abutments have evolved along with the numerous research and studies conducted on the GRS abutments. The Federal Highway Administration (FHWA) has recently released one synthesis and one implementation manual covering the background, design, construction, and performance of GRS abutments (Adams et al., 2011-a,b). Additionally, through the FHWA's Every Day Counts (EDC) initiative, the FHWA has been promoting the GRS technology with the GRS-Integrated Bridge System (GRS-IBS), which is deemed to be the proven and market-ready technology.

Recognizing the potential benefits of using GRS-IBS for local bridges, the Louisiana Department of Transportation and Development (DOTD) plans to build a GRS-IBS abutment for one single-span bridge at Maree Michel in Vermillion Parish. While the GRS bridge abutments exhibit distinct benefits over traditional abutments, following the correct practices during the construction of GRS abutments is vital in achieving satisfactory performance of GRS abutments (Abu-Hejleh et al., 2002; Wu et al., 2006; Adams et al., 2011-b). Given that the use of GRS-IBS for bridge abutments is relatively new in Louisiana, the behavior and performance of the GRS-IBS abutments must be monitored and evaluated for local soil conditions and material during and after the construction. In addition, the design of these particular GRS-IBS abutments needs to be calibrated and verified against measured stresses and deformations for both external and internal stability analyses.

OBJECTIVE

The primary objectives of this research are to monitor the short-term and long-term behavior and performance of in-service GRS-IBS abutments in the state of Louisiana, and to verify important design factors and parameters for GRS-IBS abutment, mainly stresses and deformations involved in both external and internal stability analyses.

METHODOLOGY

To achieve the objectives, a GRS-IBS abutment will be constructed on a selected single-span at Maree Michel Bridge in Vermillion Parish, Louisiana. The GRS-IBS abutment will be instrumented with various types of instruments to record the measurements of interest, including the vertical and horizontal deformations near the front wall, settlements due to the soil foundation and the GRS-IBS backfill, the stresses and/or distribution of stresses within the GRS-IBS abutments, and the distribution of strains along the geosynthetic reinforcements. Additionally, the possible development of pore water pressure will be monitored by piezometers, while thermocouples will be installed to account for potential effects of thermal cycles on the abutment and bridge responses.

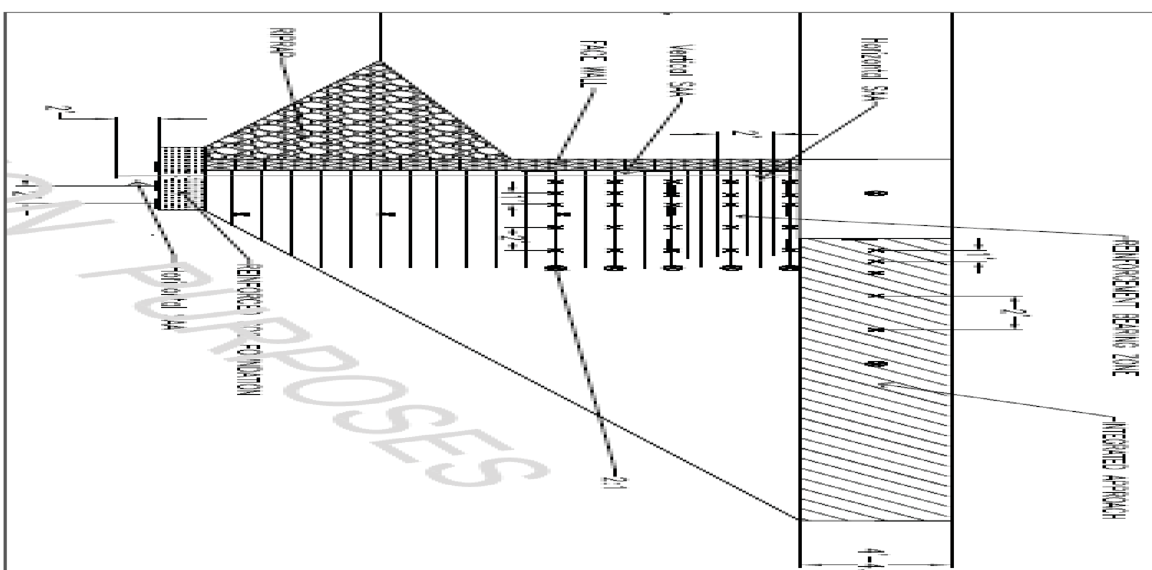
Static and dynamic/moving load testing programs using a heavy weight truck will be conducted on the bridge and abutment after the construction of the GRS-IBS abutment. The purpose of load tests is to investigate the abutment's response to static and live traffic loads. The first load test will be performed with the truck stationed at different locations along the bridge. The truck will then drive on the bridge at different speeds and at different locations along the bridge. Instrumentation data will be recorded during the tests. The measurements from this short-term testing will be used to verify/calibrate the FHWA design method as well as for future calibration of numerical models. Following that, the performance of GRS-IBS abutment will be subjected to long-term monitoring.

Results of the short-term and intermediate-term tests with a loaded truck will be analyzed to investigate the stresses and deformations in the abutments under the controlled truck load. Results of the long-term monitoring will serve to examine the performance, the internal and external stability, and the durability of the GRS-IBS abutment constructed over Louisiana subsurface soil and under live traffic load and possible adverse weather conditions such as storms and hurricanes, which are commonly experienced in the state of Louisiana.

Analyses of GRS-IBS performance and instrumentation measurements will help in verifying/evaluating the FHWA design guidelines and recommendations, and if needed, to modify their design method to fit local parameters.

IMPLEMENTATION POTENTIAL

Upon completion of this research, the responses and performance of GRS-IBS abutments under short-term and intermediate-term controlled loads and long-term live traffic loads will be examined and documented in details An in-depth analysis of the instrumentation measurements will be carried out to verify the important aspects of analysis and design of GRS-IBS abutments, which will include both the internal stability and external stability of the GRS-IRS abutments. The potential benefits of GRS-IBS abutments over conventional design will be demonstrated. Recommended design parameters of GRS-IBS abutments for local materials and Louisiana subsurface soil conditions will be provided to DOTD. Training and guidance of design and construction of GRS-IBS abutments for small and single-span bridges will also be provided to the DOTD engineers.



Instrument layout for Maree Michel Bridge GRS-IBS abutment

For more information about LTRC's research program, please visit our Web site at www.ltrc.lsu.edu.