Research Paper Engineering

Review on Performance Analysis of Geosynthetic Material in Bridge Abutment

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ABSTRACT

Field tests of segmental block-faced geosynthetic - reinforced soil (GRS) bridge abutments and piers have demonstrated excellent performance characteristics and very high load carrying capacity. One important feature of GRS abutment is that it can potentially eliminate the use of piling when situated over a weak foundation. This will not only reduce the costs but also reduce "bridge bumps" often experienced at the ends of a bridge resting on a pile-supported abutment.

Keywords : Geosynthetic material, geogrid, FEM analysis, geosynthetic reinforced soil

INTRODUCTION

Geosynthetics have proven to be among the most versatile and cost-effective ground modification materials. Their use has expanded rapidly into nearly all areas of civil, geotechnical, environmental, coastal, and hydraulic engineering.

Geosynthetics are an established family of geomaterials used in a wide variety of civil engineering applications. Many polymers (plastics) common to everyday life are found in geosynthetics. The most common are polyolefins and polyester; although rubber, fiberglass, and natural materials are sometimes used. Geosynthetics may be used to function as a separator, filter, planar drain, reinforcement, cushion/protection, and/or as a liquid and gas barrier.

ADVANTAGES

Space Savings, Material Quality Control, Construction, Quality Control, Cost Savings, Technical Superiority, Construction Timing, Material Deployment, Material Availability, Environmental Sensitivity.

GENERAL PHILOSOPHY OF FEM

Finite element method is the representation of a body or a structure by an assemblage of subdivisions called finite elements, these elements are considered to be inter- connected at points, which are called nodes. This method is a numerical procedure for analysing structures and continua. FEM is a powerful tool in structural analysis of simple to complicated geometries.

LITERATURE REVIEW

1. Sam M.B.Helwanyv, JonathanT.H.Wuv, Burkhard-Froessl (January 3,2003) presented on "GRS bridge abutments—an effective means to Alleviate bridge approach settlement"

Field tests of segmental block faced geosynthetic reinforced soil(GRS)bridge abutment sand piers have demonstrated excellent performance characteristic sand very high load carrying capacity. One important feature of GRS abutment is that it can potentially eliminate the use of piling when situated over a weak foundation. This will not only reduce the costs but also reduce ''bridge bumps '' often experienced at the ends of a bridge resting on a pile supported abutment. This study was undertaken to investigate the potential of GRS bridge abutments to all eviate bridge approach settlements. The study was conducted by the finite element method of analysis using the computer program DACSAR. The program was first calibrated by comparing its results with the measured data of the Founders/Meadows bridge abutment recently constructed by the Colorado Department of Transportation. A parametric study was then conducted to examine the effects of different foundation soils, ranging from loose sand to stiff clay, on the performance of a GRS abutment. Special attention was placed on the maximum vertical and horizontal movements of the abutment as well as the approach settlement characteristics. The study indicated that the finite element computer code DACSAR is a reliable analytical tool for analyzing the performance of GRS bridge abutments and that the GRS abutment is an effective means to reduce differential settlements between the abutment and the approach embankment.

Approach settlements

A Rigid bridge abutment supported on piles often contributes to the problem of differential settlement at the end of a bridge, commonly referred to as ''bridge bump''. Nevertheless, such a rigid bridge foundation is sometimes considered necessary when bridge spans are continuous, when proper clearance below the bridge is required, and when scouring is of concern (Briaud and Hoffman , 1997). A GRS bridge abutment is essentially a GRS mass covered with segmental block facing. The facing is used as a construction aid and as a protective barrier, and typically offers little structural resistance(Adams,2000). Therefore, the behaviour of a GRS abutment is quite different from an abutment over a rigid foundation. In a GRS abutment, the GRS mass along with the segmental facing act as a monolith (i.e., an integral unit). This massive monolith acts as a ''buffer'' (or as a massive foundation) that under lies the bridge foundation, thus the stress transferred to the foundation soil by the superstructure loads is reduced. More importantly, the GRS mass along with the abutment will settle together in a synchronized manner, thus reducing the degree of a bump at the end of a bridge. An alter-

native way to express the effect of the differential settlement at the end of A bridge is by way of an ‘‘allowable approach slope’’ criterion. This is considered by some researchers as more appropriate for describing the driver’s ‘‘discomfort’’ due to the change of slope at the end of a bridge(Wahls,1990;S tarketal.,1995). Approach slabs are usually designed to resist traffic loads in free span between the sleep slab and the abutment(see Fig).

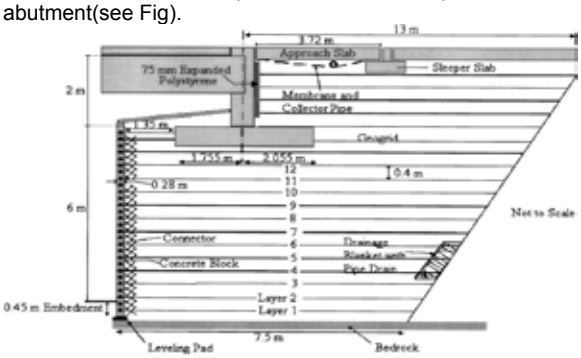

Fig. Founders/Meadows GRS bridge abutment coguration

The approach slope S; is defined as (Sa*Sb)/L; where Sa is the settlement of the approach slab at the sleeper-slab end, Sb is the settlement of the approach slab at the abutment end, and L is the length of the approach slab. The calculated approach slope is not to exceed 1/200, assuming the initial slope of the approach slab to be 0.

2. KevinZ.Z.Lee, JonathanT.H.Wu (March 10,2004)
presented on “A synthesis of case histories on GRS bridge supporting structures with flexible facing”

This paper synthesizes the measured behaviour and experiences gained from case histories of geosynthetic reinforced soil(GRS) bridge supporting structures with ‘‘flexible’’ facings. Only bridge supporting structures with wrapped face, modular block face, and rock face are included in the synthesis. The case histories were grouped into to categories: in service structure sand field experiments. Four in service structure sand six full scale field experiments from the Sand abroad were reviewed. All the structures have been instrumented to monitor their upper form under applied loads, with some being loaded to failure. The essential features and performance of each case history are briefly described in the paper. A table summarizing the main features of the GRS bridge supporting structures is also presented. The table shows comparisons of the bridge supporting structures in terms of wall height, backfill, reinforcement type, reinforcement spacing, facing type and connection, ratio of reinforcement length to wall height, maximum settlement of the loading slab, maximum lateral movement of the wall face, maximum reinforcement strain, and failure surcharge pressure. Based on the measured performance of the case histories, observations are made in relation to performance, design, and construction of GRS bridge supporting structures.

Geosynthesis of performance characteristics The main performance characteristics of the 10 case histories reviewed in this study, including four in service GRS bridge abutments and six full scale field experiments.The performance characteristics include wall height, backfill, reinforcement type, reinforcement spacing, fang type and connection, ratio of reinforcement length to wall height, maximum settlemet of loading slab, maximum lateral movement of the wall face, maximum reinforcement strain, and failure pressure. Based on the measured performance, the following observations are made in relation to performance, design, and construction of GRS bridge supporting structures: GRS bridge abutments with flexible facings are in deed aviable altenative to conventional bridge abutments. All four in service GRS bridge abutments exhibited satisfactory performance characteristics under service loads. The maximum settlements and maximum lateral displacements for all the abutments were under the tolerable movement criteria that were based on experience with real bridges 102 mm for settlement and 51mm for lateral displacement(Wahls,1990).With a well-graded and well compacted granular backfill, and with closely spaced reinforcement(say,0 .2mverticalspacing), the load carrying capacity of a GRS bridge supporting structure can be very high(ashighas900kPain). The load carrying capacity would be significantly smaller(e.g.,120–140kPain) when the back fill is of lower strength and there in for cement is not of sufficientlength(e.g.,where reinforcement extended only 0.3m beyond the back edge of the sill). With a well graded and well compacted granular backfill, the maximum settlement of the loading slab and the maximum lateral movement of the wall face can be very small under service loads. With a lower quality backfill (as in CaseB5 where the backfill was a silty gravelly sand with c ¼ 20k Pa and f ¼ 21 and in Case A2 where the backfill was a fines and_with f ¼ 32),the movements would be significantly larger.

The maximum tensile strains in the reinforcement were in the range of 0.1–1.6% under service loads, with larger maximum strains being associated wih lower strength backfill (e.g.,1.6% maximum strain in CaseA2). Reinforcement length and reinforcement type appear to have only secondary effect on the performance characteristics.The ‘‘sill clearance distance’’ (i.e.,distance between front edge of sill and back face of wall facing) employed in the cases vary fairly widely, from 0.2 min CaseB 3 to2.2 min CaseA2. With a smaller sill clearance distance, the lateral movement of facing may become excessive, especially in the upper part of the abutment wall due to its proximity to the sill. A larger sill clearance, on the other hand, will result in a longer bridge deck, thus higher costs, and may contribute to slope in stability if the reinforcement is not sufficiently long(e.g.,CaseB1). Further research is needed to determine the optimal sill clearance distance.

3. Graeme D. Skinnera, R. Kerry Rowe (October 2004)
presented on “Design and behaviour of a geosynthetic reinforced retaining wall and bridge abutment on a yielding foundation”

There has recently been an increase in the use of geosynthetic reinforced soil structures to support bridge abutments and approach roads in place of traditional pile supports. In this respect, reinforced soil walls offer a cost effective alternative to, and have been found to reduce the ‘‘bridge bump’’ effect associated with, pile supported abutments. The paper focuses on the numerical analysis of a hypothetical 6m high geosynthetic reinforced soil wall supporting a bridge abutment and approach road constructed on a 10m thick yielding clayey soil deposit. The results of the numerical analysis are compared to current design methodologies to examine the effect of the yielding soil foundation on the behaviour of the wall and abutment. The study includes the examination of both the internal and external stability of the wall, and focuses on methods of improving the external stability.

For the cases examined, increasing the length and stiffness of the bottom reinforcement layer in order to increase the bearing capacity and global stability has little overall effect on the behaviour of an already stable wall. The wall had factors of safety of 1.6 and 2.5 against global stability failure for the case of lengthening and the case of lengthening and stiffening the bottom layer, respectively, based on conventional limit equilibrium analysis and the corrected (Bjerrum, 1973) field shear vane strength. Stiffening the bottom reinforcement layer reduced the local and overall undrained shear deformation at the base of the wall under increased loading conditions (Case 1 loading), however, settlements were still large. Extending the reinforcement had an additional stabilizing effect on the backfill soil beyond the reinforced soil block and acted as a reinforcement layer within this section.

4. Myoung-Soo Won, You-Seong Kim (October 2006) presented on “Internal deformation behavior of geosynthetic-reinforced soil walls”

Local deformation of geosynthetics, such as geogrids, and nonwoven and woven geotextiles, was measured to analyze the stability of geosynthetic-reinforced soil (GRS) structures. To analyze the deformation behavior of geosynthetics applied to a reinforced soil structure, the tensile load–elongation properties of the geosynthetic and local deformation measurement data are required. However, local deformation of nonwoven geotextile (NWGT), which is permeable, is difficult to measure with strain gauges. This study proposes a new, more convenient, method to measure the deformation behavior of NWGTs using a strain gauge and examines its suitability via laboratory tests and field trials on two GRS walls. A wide-width tensile test, conducted under a confining pressure of 70 kPa, showed that local deformation of NWGT, measured with strain gauges of type AE-11-S80N-120 EL, was similar to total deformation measured with linear variable deformation transformer (LVDT). In field trials, NWGT showed a larger deformation range than woven geotextile or geogrid. However, the deformation patterns of the three materials were similar. The strain gauges attached to NWGT in the walls worked normally for 16 months. Therefore, the method proposed in this study for measuring NWGT deformation using a strain gauge was effective and valuable. Pore water pressure in the GRS wall can be ignored since the backfill remains unsaturated regardless of rainfall. However, it should be noted for design purposes that horizontal earth pressures at the wall face are greater at the bottom and top of the wall than at rest.

A laboratory wide-width tensile test conducted under a confining pressure of 70 kPa showed that the pattern of local deformation on NWGT measured with strain gauges resembled that of the total deformation measured with LVDT. In GRS walls, NWGT showed a larger deformation range than the woven geotextile or geogrid. However, deformation patterns of these three reinforcement materials were similar and the strain gauges attached to the geosynthetics functioned normally for 16 months. Therefore, the method of measuring a NWGT deformation by using a strain gauge, as suggested by this study, was effective. The backfill material probably remained unsaturated regardless of rainfall because there were no signs of drainage through NWGT from the backfill, and the pore water pressures throughout the measurement period showed negative values. Therefore, pore water pressures in the wall can be ignored. However, horizontal earth pressures at the wall face were larger at the bottom and top of the wall than earth pressures at rest. Therefore, when a GRS wall with a flexible wall face is constructed on a shallow, weak foundation, as in this study, precautions must be taken during the design and construction of the wall, since the horizontal earth pressure can be larger than earth pressure at rest at the bottom of the wall.

CONCLUSIONS

- By using geosynthetics material will get good compressive strength in bridge abutment as well in foundations.
- It acts as a solid barrier.
- It reduces the deformation so that it prevents settlement

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