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Experimental evaluation of the effect of compaction near facing on the behavior of GRS walls

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ABSTRACT

Experimental studies have been carried out to evaluate the effect of the compaction condition at the back of block facing on the behavior of geosynthetic reinforced soil (GRS) walls. Three GRS walls with 1.2 m high were constructed at the COPPE/UFRJ Geotechnical Laboratory. The walls were well-instrumented in order to monitor the values of the reinforcement load, toe horizontal load, horizontal facing displacement, horizontal stress at the back of the block facing, and vertical displacement on the top of the walls. The behavior of the walls has been investigated at the end of construction and during the surcharge application (post-construction). At the end of the loading, the toes of the walls were gradually released to also verify the influence of the different toe restraints. The results clearly show the effect and call attention to the importance of the compaction conditions near the facing on the behavior of GRS walls.

1. Introduction

The effect of backfill compaction on the behavior of reinforced soil (RS) walls has been investigated and discussed in some studies found in the literature (e.g., Ehrlich and Mitchell, 1995; Tatsuoka et al., 1997; Uchimura et al., 2003; Ehrlich et al., 2012; Ehrlich and Mirmoradi, 2016; Mirmoradi and Ehrlich, 2018). The results of these researches showed the importance of backfill compaction for the wall performance. The results, in general, showed that the induced stress due to backfill compaction may represent a kind of pre-stressing of RS walls and may reduce lateral displacement after wall construction. Koerner and Koerner (2013) provided a data base of 171 failed mechanically stabilized earth (MSE) walls with geosynthetic reinforcement. They stated that 123 (72%) of the failure case histories had poor-or-moderate compaction. It is recommended to achieve 95% standard Proctor compaction for the backfill soil (Berg et al., 2009; Collin et al., 2002; Bernardi et al., 2009; Koerner and Koerner, 2013).

Regarding compaction conditions of the backfill near the facing, some recommendations have been made, such as using lightweight compaction equipment (Berg et al., 2009) or placing higher quality backfill in this zone to obtain the desired properties with reduced compaction effort. This is done in order to minimize the compaction-induced outward deformation and lateral stresses against the back of the facing. The application of heavy compaction equipment may also cause structural damage of the wall facing. Nevertheless, it should be noted that this zone is an important part of the backfill from a structural standpoint and may have a significant effect on the wall response, such as wall deformation and reinforcement strains (Hatami et al., 2008). In recent decades, several experimental and numerical investigations have been carried out to determine the factors controlling the behavior of RS walls (e.g., Jewell and Milligan, 1993; Koerner, 1996; Palmeira and Gomes, 1996; Tatsuoka et al., 1997; Rowe and Ho, 1998; Abu-Hejleh et al., 2002; Morrison et al., 2006; Bathurst et al., 2009; Benjamim et al., 2007; Yoo and Kim, 2008; Liu and Won, 2009; Wu and Pham, 2010; Liu, 2012; Leshchinsky and Tatsuoka, 2013; Santos et al., 2013; Scotland et al., 2016; Mirmoradi and Ehrlich, 2017a). However, despite those extensive investigations, the effect of compaction conditions near the facing has rarely been considered. Hatami et al. (2008) numerically considered the influence of inadequate compaction near the facing on the construction response of wrapped-face walls. It was shown that inadequate backfill compaction near the facing could increase the wall deformation and reinforcement strains in this region.

In this study, in order to experimentally evaluate the effect of the compaction condition near the back of the block facing of GRS walls, three well-instrumented GRS walls were constructed at the COPPE/UFRJ Geotechnical Laboratory. The walls were similar except for the compaction conditions. The comparison of the walls' behaviors is presented in terms of the toe horizontal load, reinforcement load, horizontal facing displacement, horizontal stress on the back of the block facing, and vertical displacement at the top of the walls.

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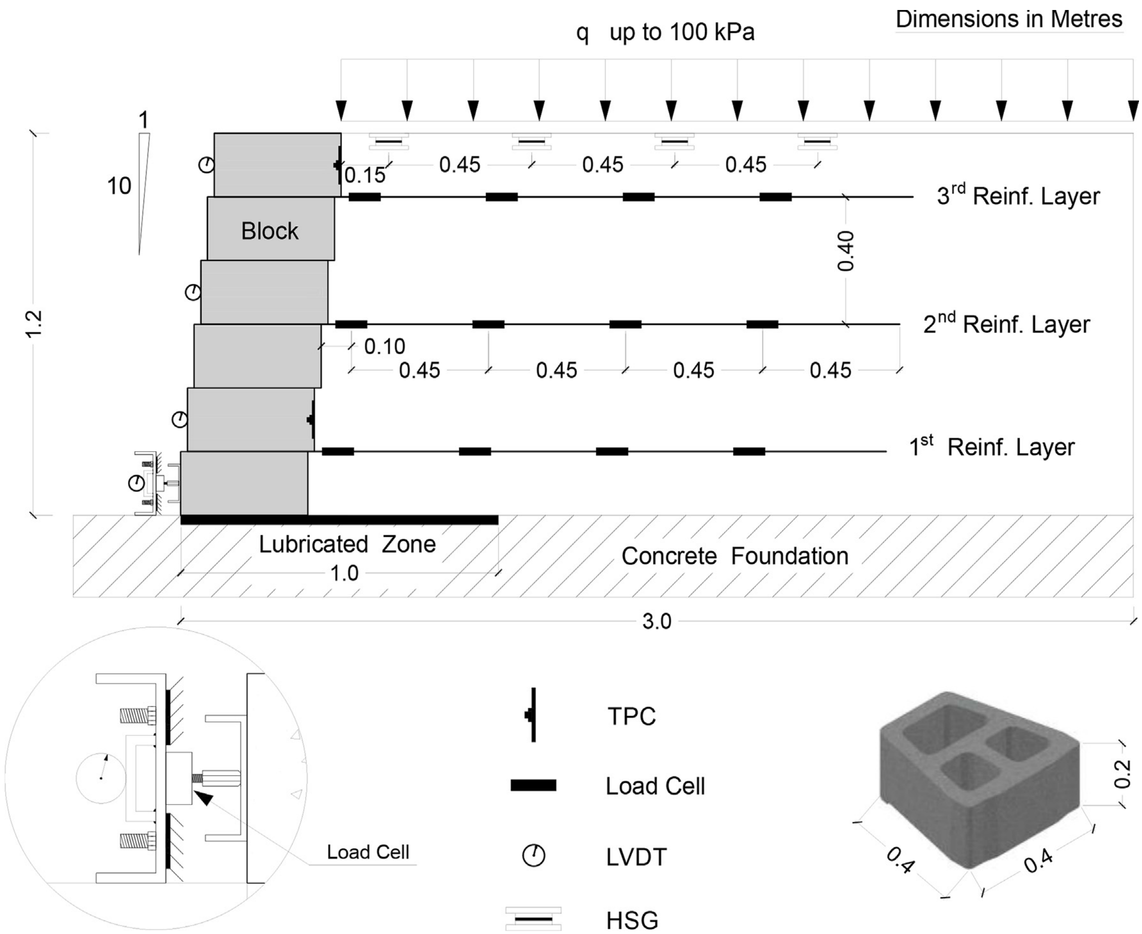

Fig. 1. A cross-sectional view of a block face wall.

2. Test characteristics and material used

A series of well-instrumented physical model walls were constructed at the COPPE/UFRJ Laboratory of Physical Models (Mirmoradi, 2015). The results of two of these walls in addition to another recently constructed wall are used in this paper to evaluate the effect of compaction near the facing on the behavior of GRS walls. The three walls described here are identified as Walls 1, 2, and 3.

A cross-section of a physical model is shown in Fig. 1. The height of each physical model wall was 1.2 m. The length and vertical spacing of the geogrid were 2.2 and 0.4 m, respectively. A flexible polyester geogrid was used as reinforcement. Precast blocks were used for the wall with block facing. The walls were constructed with the facing having an inclination value of 6° to the vertical. The characteristics of the geogrid provided by the production company are shown in Table 1.

Moreover, regarding the reinforcement length it should be mentioned that in the laboratory test model the length of reinforcement was designed in order to guarantee no pullout of reinforcement from the resistant zone. Note that, as discussed by Ehrlich and Mirmoradi (2013) the value of maximum tension in the reinforcement may be considered independent of the reinforcement length if there is enough length to guarantee no pullout failure. Furthermore, based on the AASHTO (2014) specification for RSWs, a minimum reinforcement length of 1.9–2.4 m, regardless of wall height, has been recommended.

The backfill material consists of well-graded sand, composed of crushed quartz powder with a significant amount of fines (19% < #200), D_{50} = 0.25 mm, curvature coefficient C_c = 1, uniformity coefficient C_u = 8.9, and plasticity index PI equal to zero. Fig. 2 shows the particle size distribution curve for the sand backfill. A light vibrating plate was used for the compaction operation.

In Wall 1, the entire surface of the backfill layers was compacted using a light vibrating plate (Dynapac LF 81) only. In Wall 2, first the

Table 1
Mechanical and physical properties of reinforcement.

Longitudinal tensile strength (kN/m)	≥55
Transverse tensile strength (kN/m)	≥25
Elongation (%)	≤6
Weight (g/m^2)	240
Opening size (mm)	20 × 30

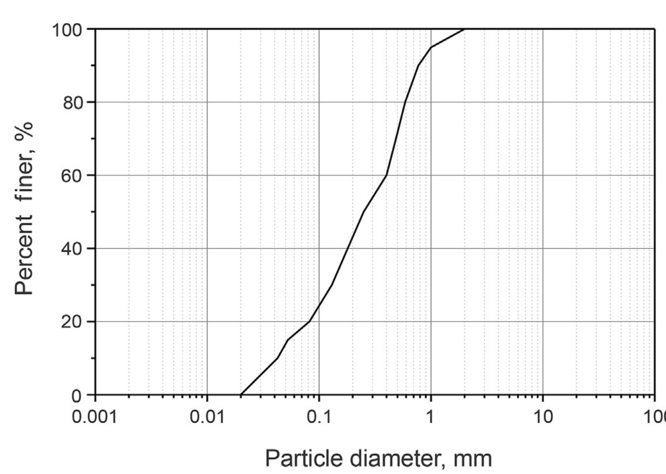

Fig. 2. Grain-size curves for backfill soil.