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Behaviour of a geogrid reinforced wall built with recycled construction and demolition waste backfill on a collapsible foundation

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ABSTRACT

The paper describes the novel use of recycled construction and demolition waste (RCDW) material as the backfill material in an otherwise conventional 3.6-m high wrapped-face geosynthetic reinforced soil wall. The wall was constructed over a collapsible foundation soil which is common in the area around the capital city of Brasilia. The wall was instrumented and then monitored though dry and wet rainy seasons. The influence of cumulative rainfall on foundation compressibility was detectable and seasonal wetting and drying was shown to quantitatively influence wall deformations, settlement, horizontal earth pressures and reinforcement strains. Nevertheless, wall performance was judged to be satisfactory when compared to the performance of other walls of similar size constructed with traditional select granular soils over non-collapsible foundation soils. The results of this investigation demonstrate that significant project cost savings may be possible by avoiding more expensive traditional backfill materials and larger societal economic savings accrued by diverting RCDW waste streams from landfills.

1. Introduction

Geosynthetic reinforced soil (GRS) retaining walls have been used successfully as earth retaining structures for more than four decades (Allen et al., 2002). The main reasons for their popularity are reduced cost, ease of construction and better performance compared to conventional unreinforced soil wall alternatives. Average cost savings of 50% over traditional concrete cantilever walls have been reported in the USA (Koerner et al., 1998) and in the UK (Jones, 1994). A corollary benefit of this technology is a reduction in environmental cost. Jones (1994) estimated that 40% less SO_2 is released to the atmosphere during fabrication of the component parts using GRS walls compared to traditional cantilever wall structures.

A major cost component for GRS walls is the soil used in the reinforced zone when it must be transported to site (typical case). Most often this material is a select material that must meet specifications regarding particle size distribution, strength and permeability. The availability of naturally occurring deposits of acceptable granular soil materials at reasonable distances from a project site can be prohibitive. A strategy to reduce this cost is to employ recycled construction and demolition waste (RCDW) as the backfill material in geosynthetic reinforced soil walls (Santos et al., 2012a,b). Part of the cost benefit is the savings that accrue from avoiding the tipping charges required to dispose of the RCDW in a landfill. As an example, approximately 70% of the waste disposed in landfills in the city of Brasilia, Brazil, comes from construction and demolition works (Santos, 2011). This figure is not much different in several other cities in the country. A description of typical construction demolition waste in Brazil is reported by Santos et al. (2010b).

This paper is focused on the performance of an instrumented 3.6-m high wrapped face soil wall that was constructed with RCDW backfill. Some preliminary results of this test wall were reported by Santos et al. (2010a). The foundation for the test wall was a naturally occurring collapsible soil that is common in Brasilia, Brazil. The construction of reinforced soil wall structures over compressible foundations due to mine subsidence has been reported in the literature (Jones, 1989; Murray et al., 1989). The current study demonstrates how the properties and performance of the collapsible foundation soil at the location of the reinforced soil wall with RCDW backfill also influenced the behaviour of the test wall.

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2. Test programme and site conditions

2.1. General arrangement and construction method

A 3.6-m high instrumented geogrid reinforced soil wall was built with recycled construction and demolition waste (RCDW) as the backfill. The project was part of a research programme on the combined use of construction waste and geosynthetics in geotechnical and geoenvironmental works at the University of Brasilia, Brasilia, Brazil. The experiment was carried out at the Foundation and Field Investigation Site of the Graduate Programme of Geotechnics of the University of Brasilia. A cross-section view of the structure and foundation condition is shown in Fig. 1.

The wall was constructed in a reinforced masonry block container (Fig. 2(a)). The internal faces were covered by three layers of lubricated polyethylene sheets to minimize the influence of soil-side wall friction. The wrapped-face reinforced soil wall was constructed at an inclination of 1:4.3: (horizontal:vertical) (wall batter of 13° from vertical). The backfill was reinforced with six layers of geogrid placed at 0.6 m vertical spacing and 2.52 m long. A nonwoven polypropylene geotextile (mass per unit area of 300 g/m^2, tensile strength of 19 kN/m and maximum tensile strain of 70%) was placed between the geogrid and the backfill at the wall face to prevent backfill particles from passing through the geogrid apertures.

The moving formwork technique was used to construct the wrapped face as shown in Fig. 2(a). The wall was constructed in 200 mm lifts of backfill. A front end loader was used to place the RCDW inside the test facility. Each lift was compacted to a dry unit weight of 17.8 kN/m^3 using a hand tamping plate (up to 1 m from the wall face) and a lightweight roller at greater distances. The decision to use light compaction equipment and to compact the RCDW below its optimum moisture content was taken to minimize construction-induced deformations of the reinforced mass. A granular drainage layer was installed on the top of the foundation soil before wall construction. The purpose of this layer was to encourage a uniform distribution of infiltration water into the foundation soil during the rainy season. Fig. 2(b) shows the installation of one of the instrumented geogrid layers and Fig. 2(c) shows the wall face at the end of construction.

2.2. Backfill and reinforcement properties

The properties of the RCDW used as backfill material are summarized in Table 1. The RCDW contained particle sizes up to 100 mm

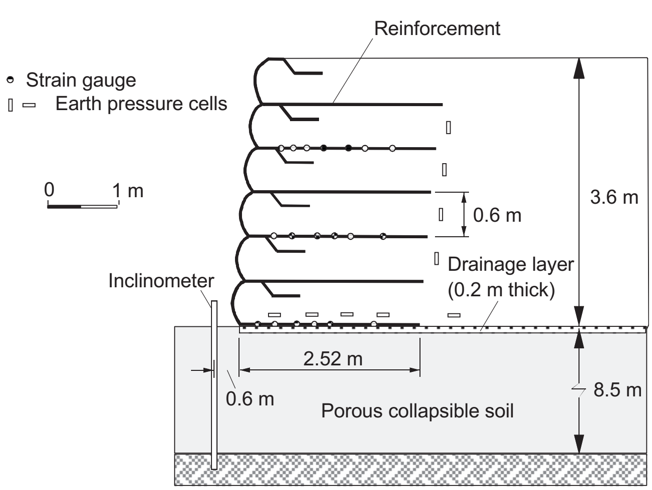
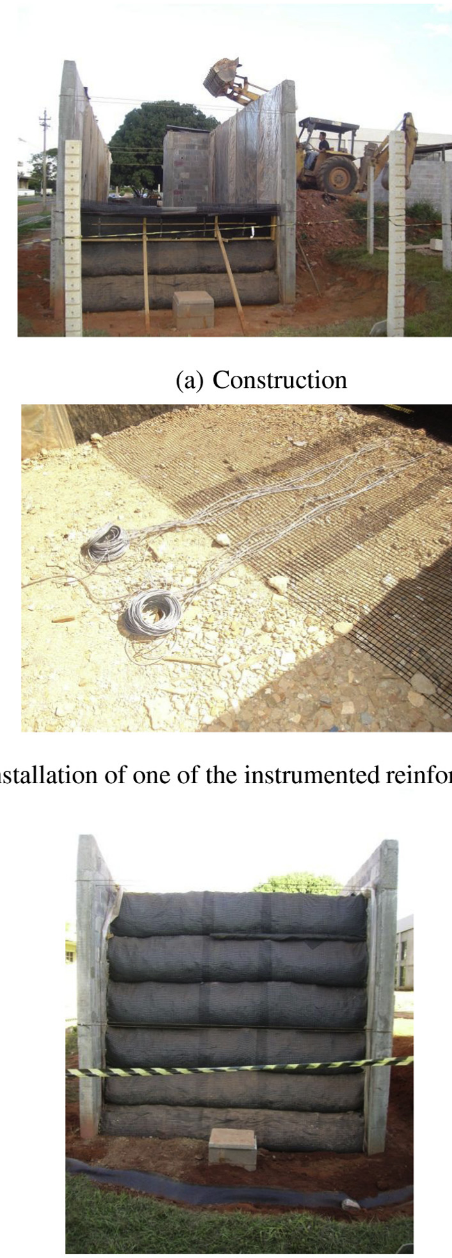


Fig. 1. Cross-section of the experimental reinforced wall.



(a) Construction

(b) Installation of one of the instrumented reinforcement layers

(c) Wall face at the end of construction.

Fig. 2. Construction and instrumentation of geogrid wrapped face reinforced RCDW backfill wall.

Table 1
Properties of the RCDW backfill material.

Property	
D_{85} (mm)	15.0
D_{50} (mm)	2.1
D_{10} (mm)	0.032
C_U	106
pH of backfill moisture	8.9
Unit weight (kN/m^3)	17.8
Moisture content (%)	6.6
Friction angle (°)	41
Cohesion (kPa)	6

Notes: D_n = diameter of the particle for which n % in mass of the remaining particles are smaller than that diameter; C_U = soil coefficient of uniformity (=D_{60}/D_{10}).