Soils and Foundations 2015;55(2):296–303

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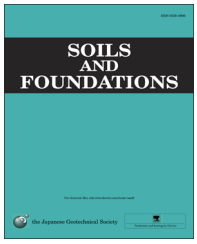

Application of recycled concrete aggregates as alternative granular infills in hollow segmental block systems

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Received 16 December 2013; received in revised form 2 October 2014; accepted 19 November 2014
Available online 21 March 2015

Abstract

Geosynthetic Reinforced Segmental Retaining Walls (GR-SRWs) are developing as well recognized earth retaining structures for their manifold economic and technical advantages. It is a matter of great concern that still now a huge volume of natural coarse aggregate is used as filler in GR-SRWs, thus depleting natural resources and presenting a challenge for sustainable development. The main objective of this study is to examine the effect of recycled coarse aggregates (RCAs) used as alternative granular infills in hollow facing column. As granular infills, two types of recycled aggregates were used along with natural coarse aggregates (NCAs). Recycled aggregates were primarily selected based on the grading of the source waste concretes to investigate its effect on the frictional behavior of recycled aggregates used as infillers. Purely frictional capacity of I-Block infilled with recycled aggregates was compared to those infilled by fresh aggregates. To eliminate the effect of shear pins on interface shear capacity of I-Block system infilled with gravels, none were used in purely frictional shear. A series of direct shear tests was performed using a specially designed and fabricated direct shear apparatus to assess the frictional behavior of infilled blocks under different normal loading conditions. The tests were conducted following the exiting ASTM and National Concrete Masonry Association (NCMA) test protocols. The test results were outlined in the form of shear stress–displacement relationship to compare the effect of recycled aggregate against the fresh aggregate. Shear capacity envelopes were also plotted using Mohr–Coulomb failure criterion to find out the angle of friction for each case. Test results reveal that the angle of friction of the blocks infilled with the recycled aggregate is almost equal to those with the fresh aggregate. The results also show that compressive strength of the source waste concretes has a little or no effect on the frictional performance of recycled concrete aggregates used in facing units.

Keywords: Recycled aggregate; Sustainability; Segmental block; Interface shear; Retaining wall

1. Introduction

Nowadays, Geosynthetic Reinforced Segmental Retaining Walls (GR-SRWs) are frequently used in many geotechnical applications as earth retaining structures due to their sound performance, esthetically fine finishes, cost effectiveness, and ease of construction. Since 1990, the use of geosynthetic reinforced walls has increased dramatically along with the introduction of segmental retaining wall (SRW) units (Hossain et al., 2009). Typically, GR-SRWs consist of polymeric reinforcement, retained soil, leveling pad and precast facing blocks as shown in Fig. 1.

In GR-SRWs, segmental retaining wall units (precast modular block units) are used as the facing column, which act as a temporary formwork during the placement and compaction of backfill soils. They also provide transverse

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Peer review under responsibility of The Japanese Geotechnical Society.

http://dx.doi.org/10.1016/j.sandf.2015.02.006
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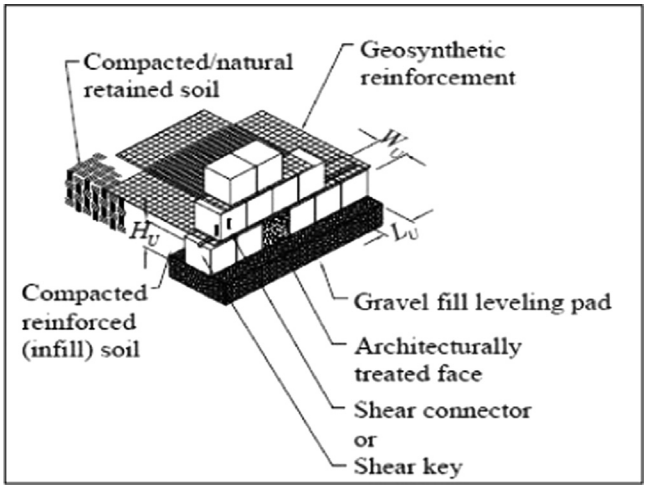

Fig. 1. A typical geosynthetic reinforced segmental retaining wall (NCMA, 2010).

rigidity and shear capacity along the height of the wall (Bathurst and Simac, 1997). In Malaysia, geotechnical engineers have been widely experimenting on GR-SRWs for the last few decades (Lee, 2000).

Even though GR-SRWs have both a competitive economic and technical advantage over other mechanically stabilized earth (MSE) technologies, sustainable development in the future is a matter to be considered for GR-SRW construction. To set up a GR-SRW, a huge volume of natural construction materials (particularly fill materials) is used. At the same time, a large volume of concrete waste is generated by the renovation and redevelopment of infrastructures for urbanization. Oikonomou (2005) reported that approximately 40% of the concrete waste produced is demolition waste. The preservation of natural resources and reduction of concrete waste is of great concern to researchers, civil engineers, government officials and society as a whole.

Precast modular units (hollow/solid) are used as the facing column for these types of walls. In the case of hollow facing units, granular infills are used to provide positive interlocking between the successive vertical courses of units, which develops additional shear capacity (Bourdeau et al., 2001). Guler and Astarci (2009) demonstrated that granular infills (gravel) increased angle of friction as compared to other infill (sand). Typically, natural aggregates are used as infill and backfill materials in retaining wall constructions, which is expensive and unsustainable since it involves the annihilation of natural resources.

During the last decade, a considerable amount of research has been done on the recycled concrete aggregates (main component of crushed old concrete) and its application into structural concretes and concrete pavements (Limbachiya et al., 2000; Chiu, 2006; Eguchi et al., 2007; Anderson et al., 2009; Simth, 2009). However, few reports can be found focused on the usage of recycled aggregates in GR-SRW construction (Santos et al., 2013; Tatsuoka et al., 2013). This study simply concentrates on the utilization of recycled concrete aggregates as alternative infiller materials for segmental retaining walls. Some preliminary results of this investigation were published by Bhuiyan et al. (2011). Two types of recycled aggregates were used as granular infills along with natural aggregates. Recycled aggregates were randomly nominated based on the compressive strength of the source waste concretes, and the effect of this strength on the frictional behavior of recycled aggregates used as infillers was investigated. The purely frictional capacity of I-Block infilled with recycled aggregates was compared to those infilled by fresh aggregates. A series of direct shear tests was conducted with different types of granular infills under different loading conditions (ASTM D 6916-06c, 2006; NCMA, 1997). Shear stress–shear displacement graphs were drawn to compare the performance of the infilled concrete units with gravels. Shear capacity envelope graphs were also plotted by using Morh–Coulomb failure criterion under ultimate strength condition.

The results of this study demonstrate that interface shear capacity of the blocks infilled with the recycled concrete aggregates (RCAs) is almost equal to those with natural coarse aggregate (NCA). The use of recycled concrete aggregates (RCAs) is not only cost effective but also environment friendly and it provides the construction industry with another alternative for use as infill for their segmental retaining walls.

2. Materials and methods

2.1. Segmental concrete wall unit

A newly designed segmental unit system is used in this research. The innovated concrete unit is named I-Block due to its geometrical shape (Fig. 2). The I-Blocks are wet cast masonry units made from 30 N/mm^2 concrete (NCMA, 2010), which consist of one center web and a tail/rear flange that extends beyond the web. The rear flange is tapered to allow the blocks to form curve walls. I-Blocks are flat interface modular concrete blocks which can be stacked either with or without shear connectors. The maximum tapered angle of the I-Block is approximately 11.3°. I-Blocks are basically double open-ended units and provide a larger hexagonal hollow space in conjunction with two units, and the equivalent hole dimensions

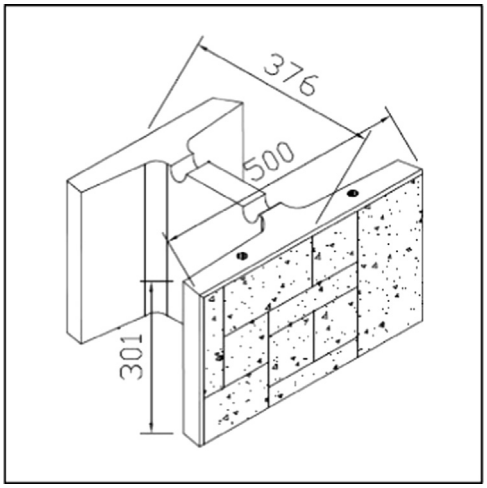

Fig. 2. Schematic of the innovated I-Block (dimensions in mm).