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Development of Pre-engineered Geomaterial for Use in Road Embankment and Retaining Structure Backfill

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ABSTRACT

Load reduction effect of using lightweight material in new construction, expansion, rehabilitation or maintenance of transportation facilities provide advantages in term of reduction of total cost, construction time and maintenance work especially in soft ground areas. Lightweight geomaterial composite with controllable geotechnical properties were developed and tested in laboratory. The results indicated that, design mix of the geomaterial composite has significant influence on its strength, elasticity and deformation characteristics.

Keywords: Lightweight geomaterial, embankment, retaining wall, soft ground

INTRODUCTION

Researchers as early as 1987, have been studying several lightweight and compressible materials that have the potential for practical applications as retaining wall backfills. Meanwhile, feasibility of the applications of lightweight material in highway embankment have been reported (Ahmed & Lovell 1993; Bosscher et al. 1997; Newcomb & Drescher 1994; Hoppe 1998; Garga, 2000; Thompsett et al. 1995) in the literatures.

In the case of compressible material used as backfill especially behind retaining walls, researchers (Ahmad 1989; Andrawes et al. 1992; Aytekin, 1998; Cecich et al. 1996; Horvath 1997; Humphrey et al. 1998; Lareal et al. 1992; Murphy 1998; Tweedie et al. 1998) have found out that compressible layers or inclusions posses the capability to reduce earth pressure exerted on the walls and control wall movements.

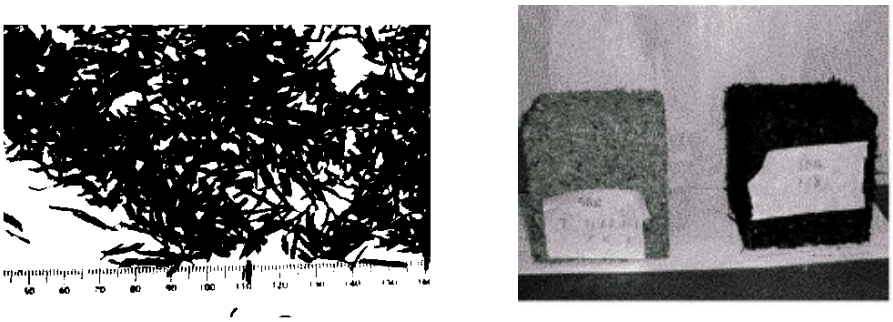
McGown et al. (1987) studied varying wall stiffness by using spring of different stiffness and found out that by reducing the wall stiffness, lateral earth pressure on the wall can be reduced and suggested the use of lightweight compressible material behind the wall.

In geotechnical related works, lightweight geomaterials were developed or utilized mostly as filling materials for road construction purposes. The lighter materials minimize foundation requirements, reduce land cutting for mountainous area, prevent settlements and shorten construction times. In the case of retaining wall, lighter fill will reduce the lateral earth pressure thus reducing the structural requirements of the wall including the foundations.

The lightweight material currently in use includes the ultra lightweight EPS (Expanded Poly Styrene), air foam mortar, expanded beads mixed with soil with controllable density, whole tire, tire chips or shreds, coal ash, hollow structures, wood chips and shells.

LIGHTWEIGHT GEOMATERIAL COMPOSITE

A composite geomaterial using lightweight material as primary ingredients or inclusions were studied in term of improving geotechnical properties, cost reduction and easy handling. A particular material in this paper will be scrap tire in shredded form as shown in Figure 1:



Shredded scrap tires | Shredded tire based geocomposite

FIGURE 1. Shredded tires and shredded tire based geocomposite

Tire wastes can be used as lightweight material either in the form of whole tires, shredded or chips, or in mix with soil. And recently, Lee (2002) has introduced the concept of cementing tire rubber bits into rubber blocks using binder materials. The concept introduced by Lee (2002) were further expanded using shreds instead of bits and especially in term of engineered strength, compressibility and drainage characteristics of tire shreds based composite geomaterial for use as retaining wall backfill layers or inclusions

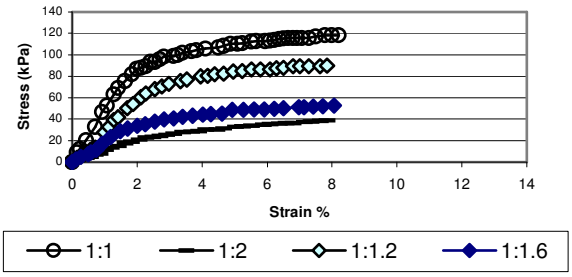
Geomaterial specimens of various design mix were tested for strength and compressibility characteristics by using Unconfined Compression test. The basic components of the geomaterial are tire

shreds and they are bonded by OPC. The purposes of the tests were to identify strength and compressibility characteristics and other related geotechnical properties for use in modelling and designing geotechnical works. The properties studied include density (γ), secant modulus (E_{50}), compressive stress, strain, and porosity and permeability.

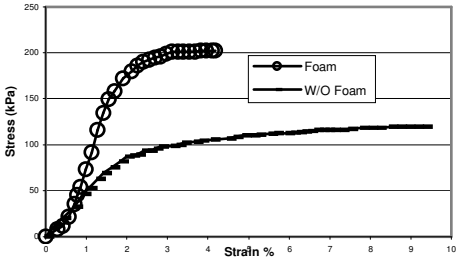
DENSITY, STRENGTH AND COMPRESSIBILITY

Density, strength and compressibility depend directly on design mix of the geomaterial. Density of current design range from 3.5 to 7 kN/m^3. In term of strength at maximum 5% compressibility, it ranges between 30 kN/m^2 and 250 kN/m^2. The variations of strength were achieved by pre-design composite compositions and proportions.

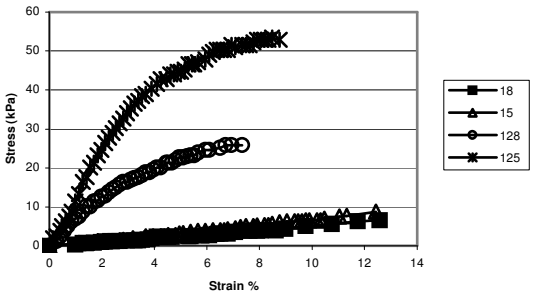
Figure 2 illustrates various strength and compressibility development based on various composition and proportions. In Figure 2(a) it can be seen that overall strength of the geocomposite can be control by shred-binder content. Meanwhile, Figure 2(b) illustrated the strength improvement method by using aqueous foam in during mixing. In 2(c), the addition of binding compound improves the elastic properties of the geocomposite. It also has been found out that the size of shred has an effect on the peak strength of the composite as shown in 2(d).



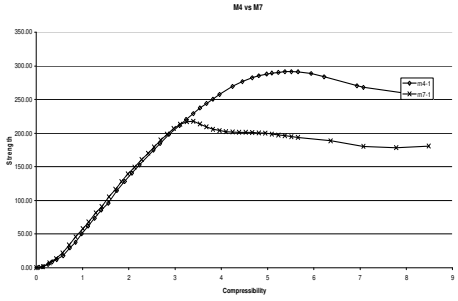
a) Effect of shred and cement content



b) Effect of aqueous foam on strength



c) Elastic effect with additives



d) Effect of shred size

FIGURE 2. Strength and compressibility of various proportion and composition

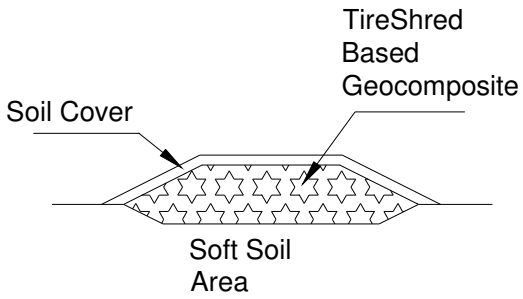
PERMEABILITY AND POROSITY

The composite provide very good draining properties which is especially useful in retaining wall, road base and drainage applications. Porosity range from 0.38 to 0.54 and coefficient of permeability of tested composites are in between 4 to 7 cm/s.

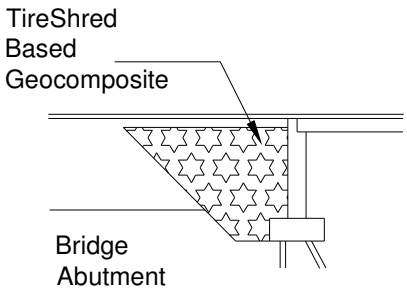
APPLICATIONS

As discussed earlier, the concept of using recycle lightweight geomaterial for civil engineering construction is feasible not only because they are environmental friendly, but it can also reduce the total project costs in term of construction and maintenance especially in areas with poor soil conditions.

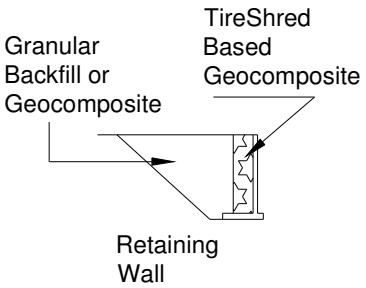
Figure 3 shows the conceptual application of lightweight geomaterial in constructions.



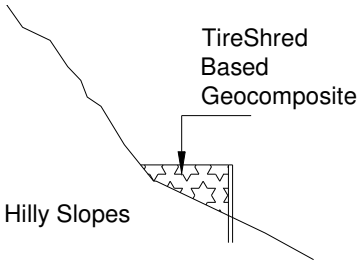
Reduce loading consequently settlement and avoiding potential sliding and soil treatment requirements.



Control differential settlement, eliminate sudden bump and maintenance, reduce lateral and vertical vressure, thus reduce foundation requirements



As compressible layers to induce active conditions for retaining wall, at the same time reduce lateral and vertical pressure.



Minimizing earthwork operations on hill slopes and reducing load on ground and retaining systems.

FIGURE 3. Practical applicability

CONCLUSION

Precast geocomposite block with predetermined geotechical properties offers compaction free installation and eliminate on site verification or testing to meet or confirm the design requirement or assumption. In order to efficiently engineered and produced the composite for various applications, design aid or a relationship between mix design and geotechnical properties must be established.

In geotechnical designs, the basic properties of fill material required for analysis and design includes density, E modulus, and permeability. Since the geocomposite will have predetermined properties, the design mix must be able to produce a predictable density, E modulus, permeability, strength and compressibility.

The next stage of this research will be to develop semi-empirical relationship for producing the pre-engineered blocks as well as to establish design aids for geotechnical applications.

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