Behavior of Shredded Rubber Tire With Sand Mixture And Interaction With Hexagonal Wire Reinforcement

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1 Introduction

Scrap tires are undesired urban waste and are increasing at alarming rates every year. This situation requires for finding new and beneficial ways to recycle and reuse large volumes of scrap tires. One of possibly practical applications consists of using shredded tires alone or mixed with soil as lightweight backfill materials for embankment and reinforced wall construction. In this study, various tests were performed to investigate engineering properties of shredded rubber tire with sand mixture (rubber-sand mixture) as well as interaction mechanism with hexagonal wire reinforcement.

2 Tested Material

Two types of backfill materials used in this study are Ayutthaya sand and shredded rubber tire. Specific gravity tests of sand and shredded rubber tire were conducted following the recommended procedures given in ASTM D854-83 and ASTM C127-01. Sieve analyses were performed to check the particle-size distribution of both sand and shredded rubber tire. This was done in compliance with the procedures given in ASTM D422-63. The results of these tests are illustrated in Fig. 1. Specific gravity of shredded rubber tire without metal content is 1.12 and its particle size of ranges from 5 to 80 mm with irregular shape due to random cutting process. Various previous researchers [1,2, 3] also reported the specific gravity of the shredded rubber tire in range of 1.08 to 1.36 depending on the metal content.

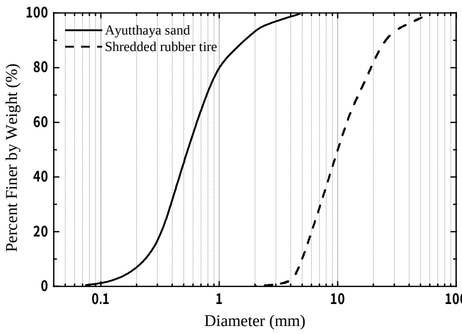

Fig.1 Particle-size distributions of tested materials

3 Laboratory testing programs

Compaction tests, following the procedure ASTM D698-91, were conducted to determine optimum water content and maximum dry unit weight of tested material. In this study, since shredded tire contains a significant amount of material in quite large size, possible effect of mold size on compaction characteristics are considered. Therefore, the modified compaction mold (305-mm-diameter mold with 180 mm in height) was utilized.

One-dimensional (1-D) compression test was carried out to observe compression characteristics of the rubber-sand mixture. From test results in Fig.2, major compression takes place in the first load cycle. A portion of this compression is irecoverable, but there is significant rebound upon unloading. The subsequent cycles tend to have similar stress-strain curve, however with less rebound than the first cycle. The compressibility of the rubber-sand mixture decreases with increasing sand content. The results in this study agreed well with previous research [1,2]. However, it should be noted that the type of soil used for the mixture and the size of mold significantly affect the magnitude of static strain [4].

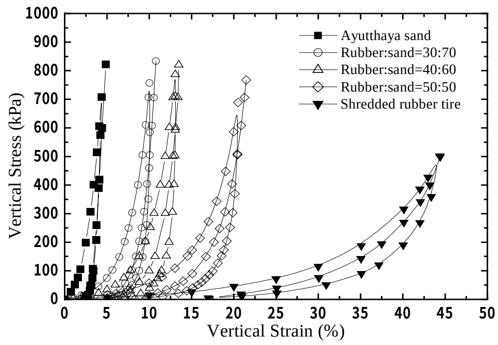

Fig.2 Stress-strain relationship from 1-D compression test

Strength characteristic of rubber-sand mixture was observed by large direct shear test. Strength envelopes of the rubber-sand mixtures are plotted together in Fig.3. Shear strength of shredded rubber tire is lower than sand. Anyway, it increases with increasing sand content in the mixture.

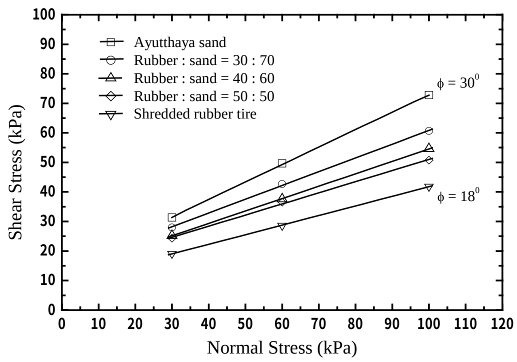

Fig.3 Strength envelops from large direct shear tests

In-soil pullout test was also performed to study the interaction mechanism between rubber-sand mixture and PVC-coated hexagonal wire reinforcement. The pullout resistances of hexagonal wire in rubber-sand mixtures

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increase with increasing applied normal pressure, but decrease with increasing shredded rubber tire portion in the mixtures. Bi-linear failures envelopes for hexagonal wire reinforcement embedded in sand backfill have been proposed by [5]. The failure envelopes were based on the failure mechanisms of a reinforcement consisting of the breakage and slippage mechanisms (Fig. 4). However, failure mechanism in shredded rubber tire is totally governed by the slippage of the hexagonal wire reinforcement.

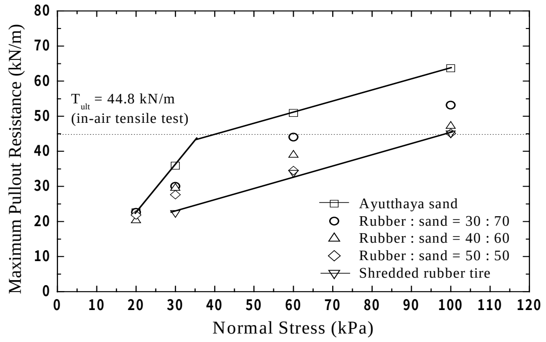

Fig.4 Maximum pullout resistance of PVC-coated hexagonal wire in rubber-sand mixture

4 Constitutive model and numerical simulation

Deformation and strength characteristics of shredded rubber tire with and without sand mixture in different mixing ratios have been investigated by performing triaxial tests by several investigators [6,7]. The test results from these studies indicated that the dilatancy characteristic consists of both negative and positive values depending on the stress state, void ratio and the mixing ratio. The constitutive model proposed by [8] base on critical state framework has been successfully applied; by [7], to capture overall strength and deformation characteristics of rubber-sand mixtures.

In this study, FLAC finite difference program was used to simulate the compression and pullout test results. The proposed constitutive model by [8] has been implemented into FLAC program for numerical simulation. The results from compression test and pullout test are compared with those from numerical simulation as illustrated in Fig. 5-7.

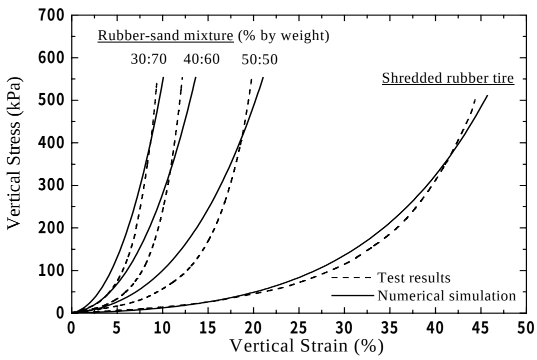

Fig.5 Comparison of stress-strain relationship between the results from 1-D compression test and simulation

5 Conclusions

The engineering properties of shredded rubber tire with and without sand at various mixing ratios have been investigated in this study. From the results, the method of adding sand into shredded rubber tires not only improved the deformation characteristic but also increased the strength and pullout resistance. The proposed constitutive model by Li and Dafalias (2000) has been successfully implemented into FLAC finite difference program. The results from simulation can broadly capture deformation characteristics and pullout resistance of rubber-sand mixture. However, for further study, the interface model needs to be developed to better capture the real interface mechanism between backfill and reinforcement.

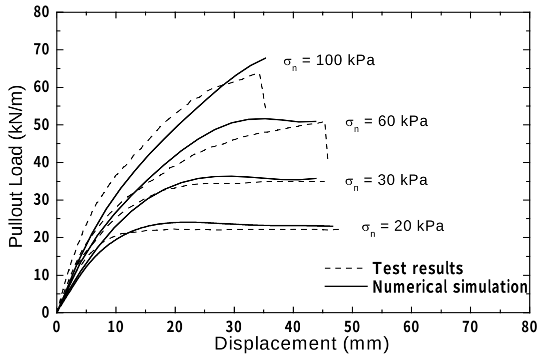

Fig.6 Pullout resistance/displacement curves of PVC-coated hexagonal wire reinforcement in sand

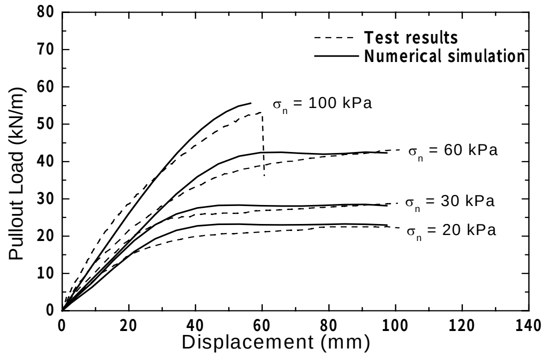

Fig.7 Pullout resistance/displacement curves of PVC-coated hexagonal wire reinforcement in rubber-sand mixture at mixing ratio of 30:70 (rubber:sand by weight)

6 References

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