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Research article

On the Shear Strength Characteristics of Sand - Recycled Tyre Wastes Composite: A Concise Overview and Research Plan

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Introduction

Versatility of sand in providing strength and stability, whilst the high level of durability becomes an advantage in construction, making sand able to withstand, cope well with the hostility of environments and variety of climates [1-13]. Applications of sand in the backfill is important due to the compressed structure of sand which makes it perfect for filling in voids, helps to create a level surface and allows for compaction, ensuring a reliable foundation [2]. However, according to United Nations Environment Programme, UNEP,[1] the greatly usage of sand as a non- renewable raw material, exceeding its natural renewal rates, becomes alarming considering the recent report about 32 billion to 50 billion tonnes of sand are extracted globally each year where sand is also the second most consumed natural resource on Earth after water [3]. Moreover, the mining and exploitation of sand has cause disrupt changes in the environment which has resulted in negative impacts towards flora and fauna, water, air, land, and soil itself including outstrip supply of sand [4].In the case of rubber waste from vehicles, the accumulation of rubber waste from automobiles becoming a major environmental concern, as 1.5 billion of waste tyres are produced worldwide each year [5].According to Khoaz [6], four billion rubber waste tyres are currently accumulating in landfills and stockpiles throughout the world releasing harmful compounds into the environment when disposed of in landfills and stockpiles as the rubber waste tyres are not biodegradable. They also serve as breeding grounds for mosquitoes and ignite uncontrollable fires [7,8]. in Malaysia in the year 2019, the Sungai Kim Kim River in Johor were polluted badly as the water was contaminated with chemical waste from pyrolysis process of tyre waste that produce low-grade oil or fuel oil as a subset of marine oil, by burning of used tyres [9].

Problem Statement

Sand exploitation will cause the environmental problems due to high demand in construction and contributes to the shortage of sand, a non-renewable material as natural resources. For rubber waste from tyres, the amount of tyre wastes at the dumping site or landfills contributes to the pollution as it is a non-biodegradable material that will highly contaminate the environment if not managed well. That is why the sand-rubber waste admixed is the main effort that is made to solve both problems as the partially usage of sand in the construction will reduce the high demand and exploitation of sand, including reducing the illegal dumping of rubber waste at landfills as the solution in reducing contamination towards environment. The shear strength parameters of sand-rubber waste admixed is evaluated using Direct Shear Test machine in order to know whether the sand-rubber waste admixed is capable to withstand shear stress under a specific load. Furthermore, this evaluation is important as the sand-rubber waste admixed will be used as backfill materials. Additionally, the sand-rubber waste admixed is formulated with mix ratio samples that will be tested for shear strength performance where the optimum mix ratio of sand-rubber waste admixed is determined. The optimum mix ratio is determine using the graphical data of the shear strength against normal stress in order to analysis the mix ratio performance of shear strength under different loading loads.

Objectives

The paper describes an overview of the experimental work designed to evaluate the shear strength parameters of sand admixed with recycled tyre wastes as backfill materials, and to formulate the optimum mix ratios for best strength performance of the composite.

Scope

The scope of the study revolves around the shear strength parameters of sand-rubber waste admixed. This study is done to identify the characteristics of sand for shear strength analysis including identification of rubber waste properties as an admixture

of sand. The materials used in the study are the sand, processed rubber waste tyre, steel wire that is both from rubber waste tyre of trailer, and Polymer Modified Cementitious chemical used as soil stabilizer. The admixture of rubber waste and sand is prepared for four different portions of ratios that is 10% rubber waste with 90% sand, 20% rubber waste with 80% sand, 40% rubber waste with 60% sand and 50% rubber waste with 50% sand. The 100% sand and 100% rubber waste are included for tested as characteristics guidelines for the mix portions. Once the sand and rubber waste is mixed according to the mixed ratio, the study is limited to the results of Direct Shear Test shear strength analysis evaluated accordance to the British Standard (BS) 1377 Methods of Test for Soils for Civil Engineering Purposes, Part 7: Shear Strength Tests, 1990 Clause 4 and also in accordance to Manual of Soil Laboratory Testing, Volume 2 for Permeability, Shear Strength and Compressibility Tests, Chapter 12 Direct Shear Test.

Literature Review

The shear strength of the soil is crucial. The angle of internal friction (φ) and cohesion (c) are the two crucial parameters that determine the shear strength of soils, are used to calculate the soil's maximum ability to withstand shear stress under a specific load. The cohesion measures the chemical cementation and ionic attraction between soil particles, and the internal friction angle illustrates the amount of friction and interlocking between soil particles. The Mohr-Coulomb shear strength equation can be used to calculate a soil mass's shear strength using cohesion and the angle of internal friction [10]. Referring to Figure 1 sand is generally defined as loose granular material that passes through a 5.00 mm British Standard test sieve and can be categorize based on the size range and soil grading, type of sand, colour of sand, and shape of sand, which can be determine using standard [11]. Following is regarding backfilling which is filling in the area that has been excavated around a foundation or building. The backfill material, can range from excavated soil, sand-and-gravel mixture, or manufactured goods can all be used as backfill material and is typically compacted to offer stability and support [12]. Apart from this, the discarded rubber waste tyres serve as a breeding ground for a variety of mosquitoes and diseases carrier like snakes and rodents that reside in waste tyres. The construction industry may find it to be a very practical choice to recycle rubber waste from old tyres. The large amount of waste rubber consumed makes these applications effective at preserving the environment and natural resources [13,14]. The life cycle of rubber tyres is shown in Figure 2 where from the whole rubber waste tyre, it is converted to rubber crumbs, rubber chips/granules, rubber powder and tire-derived fuels using different types of process like shredding, cryogenics and pyrolysis while the sand-rubber composite to be examined in the planned work can be found in Figure 3 that shows the sand-rubber waste composite when it is mix together. Lastly, the direct shear test machine shown in Figure 4 will be used in this project to test shear strength parameters equipped with a shear box test where the sample will be inserted accordingly following the arrangement in the shear box is as in Figure 5 for the shear test. The direct shear test machine as shown in Figure 4 consists of Load Hanger to place the different loading weight for sample testing, Jack Screw Assembly to retain the Load Hanger that is place with loading weight before the test is carried out and also Lever Loading Arm that hold Loading Hanger in place.

Figure 1: Size differences between sand, gravel, and silt (Atkinson, 2019)

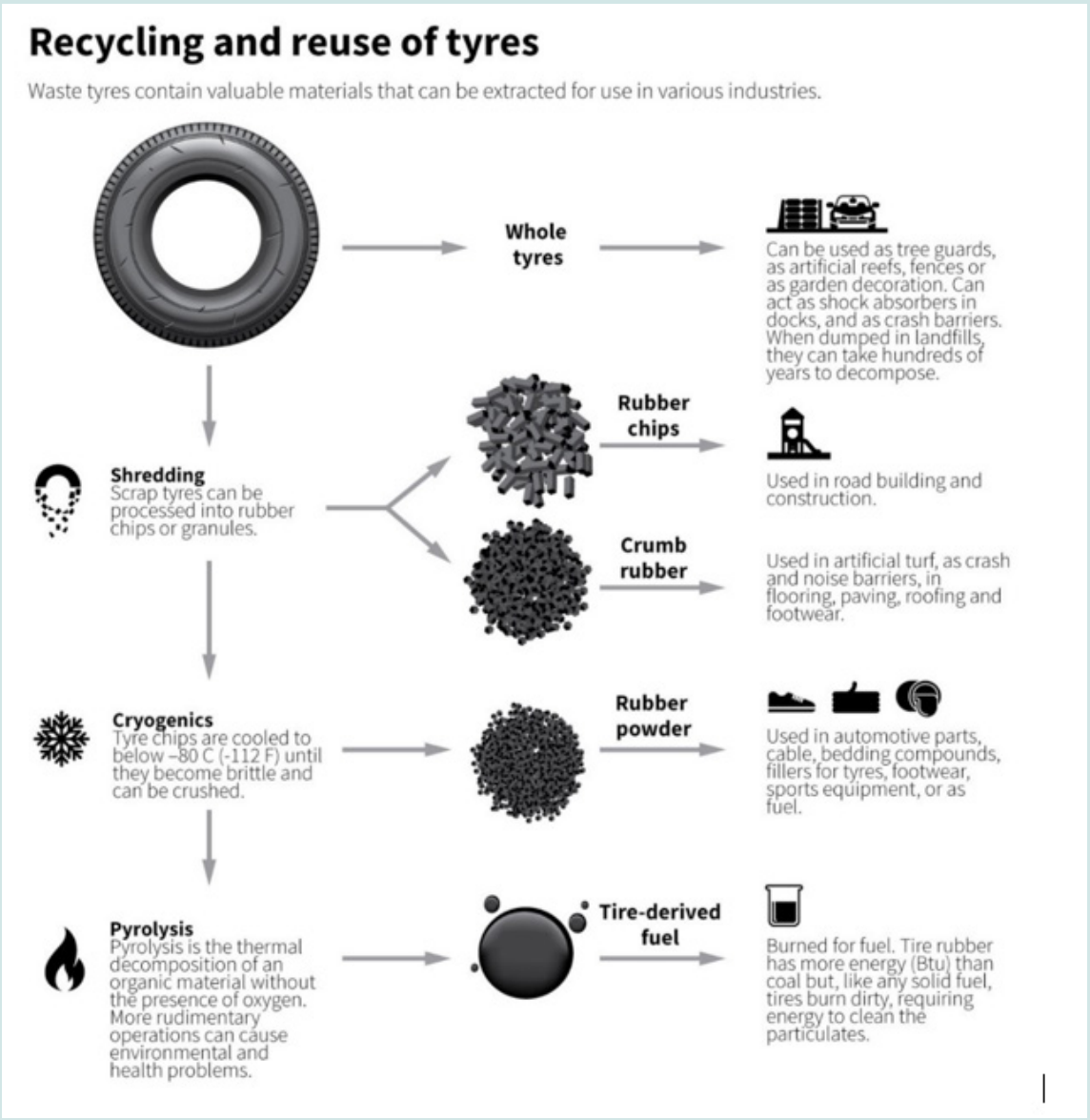

Figure 2: Rubber waste recycling process (Inton, 2020)

Figure 3: Sand mixed with granulated waste rubber

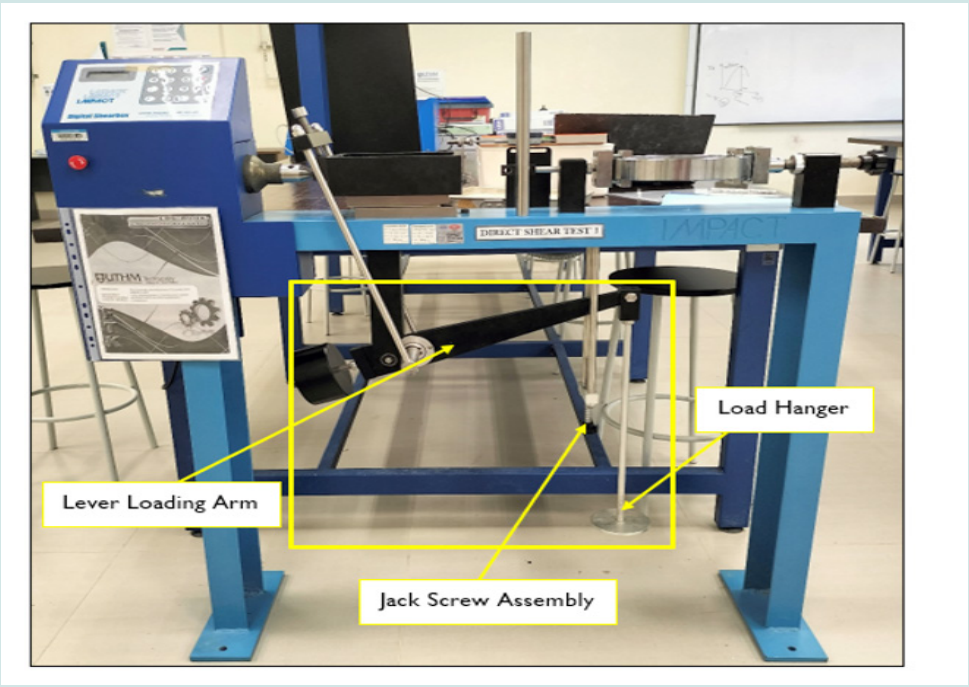

Figure 4: Direct Shear Test Machine

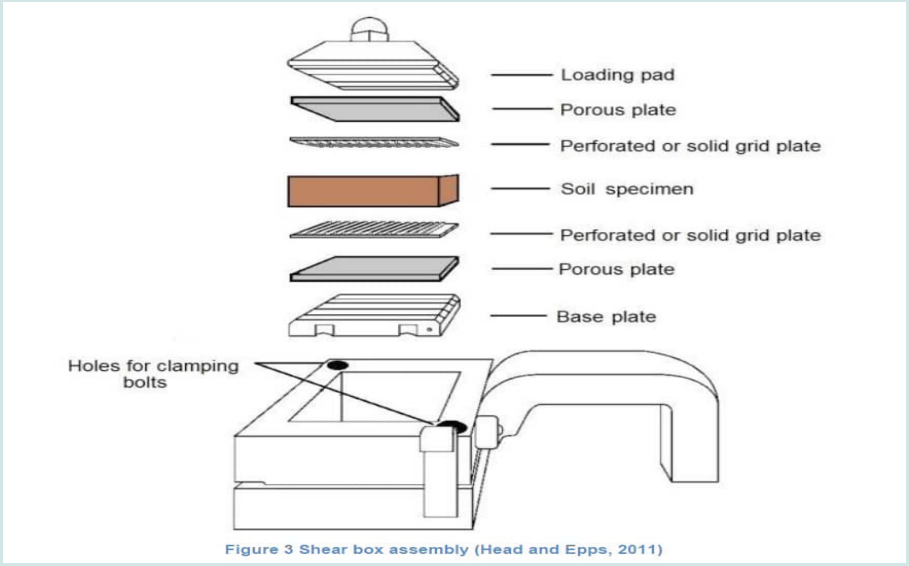

Figure 5: Shear box arrangement for sample testing

Work in the Pipeline

Referring to the Objectives laid out for the proposed work, the sand-rubber composite would be subjected to the standard direct shear test per BS1377 as mentioned earlier. Shear strength parameters of the mixed granular materials would be derived from the measurements under 3 distinctive vertical load applications. With their inherent qualities of angular texture for good interlocking and hence frictional resistance against external loading, as well as sizeable pores for good water dissipation and hence promising permeability, the composite could potentially serve well as backfill materials for civil engineering earth structures, such as road embankment and retaining walls. This further work and findings will be presented as a sequel to this paper in the near future.

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