ABSTRACT

Due to environmental and human health issues, use of scrap tires in engineering purposes is strongly advisable. According to literature, Tire-Derived Aggregates (TDA) is one of the useful materials in different field of geotechnical in order to high level of flexibility, which can be applicable in different structures like retaining wall, landfill, artificial slope and embankment. TDA properties corresponded to some significant factors like flexible, lightweight, high permeability and economic material in compare to use sand. Distribution of specific gravity for laterite soil is the main goal of this study when it can be mixed by TDA and micro silica (MS) with different percentage. A number of 15 specific gravity tests using alcohol pycnometer were carried out. As result, TDA led to reduce specific gravity and MS led to increase this value. Consequently, the best mixture in order to specific gravity distribution was obtained in this study.

KEYWORD

Specific Gravity, Pycnometer, Laterite, Tire Derived Aggregate, Water, Micro silica.

INTRODUCTION

Currently, alleviates disposal is one of the important problems in the world. In parallel, application of waste materials in engineering purposes is dramatically increased. Tire is one of the applicable waste materials that can be used in industries and constructions. In the past two decades, it is well known that the soil properties can be improved by using TDA [1]. In other words, specific gravity of the soil is one of the engineering properties, which plays an important role in analysis of geotechnical problems.

The specific gravity of soil is one of the basic properties that commonly known by a symbol with Gs. This value is a measurement of soil particle density and related to the equivalent volume of water. The degree of saturation and void ratio depend on it. Therefore, accurate determination of specific gravity is essential. In this study, the effect of TDA and MS on distribution of specific gravity is the main purpose of the present study. For this purpose, both additives as mentioned used with respect to different percentage when the maximum size was just 2 mm.

BACKGROUND

To determine specific gravity of soil particles, some standards have been developed which explained below. As stated by ASTM (D 854-10) [2], this measurement is possible while grain size is less than 4.75 mm. However, in a case of having particles, which can be readily dissolved in water or float in water, ASTM (D 550-06) [3] should be used. In this domain, two standards such as (AASHTO T 100) [4], and California test 209 [5] also can be used. For soil particles greater than 4.75 mm, California test 206 [6] or ASTM C127-12 [7] can be used.

The use of water pycnometer is commonly suggested for this purpose in all of the aforementioned standards except for ASTM (D 550-06) that emphasized to apply gas pycnometer. On the other hand, ASTM (D 6270- 12) [8] is recommended by standard test method for using scrap tires in the civil engineering objectives. The specific gravity of tire derived aggregate should be determined by using ASTM C127 [7] for size more than 4.75 mm.

To measure specific gravity, all abovementioned standards based on water pycnometer method are very
applicable. Unfortunately, they are not reliable for some purpose, as shown in Figure 1 [9]. In this Figure, TDA density is very close to the water density. Therefore, a liquid with lower density than TDA density is required.

Fig.1. Use of Powdery TDA in Water Pycnometer [9].

In this context, ethyl alcohol pycnometer is highlighted in Florida method of test for testing of ground tire rubber (FM 5-559) [10]. Therefore using this method is recommended to solve problem. The range of specific gravity for TDA is between 1.01 to 1.36 in some studies [8,11,12,13,14]. As stated by Rau and Dutta in 2006, this value was near to 1.22 and 1.15 for TDA with and without metal, approximately. On the other hand, the specific gravity of soils is 2.6 to 2.8.

METHODOLOGY

This study included two steps; the first step is material collection. Secondly, the specific gravity test was carried out by using Florida (FM 5-559) [10]. Based on this standard, alcohol pycnometer can be used for TDA powder test.

Materials

Laterite is clayey soil with reddish color and amounts of iron oxides that used in this study. This soil can be found commonly in tropical zones [9].

Tab.1. Characteristics of the natural laterite soil

<table>
<thead>
<tr>
<th>Engineering and physical properties</th>
<th>values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph (L/S=2.50)</td>
<td>5.31</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>2.88</td>
</tr>
<tr>
<td>External surface area(m²/g⁻¹)</td>
<td>42.1</td>
</tr>
<tr>
<td>Liquid Limit, LL (%)</td>
<td>74</td>
</tr>
<tr>
<td>Plastic Limit, PL (%)</td>
<td>42</td>
</tr>
<tr>
<td>Plasticity index, PI (%)</td>
<td>32</td>
</tr>
<tr>
<td>BS Classification</td>
<td>MH</td>
</tr>
<tr>
<td>Maximum dry density (kN/m²)</td>
<td>13.30</td>
</tr>
<tr>
<td>Optimum moisture content (%)</td>
<td>35</td>
</tr>
<tr>
<td>Unconfined compressive strength (kPa)</td>
<td>310</td>
</tr>
</tbody>
</table>

The soil samples are from a hillside (Balai Cerap) which located at the Skudai campus in Universiti Teknologi Malaysia (UTM). Table 1, 2 show the physical and chemical properties. Maximum and minimum size of Laterite was 2.00mm and 0.075 mm, respectively.

Tab.2. Oxides and chemical composition of Laterite soil

<table>
<thead>
<tr>
<th>Chemical composition (Oxes)</th>
<th>Value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>25.15</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>30.85</td>
</tr>
<tr>
<td>Fe₂O₃</td>
<td>36.2</td>
</tr>
<tr>
<td>CO₂</td>
<td>7.8</td>
</tr>
</tbody>
</table>

In terms of additives, two materials such as TDA and MS were applied. TDA was a powder material (80 meshes). Yong Fong Rubber Industries Sdn.Bhd made it. The powder material MS provided form Syarikat Honda Industries Sdn. Bhd.

Fig.2. Materials, a: Laterite, b: Tire driven aggregate and c: Micro silica
Test procedure

Figure 2 shows materials that used in this study. It should be noting that, tropical laterite soil was provided from University Teknologi Malaysia campus in Johor city.

This test was performed based on ASTM D-854 and Florida test method (FM 5-559). It should be noting that, the test value is strongly dependent on technical competency, suitability of the equipment and facilities. In this case, required apparatus included Pycnometer, Balance, Drying oven, Thermometric device, De-aired water, Ethyl Alcohol, Vacuum pump, Funnel, Sieve, Material, and Calculator.

The pycnometer volume was 100 ml. Pycnometer was dried for the accurate determination of its mass. To carry material into pycnometer, a dry funnel was used. The stem of the funnel must extend past the calibration mark or stopper seal. The next step dealt with adding the Ethyl Alcohol. It was added to the material until it reached 1/3 to 1/2 depth of the pycnometer main body.

The entrapped air was removed from the slurry by using vacuum pump. Figure 3 shows some of samples before vacuum pump.

The pycnometers were continually agitated under vacuum for at least 2 hours, and then they were filled by de-aired Ethyl Alcohol to the calibration mark level.

In terms of using different percentage based on weight, samples are presented in Table 3. After prepare relevant apparatus and material for test, the pycnometer mass was measured in the first phase of test. For this reason, five different pycnometers were weighed by using high-resolution laboratory balance, as shown in Figure 3.

In the next step the mass of different pycnometers were recorded again to the nearest 0.01 g using the same laboratory balance. Subsequently, mass of pycnometers with Ethyl Alchool were measured for all pycnometers. Figure 4 shows samples during vacuum pump.After performing of the aforementioned procedures, the specific gravity of each material was obtained by using equation 1.
After performing of the aforementioned procedures, the specific gravity of each material was obtained by using equation 1. Where, Mpe is mass of the pycnometer and Ethyl Alcohol, Mpes is the total mass from pycnometer, Ethyl Alcohol, and material. Md is mass of the oven dry soil solids, and Gs is specific gravity of material. The mass dimension was (g) when it was (g/ml) for specific gravity.

\[ Gs = \frac{Md}{(Mpe-(Mpes-Md))} \]  

(1)

RESULTS and ANALYSIS

According to Table 2, this test for all samples was carried out. Results indicated that, the maximum value was found for laterite when it was minimum value for TDA. As shown in Figure 5, specific gravity for micro silica is 2.234 when it is 1.129 for tire. In fact, both additives were lighter than laterite soil.

Distribution of specific gravity for sample 1 to 5 was compared, as can be seen in Figure 6. However, after laterite, the maximum value was obtained when the minimum ratio of TDA was used (See sample 2). This behavior was same in Histograms B and C. In Figure 7-B, sample 8 was maximum with 2.575 when it was 2.506 in sample 3. Based on comparison between both histograms (A and B), the convergence results was observed in 5% TDA instead of 3%TDA.

According to Figure 7-D, increase of silica led to decrease of specific gravity. It was based on maximum TDA for this group test. However, the maximum effects to increase specific gravity shown in Figure 7-C (See sample 10).

After all as discussed, the effect of TDA mixture with Laterite soil on specific gravity showed reduction performance. In addition, effect of silica mixture with TDA and Laterite soil showed the increase of value in this test.

CONCLUSION

In this paper, specific gravity test for different samples in regards to use Laterite soil with two additives such tire aggregate and micro silica was carried out. As results, this value was 2.83 for tropical laterite soil. This value was 1.129 for tire driven aggregate (mesh 80) when it was 2.234 for micro silica. According to result comparison for different samples based on both additives, the reduction performance shown using TDA.

This reduction value was improved in order to increase using silica. Finally, the maximum influence of silica was found. The best distribution to reduce differential specific gravity for mixture in compare to soil obtained with 10% additives while 30% of total additives were micro silica.
Fig. 7. Comparison of specific gravity value in different samples

REFERENCES


