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# CBR behavior of sandy soil reinforced by geofiber material

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**Abstract.** Abu Dhabi sand lacks the required engineering properties to suffice as pavement base course, subbase course, subgrade and as a foundation-support layer under buildings and various structures. Low bearing capacity is manifested on the roadways as differential settlement, waviness and undulations. Stabilization of this type of sand is one of the major geotechnical challenges in practice. In this study the sandy soil was improved by mixing with geofiber. Three different levels of geofiber was added to the sandy soil; 0.1, 0.2 and 0.4% by dry weight of sand. The results showed great increase in shear strength as indicated by the CBR values. The CBR values have increased from 19 to 55 for 0 and 0.4% geofiber content respectively.

## 1. Introduction

Abu Dhabi sand lacks the required engineering properties to suffice as pavement base course, subbase course, subgrade and as a foundation-support layer under buildings and various structures. The low density of Abu Dhabi sand due to its gradation is mainly resulted in low bearing capacity which is manifested on the roadways as differential settlement, waviness and undulations. This kind of weakness in subgrade causes a lot of distresses in the pavement and cost a lot effort and cost on maintenance and rehabilitation of the pavement. Stabilization of this type of sand is one of the major geotechnical challenges in practice. Improvement of soils with the use of geofiber is popular among practitioners due to low cost and ease of deployment of the technology, light weight of the additive (i.e., geofiber), and successful case histories. The early studies on reinforcement of sand with fibers was performed by Gray and Ohashi [1] how concluded that the shear strength of fiber reinforced sand has increased substantially as well as sand ductility. Using fiber from steel bars, polypropylene, polyester, glass fibers, and biodegraded fibers has proven to be effective for soil reinforcement [2-4]. Polypropylene fiber is the most widely used fibers to enhance the soil strength properties, to reduce the shrinkage properties and to overcome chemical and biological degradation [5-7]. In the current research geofiber with varying content was used to increase the bearing capacity and strength in general of Abu Dhabi sand.

## 2. Experimental work

### 2.1. Materials

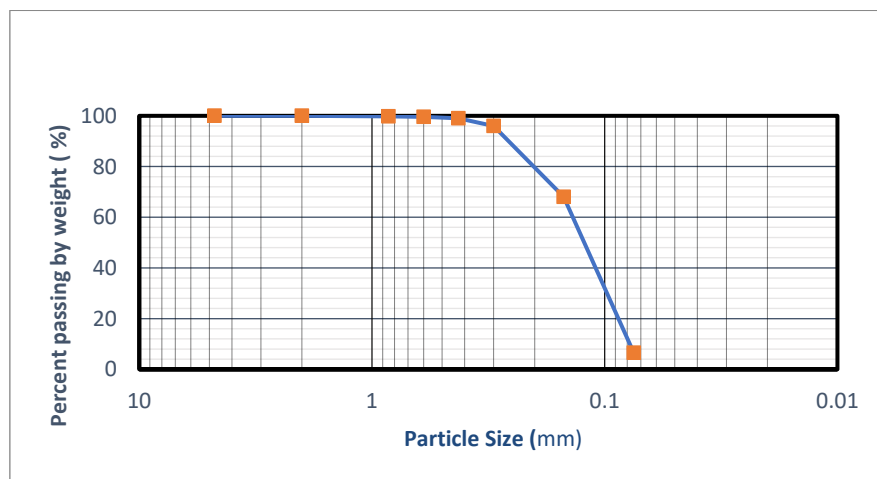
First, the soil used in this research was Abu Dhabi sand. Basic index properties of the sand were determined according to pertinent ASTM procedures [8,9], and are listed in Table 1. The particle size distribution of the sand is shown in Figure 1. It is classified as poorly graded sand (SP) according to USCS classification. This type of sand is common in UAE in particular and in gulf region in general.



Second, polypropylene geofiber was used as a stabilization material. Many researchers used geofiber in soil strengthening due to its availability, resistance to ultraviolet degradation, chemical stability, and reasonably high strength characteristics [10,11]. The properties of the geofiber used are listed in Table 2. For reinforcing the sandy soil three different levels of geofiber; 0.1, 0.2, and 0.4 % by dry weight of the sand were used in this study.

**Table 1.** Index properties of the sand investigated

| Index properties of Abu Dhabi Sand    |       |
|---------------------------------------|-------|
| Specific Gravity (ASTM C128) [1]      | 2.65  |
| D <sub>10</sub> (mm) (ASTM D6913) [2] | 0.08  |
| D <sub>30</sub> (mm) (ASTM D6913) [2] | 0.1   |
| D <sub>60</sub> (mm) (ASTM D6913) [2] | 0.15  |
| C <sub>u</sub> (ASTM D6913) [2]       | 1.875 |
| C <sub>c</sub> (ASTM D6913) [2]       | 0.83  |
| USCS Soil Classification              | SP    |



**Figure 1.** Grain size distribution of Abu Dhabi sand

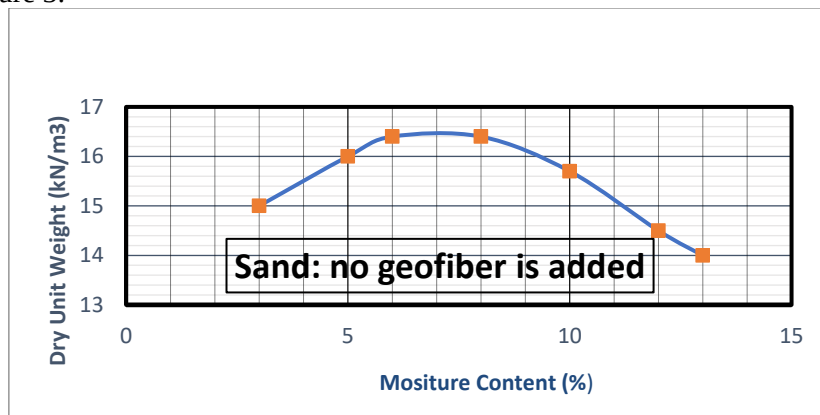
**Table 2.** Index properties of the geofiber (as provided by the manufacturer)

| Property               | Test Method       | Fiber Type             |
|------------------------|-------------------|------------------------|
|                        |                   | Fibrillated            |
| Material               | ASTM C1116/C1116M | Synthetic macro fiber  |
| Shape                  | -                 | Flat-Narrow (2mm wide) |
| Color                  | -                 | White                  |
| Moisture               | -                 | None                   |
| Specific gravity       | ASTM D792         | 0.92                   |
| Carbon black content   | ASTM D1603        | 0.5%, minimum          |
| Tensile strength (MPa) | ASTM D2256        | 620                    |
| Ignition point (C°)    | -                 | 590                    |
| Length used (mm)       | Measured          | 40                     |

## 2.2. Laboratory tests

California Bearing Ratio, CBR test was used to evaluate the strength and bearing capacity of the treated sand. Modified compaction test according to ASTM D1557 [12] was used to determine the

maximum dry density (MDD) and optimum moisture content (OMC) of the sandy soil. The compaction curve of the modified Proctor test is shown in Figure 2. Sample preparation for CBR test is shown in Figure 3.



**Figure 2.** Compaction curve of the sandy soil according to modified Proctor test



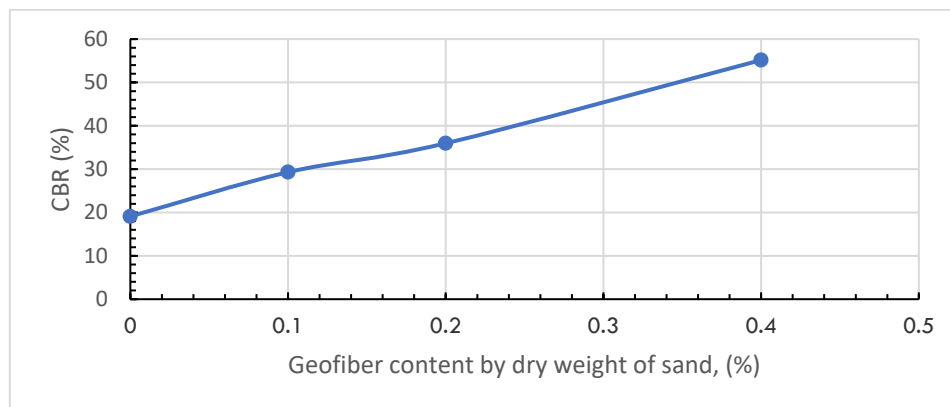
**Figure 3.** Sample preparation for CBR test

The tests were performed on specimens prepared for CBR test according to ASTM D1883 [13] at OMC. The tested sand specimens included both; specimens without geofiber additives and specimens with varying geofiber content.

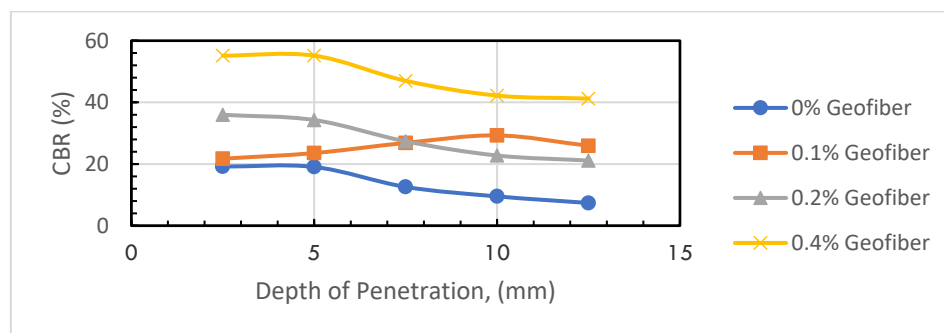
CBR test is commonly used in pavement design as an indicator of shear strength and bearing capacity of the soil. The CBR of a soil is the ratio obtained by dividing the stress required to cause a standard piston to penetrate 2.54 mm, 5.08 mm, 7.62 mm, 10.16 mm, and 12.70 mm into the soil by a standard penetration stress at each depth of penetration (ASTM D 1883). The CBR is an index value comparing the strength of the soil to that of crushed rock [14].

### 3. Results and discussion

The CBR tests were performed on samples contain three levels of geofiber; 0.1, 0.2, and 0.4 % by dry weight of the sand to evaluate the effect of the geofiber on the shear strength of the sandy soil. Also, CBR test was performed on sand specimen without addition of geofiber. Figure 4 shows that CBR values increased as the geofiber content increased and kept increasing within the amount of geofiber used in this study. CBR value increased from 19 to 55 at 0 and 0.4% geofiber respectively. This shows an improvement of 189% over the performance of unreinforced soil. Figure 5 shows comparison between the effect of varying geofiber content and different penetration depth. It shows that the CBR values has increased at all penetration depths as the geofiber content increased.



**Figure 4.** Effect of geofiber content on CBR values



**Figure 5.** Comparative CBR performance of Abu Dhabi sand with Geofiber

#### 4. Conclusion

Based on the results of this study, the shear strength of the treated soil has increased dramatically with addition of geofiber. No optimum value of geofiber content was observed. On the contrary, CBR values kept increasing in the range of geofiber content used in this study.

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