THE EFFECT OF F TYPE POLYFIBER MATERIAL ON SOME GEOTECHNICAL PROPERTIES OF ANKARA CLAY

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Abstract: Being parallel to the development of technology, many soil improvement methods have evolved and different materials have found applications in them. In this study, a series of laboratory tests was carried out to investigate the effect of net shaped polypropylene fiber material of 9 mm length on some geotechnical properties of Ankara clay. For this purpose, the unconfined compressive strength, California Bearing Ratio (CBR) and Swell tests are conducted on the compacted specimens of Ankara clay and clay-fiber mixtures. Standard Proctor and CBR test results reveal that the percentage of F type polypropylene fiber does not influence considerably the optimum moisture content, the maximum dry density and compressibility of Ankara clay. However, the unconfined compression test results show that the unconfined compressive strength of Ankara clay increases remarkably with the increase of F type polypropylene fiber up to 0.3 % fiber content but beyond that it decreases dramatically. Finally, it is found that the addition of F type polypropylene fiber to Ankara clay does not affect its swelling characteristics.

Keywords: clay; fiber; strength; swelling; compressibility

INTRODUCTION

The inclusion of randomly oriented fibers into to a soil mass is one of the most interesting phenomena studied in soil improvement engineering. The reinforcement of cohesionless (sand, silt, fly ash etc.) soils with randomly oriented fibers has been extensively studied (Gray and Ohashi, 1983; Frietag, 1986; Maher and Gray, 1990; Al-Refeai, 1991; Maher and Ho, 1994; Michalowski and Zaho, 1996; Consoli et al., 1998; Santoni et al., 2001; Carlsten et al., 2003). On the other hand, there are few attempts considering cohesive soils (Kumar et al., 2006; Cai et al., 2006). In addition, reinforcement of cohesive soils with randomly oriented fibers is incomplete and the findings are contradictory. The aim is therefore to contribute to the literature in this regard. The details of the experimental program and the findings are presented below.

Some Geotechnical Properties of Ankara Clay

The results of the sieve analysis, specific gravity, consistency limits and classification of Ankara clay and some technical properties of F type polypropylene fiber are given in Table 1 and Table 2 respectively.

Table 1. Some geotechnical properties of Ankara clay

Property	Value
Coarse sand according to USCS (4.75-2.0 mm), %	1.9
Medium sand according to USCS (2.0-0.425 mm), %	5.9
Fine sand according to USCS (475-75 µm), %	7.4
Fines according to USCS (<75µm), %	84.8
Liquid limit, %	68,2
Plasticity limit, %	27,1
Specific gravity, Gs	2,65
Classification symbol	CH

Table 2. Some technical properties of the F type fiber

Property	Value
Content	100 % pure polypropylene
Appearance	Fibril net shaped fiber
Standard	ASTM C – 1116 – 1997 Type III
Length (mm)	9
Tensile strength (kPa)	400
Young modulus (kPa)	2600
Elongation (%)	15 %
Density (g/cm^3)	0.91

Preparation of Samples for Testing

The highly plastic reddish brown clay samples were taken from an open-cut excavation in Çukurambar region of Ankara, Turkey and brought in the soil mechanics laboratory of Gazi university. It was spread out on the floor in one corner of the room and dried in open air at a room temperature of 25 °C. After drying, they were broken into small pieces by using a rubber hammer, passed through U.S. No.4 (4.75 mm) sieve and collected in a tray.

Standard Proctor Tests

Prior to compaction, clay and fiber are mechanically mixed at 0.1 %, 0.2 %, 0.3 % and 0.4 % by weight of dry clay until homogenous mixtures were obtained and then a required amount of water was added and compacted properly. Dry densities of the compacted samples are plotted against the corresponding moisture contents in Figure 1. Figure 1 shows that both the maximum dry density and the optimum moisture content of compacted Ankara clay are not affected considerably by the inclusion of randomly oriented fiber material. While the dry densities range from 1.462 Mg/m^3 to 1.485 Mg/m^3 optimum moisture contents vary from 25.77 % to 27.16 % respectively.

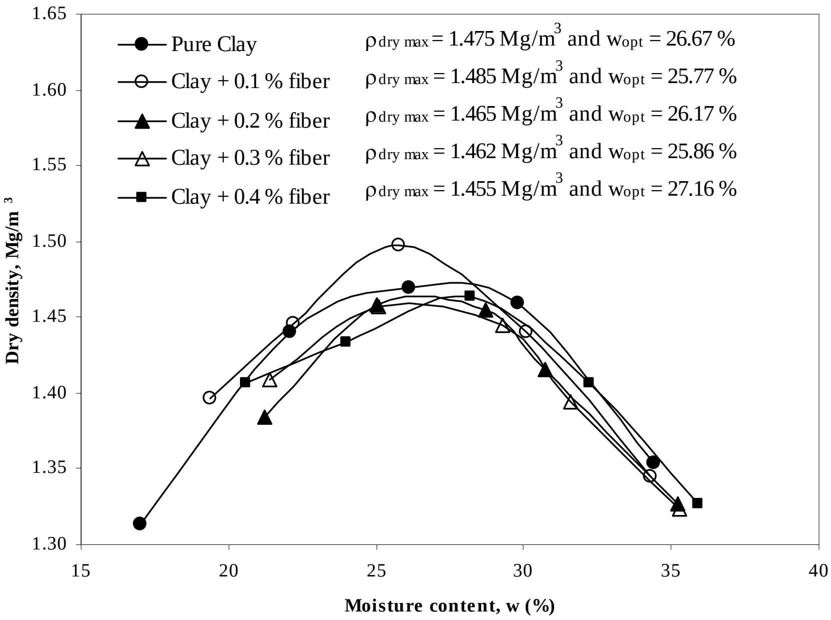

Figure 1. Compaction curves of compacted the clay-fiber mixtures

Unconfined Compression Tests

The gain or loss in the strength of fiber amended clay samples compacted at their relevant optimum moisture contents was investigated by means of unconfined compression tests at the displacement rate of 1.2 mm/min. The unconfined compressive strengths of the fiber amended clay samples and their corresponding axial deformations are given in Table 3. Table 3 shows that the unconfined compressive strength is increased by the inclusion of randomly oriented fiber material but the increase in strength continue up to 0.3 % fiber content and then it decreases dramatically. Moreover, it is seen that as the percentage of fiber content increases, the axial strain at which failure of the specimens occurs is also increased.

Table 3. Unconfined compressive strengths of the compacted specimens

Percentage of fiber	Unconfined compressive strength, kPa	Axial strain at failure, %
0	148.1	4.5
0.1	165.8	5.2
0.2	161.2	4.7
0.3	173.2	5.5
0.4	119.8	5.6

California Bearing Ratio (CBR) Tests

California Bearing Ratio (CBR) tests were carried out according to Standard Method of Test for the California Bearing Ratio (AASHTO T-193). The relationship between the fiber content and CBR values is given in Table 4. Table 4 shows that CBR values of the clay-fiber mixtures are slightly increased with the inclusion of randomly oriented fiber.

Table 4. CBR values of the compacted specimens.

Percentage of fiber	CBR, %
0	3.7
0.1	4.2
0.2	4.2
0.3	4.0
0.4	4.1

Swell Tests

Samples compacted at their relevant optimum moisture contents were subjected to swell percentage tests using an oedometer test apparatus having cells of 75.2 mm in diameter and 20.0 mm in height. According to the Standard Test Method for One-Dimensional Swell or Settlement Potential of Cohesive Soils (ASTM D 4546-03) *Method A* 1.0 kPa surcharge pressure was adopted for swell percentage measurements. The results of swell tests are given in Table 5.

Table 5. Swell percentages of the compacted specimens.

Percentage of fiber	Swell, %
0	6.8
0.1	6.5
0.2	6.9
0.3	6.9
0.4	6.9

From Table 5, it may be stated that inclusion of F type polypropylene fiber into Ankara clay does not influence swell characteristics of highly plastic Ankara clay.

CONCLUSIONS

The conclusions derived from this experimental study are as follows:

- Both the maximum dry density and the optimum moisture content of Ankara clay are not affected remarkably by the inclusion of randomly oriented F type polypropylene fiber.
- The unconfined compressive strength of compacted Ankara clay is increased by 20 percent at 0.3 % F type polypropylene fiber content but beyond that it decreases dramatically. In addition, as the percentage of fiber content increases, the axial strains where the failure of the specimens occur are also increased.
- Compressibility of compacted Ankara clay is increased slightly by the inclusion of randomly oriented F type polypropylene fiber at all fiber contents.
- Inclusion of fiber into Ankara clay does not influence its swell characteristics.

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