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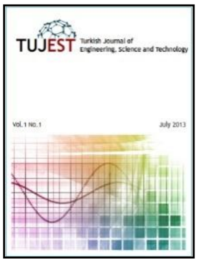

The Effect Of Polypropylene Fiber On Index Properties And Compaction Characteristics Of Clay Soil

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Abstract

This study presents laboratory experimental study on the effect of inclusion of polypropylene fiber in clay soil sample. The initial work of the experimental program presents the study of the effect of polypropylene fiber on maximum dry density and optimum moisture content with different fiber inclusions. The light compaction tests have been conducted on a clay soil sample with 0%, 0.25%, 0.50%, 0.75%, 1.0% and 1.25% in additions of polypropylene fiber and the samples have been prepared with the same dry density. At the different stages of admixtures of polypropylene fiber with clay soil sample were tested and the maximum dry density and optimum content of fiber was found. The further study of experimental work focuses on the unconfined compression test, California bearing ratio test and swelling behavior of the soil sample. The experimental test results indicated that addition of polypropylene fiber inclusions in stabilized clay results in higher bearing strength values and California bearing ratio values.

1. Introduction

Expansive soils are the main cause of damages to many civil engineering structures such as spread footings, roads, highways, airport runways, and earth dams constructed with dispersive soils. Stabilization by chemical additives, pre-wetting, squeezing control, overloading, water content prevention are general ground improvement methods that are used to mitigate swelling problems. There has been a growing interest in recent years in the influence of chemical modification of soils which upgrades and enhances the engineering properties. The transformation of soil index properties by adding chemicals such as cement, fly ash, lime, or combination of these, often alter the physical and chemical properties of soils including the cementation of the soil particles. Especially use of lime admixture has proved that is has a great potential as an economical method for improving the geotechnical properties of expansive soils.

Rao and Shivananda (2005) have examined the compressibility behavior of lime-stabilized soils[12]. According to McKeen cement and lime show different behavior in soil stabilization [10]. Cement contains the necessary ingredients for the pozzolanic reactions, whereas lime can be effective only if there are reactants in the soil. Recently there is a growing attention to soil reinforcement with different types of fiber. According to Heineck et al. (2005) experimental results gathered over the past years shows the potential of different types of fiber in reinforcing problematic soils [7]. In order to understand completely the strength behaviour of unreinforced and reinforced soils, Prabakar and Sridhar (2002) carried out a series of experiments on a non-expansive soil and assessed the suitability of sisal fibre as a reinforcement material, and concluded that a significant improvement in the failure deviator stress, and shear strength parameters (c and Ø) are achieved [11]. Freilich and Zornberg (2010) observed an increase of shear strength of soils with the presence of randomly distributed polypropylene fibers[13]. Therefore, polypropylene fiber appears to be a great potential for reducing the detrimental effects on buildings, earth retaining structures and roadways induced by expansive soils[9].

However, there is limited research done on fiber reinforcement of fine grained soils, particularly its effect on compaction characteristics, strength and hydro mechanical properties.

In this experimental investigation, the aim was to study the effect of polypropylene fiber reinforcement on the improvement of physical and mechanical properties of a clay sample obtained from an expansive clay deposit in Coimbatore, Tamilnadu, India. The experimental program was carried out on compacted soil specimens with 0%, 0.25%, 0.5%, 0.75%, 1% and 1.25% polypropylene fiber additives, and the results of compaction, unconfined compression and CBR are discussed. Despite the difficulties encountered in representative specimen preparation due to random distribution of fiber filaments, it is observed that there is a future prospect in the use of this environmental friendly additive for soil mitigation.

2. Materials

Soil

The soil is used in this study which has been obtained from the campus of GCT, Coimbatore, India. The physical properties of the soils are as depicted in Table I.

Table 1: Physical properties of soil

Sl.No	Property	Values
1	Specific Gravity	2.71
2	Sand (%)	20.29
3	Clay (%)	67.30
4	Silt (%)	12.28
5	Liquid limit (%)	53
6	Plastic limit (%)	33
7	Plasticity index (%)	20
8	Optimum moisture content (%)	31.5
9	Maximum dry density (kg/m^3)	1360
10	Soil classification	CH

Polypropylene

The most commonly used synthetic material; polypropylene fiber is used in this study. This material has been chosen due to its low cost and hydrophobic and chemically inert nature which does not absorb or react with soil moisture or leachate. The high melting point of 160°C, low thermal and electrical conductivities, and high ignition point of 590°C are other properties. The Propylene fiber is used in this study which has physical properties such as specific gravity of 0.91, and an average diameter and length of 0.06 mm and 20 mm respectively.

Sample Preparation

All the test specimens were compacted statically by applying the pressure required to achieve maximum dry density at optimum moisture content as obtained from the Standard Proctor's Compaction test. The static compaction is applied in a Standard Proctor's instrument. To prepare unreinforced samples, water is added to the soil and mellowed for 24 hours. To obtain reinforced samples, the fiber is added after the mellowing time and blended in a mixer to achieve the best possible distribution. The amount of fiber that should be added to the soil has been calculated according to the dry unit weight of the soil and has been added to the wet soil. To ensure a uniform distribution of the fibers, samples are compacted directly to the size required in special moulds..

3. Testing Procedures

To find the optimum proportion of expansive soil, the amount of polypropylene was varied from 0% to 1.25% percent by dry weight of soil in steps. Based on Compaction and Unconfined compressive strength test the maximum dry density and optimum moisture content was found at 7.5%. For conducting different tests on reinforced stabilized expansive soil, the polypropylene fiber was added from 0% to 1.25%. Standard Proctor tests were conducted without curing. The samples were prepared at the corresponding OMC and MDD, and the tests were conducted as per the procedure given by the relevant Indian standard Codes.

4. Results and Discussion

Compaction Tests

The relationship between dry density and moisture content of samples obtained by Standard Proctor test is presented in Figure 1. The test procedure consists of mixing of soil with different water contents and compacting in metal moulds of 100 mm diameter in three layers (25 blows on each layer) using a Standard Proctor's Compacter with a hammer of 2.49 kg and free fall height of 300mm. The compaction test has been performed on soils with different fiber contents of 0%, 0.25%, 0.5%, 0.75%, 1 % and 1.25% of dry mass. The compaction curves in Figure 1 indicate that optimum moisture content does not show a significant change by addition of polypropylene fiber, whereas maximum dry density reduces as well as fiber content increases. This behavior can be attributed to the reduction of average unit weight of solids in the mixture of soil and fiber.

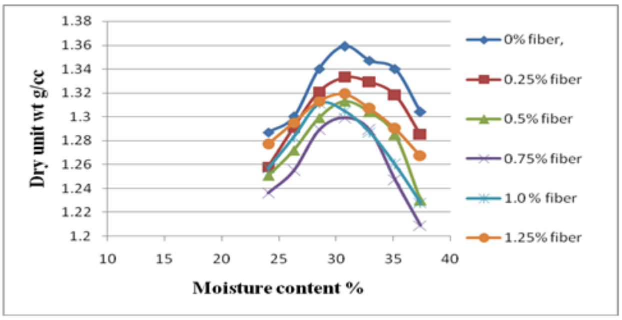

Figure 1: Standard Proctor's Compaction Curve

Unconfined Compression Test

Unconfined compression tests using strain-controlled application of the axial load, are carried out in this experiment. The unconfined compressive strength is taken as the maximum load attained per unit area or the load per unit area at 15 % axial strain, whichever is secured first during the performance of the test. Samples have been prepared at optimum moisture content and statically compacted directly in the sample preparation mould by Proctor's instrument to achieve the maximum dry density. The Figure 2 demonstrates the stress- strain relationship of fiber reinforced and unreinforced soils were an enhancement in unconfined compressive strength has been observed with an increase in fiber content. It is also observed that the failure of the fiber reinforced specimens occurs in longer time than the original soil, which indicates increase in the ductility of the soil after reinforcement.

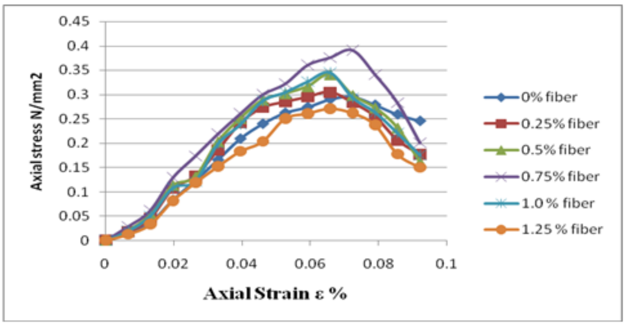

Figure 2: Stress-Strain relationship of original and fiber reinforced soils

California Bearing Ratio Test

The optimum moisture content has been used to prepare the soil sample for the testing the CBR values. In addition to polypropylene alone the CBR of the mixture is increased nearly 70%. The Effect of fiber on Soil mixture is limited because of the high plasticity of the Clay soil. CBR tests were done for unsoaked samples only. For unsoaked samples the CBR value increases significantly and decreases with increasing fiber content which shows that the use of fiber is more suitable for subgrade modification. The Figure 3 shows the effect of fiber on clay soil the CBR value increases with increasing fiber content and decreases linearly.

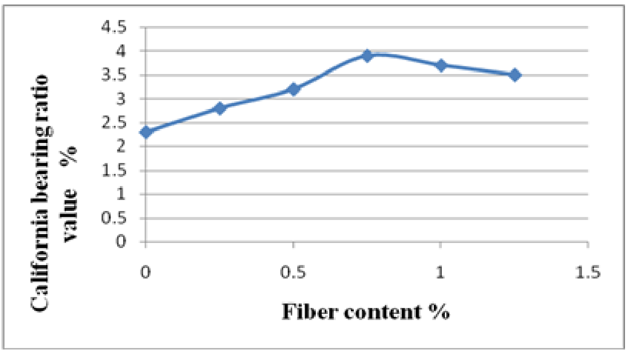

Figure 3: Variation of C.B.R with inclusion of fiber

5. Conclusion

Based on this experimental study, optimum water content is not influenced by polypropylene fiber inclusion, whereas maximum dry density has been reduced. This can be attributed to the reduction of average unit weight of solids in the soil-fiber mixture. Unconfined compressive strength increases with polypropylene fiber inclusions. Maximum value of cohesion can be observed with 0.75% fiber content which is approximately 1.34 times of the unreinforced soil. Thus fiber enhances the ductile behavior of soils, reducing shrinkage settlements during desiccation, hence detrimental damages to structures, such as roads and pavements may be prevented.

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