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Influence of Fiber and Cement on Stabilisation of Silty Clay

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ABSTRACT

Background: In this experimental study the effect of polypropylene fibers to improve the flexural and compressive strength of clay soil stabilized with cement are investigated. **Objective:** The UKM soil was stabilized with 10% of Portland cement and varying percentages (0, 0.5, 0.75 and 1) polypropylene fibers. **Results:** For comparison soil samples with 10% of Portland cement were made too. Unconfined compressive strength and tensile strength tests were performed after 28 days of curing for both samples with and without polypropylene fibers. **Conclusion:** Both compressive strength and tensile strength increased with the increase in polypropylene fibers.

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INTRODUCTION

The growing population of the world is accompanied by increase in construction activities. Soil stabilization with cement to form big development projects like dams, piling, embankment and highways has become a popular construction practice. However soil composition and cement exposed the fragility of bending and stretching modes of failure. (Wang, Q., H.E. Chen, 2003) Historically different types of fibers have been used to control cracking. Polypropylene fibers are an effective technique for improving the reliability properties of soil-cement. Behzad Kalantari (*Behzad Kalantari, N., Bujang B.K.*) concluded in their experimental studies on peat soil treated with cement and polypropylene fibres that Cement and polypropylene fibers can be used to improve the mechanical strength of the soft peat soil by adopting air curing technique. (Peat Soil Stabilization, using Ordinary Portland Cement, Polypropylene Fibers ,and Air Curing Technique)

Chaosheng Tang (2007), conducted experiments on cemented and uncemented clayey soil samples with short polypropylene. The test results showed that short polypropylene in uncemented and cemented soil caused an increase in the unconfined compressive strength (UCS), shear strength and axial strain at failure, lessened the stiffness and the loss of post-peak strength, and altered the cemented soil's brittle behavior to a more ductile one. (Strength and mechanical behavior of short polypropylene fiber reinforced and cement stabilized clayey soil

S. Twinkle (2011) studied the effect of stabilization with polypropylene and lime on expansive soils. Polypropylene of 0.75% and 6% lime increased the UCC by 3.8 times and CBR by 3.19 times after 28 days of curing. In this paper we show that polypropylene fibers increase the flexural and compressive strength of soil - cement. In this study, the percentage of polypropylene fibers (0.0 and 0.5,0.75, 1) was used to test which indicated that the unconfined compressive strength and flexural strength of cement soil and improved.

Preparation of specimens:

The soil was dried in oven at 110 for 24 hours. Soil and cement were mixed for 5 minutes until the mixture became completely homogeneous. The fibers were mixed with equal proportions as listed above. The optimum moisture content for each polypropylene dosage was determined by standard proctor ASTM D698. After the completion of compaction each sample was extruded from the mold and wrapped in plastic film and cured at a temperature of 25 ± 1 and RH humidity of $96 \pm 2\%$ for 28 days.

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Materials:

UKM soil was used in this experiment. Soil physical properties are shown in Table 1. Ordinary Portland cement was used with properties shown in Table 2 (where is table 2) and properties of PP fibers are shown in Table 3.

Table 1: Physical and mechanical properties of soil.

Soil Properties	Values
Specific Gravity	2.59
Liquid Limit	42.5%
Plastic Limit	33.1%
Plasticity Index	9.4
USUC Classification	CL
Compaction Study	
Optimum Moisture Content	14.5%
Maximum Dry Density	1.6 g/cm ³
Natural Water Content	13%
Silt	36.4%
Clay	63.6%

Table 2: Chemical composition of cement.

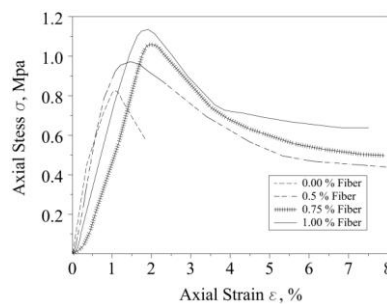
Al ₂ O ₃	Fe ₂ O ₃	SiO ₂	CaO	MgO	LOI	SO ₃
4.3	3.5	20.3	62.4	2.8	1.6	3.3

Table 3: Physical and chemical properties of fiber used.

Behavior Parameters	Values
Fiber Type	Single Fiber
Breaking Tensile Strength	400 MPa
Modulus of elasticity	4000 MPa
Average Diameter	0.038mm
Average Length	10mm
Unit Weight	0.92g/cm ³
Fusion Point	170°C
Burning Point	595°C
Acid and alkali resistance	Very good
Dispersibility	Excellent

RESULT AND DISCUSSION**Unconfined Compression test:**

Samples (diameter 10 cm and height 11 cm) were soaked in water for 4 hours after the completion of 28 days of curing. After the soaking the UCC test was conducted with an applied strain of 1 mm/ min. till the failure occurred. The results are shown in Figure 1.

**Fig. 1:** Stress Strain curve varying polypropylene content Flexural/ bending test.

For flexural test beams with dimensions 40 × 40 × 160 mm were used. Specimens were prepared according to ASTM D1635 standard. Third - Point loading method was used to calculate the ultimate flexural stress. The modulus of rupture was calculated as:

$$R = \frac{PL}{bd^2}$$

R = Modulus of rupture (Kpa)

P = Max applied load (N)

L = Span length (mm)

b = Average width of specimen (mm)

d = Average depth of Specimen (mm)

The stress-strain relationships for soil-cement with varying percentage of PP fibers are shown in Figure 2.

It can be seen that the compressive strength increases with increasing fiber content. One can also see that by increasing the amount of fiber content the tendency of fractures is reduced too. Without a doubt one of the main advantages of forming soil-cement fiber is improved.

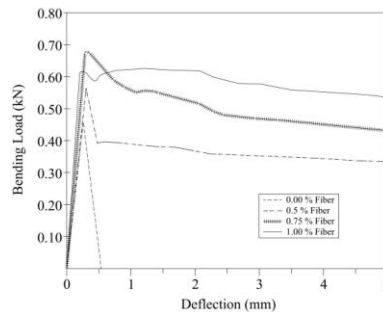


Fig. 2: Flexural stress with varying polypropylene content.

Conclusion:

Soil structure is stabilized by using fiber cement brittle to brittle behavior of the soil as the soil can be more flexible to change when stress starts to leave when loading the fibers bridge cracks develop more effective and thus hinder the opening and prevent failure of the structure is complete. Increase the fiber in this case is more common.

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