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International Journal Of Modern Engineering Research (IJMER)

Experimental Study on The Strength Characteristics of Polypropylene Fiber Reinforced And Cement Stabilized Expansive Soil

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ABSTRACT: *An Experimental program was undertaken to investigate the effects of discrete Polypropylene fiber on strength characteristics of uncemented and cemented expansive soil. In this present investigation, the samples were prepared at different percentages of Polypropylene fiber content(0.15%, 0.25%, 0.5%, and 1% by its weight) and different percentages of cement content (3%, 5%, 8%, and 12% by its weight), and the combination of the both the materials. Compaction test, direct shear test, and CBR test were carried out.*

The results has been interpreted in terms of stress-stain behaviour, effect of fiber content and cement content on optimum moisture content and maximum dry density and strength parameters are presented in this thesis. The test results indicate that the inclusion of fiber reinforced uncemented and cemented soil caused on increasing of maximum dry density and decreasing of optimum moisture content up to 0.5% and 8% of polypropylene fiber and cement respectively. Shear strength parameters like cohesion and angle of internal friction increases with addition of polypropylene fiber and cement up to 0.5% and 8% respectively. The CBR test conducted for optimum values of polypropylene fiber and cement content only. Optimum value attained at 0.5%, 8% of polypropylene fibre and cement respectively.It was observed from the laboratory test results the CBR value of mix proportion (Soil +0.5% PP fibre + 8% of cement) is 2.3 times the untreated soil.

KEY WORDS*: Polypropylene fibre, Cemented soil, Uncemented soil, OMC, MDD.*

Date of Submission: 03-10-2018 Date of acceptance: 15-10-2018

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1. INTRODUCTION

A land based structure of any type is only as strong as its foundation. For that reason, soil is a critical element influencing the success of a construction project. Soil is either part of the foundation or one of the raw materials used in the construction process. Therefore, understanding the engineering properties of soil is critical to obtain strength and economic performance. Soil stabilization is the process of maximizing the suitability of soil for a given construction purpose.

Chemical stabilization by cement or lime is a proven technique for improving the performance of the soil. However, these chemical additives usually result in a stiffness and brittle behaviour. Inco-operating the reinforcing inclusion with in soil is also effective and reliable technique in order to improve the engineering properties of soil. In comparison with conventional geosynthetics (strips, geotextile, geogrid, etc.), there are some advantages in using randomly distributed fiber as reinforcement. First, the discrete fibers are simply added and mixed randomly with soil, in much the same way as cement, lime, or other additives. Second, randomly distributed fibers limit potential planes of weakness that can develop parallel to oriented reinforcement. Therefore, it has become a focus of interest in recent years. A number of tri-axial tests, compaction tests, unconfined compression tests, CBR tests,direct shear tests on the subject have been conducted by several investigators in the last few decadesstudied the effects of short fiber reinforcement on the performance of soil wall. Based on their test results, indicated that fiber inclusion increased the crack reduction and hydraulic conductivity of compacted clay soil. All these previous studies have shown that the addition of fibre-reinforcement caused significant improvement in the strength and decreased the stiffness of the soil. More importantly, fiber reinforced soil exhibits greater toughness and ductility and smaller loss of post-peak strength, as compared to soil alone. Therefore, the discrete fiber can be considered as a good earth reinforcement material, which causes significant modification and improvement in the engineering properties of the soil.

II. OBJECTIVES OF THE STUDY

- The object of this paper is to study the strength characteristics of randomly distributed polypropylene fibre reinforced cemented and uncemented soil.
- To determine the properties of the expansive soil.
- A series of compaction tests, direct shear tests and CBR tests were carried out on samples with different percentages of fiber and cement inclusion.

III. MATERILS USED

3.1Expansive Soil: The soil samples used in the present experimental tests were obtained from the area of Amalapuram, Andhra Pradesh. The soil was air dried and broken into pieces in the laboratory. The physical and mechanical properties of the soil are listed in Table 1.

Fig.1 Expansive Soil

Table 1. Laboratory results of Expansive soil

Property	**Value**
Specific Gravity (Gs)	2.62
Free Swell Index (%)	120
Consistency Limits	
Liquid limit (%)	78.6
Plastic limit (%)	42.9
Plastic Index (%)	36.7
US classification of soil	CH
Grain Size Distribution	
Gravel (%)	0
Sand (%)	4
Silt (%)	40
Clay (%)	56
Compaction Properties	
Optimum moisture content (%)	25.1
MDD (g/cc)	1.41
CBR Values	
Unsoaked CBR value (%)	4.33
Soaked CBR value (%)	2.68
Shear Strength Parameters	
Cohesion	0.153 kg/cm^3
Angle of Internal Friction	18.2^0

3.2 Polypropylene Fiber: Anumber of materials have been reported to be successfully used as reinforcements such as steel, geofabrics, geogrid, aluminium, glass fiber, wood, rubber, and concrete. In developed countries polypropylene fibers are now preferred due to their available with desired properties and durability. PP-fiber used as a reinforcing material and it shows strength, durability, ease of handling, high adhesion or friction with soil and availability at low cost. They are highly restraint to bacteria, alkalis and acid. It can withstand high temperature without its performance being affected. PP-fibers have very good resistance to abrasion and its behaviour in water is satisfactory. It has high modulus of elasticity and has only negligible creep. It is also rot-proof, water and most chemical reagents do not affect its performance.

Fig.2 Discrete Polypropylene Fibre

Table 2: Index and Strength Parameters of PP-fibre

Parameter	Value
Fiber type	Single fiber
Unit Weight	0.91 g/cm^3
Average Diameter	0.034 mm
Average Length	6 cm
Breaking Tensile Strength	350 MPa
Modulus of Elasticity	3500 MPa
Fusion Point	165^{0}C
Burning Point	590^{0}C
Acid and Alkali Resistance	Very good
Dispersibility	Excellent

3.3 Cement: The cement used in the test was ordinary Portland cement.**Cement stabilization** of soil is done by mixing pulverized soil and Portland cement with water and compact the mix to attain a strong material. The material obtained by mixing soil and cement is known as soil-cement. The soil cement becomes a hard and durable structural material as cement hydrates and develops strength.

Fig.3 Cement

Table 3: Physical properties and Chemical Composition of cement

Description	Value
Specific Gravity	3.1
Specific Surface Area	387 m^2/kg
Compressive Strength	33.4 MPa
SiO_2	20.3 %
Al_2O_3	4.3 %
Fe_2O_3	3.5 %
CaO	62.4 %
MgO	2.8 %
SO_3	3.3%
LOI	1.6%

3.4 Laboratory Studies: The laboratory studies were carried out on the samples of expansive soil, expansive soil + PP-fiber, expansive soil+ cement,expansive soil + PP-fiber +cement mixes.

3.4.1 Compaction Test: From the compaction test, the maximum dry density (MDD) and Optimum Moisture Content (OMC) of the soil are found for the selected type and amount of compaction based on the procedure described in Indian codes of practice IS:2720 part 8 (1983).

3.4.2 Direct Shear Test: The specimens for the shear tests were shaped in a cylindrical mould with 20 mm height and 61.8 mm inner diameter by static compaction at the respective MDD-OMC state of soil. The tests were performed at the vertical normal stress of σ=1, 2, 3, 4, and 5kg/cm^2 in order to define the shear strength parameters (c andΦ). The strain rate was 0.12 mm/min in the test.

3.4.3 California Bearing Ratio Test: The California bearing ratio test are conducted on of expansive soil, expansive soil + PP-fiber, expansive soil+ cement, expansive soil + PP-fiber +cement mixes as per IS 2720 part 16 (1979). The load penetration curve for each specimen is plotted on natural scale. The load values at 2.5 mm and 5.0 mm are obtained from the load penetration curve to compute CBR values using the following equation.

$$\text{CBR(\%)} = \frac{\text{Load carried by soil sample at defined penetration level}}{\text{Load carried by standard crushed stones at the same penetration lsevel}}$$

The test was conducted at Optimum moisture content. The samples were tested in soaked condition. The tests were conducted at the curing period of 4 days.

IV. RESULTS AND DISCUSSIONS

4.1 Compaction Properties: The Polypropylene fiber was mixed with the soil by hand till uniform mixing was obtained. The polypropylene fiber was mixed in varying proportions of 0, 0.15%, 0.25%, 0.5%, and 1% of dry weight of the soil.The cement was mixed with the soil by hand till uniform mixing was obtained. The cement was mixed in varying proportions of 3%, 5%, 8%, and 12% of dry weight of the soil. The combination of material such as PP-fiber and cement were mixed in the soil by hand up to optimum values till uniform mixing was obtained. It is noted that, within the range of fiber content used in the current study, the relationship between the dry density and optimum moisture content does not differ significantly from that of unreinforced soil. However, a slight increase in MDD and decrease in OMC were observed with an increase of fiber content up to 0.5% of PP-Fiber. And also it is noted that, increase in MDD and decrease in OMC were observed with an increase of cement content up to 8% of cement content.

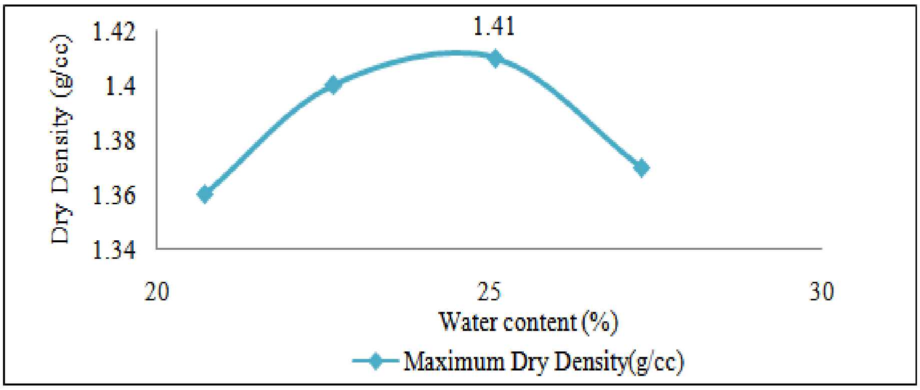

Fig 4.1 OMC and MDD values of Expansive soil

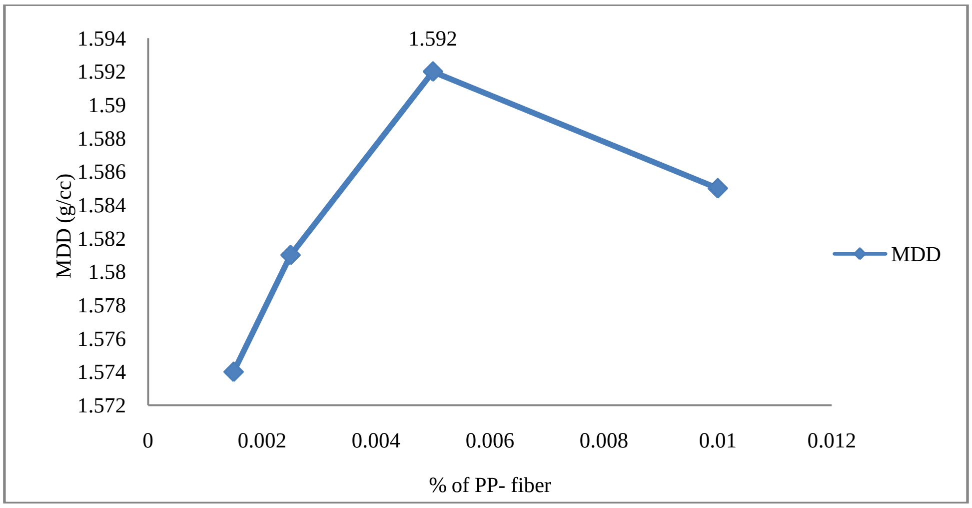

Fig 4.2 MDD valuesatvarious % of PP-fiber

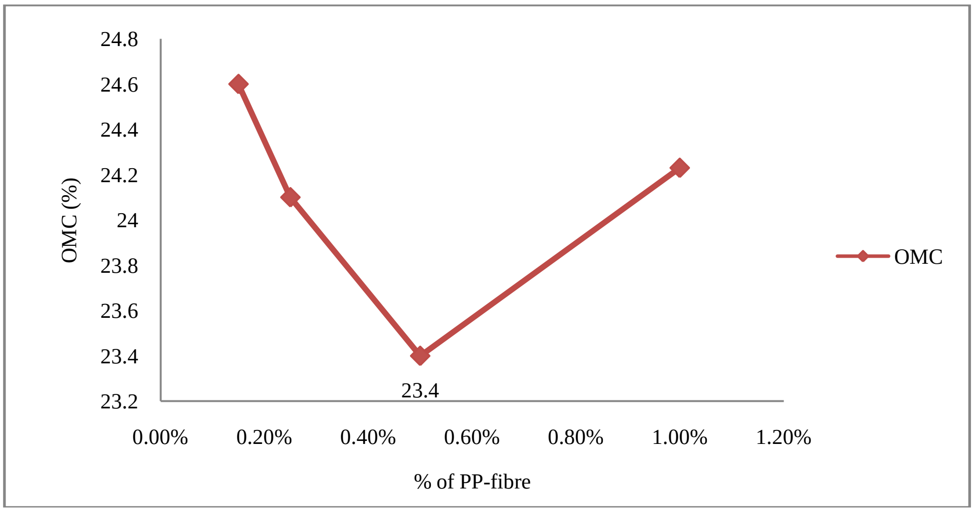

Fig 4.3 OMC values atvarious % of PP-fiber

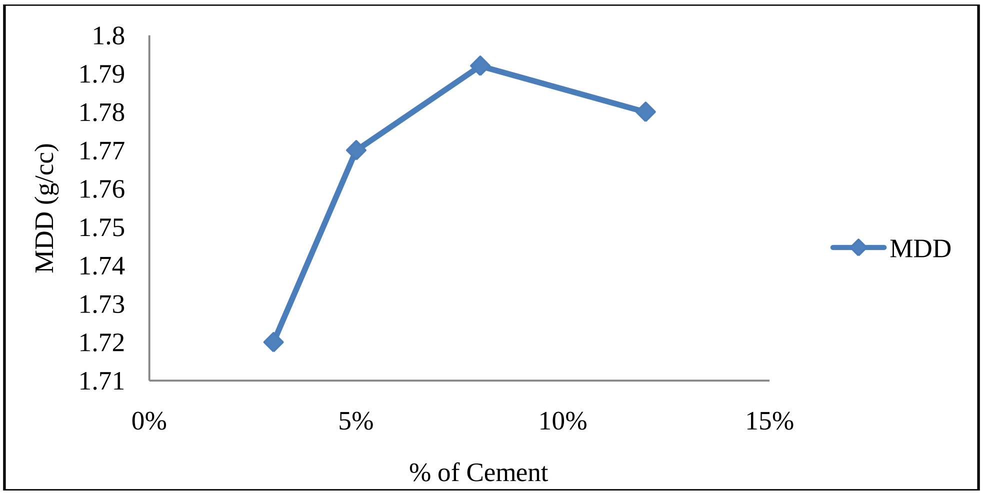

Fig 4.4 MDD values atvarious % of cement

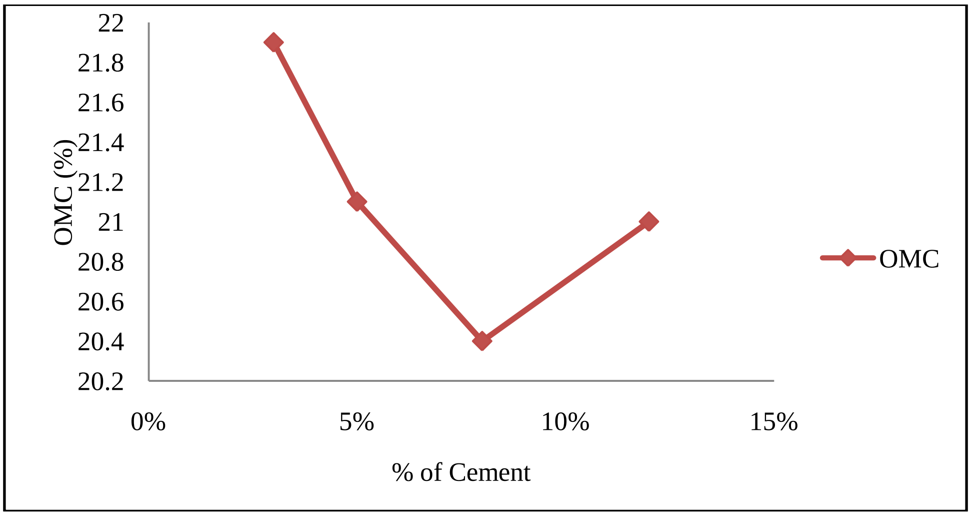

Fig 4.5 OMC values atvarious % of cement

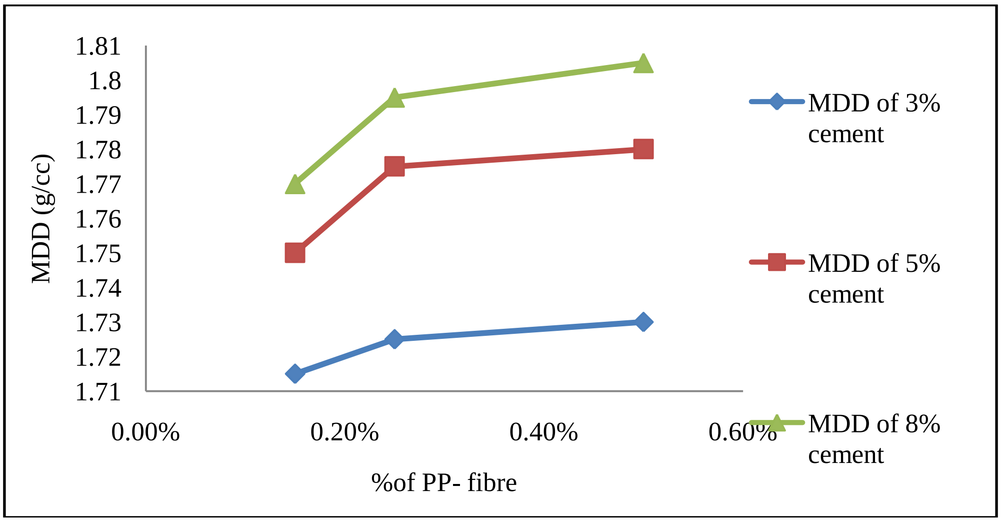

Fig 4.6 MDD values of soil at various percentages of PP-fiber and cement

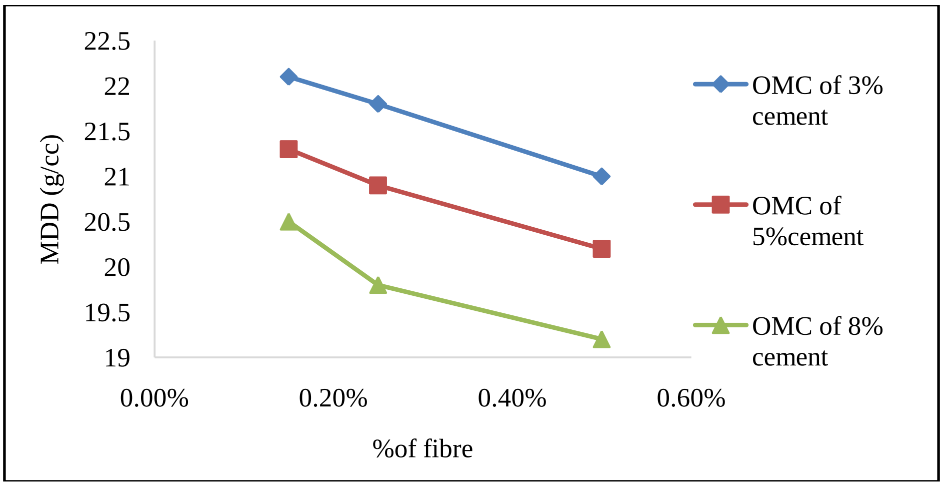

Fig 4.7 OMC values of soil at various percentages of PP-fiber and cement

Table 4.1: OMC and MDD values of soil at various % of materials.

Mix Proportion		**MDD (g/cc)**	**OMC (%)**
% of Cement	**% of PP-Fiber**		
0	0	1.41	25.1
3	0.15	1.715	22.8
3	0.25	1.725	21.8
3	0.5	1.73	21
5	0.15	1.75	21.3
5	0.25	1.775	20.9
5	0.5	1.78	20.2
8	0.15	1.77	20.5
8	0.25	1.795	19.8
8	0.5	1.805	19.2

4.2 Direct Shear Test:

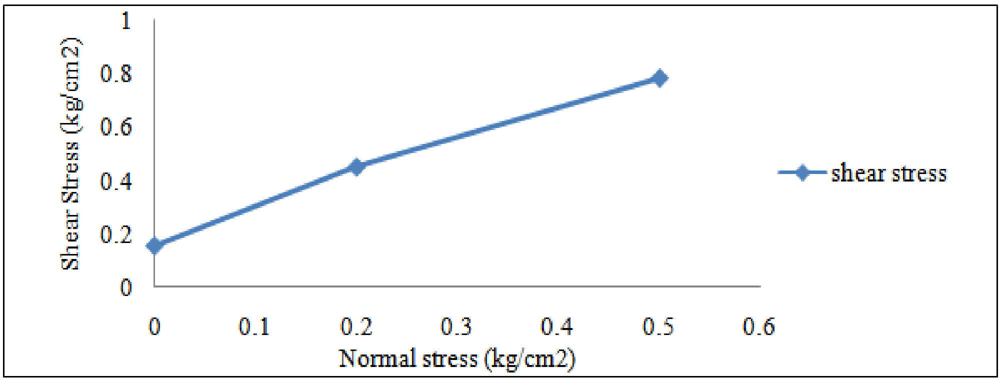

Fig 4.8 Shear Strength Parameters of Untreated Soil

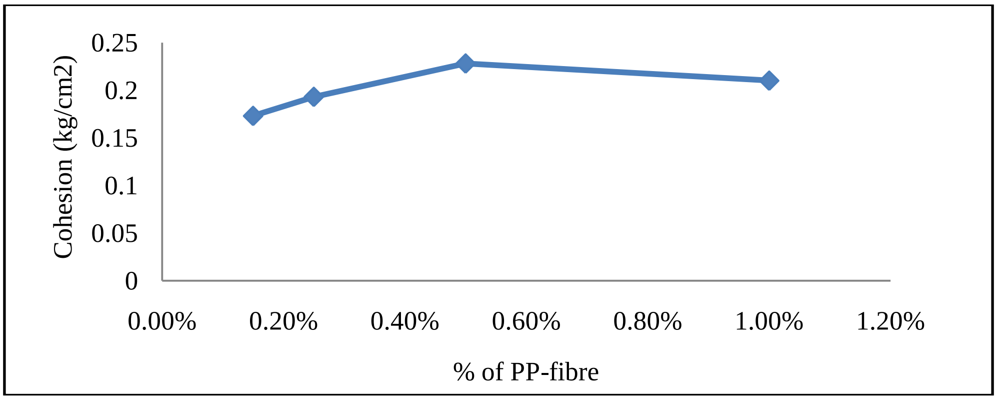

Fig 4.9 Cohesion values of treated soil at various % of PP-fiber

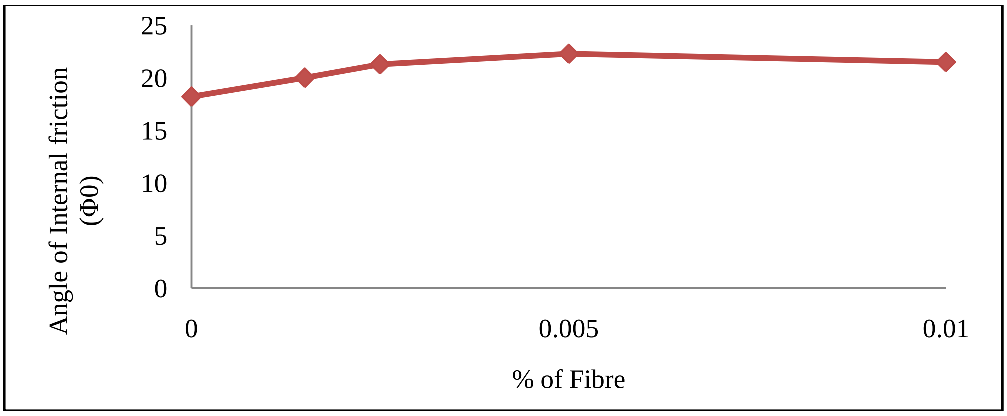

Fig 4.10 Angle of Internal Friction values of treated soil atvarious % of PP-fiber

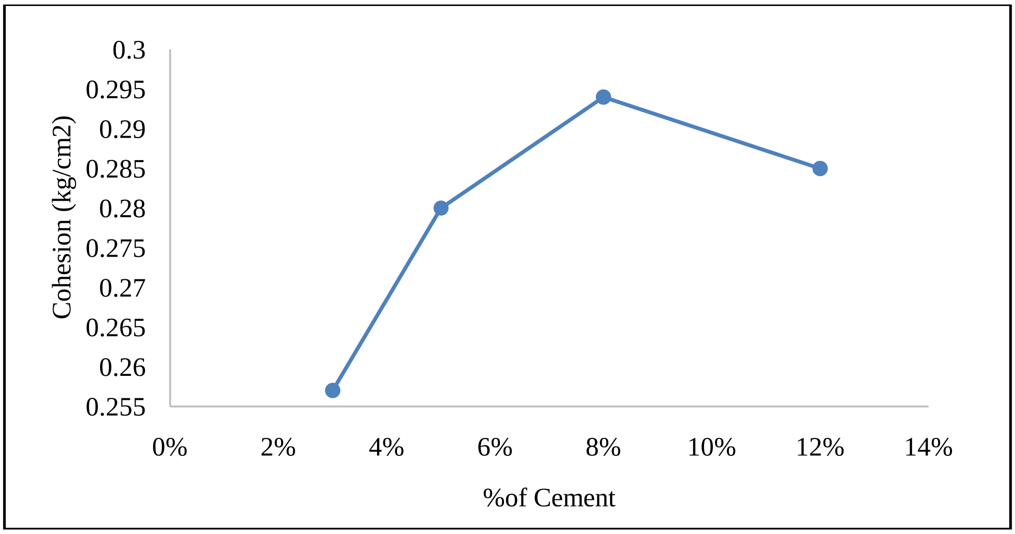

Fig 4.11 Cohesion values of treated soil atvarious % of Cement

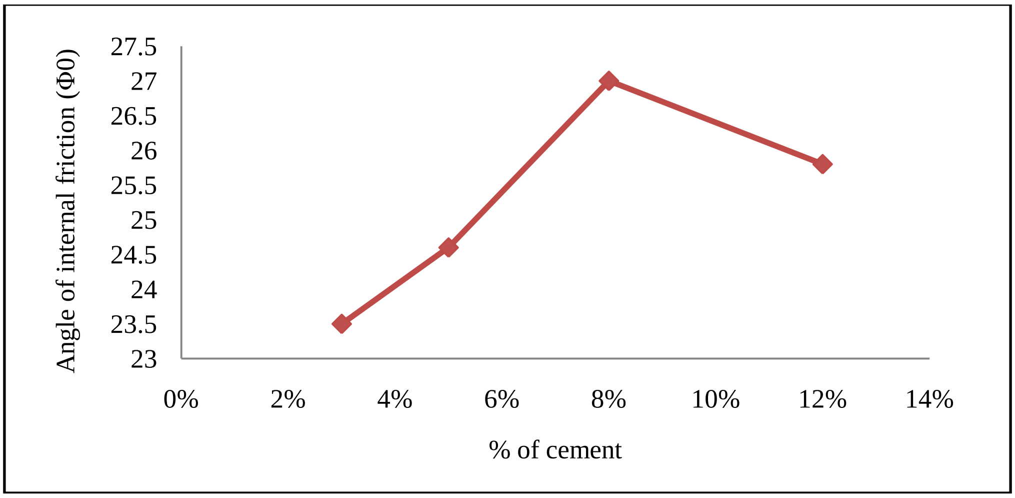

Fig 4.12 Angle of Internal Friction values of treated soil at various % of Cement

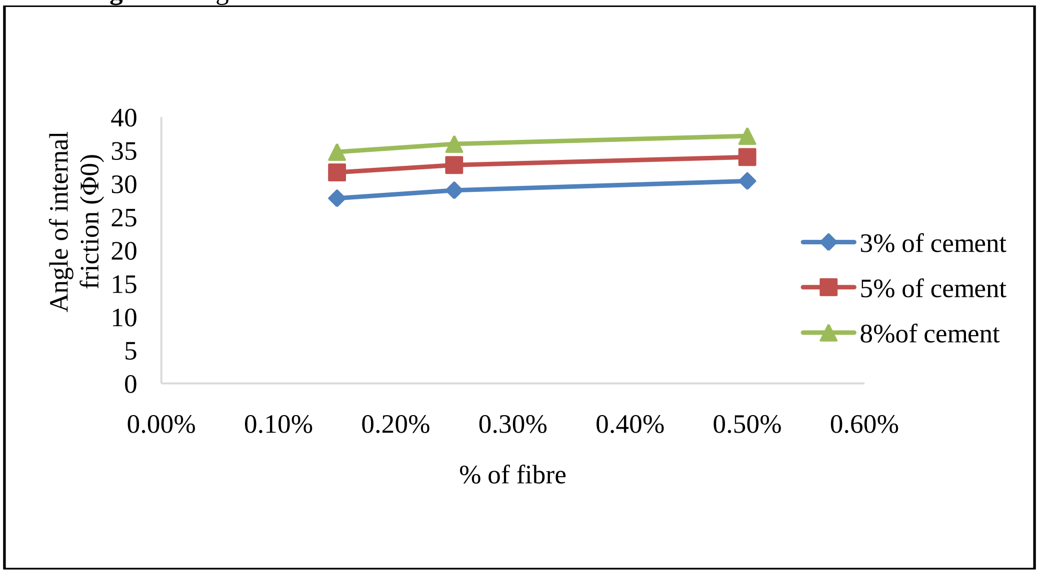

Fig 4.13 Cohesion values of soil at various % of cement and PP-fibre

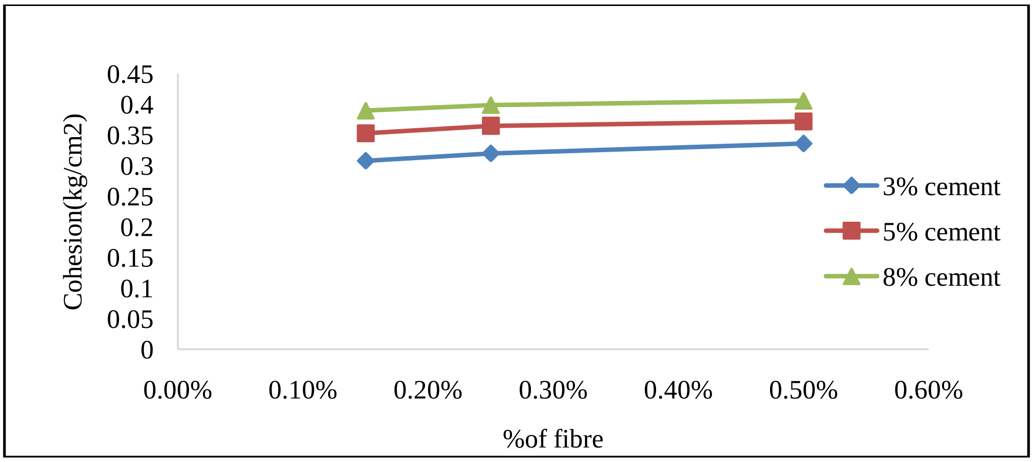

Fig 4.14 Angle of Internal friction values of soil at various % of cement and PP-fibre

Table 4.2: Cohesion and Angle of Internal friction values of soil when treated with various % of materials.

% of PP-fiber	**% of cement**	**Cohesion (kg/cm^2)**	**Angle of internal friction (Φ^0)**
0	0	0.153	18.2
0.15	0	0.173	20
0.25	0	0.193	21.3
0.5	0	0.228	22.3
0	3	0.257	23.5
0	5	0.28	24.6
0	8	0.294	27
0.15	3	0.308	27.8
0.25	3	0.32	29.0
0.5	3	0.336	30.4
0.15	5	0.353	31.7
0.25	5	0.365	32.8
0.5	5	0.372	34.0
0.15	8	0.39	34.8
0.25	8	0.399	36.0
0.5	8	0.406	37.2

4.3 CBR Test

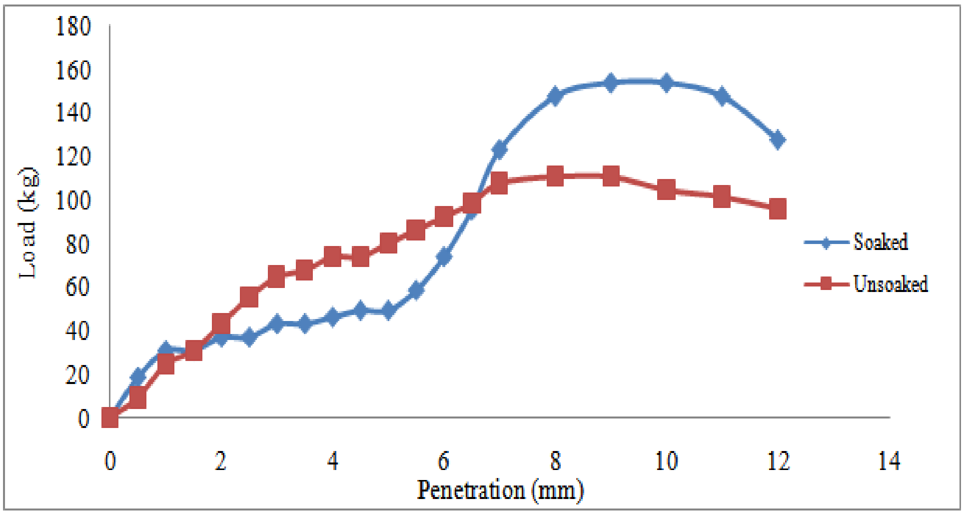

Fig 4.15 CBR Graphs for Untreated soil in both Soaked and Unsoaked condition

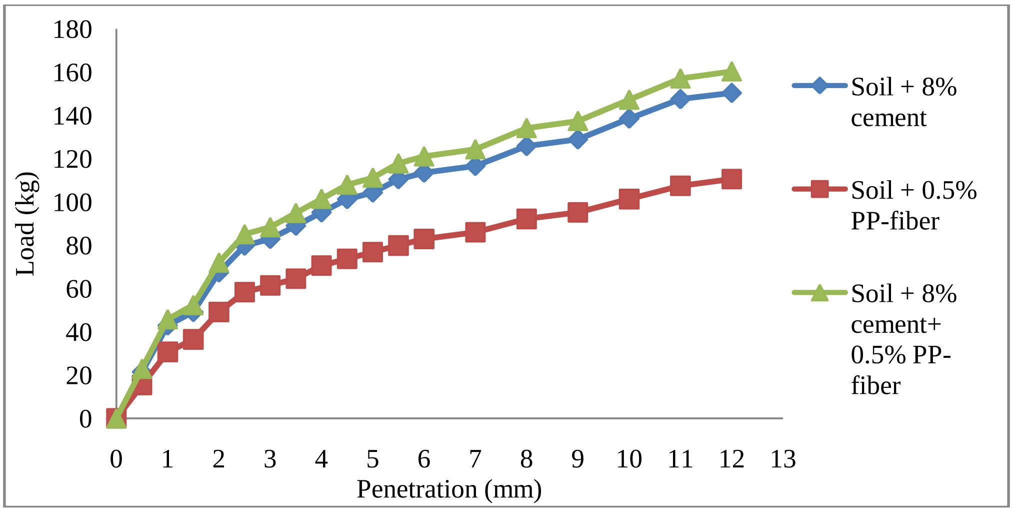

Fig 4.16CBR values of treated soil in soaked condition

V. CONCLUSIONS

- It is observed from laboratory test results the maximum dry density (MDD) of the expansive soil has been increased on the addition polypropylene fibre and cement content in various percentages up to 0.5% and 8% respectively.
- It is noticed from the test results that the maximum dry density (MDD) values are more for the soil that was treated with both polypropylene and cement content than when the soil was treated with various %of PP-fibre and cement content individually.
- It is observed from laboratory test results the optimum moisture content (OMC) of the expansive soil has been decreased on the addition polypropylene fibre and cement content in various percentages up to 0.5% and 8% respectively.
- It is noticed from the test results that the optimum moisture content (OMC) values are less when the soil was treated with the both polypropylene and cement content than the soil was treated with various %of PP-fibre and cement content individually.
- It is observed from laboratory test results the cohesion values and Angle of internal friction values of the expansive soil has been increased on the addition of polypropylene fibre and cement content in various percentages up to 0.5% and 8% respectively.
- It is noticed from the test results that cohesion values and Angle of internal friction values are more when the soil was treated with the both polypropylene and cement content than the soil was treated with various %of PP-fibre and cement individually.
- It was observed from the laboratory test results the CBR value of mix proportion (Soil +0.5% PP fibre + 8% of cement) is 2.3 times the untreated soil.

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Vana Sateesh Kumar" Experimental Study on The Strength Characteristics of Polypropylene Fiber Reinforced And Cement Stabilized Expansive Soil "International Journal Of Modern Engineering Research (IJMER), vol. 08, no. 09, 2018, pp.01-11