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EFFECT OF RANDOMLY ORIENTED POLYPROPYLENE FIBRE ON COMPRESSIBILITY CHARACTERISTICS OF BLACK COTTON SOIL

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ABSTRACT

In this Experimental Investigation Effect of randomly oriented Polypropylene fibre on engineering properties of Black Cotton Soil was studied. The soil and fibre used in the current study were procured from Village Mouda, near Nagpur, Maharashtra and Shiva Nanda Marketing Pvt. Ltd., New Delhi respectively. Fibre of sizes 6 mm and 12 mm were used in the experimental programme. The fibre was mixed in five different dosages by percent to the weight of dry soil varying from 0.05 percent to 0.25 percent. No significant trend has been observed in the variation of coefficient of compressibility with the change in pressure increment and percentage of polypropylene fibre of two sizes.It has been observed that for the range of percentage of fibres, the value of C_v is maximum at 0.05% fibre content for various stress levels and thereafter it decreases, but always remains higher than that for parent soil. It shows that with addition of fibre, time required for a given degree of consolidation decreases.

***Keywords*: Compressibility, Degree of consolidation, Randomly oriented Polypropylene Fibre**

I. INTRODUCTION

Well suited construction land and materials have become scares for the engineers at many construction sites now-a-days. These all are due to the growth and development of societies as well as environmental awareness and legal constraints, Consequently, civil engineers have been moved to find out new techniques of improving the quality of land and materials for use. Researchers have shown that use of synthetic materials substantially improves shear strength and bearing capacity of soils [1].

From the past, some natural materials including wood, bamboo, reeds, wheat straw, and rice straw were used by researchers to improve the strength of weak or poor soil. Since the synthetic fiber are also easily available so, plenty of synthetic fibers have been employed in many fields as innovative engineering materials, as well as main reinforcement agents for ground improvement. Now-a-days, carbon, steel, glass, asbestos, polyester, polyethylene, polypropylene, nylon, polyacrylonitrile, and high-elastic-modulus polyvinyl alcohol fiber are extensively used by soil engineers. These artificial synthetic fibers are laid in the soil in the monofilament or hybrid form to improve the engineering properties of soil like geogrid or geotextile.Since polypropylene fiber material is cheap and easily available in market, short discrete polypropylene fiber was employed to prepare the fiber-reinforced soil samples in this investigation [2].Reinforcing material improves the stability of weak soil by increasing its bearing capacity, and by reducing settlement and lateral deformation. Continuous inclusions of strips, fabrics, and grids into the soil mass was used in conventional methods. Now fibres are introduced randomly, which is a modification of the same technique, in which the fibers act to interlock soil particles and aggregates in a unitary coherent matrix [6].Although there are some difficulties encountered in representative specimen preparation due to random distribution of fiber filaments, since it is observed that there is a future prospect in the use of these environmental friendly additives for soil improvement [4].Expansive soils which include montmorillonite-a highly expansive mineral of clay, over- consolidated clays and shales are some problematic soils which are found in many parts of the world. They may cause serious problems in the behavior of light buildings associated with the seasonal cycles of wetting and drying[5]. Clays are generally reported as problematic soils due to their adverse consolidation settlement and volumetric change characteristics. Expansive black cotton soils normally occur in climatic zones characterized by alternate wet and dry seasons. The expansive soils swell and shrink periodically during the alternate wet and dry seasons. Such cyclic swell-shrink movements of the ground cause considerable damage to the structures founded on them[3].

The purpose of present study is to study the effect of polypropylene fibre in improving compressibility characteristics of an expansive soil. A better understanding of these characteristics will enhance the usage of polypropylene fibre in geotechnical works and thereby making clays suitable for foundation purpose.

II. MATERIAL

2.1 Black Cotton Soil

In India, the area covered by expansive soils is nearly 20 percent of the total area and includes almost the entire Deccan Plateau, Western Madhya Pradesh, parts of Rajasthan, Bundelkhand region in Uttar Pradesh and parts of Andhra Pradesh and Karnataka. The swelling soils of India are commonly known by the name black cotton soils, perhaps because of their colour and their propensity for growing cotton.

Soil used in the experiments has been collected from a village near Mouda located in Nagpur (Maharashtra). The soil is classified as highly compressible clay, CH, as per IS: 1498 (1970). The properties of soil used in the experiment are as follows:

Table 1: Properties of procured Black Cotton Soil

PHYSICAL PROPERTIES		VALUE
GRAIN SIZE DISTRIBUTION DATA	GRAVEL (%)	0
	SAND (%)	0
	CLAY+SILT (%)	100
SPECIFIC GRAVITY		2.56
LIQUID LIMIT		63
PLASTIC LIMIT		25
PLASTICITY INDEX		38
IS CLASSIFICATION		CH
OMC (%)		24
MDD (g/cc)		1.588

2.2 Polypropylene fiber

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 whichdoes not absorb or react with soil moisture or leachate. The high melting point of 160-165^{0}C, low thermal and electrical conductivities, and high ignition point of 590°C are other properties. Polypropylene fibre has been procured from Shivananda Marketing Pvt. Ltd., Ansari Road, Daryaganj, New Delhi. Polypropylene fibre has been divided into two categories on the basis of size (6mm and 12mm) for its inclusion in various percentages (fibre content = 0.05, 0.1, 0.15, 0.2, 0.25 %) by weight to the parent soil. The specific gravity of polypropylene fibre varies from 0.90 to 0.91, value as obtained from the manufacturer. Its alkaline strength is very good as reported by the manufacturer. The physical properties of polypropylene fibre as obtained from manufacturer are given in Table 2.

Table 2: Physical properties of Polypropylene Fibre

S. No.	Property	Description
1.	Shape	Triangular
2.	Cut length	6mm, 12mm
3.	Effective Diameter	25-40µm
4.	Specific Gravity	0.90-0.91
5.	Melting Point	160-165^{0}C
6.	Tensile Strength	320-490 MPa
7.	Young's Modulus	> 4000 MPa

III. EXPERIMENTAL PROGRAM AND PROCEDURE

3.1Sample Preparation

Composition of specimens

Specimens of parent soil and soil mixed with 0.05, 0.10, 0.15, 0.20 and 0.25% of polypropylene fibre of the two sizes by dry weight of soil were prepared at maximum dry density and optimum moisture content as per IS: 2720 (Part 7) (1974).

Mixing

Oven dry soil is mixed with various percentages of fibres. Sufficient quantity of distilled water is then added to bring the moisture content to the desired level. The mixture is then manually mixed thoroughly with a spatula. All the specimens are kept in polythene bags for maturing for three days.

Compaction

Specimens were compacted by static compaction in 10 cm diameter consolidation ring to the required height of 2.5 cm. The inner surface of the ring was smeared with mobile oil to help minimize friction between inner surface of the ring and the soil sample. The wet homogenous mixture was placed inside the specimen ring using a spoon in three layers, leveled and gently tap-compacted by 5cm diameter ram. Sample was placed in specimen

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ring with extension collar attached to it and both the exposed sides of the sample were covered with saturated filter papers. After that porous stone and pressure pad were inserted into the extension collar and the whole assembly was statically compacted in loading frame to the desired density. The sample was kept under static load for not less than 10 minutes in order to account for any subsequent increase in height of sample due to swelling.

3.2 Testing Programme

A series of one-dimensional consolidation tests were also conducted to determine the compressibility characteristics of untreated soil and soil stabilized with polypropylene fibre to evaluate the effect of fibre in reducing compressibility of the soil. These characteristics have been illustrated by establishing the relationships between void ratio and effective stress. In order to determine rate and magnitude of consolidation, coefficient of compressibility, coefficient of volume change, compression index and coefficient of consolidation have been calculated from the observations taken during the tests.

3.3 One-dimensional Consolidation Tests

Apparatus used:

1.Three-gang, fixed ring, one-way drained one dimensional consolidometer.

2.Fixed ring cell with specimen ring of 100 mm diameter, 25 mm height with an extensioncollar, a bottom porous stone-120 mm in diameter and a top porous stone-100 mm in diameter.

3.For applying vertical pressure, lever arm loading mechanism with a lever arm constant of 10.

4.For measurement of vertical deformation in the sample, deformation dial gauge with a leastcount of 0.01 mm.

Procedure:One-dimensional consolidation tests were conducted on parent soil and soil treated with various percentages of additives. Statically compacted specimen was placed in fixed ring consolidometer where only the top porous stone is permitted to move downwards as the specimen compresses. Consolidometer was assembled with the ring having the soil specimen and saturated porous stone at the top. Filter paper was placed between soil specimen and porous stone. Assembly was then mounted on the loading frame and the dial gauge was set in position in such a way that it is at the beginning of release run. Lever arm loading beam was leveled in a horizontal position with appropriate load transmitting member in contact with pressure pad through a ball seating before applying load. A steel ball was placed on the space provided on the pressure pad to maintain verticality of loads. **While mounting the assembly in consolidometer, specimen ring with collar was placed first and then outer ring of trough was placed in order to avoid any gap resulting from improper assembly procedure.** All the three test samples were mounted simultaneously in order to avoid any disturbance in dial gauge reading of a previously mounted specimen due to mounting of subsequent specimens. A seating load of 0.06 kg/cm^2 was applied and initial reading of dial gauge was noted at this stage. The trough was completely filled with water to keep the specimen saturated during the test. System was connected to a reservoir with the level of the water in reservoir at about the same level as that of specimen. A time gap of 15 minutes was maintained for loading the three samples. The specimen was then allowed to swell fully to reach equilibrium. The test specimen was allowed to consolidate under a number of successive increments of vertical pressure of about 0.25, 0.5, 1.0, 2.0 and 4.0 kg/cm^2 and each pressure increment was maintained on the sample for a period of 24 hours. In this manner, the pressure to increment ratio was maintained as one. The vertical compression of the specimen was measured by means of a deformation dial gauge, and dial gauge readings were taken at elapsed times of 1/4, 1/2, 1, 2, 4, 8, 15, 30, 60, 120, 240, 480 and 1440 minutes. After the completion of consolidation under the desired maximum vertical pressure, the specimen was unloaded and allowed to swell. After the completion of swelling, the final dial gauge reading was taken and the specimen was taken out of consolidometer and oven dried to determine its water content.

IV. EXPERIMENTAL RESULTS

The results of One-dimensional Consolidation Test are as follows:

Evaluation of parameters

The consolidation characteristics of various soil-additive mixtures have been observed by interpretation of observations taken during one-dimensional consolidation tests.

4.1 Pressure-void ratio curves

The relation between applied pressure and the corresponding equilibrium void ratiohas been represented in the form of pressure-void ratio graphs. Applied pressure hasbeen plotted as abscissa on a logarithmic scale and the void ratio as ordinate on anarithmetic scale. These curves for parent soil and soil treated with various percentagesof polypropylene fibre (6mm and 12mm) have been shown in Fig. 1 to 2.

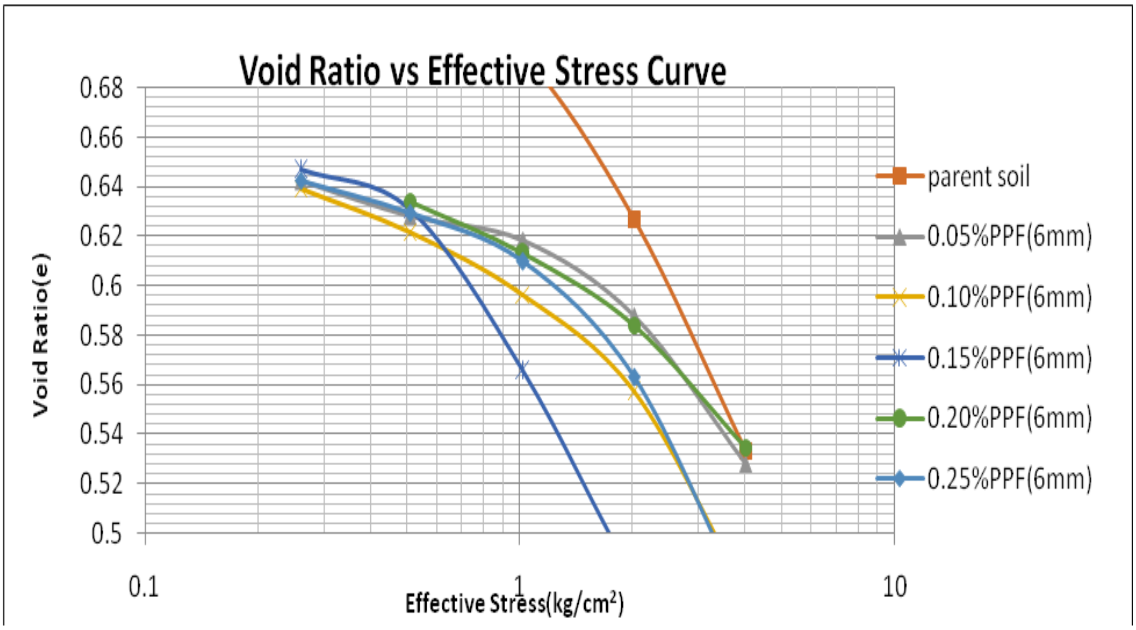

Figure 1: Void ratio vs. Effective stress comparative curves (BCS + PPF (6 mm))

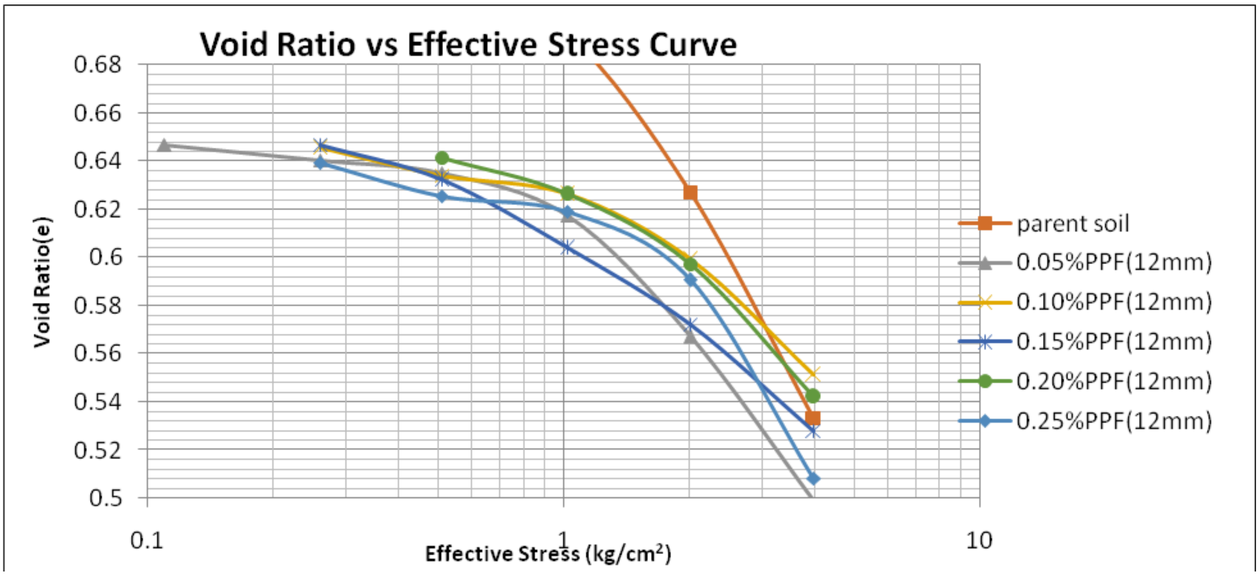

Figure 2: Void ratio vs. Effective stress comparative curves (BCS + PPF (12 mm)

4.2 Coefficient of compressibility

Coefficient of compressibility which is the ratio of change in void ratio to the corresponding change in pressure represents the slope for a given pressure increment of the pressure void ratio curves with both pressure and void ratio plotted on arithmetic scale.

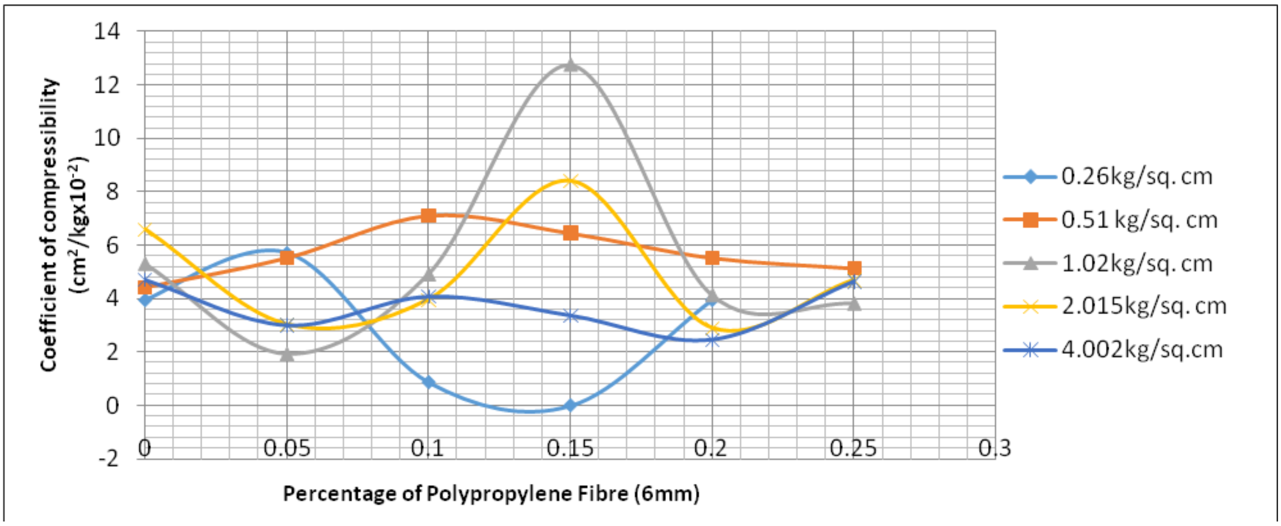

Figure 3: Variation of coefficient of compressibility with various Percentagesof Polypropylene Fibre (6mm) at different pressure increments

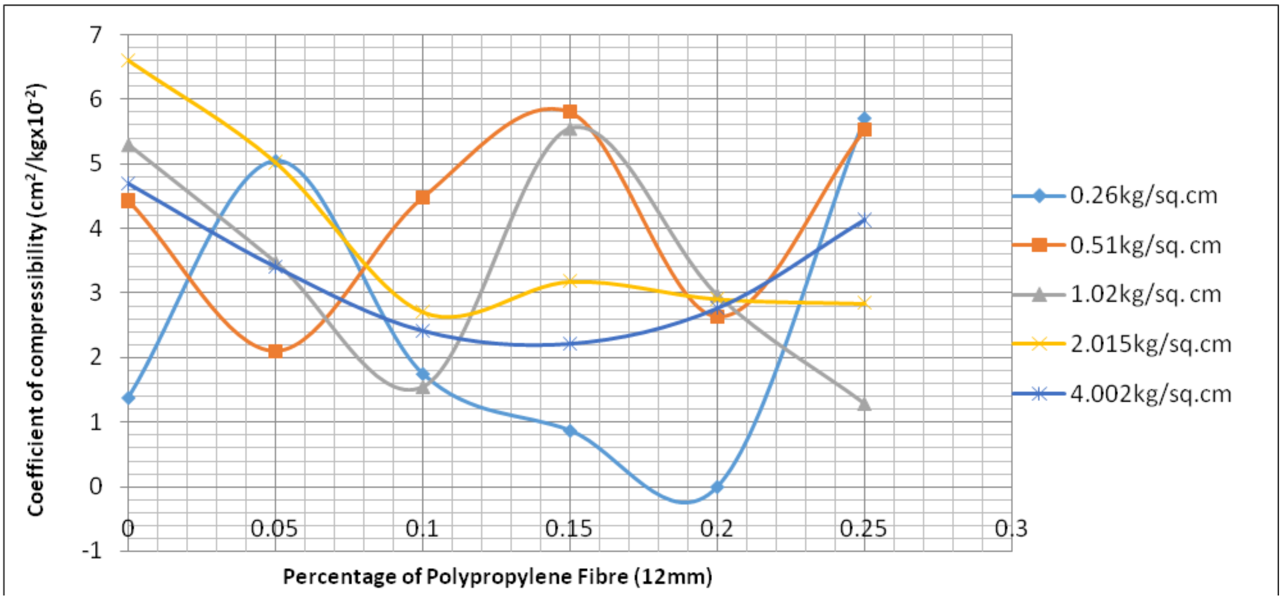

Figure 4: Variation of coefficient of compressibility with various Percentagesof Polypropylene Fibre (12mm) at different pressure increments

4.3 Coefficient of volume change

For a laterally confined soil, the change in height of soil per unit its initial height dueto a given unit increase in pressure is called coefficient of volume change. Thesevalues have been reported in Tables 3 and 4 for parent soil and soil stabilized withvarious percentages of polypropylene fibre (6mm and 12mm).

Table 3: Coefficient of Volume Change (m_v) for PPF (6mm) in cm^2/kg X 10^{-2}

SAMPLE DESCRIPTION	PRESSURE INCREMENT	PERCENTAGE OF ADDITIVE (POLYPROPYLENE FIBRE)					
		0.00 %	0.05%	0.10%	0.15%	0.20%	0.25%
BLACK COTTON SOIL + POLYPROPYLENE FIBRE (6mm)	0.26 kg/cm^2	0.79	2.39	3.46	0.52	-	2.39
	0.51 kg/cm^2	2.56	3.36	4.33	3.92	3.35	3.13
	1.02 kg/cm^2	3.08	1.18	3.02	7.80	2.52	2.33
	2.015 kg/cm^2	3.90	1.87	2.48	5.37	1.80	2.91
	4.002 kg/cm^2	2.89	1.89	2.62	2.28	1.56	2.96

Table 4: Coefficient of Volume Change (m_v) for PPF (12mm) in cm^2/kg X 10^{-2}

SAMPLEDESCRIPTION	PRESSUREINCREMENT	PERCENTAGE OF ADDITIVE (POLYPROPYLENE FIBRE)					
		0.00 %	0.05%	0.10%	0.15%	0.20%	0.25%
BLACK COTTON SOIL + POLYPROPYLENE FIBRE (12 mm)	0.26 kg/cm^2	0.79	3.06	1.06	0.52	-	3.46
	0.51 kg/cm^2	2.56	1.28	2.72	3.52	1.59	3.37
	1.02 kg/cm^2	3.08	2.12	0.94	3.40	1.80	0.79
	2.015 kg/cm^2	3.90	3.11	1.66	1.98	1.78	1.75
	4.002 kg/cm^2	2.89	2.17	1.51	1.41	1.73	2.60

4.5 Compression Index

Compression index is a dimensionless quantity which represents the slope of linearportion of the pressure-void ratio curve on a semi-log plot. The final consolidationsettlement can be expressed in terms of compression index which is constant for alarge range of effective stresses. Compression index values for the soil with andwithout additive have been shown in fig 5.

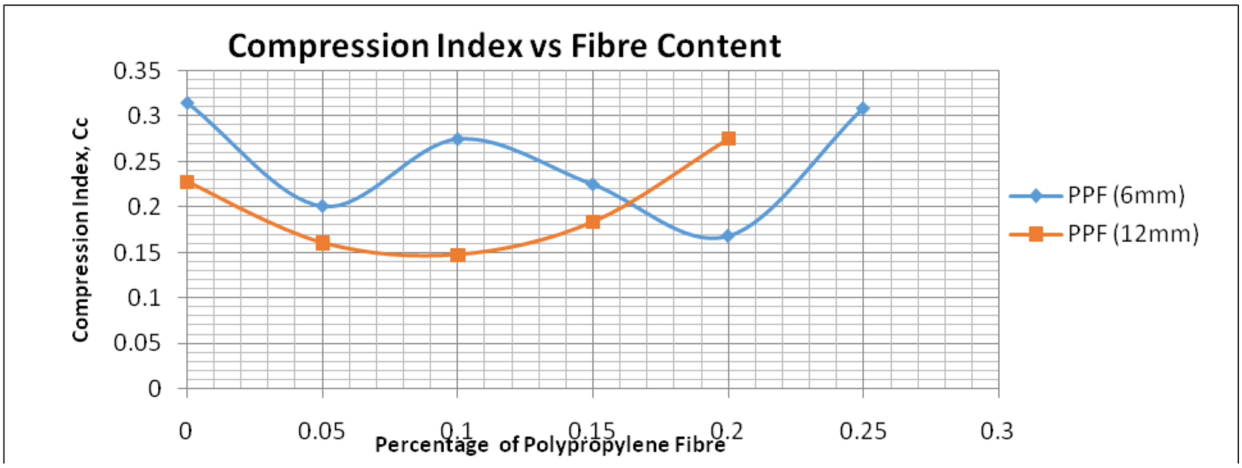

Figure 5: Variation of Compression Index with Percentages of PolypropyleneFibre

4.6 Coefficient of consolidation

The time required for settlement to occur during the life span of the structure is animportant consideration. It gives an idea of how much settlement a structure willundergo after it is constructed, and whether such a

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settlement will impair itsfunctioning or not. For assessing time rate of consolidation of statically compactedspecimens of parent soil and soil treated with various percentages of additive,coefficient of consolidation has been calculated by using Taylor's square root of timefitting method. Variation of dial gauge readings at various time intervals for aparticular stress level with respect to square root of time have been plotted and valuesof coefficient of consolidation with various Percentages of Polypropylene Fibre at different pressure increments have been shown in fig 6 and 7.

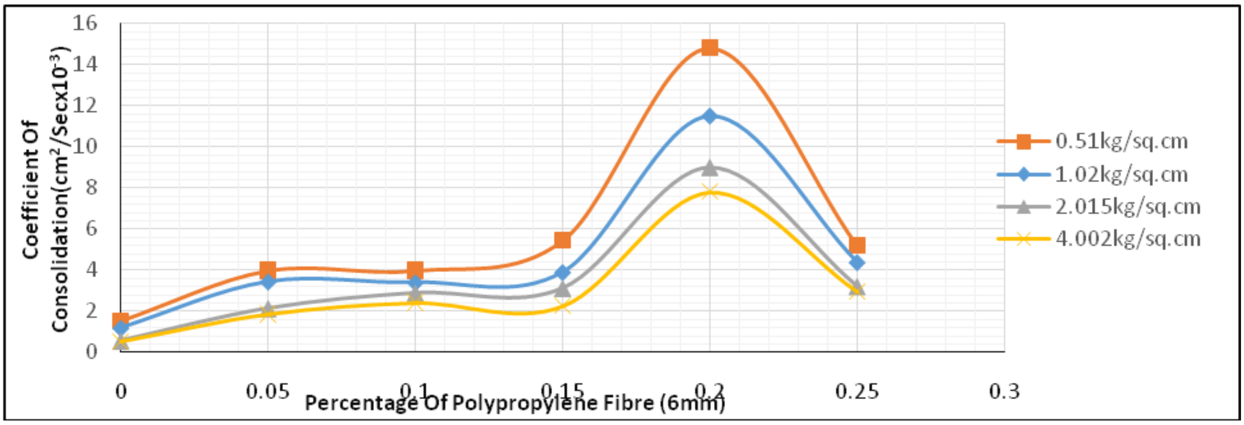

Figure 6: Variation of coefficient of consolidation with various Percentages ofPolypropylene Fibre (6mm) at different pressure increments

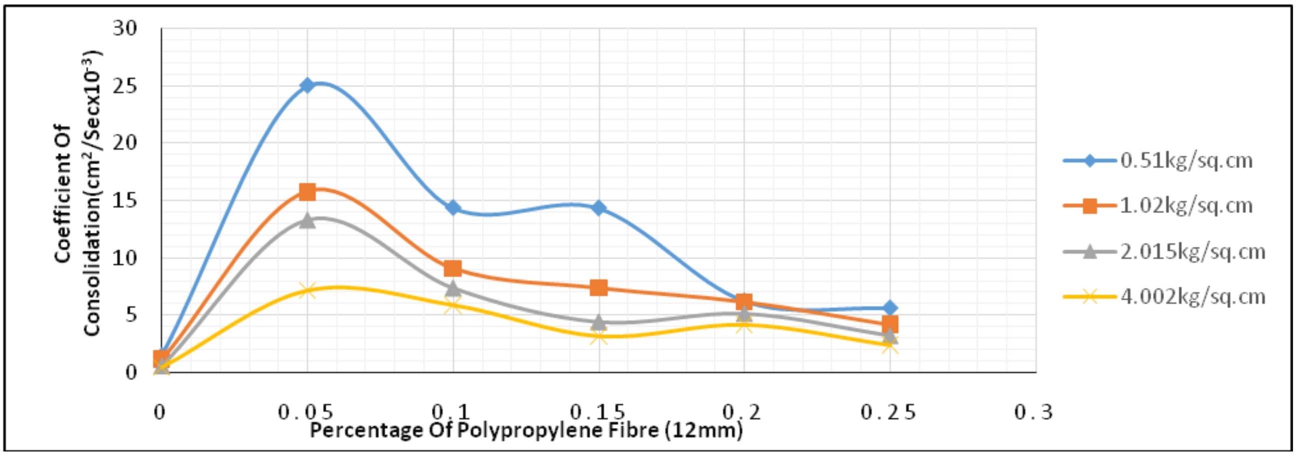

Figure 7: Variation of coefficient of consolidation with various Percentages of Polypropylene Fibre (12mm) at different pressure increments

V. CONCLUSIONS

The study investigates about the influence of polypropylene fibre on compressibility characteristics of an expansive soil. The following conclusions have been drawn based on the laboratory investigations carried out in this study:

1. No significant trend has been observed in the variation of coefficient of compressibility with the change in pressure increment and percentage of polypropylene fibre of two sizes.
2. It has been observed that there is a general decrease in the value of compression index with the increase in percentage of polypropylene fibre of 6mm size. For polypropylene fibre of 12mm size, the value of compression index is minimum at fibre percentage of 0.1%.
3. The value of C_v decreases as pressure increases for parent soil and soil treated with various percentage of polypropylene fibre. It shows that the time required for the soil to reach a given degree of consolidation increases with increase in effective stress.
4. An increasing trend has been observed in the value of C_v with increase in fibre content (6mm) at a particular stress level. It shows that with the increase in percentage of additive, time required for a given degree of consolidation decreases. It has been observed that for the range of percentage of fibres (12mm), the value of C_v is maximum at 0.05% fibre content for various stress levels and thereafter it decreases, but always remains higher than that for parent soil. It shows that with addition of fibre, time required for a given degree of consolidation decreases.

The study shows that treatment of soil with polypropylene fibre is an effective method of stabilization of problematic soils. The values of compression index for treated soil will help in estimation of settlement of foundations resting of stabilized soil beds. The curves showing variation of coefficient of consolidation with effective stress for stabilized soil will help in estimating the time-rate, at which a structure will undergo settlement during its design life. The optimal percentage of fibre for a particular project can be worked out keeping in view both the criteria for design, i.e. the shear strength criterion and settlement criterion.

REFERENCES

[1]. Mahmood R. Abdi, Ali Parsapajouh, Mohammad A. Arjomand (2008), “Effects of Random Fiber Inclusion on Consolidation, Hydraulic Conductivity, Swelling, Shrinkage Limit and
Desiccation Cracking of Clays”,*International Journal of Civil Engineering, Vol. 6, No. 4, pp. 284-292.*

[2]. Hongtao Jiang, YiCai and Jin Liu (2010), “Engineering Properties of Soils Reinforced by Short Discrete Polypropylene Fiber”, *Journal of Materials in Civil Engineering, Vol. 22, No. 12, pp. 1315-1322.*

[3].S.Twinkle&M.K.Sayida (2011), “Effect of polypropylene fibre and lime admixture on engineering properties of expansive soil”, *Proceedings of Indian Geotechnical Conference, Kochi (Paper No.H-085), pp. 393-396.*

[4]. Mona Malekzadeh, HuriyeBilsel (2012) “Effect of Polypropylene Fiber on Mechanical Behaviour of Expansive Soils”, *EJGE, Vol. 17, pp. 55-63.*

[5]. Mona Malekzadeh, HuriyeBilsel (2012) "Swell and compressibility of fiber reinforced Expansive Soil", *International Journal of Advanced Technology in Civil Engineering, ISSN: 2231 –5721, Vol. 1, Issue-2, pp. 42-46.*

[6]. Shivanand Mali and Baleshwar Singh (2014), "Strength Behaviour of Cohesive Soils Reinforced with Fibers", *International Journal of Civil Engineering Research, ISSN 2278-3652 Volume 5, No. 4, pp. 353-360.*