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Unconfined Compressive Strength of Black Cotton Soil Mixed with Cement and Polypropylene Fibre

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Abstract: The aim of the study was to determine the value of Unconfined compressive strength after stabilizing the black cotton soil with cement and with combination of cement and polypropylene fibre. In this study laboratory experiments were conducted to evaluate the effect of using polypropylene fibre to enhance the strength of cemented black cotton soil. Three fibre polymer contents were used (0.3, 0.6 and 1% by dry weight of the soil) to examine the unconfined compressive strength of black cotton soil mixed with three different cement contents (5, 10 and 15%). For broad interpretation of the fibre reinforced soil-cement behaviour several factors were considered in this study such as time period (3, 7 and 28days) and at water content 35 %. The 35% water content is taken as to improve the soil because at the time of soil excavation the water content obtained is near 35% so to improve the soil not at OMC, taken 35% water content. This investigation revealed that polypropylene fibres can improve the cemented black cottonstrength, as the random distribution of fibres forms a three-dimensional network, which can link the soil particles together to build a coherent unit and restrict the particles movement. Increasing the cement content increase unconfined compressive strength of the black cotton soil at time period of 3, 7 and 28 days. Polypropylene fibres can be used to rise up the strength of disturbed cemented black cotton soil and the UCS value increases 1.5-2.5 times in comparison to cement content at different time periods. The maximum UCS value is obtained at 15% cement content mixed with fibre content 1% in black cotton soil. From test results observation the soil mixed with cement at high dosage can be replaced by keeping low cement content and high fibre content.
Keywords: Black cotton soil, stabilization, unconfined compressive strength, polypropylene fibre, cement.

I. INTRODUCTION

There exists variety of soil types in different parts of the country. Some of the soils are problematic from construction point of view i.e. marine clay, laterite soil of Southern region and the Black Cotton (BC) soil. Black cotton soil are expansive in nature due to presence of montmorillonite and illite clay minerals. Because of the swelling and shrinkage characteristics of soil, special treatment of the soil or special design needs to be adopted.Soil stabilization is the action of increasing the power and resilience of soil.The simplest stabilization processes are compaction and drainage (if water drains out of wet soil it becomes stronger). The other process is by improving gradation of particle size and further improvement can be achieved by adding binders to the weak soils [8] (Rogers et al., 1996). Soil stabilization depends mainly on chemical reactions between stabilizer (cementitious material) and soil minerals (pozzolanic materials) to achieve the desired effect.

The chief properties of soil which are of interest to engineers are volume stability, strength, compressibility, permeability and durability [7] (Ingles and Metcalf, 1972).For a successful stabilization, a laboratory tests followed by field tests may be required in order to determine the engineering and environmental properties. Results from the laboratory tests, will enhance the knowledge on the choice of binders and amounts.

For stabilization purpose there are various materials in the like as chemical stabilizers, pozzolanic stabilizers and geosynthetics. The chemical stabilizers include cement, fly ash, lime, bitumen etc. But these stabilizers are use in very large amount to stabilize the soil. Therefore, there is a need for the development of other kinds of soil additives like fibres which stabilizes the soil in very small amount.

The process of soil stabilisation with cement involves the hydration of the cement powder with soil pore water during the in situ mixing process. The primary reaction involves the formation of the two silicate compounds (C3S and C2S) and hydrated lime is deposited as separate crystalline solid phase. The cementitious particles, thus formed, bond together and surround the soil particles forming a solid hardened skeleton.

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TABLE. 1. Cement requirement by volume for effective stabilization of various soils [4] (Mitchell, J.K.*et al*.)

Soil type		Percent cement by volume
AASHTO classification	Unified classification	
A-2 and A-3	GP,SP and SW	6-10
A-4 and A-5	CL, ML and MH	8-12
A-6 and A-7	CL, CH	10-14

Despite the advantage of ordinary Portland cement in soil improvement, several drawbacks can be considered, particularly from environmental point of view. CO2, NOx (nitrogen oxides) and particulate air suspensions are the most significant problem arises using cement. Cement is considered as one of the major causes for theemission of CO2. Almost one ton of CO2 is released with every ton of cement production.For that reason, cement alone is responsible for the production of 5% ofCO2 annually across world [6] (Huntzinger*et al.*, 2009), [10] (Worrell *et al*., 2001). NOx is another byproduct of cement production along with CO2, which is produced in the cement kiln (2.3 kg per ton of clinker produced [2] (Bremner, 2001).Therefore, finding new sustainable materials which can totally or partially replacement of the cement is an important challenge nowadays. The most commonly used synthetic material, polypropylene fibre 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.Polymer is one of the promising materials recently applied for soil stabilization, comprises of long chain of monomers which are associated with one another by adequately solid and adaptable Van der Waals force.Polypropylene fibre is the most widely used inclusion in the laboratory testing of soil stabilization. Currently, polypropylene fibres are used to improve the soil strength properties, to reduce the shrinkage properties and to overcome chemical and biological degradation. Polypropylene fibre also enhance the UCS of the soil reduce volumetric shrinkage strain and swelling pressures of the expansive clays. The effect of polypropylene fibre inclusions on the soil behavior could be visible observed during the UCS test exit the formation of unreinforced specimen resulted in the development of failure plane, while polypropylene fibre reinforced specimen tend to bulge, indicating an increase in ductility of fibre soil mixture.

II. NEED OF THE STUDY

Stabilization of soil is needed to increase the engineering properties of soil like shear strength, compressibility, permeability and hence to upgrade the load bearing capacity of subgrade to carry pavement and foundations.Many investigations are done by[1] Abdi et al. (2016),[3] Correia et al.(2015),[5]Estabragh*et al.*(2012), [9] Rudramurthy*et al.*(2019) ,[11] Yadav *et al.* (2017) on chemical soil stabilization by use of different binding materials (i.e. fly ash, lime, cement etc) and reinforcement like natural fibres (like prosopis fibre, coir fibres,etc) and artificial fibres (like nylon fibre, waste polythene, PVA fibres, polyester and polypropylene fibre) they also exploredvarious parameters like binder content (from 5 to 20%), fibre content (0.2 to 1%),timeperiod (1 to 28 days) based on various tests. All the above mentioned investigations are done on optimum moisture content of soil. As the natural water content of the soil to be improved in field is different from OMC. Investigations are done on mixing polypropylenefibre with cemented soil to improve strength behaviour at natural water content of existing black cotton soil.

III. MATERIAL USED

A. Soil

The black cotton soil used for the study was collected from Bhopal region of Madhya Pradesh. The soil sample was collected in polythene bags and then air dried.

TABLE2. Properties of Black cotton soil

S.No.	Properties	Value
1.	Consistency limits	
	Liquid limit	56%
	Plastic limit	27%
	Plasticity index	29%
2.	IS soil classification	CH
3.	Specific gravity	2.74
4.	Modified proctor test	
	Maximum Dry Density (KN/m^2)	15.50
	Optimum moisture content (%)	25.50
5.	Differential free swell index	52%

B. Cement Material

The cement which is used here is ordinary Portland cement of Grade 43.

C. Polypropylene Fibre

Properties of polypropylene fibre accordance with the product datasheet supplied by the manufacturer is listed in Table 3.

TABLE 3
Properties of Polypropylene fibre

S.No.	Properties	Value
1.	Length of fibre(mm)	12
2.	Diameter of fibre(μm)	30
3.	Specific surface(m^2/kg)	140
4.	Unit weight(kN/m^3)	8.5
5.	Tensile strength(N/mm^2)	270
6.	Young's modulus(N/mm^2)	3700

IV. METHODOLOGY

In the present investigation the soft soil i.e. black cotton soil is sieved and the soil was mixed with tap water for 5 min in a mechanical mixer at initial moisture content at 35% as at these moisture content soil has very low shear strength and it will merely able to take loads from superstructure. The cement was added after to the slurry at cement content varying from 5 to 15%, and both clay slurry and cement were mixed for 5 min. The mixture was then mixed immediately with polymer fibre (i.e. 0.3, 0.6 and 1%) for 5 min mixing time for each case. This mixture was placed in mould of size1000cc (used in standard light compaction test) in 3 layers of 25 blows using hammer of weight 2.6 kg. From the prepared mould the UCS samples were extracted using the hydraulic jack. The cylindrical shaped Unconfined Compression Test specimens were obtained by driving sample extruder and specimens were ejected out and trimmed off so that the finished dimensions of the specimen being 38mm in diameter and 76mm in length. The conventional Unconfined Compression Test was performed on samples at a strain rate of 0.5 mm per minute at time period of 3, 7 and 28 days.

Fig 1. Unconfined Compressive Strength Test

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V. RESULT AND DISCUSSION

The axial stress-strain curve is plotted and the axial stress corresponding to axial strain of 2% was taken for comparison of test result because at 10% and 15 % cement content the sample fails at strain of 2-2.5%.

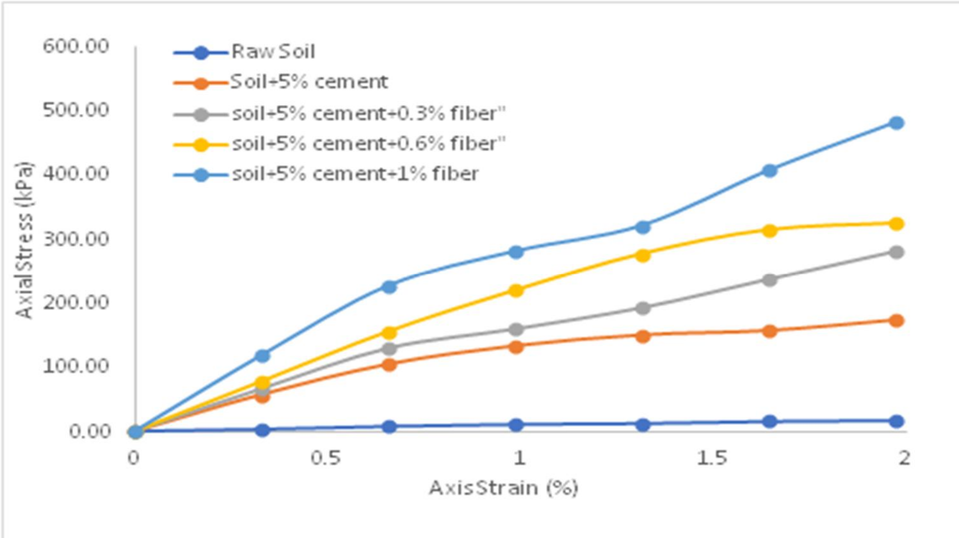

Fig 2.Axial stress-strain curve soil mixed with 5% cement and fibre content (0.3, 0.6 and 1%) at 3 days

From Figure 2, for 3 Days time period, the axial stress corresponding to axial strain 2% for raw black cotton soil was evaluated 18.67 kPa, soil mixed with 5% cement content was 174.46 kPa and soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% were evaluated 282.74 kPa, 325.89 kPa and 482.73 kPa i.e. 9.34, 15.14, 17.45 and 25.85 times of raw soil. From the curve it was also analysed that the axial stress value of soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% is 1.62, 1.87 and 2.77 times of cemented soil.

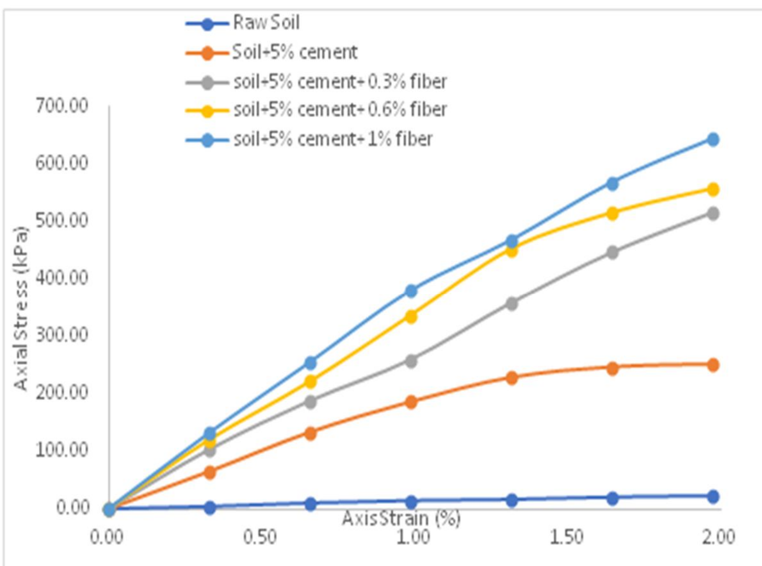

Fig 3.Axial stress-strain curve soil mixed with 5% cement and fibre content (0.3, 0.6 and 1%) at 7 days

From Figure 3, for 7 Days time period, the axial stress corresponding to axial strain 2% for raw black cotton soil was evaluated 22.59 kPa, soil mixed with 5% cement content was 251.21 kPa and soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% were evaluated 515.90 kPa, 557.07 kPa and 642.36 kPa i.e. 11.12, 22.83, 24.66 and 28.43 times of raw soil. From the curve it was also analysed that the axial stress value of soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% is 2.05, 2.21 and 2.55 times of cemented soil.

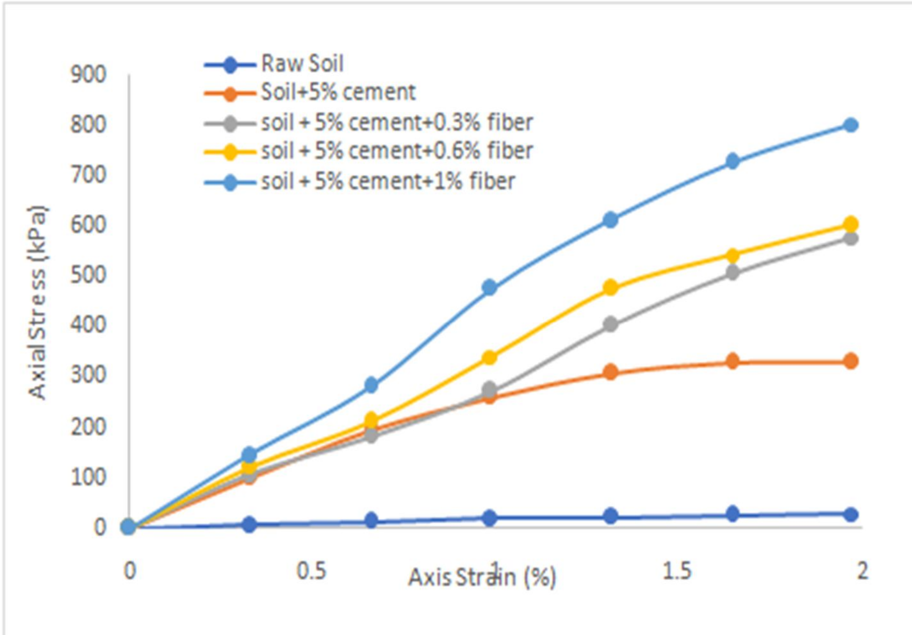

Fig 4. Axial stress-strain curve soil mixed with 5% cement and fibre content (0.3, 0.6 and 1%) at 28 days

From Figure 4, for 28 Days time period, the axial stress corresponding to axial strain 2% for raw black cotton soil was evaluated 28.80 kPa, soil mixed with 5% cement content was 329.16 kPa and soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% were evaluated 577.10 kPa, 602.56 kPa and 802 kPa i.e. 11.42, 20.03, 20.92 and 27.78 times of raw soil. From the curve it was also analysed that the axial stress value of soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% is 1.75, 1.83 and 2.43 times of cemented soil.

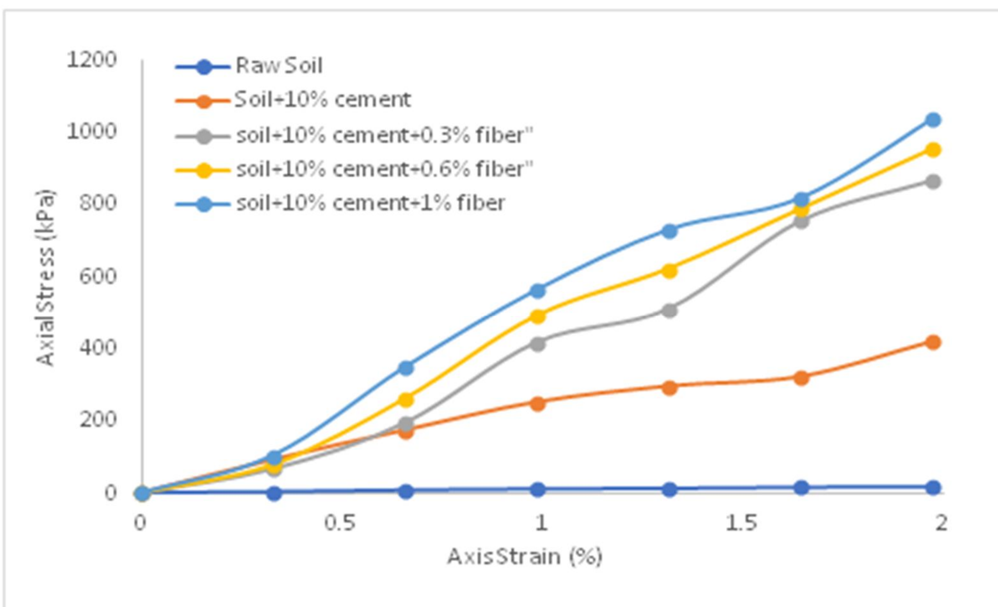

Fig 5.Axial stress-strain curve soil mixed with 10% cement and fibre content (0.3, 0.6 and 1%) at 3 days

From Figure 5, for 3 Days time period, the axial stress corresponding to axial strain 2% for raw black cotton soil was evaluated 18.67 kPa, soil mixed with 10% cement content was 419.11 kPa and soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% were evaluated 869.05 kPa, 954.93 kPa and 1040.82 kPa i.e. 22.44, 46.54, 51.14, and 55.74 times of raw soil. From the curve it was also analysed that the axial stress value of soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% is 2.07, 2.27 and 2.48 times of cemented soil.

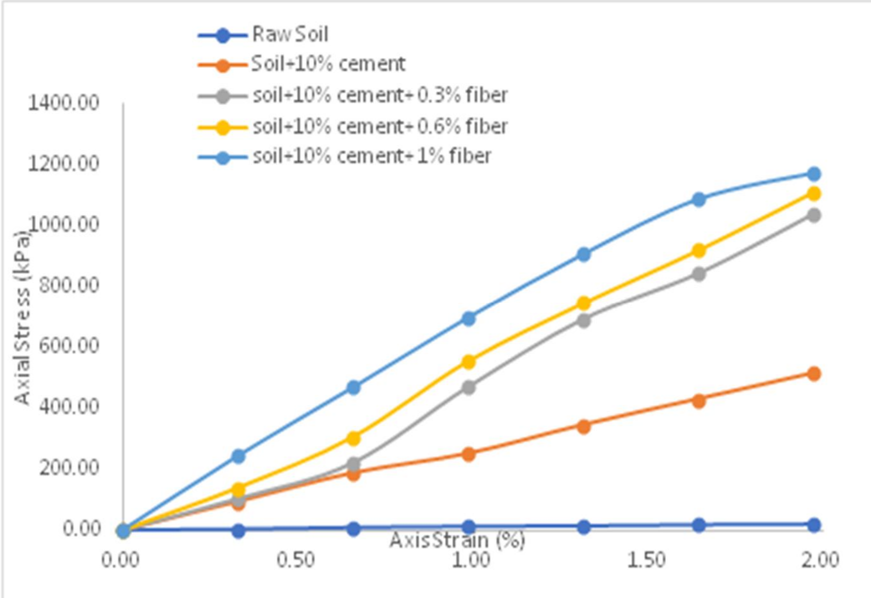

Fig 6.Axial stress-strain curve soil mixed with 10% cement and fibre content (0.3, 0.6 and 1%) at 7 days

From Figure 6, for 7 Days time period, the axial stress corresponding to axial strain 2% for raw black cotton soil was evaluated 22.59 kPa, soil mixed with 10% cement content was 512.60 kPa and soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% were evaluated 1035.16 kPa, 1109.60 kPa and 1173.52 kPa i.e. 22.67, 45.82, 49.11 and 51.94 times of raw soil. From the curve it was also analysed that the axial stress value of soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% is 2.02, 2.16 and 2.29 times of cemented soil.

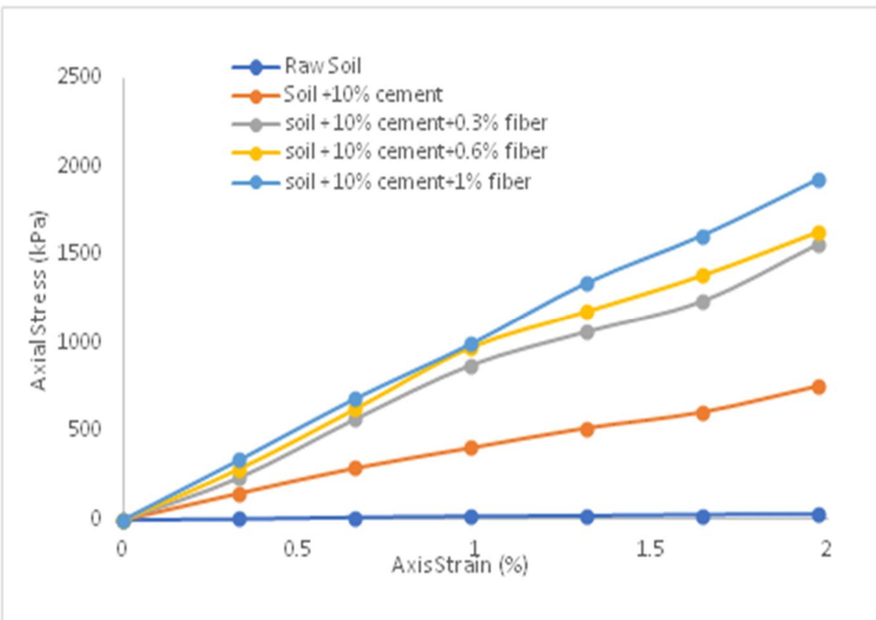

Fig 7 Axial stress-strain curve soil mixed with 10% cement and fibre content (0.3, 0.6 and 1%) at 28 days

From Figure 7, for 28 Days time period, the axial stress corresponding to axial strain 2% for raw black cotton soil was evaluated 28.80 kPa, soil mixed with 10% cement content was 755.98 kPa and soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% were evaluated 1561.57 kPa, 1632.77 kPa and 1929.32 kPa i.e. 26.24, 54.22, 56.69 and 66.99 times of raw soil. From the curve it was also analysed that the axial stress value of soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% is 2.07, 2.16 and 2.55 times of cemented soil.

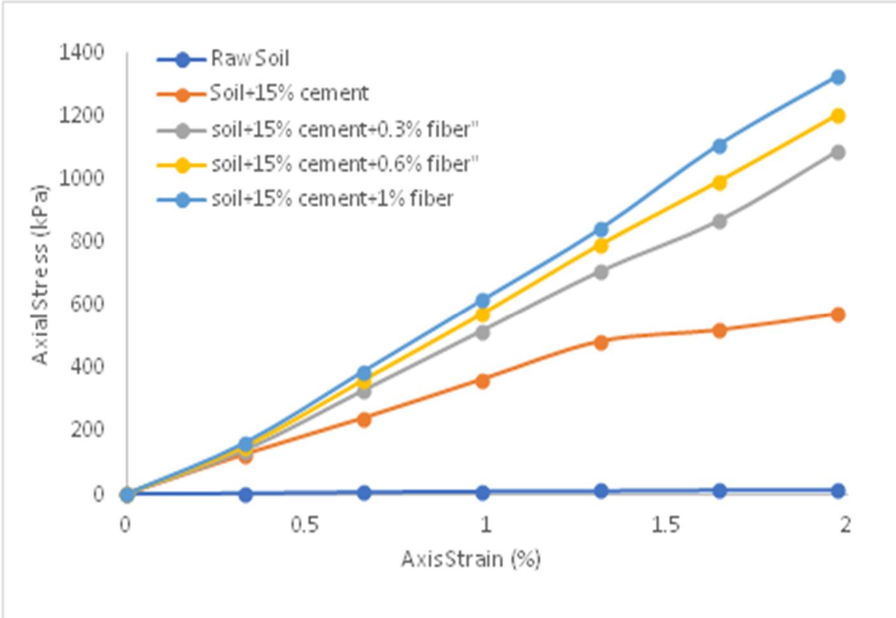

Fig 8.Axial stress-strain curve soil mixed with 15 % cement and fibre content (0.3, 0.6 and 1%) at 3 days

From Figure 8, for 3 Days time period, the axial stress corresponding to axial strain 2% for raw black cotton soil was evaluated 18.67 kPa, soil mixed with 15% cement content was 575.36 kPa and soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% were evaluated 1089.70 kPa, 1205.47 kPa and 1330.17 kPa i.e. 30.81, 58.36, 64.56 and 71.24 times of raw soil. From the curve it was also analysed that the axial stress value of soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% is 1.89, 2.09 and 2.31 times of cemented soil.

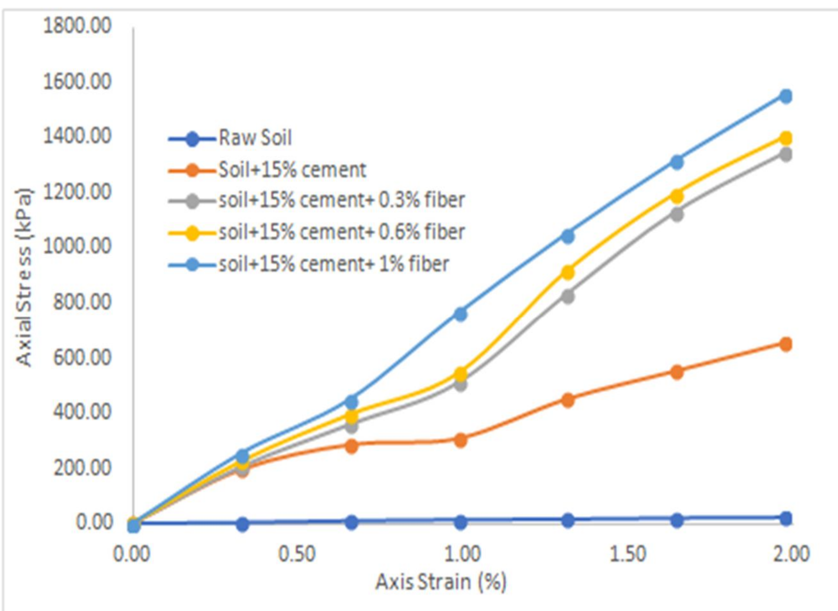

Fig 9.Axial stress-strain curve soil mixed with 15 % cement and fibre content (0.3, 0.6 and 1%) at 7 days

From Figure 9, for 7 Days time period, the axial stress corresponding to axial strain 2% for raw black cotton soil was evaluated 22.59 kPa, soil mixed with 15% cement content was 651.23 kPa and soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% were evaluated 1340.91 kPa, 1397.88 kPa and 1553.08 kPa i.e. 28.82, 59.35, 61.88 and 68.75 times of raw soil. From the curve it was also analysed that the axial stress value of soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% is 2.05, 2.14 and 2.38 times of cemented soil.

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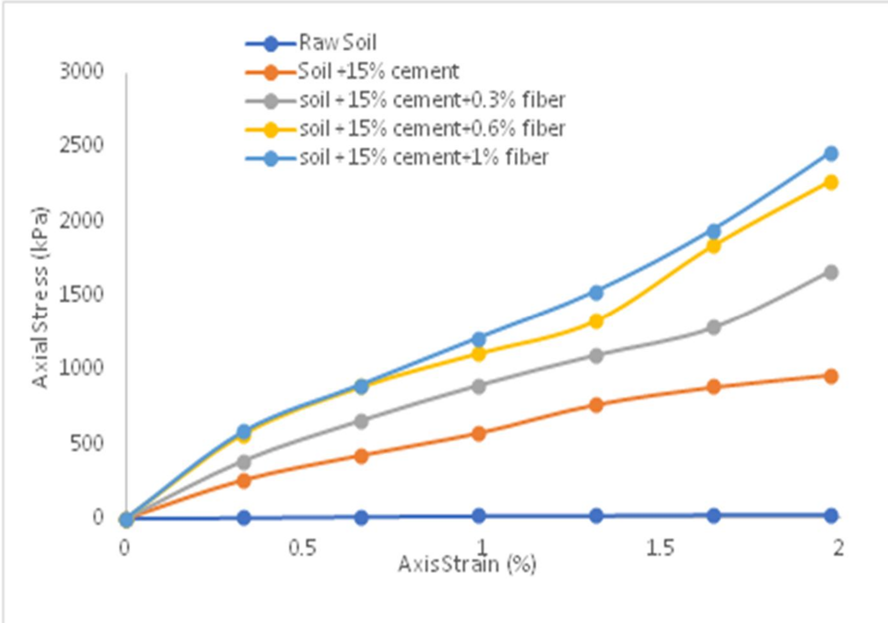

Fig 10.Axial stress-strain curve soil mixed with 15 % cement and fibre content (0.3, 0.6 and 1%) at 28 days

From Figure 10, for 28 Days time period, the axial stress corresponding to axial strain 2% for raw black cotton soil was evaluated 28.80 kPa, soil mixed with 15% cement content was 968.28 kPa and soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% were evaluated 1671.89 kPa, 2276.30 kPa and 2460.39 kPa i.e. 33.62, 58.05, 79.03 and 85.43 times of raw soil. From the curve it was also analysed that the axial stress value of soil mixed with cement and polypropylene fibre 0.3, 0.6 and 1% is 1.72, 2.35 and 2.54 times of cemented soil.

VI. CONCLUSIONS

This study has proved the ability of polypropylenefibresto be used in improving the behavior of cemented black cotton soil. Polypropylenefibres have been used in three contents (0.3, 0.6 and 1%) and mixed with cemented black cotton soil in threecement ratios (5, 10 and 15%) at natural water content i.e. 35% observed experimentally from the soil sample collected from Bhopal. From the experimental work, the following conclusionscan be drawn:

A. The UCS value of the compacted black cotton soil increase with time. The UCS value at 3 days is 18.67 kPa, and at 7days is 22.59 kPa and at 28 days is 28.80 kPa respectively. Thus the 7 days value is 1.21 times the 3 day value and 28 days value is 1.54 time the 3 days value.

B. Addition of polypropylene fibre to the cement mixed black cotton soil is studied and it is found that mixing of fibre increases the UCS value of soil. When fibre 0.3% by weight of the soil is added to 5% cement content BC soil the strength increases 1.62 times in 3 days, 2.05 times in 7 days and 1.65 times in 28 days.The same trend is near about seen in 0.6% and 1% fibre content.

C. Addition of polypropylene fibre to the cement mixed black cotton soil is studied and it is found that mixing of fibre increases the UCS value of soil. When fibre 0.3% by weight of the soil is added to 10% cement content BC soil the strength increases 2.07 times in 3 days, 2.01 times in 7 days and 2.06 times in 28 days.The same trend is near about seen in 0.6% and 1% fibre content.

D. Addition of polypropylene fibre to the cement mixed black cotton soil is studied and it is found that mixing of fibre increases the UCS value of soil. When fibre 0.3% by weight of the soil is added to 15% cement content BC soil the strength increases 1.87 times in 3 days, 2.05 times in 7 days and 1.72 times in 28 days.The same trend is near about seen in 0.6% and 1% fibre content.

E. Test results shows that the UCS value corresponding to the 15% cement content in cement mixed soil is 968 kPa and that with 5% cement content and 1% fibre content is 802kPa. These values are nearly the same thus it may be concluded that the effect of 1% fibre content is equivalent to about 10% of the cement. From these it is concluded that mixing 1% fibre content in soil reduces the cement content by 10%, i.e. economical and also environmentally better solution to stabilize the BC soil with cement.

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REFERENCES

[1] Abdi, M. R., &Mirzaeifar, H. (2016). Effects of discrete short polypropylene fibers on behavior of artificially cemented kaolinite. International Journal of Civil Engineering, 14(4), 253-262.

[2] Bremner, T. W., & Eng, P. (2001, September). Environmental aspects of concrete: problems and solutions. In All-Russian Conference on Concrete and Reinforced Concrete.

[3] Correia, A. A., Oliveira, P. J. V., &Custódio, D. G. (2015). Effect of polypropylene fibres on the compressive and tensile strength of a soft soil, artificially stabilised with binders. Geotextiles and Geomembranes, 43(2), 97-106.

[4] Mitchell, J. K., & Freitag, D. R. (1959). A review and evaluation of soil-cement pavements. Journal of the Soil Mechanics and Foundations Division, 85(6), 49-74.

[5] Estabragh, A. R., Namdar, P., &Javadi, A. A. (2012). Behavior of cement-stabilized clay reinforced with nylon fiber. Geosynthetics International, 19(1), 85-92.

[6] Huntzinger, D. N., & Eatmon, T. D. (2009). A life-cycle assessment of Portland cement manufacturing: comparing the traditional process with alternative technologies. Journal of Cleaner Production, 17(7), 668-675.

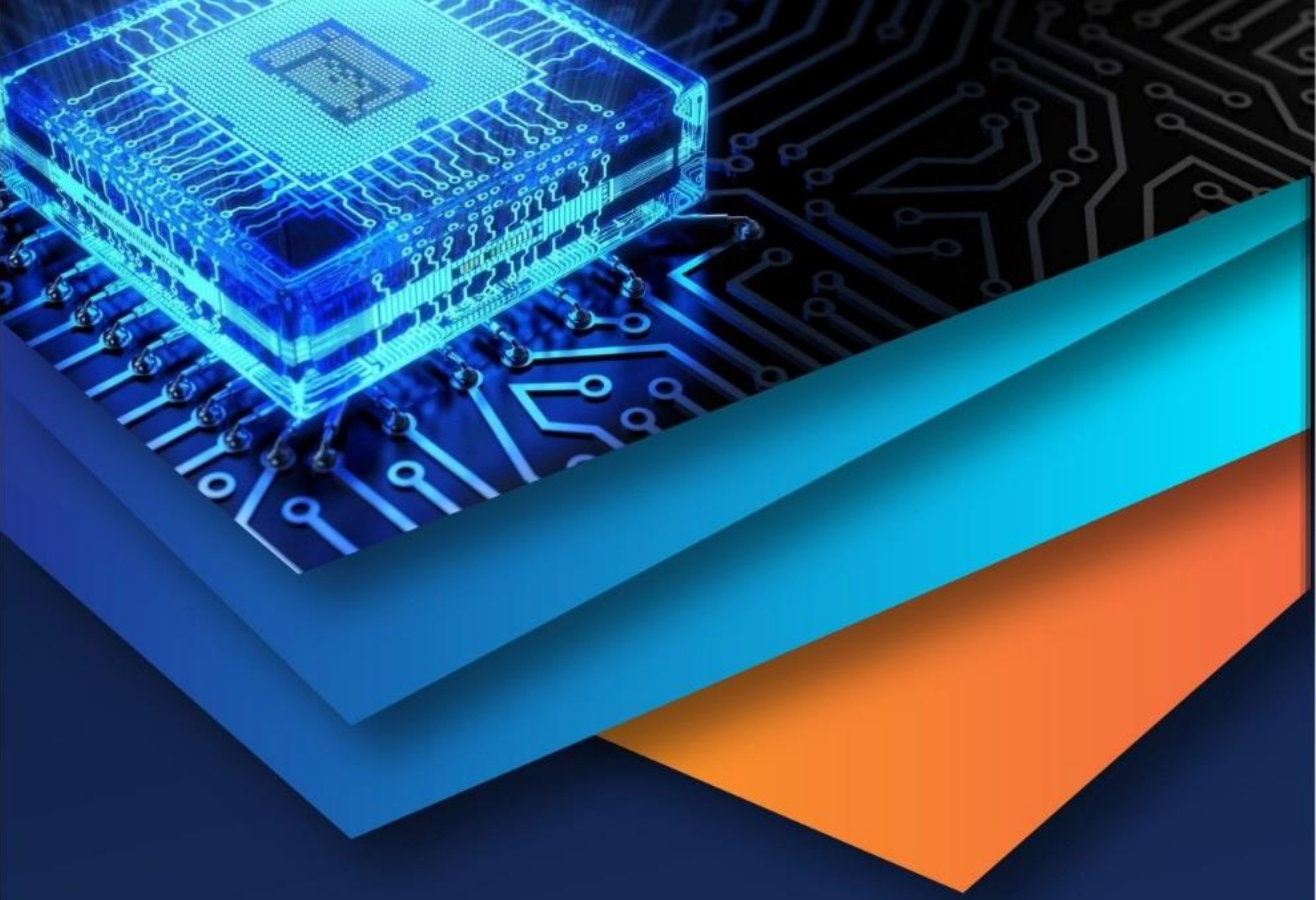
[7] Ingles, O. G., & Metcalf, J. B. (1972). Soil stabilization principles and practice (Vol. 11, No. Textbook).

[8] Rogers, C. D. F., & Glendinning, S. (1996). Modification of clay soils using lime. In Lime Stabilisation: Proceedings of the seminar held at Loughborough University Civil & Building Engineering Department on 25 September 1996 (pp. 99-114). Thomas Telford Publishing.

[9] Rudramurthy, G., Ramasamy, P., & Rajendran, A. (2019). Stabilization of Clayey Soil Using Lime and Prosopis Fibers. In Recent Advances in Geo-Environmental Engineering, Geomechanics and Geotechnics, and Geohazards (pp. 259-261). Springer, Cham.

[10] Worrell, E., Price, L., Martin, N., Hendriks, C., &Meida, L. O. (2001). Carbon dioxide emissions from the global cement industry. Annual review of energy and the environment, 26(1), 303-329.

[11] Yadav, J. S., & Tiwari, S. K. (2017). Effect of waste rubber fibres on the geotechnicalproperties of clay stabilized with cement. Applied Clay Science, 149, 97-110.



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