STABILIZATION OF BLACK COTTON SOIL USING POLYPROPYLENE FIBRE

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Abstract: In India, a major portion of total land area is covered by clayey soil. Of this, a large proportion is expansive soil. Expansive soils are often encountered in many parts of the world, especially in arid and semi-arid fields. . Soil stabilization is one of the promising techniques used to improve the geotechnical properties of soil and has become the major practice in construction engineering. This project aims to conduct a study to check the improvements in properties of black cotton soil by adding polypropylene fiber. By varying percentage of fibres (0%, 0.25%, 0.5%, 0.75% and 1%), the soil parameters such as UCS and CBR may be studied. These values are compared to that of a control specimen.As the fiber content increased, the unconfined compressive strength was increased. Finally, it can be said that stabilization of black cotton soils with polypropylene fiber is an effective method.

***IndexTerms* - Expansive soil, polypropylene fibre, UCS, CBR, Black cotton soil.**

I. INTRODUCTION

For structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their parameters which affect their condition. The stabilization process helps to achieve the required parameters in a soil needed for the work.From the beginning of construction work, the necessity of enhancing soil properties has come to the light.Expansive soils are one of the most serious problems that the geotechnical engineers encounter. They are considered a potential natural hazard, which can cause extensive damage to structures such as spread footings, roads, highways, airport runways and earth dams if not adequately treated. In the and earth dams if not adequately treated. In the United States damage caused by expansive clays exceeds the combined average annual damage from floods, hurricanes, earthquakes Some measures can be taken to prevent the damages.Recently there is a growing attention to soil. The results gathered over the years reveals the capacity of different types of fiber in reinforcing problematic soils.The experimental program was carried out on compacted soil specimens with 0%,0.25%, 0.5%, 0.75% and 1% polypropylene fiber additives and the results of unconfined compression tests and California bearing ratio test on 0%, 0.5%, 0.75% and 1 % fiber were swell tests on 0%,0.25%, 0.5%, 0.75% and 1 % fiber were discussed.

1.1) Importance:

- ❖ The first priority of soil stabilization is to ensure that the proper techniques are utilized for the modification of it so it is able to provide peak performance.
- ❖ While soil stabilization is important throughout many of different industrial sectors it is often a requirement for those who are in the industry of providing paving services for roads and airfields.
- ❖ For the engineers who are responsible for making the decision as to the suitability of the soil for the specific project it means making that decision on some specific criteria. It is critically important that the dust control products being used are not going to compromise the judgement of the engineers.
- ❖ The professionals have to determine if they should be satisfied with the present soil conditions and adjust their designs to meet the composition of the soil as it is. Or, should the soil that is there be removed and replaced with a better form of material.

1.2) Objectives:

- ❖ To evaluate the index properties of Black cotton soil.

- To increase the strength characteristic of soil by adding polypropylene fiber
- To make comparison of strength properties between Black cotton soil with fiber and without fiber.
- To increase the soil bearing capacity by adding polypropylene fibre and in varies percentages.

II. LITERATURE REVIEW

2)General:

- Muske Srujan Teja(2007),

He found that the CBR value of the soil increased with increase in fibre content. The increase in length and diameter also increased the CBR value.

- Mousa F. Attom et al. (2010),

He compared the shear strength parameters of sandy soil with two different types of polypropylene fibres. Test result showed that shear strength increased with increase in fibre content and with increases strength of soil.

- Rakesh Kumar Dutta et al. (2012),

He studied the effective use of treated fibres on unconfined compressive strength of clay. The results shows that the fibre reinforced clay was able to increase in the unconfined compressive strength was higher with CCl4 treatment.

- S. Soganci (2011),

He suggested that the inclusion of fiber reduced shrinkage percent of expansive soil. As the fiber content increased, the unconfined compressive strength was increased. Finally, it can be said that stabilization of black cotton soils with polypropylene fiber is an useful method.

- Sidali Denine (2010),

She suggested show that the geotextile reinforcement improves the cohesion strength of the reinforced soil. Here non-woven geotextile is used for reinforcement. The addition of reinforcement layer continuously increases the shear strength of the soil.

III. METHODOLOGY

Literature review
⇩
Collection of materials
⇩
Analysis of soil parameters
⇩
Stabilization of clayey soil using polypropylene fibre
⇩
Various % of adding polypropylene fibre
⇩
Test procedure
⇩
Result and Discussion
⇩
Conclusion

3.1) Collection of materials:

1) Black cotton soil

2) Polypropylene fibre

1) Black cotton soil:

- Black cotton soil is a clayey soil. They are of variable thickness,density under layered by black sticky material known as “Black soil”.
- It swells,shrinks enormously due to present of fine and dust clay particles. Hence black cotton soil must be treated by using suitable admixtures to compact it.

2) Polypropylene fibre:

S.NO.	PHYSICAL AND CHEMICAL PROPERTIES	VALUES
1	FIBRE TYPE	SINGLE FIBRE
2	UNIT WEIGHT	0.91g/cm3
3	AVERAGE DIAMETER	0.048mm
4	AVERAGE LENGTH	12mm
5	BREAKING TENSILE STRENGTH	350Mpa
6	MODULUS OF ELASTICITY	3500Mpa
7	FUSION POINT	165°c
8	BURNING POINT	590°c
9	ACID AND ALKALI	VERY GOOD
10	DISPERSIBILITY	EXCELLENT

Black cotton soil

Polypropylene fibre

3.3) Preparation of samples:

All specimens were prepared with static and dynamic compaction method specified in ASTM D698-91. Water is added to the soil and mellowed for 24 hours for preparing normal soil samples. The content of fiber is defined here in as

pf=Wf/w
Where,
Wf is the weight of fiber, and
W is the weight of air-dried soil
.

3.4) Experimental Tests:

1) Specific Gravity:

The specific gravity of the soil is ratio between weight of the solids and weight of equal volume of water.It is measured by the help of a volumetric flask in a very simple experimental setup where the volume of the soil is found out and its weight is divided by the weight of equal volume of water. The specific gravity is denoted by “G”.

Specific Gravity G = (W2−W1)/(W4−W1) –(W3−W2)

W1- Weight of bottle in gms

W2- Weight of bottle + Dry soil in gms

W3- Weight of bottle + Soil + Water

W4- Weight of bottle + Water

1) Liquid Limit:

Weigh about 120gm of soil passing through 420 micron (I.S sieve).The soil sample is placed on the operating dish and thoroughly mixed with water using spatula until the mass becomes a thick paste of putty like consistency.The casagrande's device is checked to have a correct fall of 10mm and placed a portion of the prepared paste over the brass cup.A portion of the mixture is placed in the cup and leveled with the spatula to a maximum depth of 1cm.The grooving tool is used to cut a groove in the middle of the soil cake.The cam is rotated at a rate of 2 blows per second and the rotation are counted until the groove closer over a length of 12mm.A small quantity near the centre of test sample is collected in a container and weighed it.The sample is kept in the oven for 24 hours and weighed.The difference of the two weight will give the weight of water and from the moisture content is found out by the dry weight.The experiment is repeated by adding little more water. Four trials are made so that the numbers of blows are more than 25 in two cases and less than 25 in order two cases.In each trial the moisture content is determined the result of the test are plotted as a flow curve.The moisture content values are plotted to a natural scale against the number of blows to a logarithmic scale.The moisture content corresponding to 25 number of blows will give the liquid limit for the sample.It is denoted by WL.

3) Plastic Limit:

A Sample of about 50gm is taken from the given soil sample.The sample is thoroughly mixed with water on the glass plate until it is plastic enough to be rolled into a ball.The ball of soil is taken rolled between the hand and the glass plate so as to form the soil mass into a thread of 3mm diameter without breaking.The soil is then kneaded together and rolled out again. The process of kneading and rolling thread is repeated until the soil just ceases to be plastic and crumbles.The portion of crumbled soil are gathered together and placed in a container for moisture content determination.The test is repeated twice more than fresh samples.The average of the three water contents gave the plastic limit of the soil.Plastic limit is denoted by WP.

4) Proctor Compaction Test:

Weigh the standard proctor mould with base and without collar(w_1) gm.Take about 3kg of air dried soil passing through 4.5mm sieve.Take known quantity of water (6% by the weight of dried soil) and mix well with the soil.Attach the collar with proctor mould and fill the mixed soil in the mould in the three equal layers. compact each layer by the rammer weighing 2.6 kg allowing into drop 25 times from the height of 310mm.The total height of the compacted soil should be slightly more than the height of the mould.Remove the collar and cut out the projected soils to have a level surface with the top of the mould.Weight the mould with the soil (w_2) gm.Remove the soil from the cylinder and break up the soil by hand. Now Increase the moisture content by 2% mix thoroughly. Repeat the experiment .In the repeating process each time rise the moisture content by 2% until there is a considerable fall in the weight of the mould with compacted soils.Take samples from which operations and calculate the moisture content and corresponding dry density.Draw the graph between dry density and moisture content. Find the dry density and optimum moisture content from the graph.The equations used in this experiment are as follows

Dry density= (G × ϒW) / (1+WG)

5) Unconfined Compression Test:

Place the sampling soil specimen at the desired water content and density in the large mould.Push the sampling tube into the large mould and remove the sampling tube filled with the soil. For undisturbed samples, push the sampling tube into the clay sample.Saturate the soil sample in the sampling tube by a suitable method.Coat the split mould lightly with a thin layer of grease. Weigh the mould.Extrude the sample out of the sampling tube into the split mould, using the sample extractor and the knife.Trim the two ends of the specimen in the split mould. Weigh the mould with the specimen.Remove the specimen from the split mould by splitting the mould into two parts.Measure the length and diameter of the specimen with vernier calipers.Place the specimen on the bottom plate of the compression machine. Adjust the upper plate to make contact with the specimen.Adjust the dial gauge and the proving ring gauge to zero. Apply the compression load to cause an axial strain at the rate of ½ to 2% per minute.Record the dial gauge reading, and the proving ring reading every thirty seconds up to a strain of 6%. The reading may be taken after every 60 seconds for a strain between 6%, 12% and every 2minutes or so beyond 12%.Continue the test until failure surfaces have clearly developed or until an axial strain of 20% is reached.Measure the angle between the failure surface and the horizontal, if possible.Take the sample from the failure zone of the specimen for the water content determination.

Qu = load/corrected area (A')

qu – compressive stress,A'= cross-sectional area/ (1- ε)

6) California Bearing Ratio Test:

Place the mould assembly with surcharge weight on the penetration testing machine.Seat the penetration piston at the center of the specimen with the smallest possible load, but in no case in excess of 4kg so that full contact of the piston on the sample is established.Set the stress and strain dial gauge to read zero. Apply the load on the piston so that the penetration rate is about 1.25mm/min.Record the load readings at penetration of 0.5,1.0 ,1.5 ,2.0 ,2.5 ,3.0 ,4.0 ,5.0 ,7.5, 10 and 12.5mm.Note the maximum load and corresponding penetration if it occurs for a penetration less than 12.5mm.Detach the mould from the loading equipments.Take about 20 to 50 g of soil from the top 3cm layers and determine the moisture content.

CBR = P/Ps X100

IV. RESULTS AND DISCUSSIONS

4.1)Specific Gravity:

Black Cotton Soil

S.NO	PARTICULARS	TRIAL 1(gms)
1	Mass of empty bottle (M1)	0.668
2	Mass of bottle + dry soil	1.068
3	Mass of bottle + dry soil + water	1.800
4	Mass of bottle + water	1.555
5	Specific gravity	2.52

Specific gravity of soil sample= 2.53g

Polypropylene Fibre

S.NO	PARTICULARS	TRIAL 1(gms)

1	Mass of empty bottle (M1)	0.668
2	Mass of bottle + dry soil	0.75
3	Mass of bottle + dry soil + water	1.23
4	Mass of bottle + water	1.555
5	Specific gravity	0.91

Specific gravity of polypropylene fibre = 0.91gm

4.2) Index Properties:

4.2.1) Liquid Limit:

S.NO.	MOISTURE CONTENT (%)	QUANTITY OF WATER (cc)	NO.OF.BLOWS (N)
1	15	18	128
2	20	24	97
3	25	30	63
4	30	36	38
5	35	42	17
6	40	48	4

Liquid Limit = 63%

4.2.2) Plastic Limit:

S.NO.	PARTICULARS	TRIAL (gms)
1	Mass of empty can	20
2	Mass of can + wet soil	58
3	Mass of can + dry soil	46.1
4	Mass of pore water	11.9
5	Mass of soil solids	26.1
6	Water content (%)	45.6

Plastic Limit = 45.6%

4.2.3) Plasticity Index :

Plasticity index of soil = Liquid limit – plastic limit

= 17.4%

Plasticity index of soil =17.4%

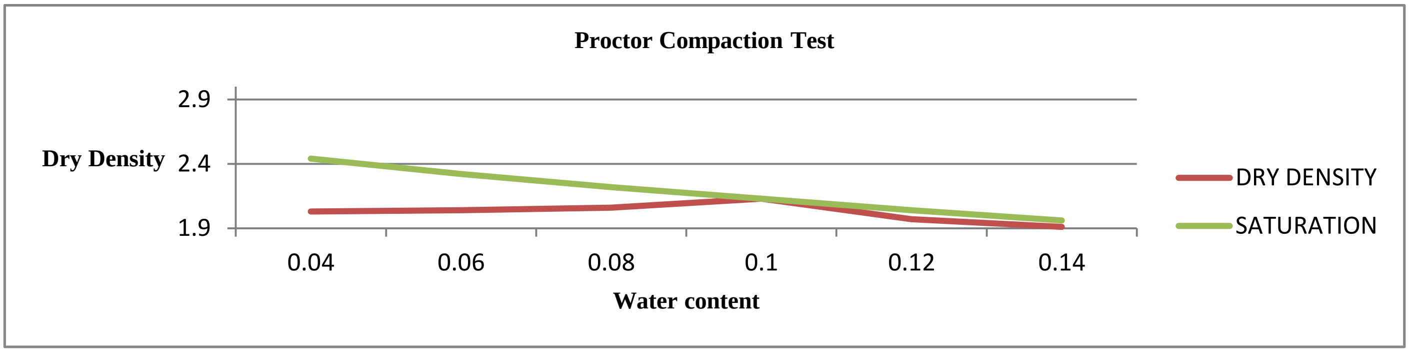
4.3) Proctor Compaction Test:

Observation:

S.NO.	OBSERVATIONS	CALCULATIONS
1	Soil sample	Dry
2	Specific gravity	2.5
3	Diameter of mould	10cm
4	Height of mould	12.5cm
5	Volume of mould	981.24cm2
6	Weight of soil taken	5kgs
7	Weight of rammer	2.5kg
8	Number of layers	3layers
9	Number of blows	25/layer
10	Weight of mould	4240gms

Tabulation:

S.NO.	PARTICULARS	TRIALS				
1	Water content	4%	6%	8%	10%	12%
2	Weight of mould + soil (w2)gm	6320	6360	6430	6490	6410
3	Weight of soil w=(w2-w1)gm	2080	2120	2190	2250	2170
4	Bulk density ϒ=w/v	2.12	2.16	2.23	2.29	2.21
5	Dry density ϒd=ϒ/1+w	2.03	2.04	2.06	2.08	1.97
6	100% of saturation	2.44	2.32	2.22	2.13	2.04



1) MAXIMUM DRY DENSITY (MDD) = 2.1g/cc

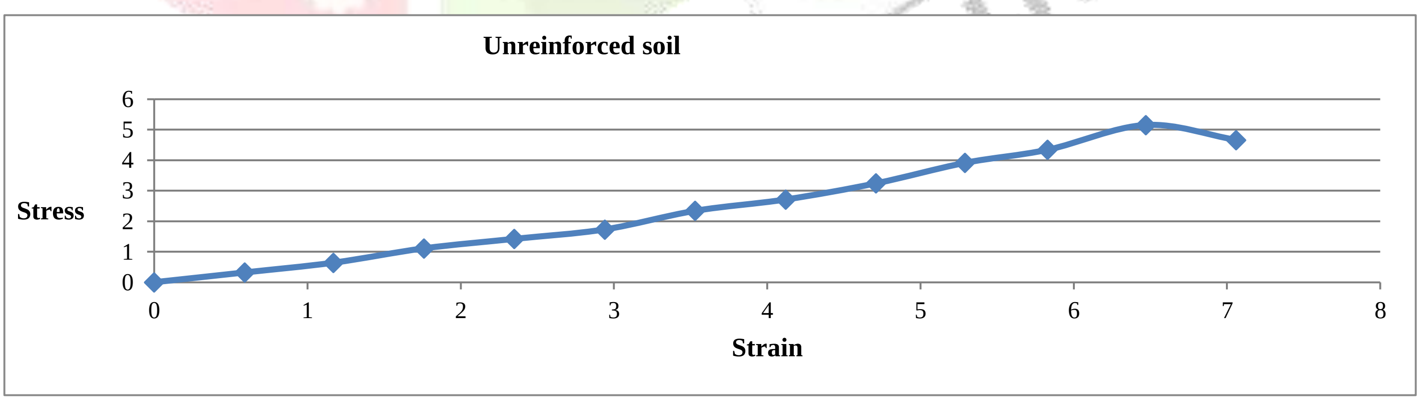
2) OPTIMUM MOISTURE CONTENT =10%

4.4) Unconfined Compression Test:

Observation:

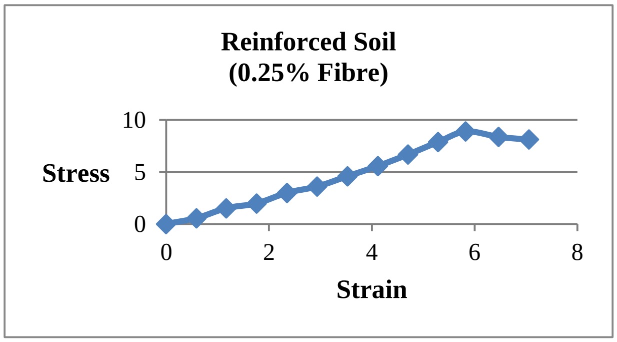
S.NO	PARTICULARS	OBSEVATIONS
1	DIAMETEROF SOIL SAMPLE	3.8cm
2	AREA OF SAMPLE	11.34cm2
3	LENGTH OF SAMPLE	8.5cm
4	WEIGHT OF SAMPLE	200g

Unreinforced Soil:



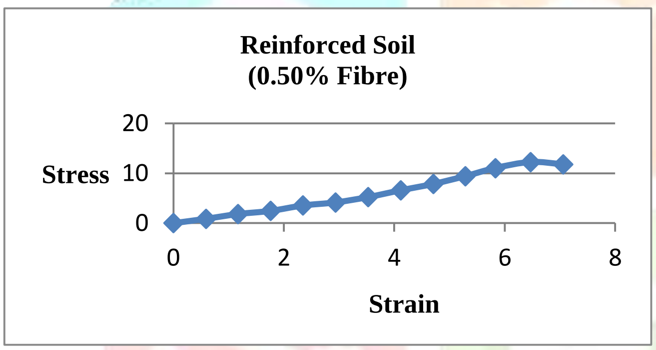
Unconfined compressive strength = 5.15Kg/cm2

Reinforced Soil (0.25% Fibre):



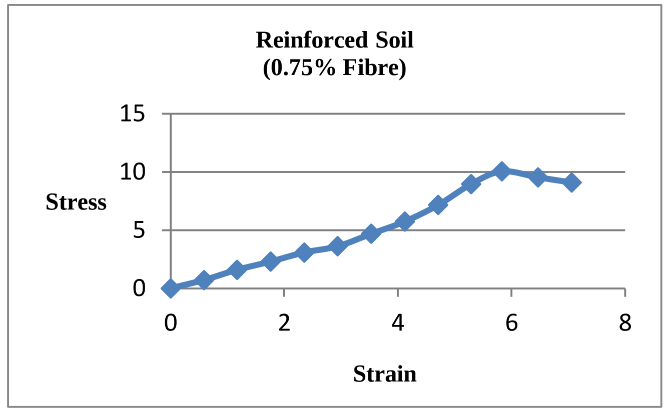
Unconfined compressive strength = 8.91Kg/cm2

Reinforced soil (0.50% Fibre):



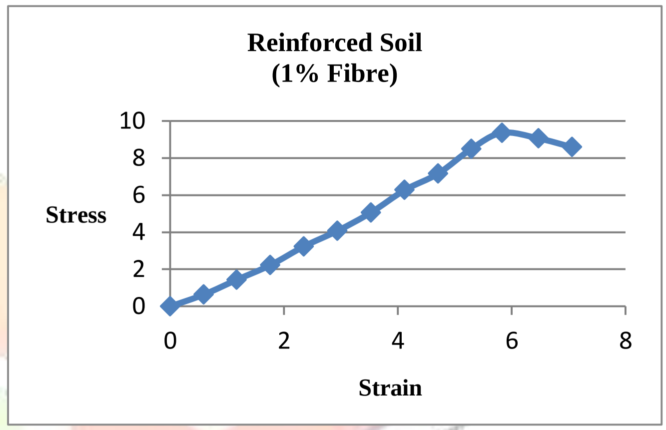
Unconfined compressive strength = 12.25Kg/cm2

Reinforced Soil (0.75% Fibre):



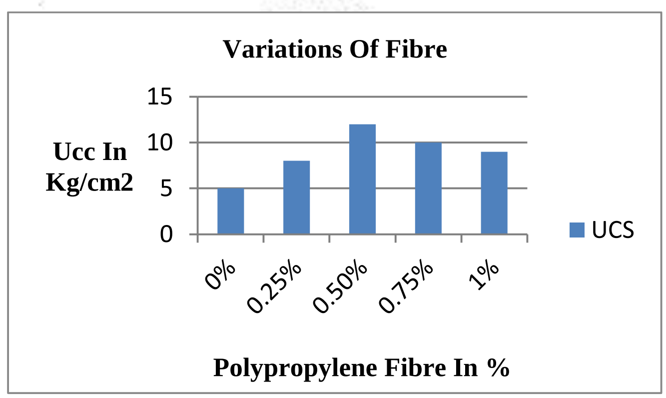
Unconfined compressive strength = 10.05Kg/cm2

Reinforced Soil (1% Fibre):



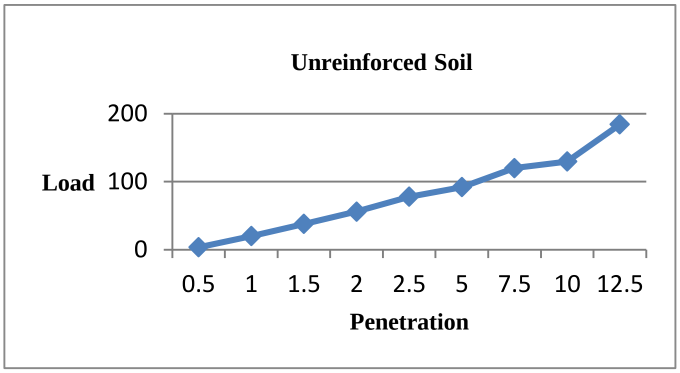
Unconfined compressive strength = 9.37Kg/cm2

4.4) Variations of unreinforced and reinforced soil:



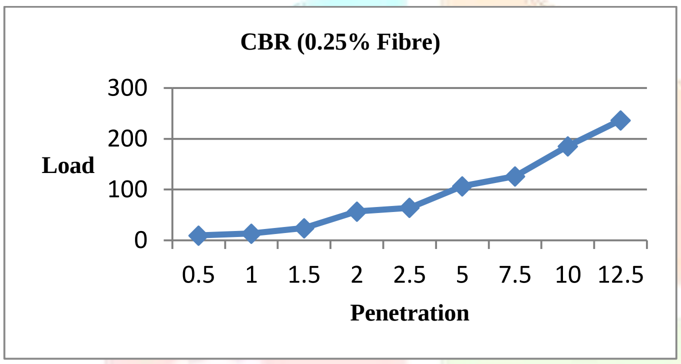
4.5) California Bearing Ratio Test:

Unreinforced Soil :



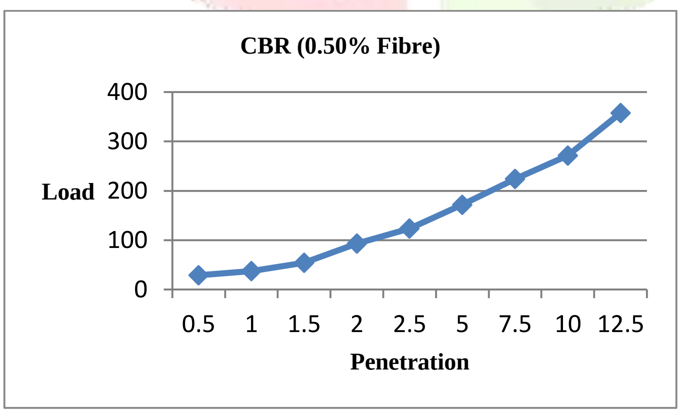
Therefore C.B.R value for unreinforced soil = 3%

Reinforced Soil (0.25% Fibre):



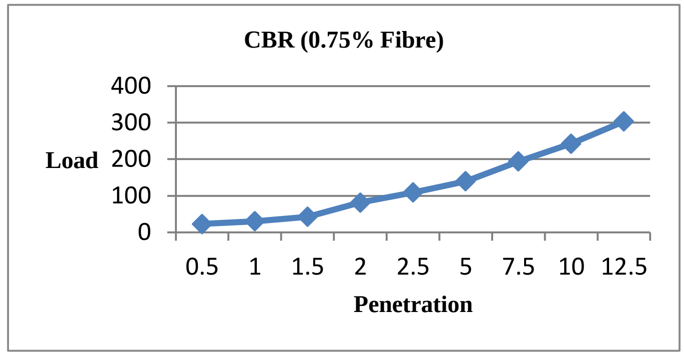
Therefore C.B.R value for unreinforced soil = 6%

Reinforced Soil (0.50% Fibre):



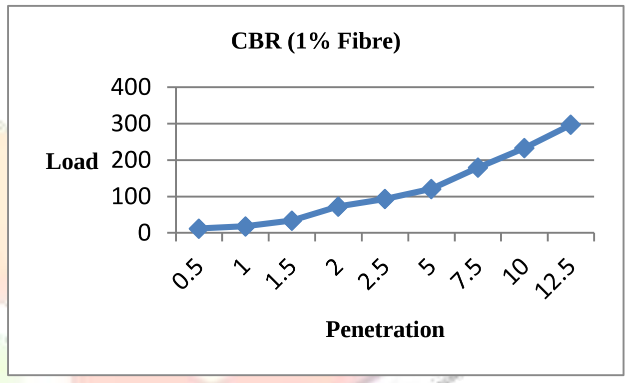
Therefore C.B.R value for unreinforced soil = 11%

Reinforced Soil (0.75% Fibre):



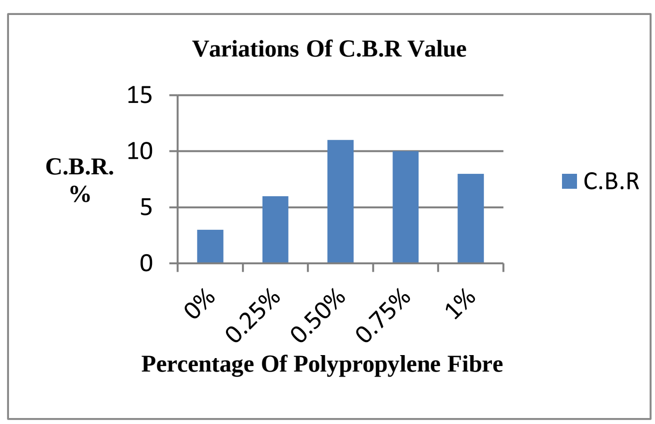
Therefore C.B.R value for unreinforced soil = 10%

4) Reinforced Soil (1% Fibre):



Therefore C.B.R value for reinforced soil = 8%

4.6) Variations of unreinforced and reinforced soil:



V. CONCLUSION AND REFERENCES

5.1) Conclusion:

- This study results that the effect of adding polypropylene fiber and strength behaviour of clayey soil.
- The effect of fiber reinforcement on clayey soil was studied by using the results obtained from a series of unconfined compressive stress and California bearing ratio test. Based on the result presented in this paper the following conclusions are drawn.
- With increase in the fiber content, the unconfined compressive stress value of reinforced soil increases to zero at 0.5% of fiber.
- Due to increase in the fiber content, the unconfined compressive stress reinforced soil decreases from 0.75% to 1% of fibre.
- The California bearing ratio of the soil increases with the addition of fiber content up to 0.5% of fiber and then decreases with the addition of 0.75% fiber.
- From this investigation, it is clearly indicated that the unconfined compressive stress and California bearing ratio value of the reinforced soil increased. Hence addition of 0.5% of stabilizer was taken as the optimum percentage of PP fiber for stabilizing the soil.
- Also the strength of the clayey soil was increased due to addition of fibre and can be concluded that Polypropylene fiber can be used effectively for the stabilization of clayey soil.

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