A STUDY OF SOIL STABILIZATION USING WASTE PLASTIC MATERIAL

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE AWARD OF THE DEGREE

OF

MASTER OF TECHNOLOGY

IN

GEOTECHNICAL ENGINEERING

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CANDIDATE'S DECLARATION

I, Aweshesh Jindal, 2K17/GTE/08, student of M.Tech (Geotechnical Engineering), hereby declare that the project Dissertation titled **"A STUDY OF SOIL STABILIZATION USING WASTE PLASTIC MATERIAL**" which is submitted by me to the Department of Civil Engineering, Delhi Technological University, Delhi in partial fulfillment of requirement of award of degree of Master of technology, is original and not copied from any source without proper citation. This work has not previously formed the basis for the award of any Degree, Diploma Associate ship, Fellowship or other similar title or recognition.

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CERTIFICATE

I hereby certify that the Project Dissertation titled **" A STUDY OF SOIL STABILIZATION USING WASTE PLASTIC MATERIAL"** which is submitted by Aweshesh Jindal, 2K17/GTE/08 of M.Tech (Geotechnical Engineering) Delhi Technological University, Delhi in partial fulfillment of the requirement for award of degree of Master Of Technology, is a record of the project work carried out by the him under my supervision. To the best of my knowledge this work has not been submitted in part or full for any Degree or Diploma to this University or elsewhere.

Place: Delhi | Prof. A.K.Gupta
Date: | **(SUPERVISOR)**

ACKNOWLEDGEMENT

I thank god and my parent almighty for bestowing his blessings and grace in completion of this thesis.

I express my sincere thanks to the University Management.

As I write this acknowledgement, I must clarify that this is not just a formal acknowledgement but also a sincere note of thanks and regard from my side. I feel a deep sense of gratitude and affection for those who were associated with the project and without whose co-operation and guidance this project could not have been conducted properly.

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ABSTRACT

Stabilization of soil is an effective and reliable method for improvement of strength, stability and bearing capacity of soils. Soil stabilization can be done in number of ways. But the stabilization using waste plastic strips is an economic method since the stabilizer used here is waste plastic materials, which is easily available and cheap. The primary objective of this project is to improve the shear strength and stability of soil using plastic cover wastes. This report presents the various tests conducted on fiber reinforced soil with varying fiber content and their results are analyzed such that it can be used in the fields. Maximum Dry Density (MDD), Optimum Moisture Content (OMC), California Bearing Ratio (CBR) and shear strength parameters (cohesion C and angle of internal friction Φ) of soil were examined. The plastic strips were added in different proportions by dry weight (0.25%, 0.5%, 1% and 1.5%) of the soil. Results conclude that, there is significant improvement in the strength of soil due to increase in cohesion. However cohesion is improved but no large variation in angle of internal friction. MDD of soil increases up to 0.5 % of plastic waste as stabilizer, but demand of water decreases as plastic does not absorb water. CBR value increased up to 1% of plastic waste as stabilizer. This could be effective method of disposal of plastic waste with respect to environmental concern.

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1) INTRODUCTION

For any land-based 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 properties and factors which affect their behaviour. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work.

From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Romans and Incas utilized various methods to improve soil strength etc., some of these methods were so effective that their buildings and roads still exist.

In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favour. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement.

Plastics are inexpensive, lightweight and durable materials. On an average, an Indian uses 1 Kg of plastics per year and the world annual average is an alarming 18 kg. As per data available on Municipal Solid Waste (MSW) 2009, approximately, 4000-5000 ton per day plastic wastes are generated. As a consequence, the production of plastics has increased markedly over the last 60 years. According to recent studies, plastic can stay unchanged for as long as 4500 years on earth. Use of this non-biodegradable product is growing rapidly and the problem is what to do the plastic waste. Several million metric tons plastic wastes are produced every year. One method to reduce some portion of the plastic waste disposal problem is by recycling and utilizing these materials in the stabilization of expansive soil.

Therefore, for sustainable development use of locally available plastic waste materials should be encouraged. The objective of this study was to make economical and to maintain environmental balance, and avoid problems of waste plastic disposal i.e. the use of plastic waste for stabilization of black cotton soil and its possible combined utilization with various proportions to obtain maximum stability.

Data on plastic waste

In 2013 utilization of plastic in India was around 120 lakh ton however it is going to achieve 200 lakh tones continuously 2020 because of developing utilization of various types of ware. The utilization of plastic in various structures is expanding by a normal of 10% consistently. Rate of age of plastic squanders in Indian urban areas runs between 0.20-0.87 kg/day, contingent on the measure of the city and expectation for everyday comforts. Consistently around 8 million tons of plastic waste is dumped in to the world's seas. Table-1.1 demonstrates various kinds of plastic squanders and their sources.

Table no.1.1 Waste plastic and its source (Tiwari and Tiwari, 2016)

Waste plastic	Origin
Low density polyethylene	Carry bags, sacks, milk pouches, bin lining, cosmetic and detergent bottles
High density polyethylene (HDPE)	Carry bags, bottle caps, house-hold articles.
Polyethylene Teraphthalate (PET)	Drinking water bottles etc.
Polypropylene (PP)	Bottles caps and closures, wrappers of detergent, biscuit and wafers packets, microwave trays for meal etc.
Polystyrene (PS)	Yoghurt pots, clear egg packs, bottle caps. Foamed, polystyrene: food trays, egg boxes, disposal cups, protective packaging etc.
Polyvinyl chloride (PVC)	Mineral water bottles, credit cards, toys, pipes, and electrical fittings, furniture, folders and pens, medical disposables etc.

2) LITERATURE REVIEW

Choudhary et.al. (2010) performed a laboratory evaluation on utilization of plastic wastes for improving the subgrade in flexible pavement. In this study the effect of waste plastic strip content (0.25% to 4%) and strip length on the CBR and secant modulus of strip reinforced soil was investigated. The study reveals that addition of waste plastic strip of appropriate size and proportions in soil result in increase in both CBR value and secant modules of soil.

Ashraf et.al. (2011) studied on the possible use of plastic bottles for soil stabilization. The analysis was done by conducting plate load tests on soil reinforced with layers of plastic bottles filled with sand. The bottles cut to halves placed at middle and one third position of tank. The test results showed that cut bottles placed at middle position were the most efficient in increasing strength of soil.

Thakare and Sonule (2013) carried out various laboratory tests to investigate the effect of reinforcement of sandy soil with model plastic water bottle through model plate load tests. The study showed that the ultimate bearing capacity of footing increases with increasing the layer of plastic bottles as reinforcement. The increase in bearing capacity may be due to the additional confinement to the soil in the vicinity of footing similar to that in case of Geocell. The bearing capacity increases with the increase in width of reinforcement and number of layers. Thus, the use of plastic bottles as reinforcement was recommended to reduce the quantity of plastic waste which creates the disposal problems.

Paramkusam et.al. (2013) performed an experimental study to investigate the stabilization effect of waste plastic on dry density and CBR behaviour of red mud, fly ash and red mud, fly ash mixed with different percentage of waste plastic (PET) content. Based on light compaction tests, authors concluded that MDD value of the red mud, fly ash mixed with plastic increases as the waste plastic increases till 2%, further increase in plastic waste reduces the MDD value. OMC value remains same in each case. A marked increase in CBR value was also observed on adding 0.5%, 1.0%, 2.0%, of waste plastic and was found to be decreased after inclusion of 3% and 4%. Increase of CBR value indicates that the thickness of pavement can be reduced by addition of waste plastic content up to 2%.

Poweth et al. (2014) investigated the effect of plastic granules on weak soil sample with plastic and without plastic granules in varying percentage. The percentage of waste plastic was taken as 0.25%, 0.5 %, 0.75%. Maximum dry density was obtained when 0.25 % plastic was added and OMC was less than the soil without plastic for this percentage of soil. Further CBR value decreases when 0.25 % plastic is added but it was found to be increased for 0.75 % of plastic. Authors also observed that for the same percentage of plastic, shear stress was maximum.

Chebet and Kalumba (2014) conducted experiments to determine the increase in shear strength and bearing capacity of two samples of locally available soil due to random mixing of strips of high density polythene material from plastic shopping bags. Strips of shredded plastic material were used as reinforcement inclusions at concentration of up to 0.3% by weight. These results indicate that the increased strength of soil was due to tensile stresses mobilized in the reinforcements.

Nagle and Ameta (2014) conducted various experiments to compare CBR of soil reinforced with natural waste plastic. They mixed polyethylene plastic bottles food packaging and shopping bags etc. as reinforced with three soil samples of expansive soil (black cotton soil), silty-clay and sandy soil. Their study showed that MDD and CBR value increases with increase in plastic waste.

Malhotra et.al. (2014) demonstrated the potential of HDPE plastic waste on the UCS of soil. In a proportion of 1.5 %, 3%, 4.5 % and 6% of the weight of dry soil HDPE plastic (40 micron) waste was added. They concluded that the UCS of black cotton soil increased on addition of plastic waste. When 4.5 % plastic waste was added, 287.32 KN/m^2 soil strength of the soil was obtained which was more than untreated soil.

Harish and Ashwini (2015) studied the effect of plastic bottles strips as a stabilizer for two soil samples, red soil and black cotton soil. Red soil consists of 4 % gravel, 88% sand and 8% silt and clay and black cotton soil 2.6% gravel, 15.1 %sand and 82.3 % silt and 0.18 % of clay. They used plastic stripes in making the pavement and it was found that there was an increase in the strength of the soil. Authors conducted a CBR ratio test to find out MDD and OMC. They observed an increase in the strength of soil and bearing ratio of 2.9 for red soil and 3.3 for the black cotton soil by mixing 0.7 % of waste plastic strips to red soil and 0.5 % for the black cotton soil.

Dhatrak and Konmare (2015) calculated the engineering properties by mixing waste plastic. It was observed that for construction of flexible pavement to improve the sub grade soil of pavement using waste plastic bottles chips is an alternative method. In a proportion of 0.5%, 1%, 1.5%, 2%, and 2.5% of the weight of dry soil, plastic waste was added to calculate CBR value. He concluded that using plastic waste strips will improve the soil strength and can be used as sub grade. It is economical and eco-friendly method to dispose waste plastic.

Subhash et.al. (2016) conducted experimental study on soil stabilization using glass and plastic granules mixed with varying percentage. Modified Proctor tests were carried out to study OMC and CBR. They concluded that there is a decrease in MDD on addition of glass and plastic in varying percentages. The MDD of 1.53 gm/cc was obtained at 6% of glass and plastic. The maximum OMC was obtained as 22.6% at 6% mixing of additive .Further, an increase in the OMC was observed, maximum value of OMC was obtained as 22.6% at 6 % glass and plastic additive with the soil. An increase in the UCS from 0.609 Kg/cm^2 to 3.023 Kg/cm^2 which is about 5 times as that of virgin soil. Maximum CBR value was 7.14 %, which is 2 times of CBR of virgin soil.

3) EXPERIMENTAL WORK

3.1 SCOPE

The experimental work consists of the following steps:

- Specific gravity
- Liquid limit (Casagrande's apparatus)
- Plastic limit
- Plasticity Index
- Prepare reinforced soil samples.
- Proctor compaction test to find out maximum dry density (MDD) and its corresponding OMC.

3.2 MATERIAL

Soil sample – Soil sample was extracted from the construction site of water treatment plant from the village **BURJ RATHI,** near MANSA, PUNJAB at the depth of 1.5 m.

Fig no. 3.1:- Soil sample

Fig no. 3.2:- Plastic waste

Plastic sample – Carry bags, Milk pouches and Bin lining of thickness 40 microns, dimension of strip is 10mm each.

3.3 Preparation of Sample

Steps carried out during mixing the fiber in the soil -

- Content of fiber in the soil is decided by

$$\rho_f = \frac{W_f}{W}$$

- The different percentage of fiber reinforcement are 0, 0.25, 0.5, 1, and 1.5.
- If fiber is not used then, the air-dried soil mixed with required water.
- If fiber reinforcement was used, the adopted content of fibers was first mixed into the air-dried soil in small increments by hand, making sure that all the fibers were mixed thoroughly, so that a fairly homogenous mixture is obtained, and then the required water was added.

Fig no.3.3:- Soil without fiber

Fig no.3.4:- Soil with fiber

3.4 Brief steps involved in the experiments

3.4.1 Specific gravity (G)

The specific gravity is needed to determine void ratio, degree of saturation etc. Soil contain organic matter and porous particles have value below 2.0

Specific gravity generally lie in 2.65-2.85.

$$\text{Specific gravity (G)} = \frac{W2-W1}{W4-W1-W2-W3}$$

W_1- Weight of bottle (gm)

W_2-Weight of bottle+Dry soil (gm)

W_3 - Weight of bottle+Soil+Water (gm)

W_4 - Weight of bottle+Water (gm)

Specific gravity is always measured in room temperature and reported to the nearest 0.1.

Fig no.3.5:- Pycnometer

3.4.2 LIQUID LIMIT (W_L)

With the help of Casagrande tool, we cuts a groove of size 2mm wide at the bottom and 11 mm wide at the top and 8 mm high. The total number of blows used for the groove to fill is noted down. A Graph is plotted taking number of blows on a logarithmic scale on the abscissa and water content on the ordinate. Liquid limit corresponds to 25 blows from the graph.

Fig no.3.6:- Liquid limit apparatus

3.4.3 PROCTOR COMPACTION TEST

This investigation gives an unmistakable connection between the dry thickness of the dirt and the dampness substance of the dirt. The exploratory setup comprises of (i) round and hollow metal shape (inside distance across 10.15 cm and inner stature 11.7 cm), (ii) separable base plate, (iii) neckline (5 cm viable tallness), (iv) rammer (2.5 kg). Compaction procedure helps in expanding the mass thickness by driving out the air from the voids. The hypothesis utilized in the trial is that for any compactive exertion, the dry thickness relies on the dampness content in the dirt. The most extreme dry thickness (MDD) is accomplished when the dirt is compacted at generally high dampness content and practically all the air is driven out, this dampness substance is called ideal dampness content (OMC). In the wake of plotting the information from the trial with water content as the abscissa and dry thickness as the ordinate, we can acquire the OMC and MDD. The conditions utilized in this test are as per the following:

$$\text{Wet density} = \frac{\text{weight of wet soil in mould (gm)}}{\text{volumeof mould(cc)}}$$

$$\text{Moisture content\%} = \frac{\text{weight of water (gm)}}{\text{weight of dry soil (gm)}} \times 100$$

$$\text{Drydensity}\gamma_d\text{(gm/cc)} = \frac{\text{wet density}}{1+\frac{\text{moisture content}}{100}}$$

Fig no.3.7:- Soil sample by standard proctor

3.4.4 CALIFORNIA BEARING RATIO TEST

The California Bearing Ratio (CBR) test is a proportion of opposition of a material to entrance of standard plunger under controlled thickness and dampness conditions. It was created by the California Division of Highways as a technique for arranging and assessing soil-sub level and base course materials for adaptable asphalts. CBR test might be directed in remoulded or undisturbed example. Test comprises of making a round and hollow plunger of 50mm distance across infiltrate an asphalt segment material at 1.25mm/minute. The heaps for 2.5mm and 5mm are recorded. This heap is communicated as a level of standard burden an incentive at a separate disfigurement level to get CBR esteem. CBR-esteem is utilized as a list of soil quality and bearing limit. This esteem is comprehensively utilized and connected in plan of the base and the sub-base material for asphalt. CBR test was directed to describe the quality and the bearing limit of the two considered soils and their blends with PET filaments. The test techniques and the arrangement of the examples were accomplished by the standard methodology. The tests were led on quality properties according to the exploratory program. The ideal level of PET added to think about the quality properties.

4) RESULTS AND DISCUSSIONS

4.1 SPECIFIC GRAVITY

Table no.4.1:-Calculation of specific gravity

sample number	1	2	3
Mass of empty bottle (M1) (gm)	446.8	446.8	446.8
Mass of bottle+ dry soil (M2) (gm)	646.8	696.8	746.8
Massofbottle+drysoil+water(M3)(gm)	1340	1369.52	1402.91
Mass of bottle + water (M4) (gm)	1212.8	1212.8	1212.8
Specific gravity	2.75	2.68	2.73
Avg. specific gravity	**2.72**		

4.2 LIQUID LIMIT

Table no.4.2:- Calculation of liquid limit

Sample No.	1	2	3
Mass of empty can	13.08	12.68	13.2
Mass of can + wet soil (gm)	53.08	52.68	53.2
Mass of can + dry soil (gm)	44.48	43.67	43.74
Mass of soil solids	31.4	30.99	30.54
Mass of pore water	8.6	9.01	9.46
Water content (%)	27.40	29.1	31

No. of blows	30	23	18

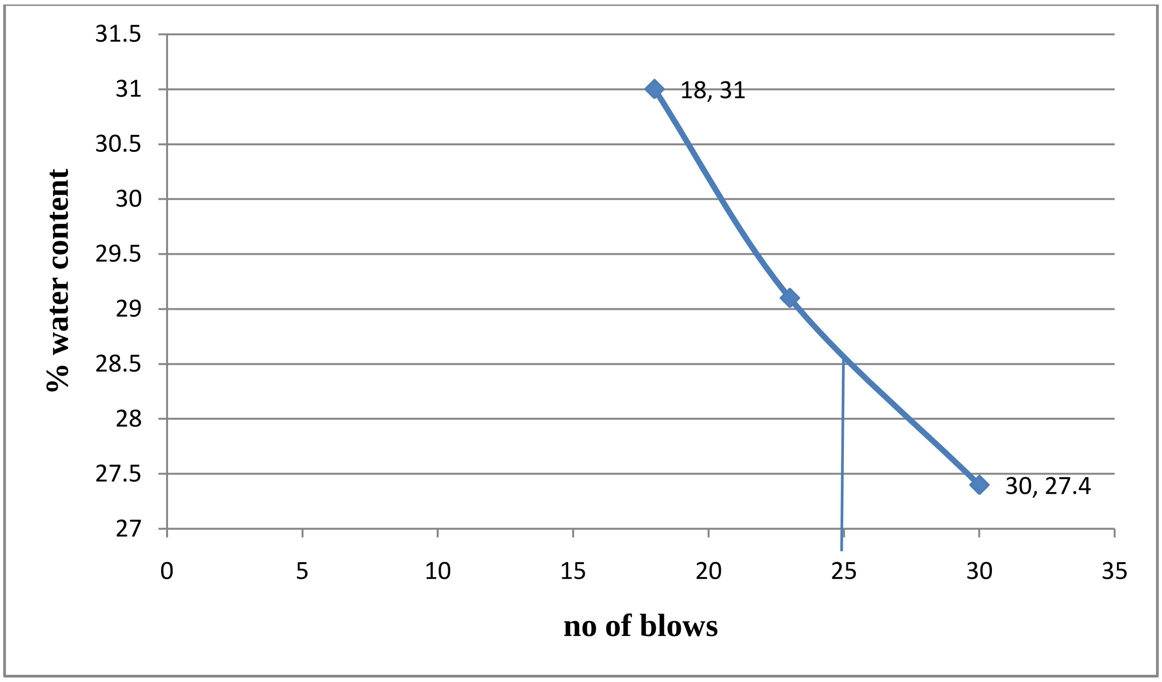

Fig no.4.1:- Liquid limit (corresponding to 25 blows)

Liquid limit as obtained from graph = 28.50 %

4.3 PARTICLE SIZE DISTRIBUTION

Weight of soil sample taken initially = 500 gm

Table no. 4.3:- Sieve analysis readings

Sieve Size (mm)	Retained (gm)	Retained (%)	Cumulative retained (%)	Cumulative finer (%)
4.75	0	0	0	100
2.36	3.9	0.78	0.78	99.22
1.18	21.55	4.31	5.09	94.91
0.6	132.75	26.55	31.64	68.36
0.3	227	45.4	77.04	22.96
0.15	78.3	15.66	92.7	7.3
0.075	36.5	7.3	100	0

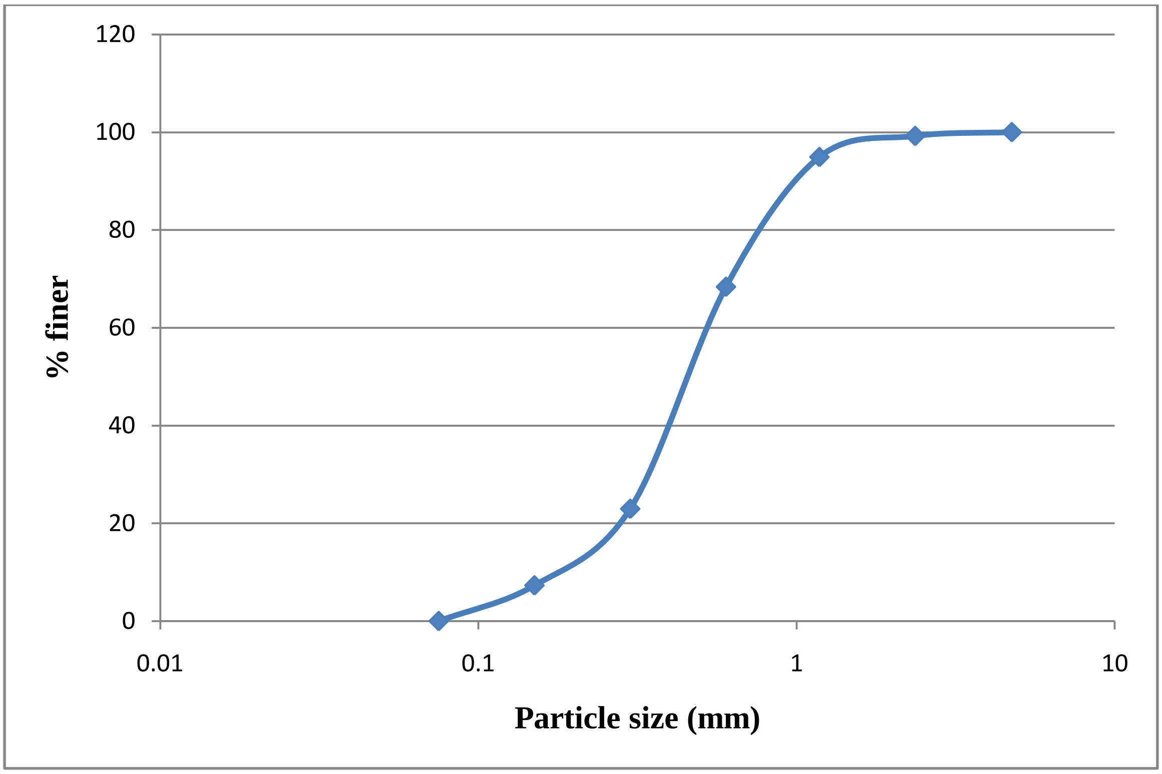

Fig no.4.2:- Grain size distribution curve

4.4 STANDARD PROCTOR TEST

4.4.1 UNREINFORCED SOIL

- Dry density and moisture content will determined of unreinforced soil.
- Refer Table A in Annexure A for dry density and moisture content values.

The dry density was plotted against the moisture content and the maximum dry density and optimum moisture for the unreinforced soil was found out.

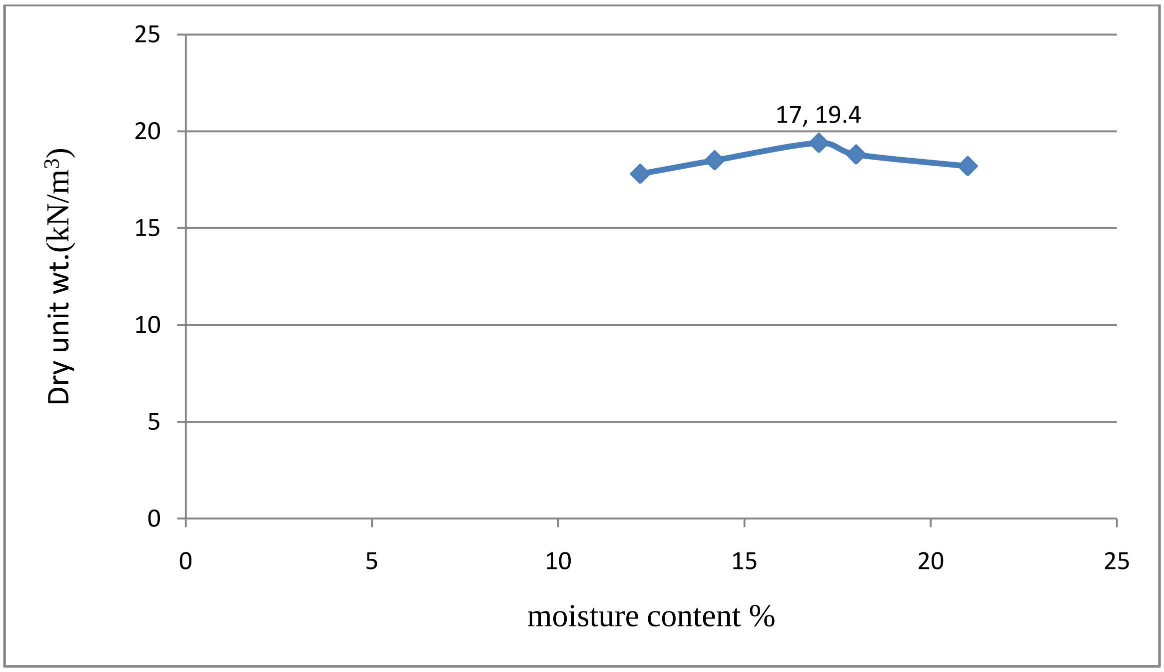

Fig no.4.3:- Proctor compaction test at 0% reinforcement

From the graph, it is evident that

Optimum moisture content (OMC) = **17 %**

Maximum dry density (MDD) = **19.4 kN/m^3**

4.4.2 REINFORCEMENT = 0.25 %

- Dry density and moisture content will determined of Soil with 0.25% fiber content.
- Refer Table A2 in Annexure A for dry density and moisture content values.

The dry density was plotted against the moisture content and the maximum dry density and optimum moisture for the reinforced soil with 0.25% fiber content was found out.

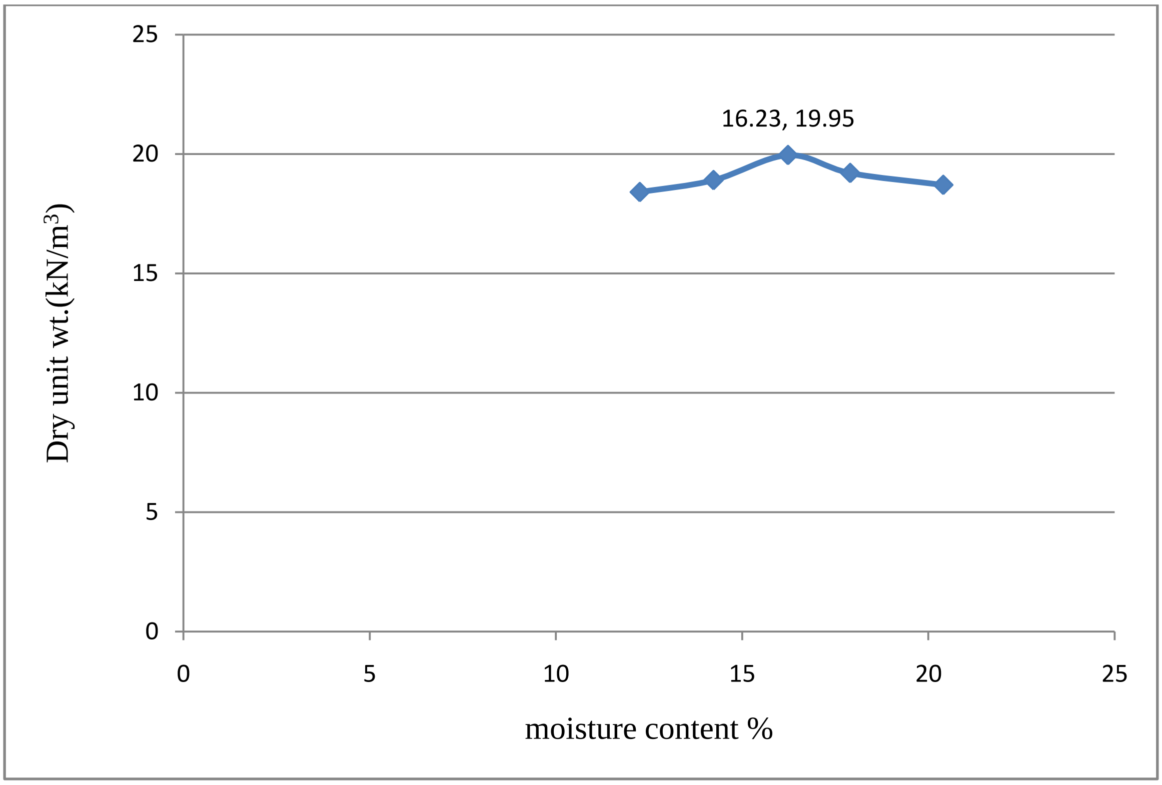

Fig no.4.4:- Proctor compaction test at 0.25% reinforcement

From the graph, it is evident that

Optimum moisture content (OMC) = **16.23 %**

Maximum dry density (MDD) = **19.95 kN/m^3**

4.4.3 REINFORCEMENT = 0.5 %

- Dry density and moisture content will determined of Soil with 0.5% fiber content.
- Refer Table A3 in Annexure A for dry density and moisture content values.

The dry density was plotted against the moisture content and the maximum dry density and optimum moisture for the reinforced soil with 0.5% fiber content was found out.

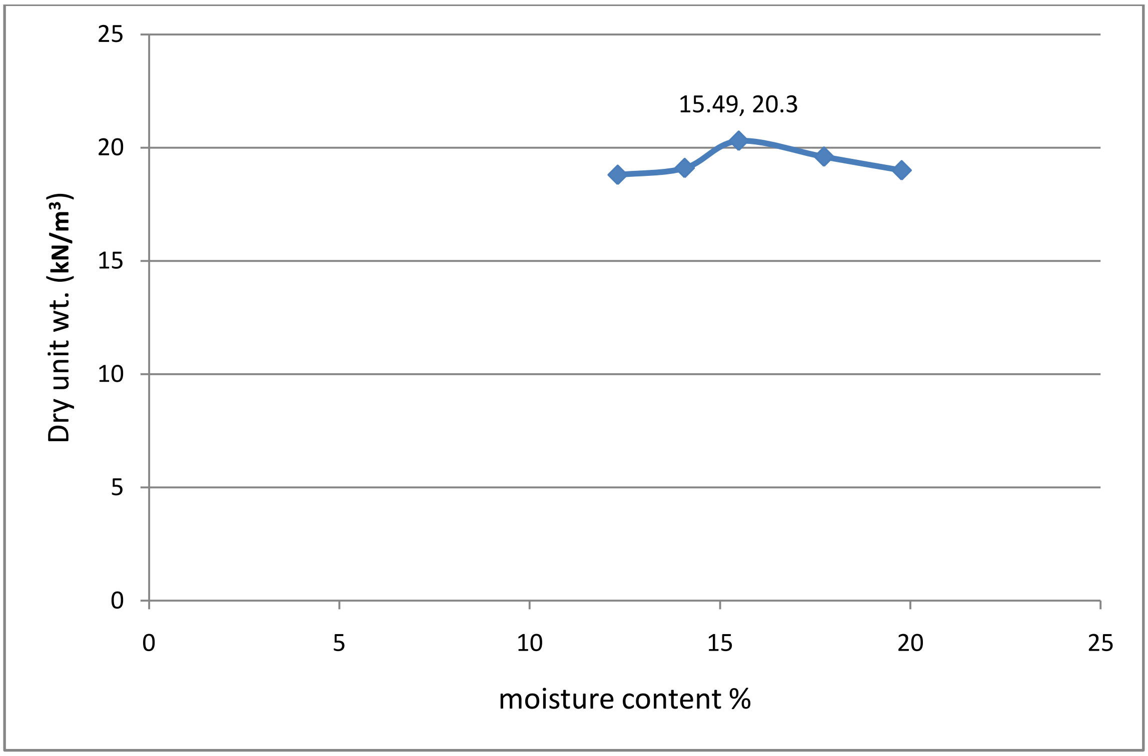

Fig no.4.5:- Proctor compaction test at 0.5% reinforcement

From the graph, it is evident that

Optimum moisture content (OMC) = **15.49 %**

Maximum dry density (MDD) = **20.3 kN/m^3**

4.4.4 REINFORCEMENT = 1 %

- Dry density and moisture content will determined of Soil with 1% fiber content.
- Refer Table A4 in Annexure A for dry density and moisture content values.

The dry density was plotted against the moisture content and the maximum dry density and optimum moisture for the reinforced soil with 1% fiber content was found out.

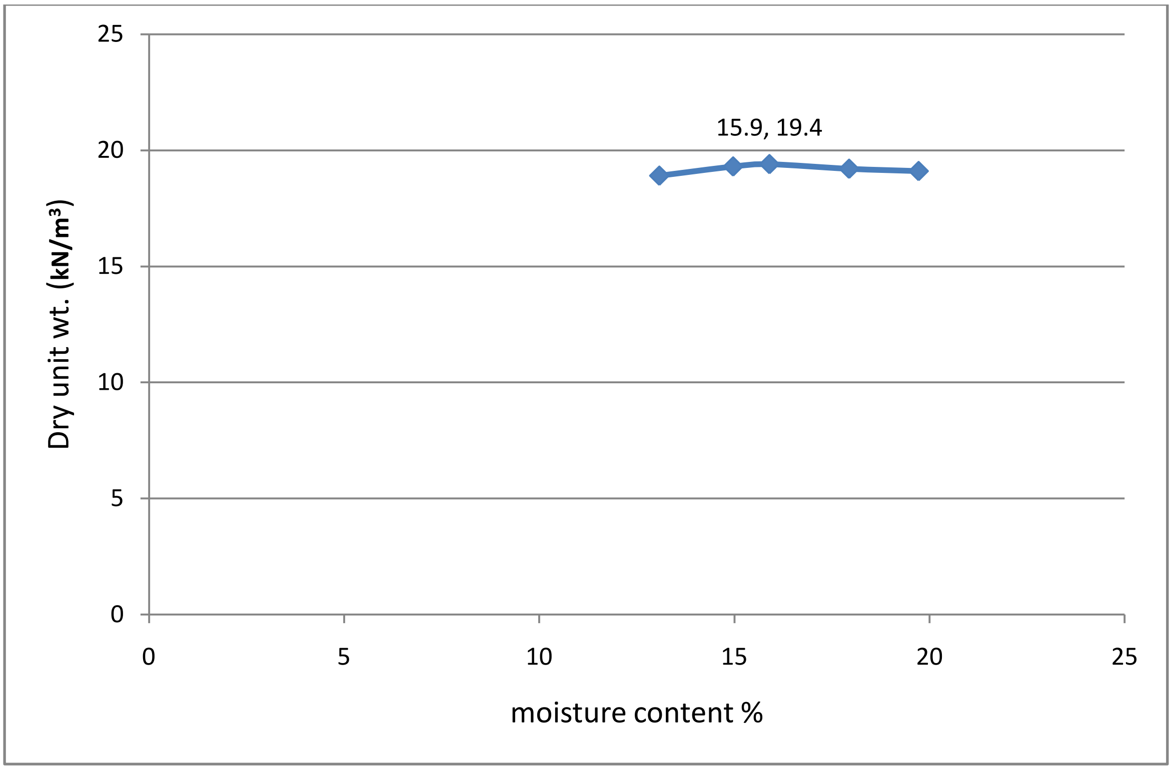

Fig no.4.6:- Proctor compaction test at 1% reinforcement

From the graph, it is evident that

Optimum moisture content (OMC) = **15.9 %**

Maximum dry density (MDD) = **19.4 kN/m^3**

4.4.5 REINFORCEMENT = 1.5 %

- Dry density and moisture content will determined of Soil with 1.5% fiber content.
- Refer Table A5 in Annexure A for dry density and moisture content values.

The dry density was plotted against the moisture content and the maximum dry density and optimum moisture for the reinforced soil with 1.5% fiber content was found out.

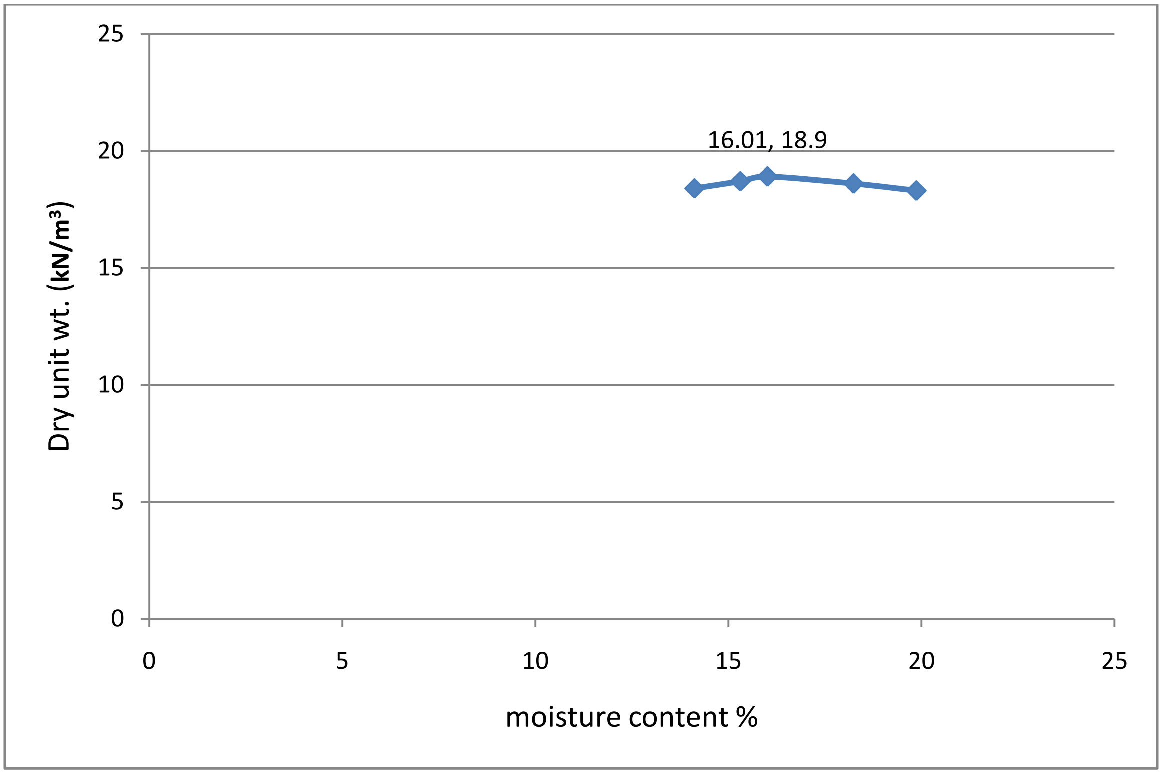

Fig no.4.7:- Proctor compaction test at 1.5% reinforcement

From the graph, it is evident that

Optimum moisture content (OMC) = **16.01%**

Maximum dry density (MDD) = **18.9 kN/m^3**

4.4.6 VARIATION IN OMC AND MDD DUE TO REINFORCEMENT

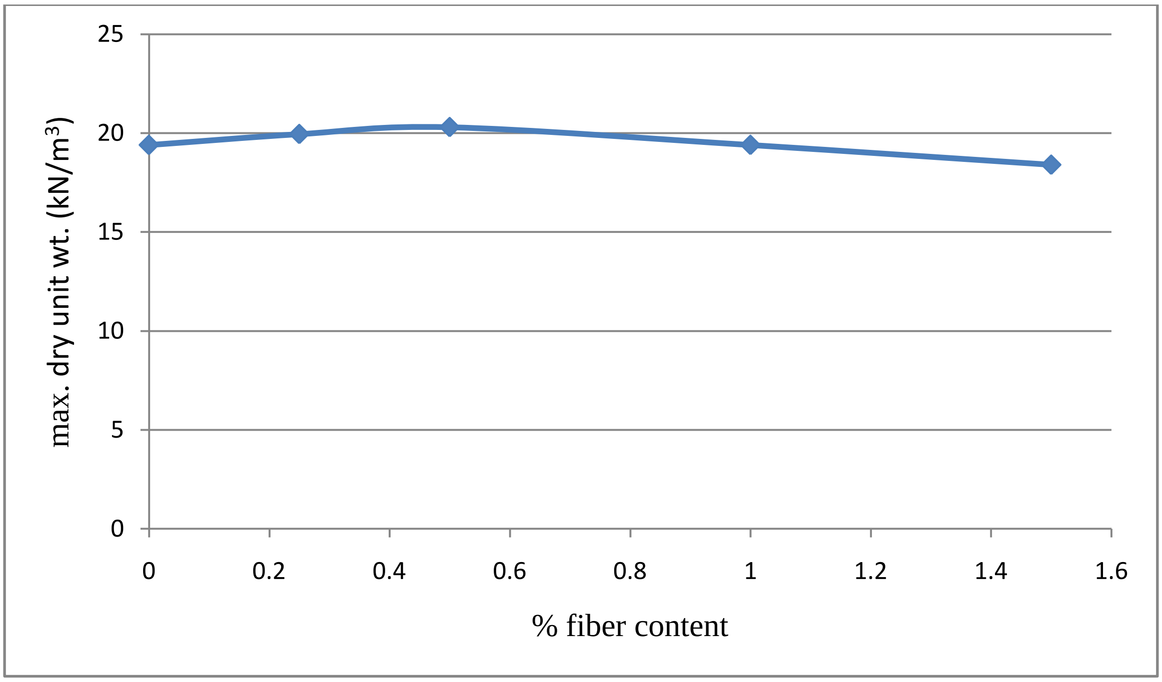

Fig no.4.8:- Relationship between max.dry density and fiber content

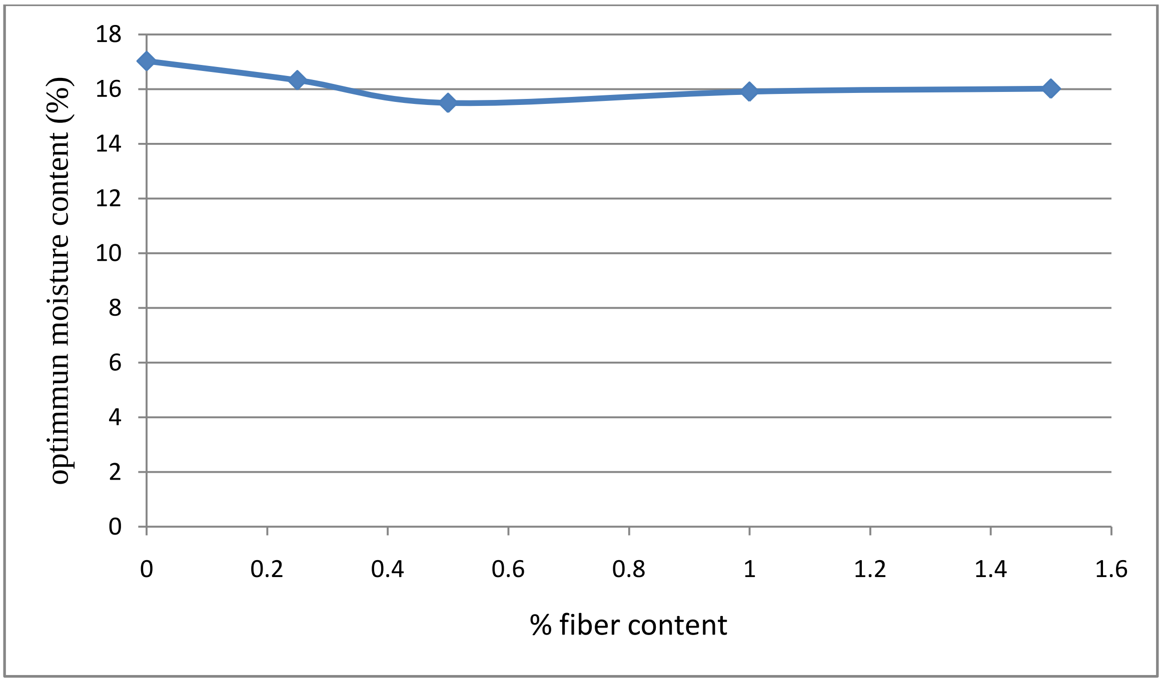

Fig no.4.9:- Relationship between OMC and fiber content

4.5 DIRECT SHEAR TEST

4.5.1 UNREINFORCED SOIL

- Optimum moisture content – 17 %
- Normal stress and shear stress will determined of unreinforced soil.
- Refer Table B1 in Annexure B for stress values.

The Normal stress was plotted against the Shear stress and cohesion and angle of internal friction of unreinforced soil will found out.

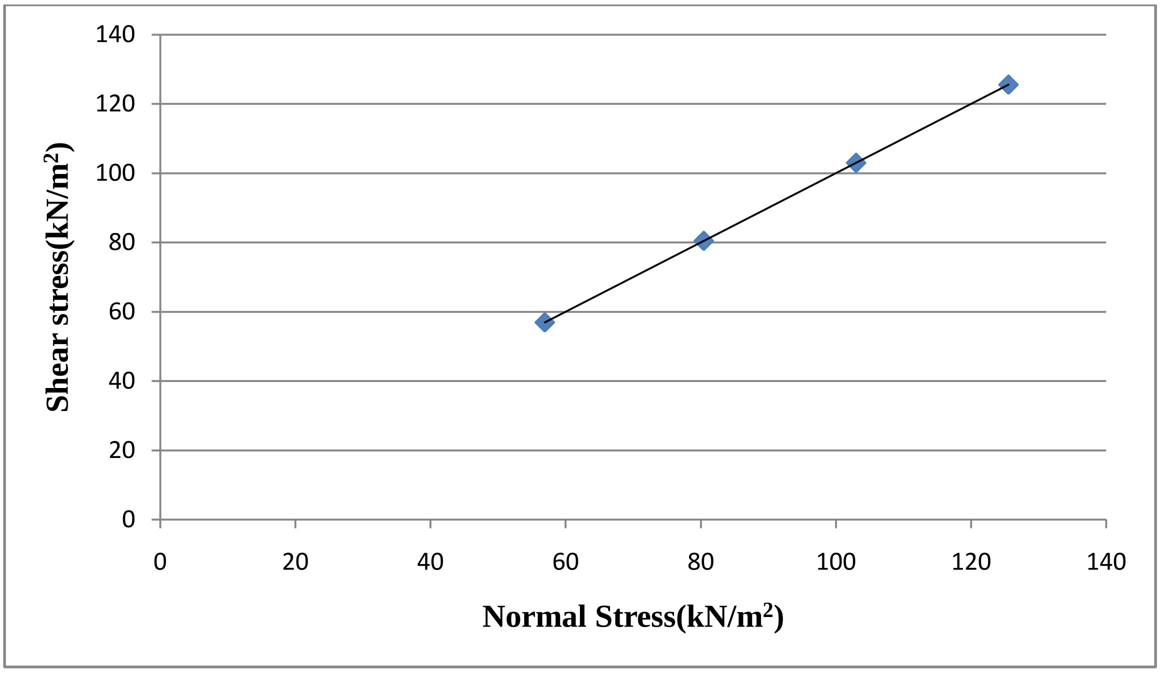

Fig.no.4.10:- Mohr-Coulomb failure envelope of soil sample with 0 % reinforcement

From the graph, it is evident that

Cohesion (C) = **1.37 kN/m^2**

Angle of internal friction (ϕ) = **45°**

4.5.2 REINFORCEMENT = 0.25 %

- Optimum moisture content – 16.23 %
- Normal stress and shear stress will determined of Soil with 0.25 % fiber content.
- Refer Table B2 in Annexure B for stress values.

The Normal stress was plotted against the Shear stress and cohesion and angle of internal friction of Soil with 0.25 % fiber content will found out.

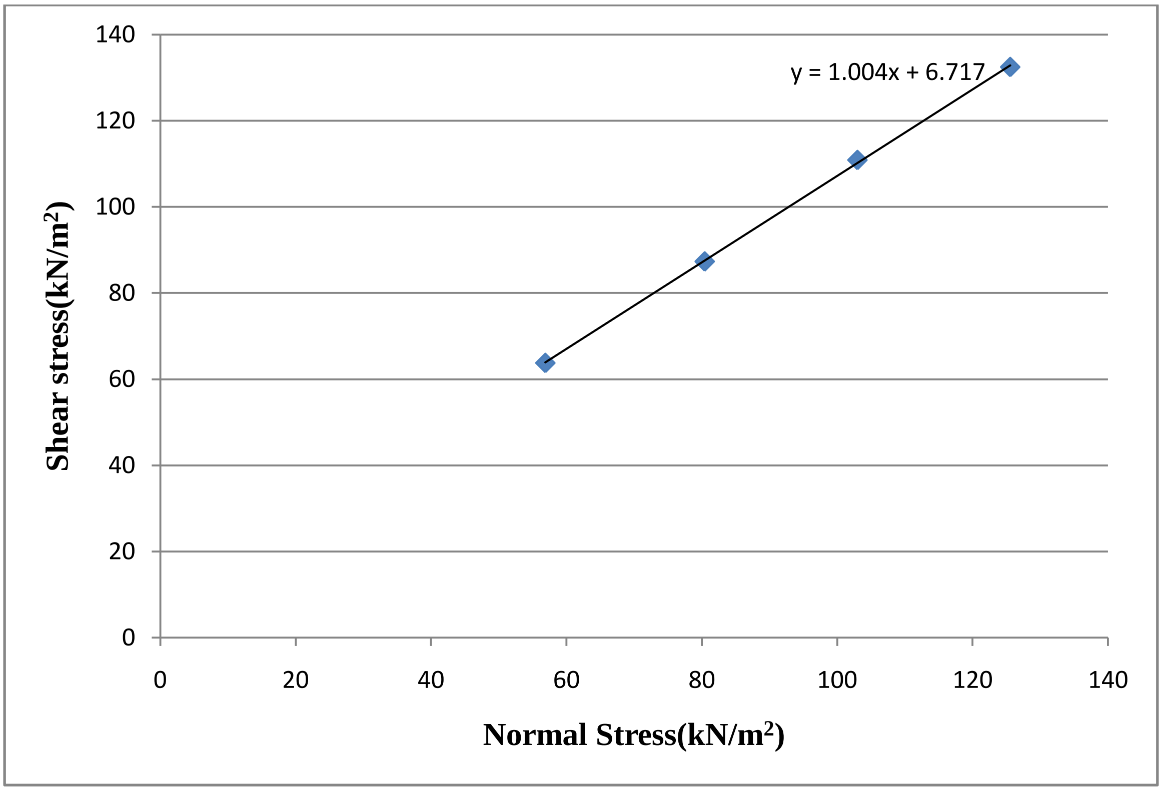

Fig no.4.11:- Mohr-Coulomb failure envelope of soil sample with 0.25 % reinforcement

From the graph, it is evident that

Cohesion (C) = **6.717 kN/m^2**

Angle of internal friction(ϕ) = **45.11**$^\circ$

4.5.3 REINFORCEMENT = 0.5 %

- Optimum moisture content – 15.49 %
- Normal stress and shear stress will determined of Soil with 0.5 % fiber content.
- Refer Table B3 in Annexure B for stress values.

The Normal stress was plotted against the Shear stress and cohesion and angle of internal friction of Soil with 0.5 % fiber content will found out.

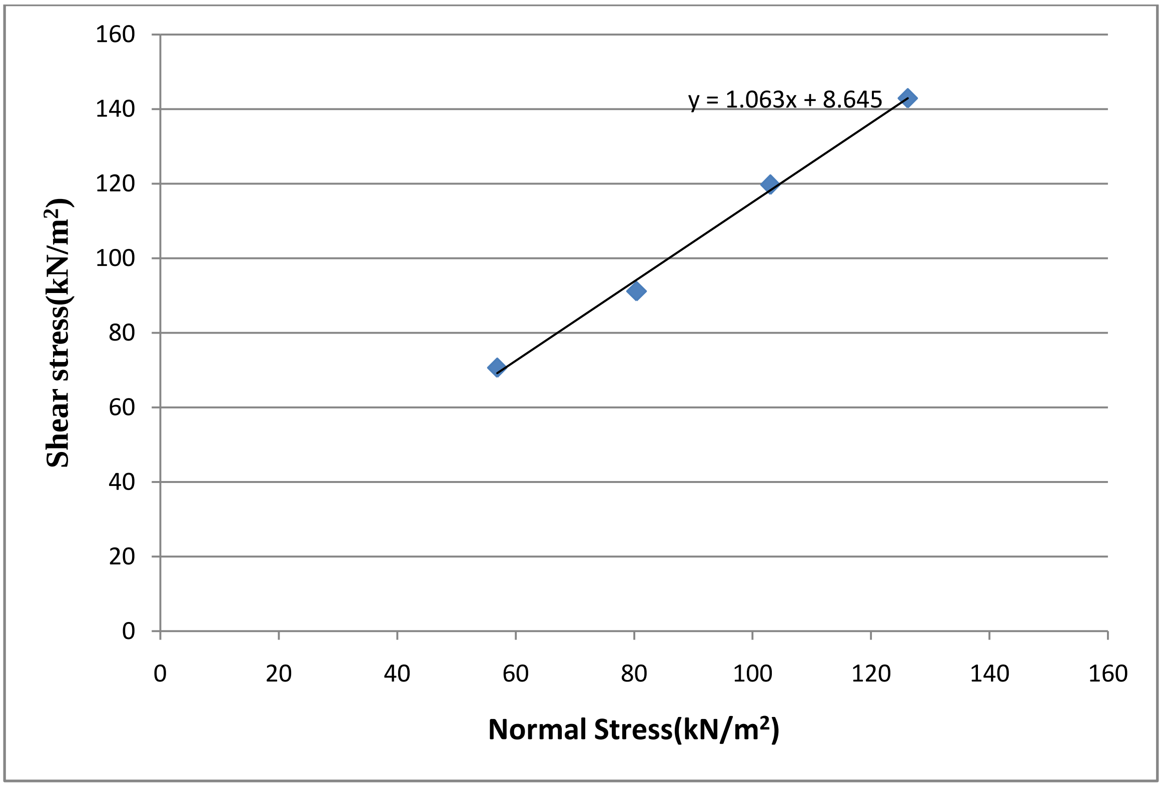

Fig no.4.12:- Mohr-Coulomb failure envelope of soil sample with 0.5 % reinforcement

From the graph, it is evident that

Cohesion(C)= **8.645 kN/m^2**

Angleofinternalfriction(ϕ)=**46.75**$^\circ$

4.5.4 REINFORCEMENT = 1 %

- Optimum moisture content – 15.9 %
- Normal stress and shear stress will determined of Soil with 1 % fiber content.
- Refer Table B4 in Annexure B for stress values.

The Normal stress was plotted against the Shear stress and cohesion and angle of internal friction of Soil with 1 % fiber content will found out.

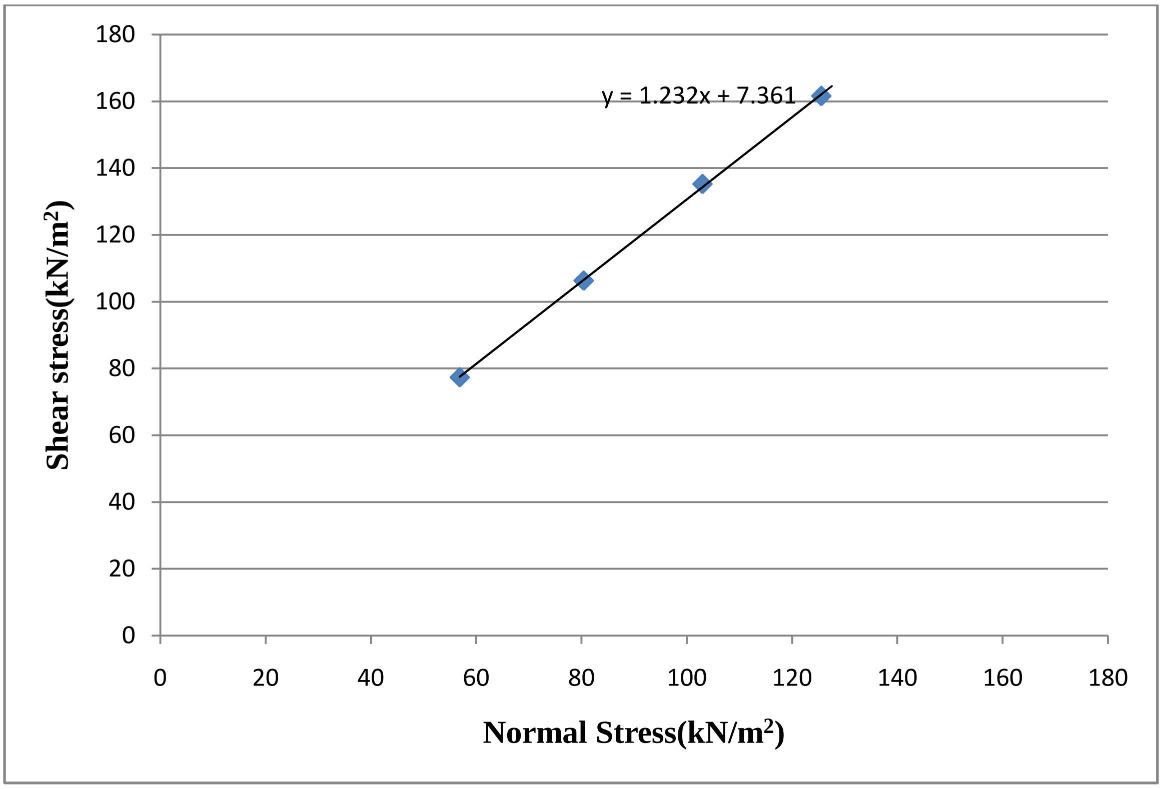

Fig no.4.13:- Mohr-Coulomb failure envelope of soil sample with 1 % reinforcement

From the graph, it is evident that

Cohesion(C)= **7.361 kN/m^2**

Angle of internal friction (ϕ)= **50.93**$^\circ$

4.5.5 REINFORCEMENT = 1.5 %

- Optimum moisture content – 16.1 %
- Normal stress and shear stress will determined of Soil with 1.5 % fiber content.
- Refer Table B5 in Annexure B for stress values.

The Normal stress was plotted against the Shear stress and cohesion and angle of internal friction of Soil with 1.5 % fiber content will found out.

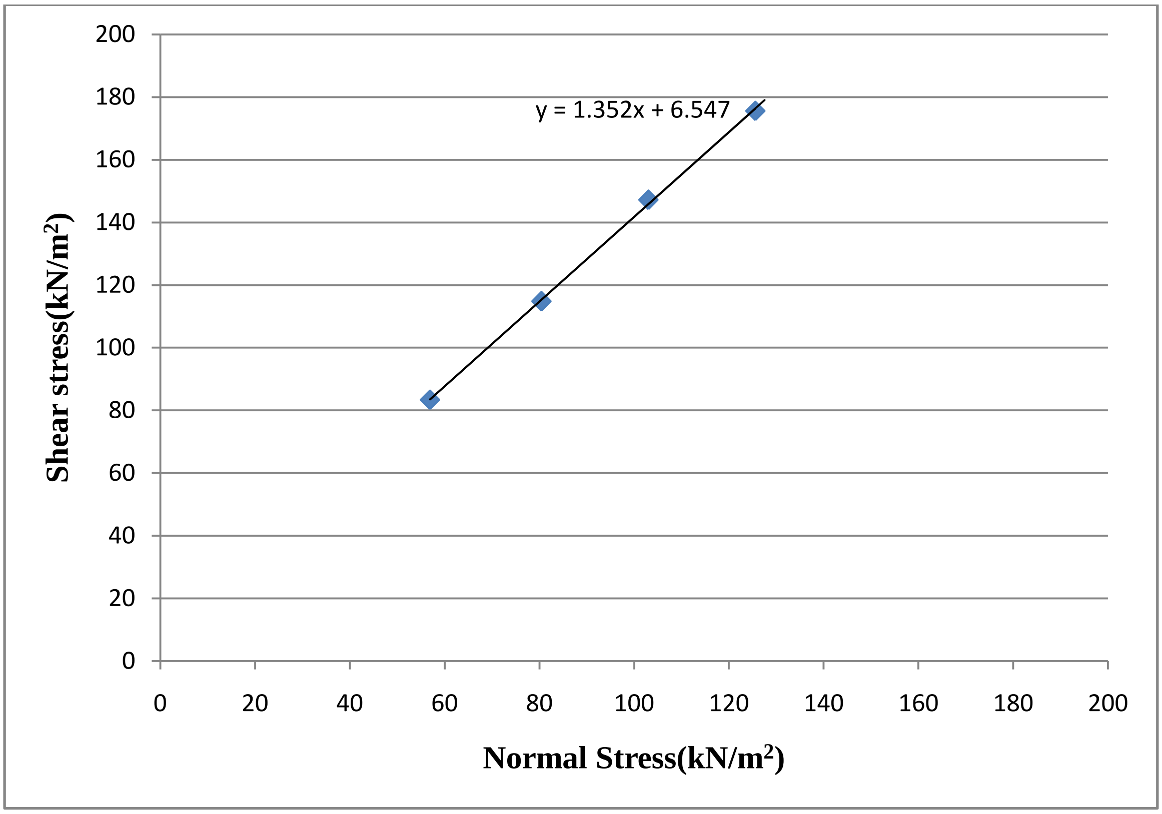

Fig no. 4.14:- Mohr-Coulomb failure envelope of soil sample with 1.5 % reinforcement

Computing from graph,

Cohesion (C) = **6.547 kN/m^2**

Angle of internal friction (ϕ) = **53.511**$^\circ$

4.5.6 Relation between shear parameters and fiber content

a) Cohesion and fiber content

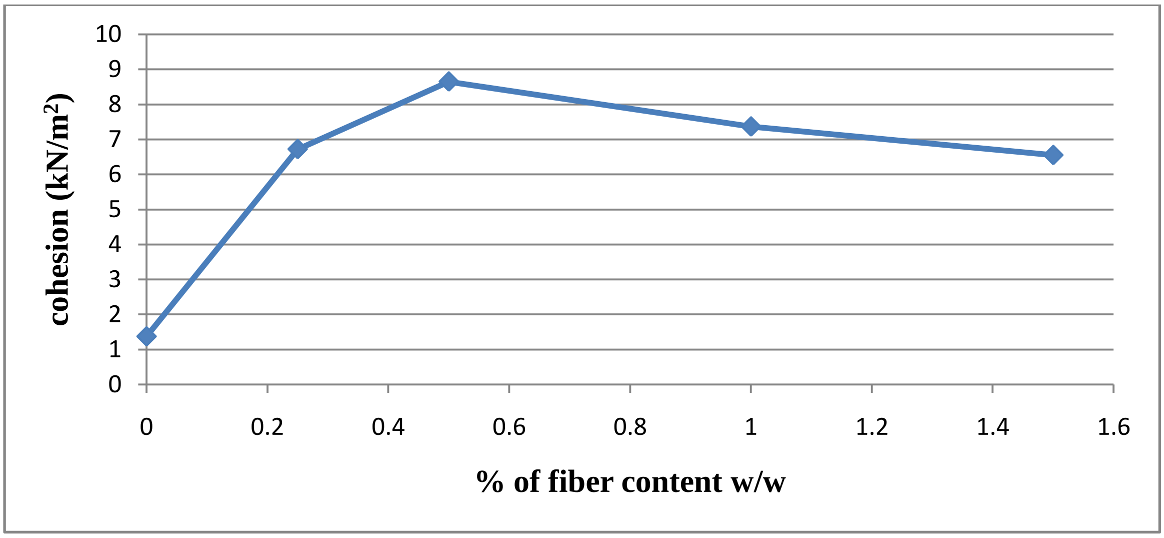

Fig no.4.15:- Relationship between cohesion and fiber content

b) Angle of internal friction and fiber content

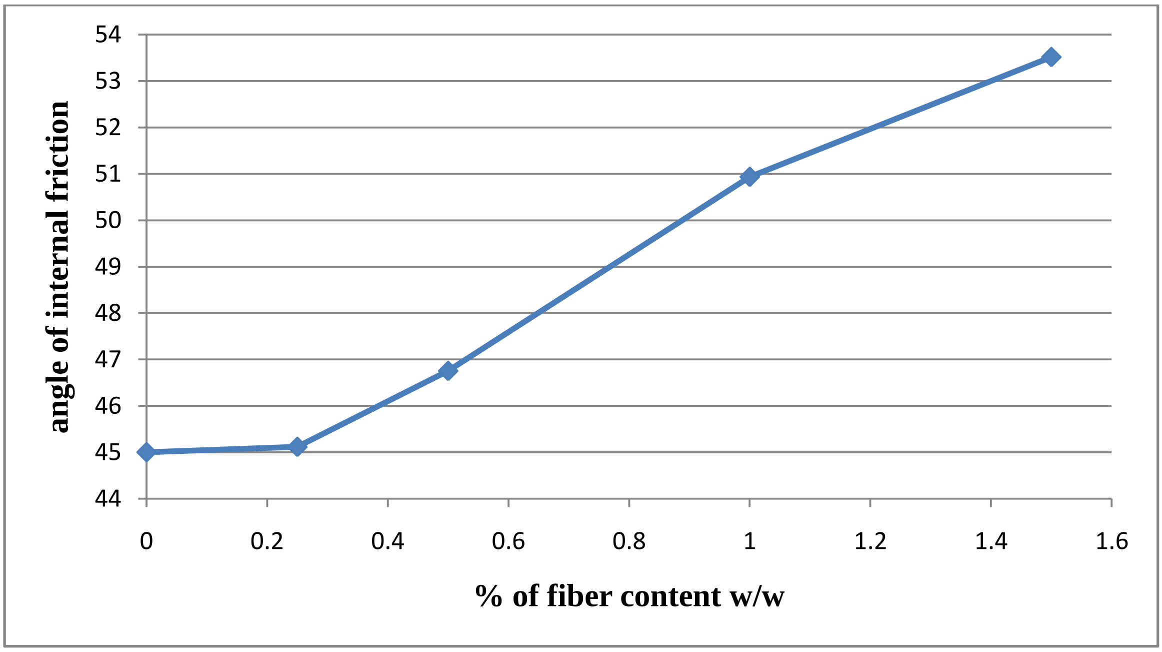

Fig no.4.16:-Relationship between angle of internal friction and fiber content

4.6 CALIFORNIA BEARING RATIO TEST

4.6.1 UNREINFORCED SOIL

- Optimum moisture content – 17.02 %
- Refer Table C1 in Annexure C for data

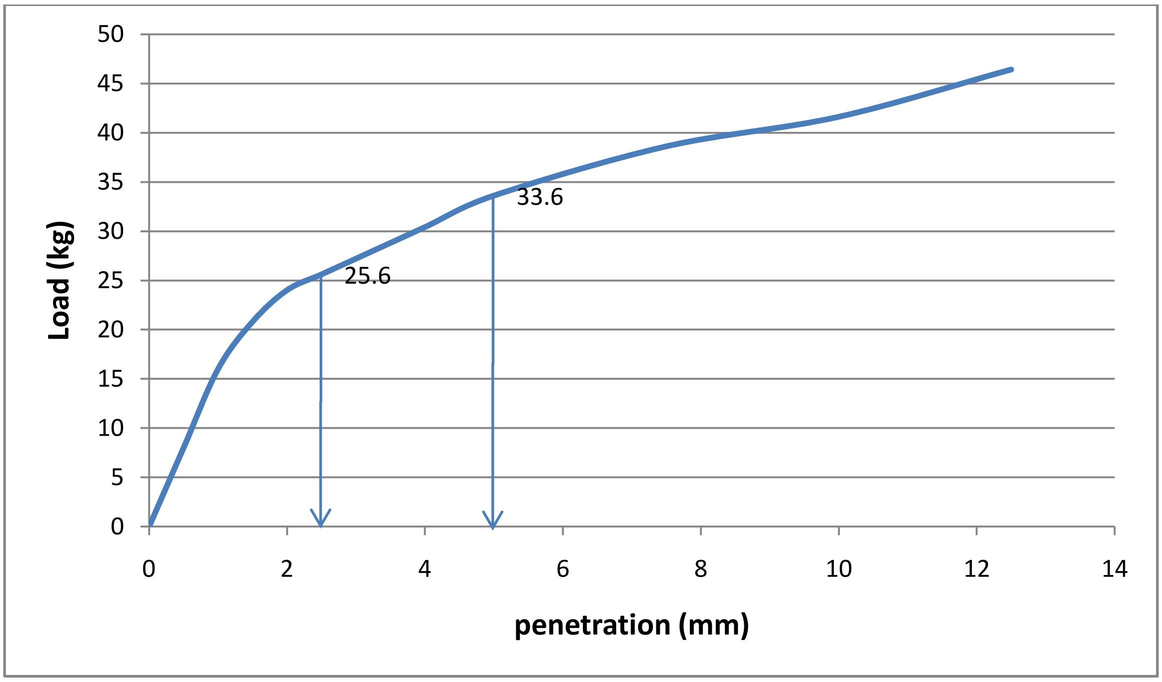

Fig no. 4.17:- CBR curve of Unreinforced soil

From the graph, Load at 2.5 mm penetration = 25.6 kg

Load at 5 mm penetration = 33.6 kg

At 2.5 mm, CBR = $\frac{25.6}{1370}$*100 = 1.868 %

At 5 mm, CBR = $\frac{33.6}{2055}$*100 = 1.635 %

4.6.2 REINFORCEMENT = 0.25 %

- Optimum moisture content – 16.32 %
- Refer Table C2 in Annexure C for data

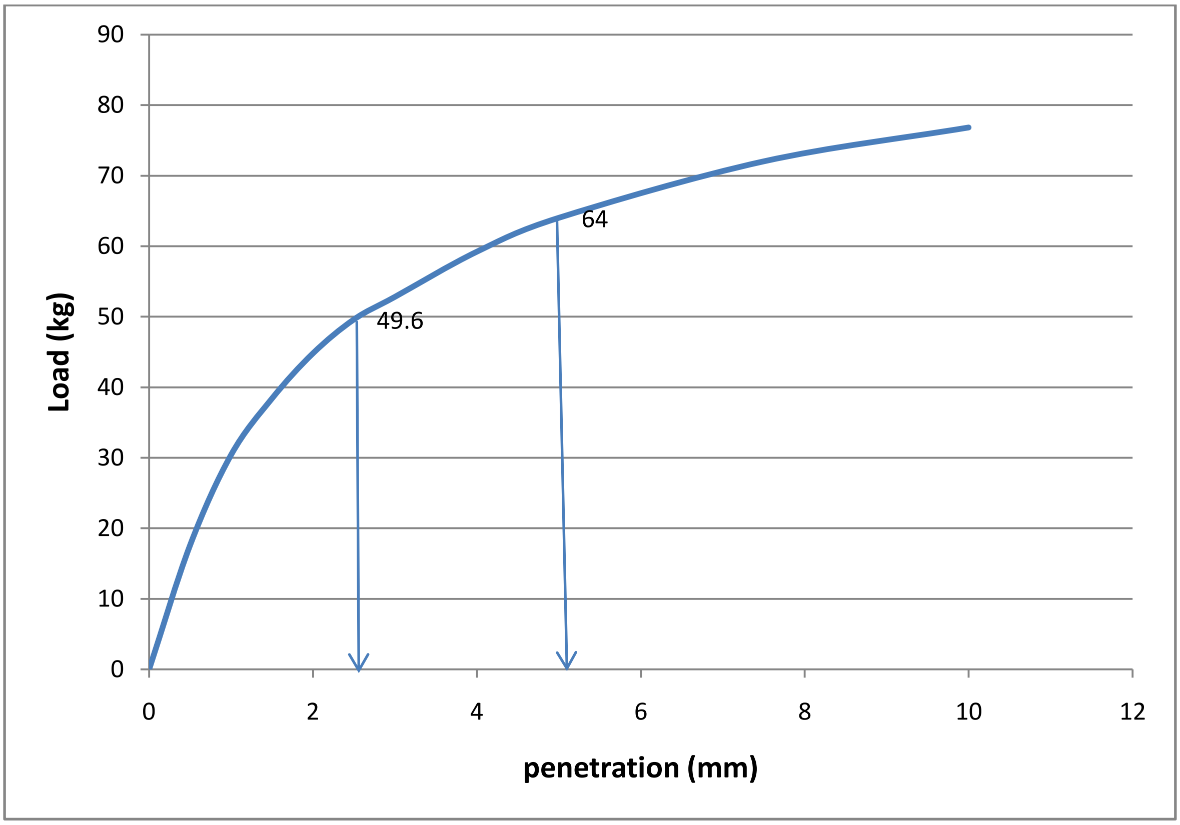

Fig no.4.18:- CBR curve of soil sample with 0.25 % reinforcement

From the graph, Load at 2.5 mm penetration = 49.6 kg

Load at 5 mm penetration = 64 kg

At 2.5 mm, CBR = $\frac{49.6}{1370}$*100 = 3.62 %

At 5 mm, CBR = $\frac{64}{2055}$*100 = 3.11 %

4.6.3 REINFORCEMENT = 0.5 %

- Optimum moisture content – 15.49 %
- Refer Table C3 in Annexure C for data

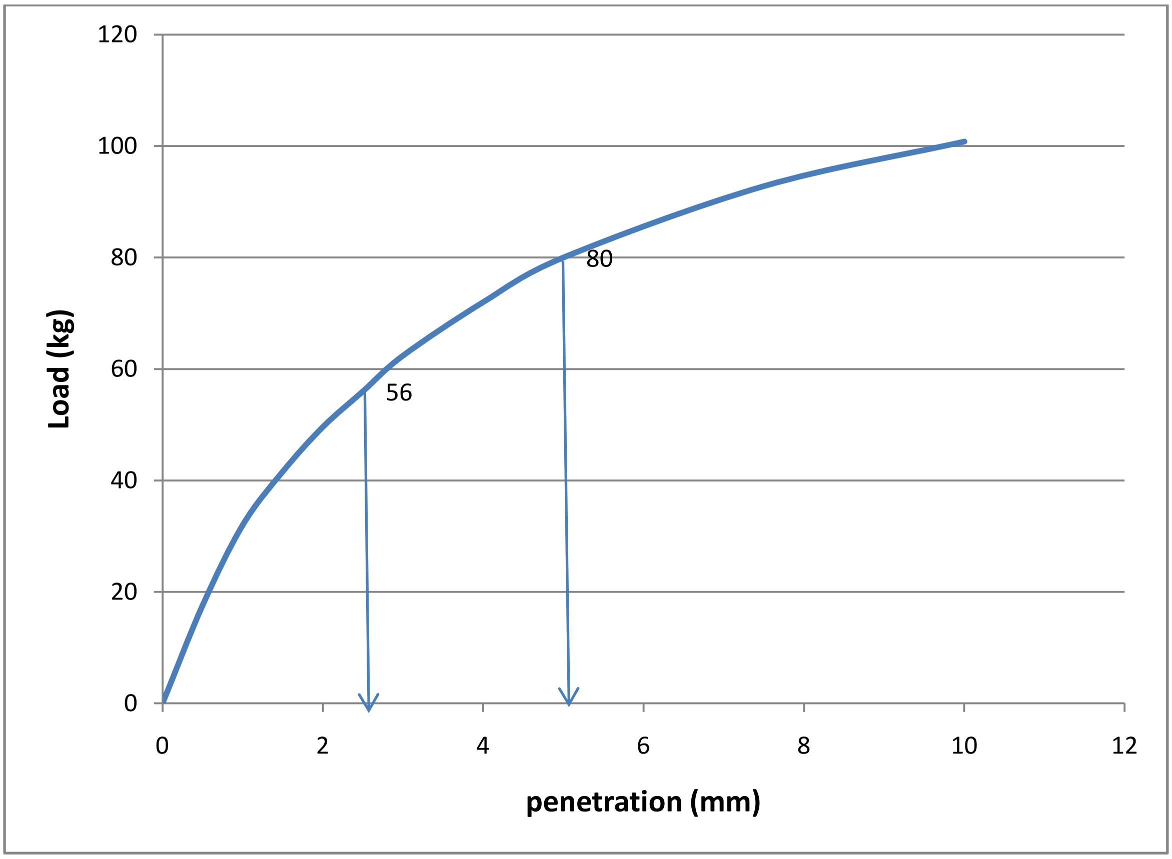

Fig no.4.19:- CBR curve of soil sample with 0.5 % reinforcement

From the graph, Load at 2.5 mm penetration = 56 kg

Load at 5 mm penetration = 80 kg

At 2.5 mm, CBR = $\frac{56}{1370}$*100 = 4.087 %

At 5 mm, CBR = $\frac{80}{2055}$*100 = 3.893 %

4.6.4 REINFORCEMENT = 1 %

- Optimum moisture content – 15.9 %
- Refer Table C4 in Annexure C for data

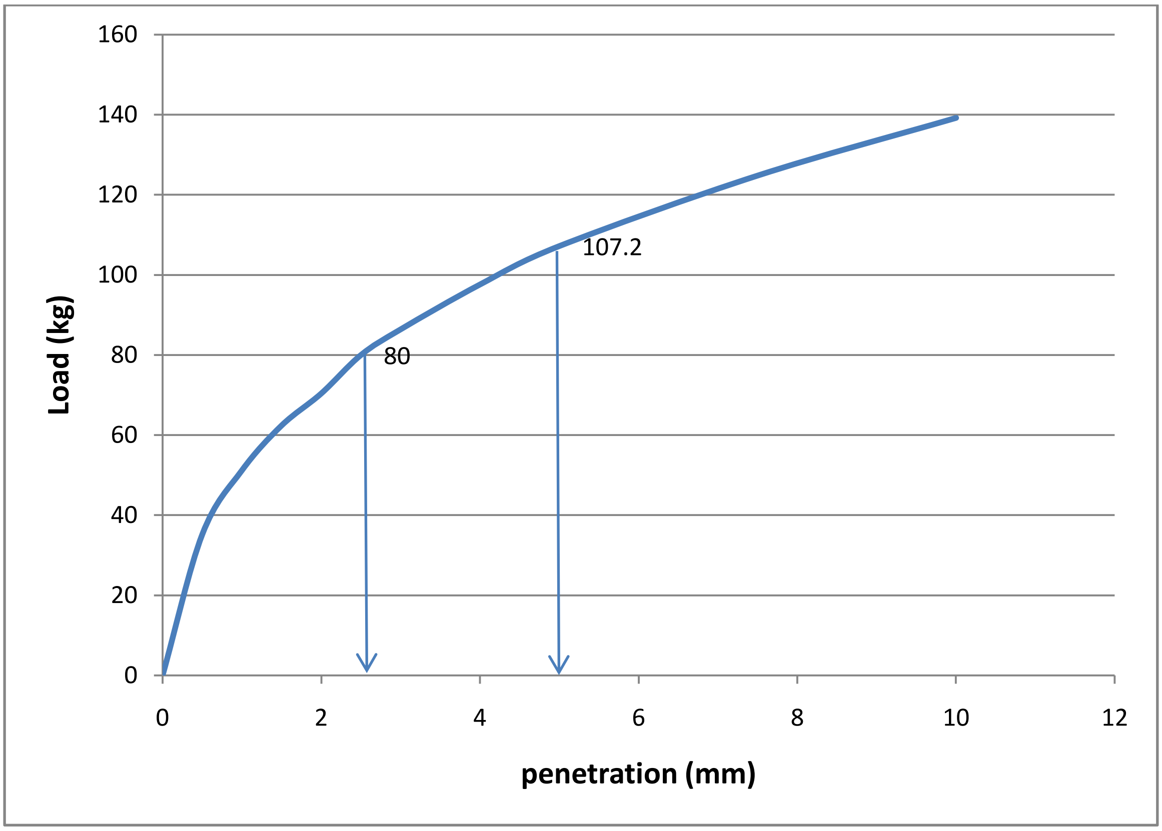

Fig no.4.20:- CBR curve of soil sample with 1 % reinforcement

From the graph, Load at 2.5 mm penetration = 80 kg

Load at 5 mm penetration = 107.2 kg

At 2.5 mm, CBR = $\frac{80}{1370}$*100 = 5.84 %

At 5 mm, CBR = $\frac{107.2}{2055}$*100 = 5.276 %

4.6.5 REINFORCEMENT = 1.5 %

- Optimum moisture content – 16.01 %
- Refer Table C5 in Annexure C for data

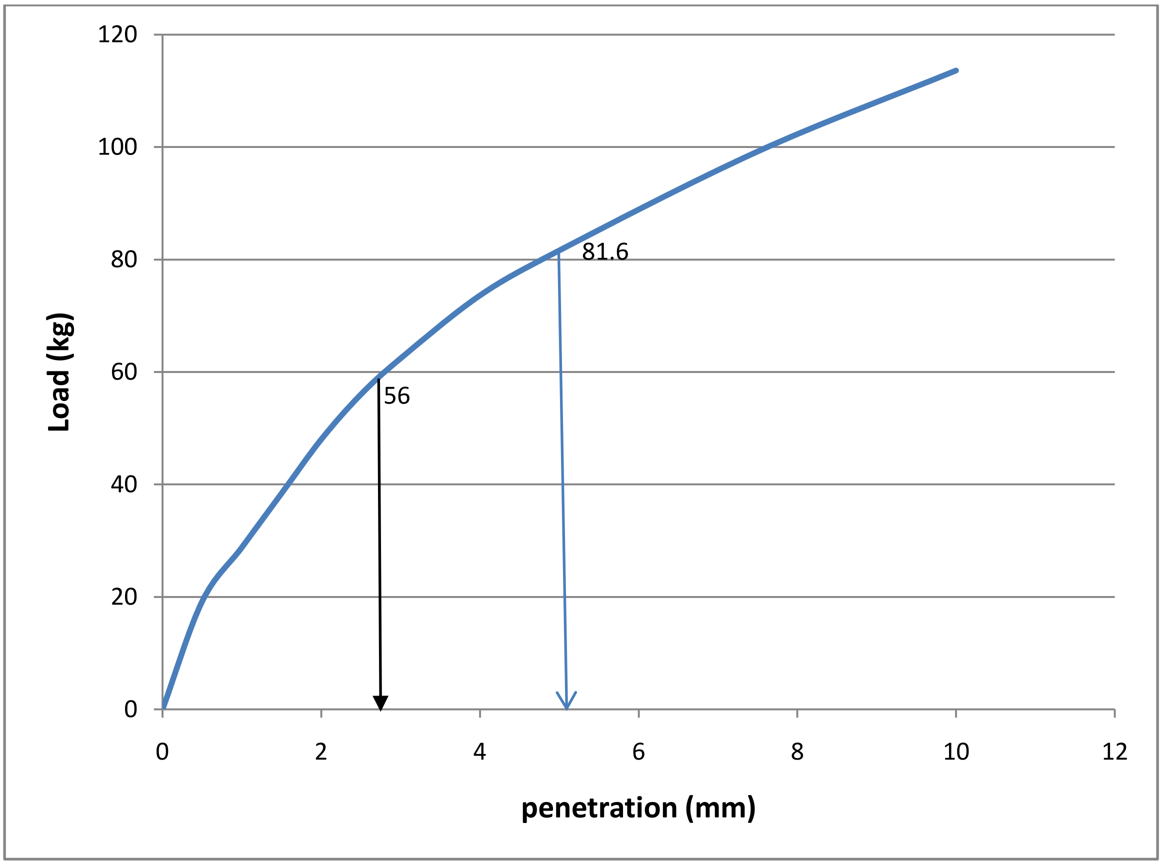

Fig no.4.21:- CBR curve of soil sample with 1.5 % reinforcement

From the graph, Load at 2.5 mm penetration = 56 kg

Load at 5 mm penetration = 81.6 kg

At 2.5 mm, CBR = $\frac{56}{1370}$*100 = 4.087 %

At 5 mm, CBR = $\frac{81.6}{2055}$*100 = 3.97 %

4.6.6 Variation of CBR value with fiber content

a) At 2.5 mm penetration

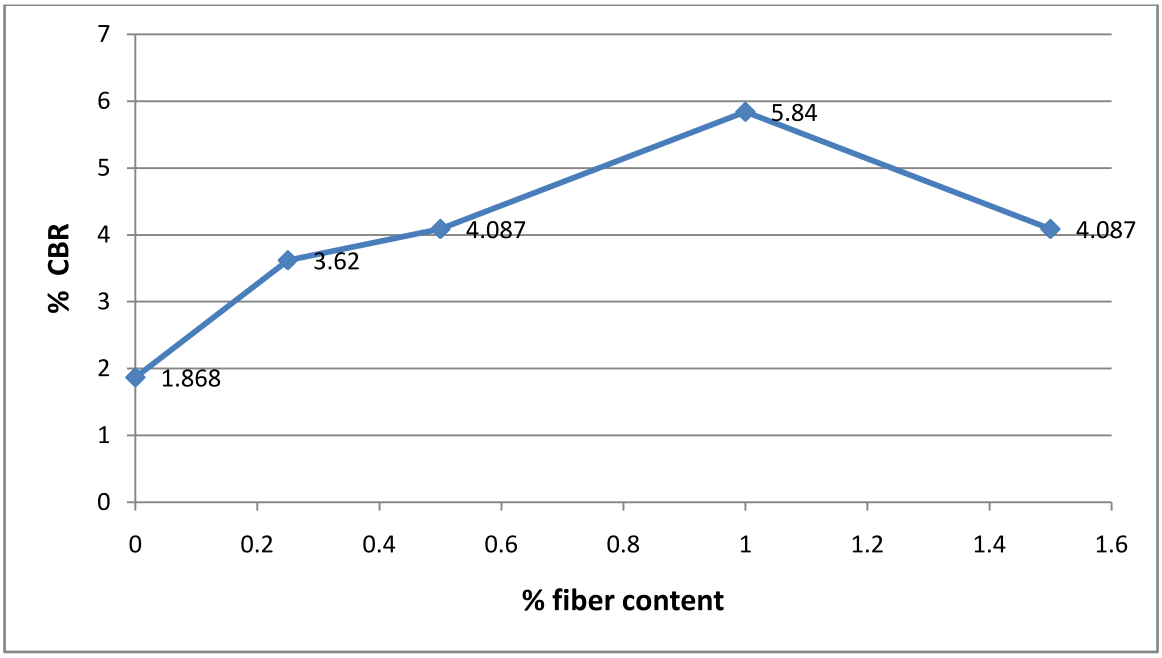

Fig no.4.22:- CBR value at various fiber content at 2.5 mm penetration

b) At 5 mm penetration

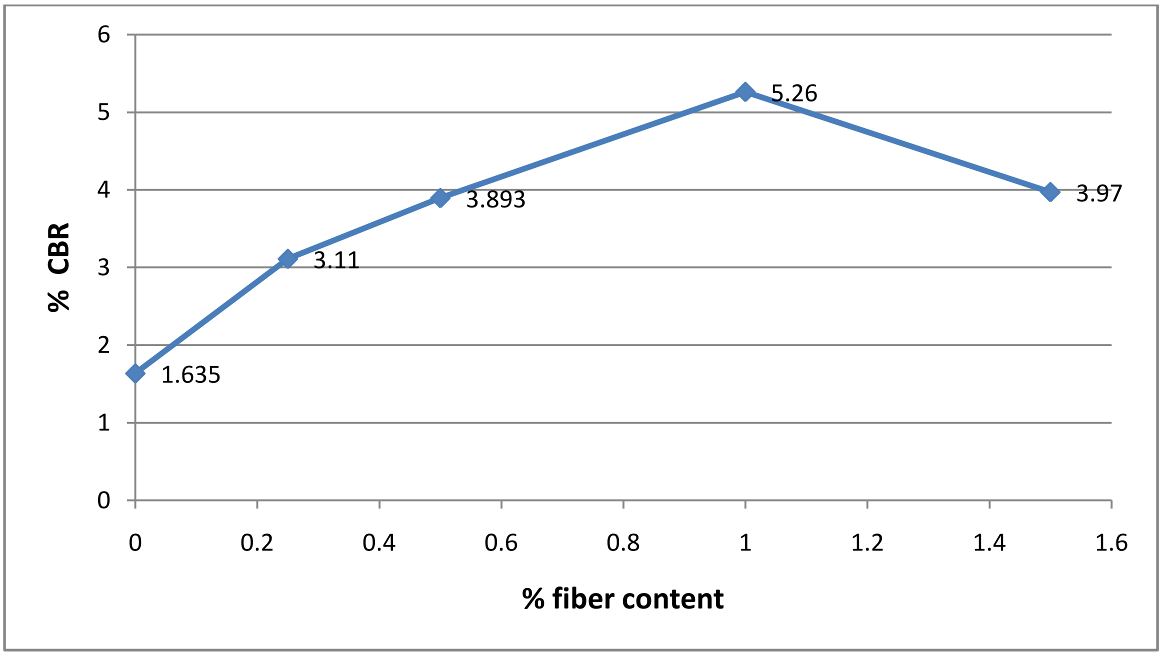

Fig no.4.23:- CBR value at various fiber content at 5 mm penetration

5) CONCLUSION

This project is focused on the review of performance of plastic fiber as a soil stabilization material. The study suggests that if plastic fiber if properly mixed and applied, can be used as a great soil stabilization technique .On the basis of this project the following results were obtained.

1) The replacement of 0.5% plastic fibers to the soil reduce its OMC and increased the Maximum Dry Density, with further replacement it was observed that the MDD & UCC was less than the 0.5% replacement but was greater than the untreated soil.

2) The increase in the Maximum Dry Density of the soil is due to the decrease in the number of voids with the addition of plastic which leads to effective compaction and also increase in the cohesion.

3) By addition of optimum percentage plastic fibers, there is high increment in cohesion and some increment in angle of internal friction, therefore we can say that, the net increment in shear strength of soil is **substantial**.

4) The percentage increase in CBR value at 2.5mm is 212.63% and at 5mm is 222.7% when soil is mixed with optimum percentage of plastic fibers.

Highlighting the need for further research study in this field may shed light on application of plastic material for stabilization of soil.

- Addition of stabilizing agents (cement, lime) with plastic waste in the soil at different percentages should try.
- Impact of soil adjustment with plastic waste ought to be examined for its fatigue behaviour.
- Utilization of plastic waste for adjustment of other sort of soils like Poorly graded soil and so on requirements to be considered.
- Utilization of different types of plastic waste (like crushed water bottles) in various forms for soil adjustment should be considered.

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ANNEXURE A: STANDARD PROCTOR TEST RESULTS

Table A1:- Proctor compaction test at 0% reinforcement

Sample no.	Dry unit wt. (Υ_d) (kN/m^3)	Moisture content (w%)
1	17.8	12.2
2	18.5	14.2
3	19.4	17
4	18.8	18
5	18.2	21.1

Table A2:- Proctor compaction test at 0.25% reinforcement

Sample no.	Dry unit wt. (Υ_d) (kN/m^3)	Moisture content (W%)
1	18.4	12.25
2	18.9	14.23
3	19.95	16.23
4	19.2	17.9
5	18.7	20.4

Table A3:- Proctor compaction test at 0.5% reinforcement

Sample no.	Dry unit wt. (Υ_d) (kN/m^3)	Moisture content (W%)
1	18.8	12.31
2	19.1	14.07
3	20.3	15.49
4	19.6	17.73
5	19	19.77

Table A4:- Proctor compaction test at 1% reinforcement

Sample no.	Dry unit wt. (Υ_d) (kN/m^3)	Moisture content (W%)
1	18.9	13.08
2	19.3	14.97
3	19.4	15.9
4	19.2	17.94
5	19.1	19.72

Table A5:- Proctor compaction test at 1.5% reinforcement

Sample no.	Dry unit wt. (Υ_d) (kN/m^3)	Moisture content (W%)
1	18.4	14.12
2	18.7	15.31
3	18.9	16.01
4	18.6	18.24
5	18.3	19.87

ANNEXURE B: DIRECT SHEAR TEST RESULTS

Table B1:- Computing shear stress at 0 % reinforcement

Sample no.	Normal load (kN/m^2)	Proving ring constant	Shear load (N)	Shear stress (kN/m^2)
1	49.05	55	201.86	56.9
2	98.1	77	285.54	80.4
3	147.15	94	366.4	103
4	196.2	115	448.7	125.6

Table B2:- Computing shear stress at 0.25 % reinforcement

Sample no.	Normal load (kN/m^2)	Proving ring constant	Shear load (N)	Shear stress (kN/m^2)
1	49.05	59	229.5	63.765
2	98.1	82	305.7	87.31
3	147.15	103	398.2	110.853
4	196.2	122	477.8	132.435

Table B3:- Computing shear stress at 0.5 % reinforcement

Sample no.	Normal load (kN/m^2)	Proving ring constant	Shear load (N)	Shear stress (kN/m^2)
1	49.05	65	251.1	71
2	98.1	87	334.09	91.2
3	147.15	110	428.2	120

4	196.2	131	496.2	138.3

Table B4:- Computing shear stress at 1 % reinforcement

Sample no.	Normal load (kN/m^2)	Proving ring constant	Shear load (N)	Shear stress (kN/m^2)
1	49.05	73	276.3	77.5
2	98.1	97	379.75	105.9
3	147.15	128	481	134.7
4	196.2	149	578	162.5

Table B5:- Computing shear stress at 1.5 % reinforcement

Sample no.	Normal load (kN/m^2)	Proving ring constant	Shear load (N)	Shear stress (kN/m^2)
1	49.05	80	297.5	82.8
2	98.1	110	410.4	115.1
3	147.15	140	525.7	146.7
4	196.2	165	625.8	177

ANNEXURE C: CALIFORNIA BEARING RATIO TEST RESULTS

Table C1:- CBR test at 0 % reinforcement

Penetration (mm)	Reading	Divison	Load (kg)
0	0	0	0
0.5	1	5	8
1	2	10	16
1.5	2.6	13	20.8
2	3	15	24
2.5	3.2	16	25.6
3	3.4	17	27.2
4	3.8	19	30.4
5	4.2	21	33.6
7.5	4.8	24	38.6
10	5.2	26	41.6
12.5	5.8	29	46.4

Table C2:- CBR test at 0.25 % reinforcement

Penetration (mm)	Reading	Divison	Load (kg)
0	0	0	0
0.5	2.2	11	17.6
1	3.8	19	30.4
1.5	4.8	24	38.4
2	5.6	28	44.8
2.5	6.2	31	49.6
3	6.6	33	52.8
4	7.4	37	59.2
5	8	40	64

7.5	9	45	72
10	9.6	48	76.8
12.5	10.2	51	81.6

Table C3:- CBR test at 0.5 % reinforcement

Penetration (mm)	Reading	Divison	Load (kg)
0	0	0	0
0.5	2.2	11	17.6
1	4	20	32
1.5	5.2	26	41.6
2	6.2	31	49.6
2.5	7	35	56
3	7.8	39	62.4
4	9	45	72
5	10	50	80
7.5	11.6	58	92.8
10	12.6	63	100.8
12.5	13.6	68	108.8

Table C4:- CBR test at 1 % reinforcement

Penetration (mm)	Reading	Divison	Load (kg)
0	0	0	0
0.5	4.4	22	35.2
1	6.4	32	51.2
1.5	7.8	39	62.4
2	8.8	44	70.4
2.5	10	50	80
3	10.8	54	86.4
4	12.2	61	97.6

5	13.4	67	107.2
7.5	15.6	78	124.8
10	17.4	87	139.2
12.5	19	95	152

Table C5:- CBR test at 1.5 % reinforcement

Penetration (mm)	Reading	Divison	Load (kg)
0	0	0	0
0.5	2.4	12	19.2
1	3.6	18	28.8
1.5	4.8	24	38.4
2	6	30	48
2.5	7	35	56
3	7.8	39	62.4
4	9.2	46	73.6
5	10.2	51	81.6
7.5	12.4	62	99.2
10	14.2	71	113.6
12.5	15.8	79	126.4