The Major Project- II

On

Influence of Natural Polymer on Geotechnical Behavior of Silty Sand

Submitted In Partial Fulfillment for the Award of the Degree of

MASTERS OF TECHNOLOGY

IN

CIVIL ENGNEERING

With Specialization In

GEOTECHNICAL ENGINEERING

By

Pankaj Goswami
(Roll No. 2K13/GTE/12)

Under The Guidance of

Prof. A.K. Sahu

Department of Civil Engineering

Delhi Technological University, Delhi

Department of Civil Engineering

Delhi Technological University,

Delhi-110042

2015

DELHI TECHNOLOGICAL UNIVERSITY, DELHI

CERTIFICATE

This is to certify that major project-II entitled— **"Influence Of Natural Polymer On Geotechnical Behavior Of Silty Sand"** is bona fide record of work carried out by Pankaj Goswami (Roll No. 2K13/GTE/12) under the guidance and supervision, during session 2015 in partial fulfillment of the degree of Master of Technology (Geotechnical Engineering) from Delhi Technological University, Delhi.

The work in this major project- II has not submitted for the award of any other degree to the best of my knowledge.

(Prof. A.K. Sahu)

Civil Engineering Department,

Delhi Technological University,
Delhi-110042
2015

DELHI TECHNOLOGICAL UNIVERSITY, DELHI

ACKNOWLEDGEMENT

As I write this acknowledgement, I clarify that this is note of thanks and regard from my side. I am very thankful toward to our honorable Vice Chancellor **Prof. Pradeep Kumar**, head of civil department **Prof. Nirendra Dev** and my project guide **Prof. A. K. Sahu**, Professor, Civil Engineering Department, and Delhi Technological University New Delhi for giving me an opportunity to work guidance.

I am also thankful to **Mr. Sunil Tirkey,** senior lab attendant of Environment laboratory and thank to Soil mechanics lab in-charge and attenders of Civil Engineering Department, Delhi Technological University to give permission to perform various soil test.

(Pankaj Goswami)
2K13/GTE/12
M.Tech (Geotechnical Engineering)

DELHI TECHNOLOGICAL UNIVERSITY,
NEW DELHI

DECLARATION

I hereby declare that the work in this Project Report entitled—**Influence of Natural Polymer on Geotechnical Behavior of Silty Sand"** is bona fide record of work carried out by me as a part of major project-II in partial fulfillment for the Master of Technology in Geotechnical Engineering.

I have not submitted the matter presented in this report for the award of any other degree.

(Pankaj Goswami)
2K13/GTE/12
M.Tech (Geotechnical Engineering)
Civil Engineering Department,
Delhi Technological University,
Delhi-110042

ABSTRACT

Soil roads are help to connect the network between rural and urban areas for peoples to survive their life and for their needs. There is need for a proper geometric design and good pavement condition. Due to increase in traffic and with high magnitude of wheel load causes rapid fractures in road pavements. So there is a need to improve the density and strength of sub grade soil. In this study a attempt is made for improving the geotechnical behaviour of silty soil using natural polymer.

India is the largest consumer of sugar in world. In India every day million tons of sugar crushed and average gives a tons of sugar, molasses, bagasse and of press mud [4]. Initially it seems very costly but actually in practical way it proved to be economically. Hence experimental investigation has been carried out to study the influence of molasses geotechnical properties of soil. The important properties which are conducted in study are specific gravity, consistency limits, max dry density, optimum moisture content, California bearing ratio and unconfined compressive test. This study has to be carried out for utilization of cane molasses for improving the soil properties of sub-grade and properties of soil mix with molasses at different varying percentage.

In this investigation cane molasses was used. Soil samples are prepared with varying percentage of cane molasses at 3%. 4.5%, 6%, 7.5%. The soil used in this study was silty sand (SM). The results show that with the use of molasses, there was increase in unconfined compressive strength and CBR value of soil. These results seem to be more effective and beneficial in modification of construction of road pavement.

KEYWORDS: molasses, soil stabilization, CBR value.

CONTENTS

LIST OF SYMBOLS

1. CBR ………………………………………… California Bearing Ratio

2. MDD…………………………………………Maximum Dry Density

3. OMC ………………………………………… Optimum Moisture Content

4. %…………………………………………….. Percentage

5. Fig…………………………………………… Figure

6.UCS……………………………………………Unconfined Compressive strength

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1 -INTRODUCTION

1.0 INTRODUCTION

1.1 General

Soil is the basic part of road network and embankments. In India roads are most important component for transport system. In case of roads it take load from the base course and sub base course but soil on various locations may not suitable for construction due to poor or low bearing capacity such as expansive or collapsible soil. Stabilization is a technique which introduce several years before with the purpose to make soil capable. Many additives like gypsum, fly ash etc have been used for stabilizing soil. Countries like India have largest production of industrial or agricultural waste. In India basically in sugar factories producing million tons of cane in which a tons of sugar and remaining should be considered as waste [4]. Silty soil is of low plasticity therefore under dry condition dust is created on the sub grade. To find all the particles either water or molasses are used as dust palliatives. Therefore it was felt to study the improvement in the compaction properties and strength characteristics of Cane molasses is one of the most additives which have been produced form sugar factories. Molasses is being produced in Uttar Pradesh [2] and no question arises for its availability. Cane molasses is used for modifying the properties of locally available soil which can be used in future for construction of road networks so as to minimize the cost of construction and make it best utilization of industrial product and used as soli stabilizing agent.

1.2 Introduction to Natural polymer

Natural polymer are the part of nature and easily everywhere in our daily life e.g. Cotton, sisal, hemp and molasses. it is the chain of repeats units called monomer. They are made up of many organic matter are which are available in nature.

1.3 Introduction to molasses

Molasses is very thick dark brown, syrupy liquid produced from the sugar cane factory. It contains organic and inorganic constituents which seem to be unfit for human health. It becomes adhesive when it gets in contact to soil. It can be used as sub-grade material in road construction.

Cane molasses is perfectly soluble in water, dark in color. Its specific weight is similar to that of water and the pH level is between 4.3 and 4.6.It has a characteristic odor. Gloves and masks are good general practice during handling. Molasses is formulates for modifying engineering properties of soil. It requires dilution in water before used. It reduces the voids between soil particles and minimizes absorbed water in soil for maximumc compaction.

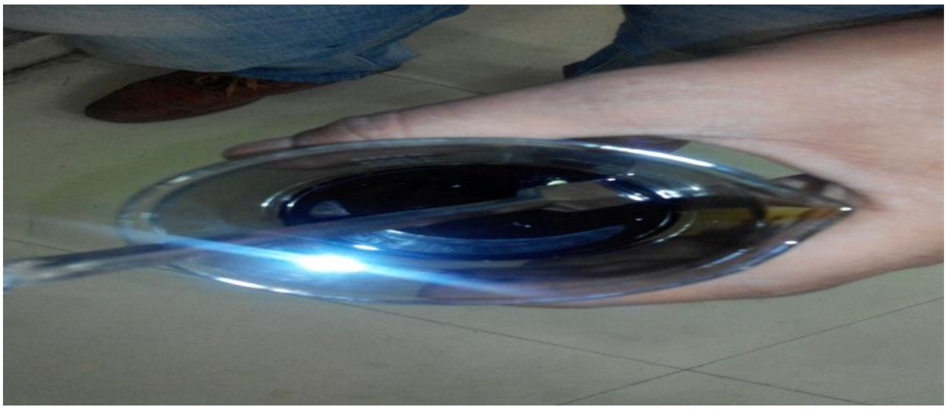

Fig. 1.1 Cane Molasses

1.3 Specification of molasses

It is non toxic and harmless to humans, animals, and marine life and the environment. It is non-irritating, non-flammable, and non-corrosive. Molasses is a concentrate that requires dilution in water for proper application rates and to achieve uniform dispersion and mixing with the particles of soil being treated. Water requirements are determined separately from the concentrate dosage. Measurements are made in the field on the day of application to determine how much water is needed to bring the actual field soil (natural) moisture content up to the optimum moisture content (OMC) needed for maximum compaction. In cases where the soil material contains high amounts of fines or higher plasticity, the molasses diluted in water and amount of water for dilution is kept one to two percents below OMC level to account for the change in working characteristics caused by molasses. Molasses is best stored at a temperature below 55° C and above freezing otherwise there is a chance of development of bacteria's which causes effect during stabilization [4].

1.4 Production of molasses

In India every day million tons of sugar crushed and average gives a tons of sugar, molasses, bagasse and of press mud [4].

1.5 Use of molasses

- **A stabilizer**- The molasses appears as viscous material in liquid form containing some organic and inorganic material which attracts with soil because of its adhesive property and used for modifying the engineering properties of soil [1].
- **Other uses** – it is used for preparing acetic acid, butanol-acetone, citric acid, Yeast, Industrial alcohol as cooking fuel, Ethyl alcohol [3].

1.6 Objectives of the Study

The primary objectives of this study are to observed:

- The effect of cane molasses on dry density of silty soil
- The effect of cane molasses on strength of silty soils.

1.7 Scope of the Study

- Cane molasses can be used in weak soils of already existing structures to improve soil strength and stability.
- To enhance strength of poor quality sub grade soil.
- To increase the density of silty soil.

The literature has been reviewed in the succeeding chapter to fulfill the aims and objectives of the project under study.

CHAPTER 2-LITERATURE REVIEW

The literature with respect to effect of polymer on the soil is meager. However, few available literature has been reviewed in the following paragraph

Many scholars have used different proportion of molasses and bio enzymes for their experiments and research that are available. Geotechnical projects are generally designed on the basic of ASTM and AASTHO standards. These are based on controlled condition but on the field these condition are different, so that premature failure occurs. In situ conditions, examine soil behavior very carefully to actual condition as possible. Molasses which is used for experiment was kept under controlled temperature taken from Nangloi New Delhi. Analyze the results which come from use of molasses on soil before use as construction material.

The outcome of various researchers who have worked using chemical additive with different types of soil from time to time are given as a literature review in the following paragraphs. The test was conducted a study on “Innovation in Road Construction Using Natural polymer. The effect of Natural Polymer i.e. Molasses on engineering properties of soil was studies. [4] Molasses is the main ingredient used in making of Terrazyme (Bio-Enzyme).Soil considered for this study mainly consisted of sand and less percentage of silt and clay. Several Tests were performed on soil samples which included Engineering properties, Laboratory unsoaked CBR Test. Proportions of Molasses added were ranged from 5% to 7.5%. By addition of 6.5% of molasses in soil, the value of liquid limit, plastic limit increased and plasticity index of modified soil is reduced. By addition of 6.5% of molasses in soil, the value of maximum dry density of modified soil is increased due to proper rearrangement of modified soil mix and due to improved binding capacity. The value of California bearing ratio of soil by addition of 6.5% molasses is increased due to increase in density of modified soil mix, which leads to soil mass having more strength. Based on the cost analysis made it clearly show that use of molasses in road construction is economical. The Bio-enzyme stabilized lateritic soil as a highway material was studied [5]. Bio-enzyme used in this study is Terrazyme, a stabilizing agent. The effect of enzyme on soil and treated soil in terms of Unconfined Compressive Strength (UCC), California Bearing Ratio (CBR), Compaction and permeability were studied. The results showed that for a dosage of 200 ml/ 2 m^3 of soil, the CBR value of lateritic soil increased by 300 percent after four weeks of curing, the unconfined compressive strength of the soil increased by 450 and permeability decreases by 42 percent. The stabilization potential of Bio-enzymes was studied [6]. Standard soil tests like Atterberg's Limits, Unconfined Compression Tests were used for enzyme-stabilized materials. The soil used was silty clay with a liquid limit of 66% and plasticity index of 42%. Results from strength and index tests (e.g. liquid and plastic limit) conducted showed an increase in the unconfined compressive strength of the stabilized material as compared to control specimens and a 15% increase in the undrained shear strength of the stabilized material. It was concluded that enzymes provided additional shear strength for soils and that the soil stabilization with enzymes should be considered for various applications. The Effect of Soil Treatment with Bio-Base on CBR% was studied [7]. Three tests specimen were considered in this study. The three specimens considered had fine, medium and coarse gradations respectively. Atterberg Limits and pH values of three soil specimens were calculated.CBR value was also calculated for untreated soil specimen. The soil specimens were then treated with Bio-Enzyme for 4 weeks. Again Atterberg Limits and CBR values were calculated.The CBR values for all gradations increased significantly with time. The CBR values for the BIO-BASE treated coarse and medium gradation specimens (15 and 24% fines, respectively) were less than those from fine gradation specimens (Appendix Figures 3, 4, 5). Improvement is projected from soil with higher percentages of clay size particles or a fine fraction with a higher plasticity index. Improvement with BIO-BASE treatment may require up at least 4 weeks to fully develop. The Swelling Properties of Bio-enzyme Treated Expansive soil was studied [8].This paper presented the results of experiments conducted on an expansive soil treated with an organic, non-toxic, eco-friendly bio-enzyme stabilizer in order to assess its suitability in reducing the swelling in expansive soils. The experimental results indicate that the bio enzyme stabilizer used in the present investigation is effective and the swelling of an expansive soil reduces on wet side of Optimum Moisture Content. The Measured Effects of Liquid Soil Stabilizers on Engineering Properties of Clay was studied [9]**.**In this study 5 types of soils from different locations were considered. 4 of the soils were high in clay content while 1 was high in silt content. Initial Tests were conducted on natural soil samples. Then soil samples were treated with bio-enzyme and their unconsolidated un drained shear strengths were considered. It was found that soil containing kaolinite mineral in them increased considerably while the samples containing montmorrilonite did not show considerable increment. The Application of Bioenzymatic Soil Stabilization in comparison to Macadam in Construction Transport Infrastructure was studied [10]. The study was designed to introduce environment friendly TerraZyme to increase engineering qualities of soil for road construction. Soil classification and earth work characteristics were analyzed for two soil types representing pulverized local and transported soil with and without TerraZyme. Results confirmed that treatment with TerraZyme increases engineering characteristics indicated by increase in CBR values from 10.47 to 16.28 with 55 % improvement .Increase of 4.28 % and 2.20 % in dry density and decrease of 18.13 % and 6.17 % in moisture content for untreated and treated soil, respectively. TerraZyme constructed road concludes cost saving of 15-20 % and maintenance cost reduction of 60 % and compared to normal water bound Macadam road. The Objective Performance Measurement of Actual Road Sites Treated with an Organic Soil Stabilizer [11] was studied. This paper discussed the soil properties effected by organic soil stabilizers i.e. TerraZyme on road sub grade DCP measurements, demonstrated that not only the benefits of soil stabilization, but also the utility of DCP usage in portraying resistance by road transverse structure level. Whole study was carried out on roads of Brazil. The sub grade of Road was treated with TerraZyme and after more than 7 months of usage, without any required maintenance many improvements were observed. It was noted that capacity to support loading by the soils (CBR) increased greatly with the curing time of TerraZyme. In all cases, the bio enzymatic treatment of the soil layers increased the CBR more than fifteen times when compared with the low initial values (5% to 7%) obtained in the laboratory on untreated soil material from the experimental section. The Stress-deformation and compressibility responses of bio-mediated residual soils was studied [12]. In this study the stress-deformation and compressibility responses of bio-mediated soil at laboratory scale. A typical residual soil was subjected to Microbially-induced calcite precipitation (MICP) under various treatment durations, concentrations and flow pressures of cementation reagents. The experimental results show that the stiffness and peak strength of soil were improved by the MICP treatment. The amount of calcite precipitated showed a linear correlation with recompression index (Cr), reasonable correlations with peak strength (p) and total settlement (Sc), but a poor correlation with compression index (Cc). The compressibility responses of bio-mediated soils show certain similarities to typical aged clays that have undergone a long period of natural cementing process.

The effect of cane molasses on strength of expansive soil [13] was studied in which molasses is used as a stabilizing agent for expensive soil. In that paper cane molasses is selected because it contains some elements which are known to react with soil minerals and the CBR test was conducted to find out the strength of clay and the results shows that the 8% of cane molasses is best suitable for the stabilization or to increase the strength of dry soil. The effect of bio-enzyme stabilization on unconfined s compressive strength of expensive soil [14] was studied in which the geotechnical properties of poor soil was increased with the help of bio-enzyme the unconfined compressive test was conducted at different variation of bio-enzyme at 1 and 7 day curing and results shows that using bio-enzyme the strength of black cotton soil increases 200% from its initial value and there is more increase in strength in 7 days curing as compared to 1 day curing. The influence of cane molasses on plasticity of expensive soil [15] was studied in which plasticity test was performed for untreated soil sample and soil sample treated with molasses at different varying percentage. The results shows that the plasticity of soil sample using molasses decreased and the plasticity index of the soil reduces from an average of 39% for untreated soil and 26% for treated soil at moisture content 8%

by weight 7 days curing and the results shows for treated sample that the plasticity of soil sample reduced.

CHAPTER 3- MATERIALS AND METHODS

3.0 INTRODUCTION

Soil testing is part of design and analysis of soil engineering. Evaluation of soil sample and determination of properties of soil in field condition is essential part of geo- technical engineering. It play important role in irrigation, highway, structure and hydraulics engineering.

3.1 MATERIALS AND TESTING PROCEDURE

It is plan to study strength and compaction properties of soil using various percentages of cane molasses. The aim of the study is to investigate the effects of various proportions of cane molasses i.e. 0%, 3%, 4.5%, 6%, &7.5%on the following parameters:

- Consistency limits
- Proctor's compaction test
- CBR test of different proportion of mixes.
- Unconfined compressive strength of different proportion of mixes.

The materials used for the study have been procured from various locations.

- Soil – DTU campus
- Molasses – The molasses was bring from the sugar cane factory located at Ghaziabad, Uttar Pradesh.

3.1.1 SOIL SAMPLES

Locally available soil (DTU library) was obtained and air-dried. It was hand sorted to remove any pebbles and vegetative matter. The soil was then sieved through 4.75mm to eliminate gravel fraction. The soil was then oven dried for 24 hours before it was mixed with cane molasses.

Following test has been performed on soil

- Determination of specific gravity
- Determination of consistency limit

- Grain size analyses
- Proctor compaction test
- California bearing ratio
- Unconfined compression test

1)DETERMINATION OF SPECIFIC GRAVITY

The Specific Gravity of soil was found out by density bottle method is **2.35**

Table 3.1 Specific Gravity Test of silty sand

Empty weight	W_1 (gm)	694.19	694.19	694.19
Empty weight + dry soil	W_2 (gm)	894.06	944.06	994.060
Empty weight + Dry ksoil +water	W_3 (gm)	1686.44	1749.33	1746.570
Empty weight + water	W_4 (gm)	1565.10	1565.10	1565.10
Specific Gravity	**S.G.**	2.54	2.58	2.53

$G_{avg} = \frac{W2-W1}{(W2-W1)-(W3-W4)} = 2.35$

2)DETERMINATION OF LIQUID LIMIT AND PLASTIC LIMIT

Liquid limit

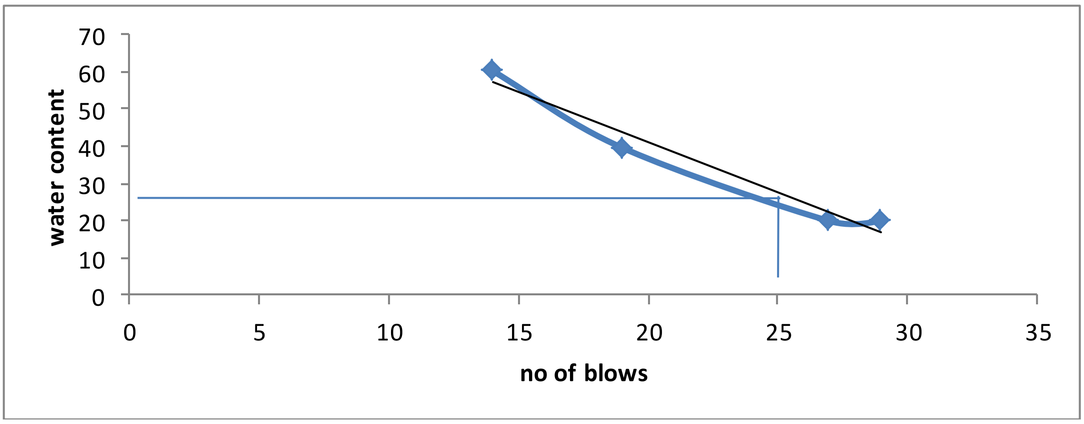

Fig.3.1Graph between water content and no. of blows

Plastic limit:

Weight of empty pan = 10.23 gm

Weight of pan + weight of soil =23.83 gm

Weight of pan + dried sample = 21.92 gm

The plastic limit of the adopted sample is 16.43 percent

Table 3.2 Consistency limits of silty sand

Liquid Limit (%)	20.60
Plastic Limit (%)	16.43
Plasticity Index (I_P)	3.57

3)**GRAIN SIZE ANALYSIS**

Table 3.3Grain size analyses

Sieve size	Mass retained	% mass retained	Cumulative % retained	% finer
4.75	32.98	3.298	3.298	96.702
2.36	7.28	0.728	4.026	95.974
1.18	6.37	0.637	4.663	95.337
0.6	9.83	0.983	5.646	94.354
0.300	531.693	53.163	59.339	40.661
0.150	219.50	21.95	81.289	18.711
0.075	12.42	1.242	82.531	17.469
pan	177.38	17.348	99.879	0.121

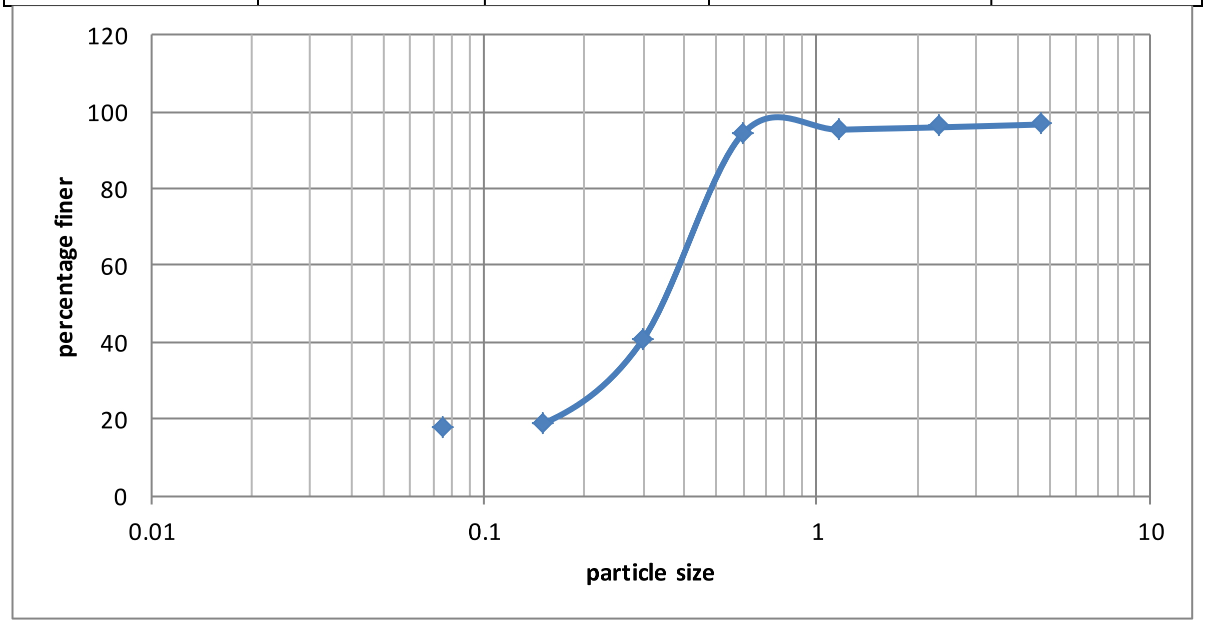

Figure 3.1: Graph for Sieve Analysis for silty sand soil

According to IS classification system

$I_P < 4$, the soil is **SM** (silty sand).

4)PROCTOR'S COMPACTION TEST

Table 3.4Standard Proctor's Test values

Weight of empty mould + Base plate(kg)	4.320	4.320	4.320	4.320	4.320
Weight of compacted soil + Base plate w_2,(kg)	6.060	6.190	6.310	6.285	6.255
Bulk unit weight of compacted soil γ (gm./cc)	17.67	18.77	20.177	19.876	19.575
Water content w (%)	8.46	9.89	13.96	14.65	19343
Dry unit weight kN/m³	16.21	16.9	17.92	17.59	16.56

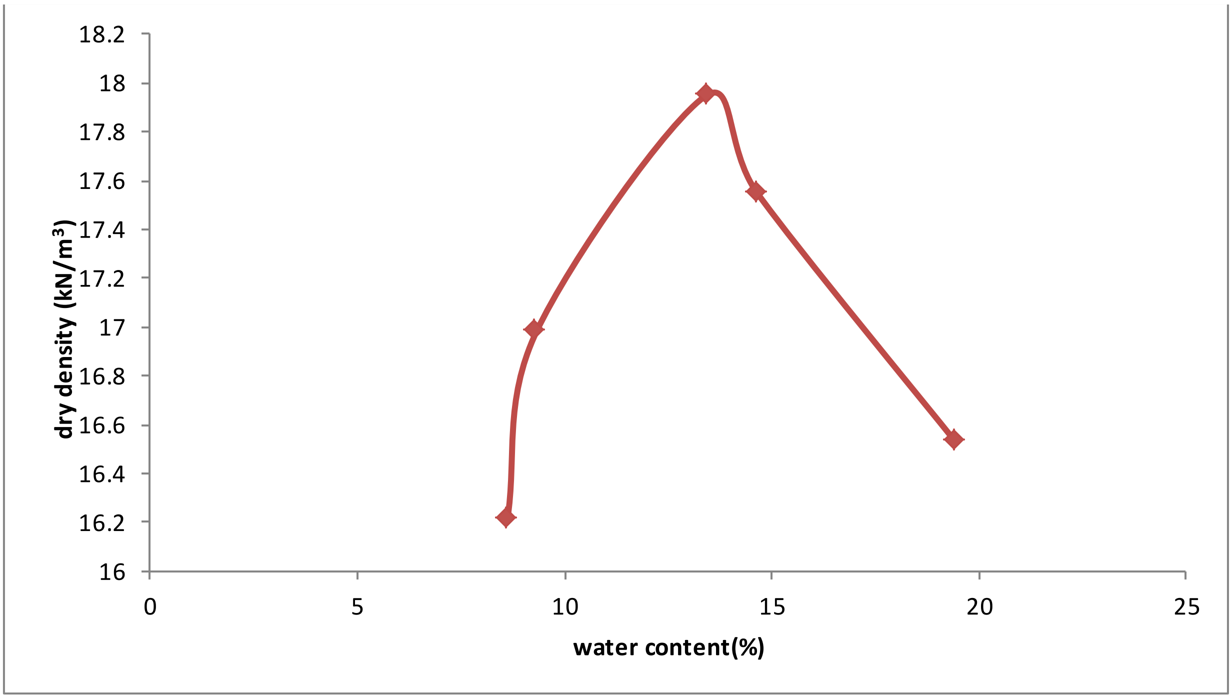

Fig. 3.2 Compaction Curve of Standard Proctor Test

Maximum Dry Density (KN/m³)	17.92(KN/m³)
Optimum Moisture Content (%)	13.96%

5) CALIFORLIABEARING RATIO

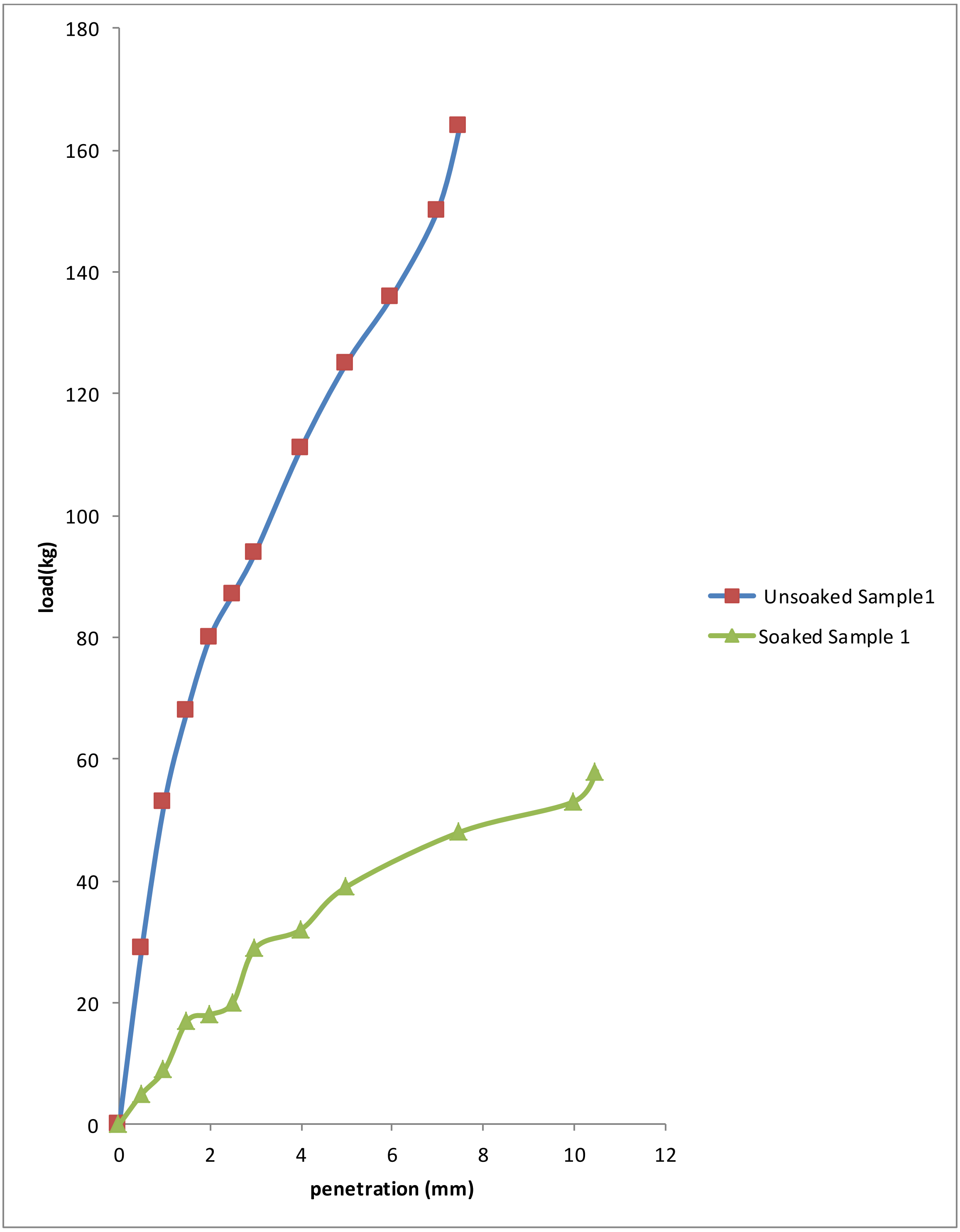

Fig. 3.3 California Bearing Ratio Sample1 of virgin soil

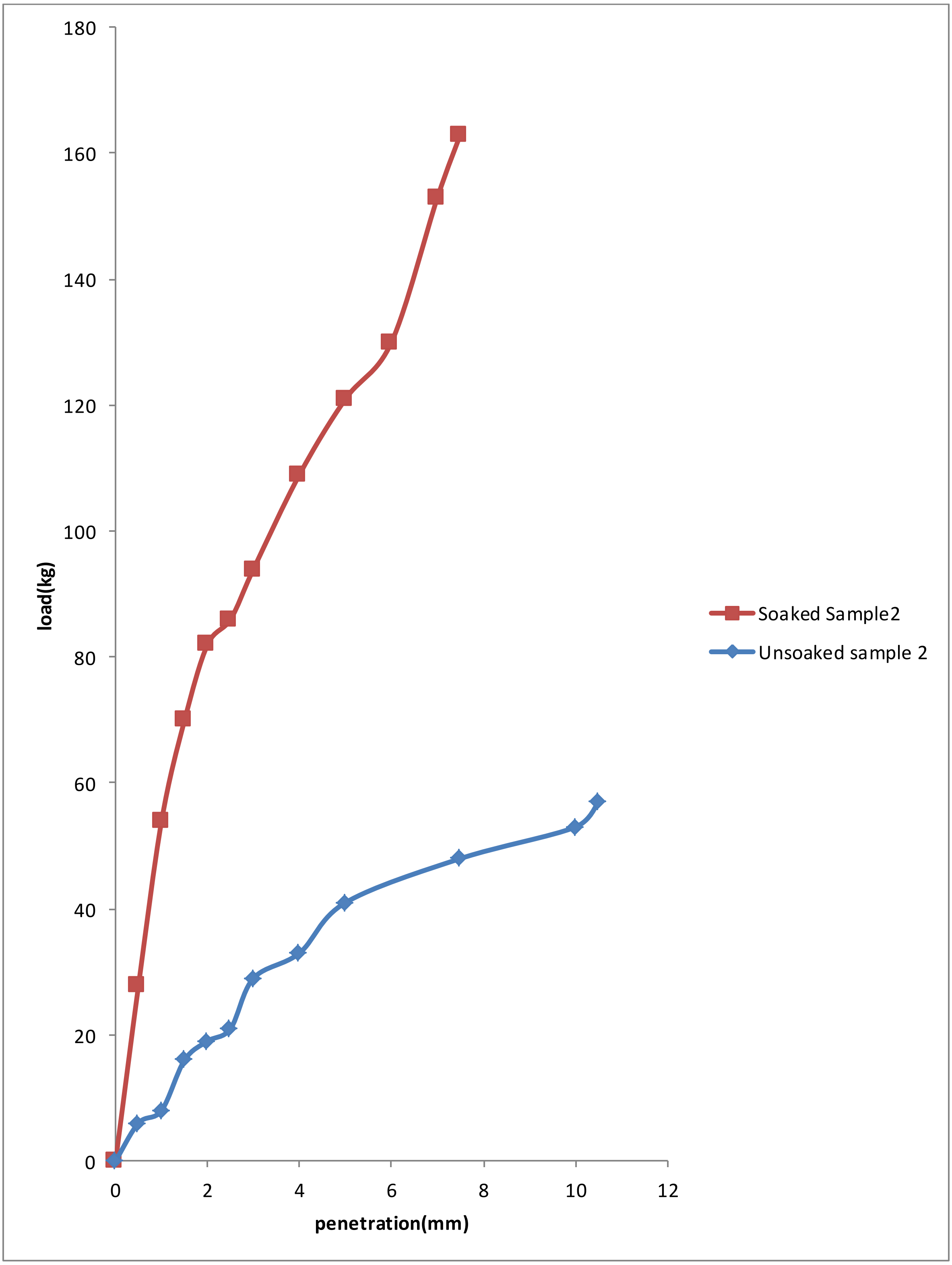

Fig. 3.4 California Bearing Ratio Sample2 of virgin soil

California bearing ratio (Sample1) of virgin soil

Table 3.5 Un-soaked California Bearing Ratio values (sample 1) of virgin soil

S.NO.	PENETRATION OF PISTON(mm)	Load taken by sample(kg)	Standard load (kg)	CBR value
1	2.5	87	1370	6.3%
2	5.0	125	2055	6.08%

Table 3.6 Soaked California Bearing Ratio values (sample 1) of virgin soil

S.NO.	PENETRATION OF PISTON(mm)	Load taken by sample(kg)	Standard load (kg)	CBR value
1	2.5	20	1370	1.45%
2	5.0	39	2055	1.89%

California bearing ratio (Sample2) of virgin soil

Table 3.7 Un-soaked California Bearing Ratio values (sample 2) of virgin soil

S.NO.	PENETRATION OF PISTON(mm)	Load taken by sample(kg)	Standard load (kg)	CBR value
1	2.5	86	1370	6.27%
2	5.0	121	2055	5.88%

Table 3.8 Soaked California Bearing Ratio values (sample 2) of virgin soil

S.NO.	PENETRATION OF PISTON(mm)	Load taken by sample(kg)	Standard load (kg)	CBR value
1	2.5	21	1370	1.53%
2	5.0	41	2055	1.99%

6)UNCOFINED COMPRESSIVE TEST

Table 3.9 Unconfined compression test

ΔL, mm	Dial gauge reading	Load, P, kg	Ɛ = ΔL/L	A = A_0/1-Ɛ	σ = P/A(N/m^2)
0	0	0	0	0	0
0.5	0.3	0.98776	0.00659	11.4162	8.65
1	0.4	1.31703	0.01318	11.4923	11.46
1.5	0.5	1.64629	0.01977	11.5694	14.22
2	0.5	1.64327	0.02636	11.6476	15.83
1.5	0.6	1.97555	0.03285	11.7269	16.84
3	0.6	1.97535	0.03944	11.8072	17.28
3.5	0.6	1.97555	0.04603	11.8886	18.00
4	0.6	1.97555	0.05262	11.9712	18.42
4.5	0.7	2.30471	0.05921	12.0549	19.11
5	0.7	2.30473	0.06579	12.1398	18.95
5.5	0.7	2.30473	0.07238	12.2259	18.85
6	0.7	2.30473	0.07897	12.3132	18.70
6.5	0.7	2.30473	0.08556	12.4018	18.50
7	0.7	2.30473	0.09205	12.4917	18.40
7.5	0.7	2.30473	0.09884	12.5828	18.30
8	0.7	2.30473	0.10523	12.6754	18.10
8.5	0.6	1.97553	0.11184	12.7692	15.40

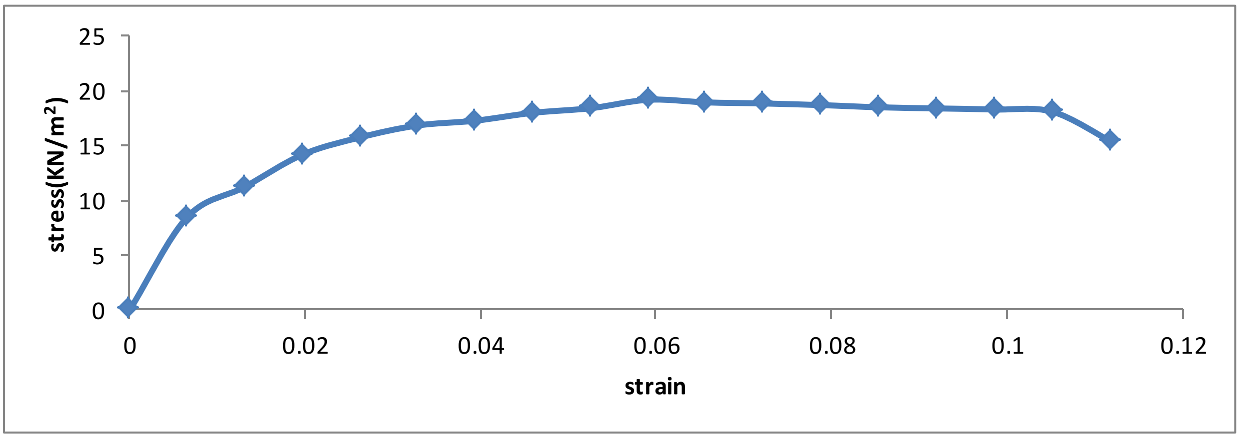

Fig.3.5 Graph between stress and strain of unconfined compressive test

Unconfined compressive strength (q_u)	18.81KN/m^2
Un drained Cohesion(c_u)	9.41 KN/m^2

Table 3.10 SUMMARY OF TEST RESULT OF SILTY SOIL

S.NO.	PARAMETER	RESULT
1.	Specific gravity	2.35
2.	Liquid limit **(%)**	27.33
3.	Gravel content (%)	3.30
4.	Sand content (%)	77.89
5.	Silt content (%)	17.80
6.	Indian Soil Classification	SM
7.	Plastic limit	17.3
8.	Plasticity index	10.03
9.	Light compaction test • MDD (kN/m^3) • OMC (%)	 17.92(kN/m^3) 13.96
10.	CBR (un soaked)	6.3
11.	CBR(soaked)	1.53
12.	Unconfined compression test	18.81KN/m^2

3.2 Properties of Cane molasses

- **pH:** PH-099 Combination pH and ORP Tester :

Fig.3.6 pH testing device

3 samples have been prepared to find the ph value

	PREPEARED SAMPLE	pH
1nd sample	5ml molasses +95 ml water	5.8
2st sample	25ml molasses + 75 ml water	5.1
Pure cane molasses	100 ml molasses	4.8

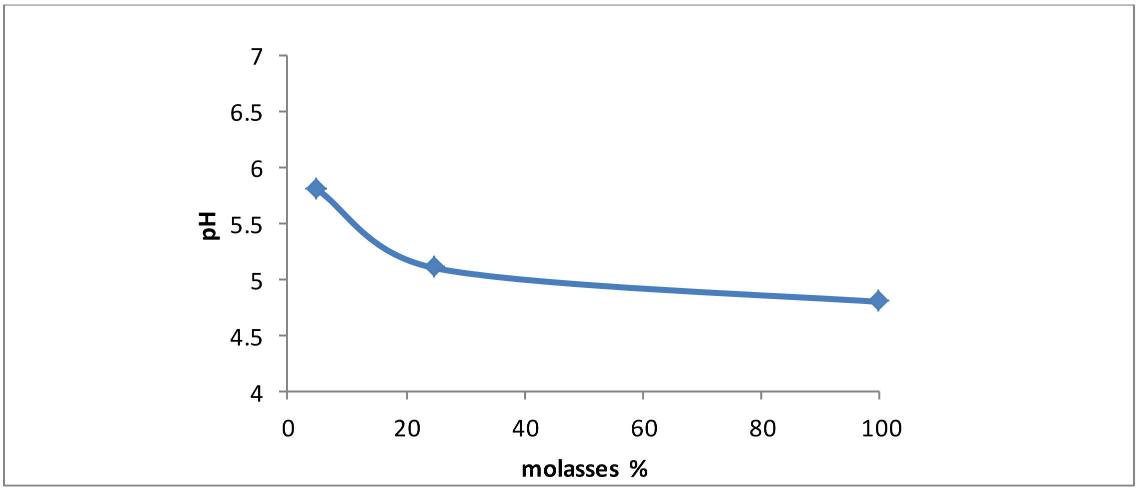

Table no. graph between molasses% and pH

From the pH test it shows when water sample mixes with molasses then the pH value of molasses sample decreases and become more acidic.

- **Viscosity**: It is determined in orifice viscometer by the time taken by 50ml of material to flow from a cup through a specified orifice and specified temperature

Viscosity (cp at 20^0C) = 1500

Ashes are found out at heating the 2gm of sample of molasses in 500^0C.

Viscosity(cp at 20^0C)	1500
Ashes	.24gm

- **Electrical conductivity:** The probe or sensor consists of two metal electrodes and a constant voltage is applied across the electrodes resulting in an electric current flowing through the sample.

Fig.3.7 Electrical conductivity measuring device

The electrical conductivity was found by preparing sample of water + molasses and water + pure soil sample of 100g.

EC of water + molasses (100g)

=1544µs/cm at 26.5^0C

Dissolved solids= 0.5 * 1544=772mg/lit

Water + pure soil sample of

100gm sample=244µs/cm at 26.5^0C

Dissolved solids= 0.5 * 244=122mg/lit

- **Alkanity:** Alkalinity was measures by using sample of 20ml of water with Molasses at .02 normal H_2SO_4

  1 drop of phenopthylene if pink color appears then titrate till it became colorless.

  If no color appears then 1 drop methyl orange then titrate till it becomes yellow to orange.

	Prepared sample	**Alkalinity as $CaCO_3$**
Sample1(pure molasses)	50ml of water + 0.5gm of molasses	90mg/lit
Sample 1(virgin soil)	50ml of water + 0.5gm of virgin soil	14mg/lit
Sample3(soil+7.5% of molasses)	50ml of water + 0.5gm of treated soil	26.89mg/lit

3.2 Different chemical elements

1. **Total organic carbon**

   The test is conducted in different samples of virgin soil and treated soil and pure molasses which were mixed with water in total organic carbon analyzer.

		Inorganic carbon(µg/l)	**Organic carbon(mg/l)**	**Total Carbon(mg/l)**
Sample1	50ml of water + 0.5gm of molasses	776.00	336.80	337.30
Sample2	50ml of water + 0.5gm of virgin soil	146.70	775.10	775.30
Sample3	50ml of water + 0.5gm of treated soil	157.10	600.40	600.50

2. **Magnesium and Silica**

The amount of mg was found out by Atomic absorption spectrometer at the wavelength of 251.6Å.

Fig.3.8 Atomic absorption spectrometer

		Magnesium(mg/l)	Silica (mg/l)
Normalized sample	50ml of water	11.87	
Sample 1	50ml of water + 0.5gm of molasses	12.32	32.62
Sample 2	50ml of water + 0.5gm of virgin soil	12.26	11.64
Sample 3	50ml of water + 0.5gm of treated soil	17.58	17.62

3. Sodium, Potassium and Lithium

These elements was found out by a device known as flame photometer

		Na (mg/l)	Ca (mg/l)	K (mg/l)	Li (mg/l)
Sample 1	50ml of water + 0.5gm of molasses	0.83	3.87	21.36	0.06
Sample 2	50ml of water + 0.5gm of virgin soil	0.81	2.87	8.60	0.04
Sample 3	50ml of water + 0.5gm of treated soil	0.61	1.02	7.35	0.03

Table 3.11 Physical property of cane molasses

S.No.	Physical properties	Molasses
1.	Color	Dark brown
2.	Specific gravity	1.4
3.	Viscosity (centipose at 20^0C)	1500
4.	Appearance	Syrupy liquid
5.	pH	4.7

Table 3.12 Chemical composition of cane molasses

S.No.	Chemical composition	Virgin soil(mg/l)	Soil +7.5% molasses(mg/l)	Molasses (mg/l)
1.	Carbon (sucrose)	775.30	600.50	337.3
2.	Sodium	0.81	0.61	0.83
3.	Calcium	2.87	1.02	3.87
4.	Potassium	8.60	7.35	21.87
5.	Lithium	0.04	0.03	0.06
6.	Magnesium	12.26	17.58	12.32
7.	Silica	11.64	17.62	32.62
8.	Fiber	-	-	-
9.	Ashes	-	-	83.64

3.2.1 Water used

Tap water was used throughout this study.

3.2.2 Mix Proportion

Soil: cane molasses are to be mixed thoroughly to have uniform mixture by hand mixing using different proportions of molasses. These are mixed in proportions given below in the table.

Name of Proportion	Soil : cane molasses
Soil: molasses (SM_0)	100:0
Soil: molasses (SM_1)	97:3
Soil: molasses (SM_2)	95.5:4.5
Soil: molasses (SM_3)	94:6
Soil: molasses (SM_4)	92.5:7.5

3.2.3 <u>SCANNED ELECTRONE MISCROSCOPIC RESULTS</u>

Virgin soil

Under SEM the soil particle in the virgin soil sample are evenly distributed and the non – moulded soil particles appears to have evenly distributed particles with low degree of segregation.

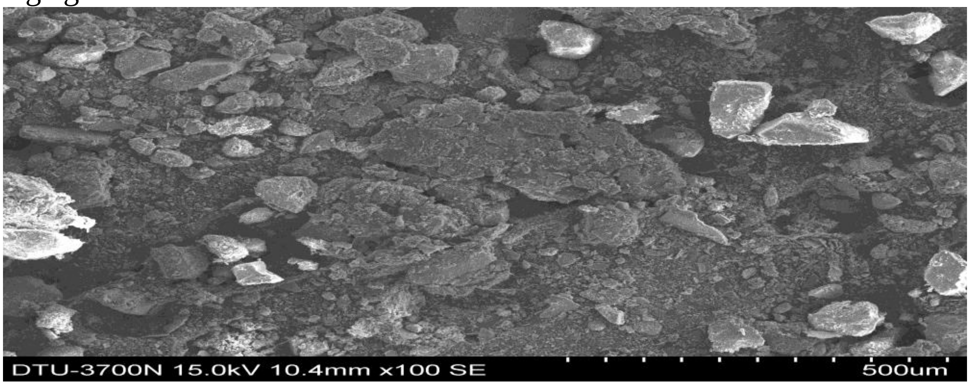

Fig.3.9 SEM results for virgin soil

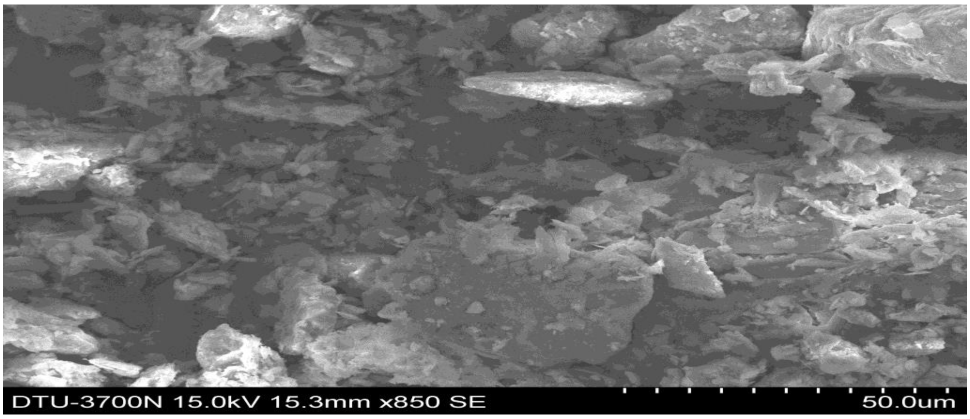

Fig.3.10 SEM results for virgin soil

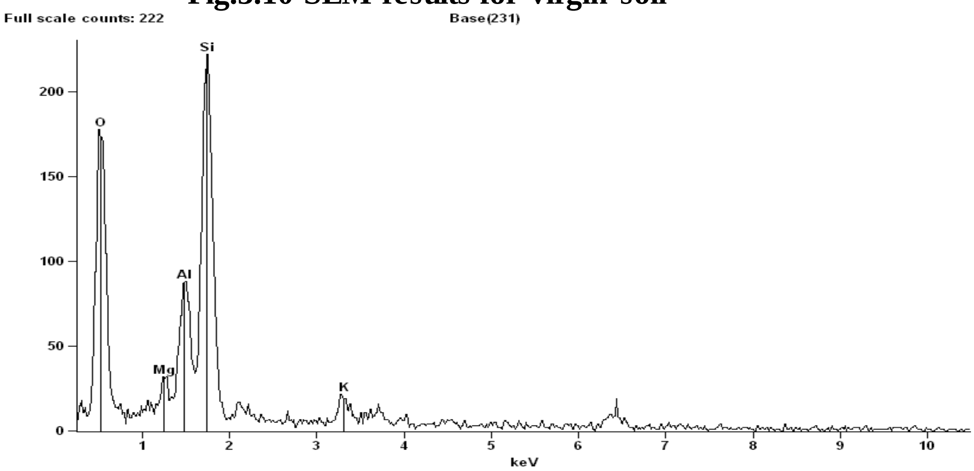

Fig.3.11 SEM graphs for virgin soil

Soil mixed with 7.5% of molasses

Under the microscopic result a brown color appears with a dark coloures with sub angular to sub granular outlines. The sizes of molasses mixed soil appears larger than virgin soil. They appears to have a high degree of segregation.

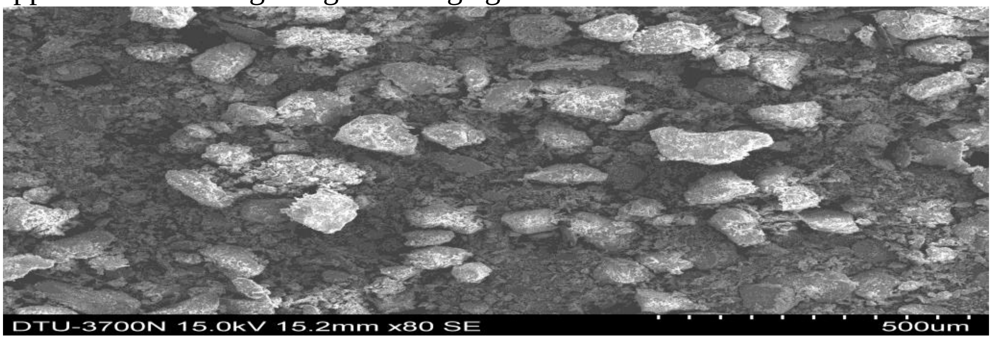

Fig.3.12 SEM results for soil and 7.5% molasses sample

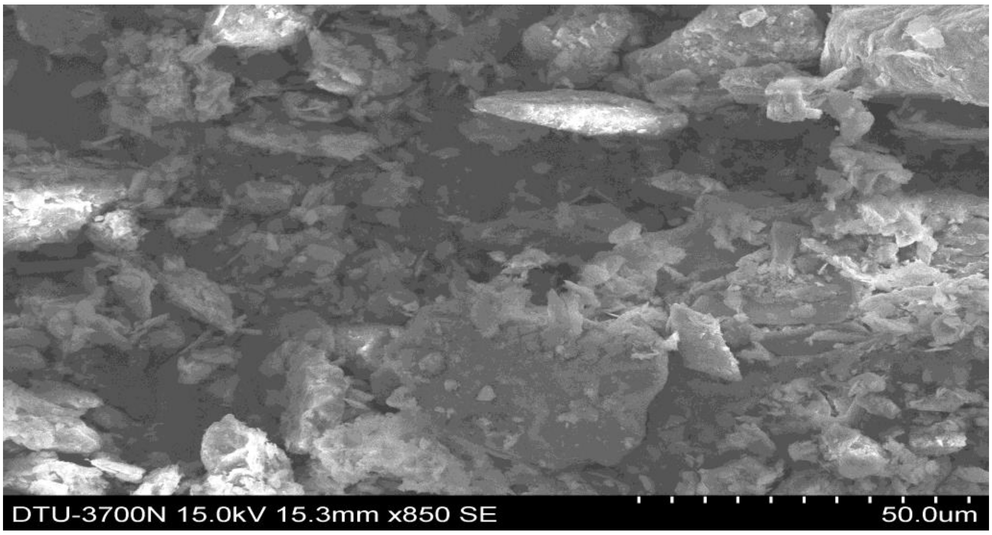

Fig.3.13 SEM results for soil and 7.5% molasses sample

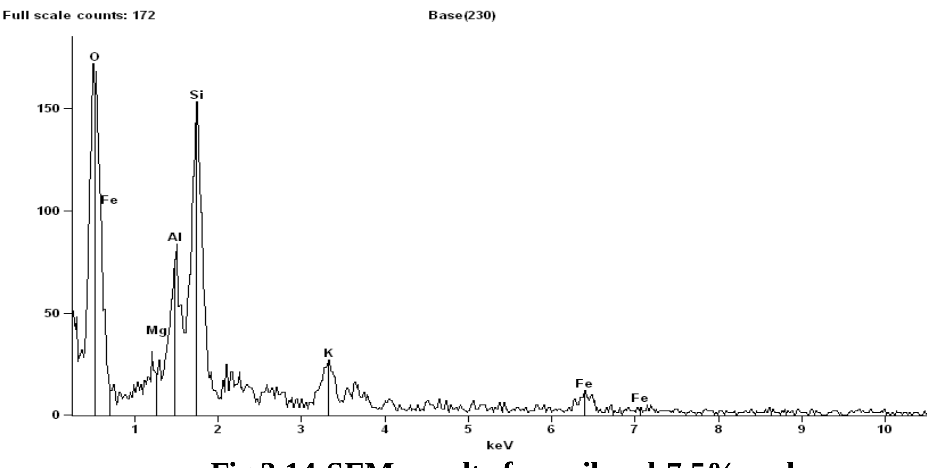

Fig.3.14 SEM results for soil and 7.5% molasses sample

3.1.6 Results obtained from SEM

Addition of cane molasses results in reduction of double layer thickness and allows the soil particles to approach each other and it results in flocculation of soil particles. The cation caused in the amount of absorbed water in soil particles and reduction in liquid limit of silty sand and increase in plastic limit of soil. The result observed that due to adhesion property of cane molasses, the soil particles form a larger particle.

3.1.7 Mechanism of stabilization when molasses is mixed with silty sand

Soil particles having net negative charge. So, they have to attract positive charge to balance. We observed that the positive charge elements like magnesium, calcium makes a bond between soil and the molasses. Sodium have higher energy of absorption so, it is also be observed that the enhancement in flocculation and soil aggregated. It should also be observed that when soil is mixed with molasses the soil sample having neutral pH and goes on reducing and become acidic.

It can be therefore said that molasses plays an important role in soil aggregate stability. The electrostatic attraction between soil particles and attracted by molasses due to its adhesive property. It results in formation of cementing bond between soil particles and molasses which increased the resistance to penetration during CBR value.

It is also be found that the major component carbon found in sucrose which has various component of hydroxyl group which is capable of bonding with hydrogen. Hydrogen attached negative ion oxygen and results in attracts. The attractive forces due to presence in Hydrogen therefore makes molasses adhesive.

As molasses is positive charge it is easily attracts with the surface of soil as they carry negative charge. When molasses is added with soil due to its adhesive property it makes a bond between them and it results in reduction of size of soil surface and results in increases in density and it makes resistance during penetration.

CHAPTER4- EXPERIMENTATIONS

4.1 INTRODUCTION

In this chapter, description of methodology and experimental programme has been given description of test has been stated. Details on proportion of cane molasses in soil are given.

4.2 TEST CARRIED OUT FOR INVESTIGATION

Following test carries out on the soil with different proportion of cane molasses

- **PROCTOR COMPACTION TEST**
- **CALIFORNIA BEARING RATIO**
- **UNCONFINED COMPRESSION TEST**

4.3 METHODOLOGY

Proctor Compaction test

- Proctor compaction test are performed according to IS2720 PART 7-1980.[14]
- This test is carried out on soil to determine maximum dry density and optimum moisture content of soil.
- Effect of addition of cane molasses has been observed on change on value of maximum dry density.

California bearing ratio test

- CBR test are performed according to IS2720 PART 16.[15]
- According to IRC 37:2012, the CBR results depend on a various factor and wide variation in value.
- In this investigation, improvement of CBR value of soil can be achieved by varying percentage of cane molasses.
- The test was carried out on optimum moisture content.

Unconfined compression test

- UCS test are performed according to IS 2720 PART10.[16]
- This test is carried out on soil to find the un drained shear strength.
- In this investigation, improvement in strength of soil can be achieved by varying percentage of cane molasses.
- The test was carried out on optimum moisture content

<u>**CHAPTER5- RESULT AND DISCUSSION**</u>

5.1 INRODUCTION

In this chapter result has been shown of various test that have been performed by mixing different percentage of cane molasses.

Tests are performed at **CIVIL ENGINEERING DEPARTMENT, DTU, and NEW DELHI**.

5.2 CONSISTENCY LIMITS

The effect of molasses addition in varying proportion with soil has been studied and consistency limit for various mix are presented in curve as shown below.

Table5.1 Effect of molasses on Consistency limit

S.No.	**Property**	**Soil + molasses mix**				
		SM_0	SM_1	SM_2	SM_3	SM_4
	Proportion Soil: molasses	100:0	97:3	95.5:4.5	94:6	92.5:7.5
1.	**Atterberg's limit**					
	Liquid limit	27.33	30.3	31.67	33.63	37.39
	Plastic limit	17.3	20.3	21.89	24.83	31.3
	Plasticity index	10.03	10	9.77	8.6	7.9

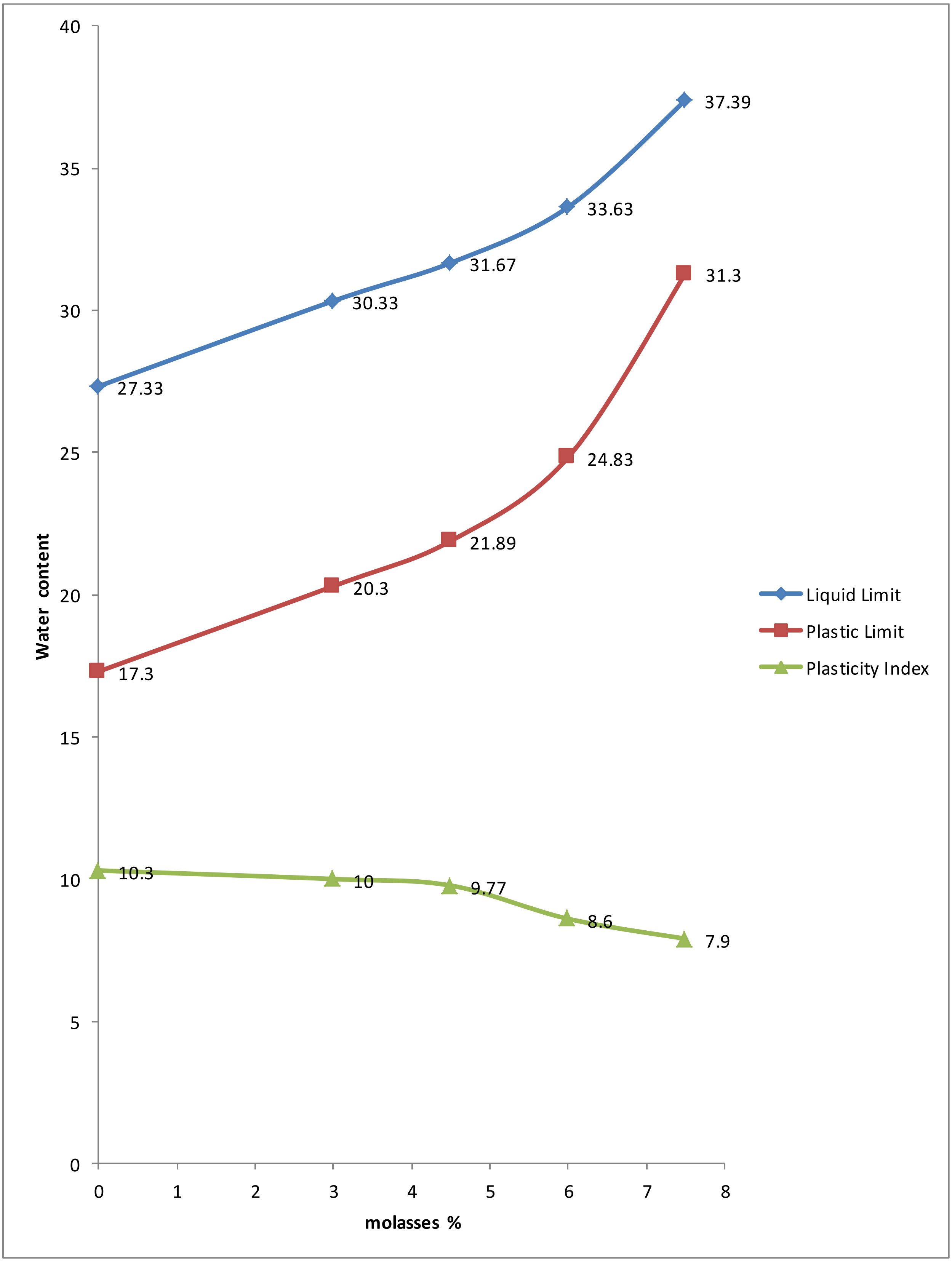

Fig.5.1 Effect of addition of molasses on Consistency limit for soil

5.3 COMPACTION TEST

The results of compaction tests are presented in the form of graphs and one table. A curve is drawn between the moisture content and dry density to obtain the maximum dry density (MDD) and moisture content (OMC).

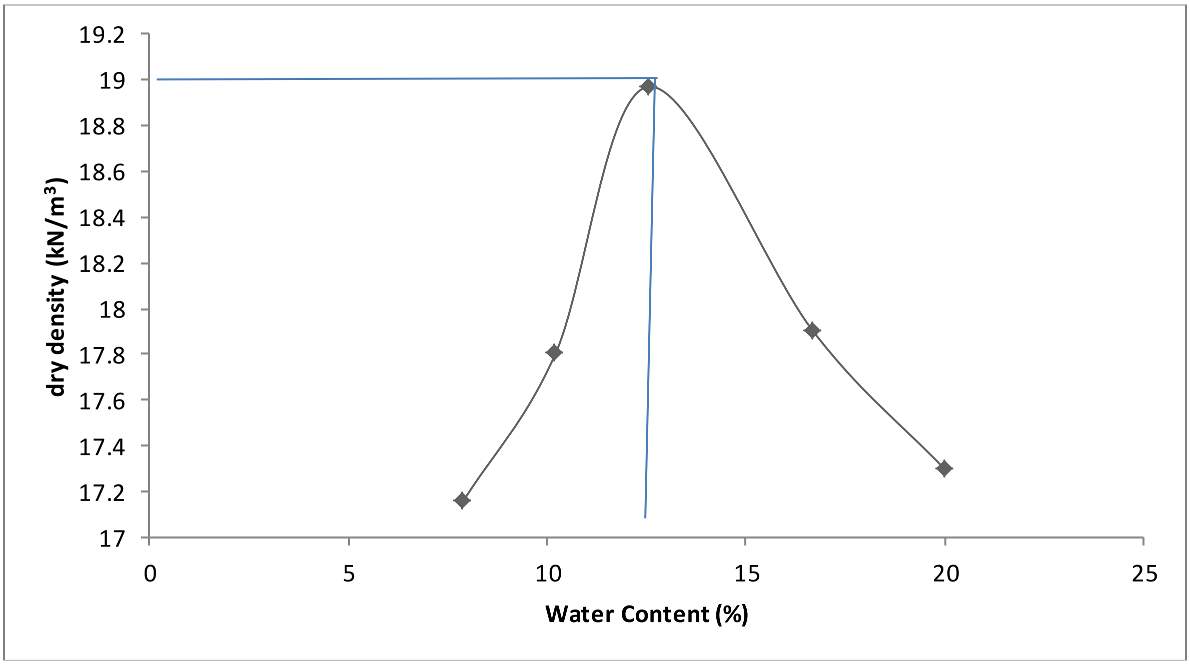

Fig. 5.2 Graph Shows Moisture- Density Relationships at 3% molasses

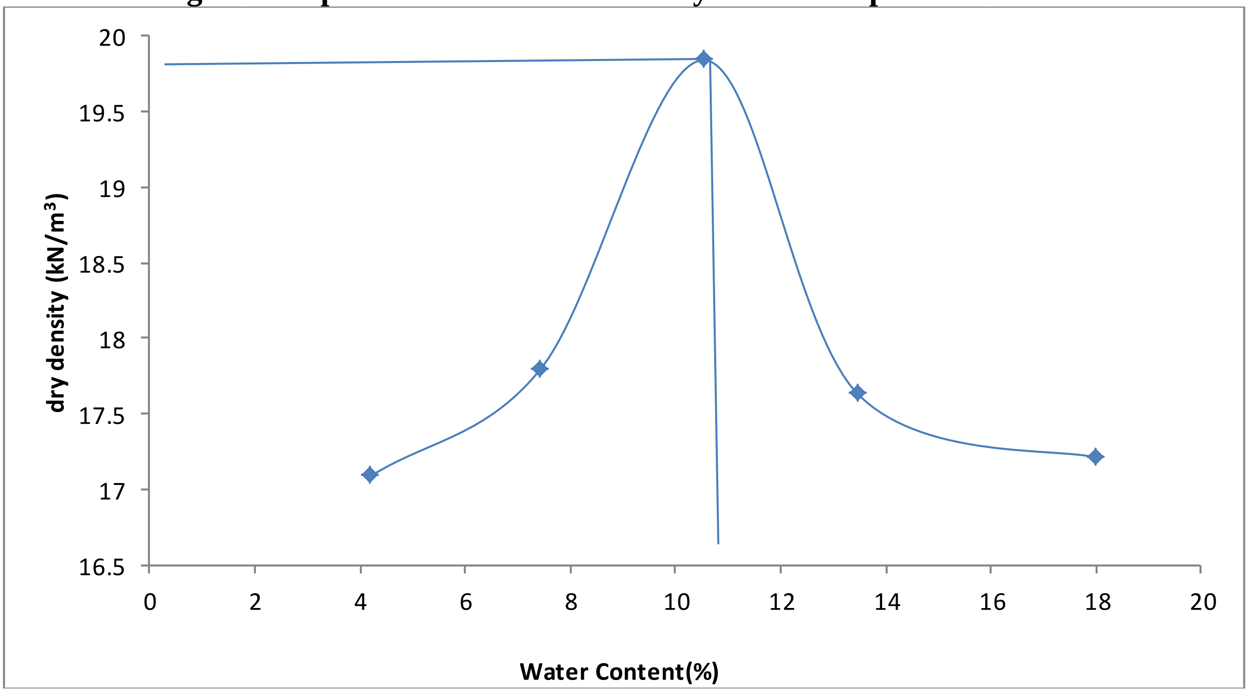

Fig. 5.3 Graph Shows Moisture- Density Relationships at 4.5% molasses

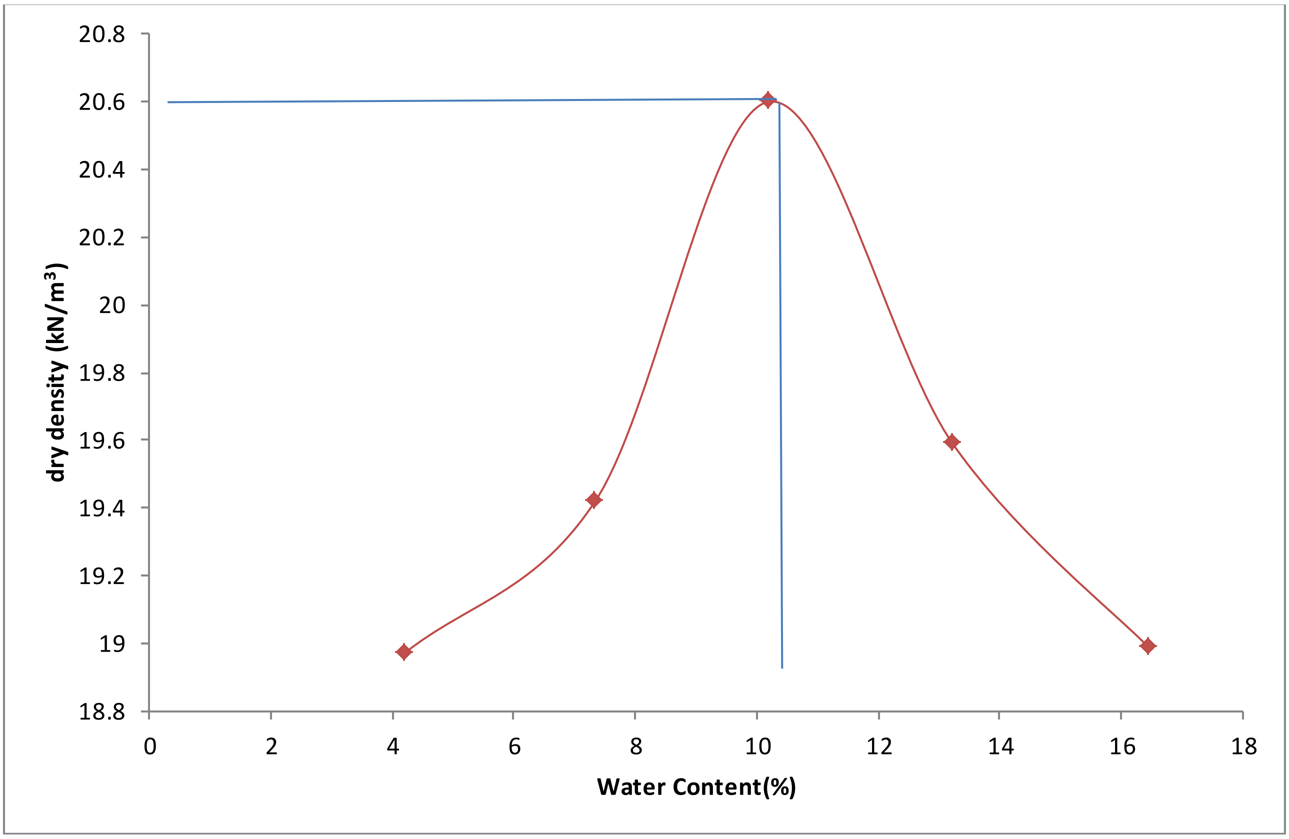

Fig. 5.4 Graph Shows Moisture- Density Relationships at 6% molasses

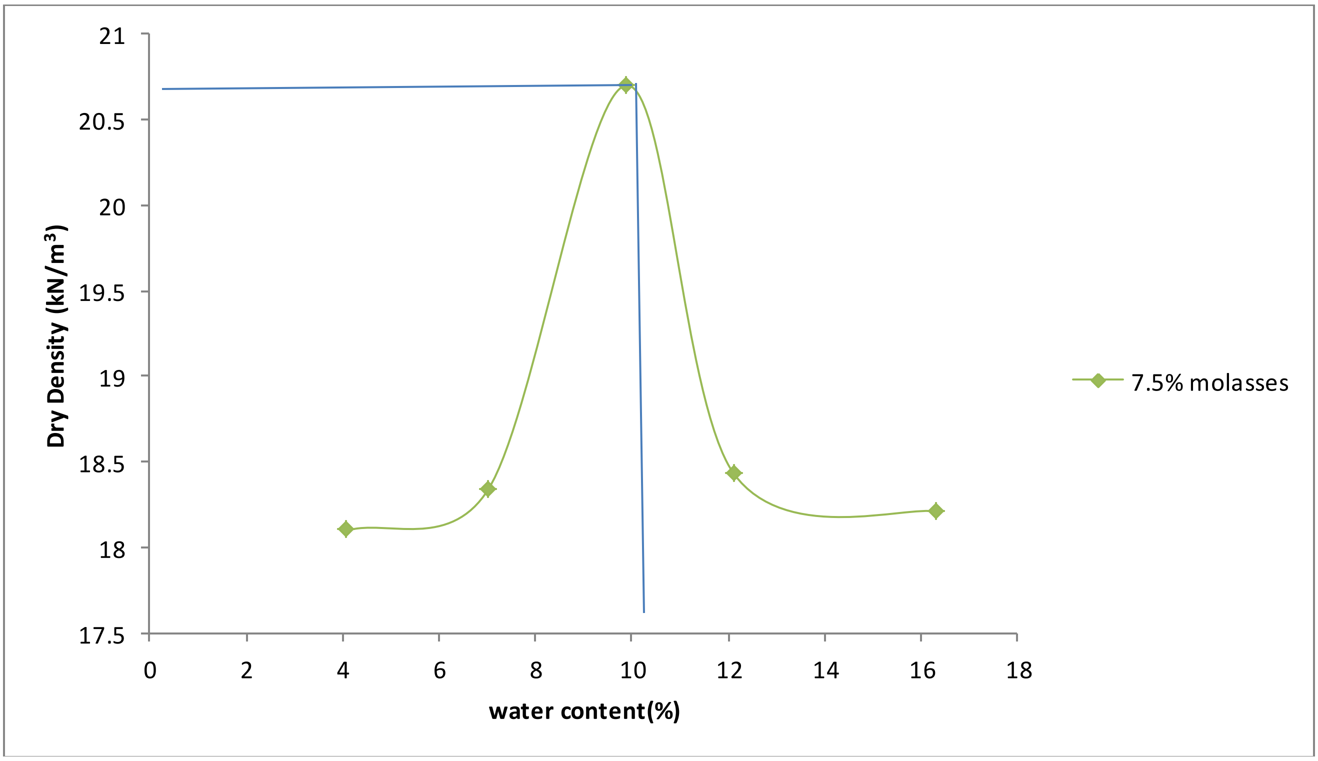

Fig. 5.5 Graph Shows Moisture- Density Relationships at 7.5% molasses

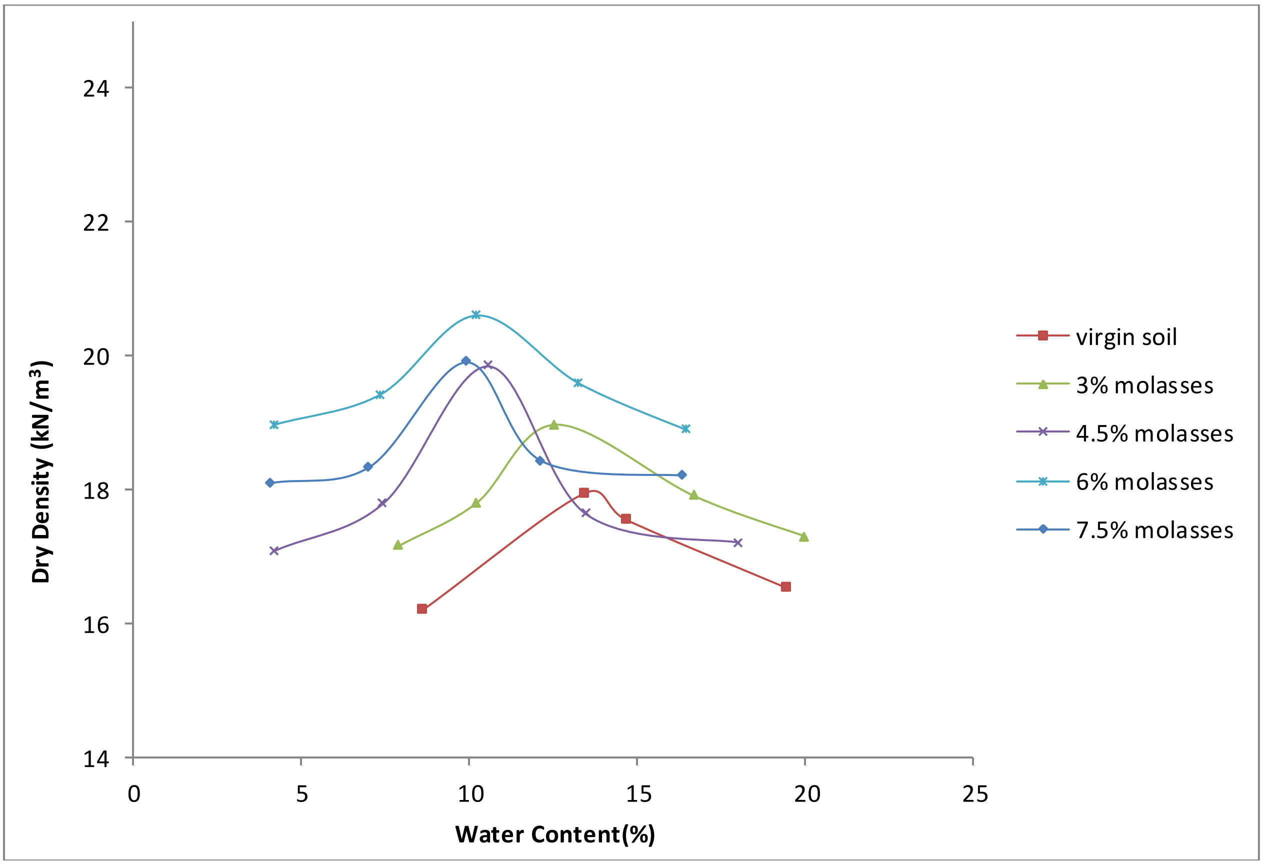

Fig. 5.6 Graph Shows Moisture- Density Relationships at varying percentage of molasses

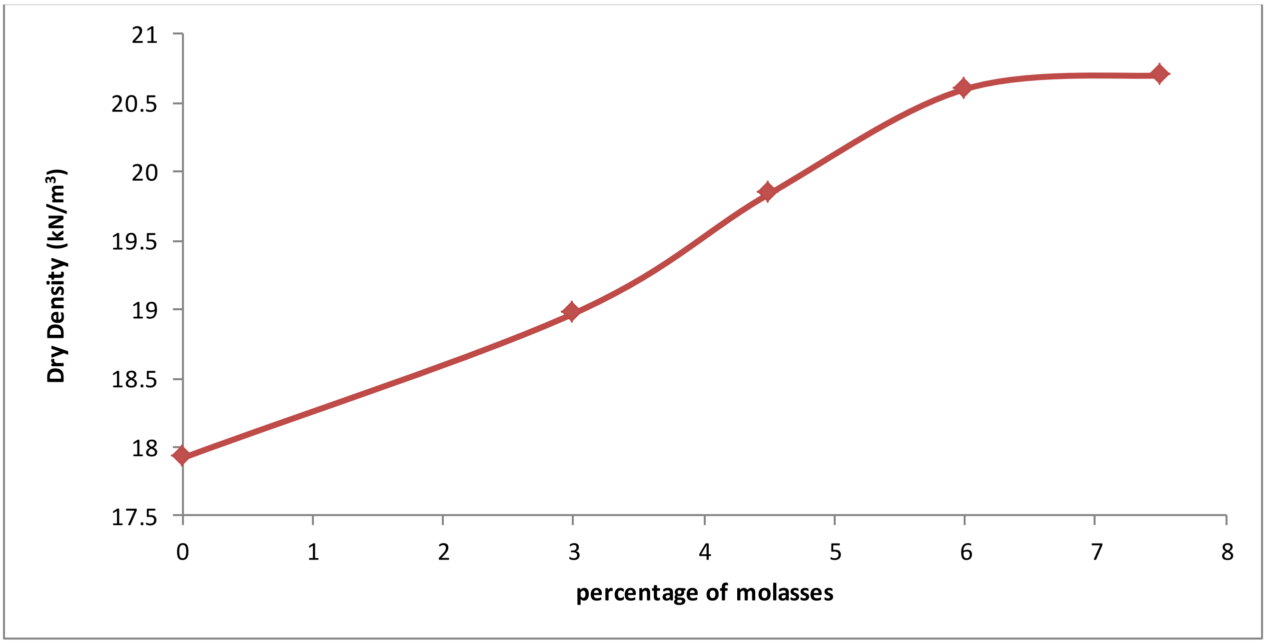

Fig. 5.7 Graph Shows Dry Density- percentage of molasses Relationship

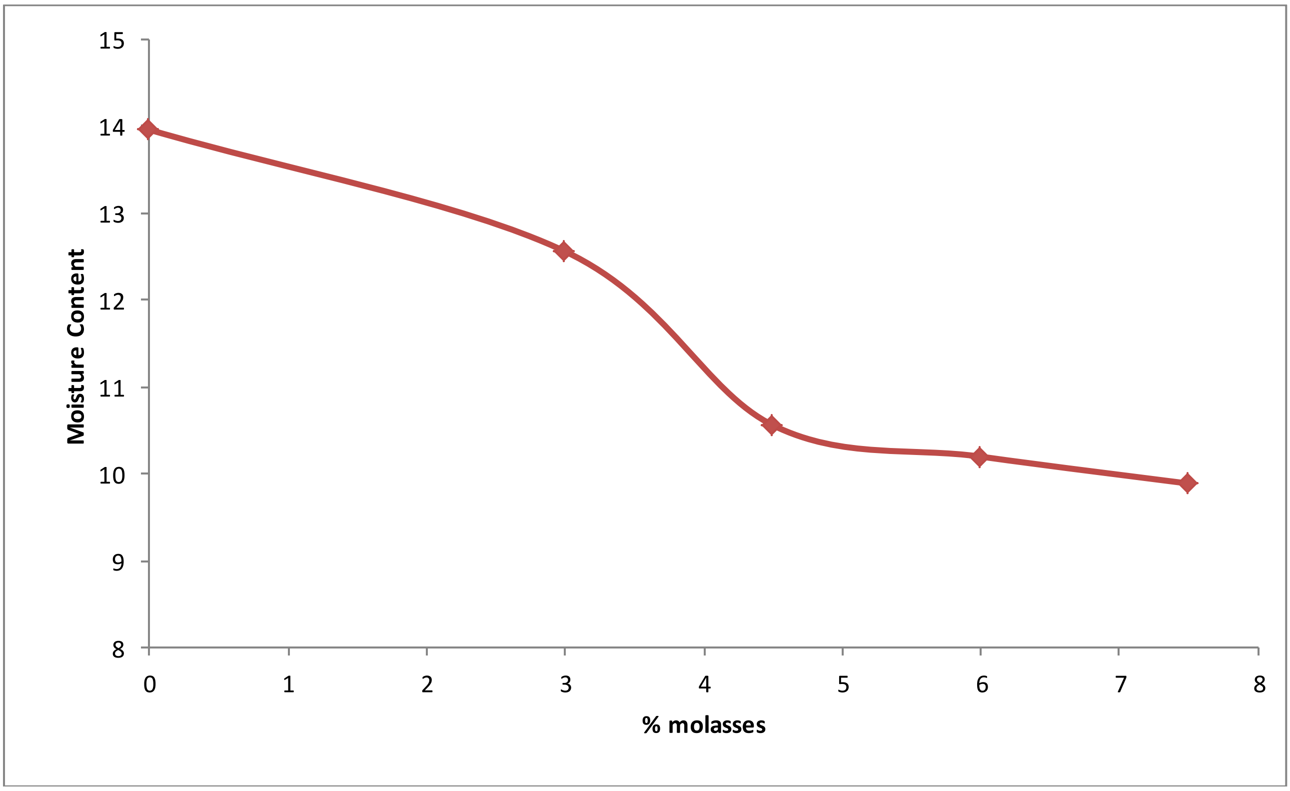

Fig. 5.8 Graph Shows Moisture - percentage of molasses Relationship

Table 5.2 Shows OMC Dry Density Variation with %Molasses

S.No.	% Molasses	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY(kN/m³)
1.	0	13.96	17.92
2.	3	12.56	18.97
3.	4.5	10.56	19.84
4.	6	10.2	20.6
5.	7.5	9.89	20.7

5.4 CALIFORNIA BEARING RATIO

The result of CBR presented below in the form of graph and table. Curves are drawn between load (kg) and penetration (mm)

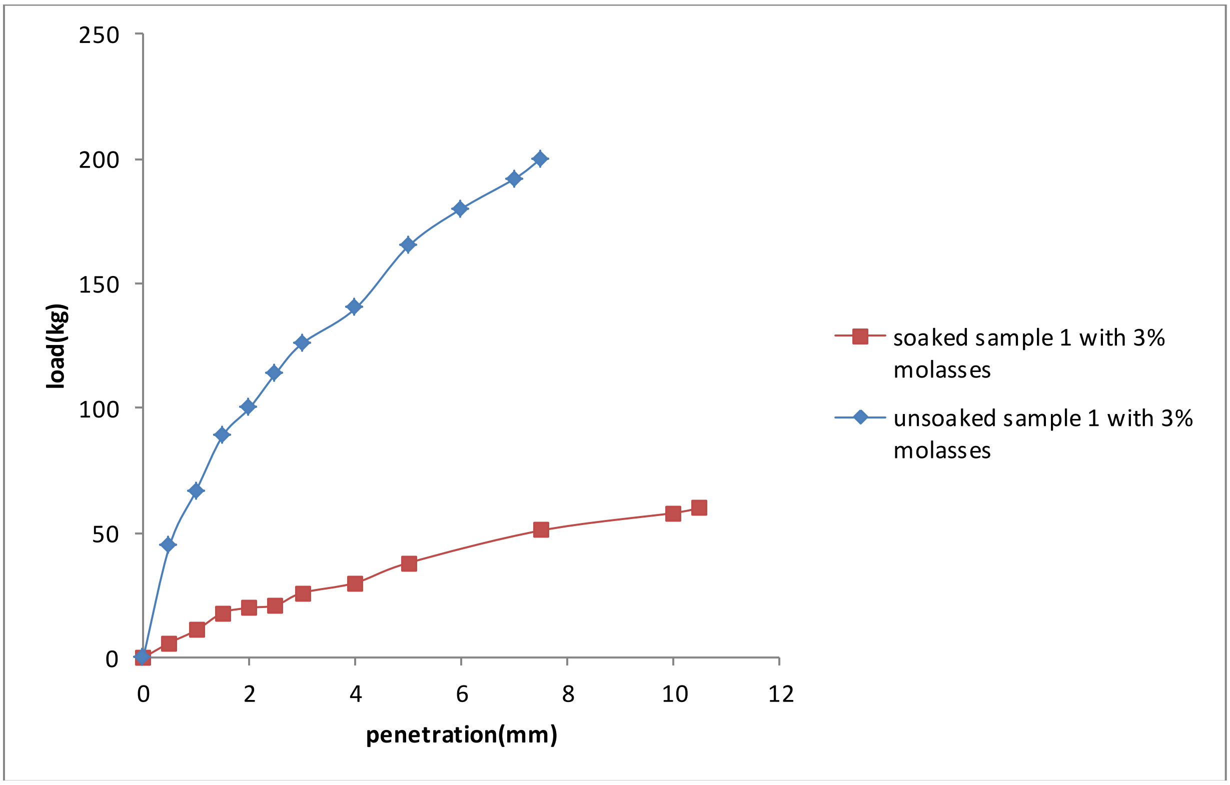

Fig 5.9 California bearing ratio of sample 1 varying with 3% of molasses

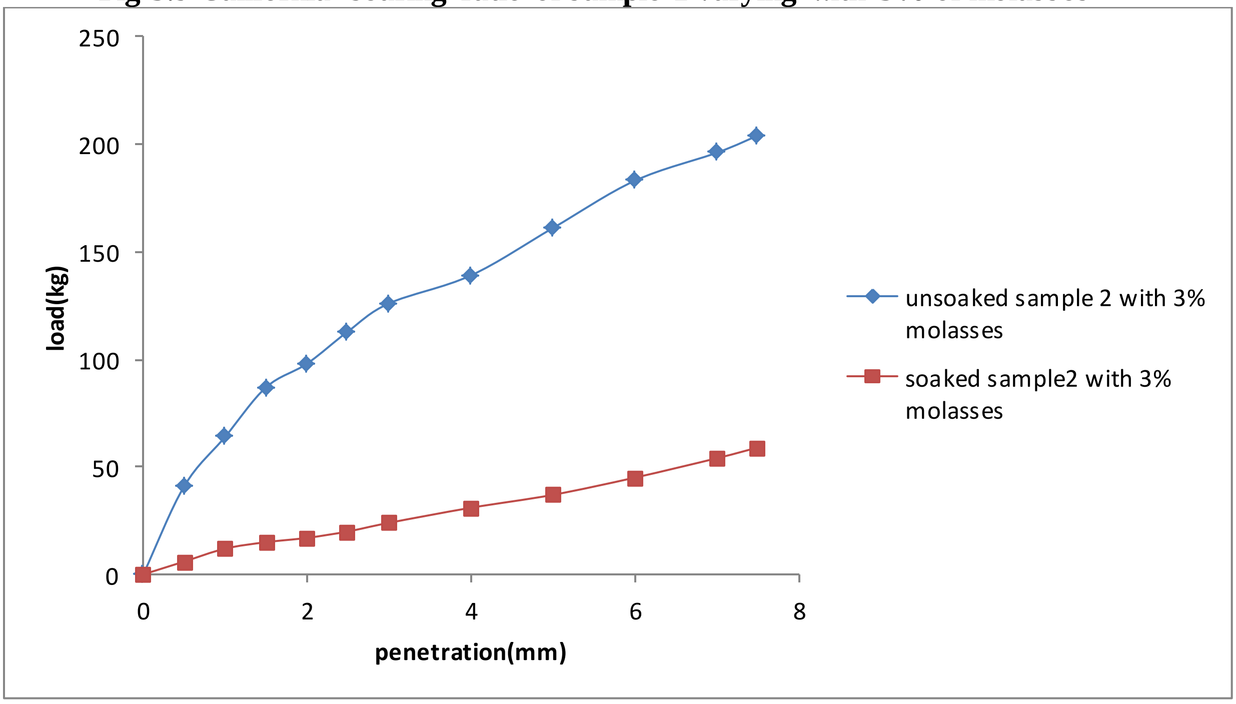

Fig 5.10 California bearing ratio of sample 2varying with 3% of molasses

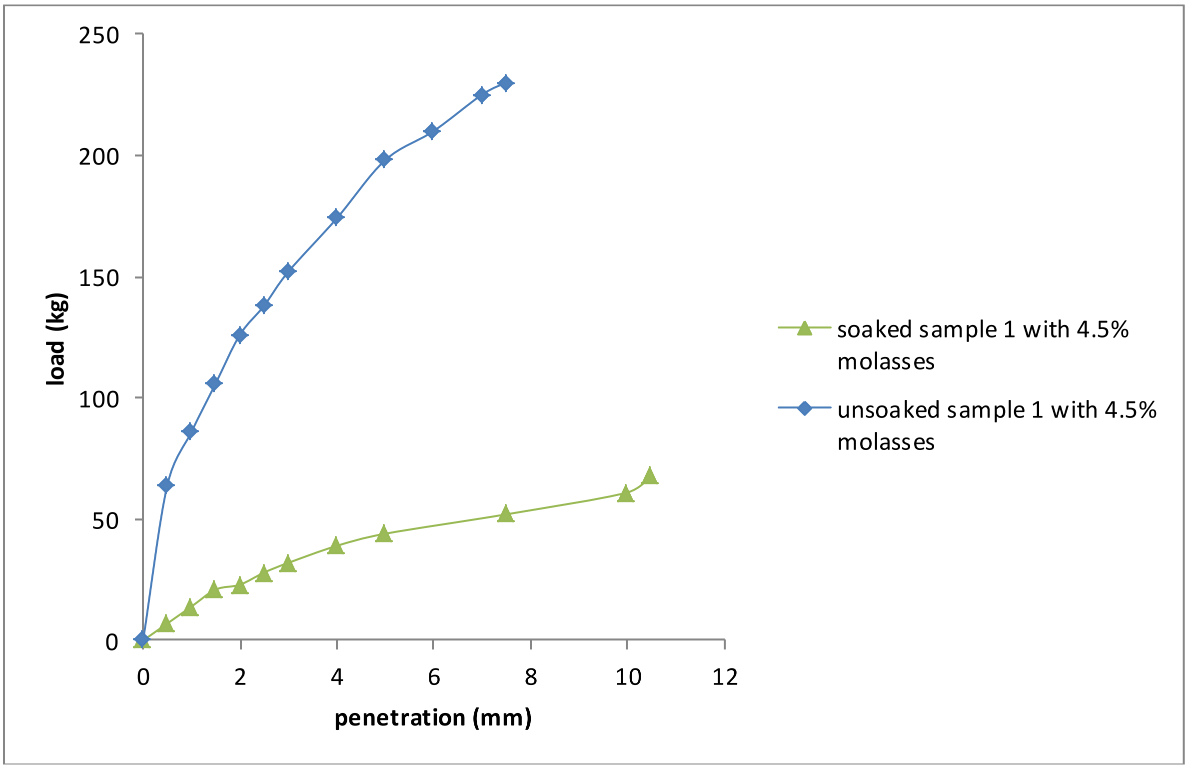

Fig 5.11 California bearing ratio of sample 2 varying with 4.5% of molasses

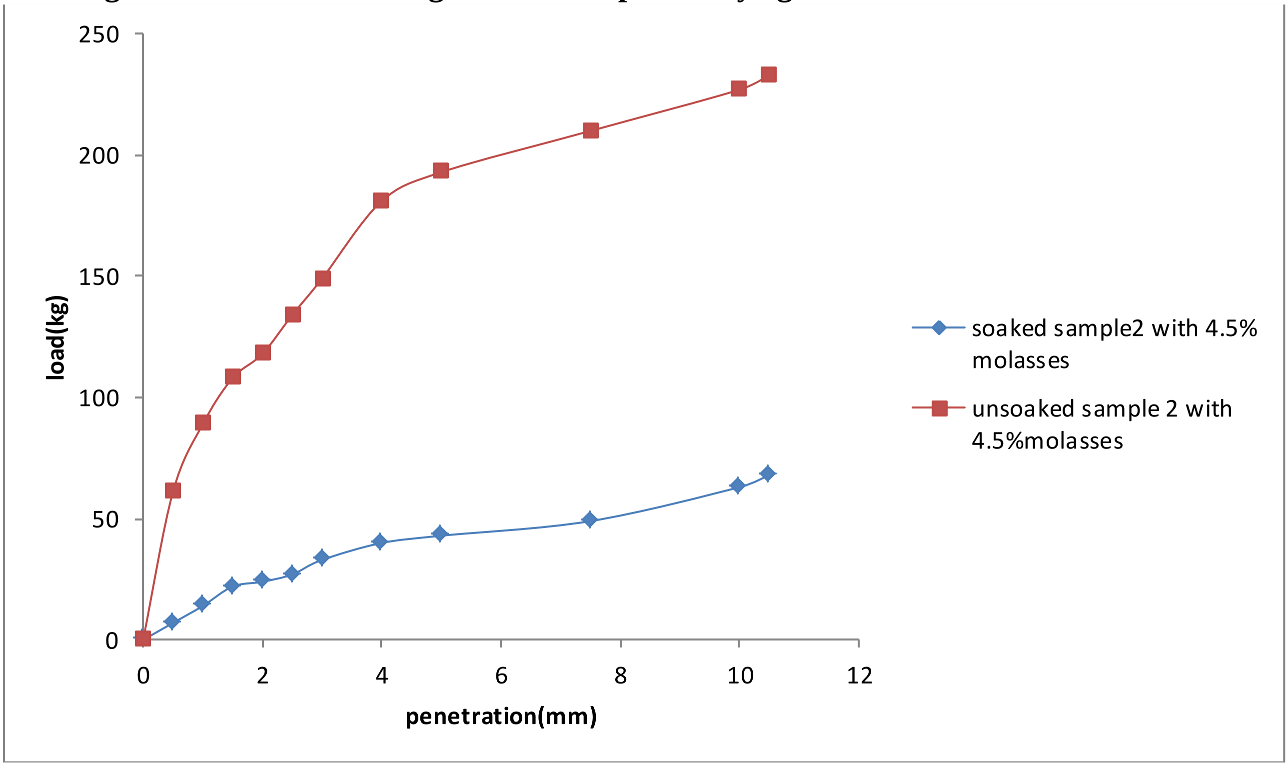

Fig 5.12 California bearing ratio of sample 2varying with 4.5% of molasses

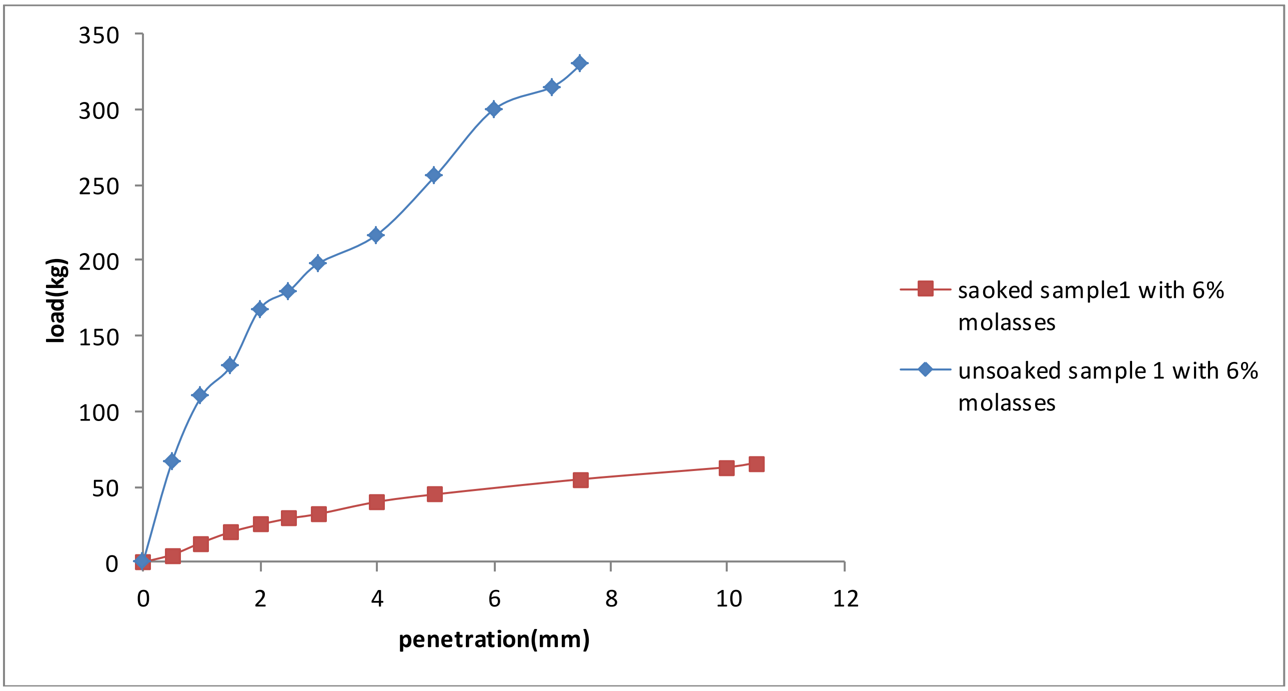

Fig 5.13 California bearing ratio of sample 2varying with 6% of molasses

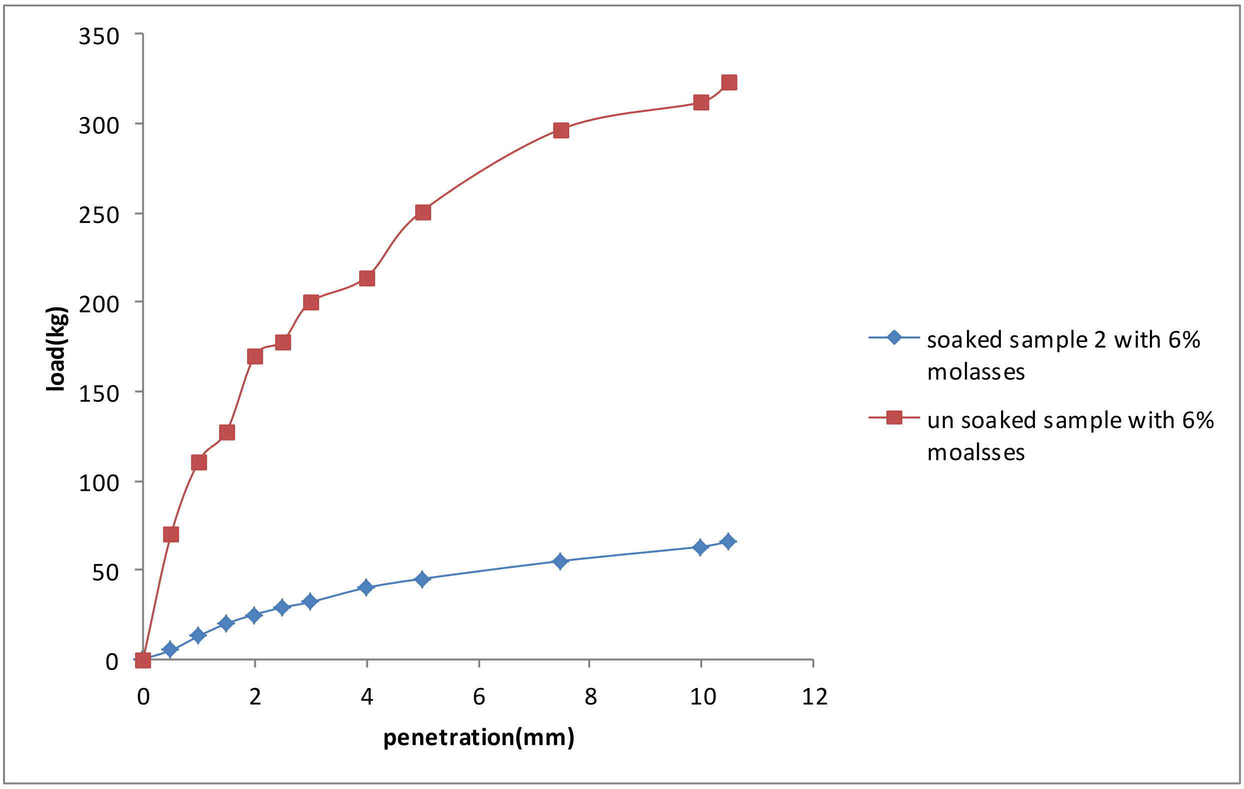

Fig 5.14 California bearing ratio of sample 2varying with 6% of molasses

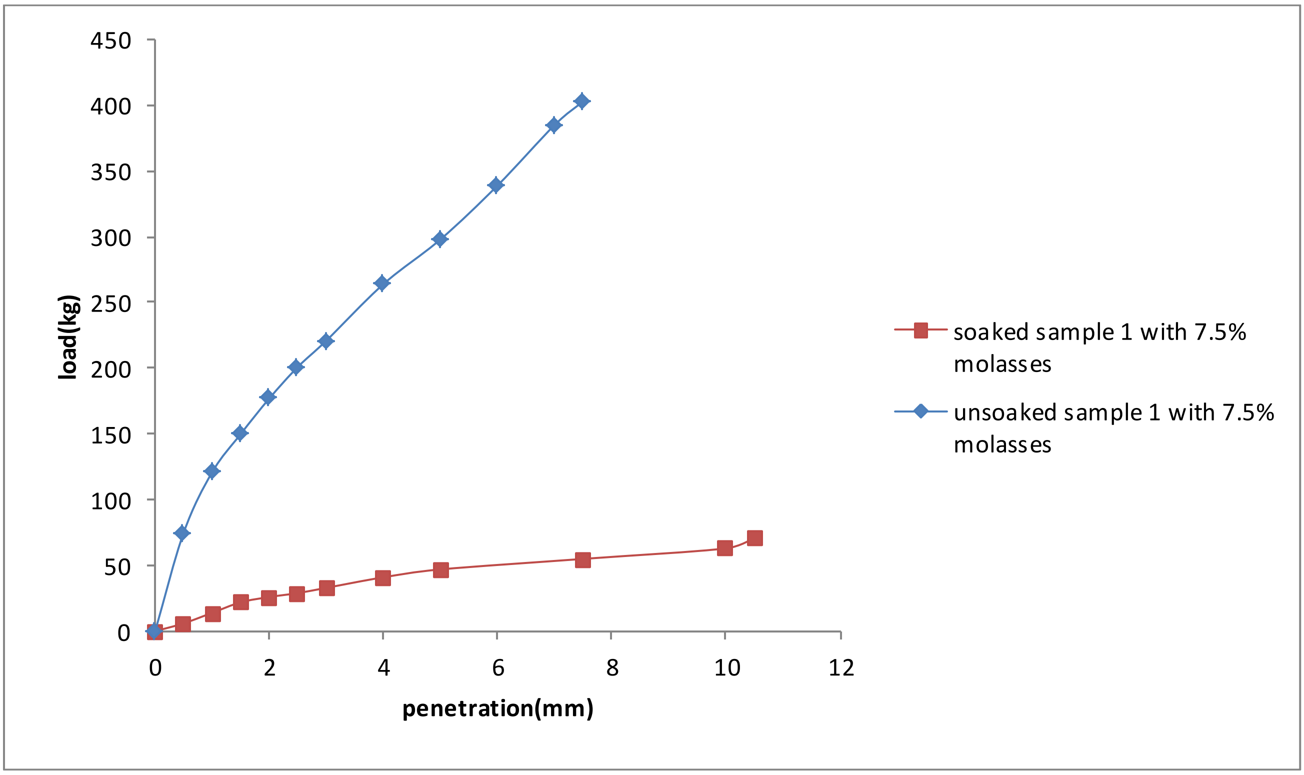

Fig 5.15 California bearing ratio of sample 2varying with 7.5% of molasses

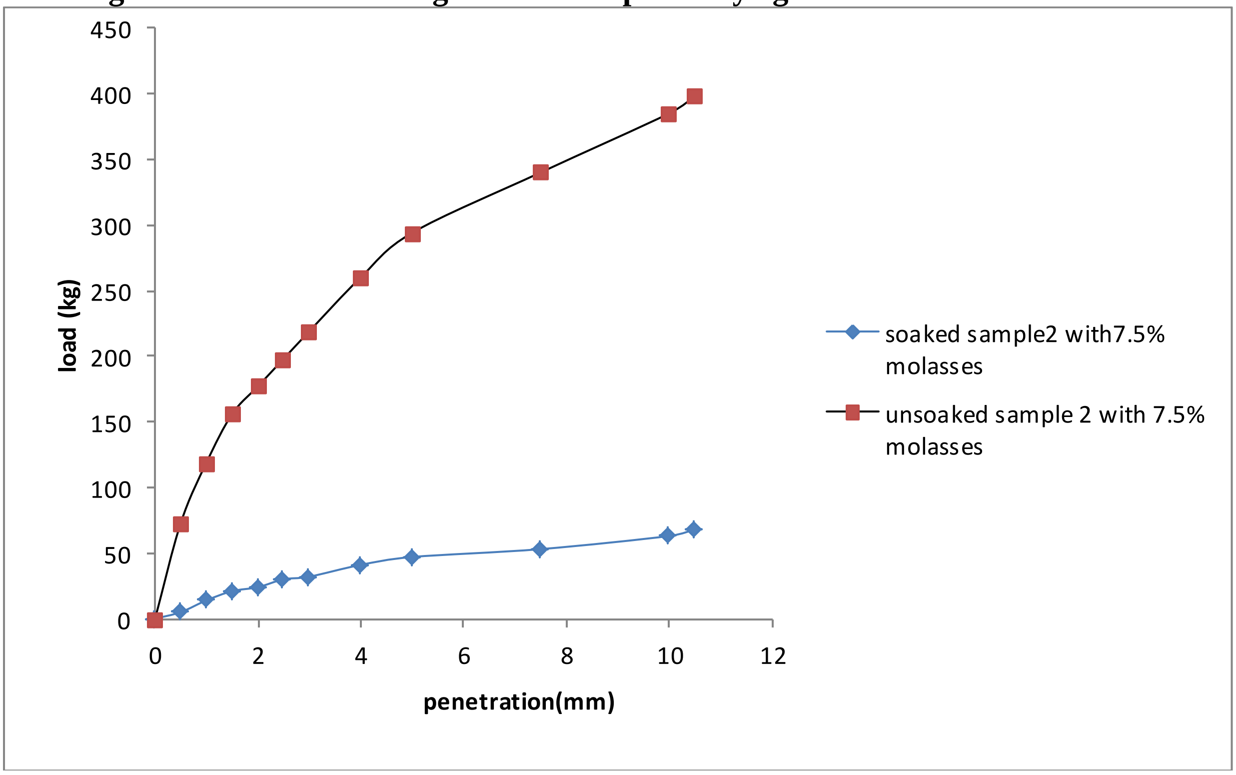

Fig 5.16 California bearing ratio of sample 2varying with 7.5% of molasses

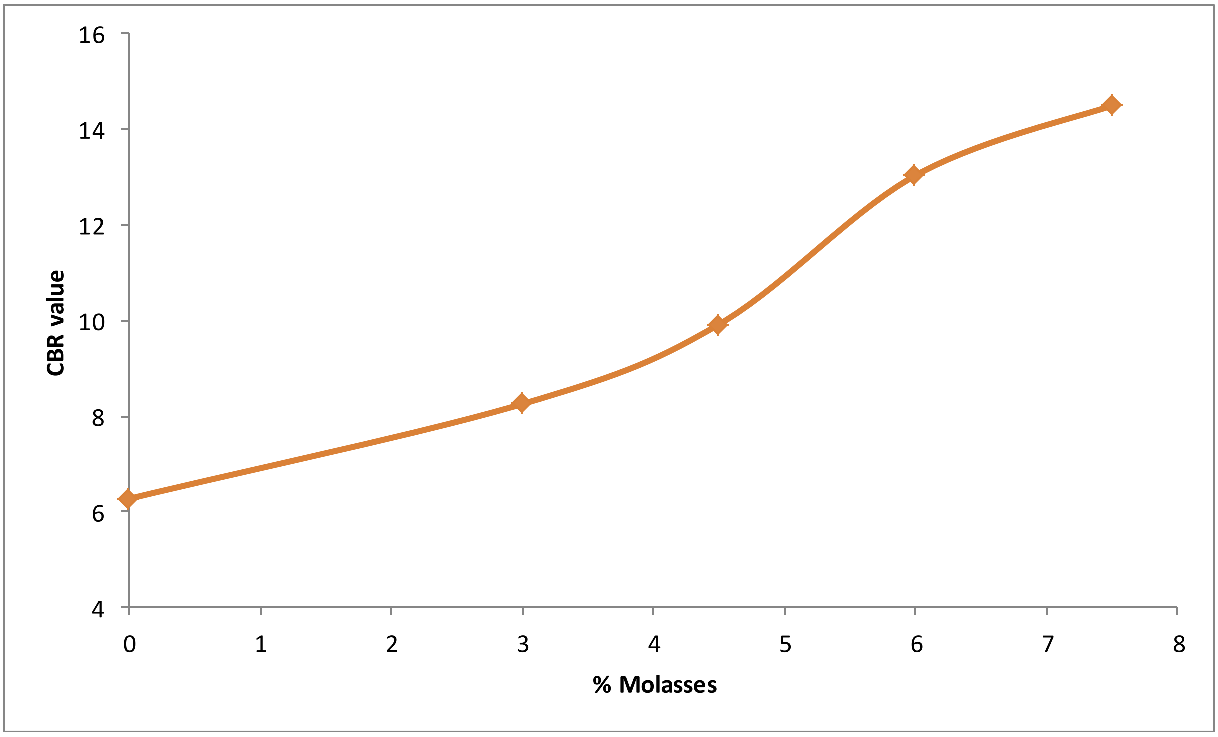

Fig. 5.17 Curves between Avg. CBR Value and %molasses of un-soaked sample

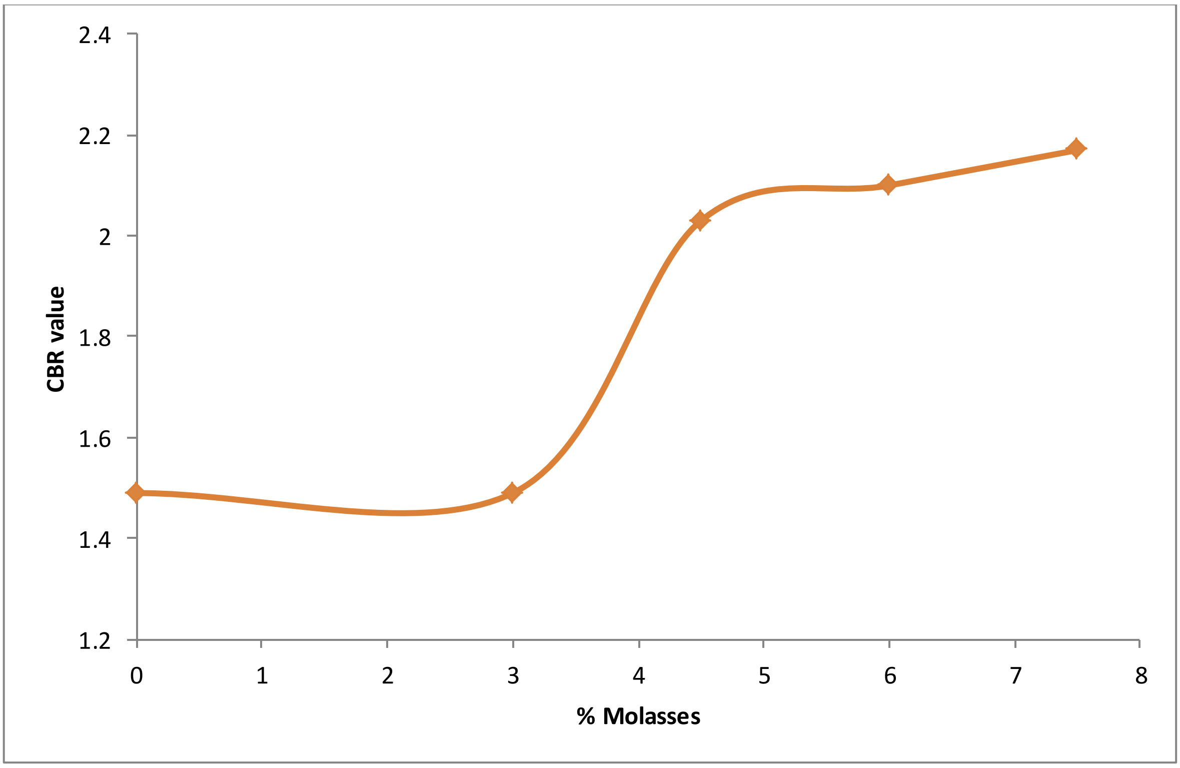

Fig. 5.18 Curves between Avg. CBR Value and %molasses of soaked sample

Table 5.3 shows CBR Un-soaked variation with % molasses

S.No.	%Molasses	CBR VALUE SAMPLE 1	CBR VALUE SAMPLE 2	AVERAGE CBR VALUE
1	DTU SOIL (0%molsses)	6.30	6.27	6.28
2	3% molasses	8.32	8.20	8.26
3	4.5% molasses	10.07	9.78	9.925
4	6% molasses	13.10	12.99	13.04
5.	7.5% molasses	14.60	14.40	14.50

Table 5.4 shows CBR soaked variation with % molasses

S.No.	**%Molasses**	**CBR VALUE SAMPLE 1**	**CBR VALUE SAMPLE 2**	**AVERAGE CBR VALUE**
1	Virgin soil (0%molsses)	1.45	1.53	1.49
2	3% molasses	1.53	1.45	1.49
3	4.5% molasses	2.04	1.99	2.03
4	6% molasses	2.1	2.1	2.1
5.	7.5% molasses	2.16	2.18	2.17

5.5 UNCONFINED COMPRESSION TEST

The results of unconfined compression are presented in the form of graphs. A curve is drawn between the stress and strain to obtain the unconfined compressive strength of soil.

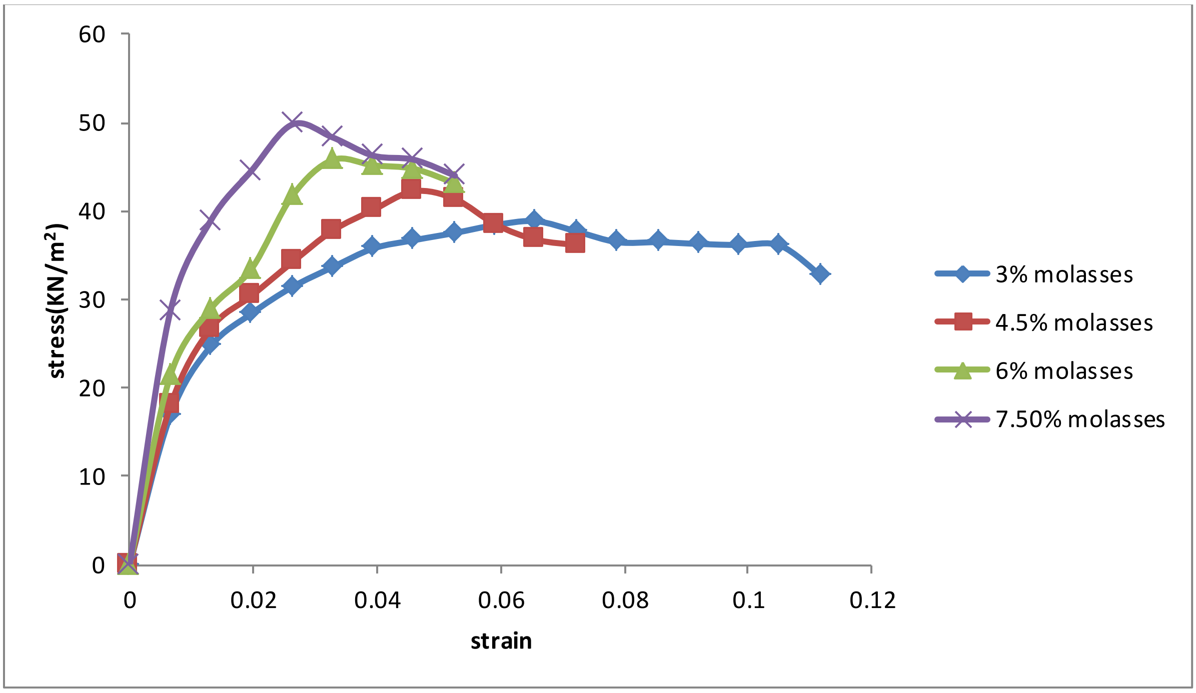

Fig.5.19 Graph between stress and strain of different varying % of molasses at 1 day curing period

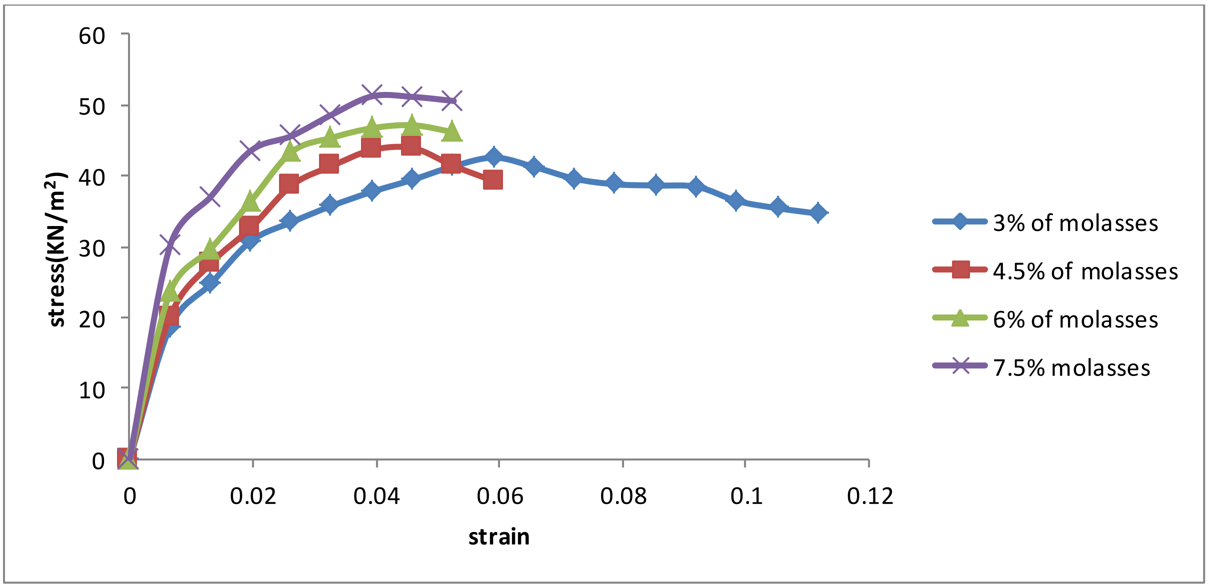

Fig.5.20 Graph between stress and strain of different varying % of molasses at 7 day curing period

Table 5.5 Unconfined compressive strength treated with molasses at 1 & 7 day curing period

S.NO.	MOLASSES (%)	UNCONFINED COMPRESSIVE STRENGTH(KN/m^2)		UNDRAINED COHESION (KN/m^2)	
		1 DAY CURING	7 DAY CURING	1 DAY CURING	7 DAY CURING
VIRGIN SOIL		18.81		9.41	
1.	3%	38.84	39.80	19.42	18.90
2.	4.5%	42.23	43.65	21.10	21.87
3.	6%	45.73	47.10	22.66	23.50
4.	7.5%	49.78	51.20	24.89	25.60

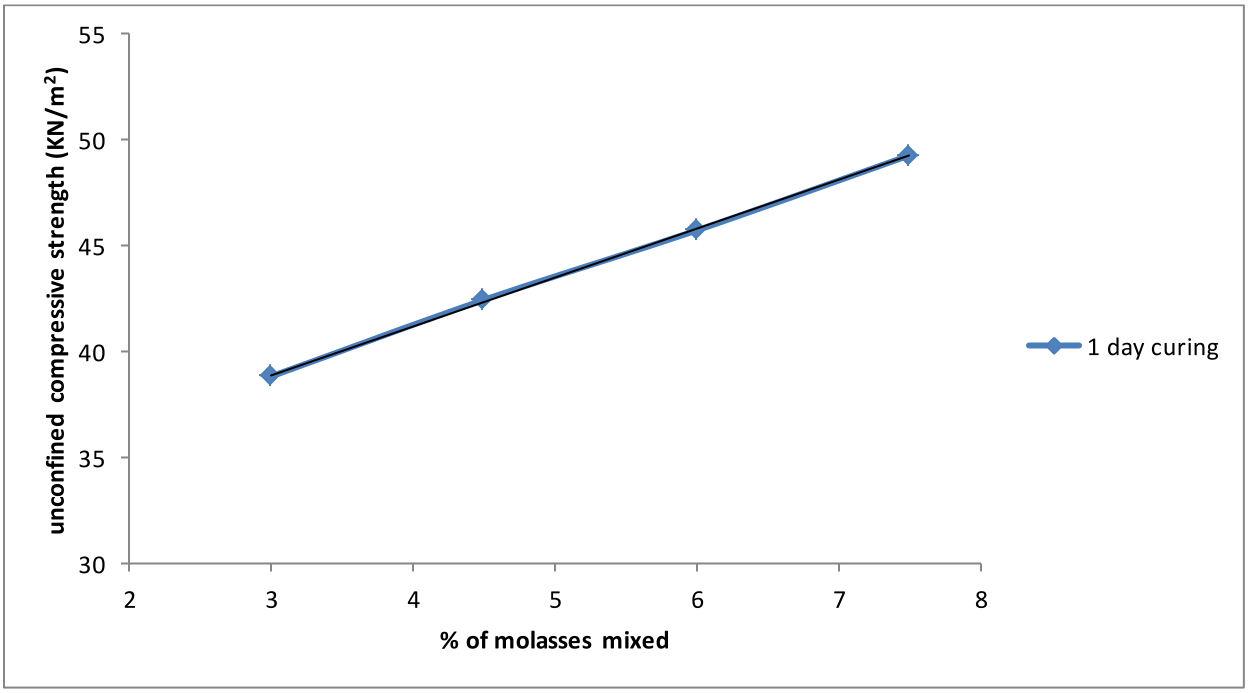

Fig.5.21 Graph between UCS and varying in % molasses at 1 day curing

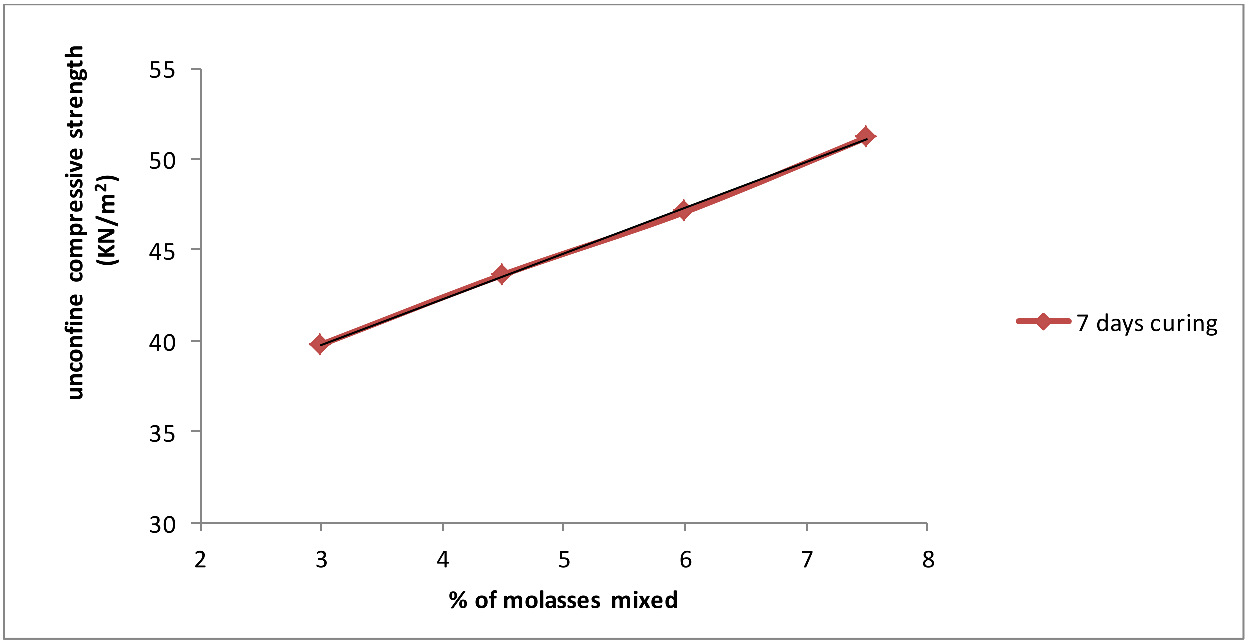

Fig.5.22 Graph between UCS and varying in % of molasses at 7day curing

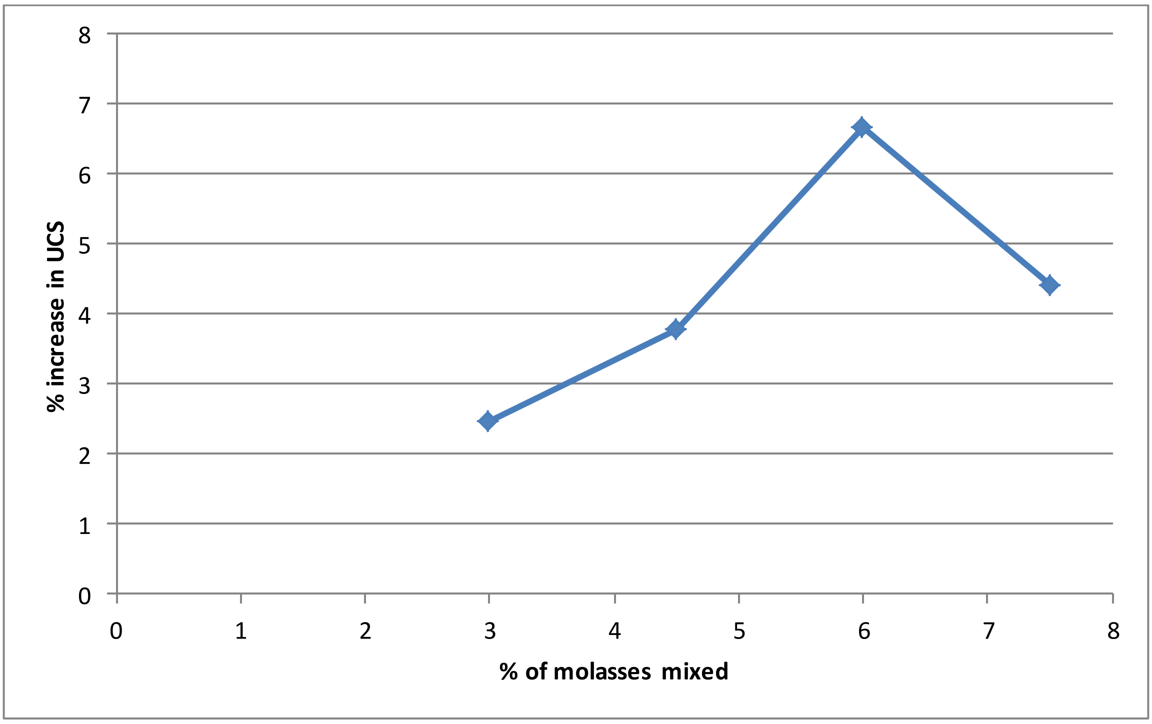

Fig.5.23 Relative increase in UCS from 1 day to 7 day

5.6 DISCUSSION

5.6.1 CONSISTENCY LIMIT

From the result obtained the effect of molasses addition in different proportion, the consistency limit if soil increases with increase in percentage of cane molasses.

5.6.2 COMPACTION CHARACTERISTIC

- From the results obtained from standard proctor test on different mixes of soils: cane molasses, Maximum dry density of silty soil is 17.92 kN/m³ which increases to a value of 18.97kN/m³ with addition of 3% RHA. With addition of 4.5%, 6% of cane molasses, MDD increases to a value of 19.84kN/m³, 20.6kN/m³ and decreases at 7.5% with the value of 19.19kN/m³ respectively. This shows increases in MDD within 6% and decreases at 7.5% with increase the cane molasses.
- Also from the results optimum moisture content of silty soil is 13.96%,

which decrease to a value of 9.89% with addition of 7.5% c. With addition of 3%, 4.5% and 6% of cane molasses the value of OMC decreases 12.56%, 10.56% and 10.2 respectively. This shows decreases in OMC with increases cane molasses.

- MDD increases to max value 14.95% and OMC decreases to max value 29.15%.

5.6.3 CALFORNIA BEARING RATIO

- From the results of CBR of different mixes of soil: cane molasses:
- Un soaked CBR value of silty soil is 6.3 which increases to a value of 14.5 with addition of 7.5% of cane molasses.
- With addition of 3%, 4.5% , 6% cane molasses , un soaked CBR value increases to value of 8.26%, 9.925% and 13.04%.
- CBR value increases up-to 1.3 times of initial value.
- Soaked CBR value of silty soil is 1.53 which increases to a value of 2.17 with addition of 7.5% of cane molasses.
- With addition of 3%, 4.5%, 6% cane molasses, soaked CBR value increases to value of 1.49%, 2.03% and 2.17%.
- CBR value increases up-to .4 times of initial value.

5.6.4 UNCONFINED COMPRESSIVE TEST

- From the results of UCS of different mixes of soil: cane molasses:
- Unconfined compressive strength of silty soil is 0.1919 kg/cm^2 which increase to value of .4978 kg/cm^2 with addition of 7.5% molasses at 1 day curing..
- With addition of 3%, 4.5% , 6% cane molasses , UCS value increases to value of 0.3884 kg/cm^2, 0.4223 kg/cm^2 and 0.4571 kg/cm^2 at 1 day curing.
- Unconfined compressive strength of silty soil is 0.1919 kg/cm^2 which increase to value of .512 kg/cm^2 with addition of 7.5% molasses at 7 day curing..
- With addition of 3%, 4.5% , 6% cane molasses , UCS value increases to value of 0.398 kg/cm^2, 0.4365 kg/cm^2 and 0.4710 kg/cm^2 at 7 day curing.
- UCS increases up-to 32% of initial value at 1 days curing.
- UCS increases up-to 28% at different percentage of molasses in 7 days curing.

CHAPTER 6- CONCLUSION AND RECOMMENDATIONS FOR THE FUTURE WORK

6.1 CONCLUSION

In this study, dry density, CBR value and UCS of Soil: cane molasses mixes has been studied. The following conclusion has been made from the results obtained from experiments.

- The soil has been used to be found to be silty sand this soil not much suitable for this grade for embankment and needs for modification.
- Due to increase in percentage of cane molasses mixed with soil the consistence limit has been increased.
- Plasticity index of treated soil is decreased by increasing the percentage of cane molasses mixed with soil.
- The increased in MDD value of treated soil is increased due to the proper rearrangement of treated soil mix with cane molasses at varying percentage.
- Soil is modifies with cane molasses by 3%, 4.5%, 6% and 7.5% the value of CBR is found to be increased by 0.3, 0.57, 1.06 and 1.3 times and in the range of 4.5% to 6% there is sudden rise in load taking behavior of soil. So it can be suggested the dose of cane molasses lies between 4.5% to 6%.
- The value of CBR of soil by adding cane molasses increases due to increase in density of treated soil mix, which leads to soil mass having good bearing capacity.
- The value of UCS of soil has been frequently increases with increase in percentage of cane molasses mixed with soil at 1 and 7 day curing.
- The result also be found that at 7 day curing the UCS of soil is increase with increase in percentage of soil as compared to 1 day curing.
- The relative increase in UCS value from 1 to 7 day is maximum at 6.5% of cane molasses mixed with slity soil.

6.2 RECOMMENDATIONS FOR THE FUTURE WORK

Many investigations had been made for improving the properties of soil-molasses mixes, which can be useful for using waste natural polymer as replacement of natural resources. These suggestions may prove that there should be best utilization of waste natural polymer.

- Based on these laboratory test in field should also be conducted to correlate the values of laboratory to field.
- Industrial waste like molasses combination with different waste to be used in place of conventional material for road construction and should be for future work.
- Strength tests are required to be investigates for 28 days & 56 days curing.
- Similar study can be carried out on different types of natural or synthetic polymer.
- Shear tests like direct shear, tri-axial test can be carried out to study the effect of natural or synthetic polymer in soil.
- Similar study has to be carried out in other type of soil like sand, organic clay etc.

REFERENCES

1. “Molasses” at “http://en.m.wikipedia.org.
2. “http://en.m.Farmer.gov.in”.
3. “Industrial policy of Uttar Pradesh”lex Universe. Retrieved 20 September 2012.
4. S.S. Shirsavkar and Prof. S.S. Koranne (2010), “Innovation in Road Construction Using Natural Polymer”, EJGE Vol. 15 [2010], Bund. O, pp 1614 -1624.
5. A.U. Ravi Shankar, Harsha Kumar Rai & RameshaMithanthayaI. (2009), “Bio-enzyme Stabilized Lateritic soil as a Highway Material”,Journal of the Indian Roads Congress, July-September 2009,pp.143-151.
6. Ahmed Al Qabanny, Kenichi Soga and Carlos Santamarina (2012),”Stablization potential of Bio enzyme”, J. Geotech. Geoenviron. Eng. 2012.138:pp,992-1001.
7. Kyle M. Rollins, “Effectof Soil Treatment with Bio-Base on Cbr%” Scholen, D.E., (1992) “Non-Standard Stabilizers”, Report No. Fhwa-Flp-92-011, Us. Dept. O Transportation. Washington, D.C.
8. Ahmed Al Qabanny, Kenichi Soga and Carlos Santamarina (2012),”Swelling properties of bioenzyme ”, J. Geotech. Geoenviron. Eng. 2012.138:pp,992-1001.
9. Alan F. Rauch, Jacqueline S. Harmon, Lynn E. Katz, and Howard M. Liljestrand “Measured Effects of Liquid Soil Stabilizers on Engineering Properties of Clay”, Transportation Research Record 1787 _ 33 Paper No. 02-3244 pp.33-41.
10. Whiffin, V.S., van Paassen, L.A., Harkes, M.P. (2007). “Measures effect of liquid stabilizer on soil” Geomicrobiol. J. 25 (5), pp 417–423.
11. Brazetti R and Sheldon R. Murphy (2000), “Objective performance measurement of actual road sites treated with an Organic Soil Stabilizer” Annual Meeting on Paving Brazil ,pp.450-459.
12. Lee Min Lee, Wei Soon Ng, Yasuo Tanaka (2013), “Stress-deformation and compressibility responses of bio-mediatedresidual soils”, Ecological Engineering 60 (2013),pp.142– 149.
13. IS: 2720 (Part 4, Part 5, and Part 6), “Methods of Tests for Soil - Determination of Atterberg’s limits”, BIS, New Delhi.
14. IS: 2720 (Part 7), “Methods of Tests for Soil – Standard Proctor Compaction”, BIS, New Delhi.
15. IS: 2720 (Part 10), “Methods of Tests for Soil – Determination of California bearing ratio”, BIS, New Delhi.

16. IS: 2720 (Part 16), "Methods of Tests for Soil –Determination of Unconfined compressive strength", BIS, New Delhi.