A Major Project Report on

UTILIZATION OF CONSTRUCTION WASTE – A USEFUL MATERIAL

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CERTIFICATE

This is to certify that the project report entitled "Utilization of Construction Waste - A Useful Material" is a bona fide record of work carried out by Jitendra Kumar Gupta (2K13/GTE/08) under my/our guidance and supervision, during the session 2015 in partial fulfillment of the requirements for the degree of Master of Technology (Geotechnical Engineering) from Delhi Technological University, Delhi. To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

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ABSTRACT

Any structure has two fundamental parts - the sub-structure and the super-structure. Sub structure must be firm enough to withhold the super-structure placed over it. The properties of the soil get adversely affected due to swelling (due to wetting) and shrinking (due to drying). These lead to decrease in the bearing capacity of the soil and create problems during construction. To increase the capacity of soil to withstand different types of loadings, certain amounts of admixtures are added to it. These processes aimed at enhancing various soil properties are known as soil stabilization. Construction wastes resulting from infrastructure development are often a source of pollution and are hazardous. There is a need for effective disposal and preferably alternative utilization of these constructions wastes.

The primary objective of this study is to explore the possibility of gainful utilization of these construction wastes for the purpose of soil stabilization. It is appreciated that if successful, this will lead to significant reduction in pollution and hazardous wastes. Besides, the easy availability of construction wastes will result in easy/improved soil stabilization/increased soil capacity. For this study on soil stabilization using construction wastes, the soil available in DTU campus and construction wastes available from different sources have been used.

For soil stabilization several mixes of admixtures have been attempted. Most of these use lime as one of the admixtures. Different proportions of lime and construction waste by mixing it with expansion soil in using different methods have been studied. These mixtures are generally compacted to maximum dry density at optimum moisture content to find out the index properties, direct shear, permeability and California bearing ratio and compare the result are compare with virgin soil. These studies show that the soil properties improved because of soil stabilization using construction wastes. Various studies reported have however not indicated the optimum percentages of admixtures to achieve the maximum improvement in soil capacities.

In this study, therefore, different proportions of lime and construction waste have been mixed with silty soil available within DTU Campus to recommend optimum percentages of these two admixtures. In order to conclude the same maximum dry density, consistency index, California bearing ratio etc have been at different proportions. Lime and construction waste mix in the range 5% to 15% to get optimum gain in strength (at OMC) has been studied.

The experiments conducted in the laboratory indicate that the recommended optimum percentage of 5% lime and 10-15% construction waste mixed with silty soil is likely to give the for best.

Key words: Lime, Construction waste, Permeability, OMC, Sub-grade, Direct shear test, CBR test.

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Soil is basic component in construction, and it holds the sub structure on which the super structure rests. The term soil in soil engineering is defined as an unconsolidated material, composed of solid particles produced by disintegration of rocks. The voids space between particles may contain air, water or both. The solid particles may contain organic matter. The soil particles maybe separated by mechanical means. Soil deposits in nature exist in an extremely erratic manner producing thereby an infinite variety of possible combination which will affect the strength of the soil and the procedures to make it purposeful.

The engineering behavior of a soil mass is expected to be greatly influenced by the mineral composition of the soil grains forming the soil mass. This, however, is only partly true. In case of coarse grained soil, the mineralogical composition of the grain hardly affects the engineering properties of the soils perhaps the grain to grain friction is influenced to a degree. In such soils, inter particle forces other than those due to gravity are of no consequence, but the finer particles, the more significant becomes the forces associated with the surface area of the grains. The chemical character of the individual grain assumes importance especially when the surface area is large related to the size of the grain - a condition which is associated with the fine grained soil. Thus, inter-particle attraction holding the grain together becomes increasingly important as the size decreases.

The soil structure means the mode of arrangement of soil particles related to each other and the forces that are acting between soil particles to hold them together in their positions. The concept is further extended to include the mineralogical composition of the grains, the electrical properties of the particle surface, the physical characteristics, ionic composition of pore water, the interactions among the soil particles, pore water and the adsorption complex.

The formation of soil structures is governed by several factors in coarse grained soils, the force of gravity is the main factor, while in fine grained soils, and the surface bonding becomes predominant. The specific surface (the ratio of the surface area of a mineral to its mass or volume) is a parameter which is often used to decide the importance of surface bonding forces relative to forces of gravity. Smaller particles have much larger surface area than the larger particles for the same void ratio water content are more for fine grained soil than for the coarse grained.

One of the basic properties of the soil which is needed in the construction is bearing capacity of the soil. It is the most important property of the soil. This is the only property which governs the load bearing capacity of the soil. It uniformly transfers the load of the super structure over it. There are many experimental methods of finding out the bearing capacity of the soil such as CBR, Unconfined compressive strength, triaxial method etc. If the bearing capacity of the soil is not good for construction or it has high compressibility, or higher swelling as in case of expansion soil, the improvement of the soil is necessary. It is also necessary in case of high rise building or when the land is limited. Improvement can be done by many methods but from economy point of view we use cost effective methods like treatment with industrial wastes and agricultural waste like fly ash, rice hush etc and it also bind the soil as it has some cement ations properties. Clayey type of soil generally exhibits some undesirable properties due to which shear strength decreases and are higher expansive in nature. The most undesirable property of soil is high expands and shrinks upon wetting and drying. Due to which large lateral pressure is develop and this tend to decrease the resilient modulus value. For this reason clay are poor materials for construction. It can be increase by using different stabilization techniques.

Stabilization is mixing of additives, such as cement, lime and fly ash to increase the strength of the soil. These poor engineering properties create a problem for construction projects and that why we need a stabilization of soil. As we have seen in the present arena lot of construction work is going and this construction waste cannot be further used in construction works. Many construction wastes lay across the road or on the agricultural land. Construction waste has being hazard to the country now days as there are no proper disposal methods. With lime we can utilize construction waste to increase bearing capacity of soil. Construction wastes can be utilized to improve the index properties, direct shear, permeability and California bearing ratio.

1.2 INDUSTRIAL AND CONSTRUCTION WASTE

Industrial wastes are generated as useless by products in manufacturing and various other types of process industries. On the other hand construction wastes are useless/residual byproduct in/during the construction process. Industries which are the source of these wastes can use their waste material in stabilization of soil. Waste materials are formulated in the table.

Table 1.1, Industrial waste used in Soil Stabilization

Waste Material	Source of Material	Usage
Fly Ash	Thermal Power Plant	-Bulk filler material. -Bituminous mix as filler. -As aggregates.
Construction and demolition waste	Construction industry	-Base/Sub-base material - Bulk filler material.
Marble Dust	Marble industry	- Bituminous mix as filler. -Soil stabilization.
Glass Waste	Glass industry	-Fibre-glass reinforcement - Bulk filler material.
Cement Dust	Cement industry	-In bituminous mix as Stabilization of base, binder.
Nonferrous Slags	Mineral processing industry	- Bulk filler material. -As an aggregates in bituminous mix.
China Clay	Bricks and tile industry	- Bulk filler material. - As an aggregates in bituminous mix.
Mill tailings	Mineral processing industry	-Granular base/sub-base - As an aggregates in bituminous mix. -Bulk filler material.
Blast furnace slag	Steel industry	-Base/ Sub-base material. -Soil stabilization.

All waste material cannot be used in the stabilization of the soil. Therefore, suitability of material is been listed in the table.

Table 1.2, Suitability of Waste Material

Waste Material	Advantages	Disadvantages
Fly Ash	-Lightweight -used to stabilized the base/sub base course.	-Homogeneity is less. -Sulphate presence. - Development of strength is slow.
Construction and demolition waste	-used as aggregates granular base because it is strong.	-Inconsistent properties.
Marble Dust	-can be used as an aggregate in asphalt mix.	-Heavy metals are present. -less affinity to bitumen
Cement Dust	-due to its hardening properties with water it is used in soil stabilization.	-Metal can be corrosive due to the presence of alkali in cement.
Nonferrous Slags	-Light weight	-Inconsistent properties.
Mill tailings	-Pozzolanic nature, it is helpful.	-poisonous materials are present.
Blast furnace slag	-Used in production of cement, granular fill.	- Pollution of ground water due to Leachate.

Construction waste is the waste which comes from the construction industry or from the dismantling of the existing structure. Construction waste mainly consist of concrete, brick pat, mortar etc which can be further used and that why they are disposed in the agricultural land. The disposal creates many problems to the cultivable land and human problem. But it have several element which can be use to enhance some of engineering properties of the soil like Index properties, Direct shear, Permeability and California bearing ratio etc. They can mainly use to increase the bearing capacity of the soil. Construction wastes are first crushed in the required shape and size which can be mixed in the soil, then a homogenous mixture is made of lime, soil and waste. Then various tests are performed on this mixture.

1.3 LIME

Lime can be used in many purposes in construction works. It can also be used in the stabilization of the soil as it has the binding properties and it bind the material. Lime is very good binder and it is cheaply available in the market. Lime was taken from Delhi market. The properties of the lime are being listed below in the table along with its proportion. These proportion are based on weight percentage which are mixed together to get the required lime.

Table 1.3, Properties of Lime

S. No	Constituent of Lime	Weight Percentage
1	Calcium Oxide	67.0
2	Magnesia	18.0
3	Silica	6.0
4	Alumina	3.0
5	Iron Oxide	2.5
6	Sulphur Dioxide	2.5
7	Alkali Oxide	1.0

1.4 OBJECTIVE AND LAYOUT

The objective of this project was to explore the possibility of utilization of construction waste in improving the bearing capacity. The sub-objective of this project is:

- Study the recycled material in construction which can be used in soil improvement.
- Variation of Strength of soil at different water content.
- Effect of lime on CBR value of the soil.

In order to achieve the above objective, the Soil has been arbitrarily reinforced with lime. So the suitability of lime is considered to enhance the properties of Soil. A cycle of experiments such as Liquid limit test, Plastic Limit Test, Standard Proctor test and California bearing ratio test (CBR) test is carried out on Soil sample with different percentages of lime and construction waste. They are performed to study the variation in bearing capacity and other properties like liquidity and plasticity behavior, and compaction behavior are studied. The CBR test is carried out to access the suitability of this composite for a road sub grade material.

As a reference test for making evaluation, the above mentioned tests are also carried out for raw soil sample.

CHAPTER 2

LITRATURE REVIEW

A large numbers of paper have been reported in this literature. Most of the research papers investigate different aspects of the soil properties mostly of lime, flyash and some with pebbles. There is, however, insignificant number of papers dealing with recycling /utilization of industrial/construction wastes and in particular dealing with improvement in bearing capacity none a combine of lime and construction wastes.

A test is conducted on Black cotton soil along with lime and result concluded that when lime is added to the soil and when it is exposed to the water, it reduces the swelling properties of the soil. Results also suggested the optimum percentage of lime, which should be mixed in the soil, lies between 3% to 4% [1]. A test is conducted on expansive soil. From the economy point of view, that quarry or stone dust which is in abundance can be use along with fly ash in soil stabilization. Various tests like index properties, Proctors compaction, swelling test and unconfined compression strength are performed. Finally, result concluded that on adding of 20 to 30% of admixture the swelling property of the soil can be controlled and noted improvement in other properties of soil. Result also state that equal proportion of stone dust and fly ash is more effective than the addition of stone dust/fly ash alone [2]. A test is conducted a test on Black cotton soil using lime and flyash separately. From the experiment, conclusion is drawn that on addition of flyash, liquid and plastic limit decreases that mean Optimum moisture content increases and maximum dry density (MDD) decreases while on addition of lime, increases liquid and plastic limit of soil that means Optimum moisture content decreases and maximum dry density increases which is very well shown in the figure 2.1(a) and 2.1 (b) [3].

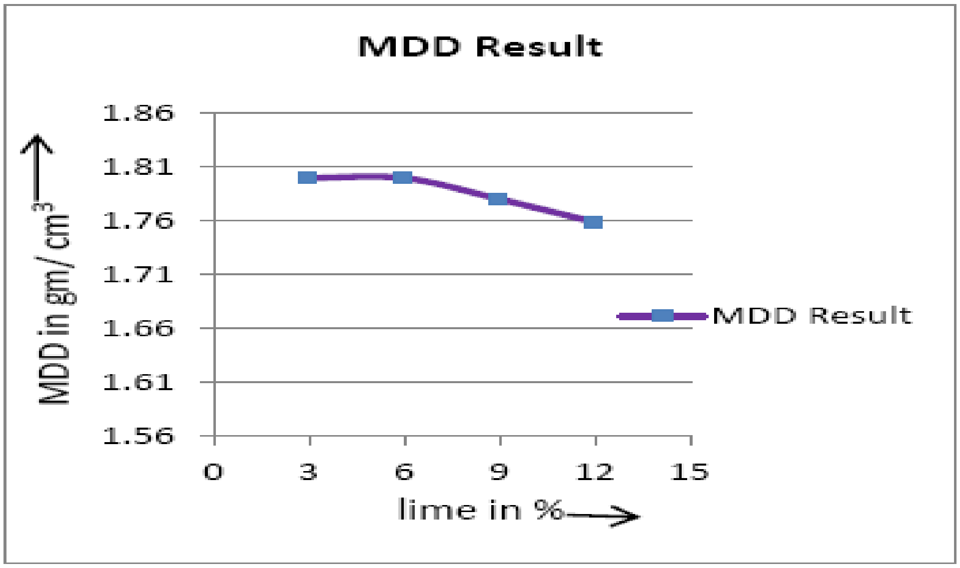

Fig. 2.1(a)

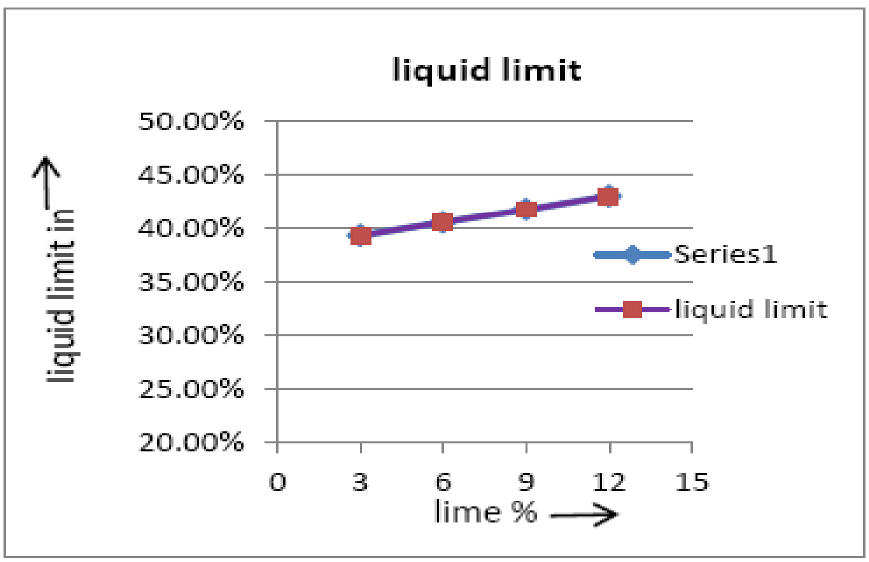

Fig. 2.1(b)

Fig. 2.1 (a) - Max dry density (MDD) vs. lime (b) – Liquid limit vs. lime

A test is conducted on the clayey soil which has high percentage of montmorillonite mineral with many stabilization processes like flyash, lime, rice husk etc. It also includes marble dust/ crusher dust to its stabilization in order to protect the environment from degradation. Result is drawn that there is a reduction in swelling potential and increase in the engineering properties [4]. A test is conducted on the stabilization of Bundelkand Black cotton soil using crusher dust. They found that optimal percentage of use of crusher dust is 40% to get the maximum utilization in index properties of soil [5]. A test is conducted on expansive soil to stabilize the soil using quarry dust and lime. Result concludes in improvement of unconfined compression strength and improvement in the soaked California bearing ratio (CBR) [6]. A test is conducted to study effect on strength due to addition of rice husk and durability effect due to addition of lime in Black cotton soil. Result showed that plastic and liquid limit gradually increases and maximum dry density reduces and optimum moisture content rises. Finally, concluded that optimum dose is 10% rice husk with 9% lime in the soil [7]. A test is conducted on Black cotton soil and lime, conclusion were made as liquid limit increases with curing period when we add lime but initially liquid limit decreases as compared with original Black cotton soil. Plastic limit of mixture increases with curing period but initially plastic limit decreases as compared to original soil when we add lime on Black cotton soil. Plastic limit has constant value for curing period. Plasticity index of the mixture reduces with increase in lime content which changes the soil from MH to CI, which is good for workability [8]. A test is conducted for soil stabilization using fly ash mixtures. In the laboratory, experiment is conducted on mixture of coarse and fine fly ash in range between 5 to 30% with Black cotton soil. Result concluded that maximum and minimum dry density occurs when 5% and 30% of fly ash is used. Difference in density occurs due to modification of degrees of soil mixtures [9].

CHAPTER 3

CHARACTERISATION OF MATERIAL AND METHOD

3.1 CONSTRUCTION WASTE

For the research purpose construction waste has been from the construction site available near by the DTU campus. Construction waste also consists of lime in it. It is a byproduct which comes from construction site or industries which may be harmful for the society if disposed not properly. Your main aim is to utilize that waste eco-friendly to increase the bearing capacity of the soil. The particle size and grain size distribution curve of the construction waste has been shown below in Table 3.1 and fig. 3.1

Table 3.1, Particle size of Construction waste

S.No.	Sieve size (mm)	Mass of waste retained (gm.)	Percentage on each sieve R_n Mass of waste/Wt. *100	Cumulative % retained S R_n	% finer, 100-S R_n
1	2	500.5	50	50	50
2	1	180	18	68	32
3	0.600	70	7	75	25
4	0.500	20	2	77	23
5	0.425	18.73	1.8	78.8	21.2
6	0.212	90	9	87.8	12.2
7	0.106	58.41	5.8	93.6	6.4
8	0.075	17.5	1.7	95.3	4.7

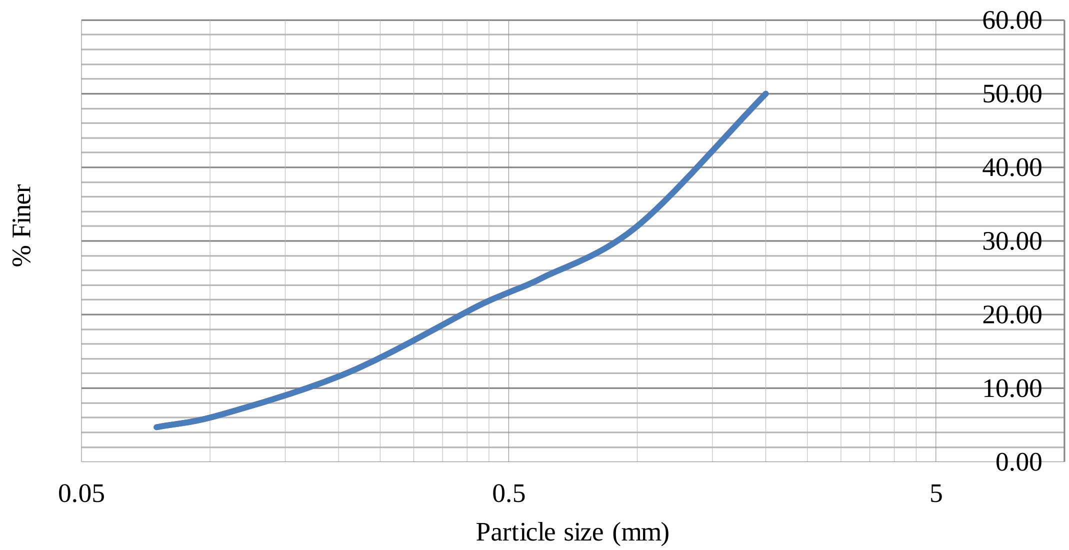

Fig. 3.1, Grain size distribution curve of Construction Waste

3.2 LIME

We use lime as a stabilizing admixture. It has a cementatious property when it is mix with water and soil due to pozzolanic reaction it gain strength with time. Lime is sometime use in place of cement in construction. Lime mainly consists of cementatious material.

3.3 SOIL

Soil consider in this study is less expansive which has little shrink and swell tendency with change of water content, as water is added, it swells and if water is removed by some means it shrinks. This soil is alluvial soil having been deposited over a mean period of time. Such tendency of soil is due to presence of montmorillonite mineral in soil. In this project we will do stabilization of Soil with Construction waste and lime. Due to high swell pressure this soil causes damage to structure which in turn loss to nation's economy. Soil has large specific area, particles below 2 micron, high cation exchange capacity and high liquid limit and plasticity index value.

Northern India comprising approximately $1/6^{th}$ of the total country has soil similar to that mentioned above. The satellite view of the Soil from where it has been taken is shown in the figure given below. The Location and satellite view of the soil is shown in the fig. 3.2 (a) and (b).

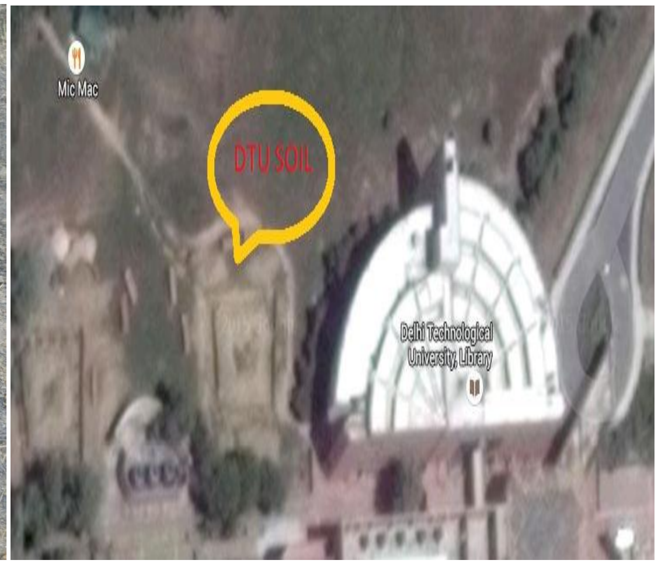

Fig. 3.2(a), Site location.

Fig. 3.2(b) Satellite View

Fig. 3.3. Shows the particle size distribution curve of soil which is also represented in the table form (table 3.2).

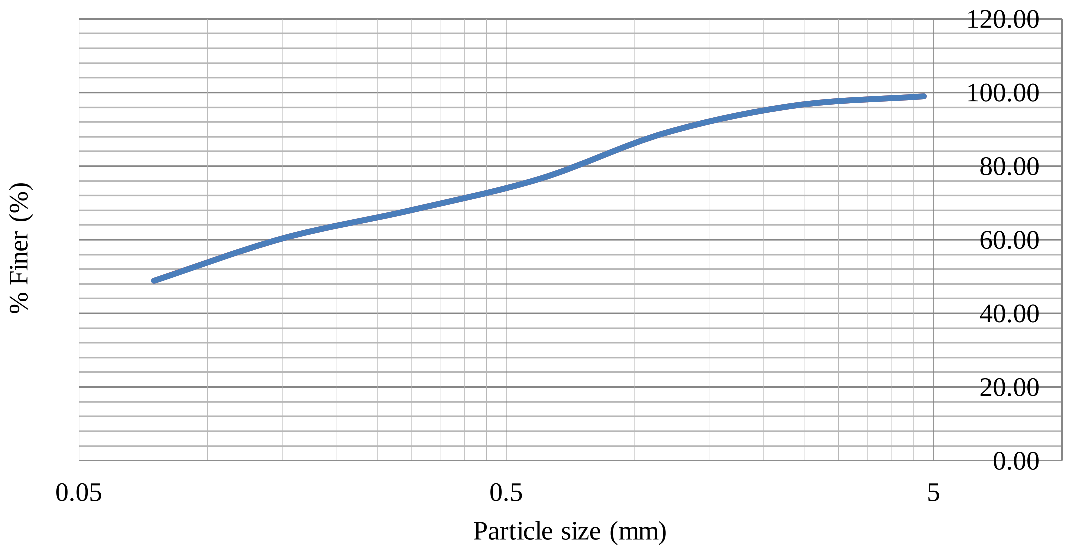

Fig. 3.3, Grain size distribution curve of Soil

Table 3.2, Particle size distribution table

S.No.	Sieve size (mm)	Mass of soil retained (gm.)	Percentage on each sieve R_n Mass of soil/Wt. *100	Cumulative % retained S R_n	% finer, 100-S R_n
1	4.75	10.31	1.031	1.03	98.97
2	2.36	25.42	2.54	3.57	96.43
3	1.18	74.06	7.40	10.97	89.03
4	.600	124.65	12.46	23.43	76.57
5	.300	85.3	8.53	31.96	68.04
6	.150	76.7	7.67	39.63	60.37
7	0.075	115.2	11.52	51.15	48.85
8	Pan	490.26	49.02	100	-

Fig. 3.4 shows the Optimum moisture content and the table 3.3 represents the laboratory reading of the standard proctor test.

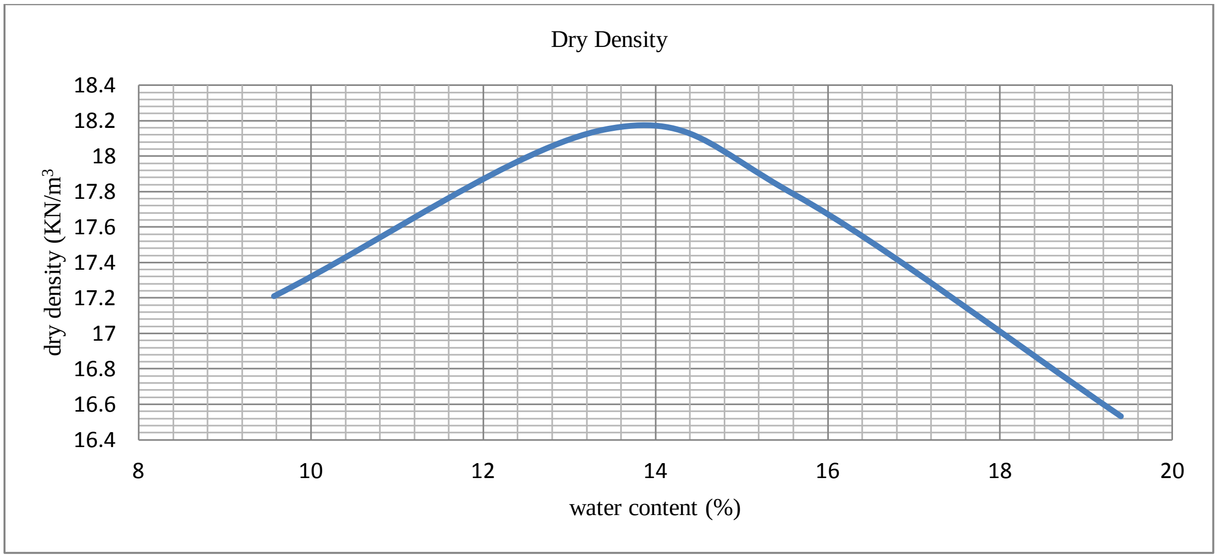

Fig. 3.4, Optimum Moisture Content

Table 3.3, Standard Proctor Test

Empty weight	W_1 (gm)	694.19	694.19	694.19
Empty weight + dry soil	W_2 (gm)	894.06	944.06	994.06
Empty weight + dry soil + water	W_3 (gm)	1679.24	1709.33	1739.57
Empty weight + water	W_4 (gm)	1565.1	1565.1	1565.1

Consolidated properties of the Soil has been represented in the table given below in Table 3.4 .

Table 3.4, Properties of Soil

S. No	Property	Notation	Value
1	Specific Gravity	G	2.35
2	Liquid Limit	LL	28.75 %
3	Plastic Limit	PL	19.2 %
4	Plasticity Index	PI	9.55 %
5	Gravel	> 4.75 mm	1.03 %
6	Sand	0.075 mm -4.75 mm	50.12 %
7	Silt	0.002 mm - 0.075 mm	41.46 %
8	Clay	<0.002 mm	7.56 %
9	Max. dry density	γ_d	1.82 gm/cc
10	Optimum moisture content	OMC	13.86 %

D_{10} = 0.093 mm, D_{30} = 0.18 mm, D_{60} = 0.53 mm.

$C_u = \frac{D60}{D10}$ =5.69, $C_c = (D_{30})^2/D_{60}*D_{10}$ = 0.657

3.4 COURSE OF PLAN

To analysis the bearing capacity of the soil, construction waste and lime in is used in optimum amount and in correct proportion so as to get the desired result. Therefore, we have to do liquid limit, plastic limit, standard proctor, and California Bearing Ratio test on Soil stabilized by different percentage of construction waste and lime.

We do change the different percentage of lime from 5 to 15 % with an increment of 5% and at the same we change the construction waste from 5 to 15 % with an increment of 5 %. In this order we get around 15 soil mixes which are

1. Soil with 0% LIME with 5% Construction waste,
2. Soil with 0% LIME with 10% Construction waste,
3. Soil with 0% LIME with 15% Construction waste,
4. Soil with 05% LIME with 0% Construction waste,
5. Soil with 05% LIME with 05% Construction waste,
6. Soil with 05% LIME with 10% Construction waste,
7. Soil with 05% LIME with 15% Construction waste,
8. Soil with 10% LIME with 0% Construction waste,
9. Soil with 10% LIME with 05% Construction waste,
10. Soil with 10% LIME with 10% Construction waste,
11. Soil with 10% LIME with 15% Construction waste,
12. Soil with 15% LIME with 0% Construction waste,
13. Soil with 15% LIME with 05% Construction waste,
14. Soil with 15% LIME with 10% Construction waste,
15. Soil with 15% LIME with 15% Construction waste.

3.5 TEST PROCEDURES

3.5.1. SCANNING ELECTRON MICROSCOPY (SEM)

A scanning electron microscope (SEM) is a type of electron microscope that images a sample by scanning it with a high-energy beam of electrons in arrester pattern. The electrons interact with the atoms that make up the sample producing signals that contain information about the sample's surface topography, composition, and other properties such as electrical conductivity.

The types of signals produced by an SEM include secondary electrons, back-scattered electrons (BSE), characteristic X-rays, light (cathodolumine scence), specimen current and transmitted electrons. Secondary electron detectors are common in all SEMs, but it is rare that a single machine would have detectors for all possible signals.

The signals result from interactions of the electron beam with atoms at or near the surface of the sample. In the most common or standard detection mode, secondary electron imaging or SEI, the SEM can produce very high-resolution images of a sample surface, revealing details less than 1 nm in size. Due to the very narrow electron beam, SEM micrographs have a large depth of field yielding a characteristic three-dimensional appearance useful for understanding the surface structure of a sample.

This is exemplified by the micrograph of pollen shown in Fig.3.5. A wide range of magnifications is possible, from about 10 times (about equivalent to that of a powerful hand-lens) to more than 500,000 times, about 250 times the magnification limit of the best light microscopes. Back-scattered electrons (BSE) are beam electrons that are reflected from the sample by elastic scattering. BSE are often used in analytical SEM along with the spectra made from the characteristic X-rays. Because the intensity of the BSE signal is strongly related to the atomic number (Z) of the specimen, BSE images can provide information about the distribution of different elements in the sample. For the same reason, BSE imaging can image colloidal gold immune-labels of 5 or 10 nm diameters, which would otherwise be difficult or impossible to detect in secondary electron images in biological specimens. Characteristic X-rays are emitted when the electron beam removes an inner shell electron from the sample, causing a higher energy electron to fill the shell and release energy. These characteristic X-rays are used to identify the composition and measure the abundance of elements in the sample.

Fig. 3.5 scanning electron microscopic

SEM of 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. The SEM result of the virgin soil has been shown the figure given below.

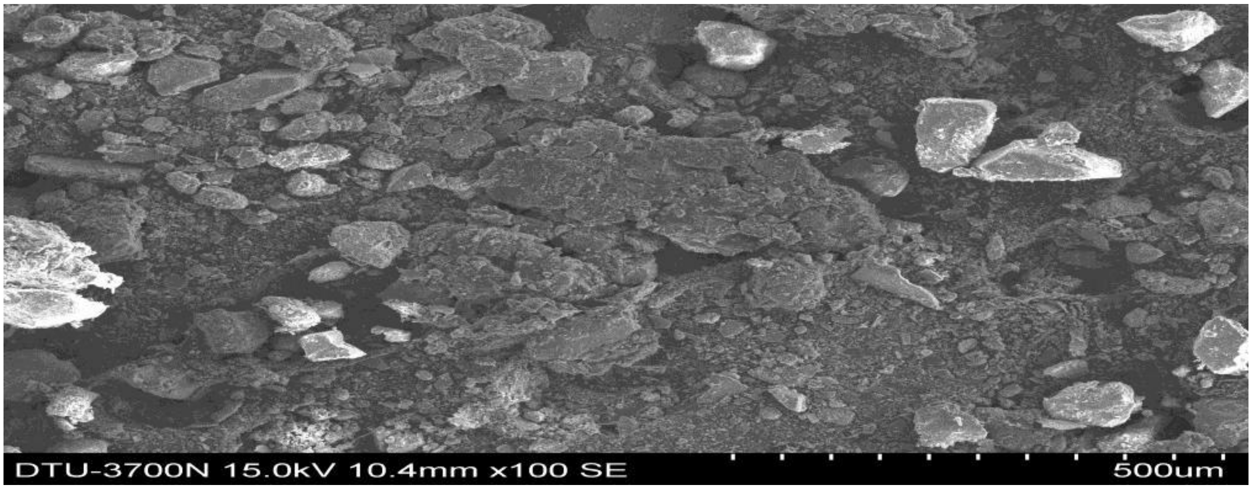

Fig. 3.6 SEM results for virgin soil

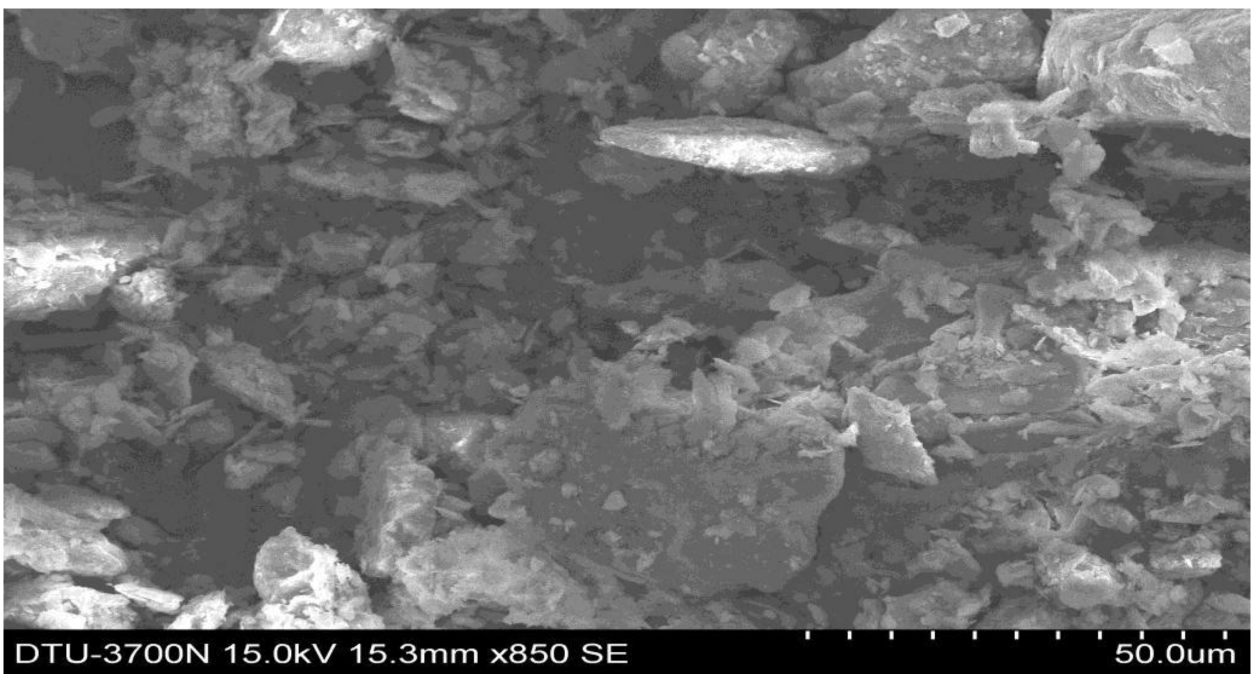

Fig 3.7 SEM results for virgin soil

3.5.2. LIQUID AND PLASTIC LIMIT TESTS

Plastic limit is water content at which the soil starts losing the strength. Liquid limit is the upper limit of the water content which can be added in the soil before it completely losses it strength and have no shear capacity. Both the limit is require to check the expansive property of the soil. With the addition of lime and construction waste the expansive properties of the soil decrease in order to check this property the liquid and plastic limit test is done.

Apparatus (As per IS code): -

- Casagrande liquid limit device
- ASTM and BS grooving tool
- Glass plate 20 x 15 cm
- 425 micron I.S. Sieve
- 3 mm diameter rod
- Balance (0.01 gm sensitivity)
- Drying oven
- Distilled water
- Measuring cylinder

Precautions:

1. Use distilled water in order to minimize the possibility of iron exchange between the soil and any impurities in the water.
2. Soil used for liquid and plastic limit determinations should not be oven dried prior to testing.
3. In liquid limit test, the groove should be closed by a flow of the soil and not by slippage between the soil and the cup.
4. After mixing distilled water to the soil sample, sufficient time should be given to permeate the water throughout the soil mass.
5. Wet soil taken in the container for moisture content determinations should not be left in the air even for some time, the containers with soil samples should either be placed in desiccators or immediately be weighed.
6. For each test, cup and grooving tool, should be clean.

3.5.3. COMPACTION TEST (STANDARD PROCTOR)

Standard Proctor is used to find out the optimum moisture content and maximum dry density of the soil. Optimum moisture content is used to get the maximum dry density which can further be used in different tests.

Apparatus (As per IS code)**:-**

1. Cylinder mould
   (Capacity 1000 c.c., internal dia. 100 mm, effective ht. 127.3 mm)
2. Rammer for light compaction (Limes dia. 50 mm, mass of 2.6 kg, free drop 310 mm)
3. Rammer for heavy compaction (Limes dia. 50 mm, mass 4.89 kg, and free drop 450 mm)
4. Mould accessories (detachable base plate removal collar)
5. I.S. Sieves (20 mm, 4.75 mm)
6. Balance (Capacity 200 gm sensitivity 0.01 gm)
7. Drying oven (temperature 105°C to 11°C)
8. Desiccators
9. Graduated jars
10. Straight edge
11. Spatula
12. Scoop

Fig. 3.8 Proctor test

Precautions:-

1. Adequate period is allowed for mixing the water with soil before compaction.

2. The blows should be uniformly distributed over the surface of each layer.

3. Each layer of compacted soil is scored with spatula before placing the soil for the succeeding layer.

4. The amount of soil used should be just sufficient to fill the mould i.e.” at the end of compacting the last layer the surface of the soil should be slightly (5 mm) above the top rim of the mould.

5. Mould should be placed on a solid foundation during compaction.

3.5.4. California Bearing Ratio test

The California Bearing Ratio (CBR) test was developed by the California Division of Highway as a method of classifying and evaluating soil sub grade and base course materials for flexible pavements. Just after World War II, the US corps of Engineers adopted the CBR test for use in designing base course for airfield pavements. The test is empirical and results cannot be related accurately with any fundamental property of the material. The method of test has been standardized by the ISI also.

The CBR is a measure of a material to penetration of standard plunger under controlled density and moisture conditions. The test procedure should be strictly adhered if high degree of re productivity is required. The CBR test may be conducted in remolded or undisturbed specimen in the laboratory. US corps of engineers have also recommended a test procedure for in situ test. Many methods exist today which utilize mainly CBR test values for designing pavement structure .The test is simple and has been extensively used to investigated for field correction of flexible pavement thickness requirement.

The test consists of cylindrical plunger of 50 mm diameter to penetrate a pavement component material at 1.25 mm/ min. The loads for 2.5 mm and 5 mm are recorded. This is expressed as a percentage of standard load value at a represented in deformation level to obtain CBR value. The standard load values were obtained from the average of a large number of tests on different crushed stones. Are as:-

Table 3.4. As per IS 2720, Standard Load values on Crushed Stones for Different Penetration Value

Penetration mm	**Standard load, kg**	**Unit standard load, kg/cm^2**
2.5	1370	70
5.0	2055	105
7.5	2630	134
10.0	3180	162
12.5	3600	183

Apparatus:-

(a) **Loading Machine: -** Any compression machine can operate at a constant rate of 1.25 mm per minute can be used for this purpose. If such machine is not available then a calibrated hydraulic press with proving ring to measure load can be used. In fig a metal penetration piston or plunger of diameter 50 mm is attached to the loading machine.

(b) **Cylindrical mould:-** Moulds of 150 mm diameter and 175 mm height provide with a collar of about 50 mm length and detachable perforated base are used for this purpose. A spacer disc of 148 mm diameter and 47.7 mm thickness is used to obtain a specimen of exactly 127.3 mm height.

(c) **Compaction Rammer: -** The material is usually compacted as specified for the work, either by dynamic compaction or by static compaction. The detail for dynamic compaction suggested by the ISI are as:-

(d) **Adjustable Stem, perforated plate, tripod and dial gauge:-**

The standard procedure requires that the soil sample before testing should be soaked in water to swelling .For this purpose the above listed accessories are required.

(e) **Annular weight: - Annular weight: -** In order to simulate the effect of the overlying pavement weight, annular weights each of 2.5 kg and 147 mm dia. Are placed on the top of the specimen, both at the time of soaking and testing the samples, as surcharge.

Fig. 3.9 CBR test apparatus

CHAPTER 4

EXPERIMENTAL RESULTS

4.1 SOIL STABILIZATION

Under this research work of stabilization of soil we alter the property of the soil by adding some admixture in optimum amount to enhance its engineering property both qualitatively and economically. In this work I have used construction waste for stabilization process of soil and compared the results with the Soil. The engineering properties after the stabilization are discussed next.

4.2. CONSISTANCY LIMITS

4.2.1. Soil+ 0% LIME + 5% CW

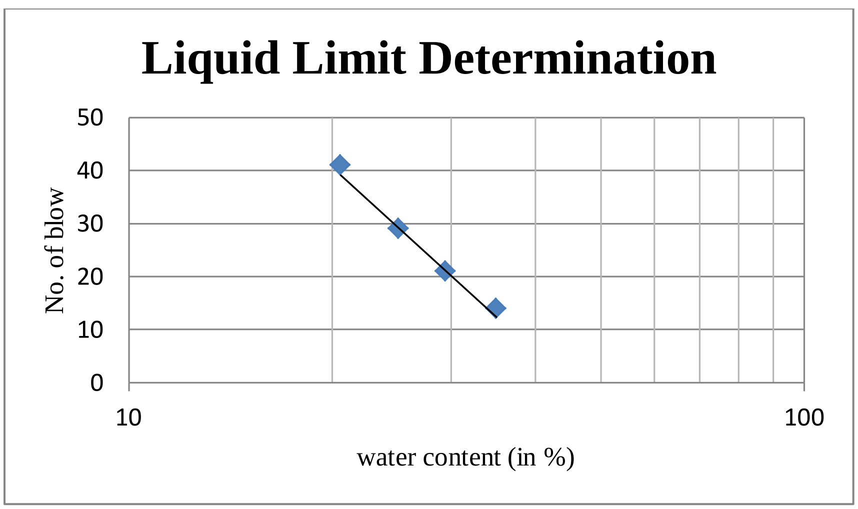

Fig. 4.1 Liquid limit curve of Soil+ 0 % LIME + 5%CW*

Liquid limit = 28.20%

Plastic limit = 18.95%

Plasticity Index = 9.25%

From the fig. 4.1, It has been observed that by addition of 5% CW in Soil, decrease in liquid limit was found 1.85% and decreasing in plastic limit was found 1.3%.

4.2.2. SOIL+ 0% LIME + 10% CW

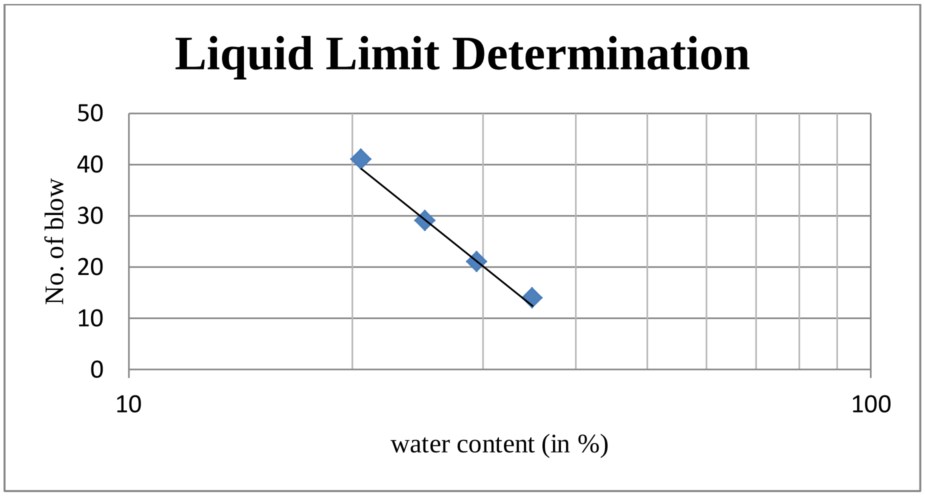

Fig. 4.2 Liquid limit curve of Soil+ 0 % LIME + 10%CW

Liquid limit = 27.83%

Plastic limit = 18.81%

Plasticity Index = 9.02%

From the fig. 4.2, It has been observed that by addition of 10% CW in Soil, decrease in liquid limit was found 3.15% and decreasing in plastic limit was found 2.08%.

4.2.3. SOIL+ 0% LIME + 15% CW

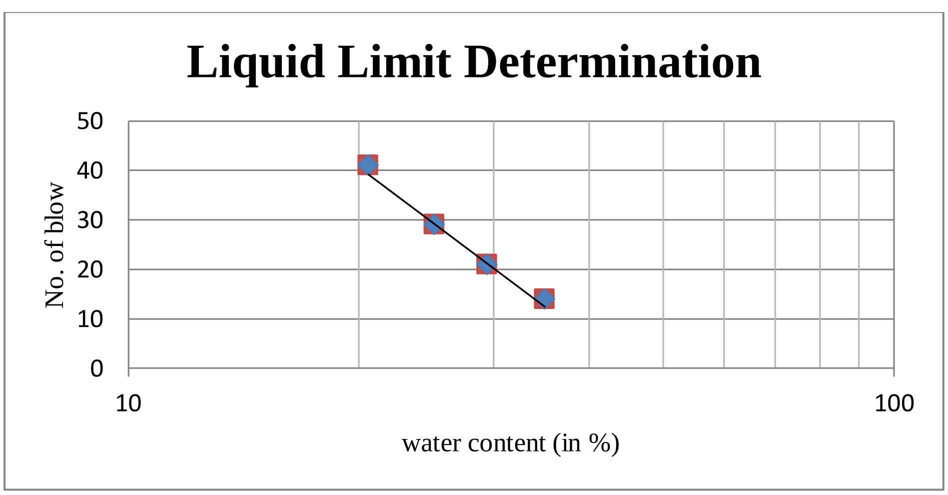

Fig. 4.3 Liquid limit curve of Soil+ 0 % LIME + 15%CW

Liquid limit = 27.64%

Plastic limit = NP

Plasticity Index = NP

From the fig. 4.3, It has been observed that by addition of 15% CW in Soil, decrease in liquid limit was found 3.83%.

4.2.4. SOIL+ 5% LIME + 0% CW

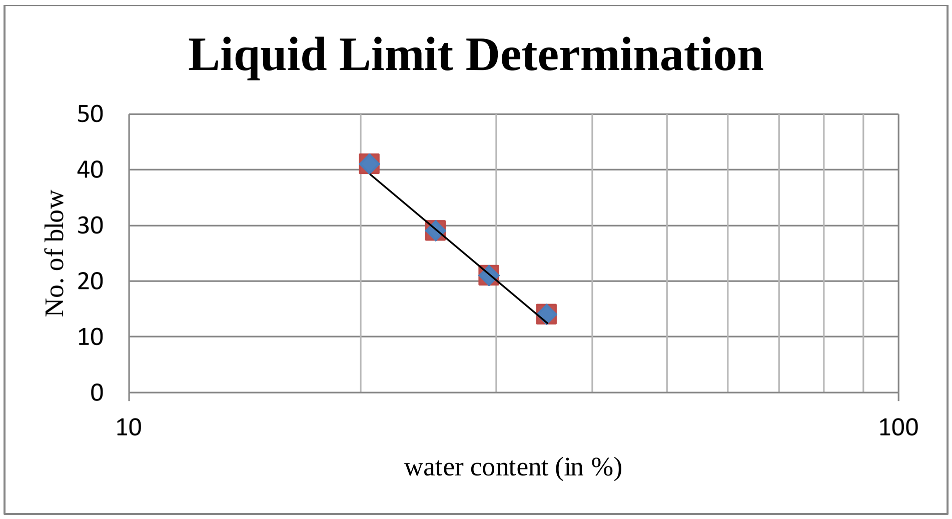

Fig. 4.4 Liquid limit curve of Soil + 5 % LIME + 0%CW

Liquid limit = 28.20%

Plastic limit = 18.95%

Plasticity Index = 9.07%

From the fig. 4.4, It has been observed that by addition of 0% CW and 5% LIME in Soil, decrease in liquid limit was found 1.87% and decrease in plastic limit was found 1.31%.

4.2.5. SOIL+ 5% LIME + 5% CW

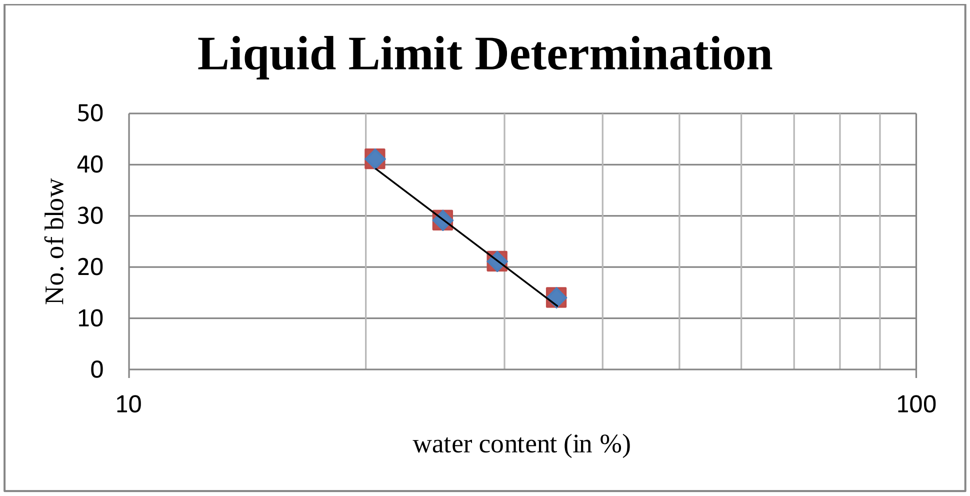

Fig. 4.5 Liquid limit curve of Soil+ 5% LIME +5%CW

Liquid limit = 28.57%

Plastic limit = 19.17%

Plasticity Index = 9.4%

From the fig. 4.5, It has been observed that by addition of 5% CW and 5% LIME in Soil, decrease in liquid limit was found 0.64% and decreasing in plastic limit was found 0.12%.

4.2.6. SOIL+ 5% LIME + 10% CW

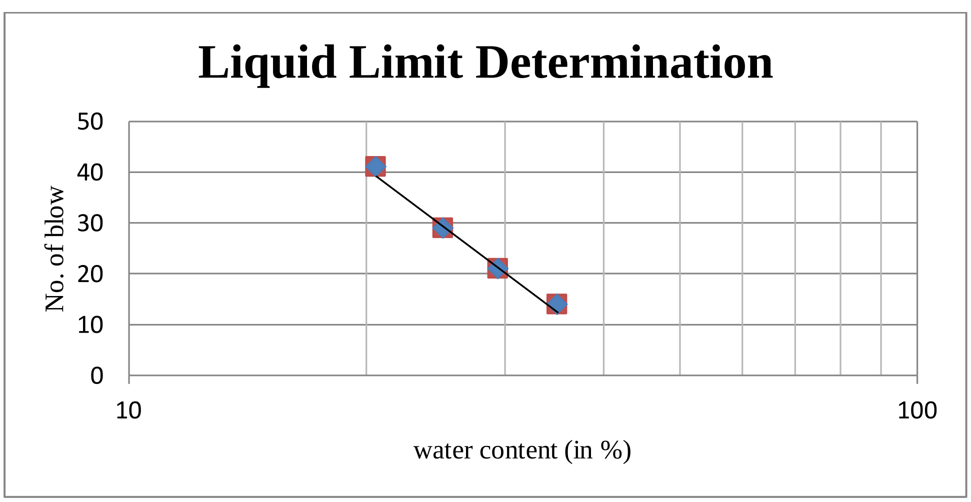

Fig. 4.6 Liquid limit curve of Soil+ 5 % LIME + 10%CW

Liquid limit = 28.7%

Plastic limit = 19.08%

Plasticity Index = 9.63%

From the fig. 4.6, It has been observed that by addition of 10% CW and 5% LIME in Soil, decrease in liquid limit was found 0.21% and increasing in plastic limit was found 0.63%.

4.2.7. SOIL+ 5% LIME + 15% CW

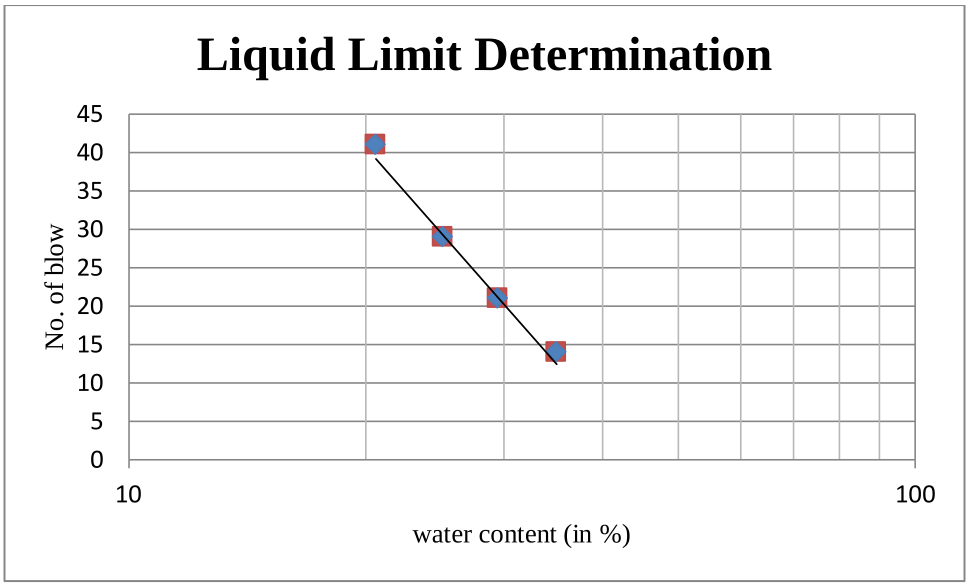

Fig. 4.7 Liquid limit curve of Soil+ 5 % LIME + 15%CW

Liquid limit = 28.43%

Plastic limit = NP

Plasticity Index = NP

From the fig. 4.7, It has been observed that by addition of 15% CW and 5% LIME in Soil, decrease in liquid limit was found 1.13%.

4.2.8. SOIL+ 10% LIME + 0% CW

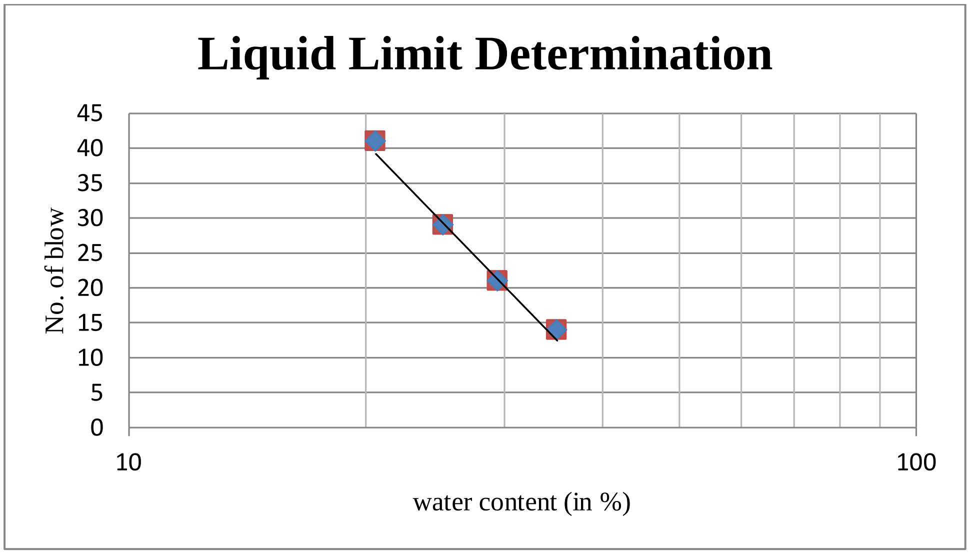

Fig. 4.8 Liquid limit curve of Soil+ 10 % LIME + 0%CW

Liquid limit =27.02%

Plastic limit = 18.65%

Plasticity Index = 8.37%

From the fig. 4.8, It has been observed that by addition of 0% CW and 10 % LIME in Soil, decrease in liquid limit was found 6.13% and decreasing in plastic limit was found 2.86%.

4.2.9. SOIL+ 10% LIME + 5% CW

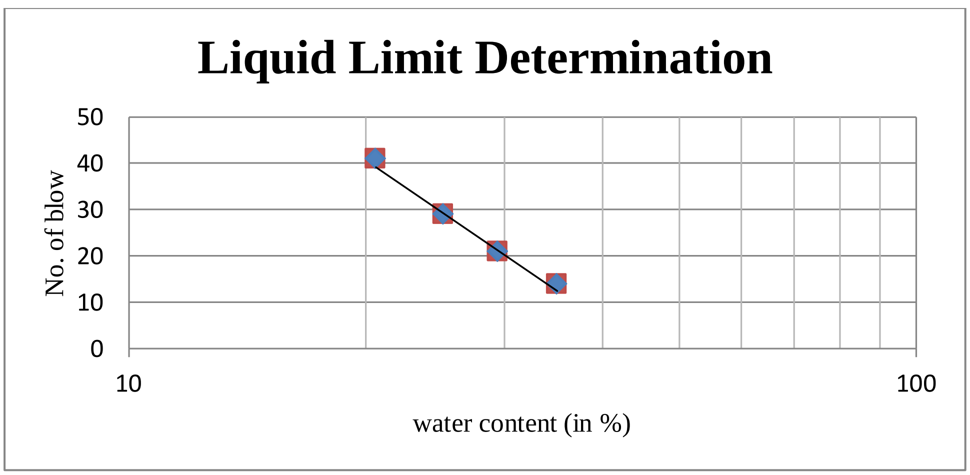

Fig. 4.9 Liquid limit curve of Soil + 10 % LIME +5%CW

Liquid limit = 27.65%

Plastic limit = 18.73%

Plasticity Index = 8.92%

From the fig. 4.9, It has been observed that by addition of 5% CW and 10% LIME in Soil, decrease in liquid limit was found 3.84% and decreasing in plastic limit was found 2.43%.

4.2.10. SOIL+ 10% LIME + 10% CW

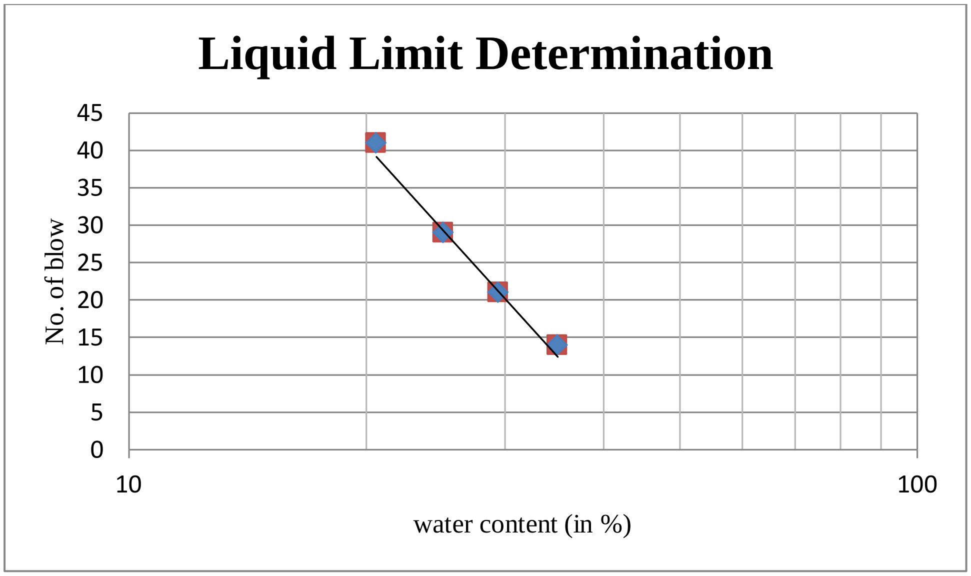

Fig. 4.10 Liquid limit curve of Soil+ 10 % LIME + 10%CW

Liquid limit = 27.83%

Plastic limit = 18.7%

Plasticity Index = 9.13%

From the fig. 4.10, It has been observed that by addition of 10% CW and 10% LIME in Soil, decrease in liquid limit was found 3.25% and decreasing in plastic limit was found 2.62%.

4.2.11. SOIL+ 10% LIME + 15% CW

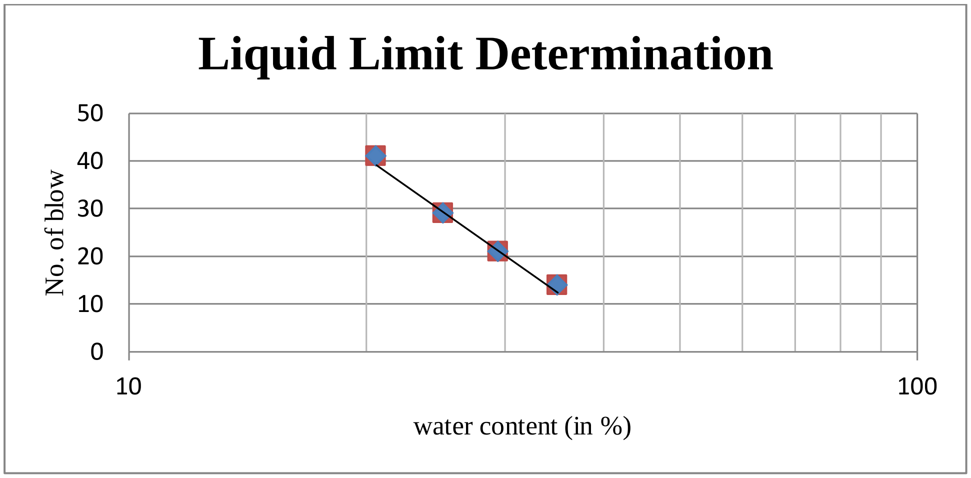

Fig. 4.11 Liquid limit curve of Soil + 10 % LIME + 15%CW

Liquid limit = 27.77%

Plastic limit = NP

Plasticity Index = NP

From the fig. 4.11, It has been observed that by addition of 15% CW and 10% LIME in Soil, decrease in liquid limit was found 3.41%.

4.2.12. SOIL+ 15% LIME + 0% CW

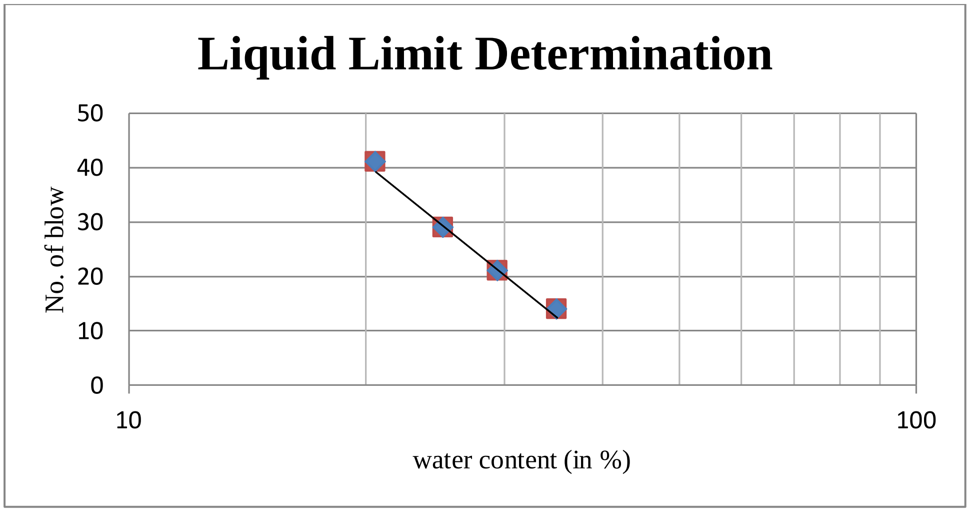

Fig. 4.12 Liquid limit curve of Soil+ 15% LIME + 0%CW

Liquid limit = 25.61%

Plastic limit = 18.38%

Plasticity Index = 7.22%

From the fig. 4.12, It has been observed that by addition of 0% CW and 15% LIME in Soil, decrease in liquid limit was found 10.92% and decreasing in plastic limit was found 4.23%.

4.2.13. SOIL+ 15% LIME + 5% CW

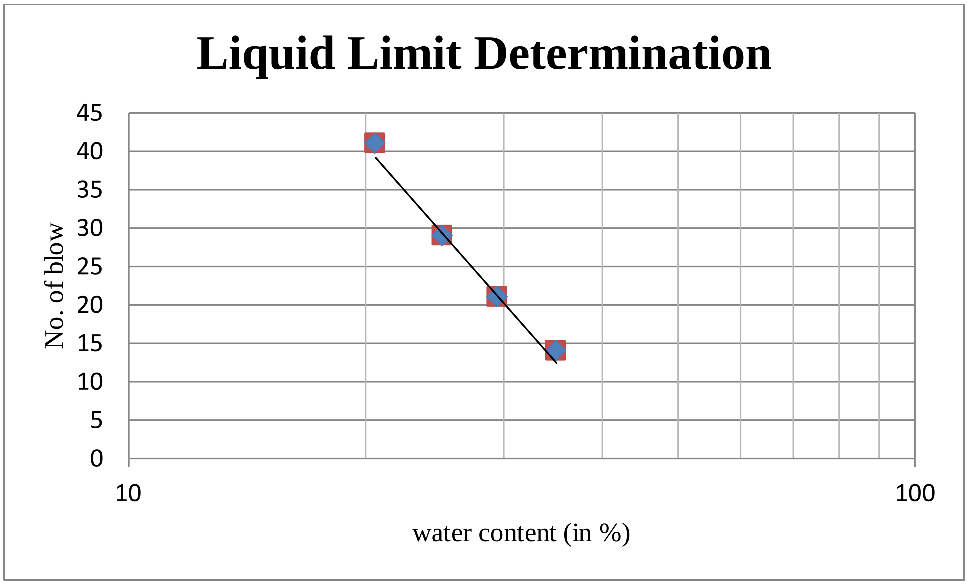

Fig. 4.13 Liquid limit curve of Soil+ 15 % LIME +5%CW

Liquid limit = 25.93%

Plastic limit = 18.53%

Plasticity Index = 7.39%

From the fig. 4.13, It has been observed that by addition of 5% CW and 15% LIME in Soil, decrease in liquid limit was found 9.81% and decreasing in plastic limit was found 3.44%.

4.2.14. SOIL+ 15% LIME + 10% CW

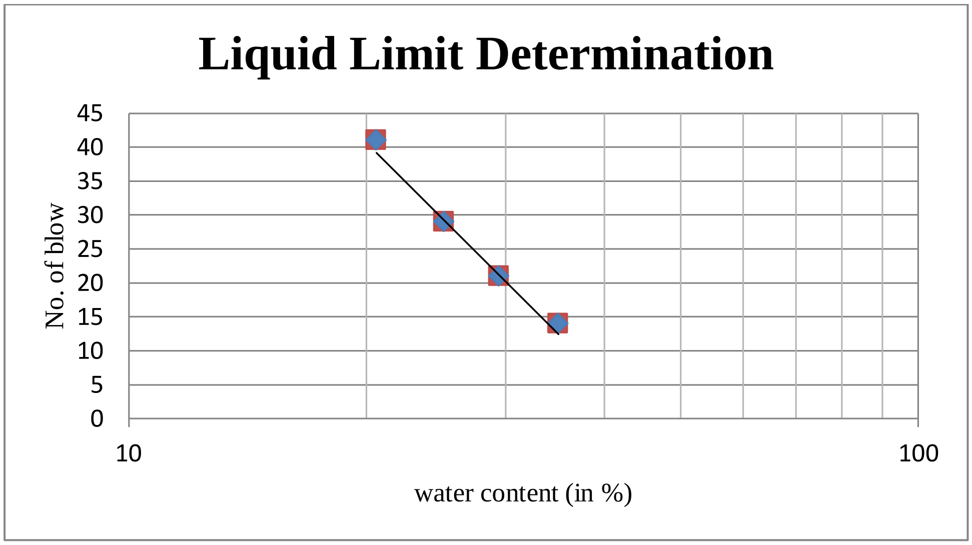

Fig. 4.14 Liquid limit curve of Soil+ 15 % LIME + 10%CW

Liquid limit = 26.16%

Plastic limit = NP

Plasticity Index = NP

From the fig. 4.14, It has been observed that by addition of 10% CW and 15% LIME in Soil, decrease in liquid limit was found 9.03%.

4.2.15. SOIL+ 15% LIME + 15% CW

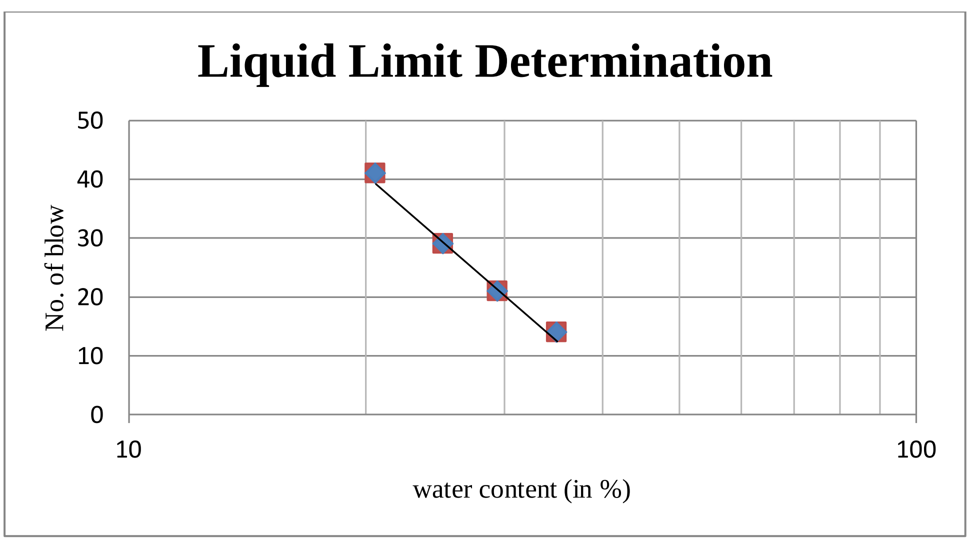

Fig. 4.15 Liquid limit curve of Soil+ 15 % LIME + 15%CW

Liquid limit = 26.36%

Plastic limit = NP

Plasticity Index = NP

From the fig. 4.15, It has been observed that by addition of 15% CW and 15% LIME in Soil, decrease in liquid limit was found 8.3%.

4.3 STANDARD PROCTOR TEST RESULT

4.3.1. SOIL+ 0% LIME + 5% CW

From the graph given below (4.16), it has been observed that maximum dry density of Soil was increased by 3.15% and optimum moisture content of Soil was decreased by 1.58% by addition of 5% CW.

Optimum moisture content W = 13.64%

Max. Dry density $(\rho_d)_{max}$ = 1.88 g/cc

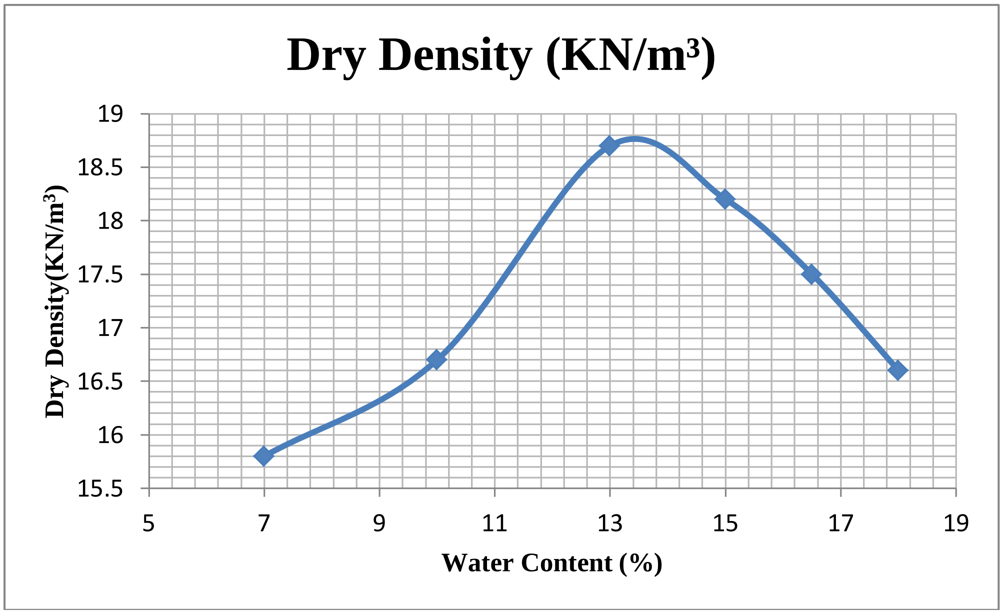

Fig. 4.16 Compaction curve of Soil+ 0% LIME + 5%CW

4.3.2. SOIL+ 0% LIME + 10% CW

From the graph given below (4.17), it has been observed that maximum dry density of Soil was increased by 3.15% and optimum moisture content of Soil was decreased by 14.4% by addition of 10% CW.

Optimum moisture content W = 11.86%

Max. Dry density $(\rho_d)_{max}$ = 1.87 g/cc

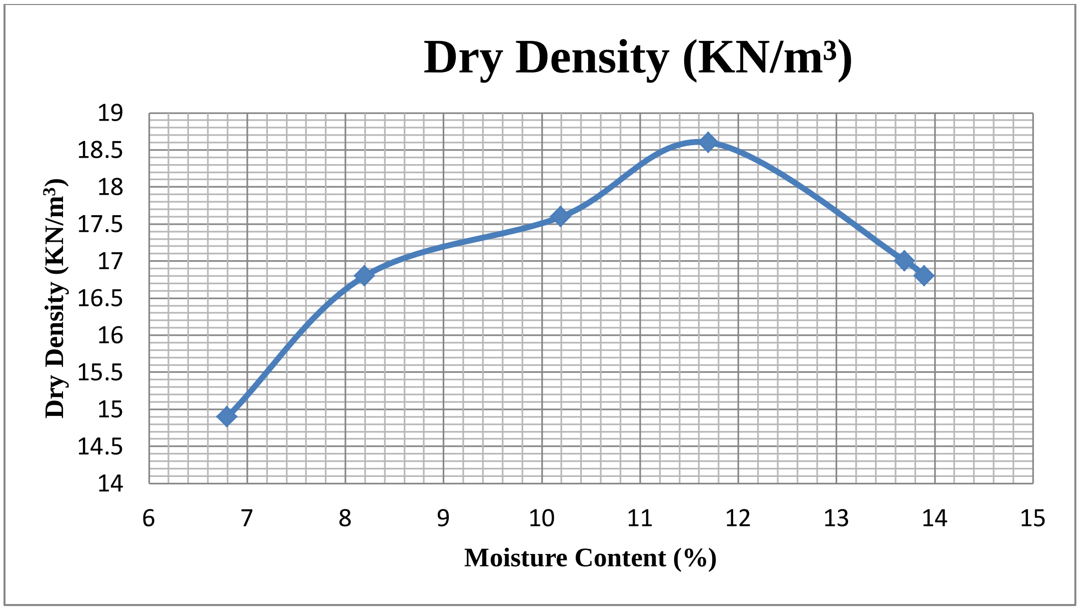

Fig. 4.17 Compaction curve of Soil+ 0% LIME+ 10%CW

4.3.3. SOIL+ 0% LIME + 15% CW

From the graph given below (4.18), it has been observed that maximum dry density of Soil was increased by 3.15% and optimum moisture content of Soil was decreased by 19.3% by addition of 15% CW.

Optimum moisture content W = 11.16%

Max. Dry density $(\rho_d)_{max}$ = 1.87 g/cc

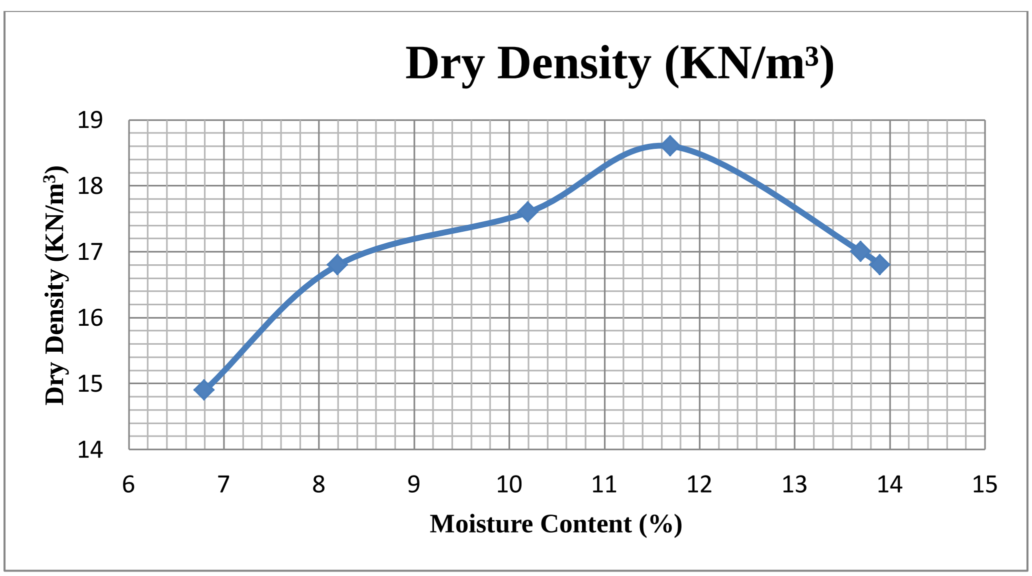

Fig. 4.18 Compaction curve of Soil+ 0% LIME + 15%CW

4.3.4. SOIL+ 5% LIME + 0% CW

From the graph given below (4.19), it has been observed that maximum dry density of Soil was increased by 0.61% and optimum moisture content of Soil was decreased by 12.37% by addition of 0% CW and 5% LIME.

Optimum moisture content W = 12.5%

Max. Dry density $(\rho_d)_{max}$ = 1.83 g/cc

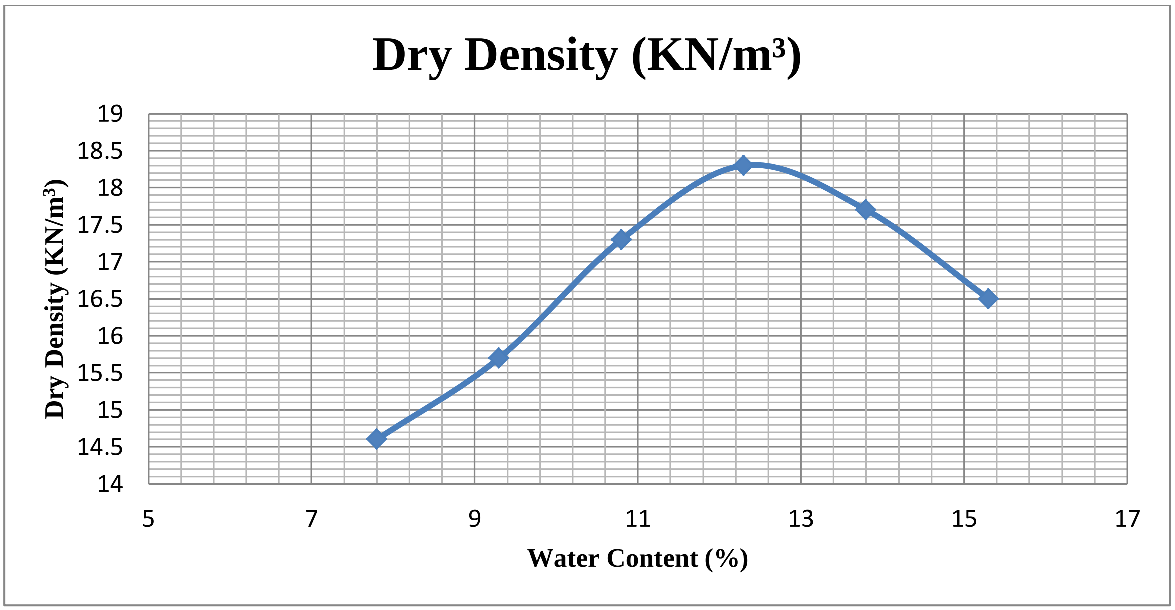

Fig. 4.19 Compaction curve of Soil+ 5% LIME + 0%CW

4.3.5. SOIL+ 5% LIME + 5% CW

From the graph given below (4.20), it has been observed that maximum dry density of Soil was increased by 2.9% and optimum moisture content of Soil was decreased by 15% by addition of 5% CW and 5% LIME.

Optimum moisture content W = 11.78%

Max. Dry density $(\rho_d)_{max}$ = 1.87 g/cc

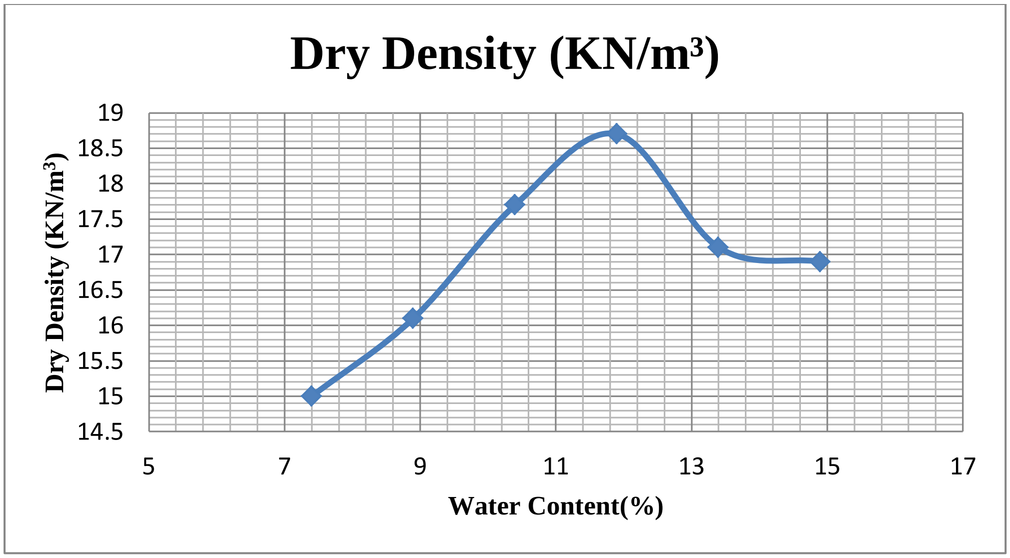

Fig. 4.20 Compaction curve of Soil+ 5% LIME + 5%CW

4.3.6. SOIL+ 5% LIME + 10% CW

From the graph given below (4.21), it has been observed that maximum dry density of Soil was increased by 5% and optimum moisture content of Soil was decreased by 22% by addition of 10% CW and 5% LIME.

Optimum moisture content W = 10.81%

Max. Dry density $(\rho_d)_{max}$ = 1.91 g/cc

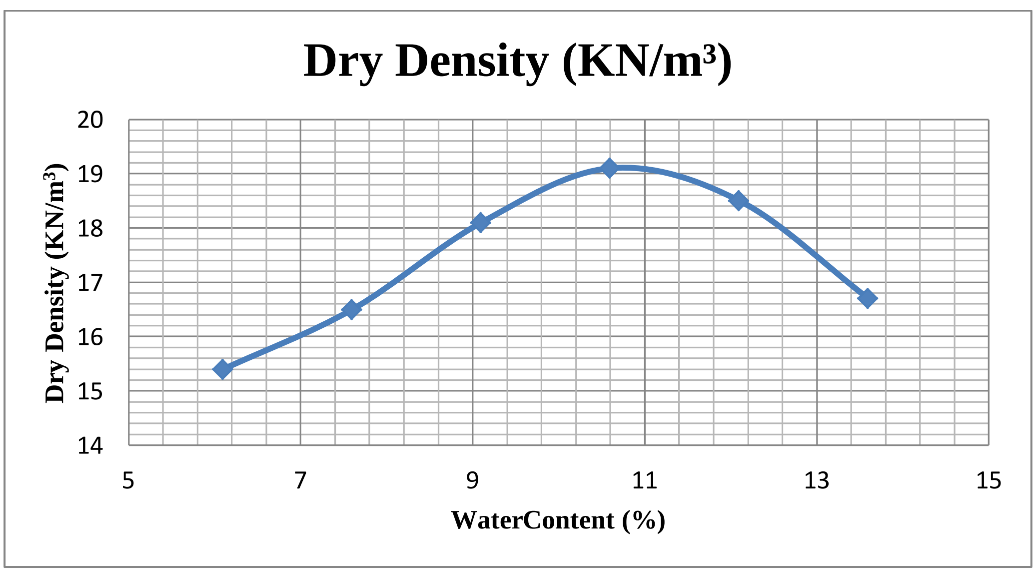

Fig. 4.21 Compaction curve of Soil+ 5% LIME + 10%CW

4.3.7. SOIL+ 5% LIME + 15% CW

From the graph given below (4.22), it has been observed that maximum dry density of Soil was decreased by 5% and optimum moisture content of Soil was increased by 22.68% by addition of 15% CW and 5% LIME.

Optimum moisture content W = 10.71%

Max. Dry density $(\rho_d)_{max}$ = 1.91 g/cc

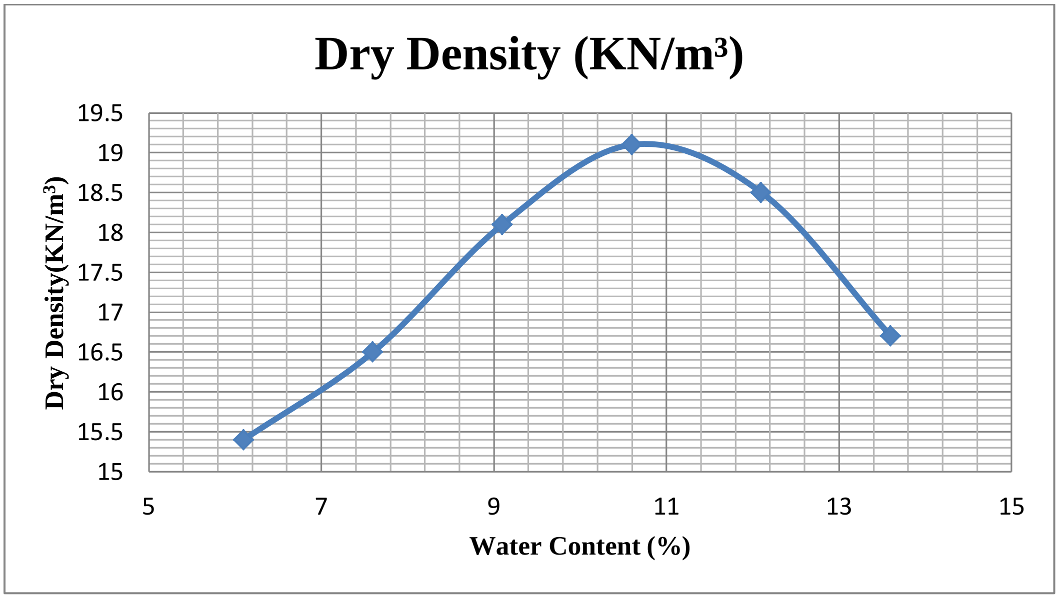

Fig. 4.22 Compaction curve of Soil+ 5% LIME + 15%CW

4.3.8. SOIL+ 10% LIME + 0% CW

From the graph given below (4.23), it has been observed that maximum dry density of Soil was decreased by 1.8% and optimum moisture content of Soil was increased by 8% by addition of 0% CW and 10% LIME.

Optimum moisture content W = 12.85%

Max. Dry density $(\rho_d)_{max}$ = 1.85 g/cc

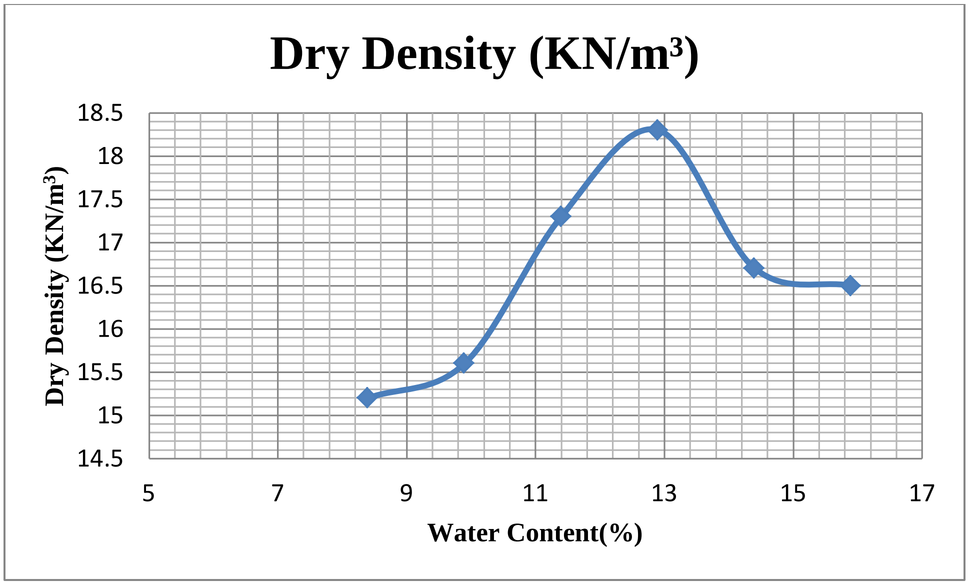

Fig. 4.23 Compaction curve of Soil+ 10% LIME + 0%CW

4.3.9. SOIL+ 10% LIME + 5% CW

From the graph given below (4.24), it has been observed that maximum dry density of Soil was increased by 0.21 g/cc and optimum moisture content of Soil was decreased by 12.5% by addition of 5% CW and 10 % LIME.

Optimum moisture content W = 12.12%

Max. Dry density $(\rho_d)_{max}$ = 1.88 g/cc

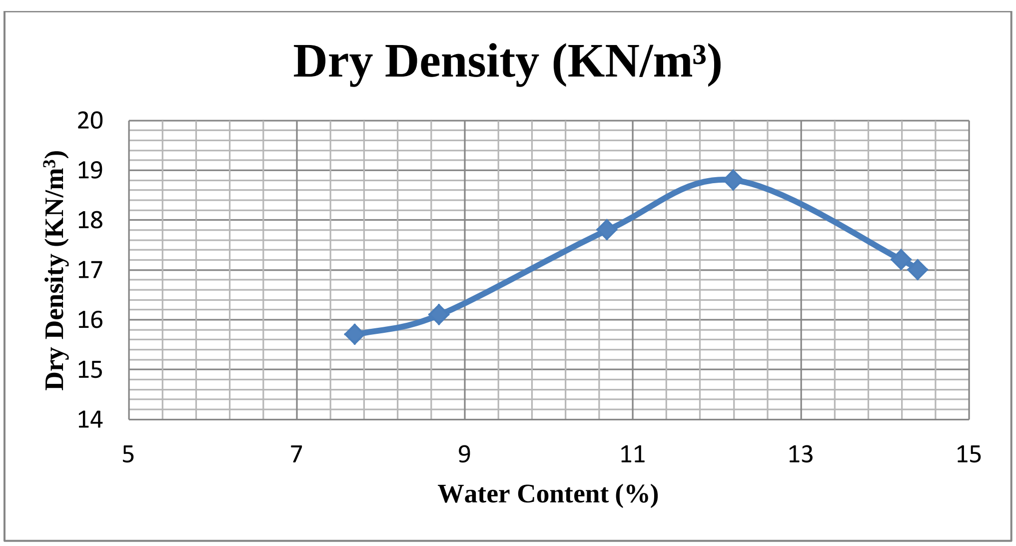

Fig. 4.24 Compaction curve of Soil+ 10% LIME + 5%CW

4.3.10. SOIL+ 10% LIME + 10% CW

From the graph given below (4.25), it has been observed that maximum dry density of Soil was decreased by 7.5% and optimum moisture content of Soil was increased by 15.8% by addition of 10% CW and 10 % LIME.

Optimum moisture content W = 11.67%

Max. Dry density $(\rho_d)_{max}$ = 1.95 g/cc

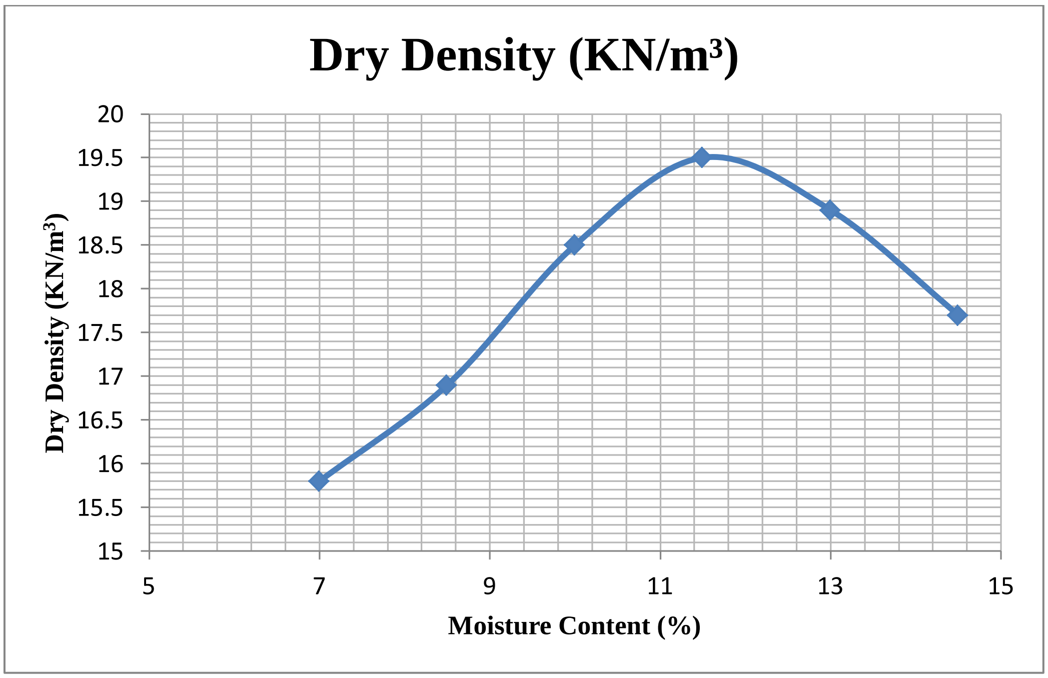

Fig. 4.25 Compaction curve of Soil+ 10% LIME + 10%CW

4.3.11. SOIL+ 10% LIME + 15% CW

From the graph given below (4.26), it has been observed that maximum dry density of Soil was increased by 15% and optimum moisture content of Soil was decreased by 20% by addition of 15% CW and 10% LIME.

Optimum moisture content W = 11.0%

Max. Dry density $(\rho_d)_{max}$ = 2.0 g/cc

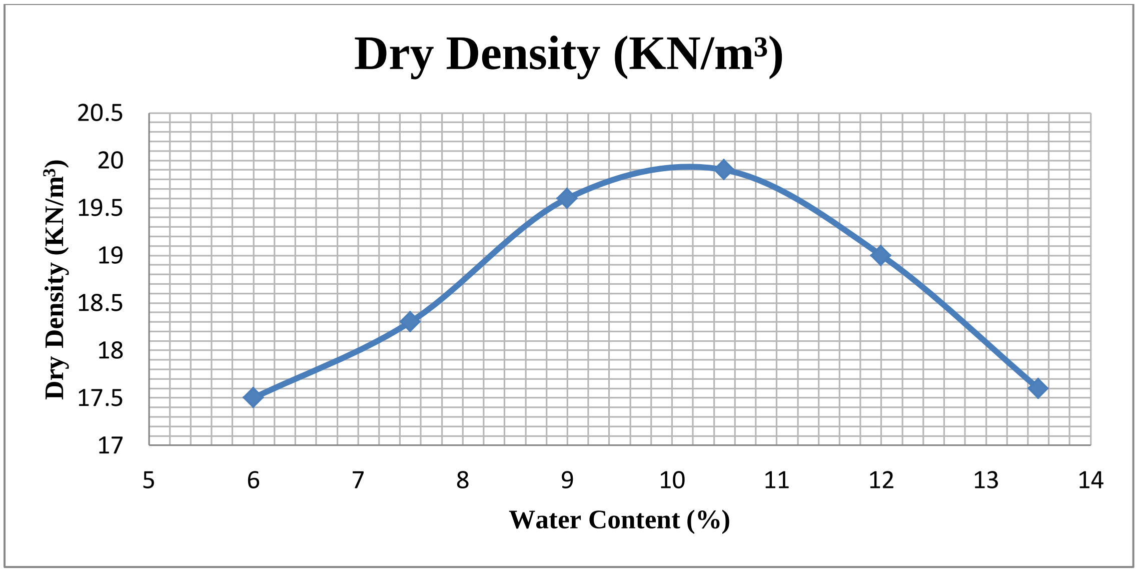

Fig. 4.26 Compaction curve of Soil+ 10% LIME + 15%CW

4.3.12. SOIL+ 15% LIME + 0% CW

From the graph given below (4.27), it has been observed that maximum dry density of Soil was decreased by 6% and optimum moisture content of Soil was increased by 7.2% by addition of 0% CW and 15 % LIME.

Optimum moisture content W = 12.86%

Max. Dry density $(\rho_d)_{max}$ = 1.92 g/cc

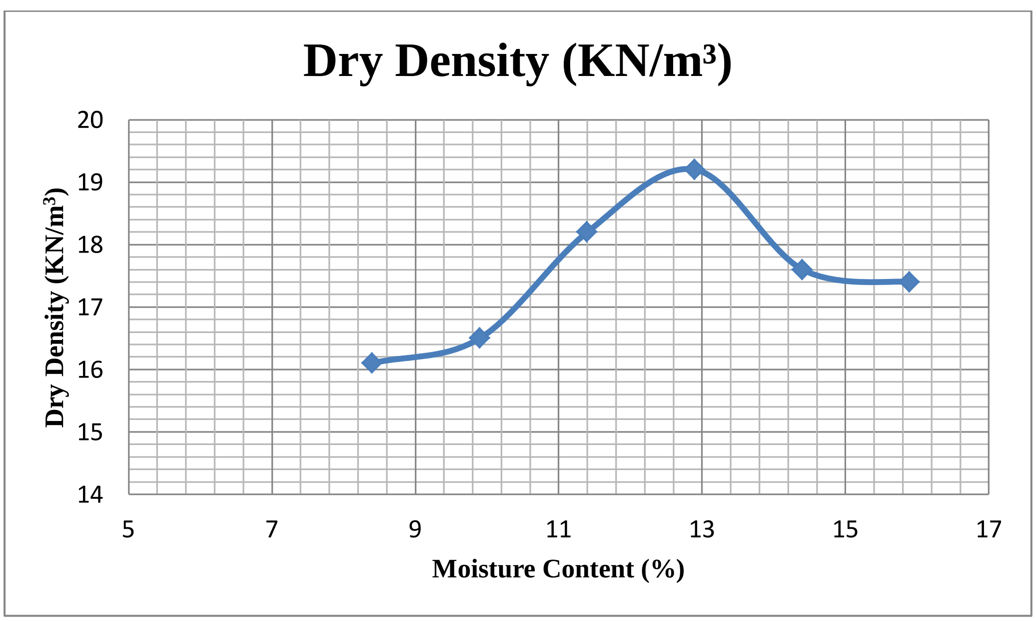

Fig. 4.27 Compaction curve of Soil+ 15% LIME + 0%CW

4.3.13. SOIL+ 15% LIME + 5% CW

From the graph given below (4.28), it has been observed that maximum dry density of Soil was increased by 8.2% and optimum moisture content of Soil was decreased by 12% by addition of 5% CW and 15% LIME.

Optimum moisture content W = 12.19%

Max. Dry density $(\rho_d)_{max}$ = 1.96 g/cc

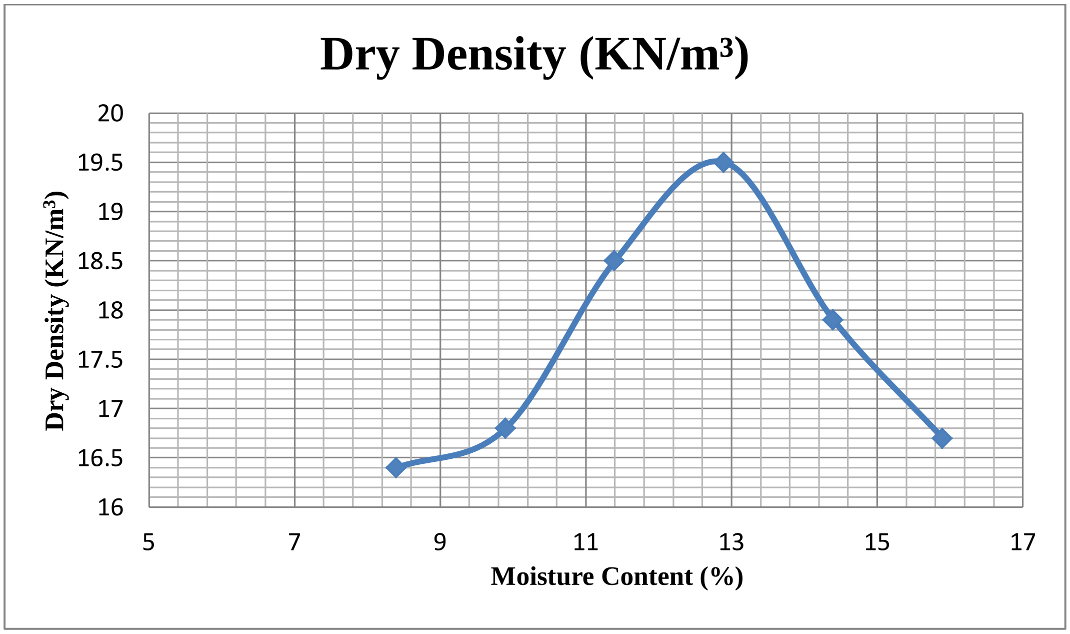

Fig. 4.28 Compaction curve of Soil+ 15% LIME + 5%CW

4.3.14. SOIL+ 15% LIME + 10% CW

From the graph given below (4.29), it has been observed that maximum dry density of Soil was increased by 12% and optimum moisture content of Soil was decreased by 15% by addition of 10% CW and 15% LIME.

Optimum moisture content W = 11.78%

Max. Dry density $(\rho_d)_{max}$ = 2.03 g/cc

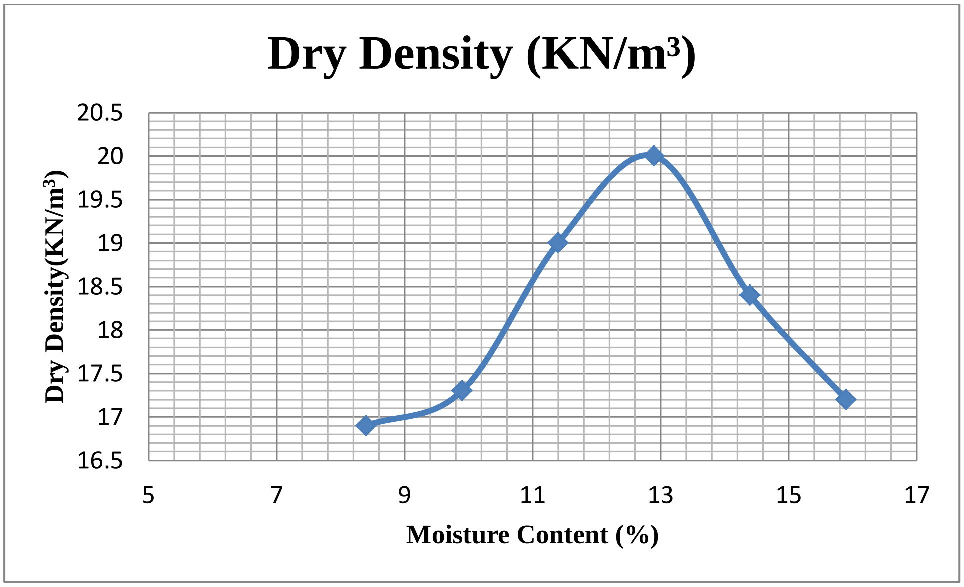

Fig. 4.29 Compaction curve of Soil+ 15% LIME + 10%CW

4.3.15. SOIL+ 15% LIME + 15% CW

From the graph given below (4.30), it has been observed that maximum dry density of Soil was increased by 16% and optimum moisture content of Soil was decreased by 20% by addition of 15% CW and 15% LIME.

Optimum moisture content W = 11.08%

Max. Dry density $(\rho_d)_{max}$ = 2.11 g/cc

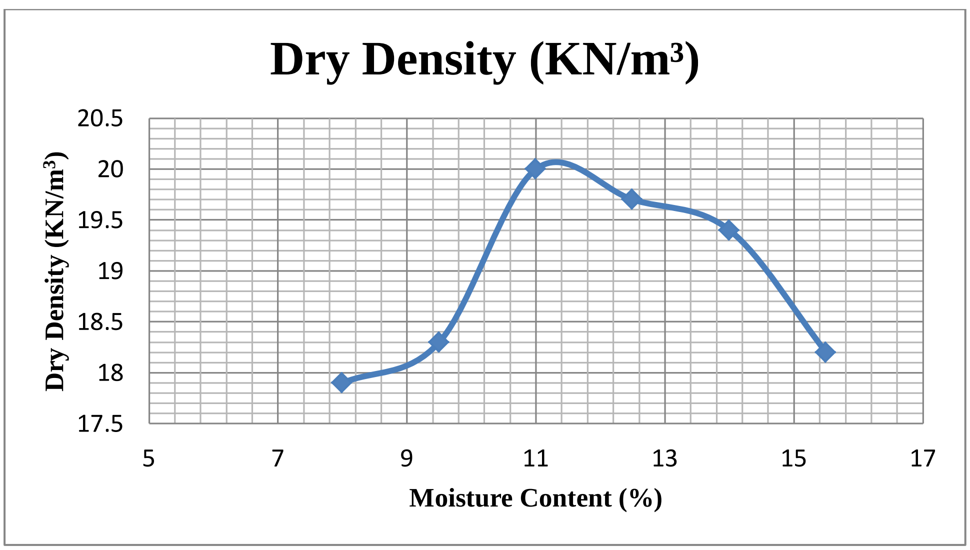

Fig. 4.30 Compaction curve of Soil+ 15% LIME + 15%CW

4.4 California Bearing Ratio

4.4.1. SOIL + 0% Lime +0% CW

From the graph given below (fig 4.31), CBR Value at 2.5 mm = 5.83,

CBR Value at 5.0 mm = 5.49

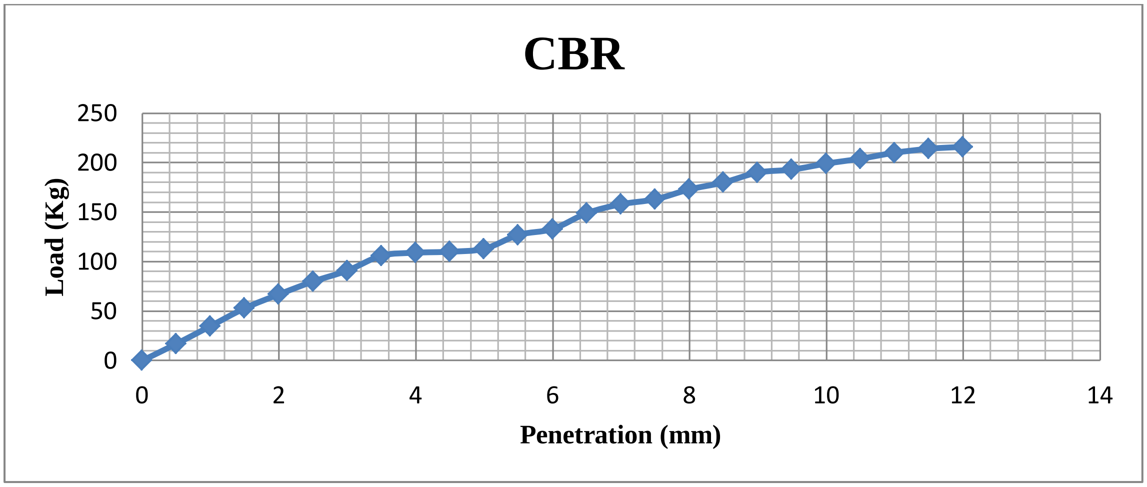

Fig. 4.31 Compaction curve of Soil+ 0% LIME + 0%CW

4.4.2. SOIL + 0% Lime +5% CW

From the graph given below (fig 4.32), CBR Value at 2.5 mm = 5.98

CBR Value at 5.0 mm = 5.79

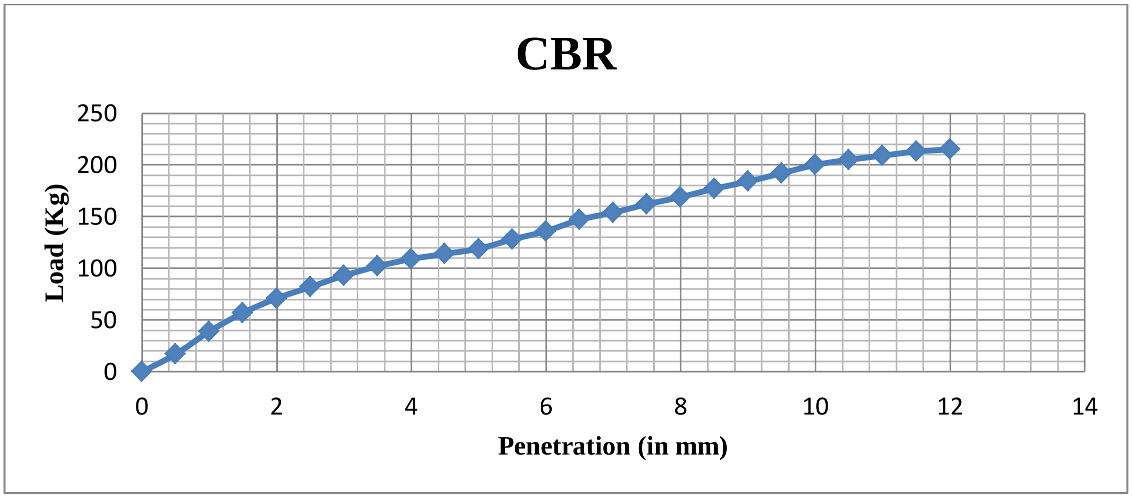

Fig. 4.32 CBR curve 0% Lime +5% CW

4.4.3. SOIL + 0% Lime +10% CW

From the graph given below (fig 4.33), CBR Value at 2.5 mm = 6.20

CBR Value at 5.0 mm = 6.08

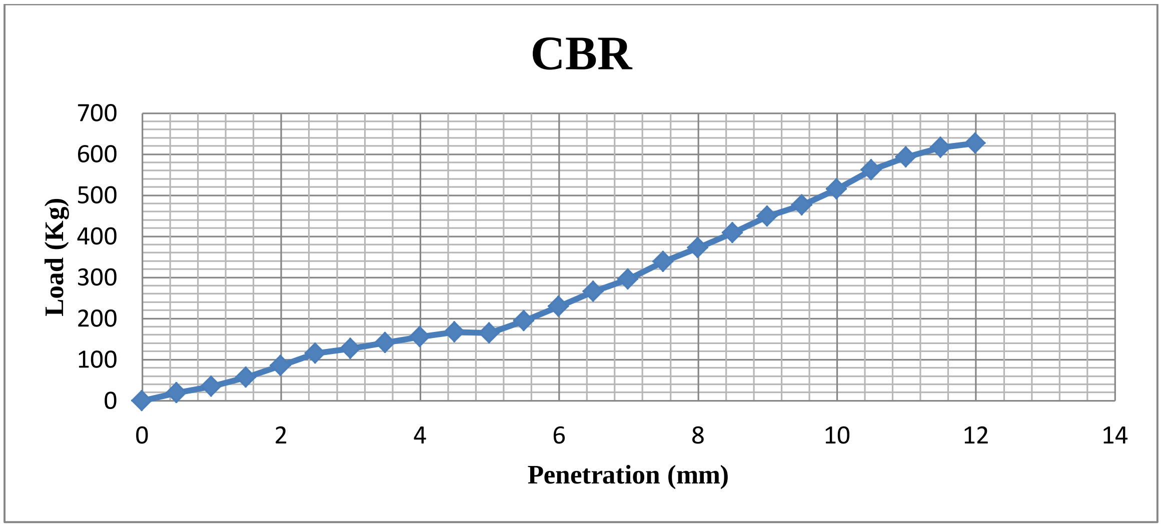

Fig. 4.33 CBR curve 0% Lime +10% CW

4.4.4. SOIL + 0% Lime +15% CW

From the graph given below (fig 4.34), CBR Value at 2.5 mm = 7.15

CBR Value at 5.0 mm = 7.0

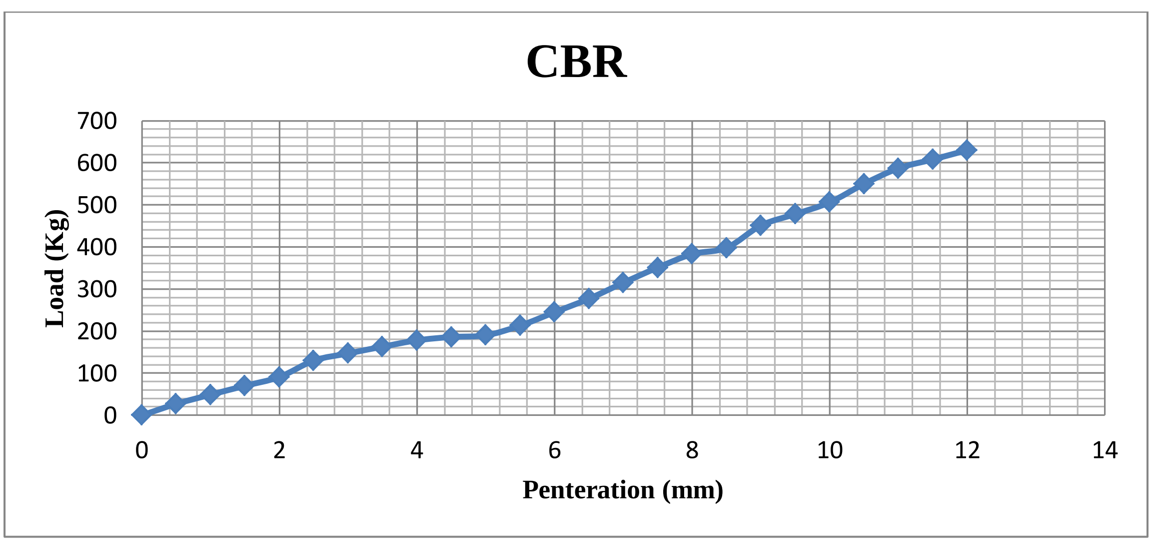

Fig. 4.34 CBR curve 0% Lime +15% CW

4.4.5. SOIL + 5% Lime +0% CW

From the graph given below (fig 4.35), CBR Value at 2.5 mm = 7.44

CBR Value at 5.0 mm = 7.34

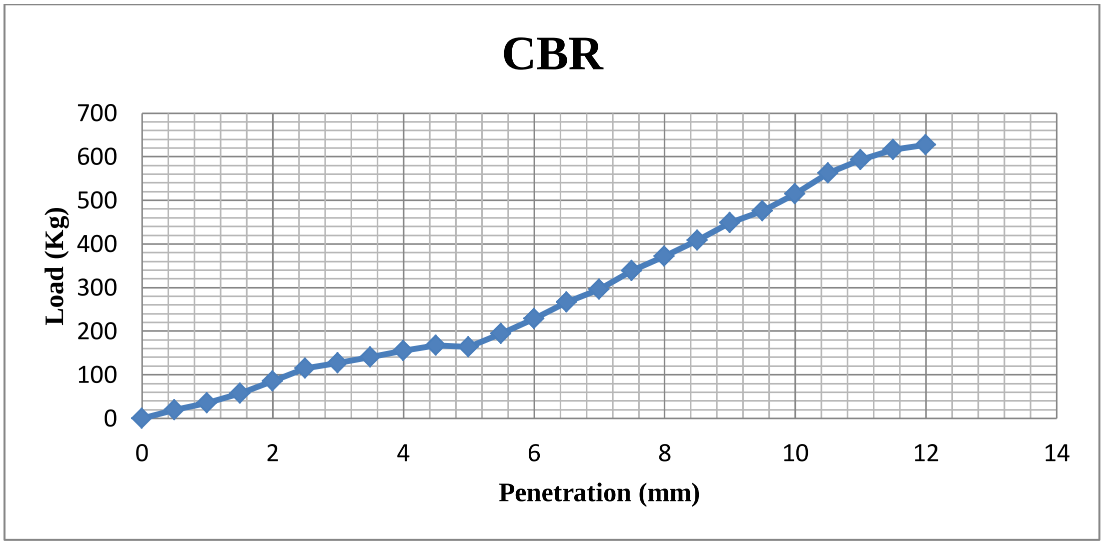

Fig. 4.35 CBR curve 5% Lime +0% CW

4.4.6. SOIL + 5% Lime +5% CW

From the graph given below (fig 4.36), CBR Value at 2.5 mm = 8.39

CBR Value at 5.0 mm = 7.98

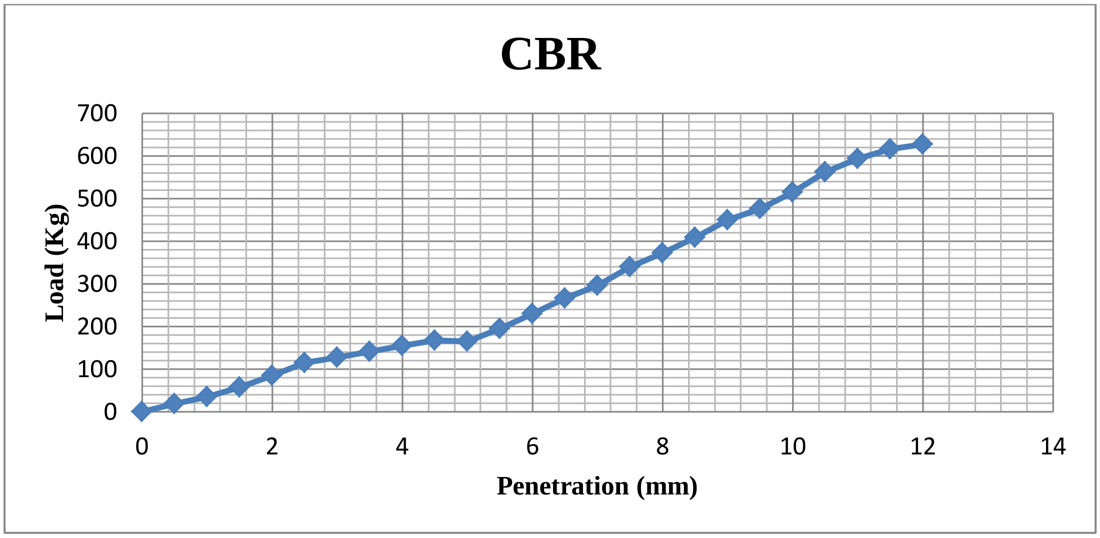

Fig. 4.36 CBR curve 5% Lime +5% CW

4.4.7. SOIL + 5% Lime +10% CW

From the graph given below (fig 4.37), CBR Value at 2.5 mm = 8.75

CBR Value at 5.0 mm = 8.17

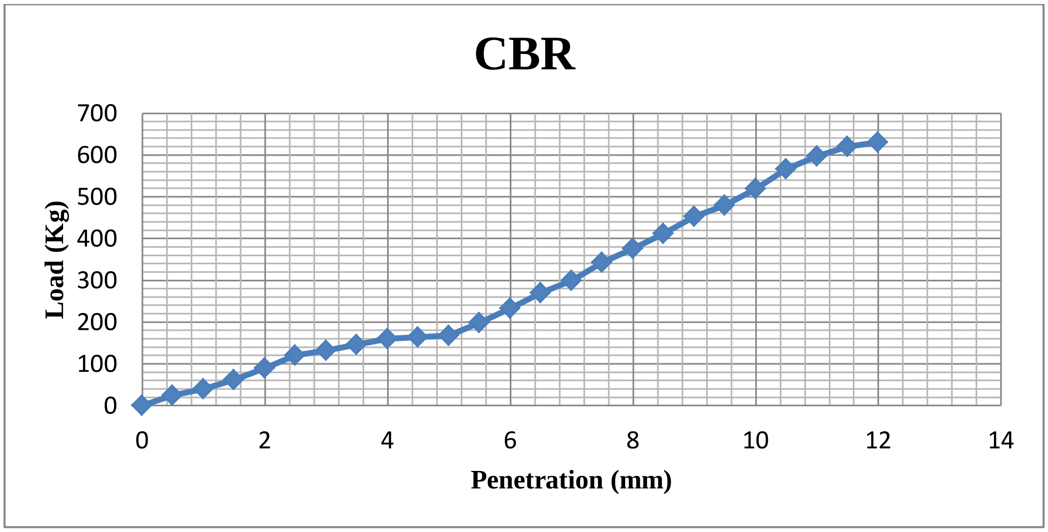

Fig. 4.37 CBR curve 5% Lime +10% CW

4.4.8. SOIL + 5% Lime +15% CW

From the graph given below (fig 4.38), CBR Value at 2.5 mm = 8.98

CBR Value at 5.0 mm = 8.90

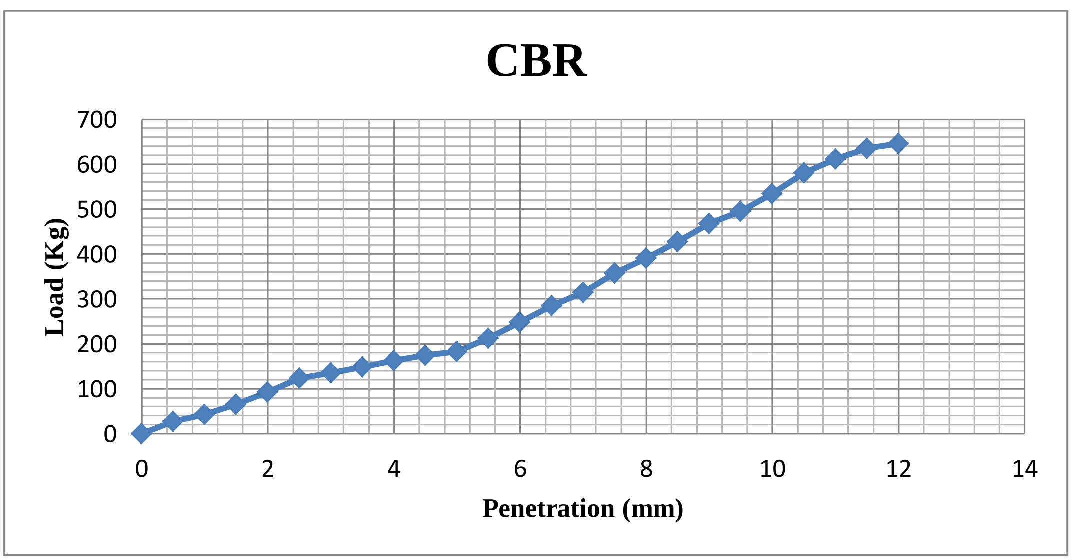

Fig. 4.38 CBR curve 5% Lime +15% CW

4.4.9. SOIL + 10% Lime +0% CW

From the graph given below (fig 4.39), CBR Value at 2.5 mm = 7.29

CBR Value at 5.0 mm = 6.81

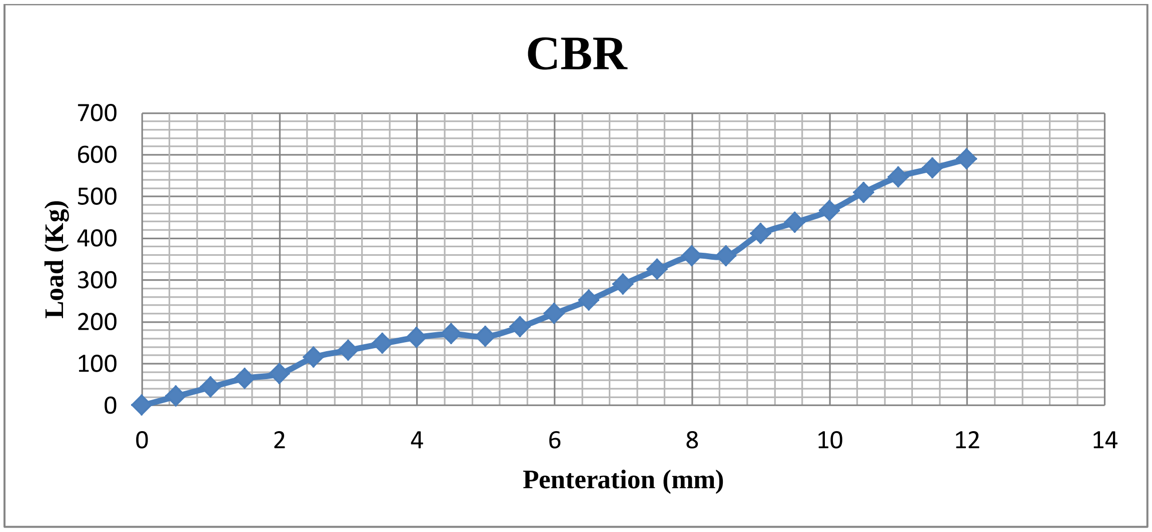

Fig. 4.39 CBR curve 10% Lime +0% CW

4.4.10. SOIL + 10% Lime +5% CW

From the graph given below (fig 4.40), CBR Value at 2.5 mm = 8.39

CBR Value at 5.0 mm = 8.03

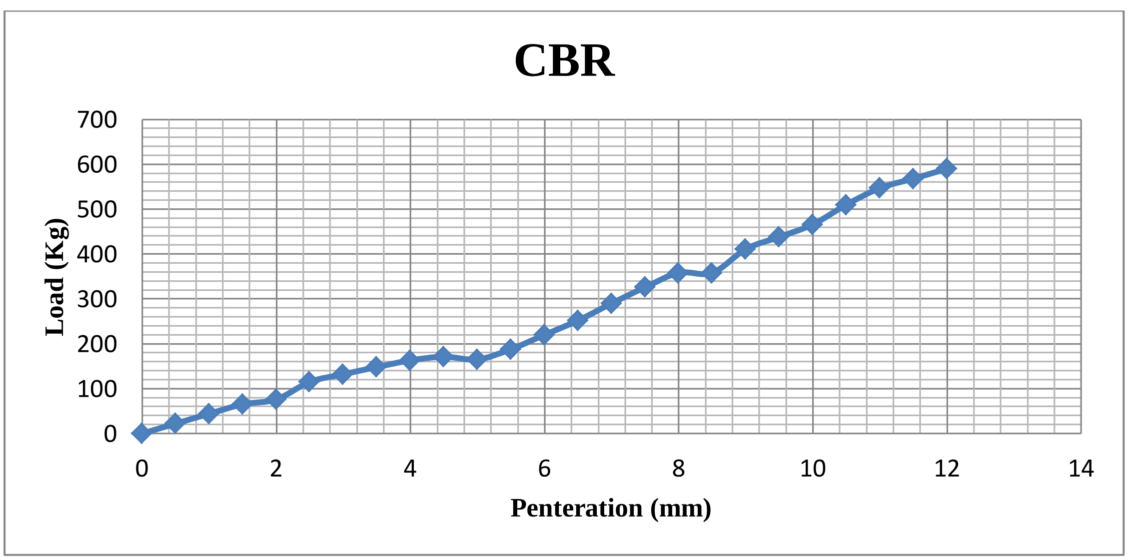

Fig. 4.40 CBR curve 10% Lime +5% CW

4.4.11. SOIL + 10% Lime +10% CW

From the graph given below (fig 4.41), CBR Value at 2.5 mm = 9.49

CBR Value at 5.0 mm = 9.24

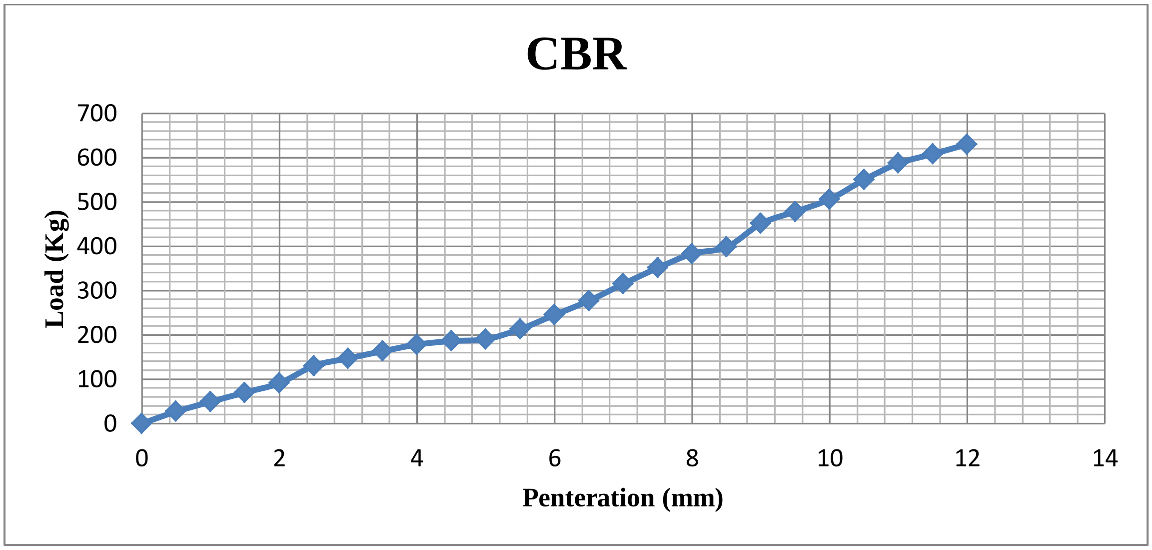

Fig. 4.41 CBR curve 10% Lime +10% CW

4.4.12. SOIL + 10% Lime +15% CW

From the graph given below (fig 4.42), CBR Value at 2.5 mm = 10.58

CBR Value at 5.0 mm = 10.46

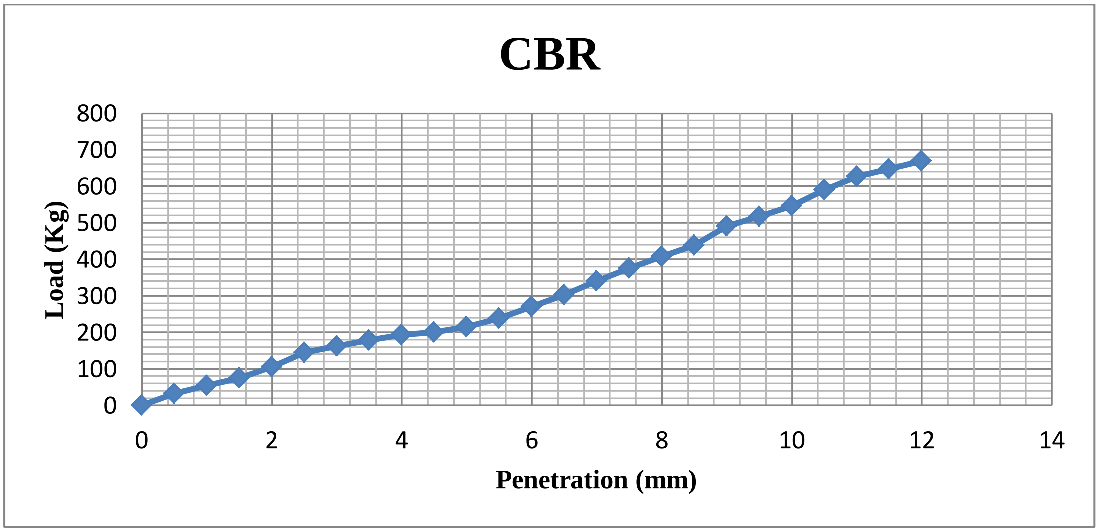

Fig. 4.42 CBR curve 10% Lime +15% CW

4.4.13. SOIL + 15% Lime +0% CW

From the graph given below (fig 4.43), CBR Value at 2.5 mm = 10.65

CBR Value at 5.0 mm = 9.19

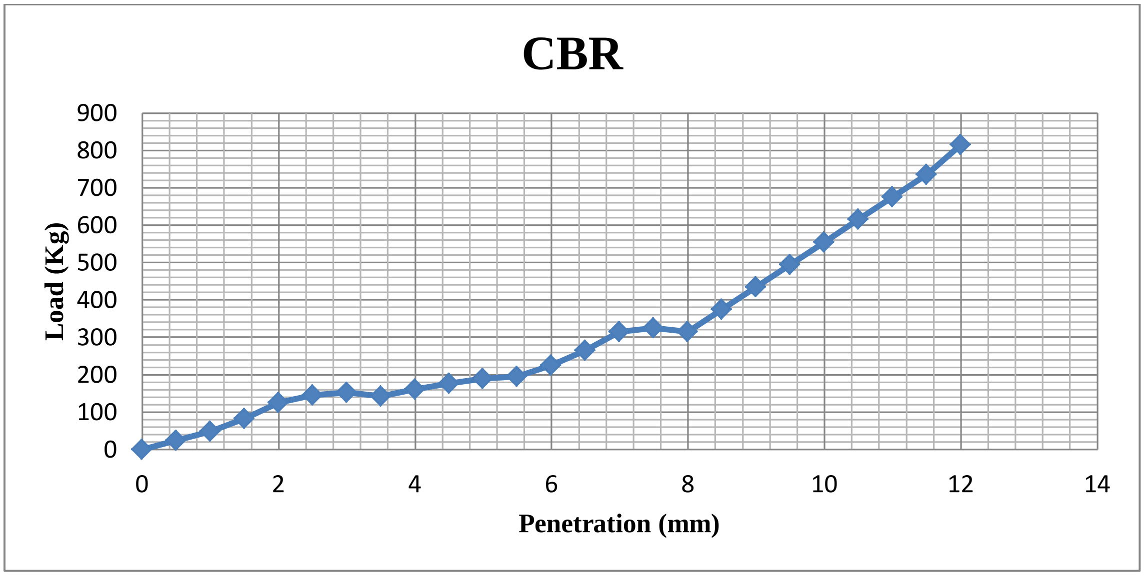

Fig. 4.43 CBR curve 15% Lime +0% CW

4.4.14. SOIL + 15% Lime +5% CW

From the graph given below (fig 4.44), CBR Value at 2.5 mm = 10.87

CBR Value at 5.0 mm = 9.98

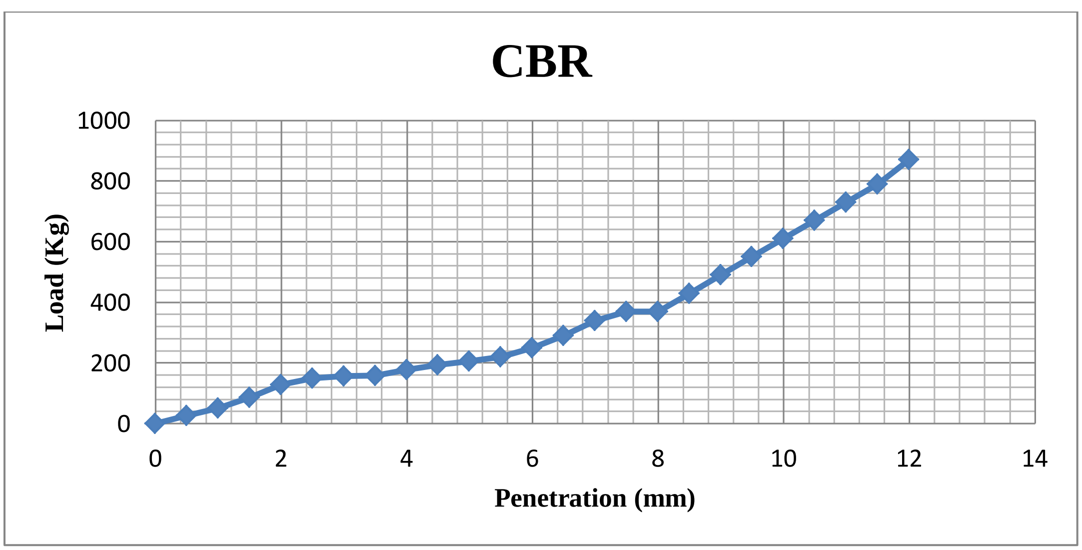

Fig. 4.44 CBR curve 15% Lime +5% CW

4.4.15. SOIL + 15% Lime +10% CW

From the graph given below (fig 4.45), CBR Value at 2.5 mm = 11.09

CBR Value at 5.0 mm = 10.75

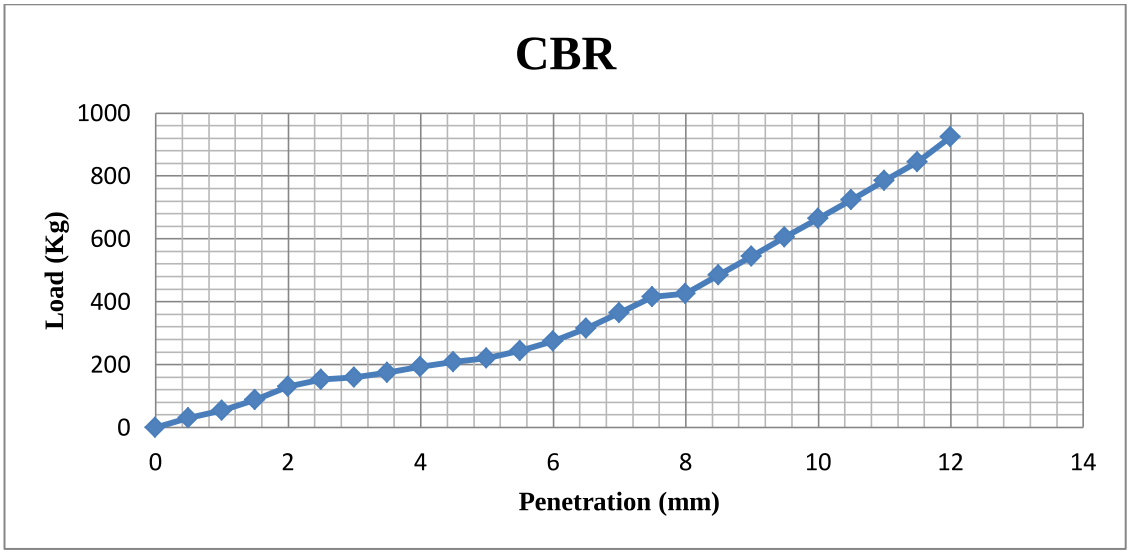

Fig. 4.45 CBR curve 15% Lime +10% CW

4.4.16. SOIL + 15% Lime +15% CW

From the graph given below (fig 4.46), CBR Value at 2.5 mm = 11.75

CBR Value at 5.0 mm = 11.53

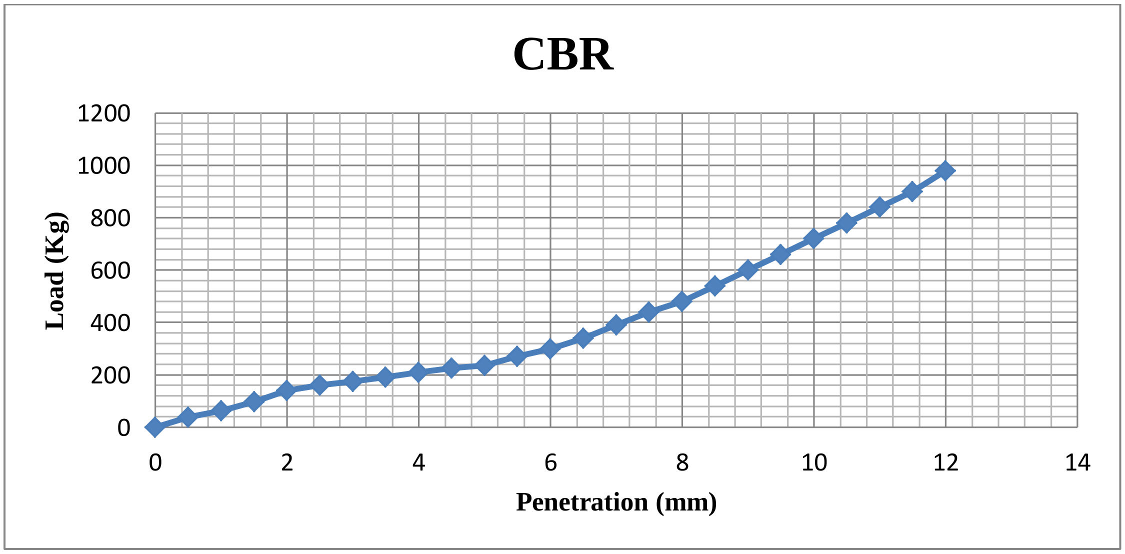

Fig. 4.46 CBR curve 15% Lime +15% CW

CHAPTER 5

ANALYSIS OF RESULTS

5.1. LIQUID LIMIT

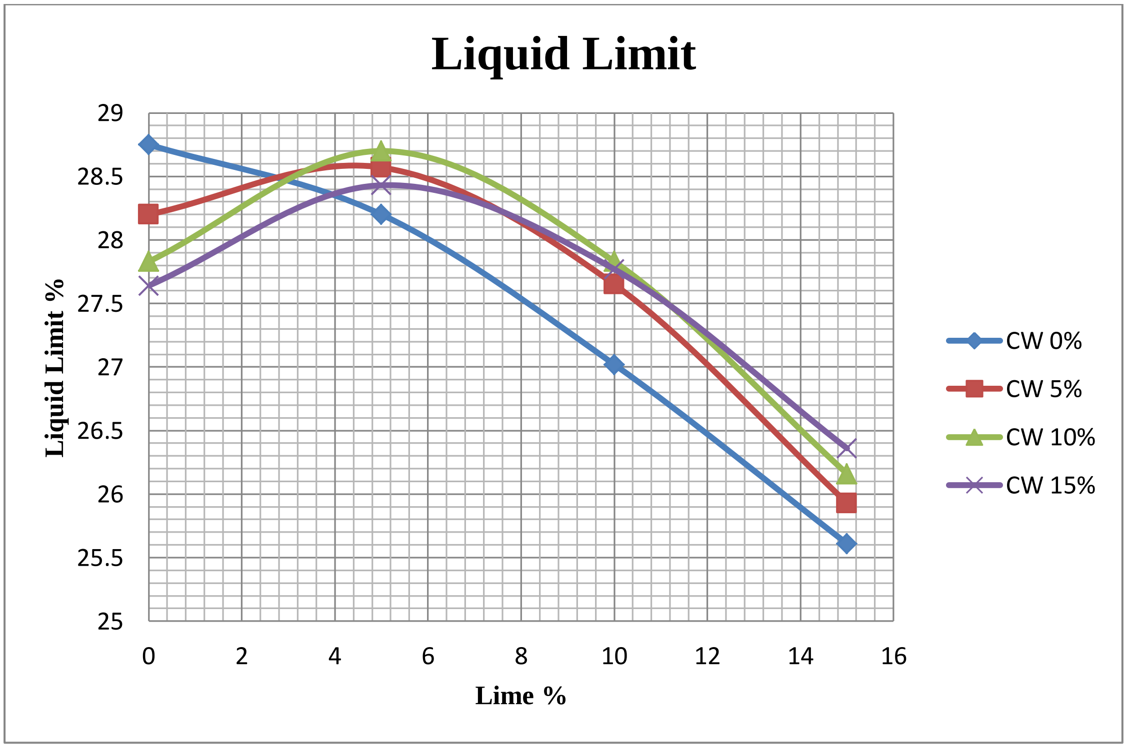

Fig 5.1 Variation of liquid limit with admixtures

Fig. 5.1 shows variation in liquid limit of Soil, such that when we add LIME to Soil, it reduces liquid limit and addition of Construction waste decreases the liquid limit of soil. Reduction in liquid limit when we add lime is due to decrease in thickness of diffused double layer which in turn decrease in water holding capacity of soil. While when we add Construction waste decrease in liquid limit takes place because soil-lime–CW mix result in formation of more coarse aggregate with flocculated structure of particles, water entrapped in large void space of flocculated structure decrease liquid limit.

5.2 PLASTIC LIMIT

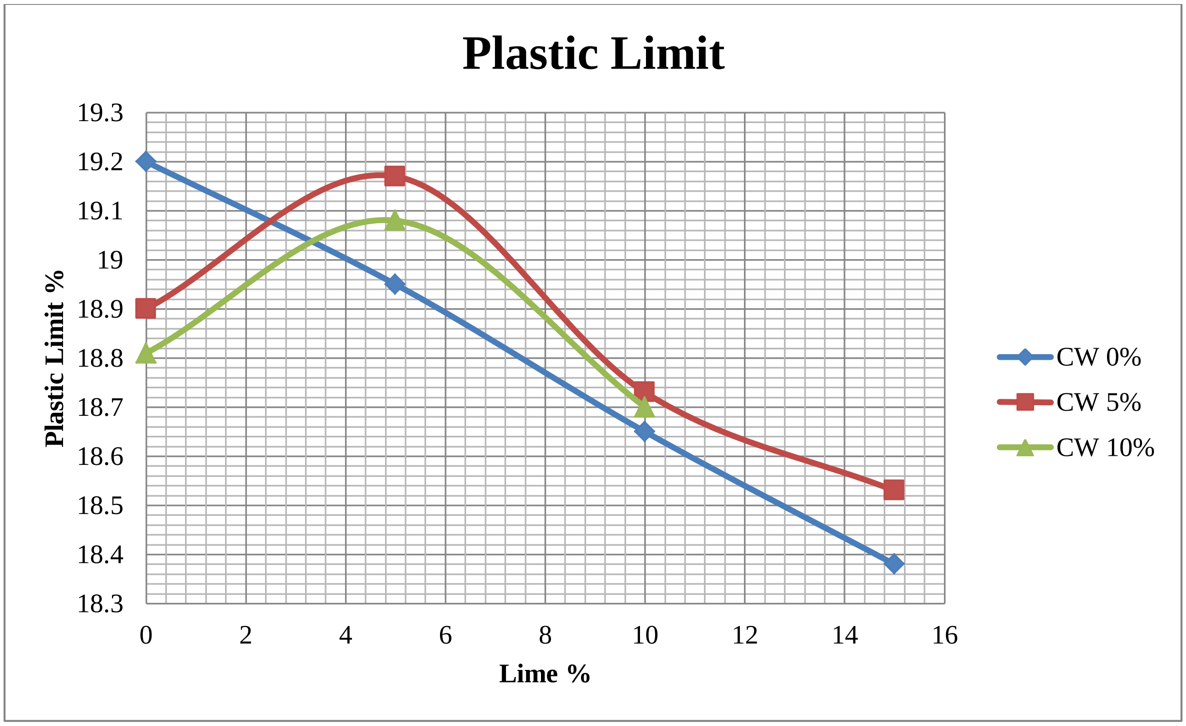

Fig .5.2 Variation of Plastic limit with admixtures

Fig. 5.2 shows variation in plastic limit of Soil, such that when we add LIME to Soil, it reduces plastic limit while addition of Construction waste decreases the plastic limit of soil mix. As lime is non plastic in nature so when we add lime to the soil it decrease the value of plastic limit and when construction waste is added then plastic limit decreases because pozzolanic reaction takes place which result in formation of cementatious material which provide plasticity to the soil.

5.3 PLASTICITY INDEX

Fig. 5.3 shows variation in plasticity index of Soil, such that when we add LIME to Soil, it reduces liquid limit while addition of construction waste decreases the plastic limit of soil mix. The plasticity index is a relative term which depends on the value of liquid limit and plastic limit. Reduction of plasticity index increases the workability of soil, as we know that those soils which have lesser plasticity index will be stiffer and more workable.

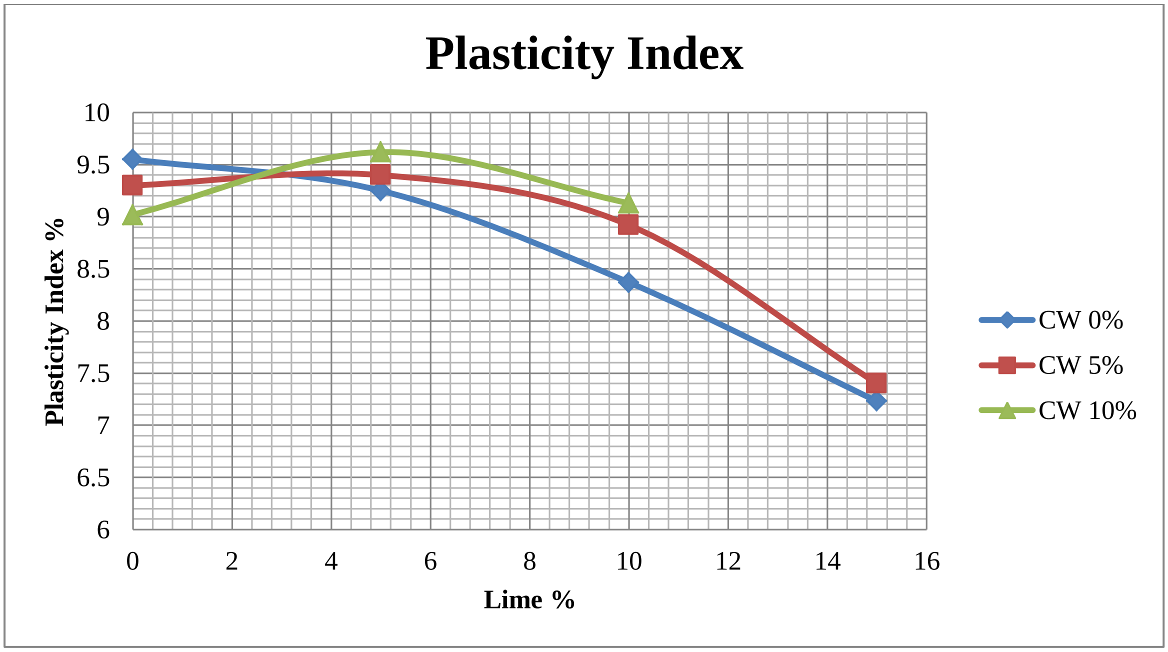

Fig 5.3 Variation of Plastic Index with admixtures

5.4 STANDARD PROCTOR TEST

Fig. 5.4 shows variation in OMC of Soil, such that when we add LIME to Soil, it decreases OMC, similarly addition of construction waste decreases the OMC of soil mix. Soil have up to 5 % of void ratio whereas lime has up to 15 % void ratio at maximum dry density , more void ratio result in built up of more pore pressure during proctor test thus it have a large range of water content over compaction.

Fig. 5.5 shows variation in MDD of Soil, such that when we add LIME to SOIL it increases MDD, similarly addition construction waste increases the MDD of soil mix. The increase of the MDD of soil mix rises with of the percentage of lime.

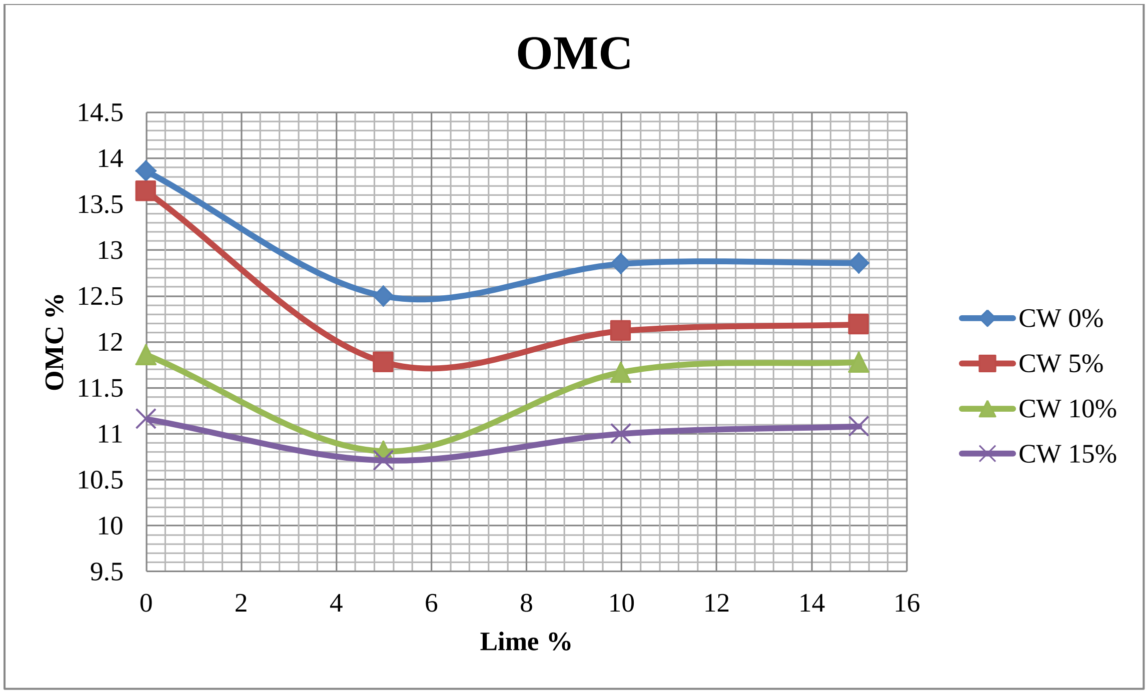

Fig 5.4 Variation of OMC with admixtures

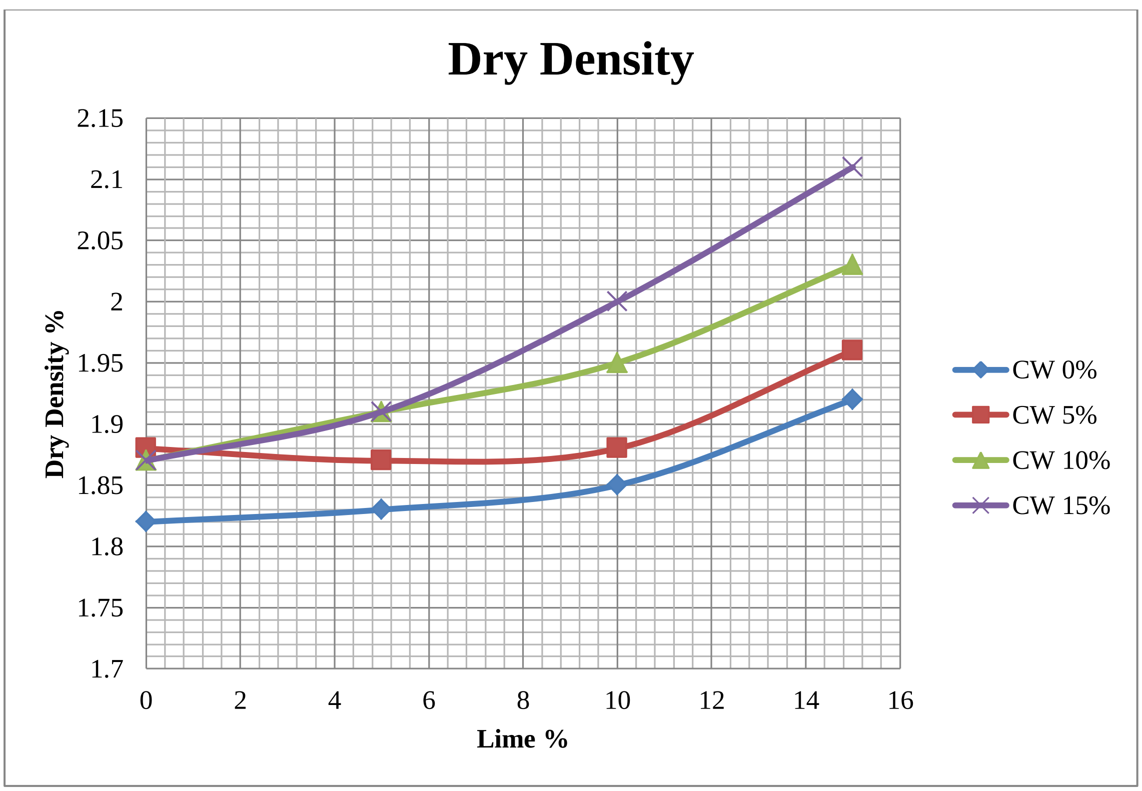

Fig 5.5 Variation of MDD with admixtures

5.6 CBR RESULT

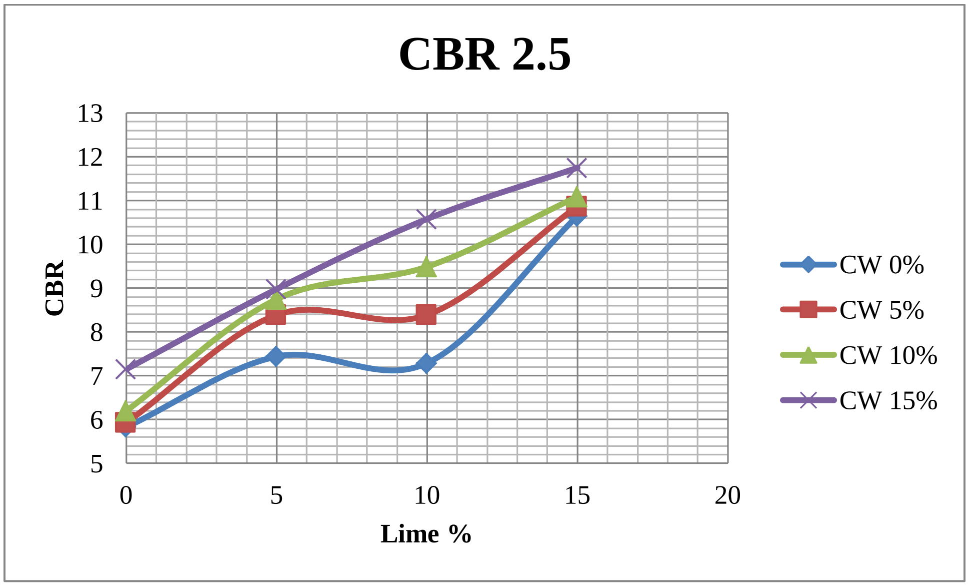

Fig 5.7 Variation of CBR with admixtures

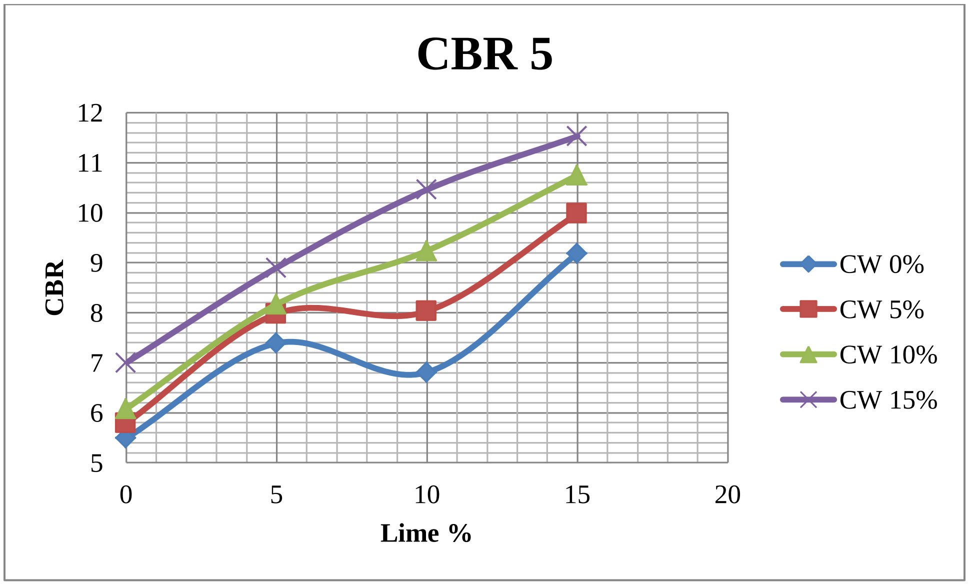

Fig 5.8 Variation of CBR with admixtures

CHAPTER 6

CONCLUSIONS AND FUTURE SCOPE

6.1 CONCLUSIONS

The present thesis can serve as an effective study to utilize construction waste and lime in the stabilization of expansive soil. The conclusions are based on the tests carried out on various sample of Soil, construction waste and lime mixes selected for the same. Following conclusion may be drawn from the analysis of results:-

1. The optimum value of maximum dry density was found at 5% lime & 15 % construction waste.
2. Optimum moisture content was found to gradually decrease on addition of admixtures and maximum reduction in OMC was found at 5% lime & 15 % construction waste.
3. Increase in plastic limit was very less up to addition of 5% lime & 5% construction waste further addition of admixtures plastic limit was gradually decreased up to 5% lime & 15% construction waste and after addition soil was found non plastic.
4. Maximum CBR value of Soil was found at addition of 15% lime & 15% construction waste.
5. It was found that there is a maximum improvement in strength properties for the combination of lime and construction waste as compared to lime or construction waste individually. This helps to find an application for construction waste to improve the properties of Soil in both embankments and pavement constructions.

So the optimum percentages of lime and construction waste were observed at 5% lime and 10-15 % construction waste for improving the properties of expansive soil. Construction waste and lime has good potential for use in geotechnical application of soils is a proven method to save time and money on construction projects. Lime drying of wet soils minimizes weather-related construction delays and permits the return to work within hours. Lime modification chemically transforms clay soils into friable, workable, compactable material.

6.2 FURTHER SCOPE OF STUDY

A number of research works has been done/in progress in gainful utilization of construction waste which can not only reduce the construction costs but also aid improvement in soil strength economically, besides reducing pollution hazards. Following suggestion are made for further study.

1. Based on these laboratory tests further test in field should also be conducted to correlate the result achieved in lab.
2. Strength and durability tests are required to be investigated for 28 days & 56 days of curing to know the geotechnical properties.
3. Durability on the soil- lime and construction waste on the basis of freezing and thawing may also be investigated.

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