IMPROVISATION AND CHARACTERISATION OF SILTY AND ORGANIC SOILS USING LIME AND GOOD EARTH

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Abstract - Modification means the minor change in soil property while as improving soil's engineering property is known as soil stabilization. Soil stabilization means the enough changes in engineering properties hence made to allow field construction. As per Thagesen (1996) any process which improves a soil material and makes it more stable is called as stabilization. Soil is the most important and critical element that influences the success of any construction project. Soil can play the role of one of the raw materials in construction or it can be the part of its foundation. This research involves the characterisation and stabilization of the soft soil present at Ganderbal site. In this study lime is used because of its various advantages. One of main advantage of using lime is its cost effectiveness as compared to materials like cement etc. As we know lime has been used since past and many researchers have studied it also. The soil here is not only treated with lime but also a specified amount of clay too. Hence its strength is further increased by clay content. Various reactions like cation exchange, flocculation and pozzolonic reaction occur. To study effect of lime and good earth on the soil sample and determining their percentage at which the soil gets maximum strength is the main aim or purpose of this project. After conducting various tests we collected lot of information about the effect of lime and clay on soil sample. From the direct shear test results we conclude that the value of cohesion increases on addition of lime with an optimum percentage of 4%.On addition of the filler material we can observe a rise in strength. With the addition of lime the stability increased due to its chemical nature of reacting with water by virtue of which it reduces the water content of the sample.

Key Words: Soil stabilization, Specific Gravity, Lime Test, Atterberg Limit Test, Grain Size.

1. INTRODUCTION

In nature soil is present in large quantity. Nearly every structure on earth is either built with soil or built upon soil. Sometimes such conditions are encountered which are not suitable for construction. In that case, there are following options for the authority in concern:

1. Check for any alternative construction site.
2. Redesign the structure so that it can be constructed on the poor soil without facing any problem.
3. Replace the poor soil with good soil.
4. Improve the engineering properties of the soil at existing site.

Modification means the minor change in soil property while as improving soil's engineering property is known as soil stabilization. Soil stabilization means the enough changes in engineering properties hence made to allow field construction. As per **Thagesen (1996)** any process which improves a soil material and makes it more stable is called as stabilization [1][2].Improvement of engineering properties by a treatment is called as stabilization, [by **Garber and Hoel (2000)][1,3]**.In general we can say, the process of creating or improving certain properties in a soil material so that it becomes stable and useful for some definite purposes is known as stabilization. The stabilization had made big impression in engineering section. Because of it most of soil materials that were thought useless have found application in various fields of engineering. As per **McNally (1998)** various engineering properties that get improved by stabilization include increase in soil strength (shearing resistance), stiffness (resistance to deformation), and durability (wear resistance), reduction in swelling potential or dispersivity of wet clay soils and other characteristics [1,4].As per **Ola (1975),** stabilization of soil is carried out when it is more economical to tackle the problem in available material than to bring the suitable alternative [1,5].Stabilization is mostly used in road construction field but it is now playing a good role in foundation strengthening also to some extent.

Stabilization can be mechanical or chemical. Soil compression is common form of mechanical stabilization. Chemical or additive method of soil stabilization involves addition of cement, bitumen, lime or other agents. Either mechanical additives or chemical additives are used during chemical soil stabilization. Soil cement is a mechanical additive, these additives alter the soil mechanically. By adding a suitable quantity of material having engineering properties the load bearing capacity of soil is upgraded.

While as, chemical additives alter the soil chemically and hence improve the load bearing capacity of soil example lime. Every stabilization agent is effective for a particular soil material to which when they are applied would produce the desirable characteristics. According to **McNally (1998)** the selection of an appropriate agent and construction procedure involves various number of considerations [1,4].

1.1 When and why we use stabilization

For making the predication of load bearing capacity of constructed layers easy, it was a tradition to construct sub grades, sub base and bases by using selected well graded aggregates. With the use of selected materials, the engineer becomes aware that foundation will support the design loads. Gradation is one of the most important soil characteristic which should be understood. It provides an idea about the size of particles in the materials. A soil may be either well graded soil or uniformly graded soil. A soil is said to be of uniform gradation, if it contains soil particles of nearly same size. While as in well graded soil materials there is a wide range of particle size. As we knew from engineering point of view solid foundation having consistent density should be preferred for construction purposes as much as possible. Thus one of the goals of soil stabilization is to provide a solid and efficient foundation. Density is one of the trustworthy property of material to check its suitability for construction purposes. If the density is higher, voids present in material are fewer. Voids make material less stable by allowing moisture to pass through them. Due to this material conditions get affected by temperature, pressure changes and changes in moisture conditions.

Some of the main advantages of soil stabilization are:

1. Soil stabilization helps to reduce cost of project.
2. Soil stabilization improves workability of soil.
3. Soil stabilization makes the soil water tight/waterproof.
4. Soil stabilization increases durability.
5. Soil stabilization helps in conservation of aggregate materials.
6. Soil stabilization helps in drying of wet soils.
7. Soil stabilization decreases the volume changes in soil which may occur due to temperature or moisture.
8. Soil stabilization increases the strength of soil.
9. Soil stabilization provides an efficient working platform for the project.
10. Soil stabilization helps in using inferior materials by improving their characteristics.
11. Soil stabilization helps in conservation of energy.

Figure 1.1 Laying of pavement by soil stabilization process

1.2 Chemical Stabilization

There are various methods of improving the engineering of soil. One of them is addition of chemicals or some other materials for the improvement of existing soil. Use of stabilizing agent to improve the characteristics of an in place soil material comes out economical than importing of aggregates to form base course. These additives can be mechanical or chemical additives. Mechanical additives help to improve the engineering characteristics of parent soil with the help of their own load bearing property. Chemical additives upgrade the engineering characteristics of soil by the reaction that takes place upon their addition. However every additive should be used in a proper way that is they should be used in a proper amount and at proper place where they are effective. Use of additives in a wrong way will cause destructive results on the project.

For proper implementation of this technique, following points should be kept in view:

1. An idea about the desired result.
2. Type of soil and its characteristics on site should be understood.
3. Knowledge about the use of additives, their reaction with soil type and other additives and their effect on the surrounding environment.
4. Way of mixing of additive should be known.
5. An idea about how the improved soil will perform.

Various machines are used to combine or mix the additives with soil. The method that is to be used will depend on three factors (a) machine available (b) location (c) type of additive. Uniform mixing should be done as far as possible.

Pug mill is used where high precision is required. It is a large mixing chamber and is similar to a cement mixer. Pre graded aggregates, additives and water in measured quantities are mixed in the pug mill and then applied to a uniform thickness. Pug mills work slowly with high cost but produce high quality stabilization. Rotary mixer is a large machine. It mixes the additives with soil by tumbling them in a large mixing chamber having a rotor that breaks up materials and then mixes them. It is the most economic and time saving method.

Blade mixing is not as efficient as the above discussed methods, but it is not complex. Blade mixing is done using a motor grader.

Figure1.2 addition of chemical to the soil

1.2.1 Additives

There are various types of additives. A single additive will perform differently when treated with different soils. However each and every additive will not work properly with all types of soils. Additives are used to (a) increase the soil density (b) alter the moisture effects (c) decrease or neutralize the harmful effects of substances present in the soil.

Some of the additives that are widely used are as under

1) Portland cement 2) Quick lime/ Hydrated lime 3) Fly Ash 4) Bitumen 5) Calcium Chloride

6) Chemical or Bio remediation

Fig 1.3 Fly ash

Figure1.3 bitumen mixed with aggregates

1.3 LIME STABILIZATION

Lime stabilization is the oldest technique for improving the engineering characteristics of soils. This process can be used for stabilizing base as well as sub base materials (Garber & Hoel) [1,3].When lime is added to fine grained soils, various engineering properties of the soil get beneficially affected. For example, reduction of plasticity and swelling potential, improvement in workability, increased strength and stability etc occurs. Lime can be also used for unbound base and sub base to improve their strength and stiffness properties. Lime can be used in varying degrees as per the requirements. When the objective is only to dry and modify soils, least amount of lime treatment is required. However when permanent structural stabilization is required, a greater degree of treatment with lime is required, which is supported by testing, design etc.

The materials that are commonly used for lime stabilization are calcium hydroxide and dolomite i.e. $Ca(OH)_2$ and {$Ca(OH)_2$ + MgO} (Garber & Hoel) [1,3].

Calcium hydroxide is formed by slaking quick lime CaO with water, while as quick lime is produced by heating limestone in kilns (Thagesen,1996) [1,2].

Quick lime is also an effective stabilizer but it is not usually used for stabilization because it is dangerous to handle. Quick lime is susceptible to moisture and gives off much heat during hydration (Mc Nally,1998). Dolomite is also used as stabilizing agent, it contains upto 36% by weight of magnesium oxide (MgO).

Type of soil to be stabilized decides the percentage of lime required. The determination of quantity of lime is based on analysis which shows the effect of different lime percentages on reduction of plasticity and increase in strength of soil. Engineering properties of fine grained soils and fine grained fractions of more granular soils get extensively changed by lime. Lime treatment is mostly suitable for plastic clays which possess large water holding capacity. Various reactions take place upon the addition of lime to fine grained soils. Cation exchange and flocculation- agglomerations are the two primary reaction that occur and improve soil plasticity, workability, strength etc. This effect of lime on soils has two types one is immediate and other is long term.

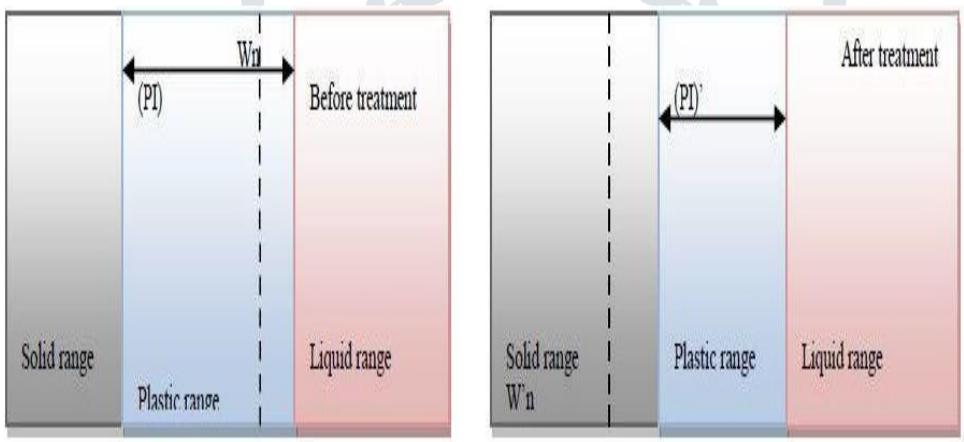
1.3.1 Chemistry of lime treatment

Drying

Quick lime when used immediately combines with water (hydration) and releases heat. Because of this reaction soil gets dried due to two reasons, one is reduction of moisture that took part in reaction and other is reduction of moisture that gets evaporated by the heat generated from the hydration. The hydrated lime formed by hydration will subsequently react with clay particles . These reactions will produce additional drying. If only hydrated lime or hydrated slurry is used, drying will occur due to chemical changes in soil by reduction in water holding capacity and increase in stability.

Modification

After mixing, calcium ions get migrated to surface of clay particles and displace water and some other ions. The soil thus becomes granular and friable, hence making work and compaction easier. The plasticity index of the soil gets decreased which results in reduction of swelling and shrinkage. In few hours the process of flocculation and agglomeration occurs.



Stabilization

The PH of the soil increases to above 10.5 after the addition of adequate quantities of lime and water. This helps in breakdown of clay particles. Silica & alumina gets released and react with calcium (from lime) to form calcium silicate hydrates (CSH) and calcium aluminate hydrates (CAH). CSH & CAH act as cementitous product and contribute to the strength of lime stabilized soil layers. The soil becomes hard and relatively impermeable with significant load bearing capacity. The process starts in few hours and continues for years in a properly designed system.

1.4 Numerous advantages of lime treatment:

1. Lime makes it possible to transform an unconditional soil into a stabilized soil that can carry the traffic loads efficiently. The soil also becomes less sensitive to moisture with the help of lime. One of the best effects is formation of job site roads that can be used irrespective of whether condition.
2. This technique makes it possible to use on site materials for good application. We can use the moist plastic soil after treating it with lime. This results in saving of cost, time and soil disposal sites.
3. With the help of lime treatment good quality capping layers and beds for roads, runways and railway tracks can be constructed.
4. In small scale projects, like foundation for car parks, industrial platforms, agricultural and forestry roads lime stabilization process becomes much easy. However, it provides great benefits by saving aggregates and disposal charges in case of major earth moving projects too.

1.5 Economic benefits of lime stabilization

Need of embankment materials brought in from outside get reduced and transportation cost also decreased.

1. Transportation movement in the vicinity of construction site reduced.
2. Improvement in production took place due to the reduction in delays because of weather conditions. Machines can move with much greater ease. Hence the overall construction time period and cost can be reduced.
3. Service life of structures (embankments etc) is longer and maintenance is cheaper.

2. LITERATURE SURVEY

The chemical soil stabilization by lime has been presented as a tried and tested technique for strength development of the soil in a journal article by Aldaood, et al (2014). This is obviously true when examining several experiments and review studies documented by various different authors. They all have reported that lime has been used widely and beneficially with main objective of increasing bearing capacity of the soil, resistance to weathering process, assisting with soils permeability and others (Negi et al. 2013). Depending upon the nature of soil, its behaviour and final use of soil, various technological practices of increasing the bearing capacity of the soils are being used in different parts of the world. Some practices adopted are like mechanical soil stabilization, chemical soil stabilization, electrical soil stabilization, thermal soil stabilization. However these practices function differently in different regions because of nature of the soil treated, behaviour of soil when stabilized and due to the intended final use of the soil being stabilized.

Because of various benefits, the chemical soil stabilization using lime has become a common practice. These benefits include increasing of PH range of acidic soil in order to promote the effective soil stabilization. When lime and water are mixed with soil (particularly clay soils), the soils physical and chemical properties change and hence improves its engineering behaviour. Kestler, 2009) Chemical stabilization specifically through the use of lime is achieved by mixing lime itself with soil to form a stronger composite material. This process is more effective to almost all soils that are fine grained with more sudden development occurring in soils with clay content and high plasticity in the presence of desired moist in the soils treated. The reactive soils mentioned above relates to soil with enough clay content (National Lime Association, 2004; Yong and Ouhadi, 2007; Khattab and Hussein, 2012; Aldaood, Bouasker and Mukhtar, 2014b; Khemissa and Mohamedi, 2014).

For the first time in the design of major interstate highway pavement in Pennsylvania, Qubain et al. (2000) introduced the benefits of subgrade lime stabilization.

The project involved widening and reconstruction of nearly 21 km of the Pennsylvania turnpike in Somerset country. The subgrade was fairly homogenous with medium to stiff clayey soils as per the field explorations. Lime modification has been utilized traditionally for the project to safeguard against softening potential due to rain. Improvement of strength by lime involves three mechanisms: hydration, flocculation and cementation. The first two mechanisms occur immediately upon introduction of lime but the third mechanism is prolonged one. The first two mechanisms which are hydration and flocculation were investigated by Qubain (2000). To study the immediate benefits of lime stabilization for design laboratory tests were performed. Both the samples that are natural and treated sample were subjecting to CBR and resilient modulus testing. The lime treated specimens were not cured for the prevention of cementation. However the strength was increased which resulted in various savings.

Ismail (2004) treated and stabilized the materials involved in road construction by using lime, cement and lime/cement. He determined compaction properties, shear strength, uniaxial strength, consistency limits. He concluded that by increasing OMC (optimum moisture content) of the soil mixture (treated materials), the maximum dry density decreased, the cohesion and angle of friction increased for all the treated mixtures. The cohesion decreased by curing time in case of lime treated materials.

3. PROBLEM FORMULATION and NEED of PROPOSED RESEARCH WORK

3.1 PROBLEM FORMULATION

As we know that the earth substantially based structure of any type truly is only as strong as its foot or foundation. For this reason, soil is the most important and critical element that influences the success of any construction project. Soil can play the role of one of the raw materials in construction or it can be the part of its foundation. Therefore it is crucial to understand the engineering properties of soil to obtain its permanency in terms of strength and economy. In order to make the soil suitable for a given constructional purpose soil stabilization is done. The site allotted for Central University of Kashmir at Ganderbal is selected for this study. The problem that is related with this site is that it is marshy land with nearly 100% water saturation. The soil is uniformly silt graded with vegetative organic matter. To improve its gradation use of good earth is done so that artificial base over soil is created.

Following data has been apprehended from the geotechnical investigation.

The subsoil strata for different structures like administration block, hostel building etc. at university site Ganderbal comprises of generally three types of layers as per laboratory test results. Based on field and laboratory classification, description of each layer is provided below with some engineering properties.

3.2 NEED AND SIGNIFICANCE OF THE PROPOSED RESEARCH WORK

This research has main objective to investigate the soft soil and then improve it. The soil improvement is done by using additives and by improving gradation also. In this study lime is used because of its various advantages. One of main advantage of using lime is its cost effectiveness as compared to materials like cement etc. As we know lime has been used since past and many researchers have studied it also. Many of these studies are based on evaluating the effect of percentage of lime content on the behaviour of lime stabilized grounds.

But the lime stabilization method presented here is different from other lime stabilisation methods. The soil here is not only treated with lime but also a specified amount of clay too. Hence its strength is further increased by clay content. The increase in strength occurs because of two reasons. First reason is chemical reaction that occurs between lime and silica which is present in clay. Various reactions like cation exchange, flocculation and pozzolanic reaction occur. The second reason of strength gaining is filling of spacing between coarse grains by small sized clay particles. Thus the soil becomes stronger. To study effect of lime and good earth on the soil sample and determining their percentage at which the soil gets maximum strength is the main aim or purpose of this project.

The primary objectives of the study are given as:

1. The identification, characterization, and determination of the engineering properties of soil sample and good earth.
2. Investigating the effect of stabilization by adding good earth with varying percentage to soil sample.
3. To investigate the effect by decreasing the amount of good earth and adding the lime in different percentage.
4. Using lime and good earth mixture in proper percentage to obtain the desired strength.

4. Methodology And Analysis

4.1 Introduction

Disturbed soil collected from Central University, General was preserved in polythene covers and transported to laboratory. One more cover was provided to prevent loss of moisture during transit period.

Fig 4.1 Ganderbal Central University site

Figure 4.2 Sample Collection

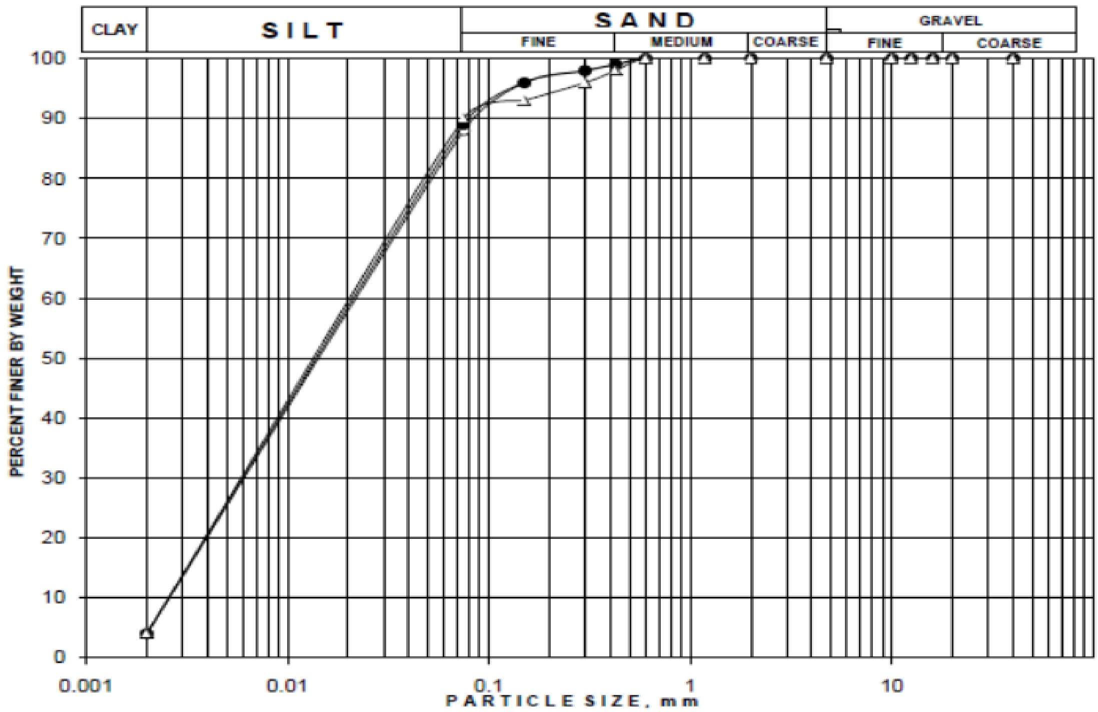
The laboratory tests that have been done as per IS: 2720 are given below. These tests were performed on natural as well as stabilized soil.

1. Specific gravity test.
2. Grain Size Analysis.
3. Hydrometer analysis.
4. Organic content determination.
5. Atterberg's Limit Test.
6. Proctor Compaction Test.
7. Unconfined Compression test
8. Direct shear test.
9. Swell Index Test.

Result Analysis

4.1 Soil identification and classification

4.1.1 Soil Gradation



Symbol	BH No.	Depth, m	Soil Description	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
○	BH-03	1.50	Grey Sandy SILT (OL)	0.00	12.00	84.00	4.00
●	BH-03	4.50		0.00	11.00	85.00	4.00
△	BH-03	6.00		0.00	10.00	86.00	4.00

RESULT: The particle size distribution curve for the soil sample shows that soil is predominantly silty with silt fraction of 85%.

Hydrometer Analysis- Organic Soil Sample:

Sample taken = 50g (oven dried, 75µ passing)
Temperature = 19ºC Absolute viscosity = .0010391 poise
M = .01784 % passing 75 µ =4% G =1.9978

Table 4.1 Hydrometer chart of soil sample

TIME T(min)	Hydrometer Reading(R_0)	R_w	R_h= R_0-R_w	R_h'= R_h+C_m	He(cm)	SQRT {He/t}	D=M* SQRT{He/t}	R= R_h-C	N%	N'%
1	1020	1000	20	20.25	11.815	3.437	.0613	19.5	79.25	3.17
2	1017	1000	17	17.25	12.955	2.545	.0454	16.5	67.06	2.68
5	1016.5	1000	16.5	16.75	13.145	1.621	.0289	16	65.03	2.6
10	1008.5	1000	8.5	8.75	16.185	1.272	.02269	8	32.51	1.3
15	1007	1000	7	7.25	16.755	1.057	.01885	6.5	26.42	1.06
30	1005	1000	5	5.25	17.515	.0764	.01363	4.5	18.29	.73

60	1003	1000	3	3.25	18.275	.5518	.00983	2.5	14.23	.561
120	1002	1000	2	2.25	18.655	.394	.00702	1.5	10.16	.406
240	1001.5	1000	1.5	1.75	18.845	.2802	.005	1	4.064	.162
1440	1001	1000	1	1.25	19.035	.1149	.00205	.5	2.032	.08

RESULTS: Clay = 0.08% Silt = 99.92 %

Grain size distribution curve

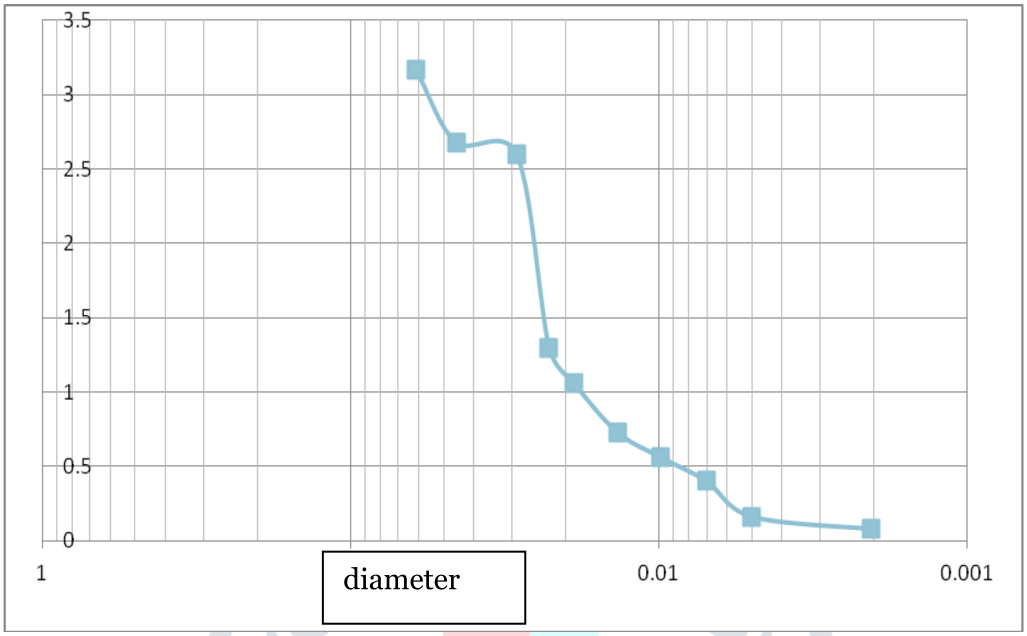


Fig.4.3 Grain distribution curve of soil sample

Hydrometer Analysis - Filler

Sample taken = 50g (oven dried, 75µ passing), Temperature = 19ºC, Absolute viscosity =.0010396 poise
M = .004698 % passing 75 µ = 98% G = 2.44

Table 4.2 Hydrometer chart of filler

TIME T(min)	Hydro meter Reading (R_0)	R_w	R_h= R_0-R_w	R_h'= R_h+ C_m	He(cm)	SQRT {He/t)	D=M* SQRT{He/t}	R= R_h-C	N%	N'%
1	1029	1000	29	29.25	11.435	3.382	.01588	28.5	96.56	94.9
2	1025	1000	25	25.25	12.955	2.545	.011956	24.5	83.01	81.35
5	1020	1000	20	20.25	14.855	1.724	.008097	19.5	66.07	64.77
10	1017.5	1000	17.5	17.75	15.805	1.257	.005905	17	57.60	56.44
15	1016	1000	16	16.25	16.375	1.045	.004908	15.5	52.51	51.46
30	1012.5	1000	12.5	12.75	17.705	.768	.003608	12	40.66	39.84
60	1010	1000	10	10.25	18.655	.5576	.002619	9.5	32.19	31.54
120	1007.5	1000	7.5	7.75	19.605	.0404	.001897	7	23.72	23.24
240	1003	1000	3	3.25	21.315	.298	.0014	2.5	8.47	8.301
1440	1002	1000	2	2.25	21.695	.1227	.000576	1.5	5.082	4.98

RESULTS: CLAY 24.72% SILT 75.31%

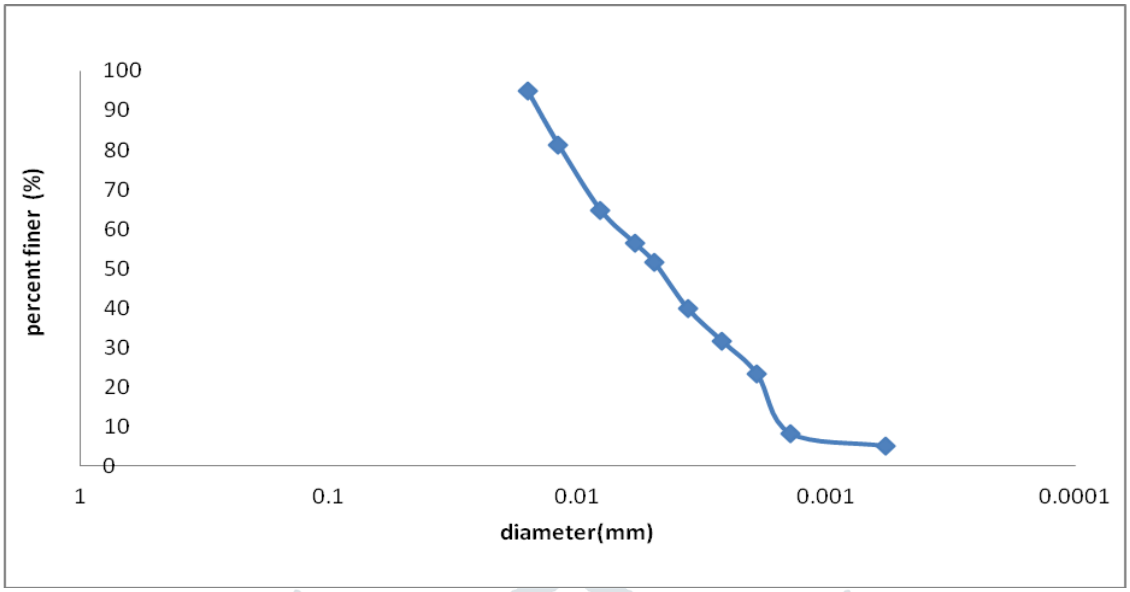


Fig.4.4 Grain distribution curve of filler

Grain size analysis (filler+aggregates)

Weight of soil sample = 2.3kg Weight of sample retained on 75µ = 1.182 kg

Table 4.3 Sieve analysis table filler + aggregate

Sieve opening (mm)	Mass of soil retained(g)	Cumulative mass retained	Cumulative % of soil retained	% finer (100-(col. (4)) (%)
1	2	3	4	5
80	0	0	0	100
40	227.5	227.5	19.2	80.8
20	346.15	574	48.6	51.4
10	185.36	759.36	64.29	35.71
4.75	177.33	936.69	79.31	20.69
pan	243.97	1.181	100	0

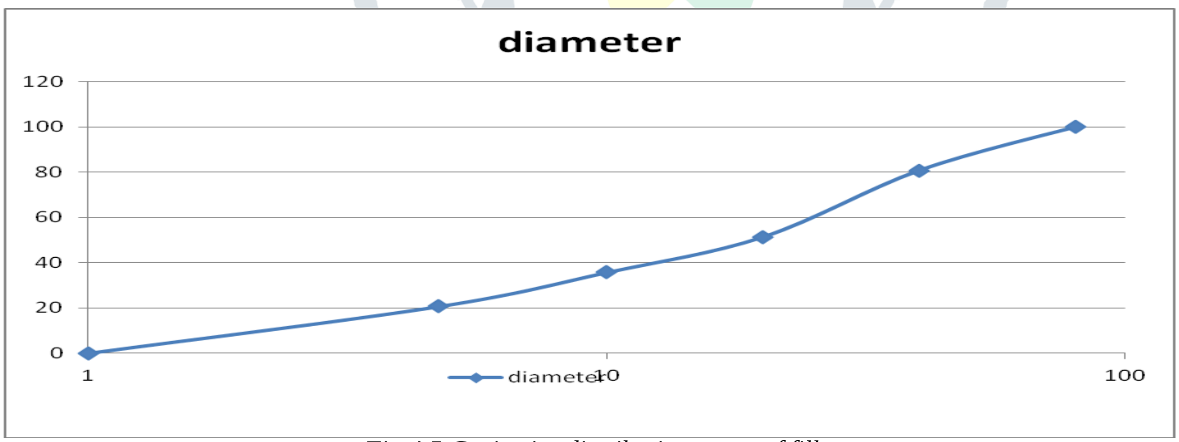


Fig.4.5 Grain size distribution curve of filler + aggregate

Grain Size Analysis – Filler + Aggregate

Weight of sample=243.97 g

Table 4.4 Sieve analysis table filler + aggregate

Sieve opening (mm)	Mass of soil retained(g)	Cumulative mass retained	Cumulative % of soil retained	% finer (100-(col. (4)) (%)
1	2	3	4	5
1.18	107.45	107.45	44.145	55.86
.600	68.33	175.78	72.21	27.8
.420	7.35	183.13	75.238	24.8

.300	13.16	196.29	80.6	19.4
.150	29.97	226.96	92.95	7.05
.075	16.7	242.96	99.819	.18
pan	.44	243.4	100	0

RESULTS: % FINER THAN 75 μ = 48.6 %, GRAVEL = 40.78%, SAND =10.58%

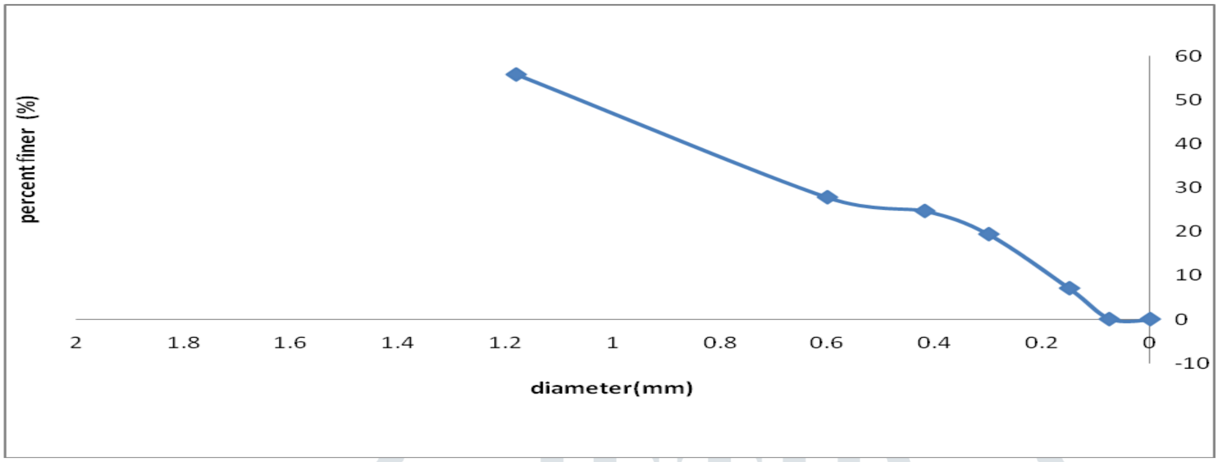


Fig. 4.6 Grain Size Analysis – Filler + Aggregate

Grain size distribution (filler):

Weight of sample = 200g

Weight of mass retained on 75 micron sieve = 4.3g

Table 4.5 Sieve analysis table filler

Sieve opening (mm)	**Mass of soil retained(g)**	**Cumulative mass retained**	**Cumulative % of soil retained**	**% finer (100-(col. (4)) (%)**
4.75	.08	.08	1.8605	98.1395
1.18	.65	.73	16.977	83.023
.600	.03	.76	17.674	82.326
.425	1.03	1.79	41.628	58.372
.300	.39	2.18	50.698	49.302
.200	.08	2.26	52.558	47.442
.150	.3	2.56	59.535	40.465
.075	.73	3.29	76.512	23.488
pan	1.01	4.3	100	0

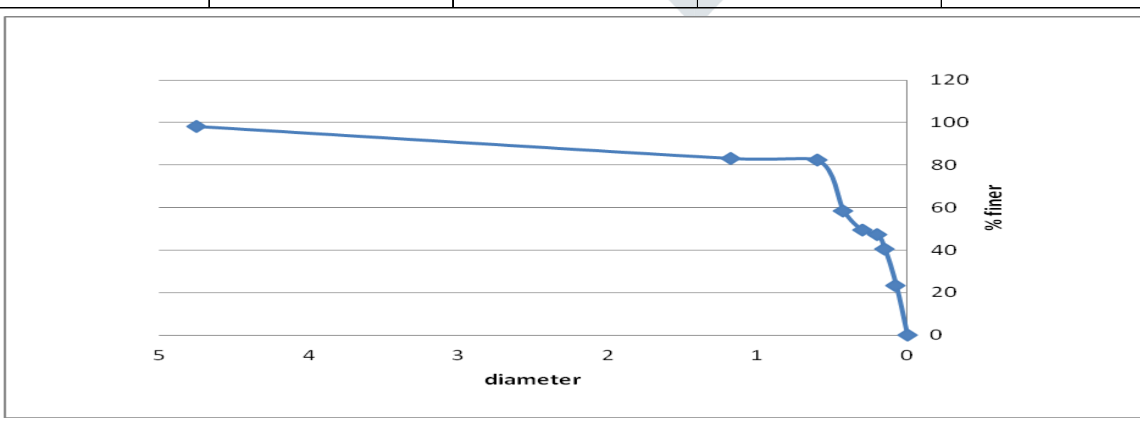


Fig. 4.7 Grain size distribution of filler

RESULT: % PASSING 75μ =97.85%

4.1.2 Atterberg's limit test

Liquid Limit of Filler:

Table 4.6 Liquid limit table filler

No. Of blows	Weight of container (g)	Weight of container +soil (g)	Weight of container+ dry soil (g)	Water content (%)
14	16.14	31.79	27.14	42.27
18	16.6	29.64	25.88	40.52
29	16.91	32.07	27.78	39.47
43	16.79	33.93	29.08	39.46
45	15.78	27.52	24.27	38.28

Plastic limit of filler

Table 4.7 Plastic limit table filler

	Weight of container (g)	Weight of container + wet soil (g)	Weight of container + dry soil (g)	Water content (%)
Trial 1	16.14	21.96	20.79	25.16
Trial 2	15.94	22.46	21.2	23.95

Soil classification of Filler:

Table 4.8 Soil classification of filler

Liquid limit (%)	Plastic limit (%)	Plasticity index	Plasticity Index (%) A-Line	Soil classification
37.82	24.555	13.265	13.0086	CL

RESULT:C-Clay with liquid limit less than 50%

FILLER IS MEDIUM PLASTIC

Liquid Limit of Organic Soil Sample:

Table 4.9 Liquid limit of organic soil sample

No. Of blows	Weight of container (g)	Weight of container +soil (g)	Weight of container+ dry soil (g)	Water content (%)
11	4	26.08	16.82	72.23
20	4	21.98	14.58	69.94
38	4	33.18	21.34	68.28
50	4	23.45	15.65	66.95

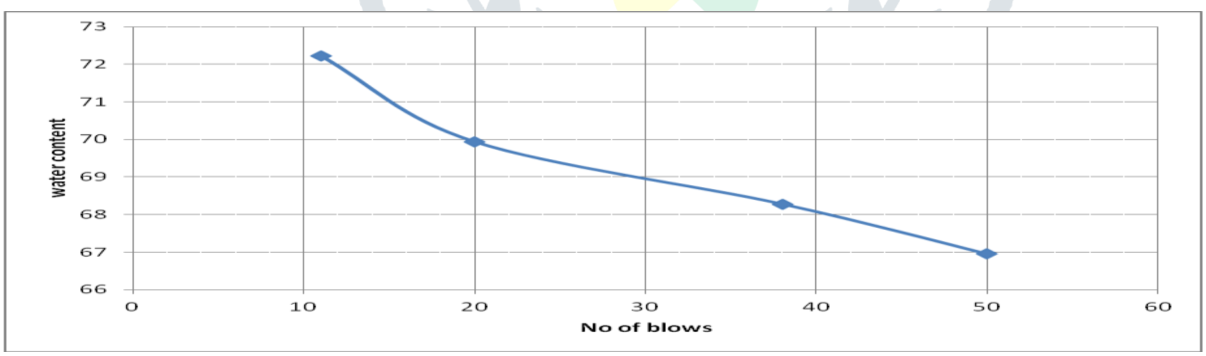


Fig. 4.8 liquid limit

Plastic Limit of Organic Soil Sample:

Table 4.10 Plastic limit table of organic soil sample

	Weight of container (g)	Weight of container + wet soil (g)	Weight of container + dry soil (g)	Water content (%)	Average water content (%)
Trial 1	4	14.52	10.7	60.014	60.307
Trial 2	4	15.87	11.53	60.6	

Table 4.11 Soil classification of soil sample

Liquid limit	Plastic limit	Plasticity index	Plasticity index (%) A Line	Soil classification
69.405	60.307	9.10	36.1131	M or O

RESULT: M or O-Silt or organic soil with liquid limit > 50% soil sample is low plastic

From U-Line it is found that the mineral present in soil is KAOLINITE

4.1.3 Specific Gravity

Specific gravity – Filler Sample

Table 4.12 Specific gravity of filler

Bottle No.	1
Weight of bottle + water + soil in grams (W_1)	90.09 g
Temperature T in °C	24°C
Weight of bottle + water in grams (W_2)	84.19 g
Weight of dish + dry soil in grams	43.82 g
Weight of dish in grams	33.82 g
Weight of soil W_s in grams	10 g
Specific gravity of water at T °C, G_t	0.9968
Specific gravity of filler $G_s = \frac{G_t W_s}{W_s - W_1 + W_2}$	2.441

SPECIFIC GRAVITY OF FILLER = 2.441

Specific gravity of organic soil sample:

Table 4.13 Specific gravity of soil

Bottle No	2
Weight of bottle + water + soil in grams (W_1)	88.84 g
Temperature T in °C	24°C
Weight of bottle + water in grams (W_2)	83.85 g
Weight of dish + dry soil in grams	44.05 g
Weight of dish in grams	34.05 g
Weight of soil W_s in grams	10 g
Specific gravity of water at T °C, G_t	0.998
Specific gravity of filler $G_s = \frac{G_t W_s}{W_s - W_1 + W_2}$	1.997

SPECIFIC GRAVITY OF SOIL = 1.997

4.1.4 Swell test

Swell Index Test – Organic Soil Sample:

Table 4.14 Swell index organic soil sample

Weight of soil sample	10g
Sample in distilled water	
Initial volume	14ml
Final volume	16ml
Sample in kerosene	
Initial volume	13ml

Final volume	15ml
Swell index	
6.67%	

Swell index < 20%, therefore soil sample shows very low expansion

Swell Index Test – Filler

Table 4.15 Swell index filler

Weight of soil sample	10g
Sample in distilled water	
Initial volume	7ml
Final volume	15ml
Sample in kerosene	
Initial volume	10ml
Final volume	14ml
Swell index	
0%	

Expansion=0, filler shows no expansion

4.2 Compaction Test

Compaction Test of Filler:

Weight of mould = 2014g Volume of mould =1000 c

Table 4.16 Compaction test table filler

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Weight of mould + compacted soil (g)	3656	3802	3916	4040	4008
Weight of compacted soil (g)	1642	1788	1902	2026	1994
Water content (%)	5.82	12.8	15.67	17.87	20.06
Weight of container (g)	16.00	16.00	16.00	16.00	16.00
Weight of container + wet soil (g)	44.00	36.00	38.00	36.00	44.00
Weight of container + dry soil (g)	42.46	33.73	35.02	32.97	39.32
Weight of dry soil (g)	26.46	17.73	19.02	16.97	23.32
Percent water added	6.00	9.00	12.00	15.00	18.00
Dry unit weight (kN/m^3)	15.52	15.85	16.64	17.02	16.61
Bulk density (kN/m^3)	16.42	17.88	19.02	20.26	19.94

Compaction test

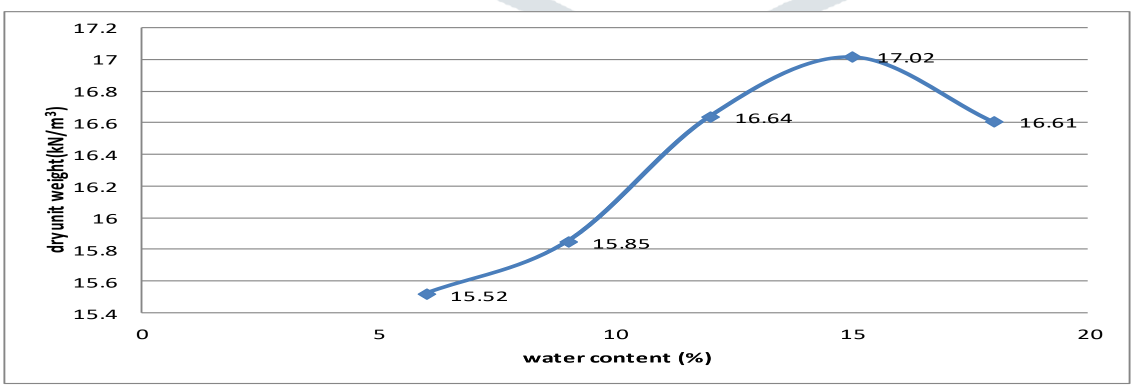


Fig. 4.9 Compaction test graph filler

RESULT:

OMC = 15% MDD = 17.019 KN/m^3

Compaction test of Soil Sample

Weight of mould =2014g Volume of mould =1000 cc

Table 4.17 Compaction test table soil sample

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6	Trial 7	Trial 8	Trial 9
Weight of mould + compacted soil (g)	3158	3258	3322	3372	3424	3500	3558	3598	3556.0
Weight of compacted soil (g)	1144	1244	1308	1258	1410	1486	1544	1584	1542.00
Water content (%)	12.33	17.73	22.33	25.92	30.11	35.94	41.06	44.31	49.96
Weight of container (g)	29.75	30.49	29.28	28.73	29.62	29.23	33.28	27.35	16.89
Weight of container + wet soil (g)	60.54	53.20	51.41	46.13	48.09	61.04	58.17	50.67	33.85
Weight of container + dry soil (g)	57.16	49.78	47.37	42.55	43.80	52.63	50.91	43.51	26.20
Weight of dry soil (g)	27.41	19.29	18.09	13.82	14.18	23.40	9.85	16.16	9.31
Percent water added	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00
Dry unit weight (kN/m^3)	10.18	10.57	10.69	10.79	10.84	10.93	10.95	10.98	10.28
Bulk density (kN/m^3)	11.44	12.44	13.08	12.58	14.10	14.86	14.44	15.84	15.42

Compaction test

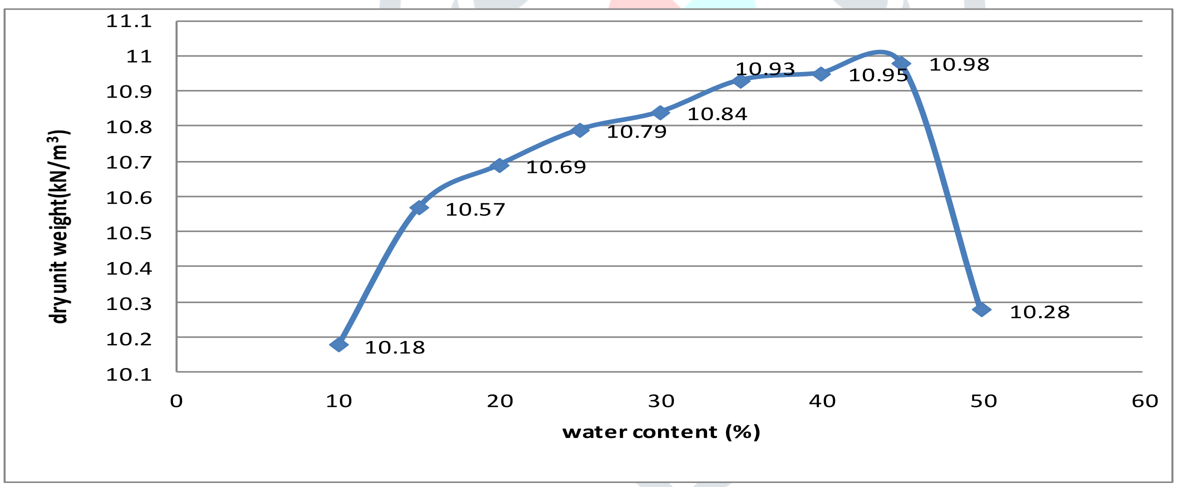


Fig. 4.10 Compaction test graph soil sample

RESULT: OMC = 45% MDD = 10.98 kN/m^3

Variation of OMC curve with addition of lime(4%)

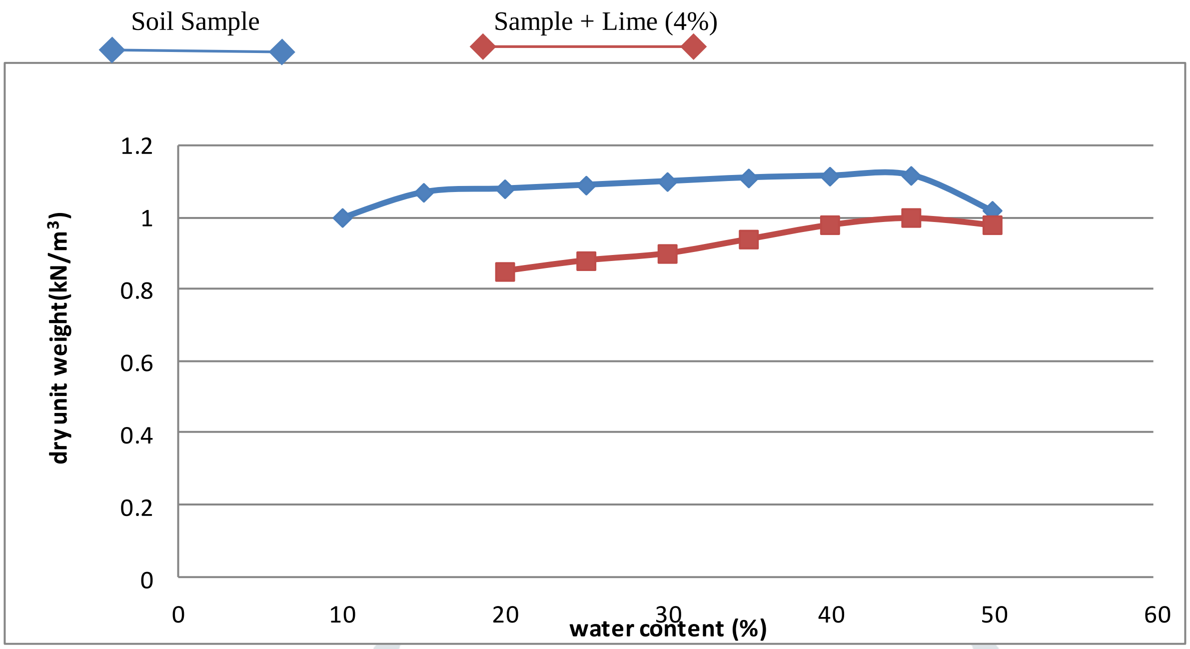


Fig. 4.11 Compaction test graph soil + lime

Variation of OMC curve with addition of filler

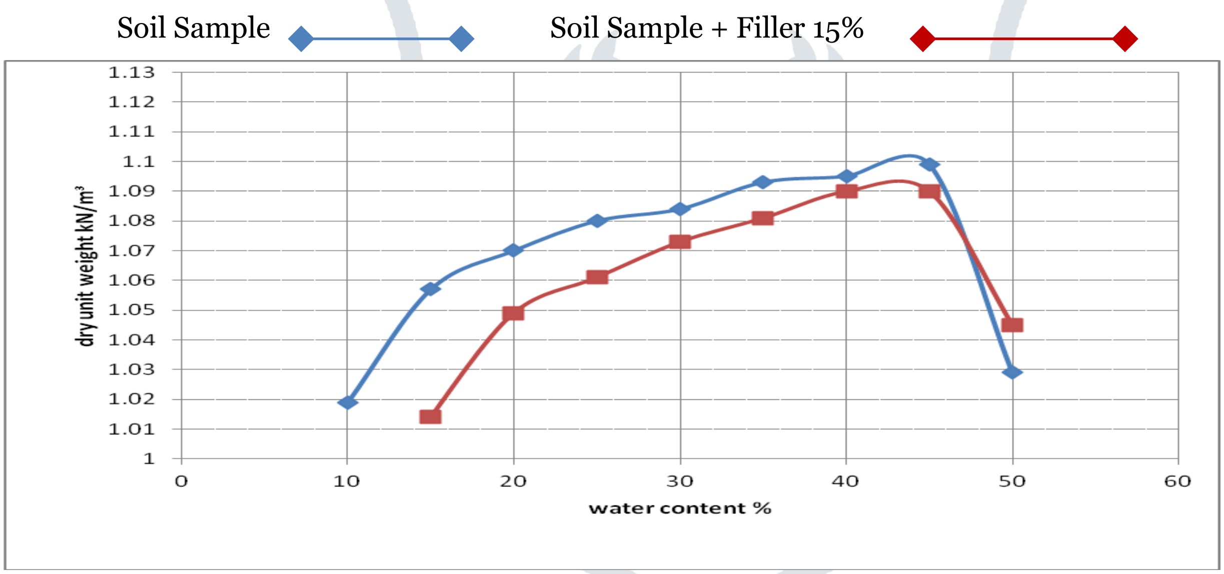


Fig. 4.12 Compaction test graph soil + filler

4.3 Organic Content

Table 4.18: Organic content table

Initial weight of sample, W1	50 gms
Final weight of sample, W2	35.5 gms
Organic content t= (W1-W2/W1)x100	29%

% Organic content = 29%

4.4 Natural Water Content

Weight of container = 29.17 g
Weight of container + soil sample = 60.95 g
Dry weight of soil + container = 43.26g
Water Content = 125.6%

4.5 DST Results

DST results for soil and filler

Table 4.19 DST results

	Ø	C (kN/m²)
Filler	28.61	19.35
Soil sample	28.61	0.54
Soil + 5% filler	33.365	1.059
Soil + 10% filler	36.553	1.089
Soil + 15% filler	26.212	52.846
Soil + 20% filler	30.246	19.7

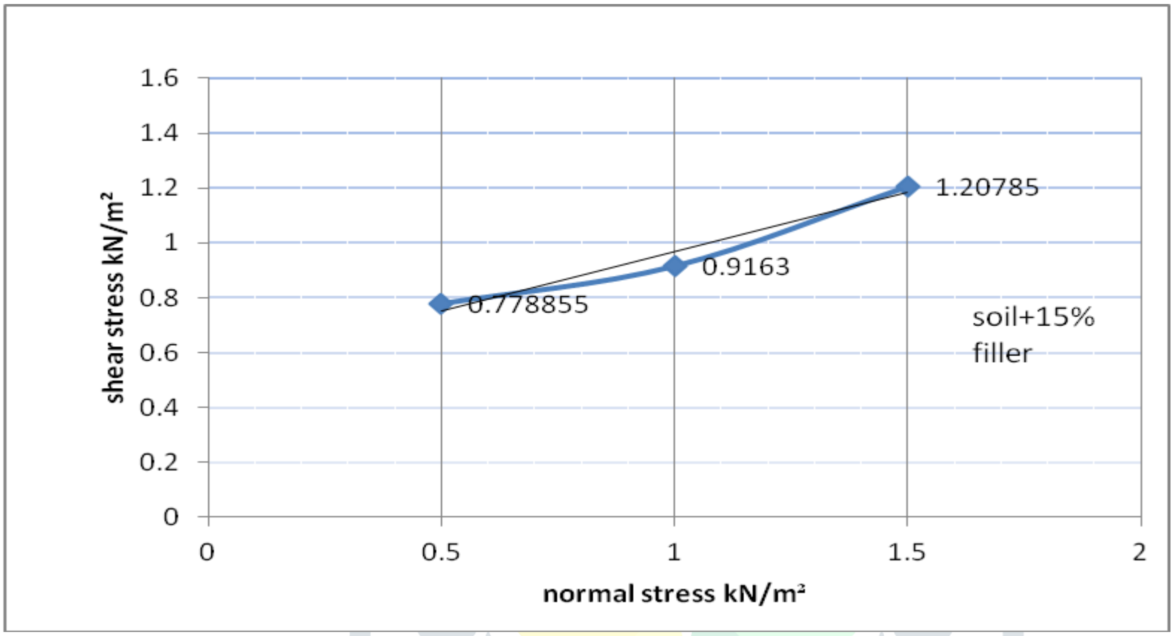


Fig. 4.13 shear stress vs normal stress graph

DST results for soil and lime

Table 4.20 DST results with lime

	Ø	C (kN/m²)
Soil + 2% lime	32.166	56.25
Soil + 3% lime	32.676	59.24
Soil + 4% lime	27.7	62.107

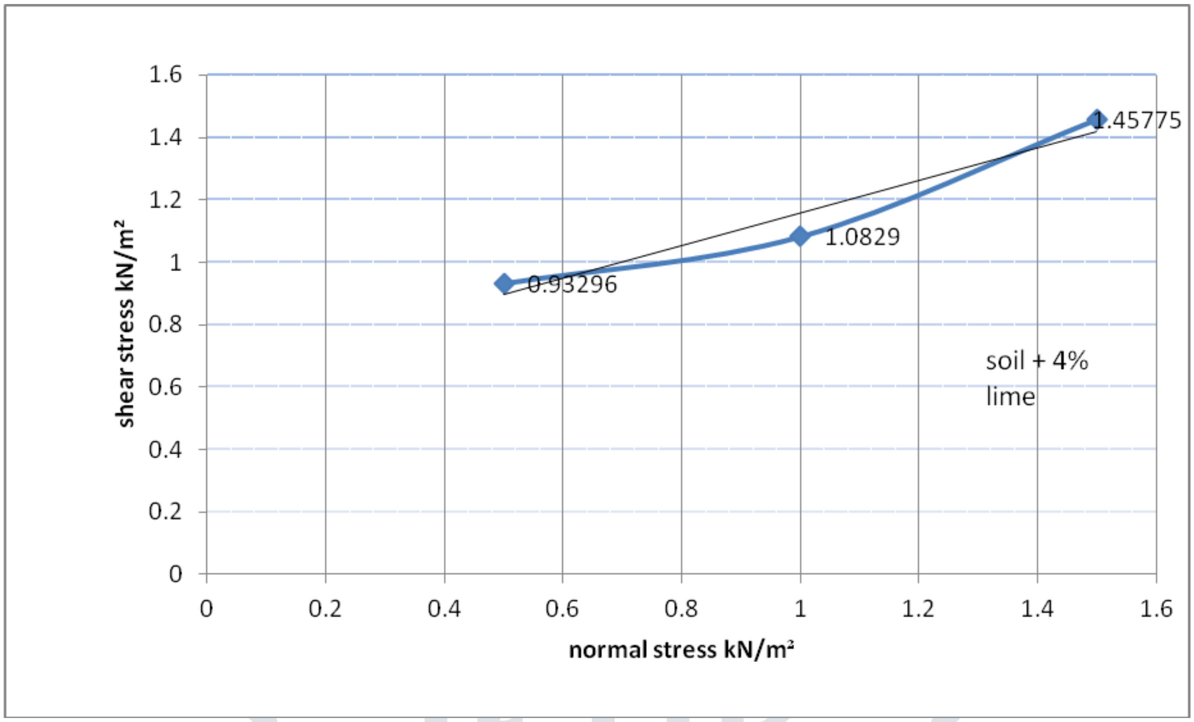


Fig. 4.14 shear stress vs normal stress

4.6 UCT Results

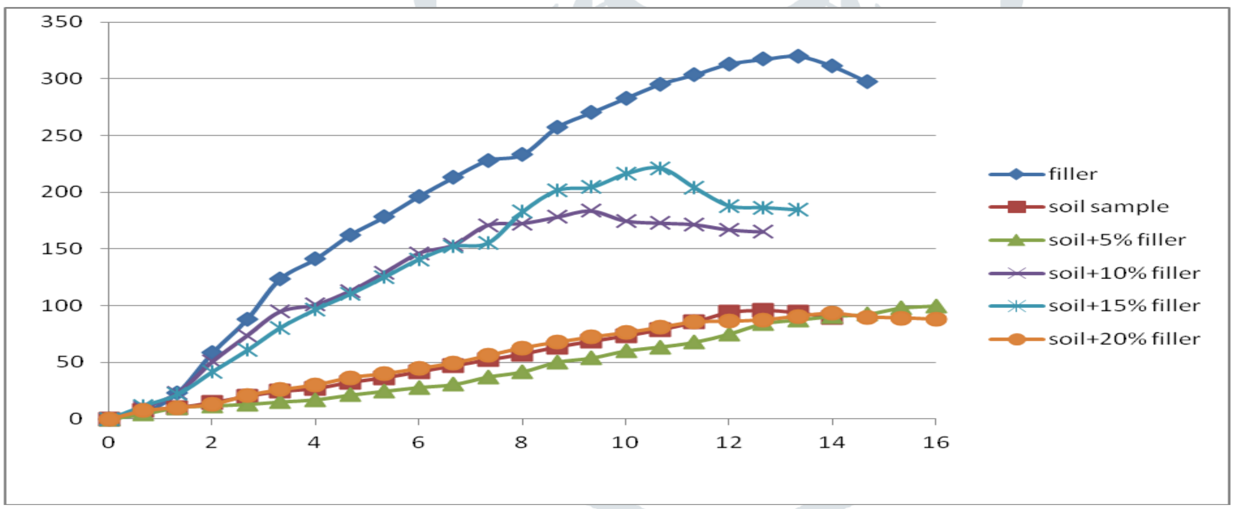


Fig. 4.15 UCT results

. Above graph show the variations of stress and strain for different filler percentages. From the unconfined compression tests results we can conclude that by the addition of filler material the unconfined compressive strength of the sample increases. The optimum %age is taken to be 15% beyond which the strength starts to recede.

5. Conclusion

1. On addition of filler and lime we can see that the MDD of the soil decreases with OMC shifting towards right. This property of lime and filler enables them to absorb excess moisture from the soil.
2. From the direct shear test results we can conclude that by adding the filler (good earth) in the soil sample the cohesion increases with an optimum of 15% above which the cohesion starts to recede.
3. From the unconfined compression tests results we can conclude that by the addition of filler material the unconfined compressive strength of the sample increases. The optimum %age is taken to be 15% beyond which the strength starts to recede.
4. From the direct shear test results we conclude that the value of cohesion increases on addition of lime with an optimum percentage of 4%.
5. From the gradation results of the sample above we get a clear picture of the problems encountered while working on this soil. The main problem lies in the high silt and organic content of the soil.

6. However on addition of the filler material we can observe a rise in strength, reason being an increase in the clay content. On addition of filler, sample that was initially uniformly graded somewhat becomes more like a well graded soil. From the above test results we found that the strength of the sample increases with addition of filler and also the optimum %age (15%) to be added for max stability.

7. Also with the addition of lime the stability increased due to its chemical nature of reacting with water by virtue of which it reduces the water content of the sample. From the test results we found the optimum (4%) of lime to be added for max stability.

8. The addition of lime can reduce the amount of filler to be used and also enable quick drying of soil for compaction. This will reduce the cost of construction and reduce the construction period.

REFERENCES

[1] The Suitability and Lime Stabilization Requirement of Some Lateritic Soil Samples as Pavemen :Olugbenga Oludolapo Amu 1,*, Oluwole Fakunle Bamisaye 2 and Iyiola Akanmu Komolafe 3

[2] B. Thagesen, Tropical rocks and soils, In: Highway and traffic engineering in developing countries: B, Thagesen, ed. Chapman and Hall, London, 1996.

[3] N. J. Garber and L. A. Hoel, Traffic and highway engineering, 2nd ed. Brooks/Cole Publishing Company, London, 2000, 481- 492, 927- 930.

[4] G. H. McNally, Soil and rock construction materials, Routledge, London, 1998, 276-282, 330-341.

[5] S. A. Ola, Stabilization of Nigerian lateritic soils with cement, bitumen, and lime, Proceedings of the 6th Regional Conference for Africa on Soil Mechanics and Foundation Engineering, 1975.

[6] Chaddock, B. C. J., (1996), “The Structural Performance of Stabilized Road Soil in Road Foundations,” Lime stabilization. a. Thomas Telford.

[7] Evans, P., (1998). “Lime Stabilization of Black Clay Soils in Queensland, Australia,” Presentation to the National Lime Association Convention, San Diego, California.

[8] Graves, R. E., Eades, J. L., and Smith, L. L., (1988). “Strength Developed from Carbonate Cementation of Silica-Carbonate Base Course Materials,” Transportation Research Record No.1190

[9] Basma, A. A., and Tuncer, E. R., (1991), “Effect of Lime on Volume Change and Compressibility of Expansive Clays,” Transportation Research Record No. 1295.

[10] Dawson, R. F., and McDowell, C., (1961), “A Study of an Old Lime-Stabilized Gravel Base,” Highway Research Board, Lime Stabilization: Properties, Mix Design, Construction Practices and Performance, Bulletin 304.

[11] Doty, R., and Alexander, M. L., (1968) “Determination of Strength Equivalency for Design of Lime-Stabilized Roadways,” Report No. FHWA-CATL-78-37.Dumbleton, M. J. (1962) “Investigations to Assess the Potentialities of Lime for Soil Stabilization in the United Kingdom”, Technical Paper 64, Road Research Laboratory, England.