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Effect of Cement and Lime on the Index Properties of Nizwa Clayey Soil

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Abstract- Soil stabilization can be interpreted as modifying soil properties process by chemical or physical means to improve soil engineering behavior. One of the major objectives of the stabilization of fine soil is to modify its properties and in particular the index properties thenafter a stable soil will be achieved. In this study a fine soil is taken from two locations from Nizwa area. Cement and lime were used to modify the index properties of these soils. Different percentages of stabilizers were chosen to study the effect of stabilization on these soils. The results indicated a noticeable effect as a reduction of the plasticity behavior of the soils as well as improving the gradation and compaction characteristics.
Key words. Fine soil, Plasticity, Specific gravity, Stabilization, Cement, Lime

I. INTRODUCTION

Soil stabilization is considered to be a soil properties improvement process. It can be implemented by using mechanical, admixture, or chemicals methods. In general for cohesionless soils cement or bituminous stabilization is used while the lime stabilization is used for fine soils and swelling one in particular. Fly ash, Silica fume or chemicals can be used as well separately or in combination with cement or lime.[1].
Using cement or lime stabilization can improve the soil index properties leading to enhance the soil stability. As a matter of fact, more than one million huge amount of lime is utilized every year in U.S for treatment [2].
The lime stabilization was found to reduce the soil plasticity of black cotton clay having a specific gravity of 2.70 due to lowering its liquid limit when 3% lime is used for treatment [3].
Similar effect was found by Jain A. and Yadav R.K. [4]
on plasticity of black cotton clay when different lime content were added, namely, 2,4,6,8 and 10% and the reduction in plasticity index was found to be 10% for optimum lime content of 8%. The effect of short and long time term lime stabilization on highly plastic soil was studied by Negi A.S. et al. [5].
The parameters studied included plasticity and strength (CBR) characteristics. The various lime content used showed a high and quick effects on plasticity, within an hours after mixing, and increasing the strength for long term study getting more than two folds of increasing[5]. Effect of cement stabilization on granular soil taken from Nizwa area (175 kM South-West Muscat - Oman) was studied by Ali S.A and Abd-Al Nasser A. J[6]
considering the compaction and strength characteristics. A remarkable increasein unconfined compressive strength and maximum dry density were determined as well as an increase of optimum moisture content with increasing cement content. A study of correlation between plasticity index, maximum dry density and optimummoisture content of different fine soils with the contents of added lime, fly ash and combination of both was performed. The results showed that there are good correlations exist between these characteristics which indicating an noticeable improvement with stabilization [7].
The objectives of this study are to collect two different fine soils from Nizwa area (175 kM South-West Muscat–Oman) and studying the effects of cements and lime stabilization on their index properties.

II. MATERIALS AND METHODOLOGY

2.1 Fine Soil:

Fine soils of clayey nature are taken from two locations 15 kM apart in Nizwa area. Representative samples are selected from a depth of 0.50 -1.0 m below the ground surface in order to remove the top weathering affected soils.

2.2 Water:

Potable water is used for determination of index properties, compaction process and for the stabilization of the soil with the cement and with lime individually.

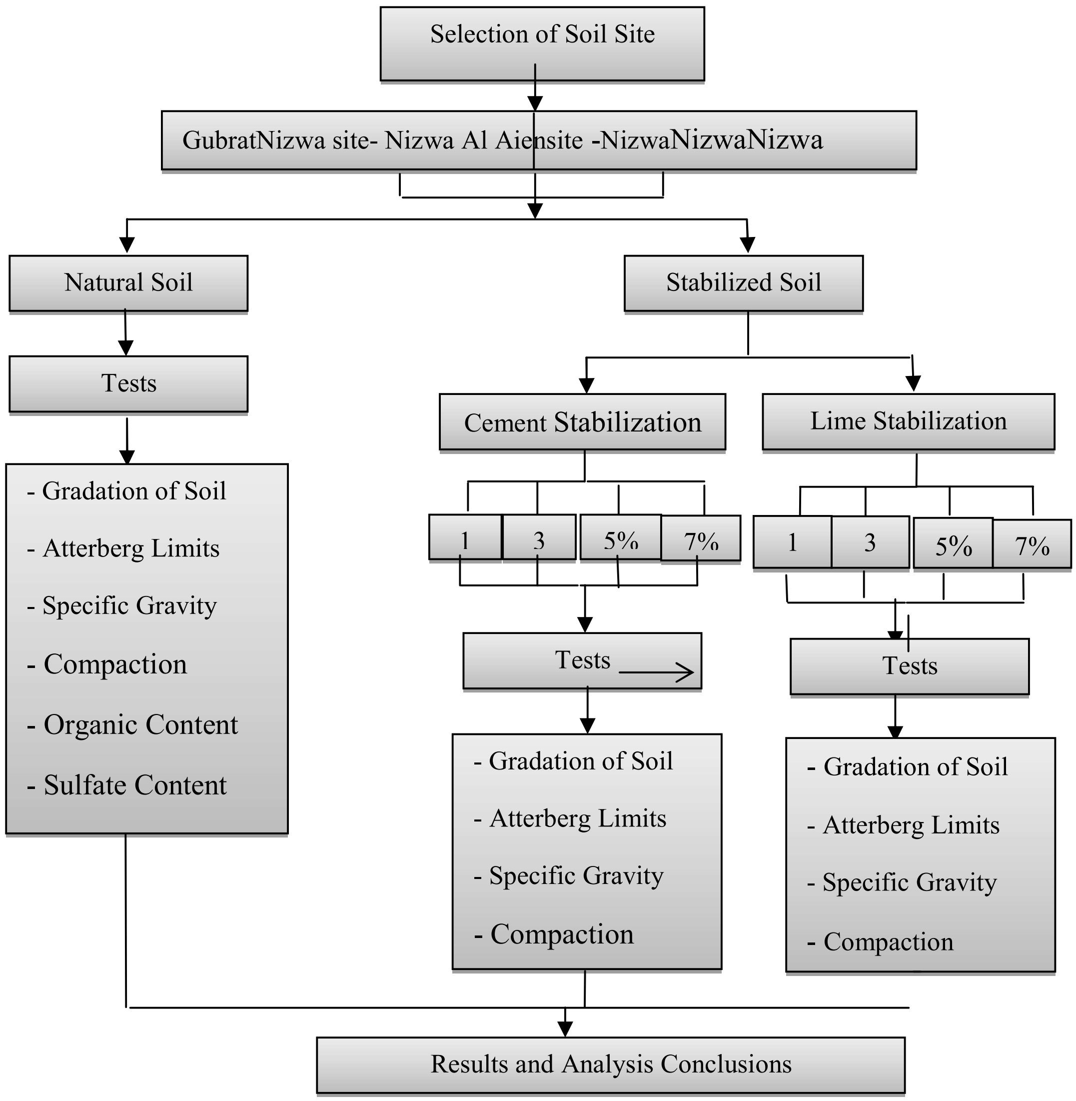
2.3 Cement:

Ordinary Portland Cement is used for stabilizing the soil with cement.

2.4 Hydrated lime,Ca (OH) 2:

Hydrated lime is used for soil stabilization. It has a white powder appearance; specific gravity of particles of 2.24 and the percent finer than 0.074 mm (# 200 sieves) is 97%.

2.5 Experimental Program



III. RESULTS AND DISCUSSION OF RESULTS

3.1 Index Properties of Natural Soils:

Table 1 shows the index properties of soil (1) taken from Ghubrat Nizwa and soil (2) taken from Al-Aein- Nizwa. It can be seen that both are soils classified as clay with low plasticity according to Unified Soil Classification System (USCS).

Table 1. Index Properties of Natural Soils

Soil Sample / Index Properties	Soil (1)	Soil (2)
Liquid Limit (L.L), %	40%	38%
Plastic Limit (P.L), %	16%	17%
Plasticity Index (P.I), %	24%	21%
Optimum Moisture Content (O.M.C), %	14.03%	15%
Maximum Dry Density (M.D.D), kN/m3	16.62	18.45
Specific Gravity	2.703	2.707
Organic Content, %	0.811%	0.7%
Sulfate Content,%	0.00056%	0.0001%
Classification, USCS	CL	CL

3.2 Index Properties of Stabilized Soils:

3.2.1 Atterberg Limits

Figures 1 and2 show the effect of the cement and lime on the Atterberg limits of the soil (1). While Figures 3 and 4 show the effect of the stabilizers on the Atterberg limits of soil (2). It can be seen that the addition of various percentages of cement and lime stabilizers cause a decreases of liquid limit, increase of plastic limit and correspondingly the plasticity index decreasesThe relation between plasticity index and lime content is shown to be nearly a linear for soils 1 and 2. Similar relaions are obtained for cement stabilization. It can be noted that as the cement and lime contents increase the plasticity index of soil (1) lowering by 12.5% and 20% respectively, while a decrease of 15.8% and 21.1% obtained for soil (2) when it is stabilized with cement and lime respectively. The results of the effect of lime on liquid limit and plasticity index of soils were agreed with results obtained byJain A. and Yadav R.K. [4]. This means that the cement and lime alter the soil plasticity towards lower values.

3.2.2 Specific Gravity of Soil Solids

Figure 5 and Table 2 show the effect of cement on specific gravity of soil (1) and soil (2). It can be seen that the cement increases the specific gravity of both soils providing that the rate of increase is lower for higher cement content. This is attributed to the fact that the cement of higher specific gravity is coating the soil particles. Figure 6 and Table 3 show the lime affects the specific gravity of soils (1) and (2). It can be noted that lime decreasing the soil specific gravity with a constant rate for the study percentages of lime. The decrease may be due to effect of soil particles aggregation during stabilization which is giving higher volume for same mass.

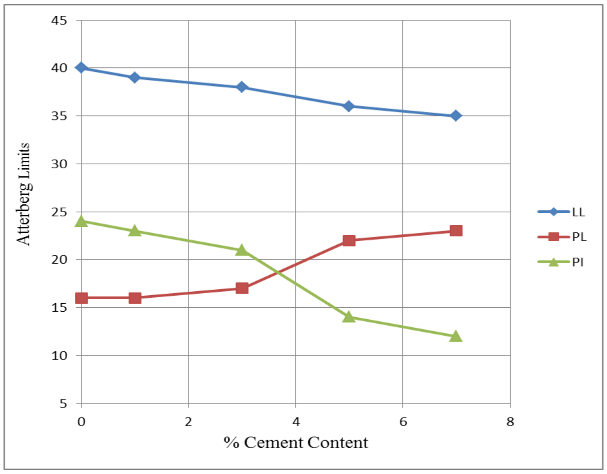


Figure 1: Effect of Cement on Atterberg Limits of Soil 1

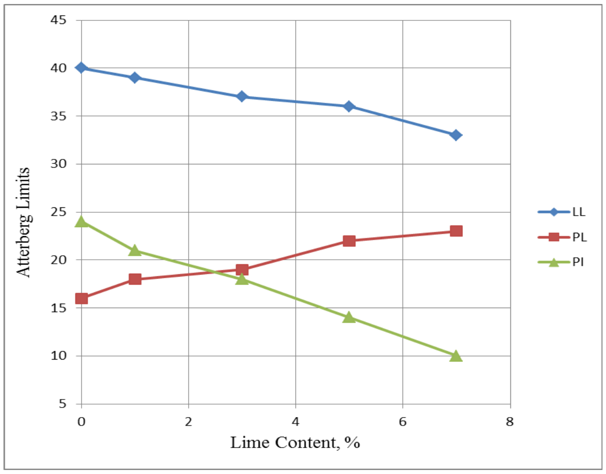


Figure 2: Effect of Lime on Atterberg Limitsofsoil 1

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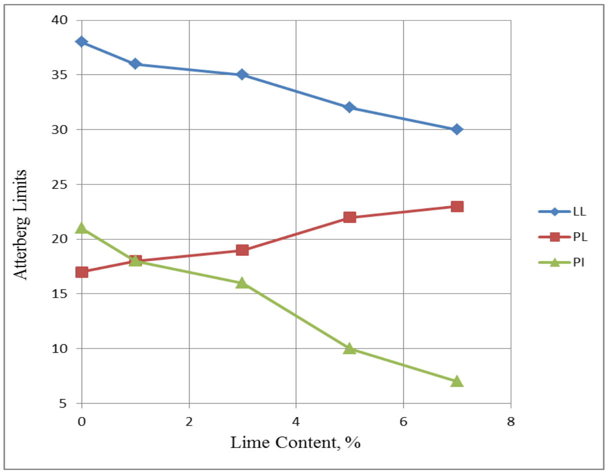

Figure 3: Effect of Cement on Atterberg Limits of Soil 2

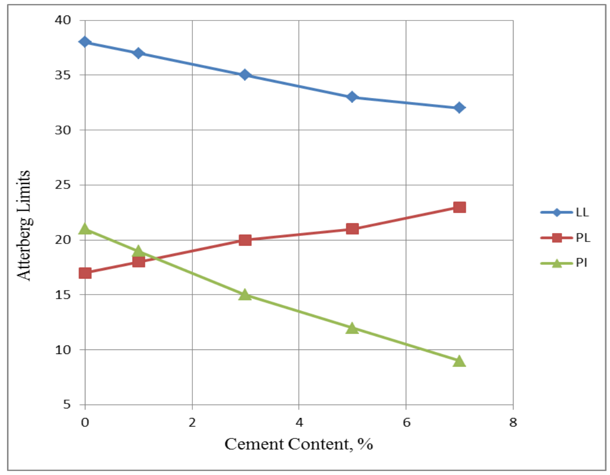

Figure 4: Effect of Lime on Atterberg Limits of Soil 2

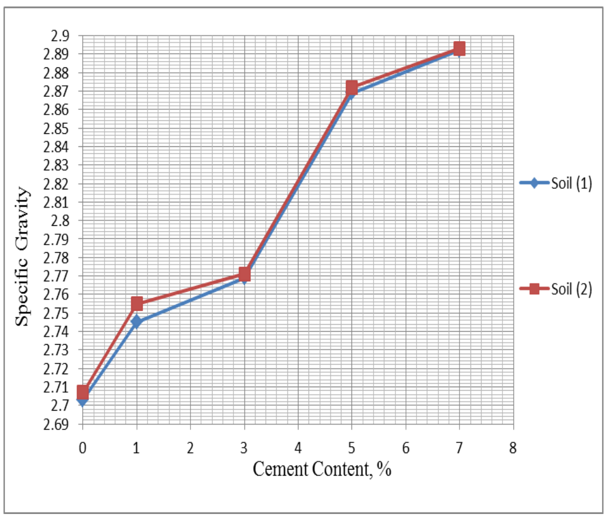

Figure 5: Effect of Cement on Specific Gravity of Soil (1) and Soil (2)

Table 2: Effect of Cement on Specific Gravity of Soil (1) and Soil (2)

Cement Content, %	Specific Gravity of Soil (1)	Specific Gravity of Soil (2)
0	2.703	2.707
1	2.745	2.755
3	2.769	2.771
5	2.869	2.872
7	2.892	2.893

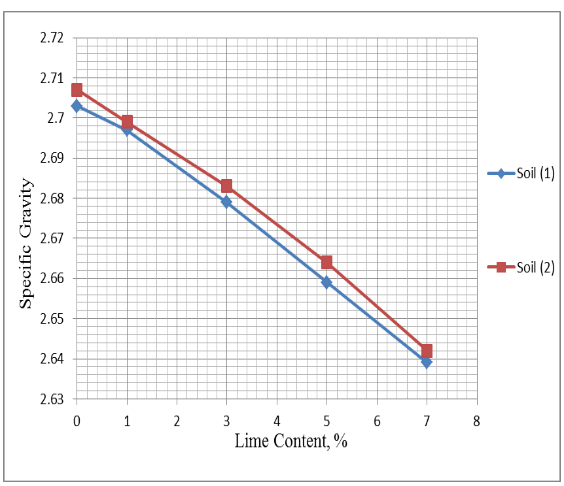

Figure 6: Effect of Lime on Specific Gravity of Soil (1) and Soil (2)

Table 3: Effect of Lime on Specific Gravity of Soil (1) and Soil (2)

Lime Content, %	Specific Gravity of Soil (1)	Specific Gravity of Soil (2)
0	2.703	2.707
1	2.697	2.699
3	2.679	2.683
5	2.659	2.664
7	2.639	2.642

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3.2.3 Compaction Characteristics

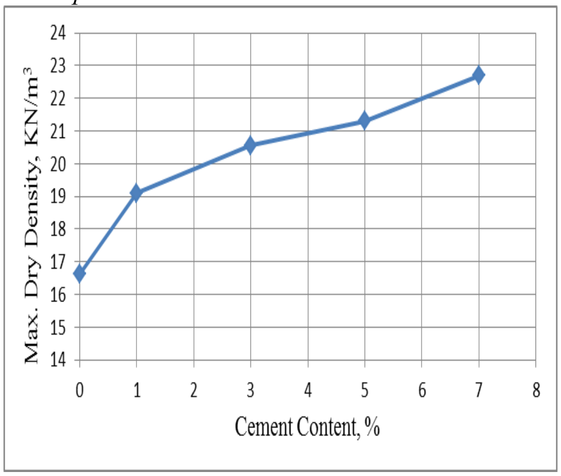

Figure 7: Effect of Cement on Compaction Characteristics of Soil (1)

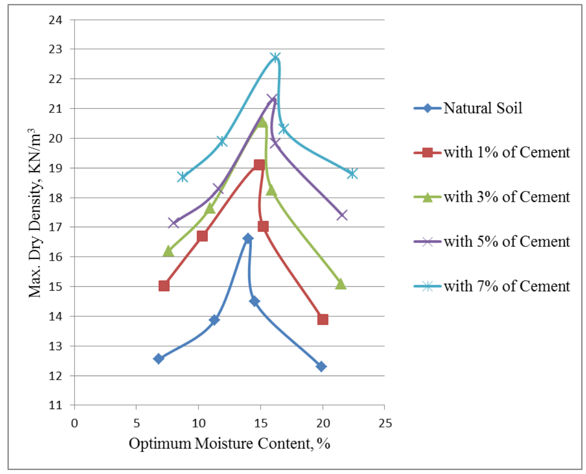

Figure 8: Effect of Cement on Maximum Dry Density of Soil (1)

The cement stabilization effects on compaction characteristics of soils are shown in Figures 7, 8, 9 and 10.

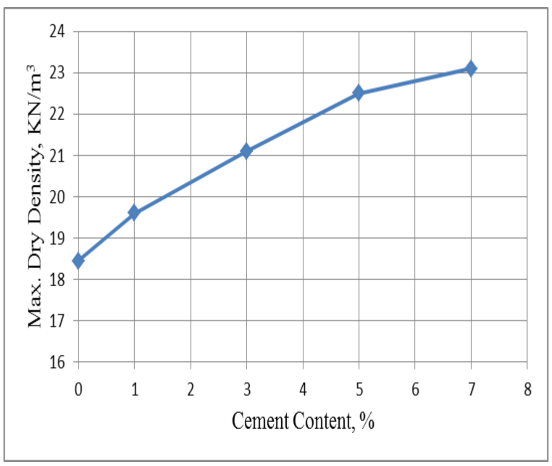

Figure 9: Effect of Cement on Compaction Characteristics of Soil (2)

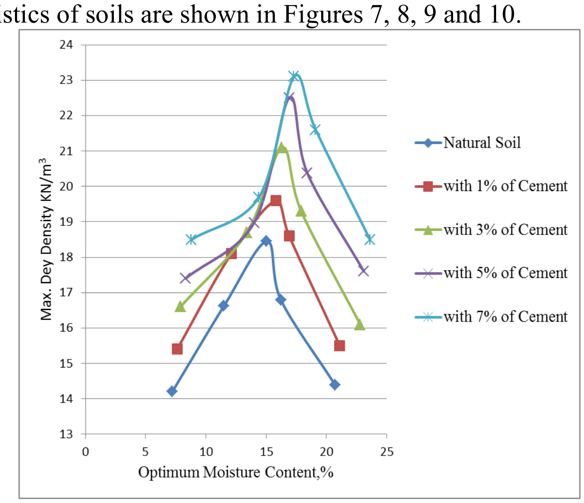

Figure 10: Effect of Cement on Maximum Dry Density of Soil (2)

All compaction curves for natural and stabilized soils with different percentages show a typical trend of behavior. Results indicated an increase in maximum dry density and optimum moisture content as the cement content increases providing that rate of increase becomes lower for higher cement content.The maximum dry density of soil (1) increases from 16.62 kN/m3 to 22.7 kN/m3 and from 18.45 kN/m3 to 23.1 kN/m3 for soil (2) when it is stabilized with a maximum percent of cement of 7%. This is due to the higher specific gravity of cement which is 3.15 while the specific gravity of both soils is 2.71.

The lime stabilization effect on the dry density of soils is shown in Figures 11, 12, 13 and14).Similar patron of typical curves for different lime contents is obtained. It can be seen that lime stabilization decreasing the maximum dry density of stabilized soil. this can be due to lower specific gravity of lime than that of soil and due to aggregation taken place during stabilization. A decreases in maximum dry density down to 11.92 kN/m3 and 16.1 kN/m3 for soil (1) and soil (2) respectively with addition of maximum lime content is obtained..

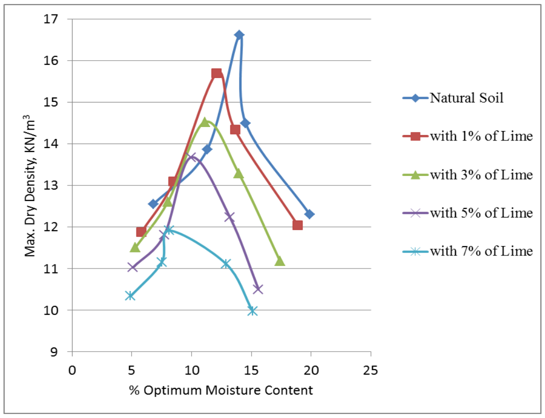

Figure 11: Effect of Lime on Compaction Characteristics of Soil (1)

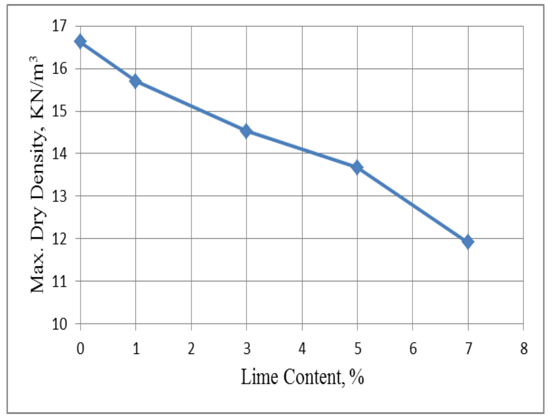

Figure 12: Effect of Lime on Maximum Dry Density of Soil (1)

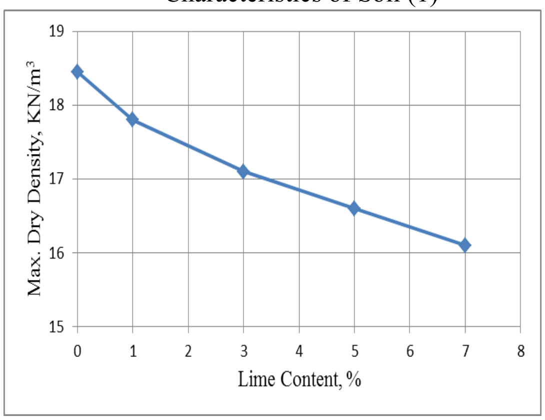

Figure 13: Effect of Lime on Compaction Characteristics of Soil (2)

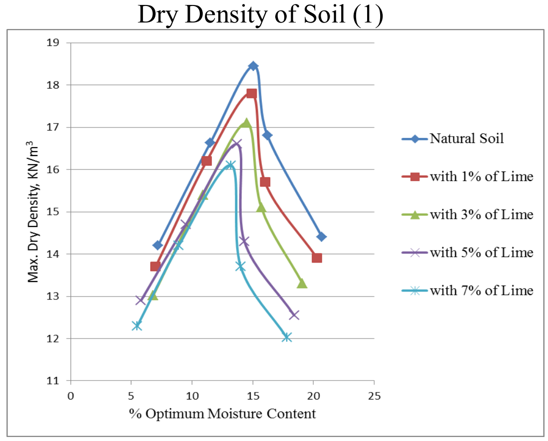

Figure 14: Effect of Lime on Maximum Dry Density of Soil (2)

The addition of cement to soil iscausing increase in optimum moisture content, as shown in Figures 15 and 16 for soil 1 and 2 respectively. Rate of increase becomes lower for higher cement content.

The increase in optimum moisture content is due to more water needed for cement hydration. On the other hand, the lime causesa decreasing in optimum moisture content of both soils (1) and (2) due to aggregation process occur when adding lime,see Figures17 and 18.

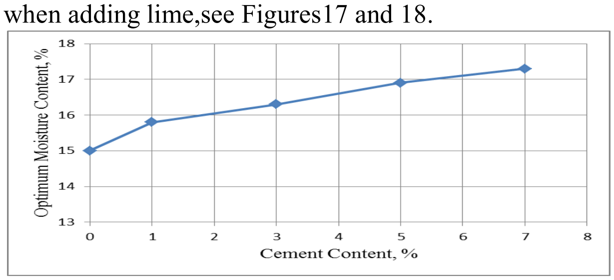

Figure 15: Effect of Cement on O.M.C of Soil (1)

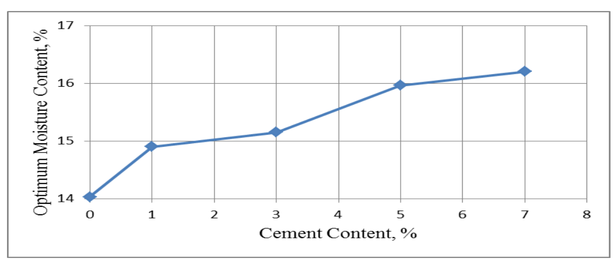

Figure 16: Effect of Cement on O.M.C of Soil (2)

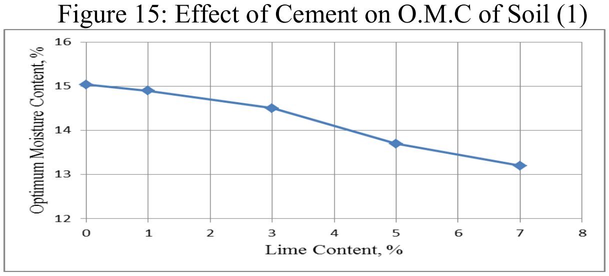

Figure 17: Effect of Lime on O.M.C of Soil (1)

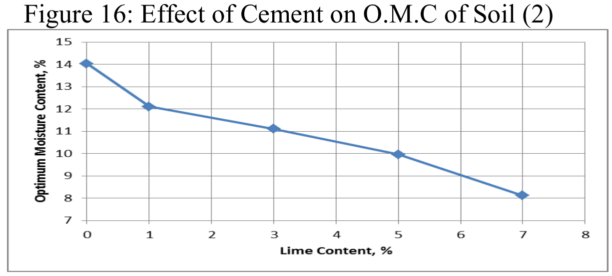

Figure 18: Effect of Lime on O.M.C of Soil (2)

Soil grading forms

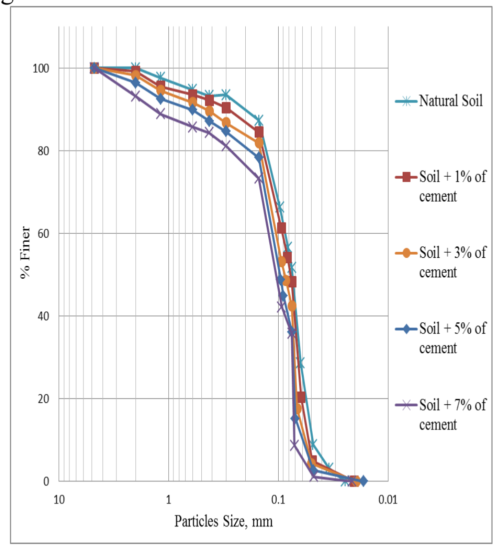

Figure 19: Effect of Cement on Gradation of Soil (1)

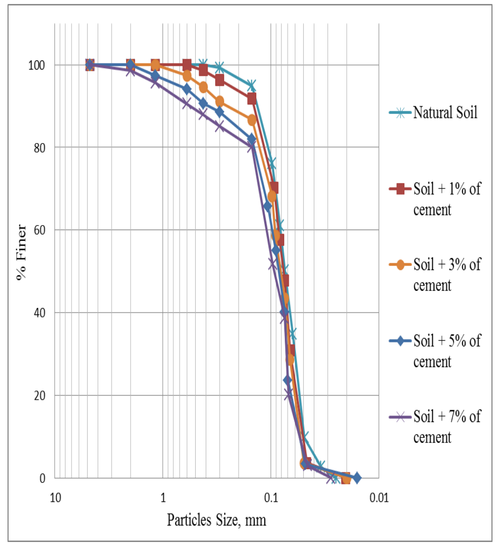

Figure 20: Effect of Cement on Gradation of Soil (2)

Figures 19 and 20 show the effect of cement stabilization on soil grain size for soil (1) and (2) respectively and the efffect of lime on soil grain size is shown in Figures 21 and 22 for soil(1) and (2). It is worth to note that addition of cement and lime causing the soil grain to be coarser, and this effect shown to be valid within the study percentages of stabilizer (1 – 7%).As the percent of the stabilizer increase the particle size becomes coarser. The lime is found to be more effective in increasing the grain size than cement. It can be noted that the percent finer than 0.075 mm (#200 sieve) changed from (52 to 36%) and (from 50 to 39%) in soil 1 and soil 2 after stabilization with cement. In case of lime stabilization the change happened to be from (52 to 29%) and fro (50 to 28%) for same size in soil (1) and soil (2). In cement stabilization the soil particle size increase due to coating the soil particle by cement individually, while in case of lime stabilization the lime coating a group of soil particles making aggregate like shape.

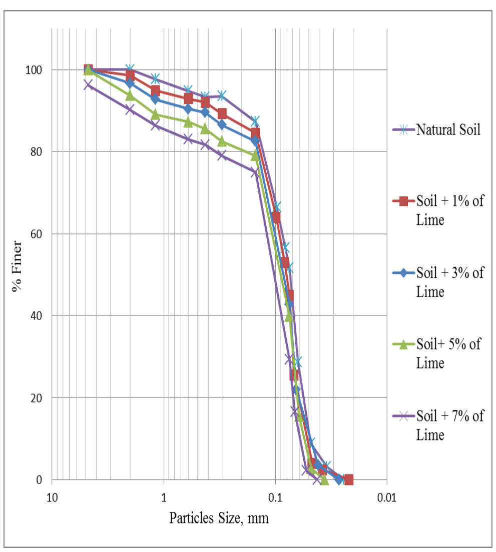

Figure 21: Effect of Lime on Gradation of Soil (1)

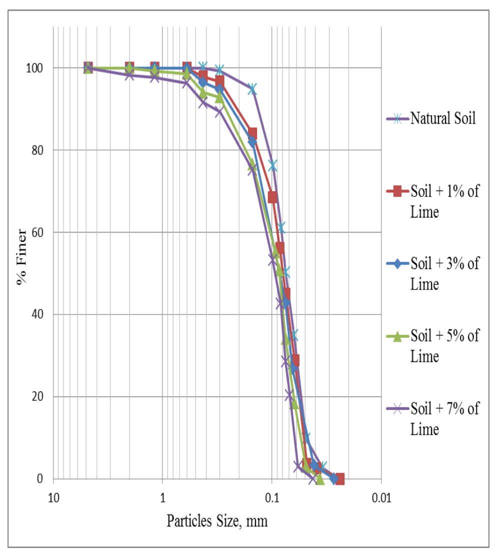

Figure 22: Effect of Lime on Gradation of Soil (2)

IV. CONCLUSIONS

The following conclusions can be drawn from the obtained results:

1- The soil plasticity decreases when stabilized by cementor lime, as the stabilizers content increasing the plasticity of soil decreases

2-The optimum moisture content increasing with cement content in cement stabilization and decreasing with lime content in lime stabilization.

3-The maximum dry density of stabilized soils becomes higher with cement content and lower with lime content.
4-The soil grain changes to coarser size after stabilizing with cement or lime, lime is more effective in this manner.
5-The specific gravity of soils solids is increasing with cement content, while it is decreasing with lime content. A constant rate of decreasing is shown in lime stabilization.
6-The lime stabilization in general is more efficient than cement stabilization for modifying the fine soil index properties.

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