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Uniaxial Compressive Strength Enhancement in Clayey Soil with Lime Addition

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***Abstract*— In many countries engineers have to face the problem of low strength of clayey soil in designing road pavement construction. This leads to developments of cracks and settlements of pavement due to heavy transportation system. This paper presents the enhancement in the strength properties of clayey soil by utilization of Lime. For experimental work 2%, 4%, 6%, 8% and 10 % mixed to the clayey soils to obtained higher strength of pavement. Maximum Dry Density of clayey soil reduced to 17.06kN/m^3 to 14.97kN/m^3 with increasing proportion of Lime. The Unconfined strength of clayey soil improved from 242kN/m^2 to 547kN/m^2 at 0% to 8% of Lime.**

Keywords — Clayey soil; Road Pavement; Unconfined Compressive Strength; Lime

I. INTRODUCTION

Indian clayey soils can be problematic for direct utilization for road pavement construction. Clayey soil is the type of soil that exhibits generally undesirable engineering properties. They tend to have low shear strengths and loose shear strength further upon wetting and other physical disturbances. They can be plastic, compressible and some types expand and shrink greatly upon wetting and drying. Cohesive soils can creep over time under constant load, especially when the shear stress is approaching its shear strength, making them prone to sliding. They develop large lateral pressures. For these reasons, clays are generally considered poor materials for sub grade strength of pavement. The presence of water, which is relatively unimportant in coarse grained soil, plays a decisive role in engineering behavior of clayey soil. On other hand, grain size distribution and grain shape influence the engineering behavior of granular soil and hardly affect the behavior of clay. Therefore the improvement of the properties of clayey soil is very important.

Strength development of clayey soil is method of improvements of geotechnical properties of soil. For present research Lime is added to the soil in different percentage and conducted laboratory experiments for analysis strength of clayey soil. 2%, 4%, 6%, 8% and 10% Lime added to the clayey soil to obtained optimum percentage of Lime. Proctor and Unconfined strength test followed as per Indian Standard Code to perform tests in lab. It also helpful to reduced the failure criteria of Road Pavement during transportation and other effects to the Sub – grades.

II. MATERIAL AND METHODOLOGY

A. Material

a) *Soil Sample:* The sample of Clay Soil collected from the field of Sitarganj (Khatima), Udham Singh Nagar district of Uttarakhand, India.

b) *Lime:* Industrial Lime purchased from Udham Singh Nagar district of Uttarakhand, India for experimental work.

B. Methodology

a) *Particle Size Analysis*: The particle size of clayey soil determined according to IS: 2720 Part IV-1985.

b) *Consistency Limit:* Liquid Limit, Plastic Limit, Plasticity Index and Shrinkage Index of clayey soils determined according to IS: 2720 Part V – 1985.

c) *Proctor Compaction Test:* Standard Proctor Compaction test performed in a cylindrical mould of 1000 ml capacity using rammer of 2.6kg weight with 310mm height of free fall as per IS: 2720 Part VII – 1980.

d) *Unconfined Compressive Strength:* Unconfined Compressive Strength Test performed as per IS: 2720 Part X – 1991 in the laboratory. The sample compacted at Optimum Moisture Content in three layers in cylindrical mould of 38 mm in diameter and 76 mm in height and cured the specimen after taken out from moulds for 7 and 14 days.

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TABLE I. GEOTECHNICAL PROPERTIES OF CLAYEY SOIL

S. No.	Geotechnical Parameter of Clay Soil	
	Parameter	*Results*
1.	Particle Size Analysis a) Clay Size Fraction (%) b) Silt Size Fraction (%) c) Sand Size Fraction (%)	 15.50 61.50 23.00
2.	Liquid Limit (%)	26.80
3.	Plastic Limit (%)	16.27
4.	Plasticity Index (%)	10.53
5.	Shrinkage Limit (%)	19.47
6.	Soil Type as per IS: 1498 – 1970	CL

III. RESULTS AND DISCUSSION

A. *Particle Size Analysis:*

Particle Size analysis conducted in the laboratory for coarse grained and fine grained Soil. Sitarganj clayey soil collected at the depth of 1 to 2m from ground surface for experimental work. After Sieve and Hydrometer analysis Table 1 shows the percentage of clay, silt and sand fraction in soil.

B. *Consistency Limit:*

Minimum water content of soil at which soil has tendency to flow is called Liquid Limit and minimum water content of soil at which soil in plastic stage is called Plastic Limit of Soil. Liquid Limit, Plastic Limit, Plasticity Index and Shrinkage Limit of clayey soil was obtained 26.80%, 19.18%, 6.90% and 19.47% respectively after conducting laboratory test.

C. *Proctor Compaction Test:*

Standard Proctor Test is performing to determined Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of clayey Soil with different proportion of Lime. Maximum Dry Density of clayey soil decreased with increasing the proportion of Lime 2 % to 10% and Optimum Moisture Content increased 18.2% to 25.0% at 2% to 8% Lime. Proctor test performed for clayey soil after adding 2%, 4%, 6%, 8% and 10% lime.

Fig. 1. Relationship graphs between dry density and Water Content

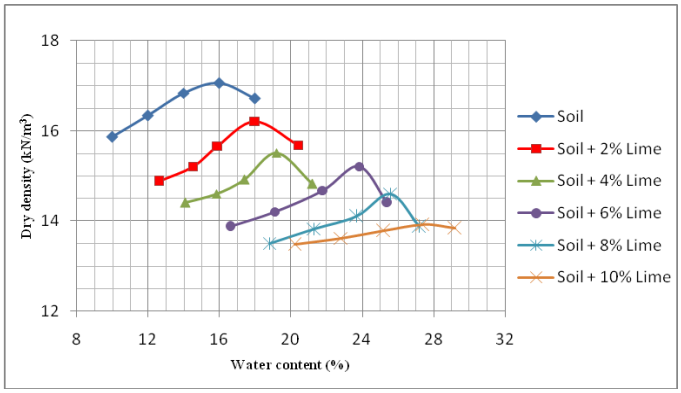

TABLE II. OMC AND MDD OF CLAYEY SOIL WITH LIME

Table Head	Standard Proctor Compaction Results		
	Mixed Used	*OMC (%)*	*MDD (KN/m³)*
1.	Soil	16.0	17.06
2.	Soil + 2% Lime	18.2	16.71
3.	Soil + 4% Lime	20.3	16.30
4.	Soil + 6% Lime	23.2	15.91
5.	Soil + 8% Lime	25.0	15.47
6.	Soil + 10% Lime	24.2	14.97

Figure 1 shows the relationship curves between density and water content and also noticed that the value of density going to decreaeses after obtaining higher density for different soil sample with Lime; is called Maximum Dry Density (MDD). OMC and MDD values summarized in the Table II for Clay with 2% to 10 % Lime.

D. *Unconfined Compressive Strength Test:*

Unconfined Compressive Strength Test of soil is a special case of Tri – axial in which confining pressure is zero. Unconfined Strength of clayey soil determined with different percentage of Lime mixed to the soil. UCS tests value for untreated soil sample was found 242KN/m^2 for uncured condition sample. Clayey Soil mixed with 2% to 10% Lime for experiment work and Samples were compacted at Optimum Moisture Content (OMC) in three layers in cylindrical mould of 38 mm diameter and 76 mm height. All specimens were taken out from the moulds and cured for 0, 7 and 14 days. After reaching the specified curing time, the cylindrical specimens were subjected to a gradually increased axial compression load in UCS test machine until failure of specimen.

Table – III summarized the UCS value for soil sample with different proportion of Lime. Results showed that with increased curing time, strength of soil specimen increased. The results of different mixed used in UCS tests determined the optimum percentage of Lime for obtaining maximum strength of test specimen. And conclude that 8% Lime content given the higher strengths of Clayey Soil.

Figure – 2 shows the variation of UCS value for clayey soil with different percentage Lime Content after conducting a series of Unconfined Compressive Strength Tests in the Laboratory.

TABLE III. UCS VALUE OF CURED CLAYEY SOIL SPECIMEN WITH LIME

S. No.	UCS (KN/m^2)			
	Mixed Used	*0 days*	*7 days*	*14 days*
1.	Soil	242	298	353
2.	Soil + 2% Lime	257	333	453
3.	Soil + 4% Lime	279	353	489
4.	Soil + 6% Lime	297	386	531
5.	Soil + 8% Lime	301	401	547
6.	Soil + 10% Lime	281	389	513

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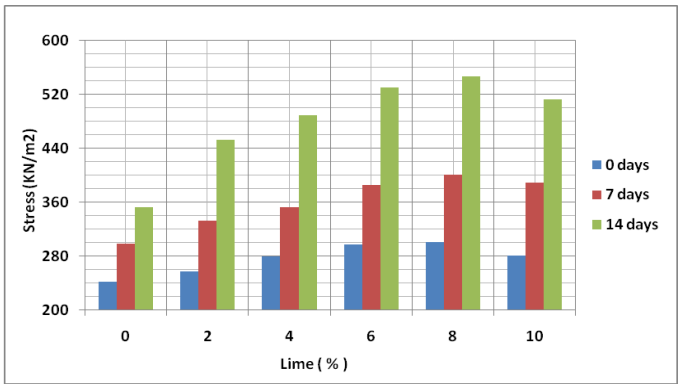
Fig. 2. Variation of UCS for Clayey soil with different percentage of Lime



IV. CONCLUSION

1. Experimental work done on clayey soil with 2% to 10% Lime for obtaining Optimum mixed of Lime.
2. OMC followed an increasing trend and the MDD followed a decreasing trend with increasing percentages of Lime.
3. The optimum mix was 10% Lime for minimum value of Maximum Dry Density of sample.
4. Maximum Dry Density reduced and Optimum Moisture Content increased with increment of Lime content to the clayey soil.
5. Unconfined Compressive Strength of Specimen obtained maximum at 8% Lime i.e. 547 KN/m^2 at 14 days curing.
6. Optimum proportion of Lime was obtained to the clayey soil for civil engineering projects.

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