Effect of Lime on Atterberg Limits and Compaction Properties of Soil

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Abstract— Soil having properties shrink and warp during the rainy season and dry season. The percentage of lime added to the soil reduces the changing the volume of soil in different season and enhancing the engineering properties of soil. A series of laboratory test determine the optimum percentage of lime to give higher strength of the soil. After tests Liquid Limit, Plastic Limit, Shrinkage limit and Proctor test on soil give an idea about the behavior of soil. It shows that 9% of lime is the optimum mix for soil strength.

Keywords: Soil, Stone Dust, OMC and MDD

I. INTRODUCTION

Expansive soil is a clay or soil that prone to large volume change that is directly related to change in water content. Wet condition of expansive soil swells it and increase plasticity, while dry condition produce crack and warp on the soil. Soil become very hard and volume decrease excessively during dry condition. It induces large settlement of ground surface. There is requirement of stabilizing agent which is helpful to improve strength of soil. Lime is collected from lime stone or chalks are composed primarily of calcium carbonate. They may be cut, crushed, or pulverized and chemically altered. This is widely used in building and engineering material. Lime is calcium containing organic mineral composed primarily of calcium oxide.

II. MATERIAL AND METHODS

A. Materials:

1) Soil:

The soil is the main materials used in this study and the sample shown in Fig.1 was collected from the fields of Chamba, Tehri Garwal Uttarakhand (India).

Fig. 1: Sample of Soil

2) Lime:

Lime purchased from the market of New Tehri, Tehri-Garwal, Uttarakhand (India).

Fig. 2: Sample of Stone Dust

B. Methods:

1) Particle Size Distribution:

Sieve analysis helps to determine the particle size distribution of the coarse and fine aggregates. This is done by sieving the aggregates as per IS 2720 (part IV) – 1985. In this, we use different sieves as standardized by the IS code and then pass aggregates through them and thus collect different sized particles left over different sieves.

2) Atterberg Limit:

Liquid Limit and Plastic Limit of Soil and Soil with Lime was calculated as per IS: 2720 (Part V) – 1985

a) Liquid limit:

About 200g of specimen passing through 425 micron sieve is mixed thoroughly with distilled water in the evaporation dish to form a uniform paste. A portion of the paste is placed in the cup over the spot where the cup rests on the base and the groove is cut in soil pat. The handle is rotated at the rate of about 2 revolution per second and the no. of blows are counted until the 2 parts of soil sample come into contact at the bottom of the groove along a distance of 10 mm. after recording the no. of blows approx. 10 gm of soil from near the closed groove is taken for water content determination. The liquid limit is determined by plotting a graph between no. of blows as abscissa on a logarithmic scale and corresponding water content as ordinate.

b) Plastic limit:

To determine plastic limit the soil specimen passing 425 micron sieve is mixed thoroughly with distilled water until the soil mass becomes plastic enough to be easily moulded with fingers. It should be left for enough time to allow the water to permeate through the soil mass. A ball is formed with 8 g of this plastic soil mass and rolled between the fingers and a glass plate to roll the mass into a thread of uniform diameter. When a dia. of 3 mm is reached the soil is remoulded again into a ball. This process is repeated until the thread starts just crumbling at the diameter of 3 mm. the crumbled threads are kept for water determination.

3) Shrinkage Limit:

A saturated soil sample is taken and allowed to dry up gradually, its volume will go on reducing till a stage will come after which the reduction in the soil water will not result in a further reduction in the total volume of the soil sample.

The water content corresponding to that stage is known as the shrinkage limit. About 50g of soil passing 425 microns IS sieve is mixed with distilled water to make the soil pasty enough to be readily worked into the shrinkage dish without the inclusion of air bubbles. The inside of the shrinkage dish is coated with a thin layer of Vaseline. The dish is gradually filled by adding soil in Installment followed by gentle tapping. Soil adhering to the outside of the dish is wiped off. The dish filled with soil is then immediately weighted. The dish is then placed in the oven. The soil pat will have volumetric shrinkage on drying. The mass of the dry soil pat is found. To find the volume of the dry soil pat, the glass cup is filled with mercury and the excess mercury is removed. The dry soil pat is placed on the surface of the mercury of the cup and is carefully forced down. The mass of the mercury so displaced divided by its density gives the volume of the dry soil pat. The shrinkage limit is then calculated.

Shrinkage limit of Soil and Soil with Lime was determined in Laboratory as per IS: 2720 (Part – VI) 1972.

4) Standard Proctor Test:

The standard proctor test is used to determine optimum moisture content and maximum dry density of soil in the laboratory. In this method the soil filled into the mould in three layers and each layer compacted by 25 number of blow from a 2.6 kg hammer weight with fall of 310 mm. The process is repeated for different soil sample to determine optimum moisture content and maximum dry density. The plot between dry density and water content is drawn on the graph to find out optimum moisture content and maximum dry density.

Standard Proctor Test is conducted as per IS: 2720 Part VII-1980 to perform the experiment.

III. Review of Literature

Many researchers have worked on the properties of Lime to judge its suitability as a construction material in the field of civil engineering. Some of the important findings are briefly reproduced.

O. Amu et al. (2011) collected soil from Owena Village along ILE-Ife, Ogudu road of Osun state for optimum percentage of Lime mixed with soil for high strength. Plasticity index changes 32.5% to 26.7% with the increase in lime content. OMC and MDD increased from 22.2 to 27.5% and 16.2 to 16.55kN/m^2 with an increment of lime to the soil respectively. Cohesion and angle of internal friction is optimum at 8% Lime i.e. 187kN/m^2 and 20 degrees respectively. 822.94kN/m^2 is the higher value of Unconfined Compressive Strength test at 8% Lime. For unsoaked and soaked condition higher value of CBR obtained 29.0% and 28.0% respectively at 8% Lime. From the above test results, 8% found to be the optimum percentage of lime mixed to the soil.

P. Kaur et al. (2012) conducted Standard Proctor and Unconfined Compressive Strength of soil with the addition of lime. Results conducted on soil with different percentage of lime i.e. 3%, 6% and 9%. In which OMC increases 10% to 12.7% with increases the lime content to the soil. Lab results determined the 6 % Lime is the optimum percentage mixed to the soil for higher strength. Similarly UCS value increases 207.9kN/m^2 to 507.9kN/m^2 at 6% Lime.

A. Muhmed et al. (2013) used lime for experimental program on kaolin clay to improve its strength. For experiment 5% lime added to analysis strength of soil. Liquid Limit, Plastic Limit and Plasticity Index of the soil changes 65.9% to 86.5%, 33.3% and 56.9% at 5% Lime added to clay. OMC and MDD increases and decreases respectively with increases the proportion of Lime to the soil. UCS test conducted for 7, 14 and 28 days curing and found 390.1kN/m^2 higher strength of soil with 5 % Lime at 28 days.

IV. Result and Discussion

A. Geotechnical Properties of Soil:

Geotechnical properties of soil calculated after conducting a series of laboratory test as per IS Code 2720. The laboratory results described as:

S. No.	Parameter	Test Method	Results
1.	Soil Type as Per IS 1498-1970	IS 2720 (Part IV) 1985	Clay
2.	Liquid Limit	IS 2720 (Part V) 1985	32.72 %
3.	Plastic Limit	IS 2720 (Part V) 1985	20.42 %
4.	Shrinkage Limit	IS 2720 (Part VI) 1972	11.80 %
4.	Plasticity Index	IS 2720 (Part III) 1980	12.30 %
5.	Standard Proctor Test MDD OMC	IS 2720 (Part VII) 1980	16.74 Kn/m^3 14.20 %

Table 1: Geotechnical Properties of Soil

B. Atterberg Limit:

Liquid limit is that min water content at which soil has tendency to flow. The results obtained have been used to draw inferences under each category of mixes as follows:

S. No.	Material	Liquid Limit (%)
1.	Soil + 3% Lime	28.72
2.	Soil + 6% Lime	24.62
3.	Soil + 9% Lime	22.72
4.	Soil + 12% Lime	20.52

Table 2: Liquid Limit of Soil with Different Percentage of Lime

Plastic limit is that min water content at which soil is in plastic stage and plasticity index is defined as the range of consistency within which soil behave as plastic material. The results obtained have been used to summarize under each category of mixes as follows:

S. No.	Material	Plastic Limit (%)
1.	Soil + 3% Lime	18.32
2.	Soil + 6% Lime	16.42
3.	Soil + 9% Lime	15.32
4.	Soil + 12% Lime	14.12

Table 3: Plastic Limit of Soil with Different Percentage of Lime

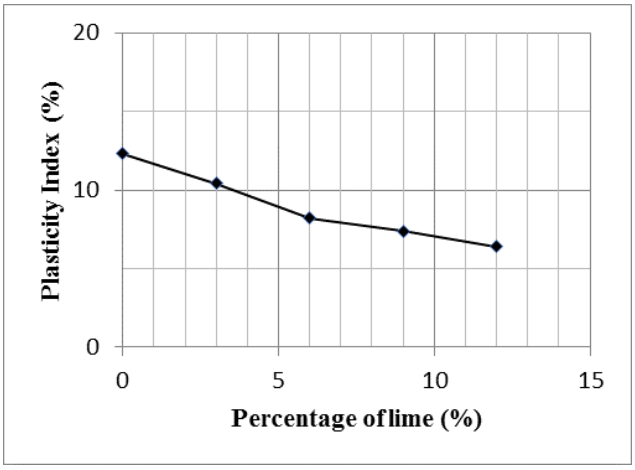

Fig. 3: Variation of plasticity Index with different percentage of lime

C. Shrinkage Limit:

Shrinkage limit is that max. Water content at which, further reduction in water content will not cause any reduction in volume of soil sample. The results obtained have been used to summarize under each category of mixes as follows:

S. No.	Material	Shrinkage Limit (%)
1.	Soil + 3% Lime	18.32
2.	Soil + 6% Lime	16.42
3.	Soil + 9% Lime	15.32
4.	Soil + 12% Lime	14.12

Table 4: Shrinkage Limit of Soil with Different Percentage of Lime

D. Standard Proctor Test:

Standard proctor tests were conducted to determine the relationship between moisture content and dry density of the samples for a specified compactive effort. These tests were performed using various combinations of soil, rice husk ash and cement samples. The results obtained have been used to draw inferences under each category of mixes as follows:

1) Soil with 3% lime:

Fig.4 shows the typical plot of standard proctor test for soil mixed with 3% lime. From Fig.4, it is evident that the sample at 15.8% water content attained maximum dry density of 15.84 kN/m^3.

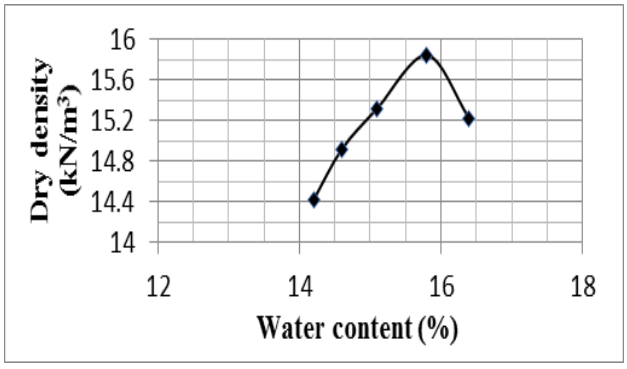

Fig. 4: OMC and MDD of soil with 3% lime

2) Soil with 6% lime:

Fig. 5 shows the typical plot of standard proctor test for soil mixed with 6% lime. A perusal of Fig. 5 shows that at 18.3% water content, the sample attained maximum dry density having value 15.12 kN/m^3.

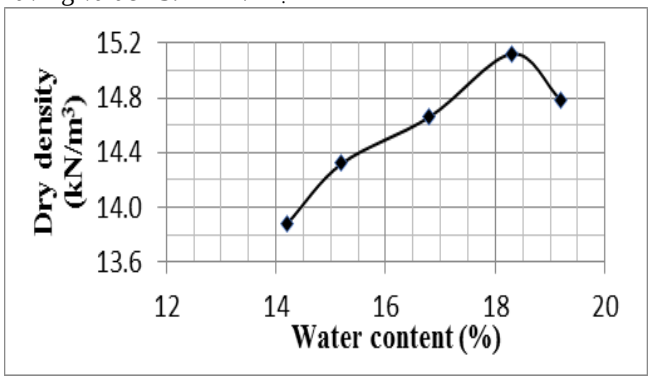

Fig. 5: OMC and MDD of soil with 6% lime

3) Soil with 9% lime:

Fig. 6 shows the typical plot of standard proctor test for soil mixed with 9% lime. From Fig.6, it is evident that the sample attained maximum dry density having value of 14.92 kN/m^3 at 22.4% water content.

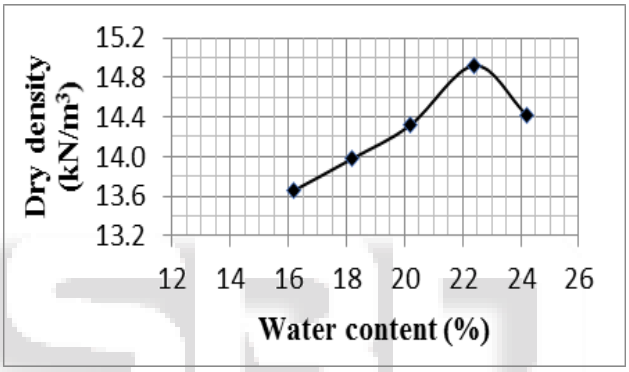

Fig. 6: OMC and MDD of soil with 9% lime

4) Soil with 12% lime:

Fig.7 shows the typical plot of standard proctor test for soil mixed with 12% lime. A perusal of Fig.7 clearly shows that the sample attained maximum dry density of 14.42 kN/m^3 at 21.8% water content.

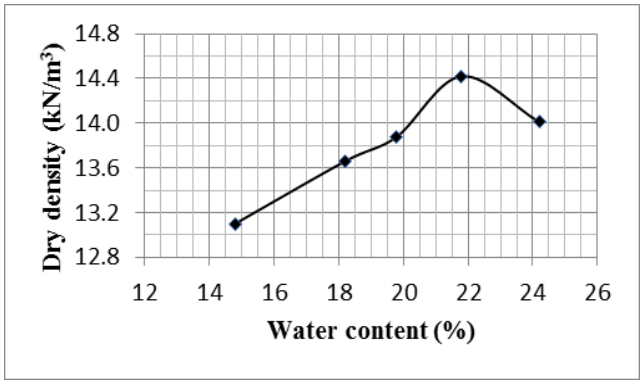

Fig. 7: OMC and MDD of soil with 12% lime

S.No.	Material	OMC (%)	MDD (kN/m^3)
1	Soil + 3 % Lime	15.8	15.84
2	Soil + 6 % Lime	18.3	15.12
3	Soil + 9 % Lime	22.4	14.92
4	Soil + 12 % Lime	21.8	14.42

Table 5: OMC & MDD of Soil with Different Percentage of Lime

V. CONCLUSION

1) Liquid Limit of Soil decreasing with increasing percentage of lime i.e. 20.52 % (at 12% lime to the soil).
2) Plastic Limit of Soil decreasing with increasing percentage of lime i.e. 14.12 % (at 12% lime to the soil).
3) Plasticity index of Soil decreasing with increasing of lime i.e. 6.4 % (at 12% lime to the soil).
4) OMC & MDD of soil with 9 % Lime is 14.92 kn/m3 and 22.4%.
5) The optimum mix was 9% Lime for maximum vale of MDD and minimum value of OMC.

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