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Influence of Fine Quarry Dust and Quick Lime on the Properties of Clayey Soil

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Abstract— Clayey soils are associated with many undesirable engineering properties. To make it useful most common ways are reduction of plasticity and water holding capacity. This study is to find the trend of variation in properties of clayey soil (non-swelling) while adding fine quarry dust and quicklime together and separately into it. It is mainly focussed on plasticity characteristics and Optimum moisture content to give maximum dry density.

Key words: Clayey soil, CaO, Atterberg's limits, OMC (Optimum Moisture Content), MDD (Maximum Dry Density)

I. INTRODUCTION

Clayey soils are widely distributed all over the world which is associated with undesirable engineering properties such as high compressibility and low shear strength. These are mainly due to plasticity and water absorption capacity of soil. We cannot avoid soil in civil engineering works because it is the subgrade material for any construction on earth. As clayey soil is cohesive addition of cohesionless materials such as quarry dust can convert the properties to desirable. Also, one can alter the properties of clay chemically using quick lime.

Very fine quarry dust (particle size less than 425 micron) cannot be used for other purposes such as concrete works and as it is cheap and cohesionless it can be used for stabilization of clayey soil. Lime is commonly used to reduce water absorption in soil as quick lime contain approximately 25 percent more available lime it is economical than hydrated lime.

This study aims to find the trend of variation in plasticity characteristics and Optimum moisture content to give maximum dry density of clayey soil (non-swelling) while adding fine quarry dust and quicklime together and separately into it.

II. MATERIALS USED

Three different materials were used in this research: clayey soil, Quarry dust and Quick lime (CaO).

A. Clayey Soil

The soil used for work was collected from Thonnakkal, Thiruvananthapuram, Kerala, India. In this the dominant clay mineral is Kaolinite. The properties of soil were tested and tabulated in Table I. Based on Indian Standard Classification System (ISCS), the soil is classified as Clay of low compressibility (CL). Unconfined compression test was conducted to confirm the soil is soft. The grain size distribution of clay was found out using hydrometer analysis (IS: 2720 (Part 4)- 1983) is shown in Fig. 1.

B. Quarry Dust

The quarry dust used in the study was collected from a local stone crushing site in pallichal, Thiruvananthapuram, Kerala, India. The collected quarry dust was first dried and screened over sieve size 4.75mm to remove any impurities. Then it was sieved through sieve size 425 micron to obtain fine quarry dust particles. The properties of fine quarry dust were tested and tabulated in Table II. The grain size distribution of quarry dust was found out by sieve analysis (IS: 2720 (Part 4)- 1983) is shown also in Fig. 1.

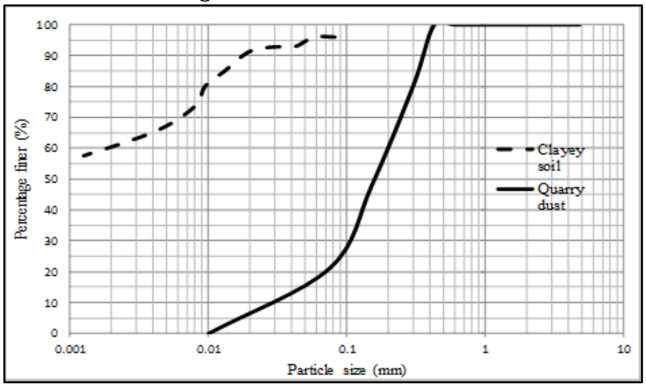


Fig. 1: Grain size distribution curves for clayey soil and Quarry dust

C. Quick Lime (Calcium Oxide, CaO)

Laboratory reagent grade Calcium Oxide (CaO) was used. Distilled water was used in preparing the test specimens and for curing.

Soil Properties	Values Obtained
Specific gravity	2.53
Liquid limit (%)	33
Plastic limit (%)	20.2
Shrinkage limit (%)	18.3
Plasticity Index (%)	12.9
IS Classification	CL
OMC (%)	24.5
Percentage of clay (%)	60
Percentage of silt (%)	36
Percentage of sand (%)	4
UCS (kPa)	28.7

Table 1: Properties of Clayey Soil

Soil Properties	Values Obtained
Specific gravity	2.7
Effective Size D10(mm)	0.03
D60(mm)	0.2
D30(mm)	0.1
Co-efficient of curvature, C_C	1.67
Uniformity Co-efficient, C_u	6.67
% fines below 0.425mm	100
Angle of internal friction (Φ)	47^0
Cohesion, c (kPa)	0

Table 2: Properties of Quarry Dust

III. METHOD OF STUDY

A. *Tests conducted*

Following tests were conducted.

1) Atterberg's limit test (IS: 2720 (Part 5)-1983)
2) Standard proctor test (IS: 2720 (Part 7)-1983)

B. *Method of Study*

The dried soil samples were collected. Mechanical and hydrometer analysis were used to obtain the particle size distribution of the soil samples in accordance with the standard specifications. Similar tests were conducted in quarry dust. For the particle size analysis, gravel was defined as particles larger than 4.75 mm and silts were particles smaller than 0.075mm while clay contents are percentages of soil fractions smaller than 0.002mm.

Plasticity characteristics (liquid limit (w_L), plastic limit (w_P) and plasticity index (I_P)), compaction characteristics (OMC and MDD) clayey soil quarry dust mix and clayey soil quarry dust mix were determined in accordance with IS specifications. Mixes which give maximum MDD were selected. Same characteristics were determined on clay-quick lime and clay-quarry dust-quick lime mix to obtain the trend of variation.

IV. RESULTS & DISCUSSIONS

A. *Variation of Properties of Clayey Soil by the addition of Quarry Dust*

To study the variation of Atterberg's limits (liquid limit (w_L), plastic limit (w_P) and plasticity index (I_P)) clayey soil – quarry dust mixes were prepared with varying percentages of quarry dust. Atterberg's limits were determined as per IS: 2720 (Part 5)-1983. The results obtained are shown in Table III. The variation of Atterberg's limits is shown in Fig. 2.

Soil mix	Liquid limit, w_L (%)	Plastic limit, w_P (%)	Plasticity index, I_P (%)
Clay	33.1	20.2	12.9
Clay + 10% Quarry dust	32.3	19.5	12.8
Clay + 20% Quarry dust	30.5	19.1	11.4
Clay + 30% Quarry dust	29.5	18.4	11.1
Clay + 40% Quarry dust	28.4	18.1	10.3
Clay + 50% Quarry dust	27.4	17.5	9.9

Table 3: Atterberg's Limits of Clayey Soil- Quarry Dust Mixes

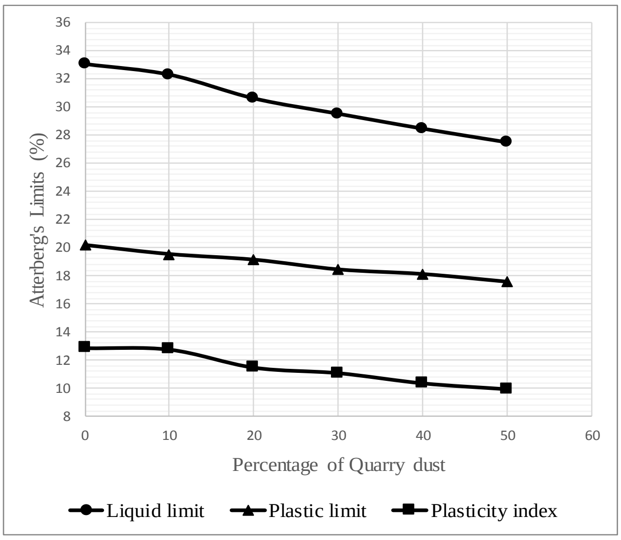


Fig. 2: Variation in Atterberg's limits with varying percentages of quarry dust in Clayey soil

It was observed that the all Atterberg's limits are decreasing with increase in percentages quarry dust. The decrease in liquid limit and plastic limit is due to the decrease in percentage of cohesive clay particles in the mix [1]. The decrease in plasticity index is due to more decrease in liquid limit than decrease in plastic limit.

Clayey soil with varying percentages (0,10,20,30,40 and 50) of quarry dust were prepared and compaction characteristics (Optimum Moisture Content, OMC and Maximum Dry Density, MDD) were determined for each mix using standard proctor test as per IS: 2720 (Part 7)-1983. The obtained values of MDD and OMC are tabulated in Table IV. Variation of MDD and OMC with varying percentages of quarry dust in clay is shown in Fig. 3.

Soil mix	Compaction characteristics	
	MDD (g/cc)	OMC (%)
Clay	1.64	24.5
Clay + 10% Quarry dust	1.66	21
Clay + 20% Quarry dust	1.67	19
Clay + 30% Quarry dust	1.81	18
Clay + 40% Quarry dust	1.89	17
Clay + 50% Quarry dust	1.83	20

Table 4: Compaction Characteristics of Clayey Soil- Quarry Dust Mixes

It was observed that the OMC is decreasing with increase in percentages quarry dust in clayey soil up to a certain limit. But MDD is increasing with increase in percentages of quarry dust in clayey soil up to a certain limit. The increase in MDD is due to the high specific gravity and coarse particle size of quarry dust. The decrease in OMC is due to the reduction of clay particles in the mix. After a certain limit the quantity of cohesionless particle get increases in the mix and the clay content will became insufficient to hold cohesionless particles after this limit OMC starts increasing and MDD starts decreasing by further addition of quarry dust.

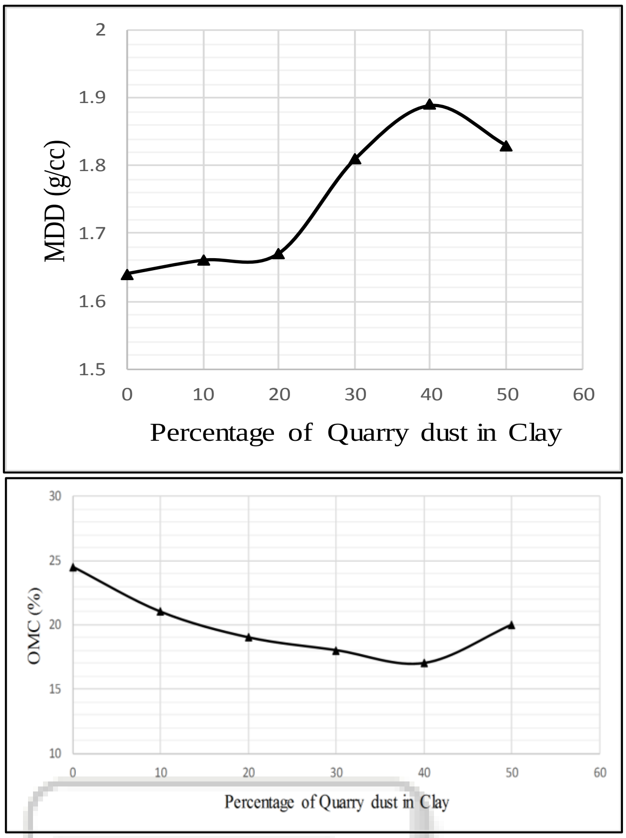


Fig. 3: Variation of MDD with different percentages of quarry dust in Clayey soil

B. Variation of Properties of Clayey Soil and Quarry Dust Stabilized Clayey Soil Treated with Quick lime (CaO)

Clayey soil with different percentages of CaO content and quarry dust stabilized clayey soil with different percentages of CaO content were prepared. Atterberg's limits were determined as per IS: 2720 (Part 5)-1983. The results obtained are shown in Table V.

Percentage of CaO added (% by dry weight of soil)	Liquid limit, w_L (%)		Plastic limit, w_P (%)		Plasticity Index, I_P (%)	
	In clayey soil	In Clayey soil +40% Quarry	In clayey soil	In Clayey soil +40% Quarry	In clayey soil	In Clayey soil +40% Quarry
0	33.04	28.4	20.17	18.09	12.87	10.31
1	32.4	27.9	20	18	12.4	9.9
2	31.5	27.5	19.8	17.7	11.7	9.8
3	30.6	28	19.5	18	11.1	10
4	29.5	28.5	19	18.2	10.5	10.3
5	30.02	28.5	19.4	18.2	10.62	10.3

Table 5: Atterberg Limits of Clayey Soil and Quarry Dust Stabilized Clayey Soil Treated With Calcium Oxide

Liquid limit behavior of quick lime treated soil can be described as having three different phases. The first phase is the reduction in thickness of the diffuse double layer, which takes place quickly and leads to a lower liquid limit. The second phase is the increase in the liquid limit attributable to fabric changes giving rise to flocculated structures. The last phase is the pozzolanic reactions, producing water holding gelatinous materials, which enhances the liquid limit. This phenomenon is dominant for silica rich soils [2]. In this study the dominant clay mineral in clay is kaolinite. For clayey soil treated with CaO the reduction in thickness of diffuse double layer will continue up to 4% lime content. After this limit flocculation and agglomeration will occurs and increase in liquid limit occurs. For quarry dust stabilized clayey soil treated with CaO, due to high percentage silica content the pozzolanic reactions occurs at 2% clay content. After this limit increase in liquid limit occurs.

The plastic limit is a measure of the water content of soil when it approaches a certain shear resistance. With the addition of quick lime, CEC will increase which increases the charge concentration and thereby the viscosity of the pore fluid. As a result, the interparticle shear resistance increases, leading to a sharp increase in the plastic limit. Moreover, the lime-induced flocculation enhances the interparticle resistance against movement, leading to an increased plastic limit [2]. In this study the CEC of clay mineral is less and a decrease in plastic limit occurs at first and then increases after the formation of gelatinous materials. For quarry dust stabilized soil there is no much increase or decrease in plastic limit due to low clay content in mix.

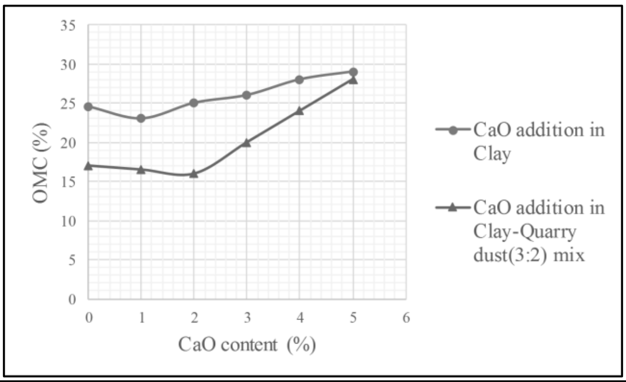
As plastic limit and liquid limit decreases during the addition of CaO in both mixes, the plasticity index remains almost constant.

Clayey soil with different percentages of CaO content and quarry dust stabilized clayey soil with different percentages of CaO content were prepared. Compaction characteristics were determined as per IS: 2720 (Part 7)-1983. The results obtained are shown in Table VI. Variation of MDD and OMC with varying percentages of quarry dust in clay is shown in Fig. 4.

Percentage of CaO added (% by dry weight of mix)	In clayey soil		In Clayey soil +40% Quarry dust	
	MDD (g/cc)	OMC (%)	MDD (g/cc)	OMC (%)
0	1.64	24.5	1.89	17
1	1.68	23	2.02	16.5
2	1.72	25	2.5	16
3	1.85	26	3.05	20
4	1.9	28	2.6	24
5	1.8	29	2.2	28

Table 6: Compaction Characteristics Of Clayey Soil And Quarry Dust Stabilized Clayey Soil Treated With Quick Lime

In clayey soil treated with CaO, the MDD increases very slightly up to lime fixation point (4%) due to drying action and decrease in diffuse double layer. In clayey soil treated with CaO, the MDD increases very rapidly up to 3% due to drying action and earlier formation of Calcium silicate hydrate (CSH) [3]. The OMC decreases and then increases for both soil mixes due to pozzolanic reaction of CaO.



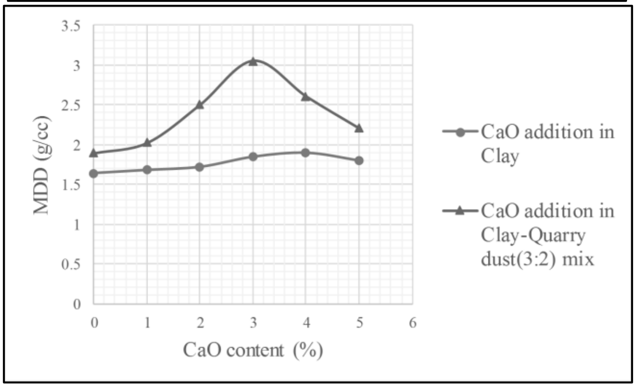


Fig. 4: Variation of MDD and OMC with various percentages of CaO in clayey soil and quarry dust stabilized clayey soil

V. Conclusions

The following conclusions are deduced from this study:

1) The addition of Quarry dust shows a reduction in the liquid limit and plastic limit due to the decrease in the quantity clay particles of both soils.
2) The addition of Quarry dust increases the OMC but decreases the MDD of soil mix.
3) Optimum percentage of Quarry dust was found out as 40%.
4) Clayey soil treated with 4% CaO and Clay-Quarry dust mix treated with 3% CaO will give maximum dry density.
5) Clayey soil needs more CaO content because of high clay content.
6) The reduction in Atterberg limits is the indicator of reduction in compressibility of clayey soil so that quarry dust and quick lime together can be used for clayey soil stabilization.

References

[1] Chetia, M., and Sridharan, A., "A Review on the Influence of Rock Quarry Dust on Geotechnical Properties of Soil", In Geo-Chicago 2016, ASCE, pp. 179-190, 2016.
[2] Dash, S. K., and Hussain, M., "Lime stabilization of soils: reappraisal", Journal of materials in civil engineering, ASCE, 24(6), 707-714, 2011.
[3] Kumar, A., Walia, B. S., & Bajaj, A., "Influence of fly ash, lime, and polyester fibers on compaction and strength properties of expansive soil. Journal of materials in civil engineering", 19(3), 242-248, 2007

