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Stabilization of Soil by using Marble dust with Sodium silicate as binder

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Abstract: Soil stabilization is the alteration of soil to enhance their physical properties. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work. Weak soil generally swells and shrinks depending upon the presence of moisture content. Stabilization can increase the shear strength of a soil and control shrinkage properties of a soil and thus improving the load bearing capacity of a soil. In this project clayey soil is collected. Generally, clayey soils are problematic soil having poor strength and low bearing capacity. The weak soil mixed with different percentage of marble dust with sodium silicate as binder. The different percentage of 5%, 10%, 15% and 20% of marble dust and 2.5%, 5%, 7.5% and 10% of sodium silicate is mixed with weak soil. Liquid limit test, Plastic limit test, Standard proctor test, direct shear test and California Bearing Ratio (CBR) test were conducted on soil stabilization. Finally, the Engineering properties of soil to be improved.

Keywords: Stabilization, Marble dust, Sodium silicate, clayey soil.

I. INTRODUCTION

Generally, clayey soils are problematic soil having poor strength and bearing capacity. Engineers face many problems because of such soil. Clayey soils do not possess sufficient strength to support the loads of the structure coming on them during construction or service life of the structure. Hence, this type of soil needs to be stabilized.

In this project, soil is stabilized by using marble dust with sodium silicate as binder. Over the last few years, use of industrial waste like marble dust, fly ash, blast furnace slag etc. has increased as stabilizing materials. The study also focuses on the reduction of cost in stabilization materials.

OBJECTIVE

- To evaluate the property and suitability of soil before and after the stabilization by marble dust with sodium silicate as binder.
- To reduce the plasticity of the soil and achieve more stable soil.
- To increase the California Bearing Ratio (CBR) value of the soil.
- To evaluate the strength of soil with varying percentage 5%, 10%, 15% and 20% of marble dust and 2.5%, 5%, 7.5%,and 10% of sodium silicate in weak soil.

II. MATERIALS COLLECTION

A. Collection of soil sample

The soil sample used in experiment has been collected from Otteri at Vellore in Tamil Nadu.

Table 1: Physical properties of soil

Sl. No.	Parameters	Values
1.	Natural moisture content	28.57%
2.	Specific gravity	2.47
3.	Liquid limit	85.71
4.	Plastic limit	50
5.	Plasticity Index	47.97
6.	Standard proctor test I. Maximum dry density II. Optimum moisture content	 1.294 20%
7.	Shear strength	0.11
8.	CBR value @ 2.5mm penetration	1.51

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B. Marble Dust

Marble dust is the waste obtained during cutting and cleaning of marble. The marble dust is a successful waste material in soil stabilization strategy which enhances the compaction qualities, subgrade characteristics, swelling characteristics, compressibility characteristics.

The major constituent of marble dust is calcium carbonate which aids in the stabilization of the soil. The marble dust is mixed with weak soil in percentage 5%, 10%, 15% and 20%.

C. Sodium Silicate

Sodium silicate is a white powder or colourless solution that is readily soluble in water, producing an alkaline solution. The compound of sodium silicate belongs to the family of Sodium Meta silicate. Sodium silicate increases the strength and durability of soil.

Fig. 1 Soil stabilizers are Marble dust and Sodium silicate

IV. METHODOLOGY

The literatures have been collected according to the title we have selected. Then we study the codal provision such as IS 1498-1970, IS 2720 (part-2, 4, 5, 7, 13 & 16). The soil sample is collected from selected area for the experimental work. The soil is oven dried and then it is sieved through respective sieve sizes (425µ, 90µ, 4.75mm) for corresponding test. The marble dust and sodium silicate is mixed with respective soil sample at different proportions. The soil mixture is later transformed to the container and it is dried in oven for 24 hours at 110ºc and then sample is tested for experimental work.

V. TEST RESULTS AND DISCUSSIONS

A. INDEX PROPERTIES

Index properties of the soil were obtained by using various percentages of marble dust and sodium silicate as binder. The Liquid limit test and Plastic limit test were conducted on the soil sample according to IS 2720-1985 (part5).

Table 2: Determination of plasticity index of sample on replacement of marble dust and sodium silicate

%of marble dust	% of Na_2Sio_3	Liquid limit	Plastic limit	Plasticity index (IS1498-1970)	Group (IS1498-1970)
5%	2.5%	57	44.44	27.01	CH
5%	10%	53.84	50	24.7	CI
10%	7.5%	50	50	21.9	CI
10%	10%	38.46	50	13.48	CL
15%	7.5%	33.33	49.9	9.73	CL
15%	10%	30	38.89	7.3	ML
20%	5%	50	50	21.9	CI

From the table, it can be evaluated with the addition of marble dust up to 15% and Na_2SiO_3 up to 10% the liquid limit and plastic limit decreases beyond this limit the value increases. As per IS 1498-1970 the soil group changes from CH group to ML group.

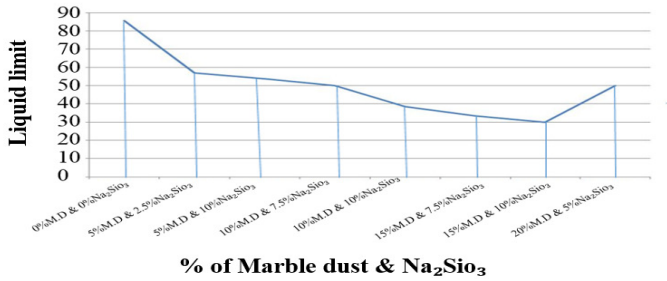

Fig 2. Liquid limit result with varying %of marble dust & Na_2SiO_3

From the fig 2, it increases the % of marble dust & Na_2SiO_3 the liquid limit of soil decreases from 85.71% to 30% and slightly increases on addition of 20% marble dust and 5% of Na_2SiO_3.

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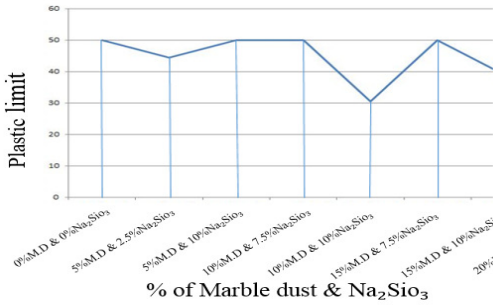

Fig. 2. Plastic limit result with varying % of Marble dust & Na_2SiO_3

From the fig 3, it is known that by increasing the % of marble dust & Na_2SiO_3, the plastic limit of soil decreases from 50% to 38.89% and slightly increases on addition of 20% marble dust and Na_2SiO_3.

B. *STANDARD PROCTOR TEST*

Compaction is the process of densification of soil by reducing air voids. The degree of compaction is measured by dry density. The dry density is maximum at optimum moisture content. The soil sample is passed through 4.75mm sieve and mixed with different %of marble dust & Na_2SiO_3. The sample is compacted in three equal layer by giving 25 blows using rammer. According to IS2720-1980(part-7).

Table.3 Determination of dry density of sample replaced with varying % of marble dust & Na_2SiO_3

%of Marble dust	%of Na_2SiO_3	MDD(gm/cc)	OMC
5%	2.5%	1.465	20%
5%	10%	1.505	20%
10%	7.5%	1.669	16%
10%	10%	1.759	16%
15%	7.5%	1.887	16%
15%	10%	1.999	12%
20%	5%	1.497	20%

From the table, it can be evaluated the maximum dry density and increases with the addition of marble dust up to 15% and Na_2SiO_3 up to 10% and decreases beyond this limit.

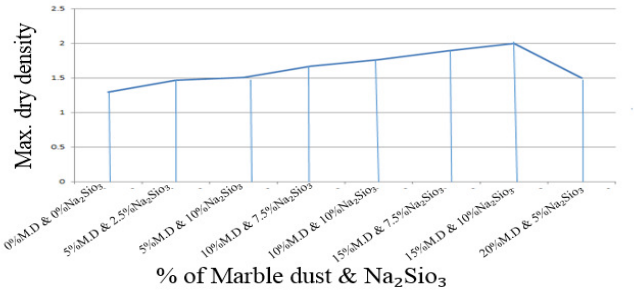

Fig. 4. Maximum dry density with varying % of Marble dust & Na□SiO□

From the fig.4 it can be obtained the addition of marble dust and Na_2SiO_3 increases maximum dry density 1.294 to 1.999.

C. *DIRECT SHEAR TEST*

The shear strength of a soil is one of the most important characteristics. The shear strength of a soil is its resistance to the deformation caused by the shear stresses acting on the loaded soil. This test determines the shear strength of the soil by using shear box apparatus. The test were conducted as per IS 2720 part13-1986.

Table.4 Determination of shear strength of sample replaced with varying % of marble dust & Na_2SiO_3

%of Marble dust	%of Na_2SiO_3	Shear stress at failure(Kg/cm²)
5%	2.5%	0.119
5%	10%	0.183
10%	7.5%	0.202
10%	10%	0.229
15%	7.5%	0.257
15%	10%	0.293
20%	5%	0.128

From the table, it can be evaluated the shear stress and increases with the addition of marble dust up to 15% and Na_2SiO_3 up to 10% and decreases beyond this limit.

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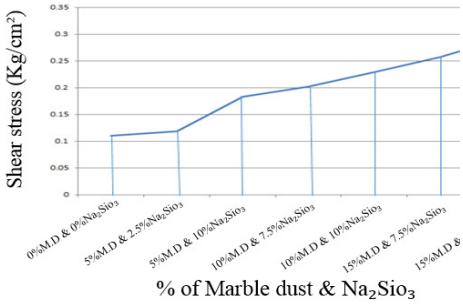

Fig. 5. Shear stress value with varying % of Marble dust & Na_2SiO_3

From the fig.5 it can be obtained the addition of marble dust and Na_2SiO_3 increases the shear stress value from 0.11 to 0.293.

D. *CALIFORNIA BEARING RATIO TEST*

This test is load penetration test. It is used to determine the California Bearing Ratio value of soil. CBR test carried out for evaluating the suitability of sub grade. The soil is mixed with different percentage of marble dust and sodium silicate and then compacted in mould and then load is applied and reading is taken at penetration of 2.5, 5, 7.5, 10, and 12.5mm respectively.

Table.5 Determination of shear strength of sample replaced with varying % of marble dust & Na_2SiO_3

%of Marble dust	%of Na_2SiO_3	CBR value @ 2.5mm penetration
5%	2.5%	3.86
5%	10%	4.17
10%	7.5%	9.97
10%	10%	10.53
15%	7.5%	11.83
15%	10%	16.24
20%	5%	7.03

From the table, it can be evaluated the CBR value at 2.5mm penetration increases with the addition of marble dust up to 15% and Na_2SiO_3 up to 10% and decreases beyond this limit.

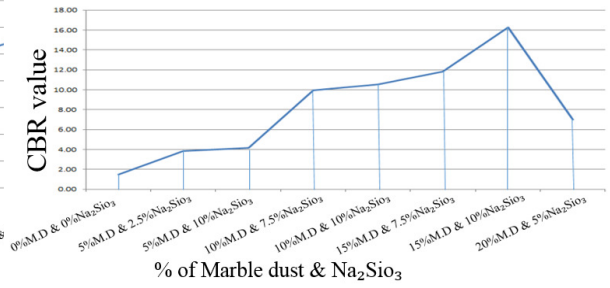

Fig. 6. CBR value with varying % of Marble dust & Na_2SiO_3

From the fig.5 it can be obtained the addition of marble dust and Na_2SiO_3 increases the CBR value from 1.51 to 16.24%.

V. CONCLUSION

By conducting series of laboratory tests on soil sample, we have observed and recorded the changes in soil properties after adding marble dust and sodium silicate. Conclusions were made based on the results as following,

- By the addition of Marble dust and Na_2SiO_3 the liquid limit & plastic limit of the soil decreases up to 15% and increases beyond this limit.
- By adding marble dust and Na_2SiO_3 the soil group from CH to ML according to IS1498-1970.
- The MDD increases with 15% marble dust, 10% Na_2SiO_3.
- The CBR value has increased with increase in addition of marble dust and Na_2SiO_3.

Using these results, it is concluded that the marble dust 15% and Na_2SiO_3 of 10% should be added.

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