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Use of Waste Marble Powder to Improve the Characteristics of Black Cotton Soil

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***Abstract*— Results of a laboratory study undertaken to investigate the effect of marble powder on the index properties of clay soil. The clay soil has a poor supporting capacity and large change in volume on variations of moisture content. Such expansive soils may need to be improved to make them suitable for construction activities. The objective of study is to evaluate the feasibility of industrial waste like marble dust as soil stabilization material. To investigate the effect of marble Powder on index properties of clay soil a series of laboratory experiments have been conducted on black-cotton soil samples mixed with 20% to 60% of marble Powder by weight of dry soil. The test results showed a significant change in consistency limits of samples containing marble dust. The liquid limit would decrease from 31.3% to 23.5%. The plasticity index decreased from 11.57% to 4.35%. The CBR test increases from 10.36 to 27.19. From this laboratory investigation it is concluded that the waste material like marble Powder generated from stone industries has a potential to modify the characteristics of expansive clay like clay soil. There is significant improvement in the index properties of the clay soil on addition of marble Powder into it. The expansive behavior of the clay has reduced to a great extent.**

***Keywords*— Marble dust, Black-cotton soil, Soil stabilization, CBR**

INTRODUCTION

1. *Clay Soil*

In this thesis, soil is collected from Vijapur road, on the under construction from RTO junction. The soil used is the extracted waste soil which on visual test and by laboratory test known to be clay soil. The soil is intermediate plastic clayey soil i.e. CH soil. Test according to Indian Standards are performed on the soil to check the properties of untreated and treated soil with stabilizer.

The Clay soil is a type of expansive soil with intermediate plasticity and can retain moisture throughout the dry season which is why they are valuable for growing crops. It exhibits low bearing capacity, low permeability and high volume change with variation in environment. The maintenance of roads not only expansive but also difficult and the pavements shows early signs of failures. Following are the problems with Clay soil.

- In rainy season, these soils become very soft by filling up of water in the cracks and fissures. These soft soils reduce the bearing capacity of the soils.
- In saturated conditions, these soils have high consolidation settlements.
- These soils have high swelling nature. Due to this structure causes damages.
- When lands are applied on these soils in wet conditions. These soils get Shrinkage.

2. *Marble Powder*

Marble is a non-foliated metamorphic rock composed of re-crystallized carbonate minerals, most commonly calcite or dolomite. Geologists use the “marble” to refer to metamorphosed limestone, however stonemasons use the term more broadly to encompass un-metamorphosed limestone. Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of marble is responsible for its color and appearance; it is white if the limestone is composed solely of calcite. Marble is used for construction and decoration; marble is durable, has a noble appearance, and is consequently in great demand.

Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. The other mineral constituents vary from origin to origin. Quartz, muscovite, tremolite, actinolite, micro line, talc, garnet, osterite and biotite are the major mineral impurities whereas SiO_2, limonite, Fe_2O_3, manganese, $3H_2O$ and FeS_2 are the major chemical impurities associated with marble. The main impurities in raw limestone which can affect the properties of finished cement are magnesia, phosphate, leads, zinc, alkalis and sulfides.

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Fig 1: Marble Dust

Table 1: Chemical properties of marble dust

Oxide compounds (mass %)	Marble dust
SiO_2	28.35
AL_2O_3	0.42
Fe_2O_3	9.70
CaO	40.45
MgO	16.25
Density	2.80

Application of Marble dust

- Power coating, paints and ceramic industry
- Reinforced polyester glass fiber
- Leather cloth and flooring applications
- Detergent applications 5.glass industry (in manufacturing sheet & optical glasses).

Advantages of Marble dust

- Marble powder can be used as a filler in concrete and paving materials and helps to reduce total void content in concrete.
- Marble powder can be used as an admixture in concrete, so that strength of the concrete can be increased.
- We can reduce the environmental pollution by utilizing this marble powder for producing the other products.
- Marble dust is mixed with concrete, cement or synthetic resins to make counters, building stones, sculptures, floors and many other objects.
- Marble dust gives an iridescent feel to the object because of the crystallized particles present in the dust from the marble. These cultured marble objects are often seen in luxury settings. Synthetic marble objects made with marble dust are more commonly used than 100 percent solid marble objects.
- Marble dust is also used to make paint primer for canvas paintings, and as a paint filler.
- Used as a component for manufacture of white cement.
- The marble powder is also used to create carbonic acid gases which is used in the bottling of beverages.

Disadvantages of Marble dust

- Only 20% of the final product is obtained from stone industry.
- Marble powder is not available in all the places.

I. Methodology Flow Chart and Experimental Set Up

In the proposed study with marble dust start preparation of work plan for Laboratory experimentation of Physical properties of soil and marble dust which must satisfied the requirement as per Indian Standard codes.

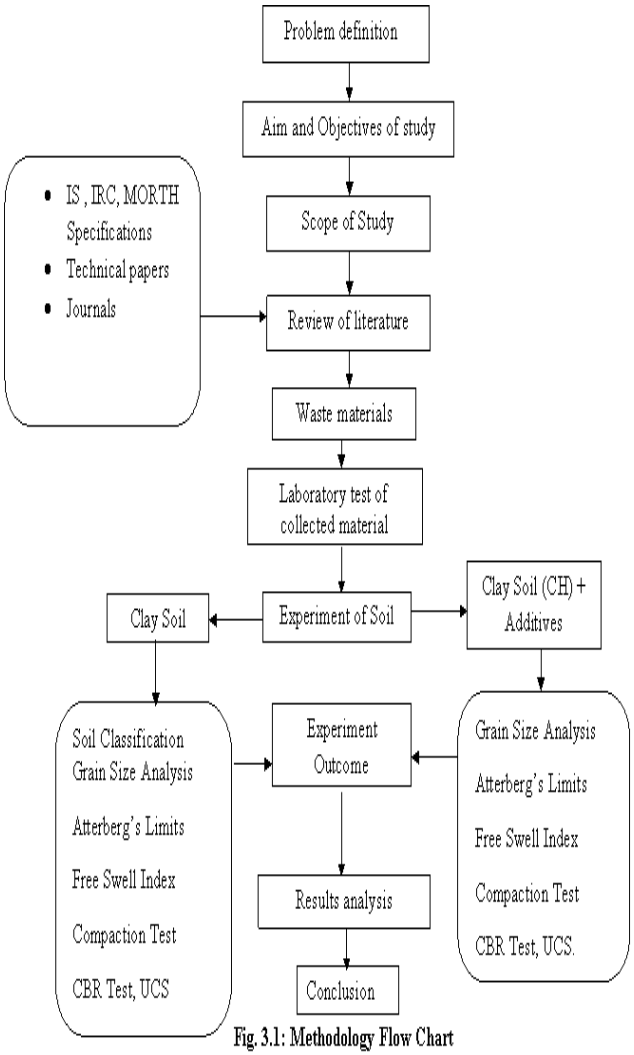

Fig. 3.1: Methodology Flow Chart

2. Laboratory Tests for Soil (As per Indian Standards)

To identify the engineering properties as per Indian Standard provision, various tests were performed which are enlisted as follows.

- Determination of Grain Size Analysis (IS: 2720 (Part IV) – 1985)
- Determination of Liquid & Plastic Limit (IS: 2720 (Part V) – 1986)

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- Determination of Free Swell Index of Soils (IS: 2720 (Part XL) – 1977)
- Determination Of Water Content - Dry Density Relation Using Heavy Compaction (IS: 2720 (Part VIII) – 1997)
- Laboratory Determination of California Bearing Ratio (IS: 2720 (Part XVI) – 1987)
- Determination of Unconfined Compressive Strength (IS: 2720 (Part X) – 1991)

3. *Laboratory Test Results and Analysis*

Soil Classification, FSI & Atterberg's Limit

IS: 1498 – 1970 describes the Indian Standard on Classification and Identification of soils for general engineering purposes. To determine the classification of soil, data for gradation, Atterberg's limits are required which were performed in the laboratory as per Indian Standards. Following are the results for the given soil.

Table 2: Soil Classification, FSI & Atterberg's Limit

Soil	Grain Size Distribution			Atterberg's Limit			Free Swell Index (FSI)	IS Classification
	Gravel (%)	Sand (%)	Silt/Clay (%)	L. L (%)	P. L. (%)	P. I. (%)		
Clay Soil	1	27	72	43.2	22.17	21.02	50%	CI

From fig 3.2 in X – axis represents liquid limit and Y – axis represents plasticity index. And at which plasticity (low, intermediate, high, very high, extremely high) of soil can be found. For black cotton soil point P is shown in fig. where P represents Liquid Limit = 56 on X – axis and Plasticity Index represents = 24 on Y – axis. And point is above a point. Soil is intermediate plastic. In flow diagram dark portion represents black cotton soil and from that flow diagram, it can be concluded that given Clay soil type is CI.

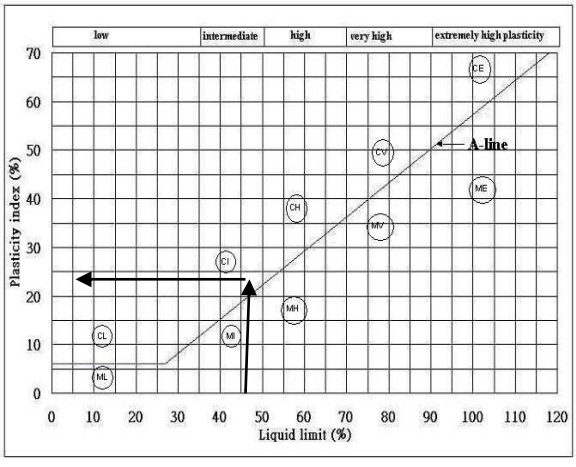

Fig. 2: Plasticity Chart (I.S. Soil Classification)

Test for Soil

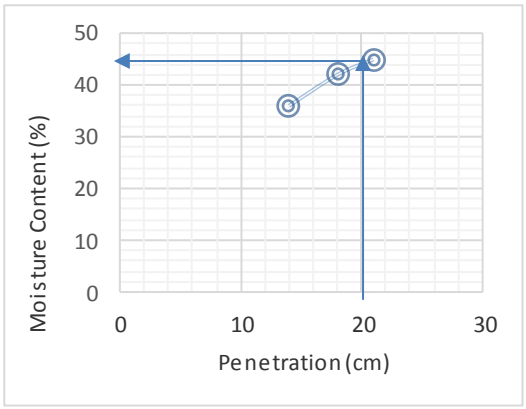

Fig. 3: Moisture content % vs. No of Blows for Clay soil

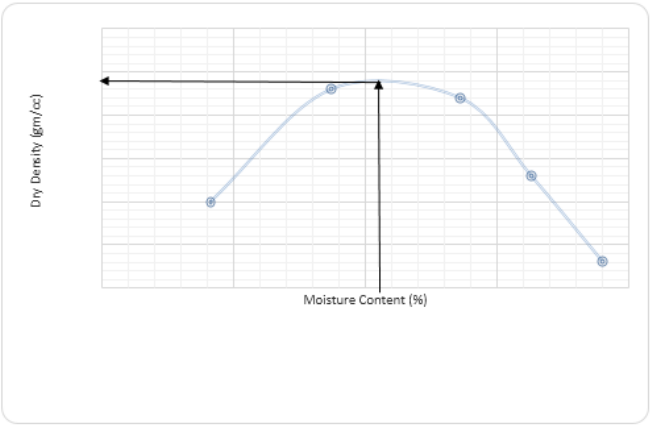

Fig. 4: MDD vs. OMC for Clay Soil

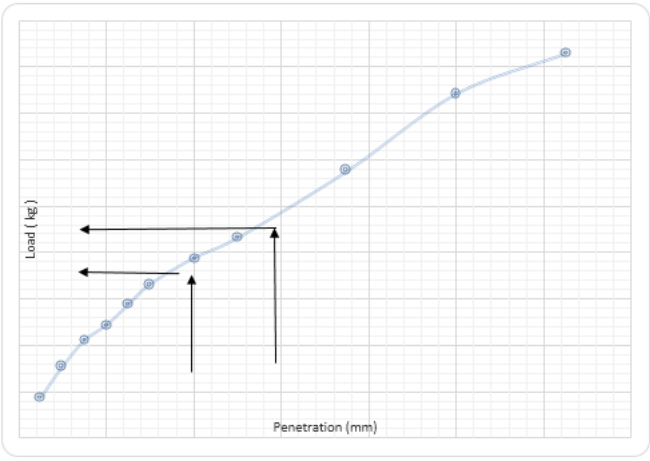

Fig 5: CBR Graph for Clay Soil

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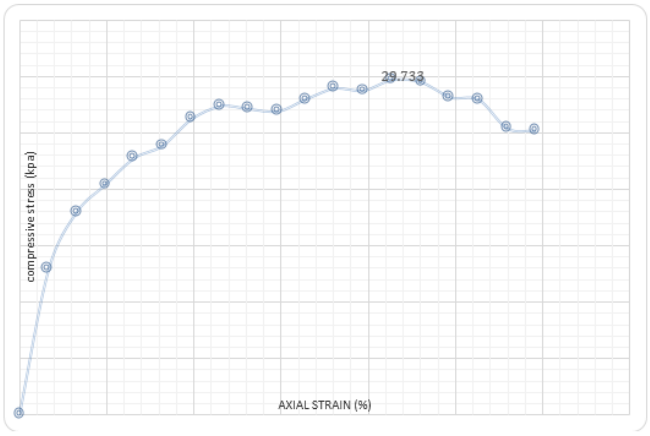

Fig 6: Stress VS Strain for Clay Soil

4. Tests on Soil + Marble Powder

Soil + 20 % Marble Powder

Soil + 30 % Marble Powder

Soil + 40 % Marble Powder

Soil + 60 % Marble Powder

Table 2: Atterberg's Limit

	LL	PL	PI	FSI
Soil + 20% Marble powder	31.3	19.725	11.57	34.44
Soil + 30% Marble powder	27.6	16.4	11.2	32.81
Soil + 40% Marble powder	25	15.34	9.66	30.77
Soil + 60% Marble powder	23.5	19.15	4.35	29.78

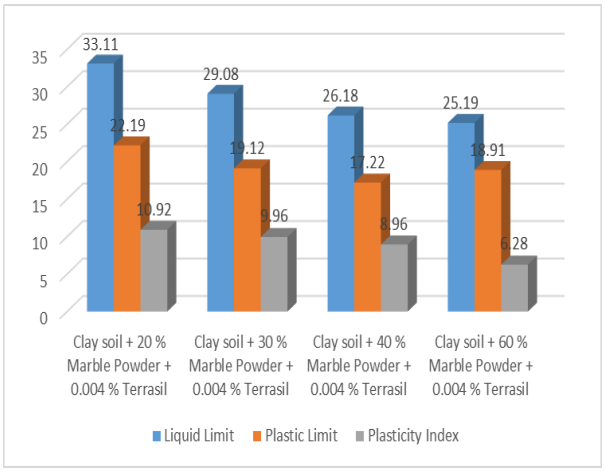

Fig. 7: Comparison of Atterberg's Limit chart

Table 3: CBR and UCS test for Marble Powder

Material	CBR	UCS
Soil + 20% Marble powder	4.63	37.134
Soil + 20% Marble powder (7 day)	5.75	86.872
Soil + 20% Marble powder (14 day)	6.23	85.051
Soil + 20% Marble powder (21day)	8.3	91.96
Soil + 20% Marble powder (28day)	10.36	123.383
Soil + 30% Marble powder	5.22	41.019
Soil + 30% Marble powder (7 day)	6.45	128.175
Soil + 30% Marble powder (14 day)	8.39	123.692
Soil + 30% Marble powder (21day)	10.11	135.363
Soil + 30% Marble powder (28day)	11.54	197.654
Soil + 40% Marble powder	10.29	39.53
Soil + 40% Marble powder (7 day)	12.65	114.998
Soil + 40% Marble powder (14 day)	13.32	118.233
Soil + 40% Marble powder (21day)	14.91	113.8
Soil + 40% Marble powder (28day)	16.8	188.07
Soil + 60% Marble powder	22.38	44.006
Soil + 60% Marble powder (7 day)	24.43	135.363
Soil + 60% Marble powder (14 day)	24.98	188.07
Soil + 60% Marble powder (21day)	26.05	200.049
Soil + 60% Marble powder (28day)	27.19	247.385

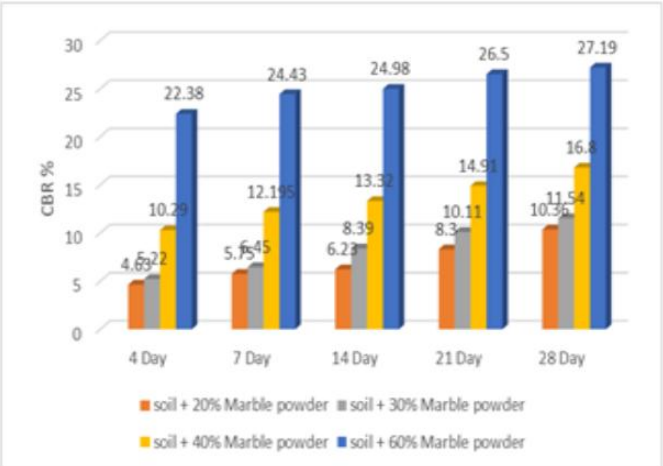

Fig. 8: CBR graph for Clay Soil + Marble Powder

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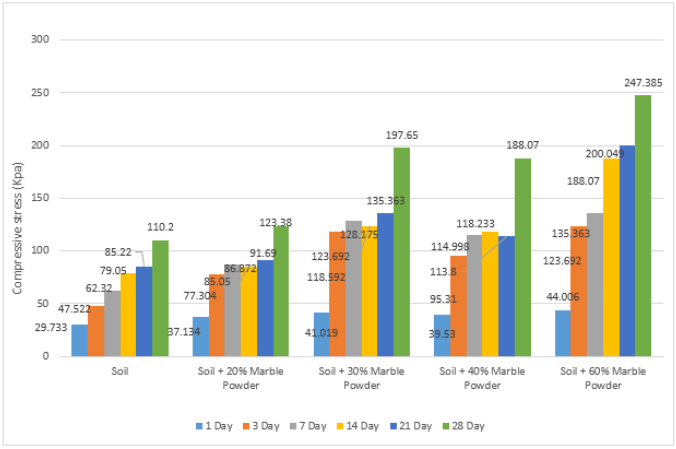

Fig. 9: Comparison Stress Vs Strain for Clay Soil + % of Marble Powder

5. THICKNESS DESIGN & COST

Thickness Design of Flexible Pavement as Per IRC: 37 – 2001 & IRC: 37 – 2012

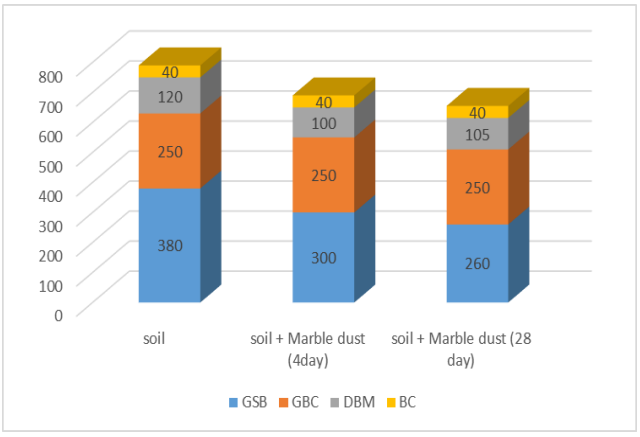

Fig. 10: Comparison of Thickness layers with and without additives

Table 6:Summary of Cost Analysis

Sr. No.	Materials	Cost (Rs.)
1	Clay Soil	12152728
2	Clay Soil + Marble dust	10300638

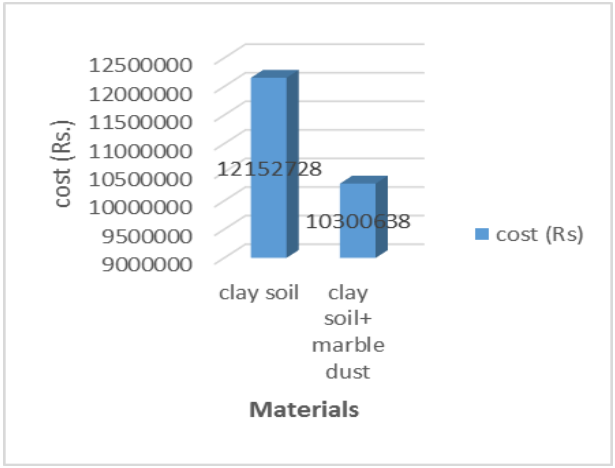

Fig.11: Summary of Cost Analysis

6. CONCLUSION

The unconfined compressive strength and the California bearing ratio of the clay soil increases by stabilizing the soil with Marble powder. It is one of admixture out of remaining admixture like stone dust, fly ash, rice husk, polymers, Portland cement, lime and ionic stabilizers. We can say it is a little bit of effective in using Marble powder as admixtures when compared with other stabilizing agents. CBR is perameter to check the strength of sub grade soil and in case of stabilize sub grade as per IRC guidline. It is required to findout UCS both perameter verifying exabution.

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