Effects of Marble Powder and Fine Sand on Properties of Expansive Soil

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Abstract *— Considerable efforts have been made to improve the properties of Expansive soils. This paper presents the effects of marble powder and sand on compaction characteristics, Atterberg's limit, California bearing ratio, permeability and shear strength parameters of clay soil. The clay soil was mixed with marble powder and sand from 30% to 50% and 20% to 40% respectively at an interval of 10%. From the analysis of test results it was found that, liquid limit, plasticity index, optimum moisture content, permeability and cohesion decreased and plastic limit, shrinkage limit, maximum dry density, California bearing ratio and angle of internal friction increased with an increase in marble powder content. From the economic analysis it was found that, marble powder up to 20% is optimum for sand mixed with clayey soil which can be used in strengthening the sub grade of flexible pavements to save the cost of construction.*

Keywords *— Soil, Marble powder, Sand, Compaction Characteristics, California Bearing Ratio, Permeability, Shear strength parameters.*

I. INTRODUCTION

The construction on clay soil always creates a problem for civil engineers because of its swell and shrinks behavior. When the black cotton soil comes in the contact of water then excessive swelling is caused and when water content decreases shrinkage occurs in the soil. Because of this movement lightly loaded structures such as foundations, pavements, canal beds, linings, and residential buildings founded on them are severely damaged (Chen, 1988). It has been estimated that the annual damage to structural on expansive soil are $1000 million in USA, £150million in UK and $1000 million pounds in worldwide (Gourley *et al.*, 1993). In India expansive soils covers about 0.8 × 106 Km2 area approximately 20% of surface area. The black cotton soil contains high percentage of montmorillionite mineral which imparts expansive behavior to it. Disposal of waste materials generated from different industries causes many problems like environment pollution in the nearby locality, scarcity of land for disposal, etc. Industrial waste like blast furnace slag, fly-ash, silica-fume, rice husk ash and stone dust, etc., are considered as alternative materials for soil stabilization. The marble dust is generated from cutting and polishing of marble stone. The amount of marble slurry generated is very substantial, being in the range of 5-6 million tons per annum. This paper envisages the effect of marble powder on the properties of clay.

II. LITERATURE

Eskoglou (1996) evaluated the effectiveness of marble dust as a soil stabilizer. The study revealed that the geotechnical parameters of forest soils are improved substantially by the addition of marble dust. Significant PI reductions occurred with MD treatment, particularly for high PI soils. Zorluer and Usta (2003) mixed soil samples with different percentages of marble powder to determine the swelling potential of the samples based on the dry weight of clay compacted at standard Proctor compaction energy and found that waste marble powder affected the swelling potential of clay.

Sabat et al. (2005) it stated that rice husk ash cannot be used alone for stabilization of soil due to lack of cementations properties. So it is used along with a binder like lime, cement, lime sludge, calcium chloride for stabilization of soil.Taspolat et al. (2006) studied the effect of marble powder used in the landfill liners on the freezing–thawing property of clay. They added different proportions of marble powder to the clay containing 10 % bentonite and 90 % kaolinite. As a result of the study, it was concluded that the addition of 10% and 15 % marble powder increased the durability of impermeable clay against environmental conditions.

Baser (2009) for his master's thesis prepared an artificial sample of expansive soil in the laboratory and added waste limestone powder and waste dolomitic marble powder to this sample. The analysis showed that increase in the stabilizer percentage resulted in a decrease in the swelling percentage and an increase in the rate of swelling.

Joulani (2012) investigated the effect of stone powder on strength, compaction and CBR properties of fine grained soil. The variables of research were two additives and three percentages (10%, 20% and 30%). The direct shear, compaction and CBR tests were conducted on soil with stone powder. Arora, Ameta and Samar (2014) studied Enhancement of engineering characteristics by use of marble slurry in Udaipur region It was observed that the plasticity index and liquid limit decreased while the shrinkage limit increased with increase in the marble dust percentage in the soil sample. MDD and OMC both decreased with increases in marble dust percentage.

From CBR test, the optimum percentage of marble dust was found 10 per cent for Kanpur village area soil and 20 per cent for Ayad village and Fatehpura area of the Udaipur.

Muthu Kumar and Tamilarasan (2015) conducted experimental study on expansive soil with Marble Powder. From experimental work results were Utilization of waste marble powder may reduce the disposal problem and preserve the ecological system.

III. Methodology and Materials

The purpose of this study was to investigate the effects on clay soil sample by addition of waste marble powder and sand. The effects were studied by taking measurements of Atterberg's limits, compaction characteristics, CBR value, permeability and shear characteristics.

Material -- For this study, samples of clay and sand were collected from Udaipur region and Dangiyawas– Banar villages. Each sample was dried and passed through IS sieve 4.75 mm before usage Waste marble powder was collected from marble industry of Kishangarh, Ajmer. It was passed through IS sieve 75µm before using it for preparing samples.

IV. Tests Performed

Following tests were performed on various specimens made out the soil sample brought from the site.

Proctor Compaction Test – To determine the measure of compaction and water content required on site, compaction tests are executed on the same soil in laboratory under similar conditions. The tests show the relationship between the water content and dry density and the water content at which the peak dry density is observed from the curve plot is obtained.

The tests are repeated and different corresponding values of dry density and water content are determined to be used for making the compaction curve. The compaction curve with water content on abscissa and the corresponding dry density as the ordinate is plotted.

The maximum dry density and optimum water content for various percentages of clay with marble powder and sand is given in Table. MDD of soil increases and OMC decreases with the addition of sand and marble powder to clay.

Composites	Proportions (%)	MDD(gm/cc)	OMC(%)
Clay	100	1.65	17.09
Clay:marble	70:30:00	1.8	13.89
	60:40:00	1.83	13.63
	50:50:00	1.842	13.37
Clay:sand	80:20:00	1.71	7.99
	70:30:00	1.78	7.57
	60:40:00	1.706	8.32
Clay:sand:marble	63:27:10	1.81	7.1
	56:24:20	1.86	6.6

Table 1. MDD and OMC for Various Percentages of Clay mixed with Sand and Marble powder.

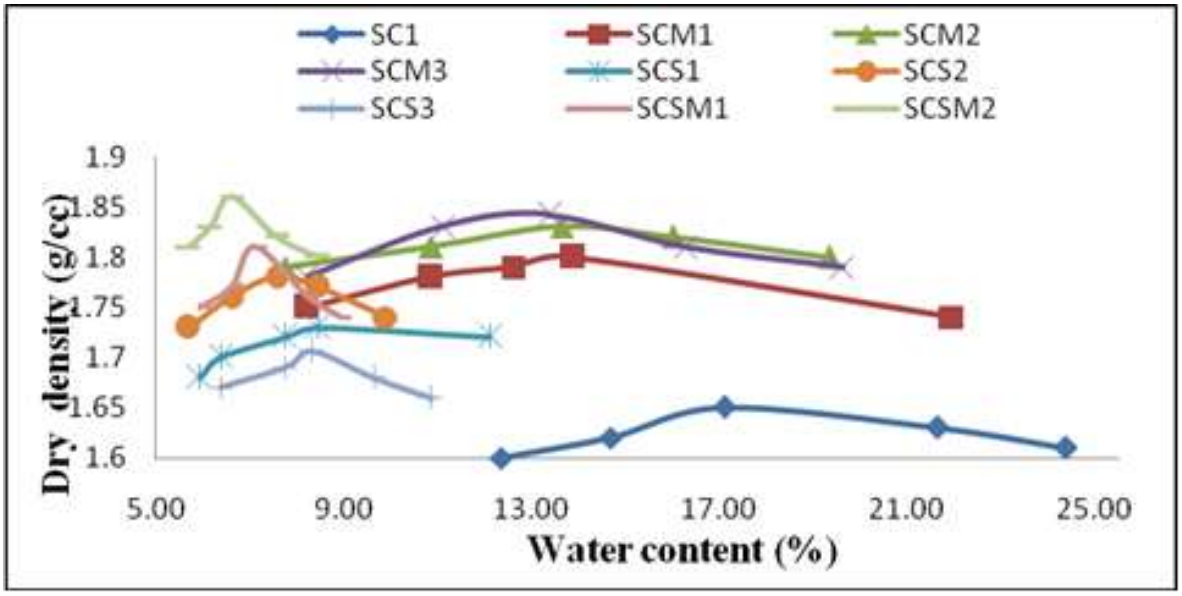

Fig 1. Variation of MDD and OMC of clay mixed with marble powder and sand and clay.

Figure 1 shows that on mixing of clay with marble powder and sand shows the increase of MDD from 1.65 gm/cc for clay to 1.84 gm/cc up to 50% MP and 1.78 gm/cc for 30% sand and after that shows the opposite trend that is reduced to 1.706 gm/cc for 40% sand. And OMC reduces from 17.09% for clay to 8.32 for 40% sand.

California Bearing Ratio Test – CBR test is executed for the evaluation for checking the suitability of subgrade and the materials used as sub-base and base courses. The results found are then correlated with the thickness of the different materials that are required for construction of flexible pavements. The tests were conducted with a prepared specimen in a mould. The plunger at the rate of 1.25 mm per minute is applied to penetrate the specimen.

It has been observed that generally, the CBR for 2.5 mm penetration is high, but if the CBR for the 5 mm penetration is greater than that for 2.5 mm then the test shall be repeated.

The specimen was also covered with a surcharge mass in the test to simulate the effect of overlying materials. California bearing tests were conducted on the samples of clay with marble powder and sand for both soaked and un-soaked condition. Test results obtained show that CBR value increases with increase in marble powder and sand in clay.

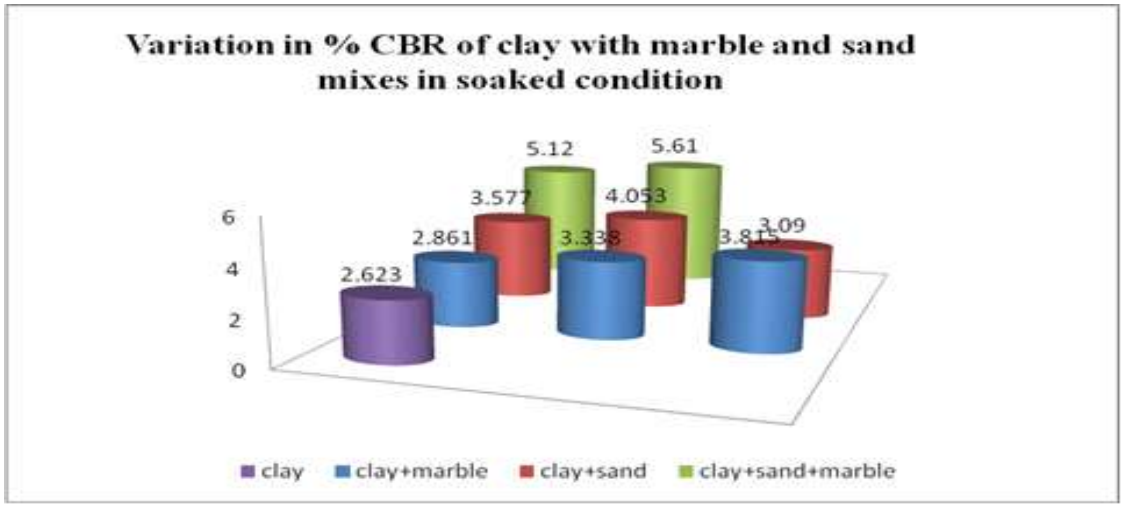

Fig 2. Variation of soaked CBR value of clay with sand and marble powder mixes.

Falling Head Permeability Test – Coefficient of permeability of the soil sample has been determined by using the Variable-head permeability test since this test is suitable for relatively less permeable soils. The permeameter mould is same as that used in the constant head permeability test. The sample was placed between two porous discs. The values for initial head and the final head level were determined and the time taken was recorded.

These tests were performed with a Variable Head Permeameter as per IS 2720 (Part XVII). The mix composition of marble, sand and clay were tested. The following variation was observed from the examinations.

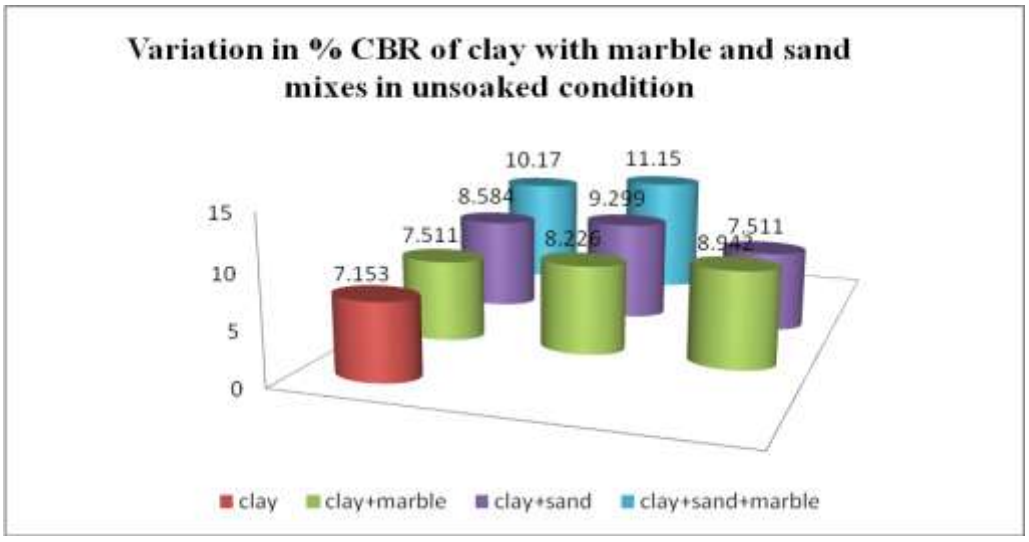

Fig 3. Variation of un-soked CBR value of clay with sand and marble powder mixes.

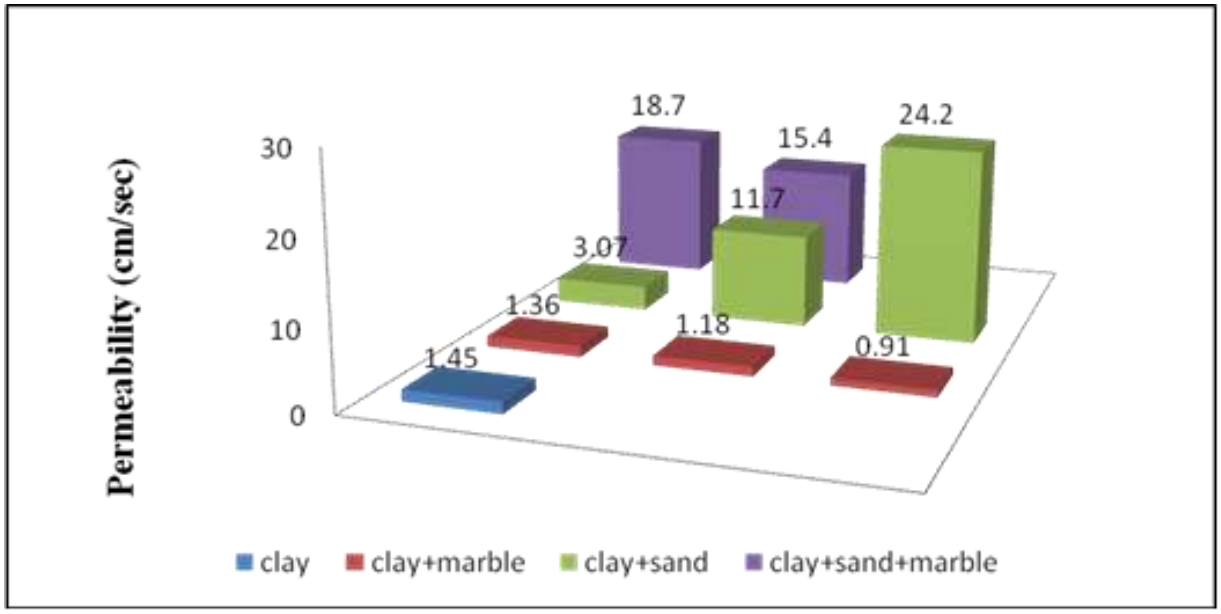

Fig 4. Variation of Coefficient of Permeability.

The above results show the permeability value of clay soil was 1.45×10^{-07} (cm/sec). After mixing of marble powder in the clay soil, permeability value decreases to $9.1x10^{-8}$ and on adding sand to clay permeability increases to $2.42x\ 10^{-6}$.

Direct Shear Test – A compacted soil specimen was made and placed in the shear box. The proving ring records the movement in box position, therefore recording the shear force. The shear displacement was observed with the dial gauge fitted to the container. This test is used to find out the cohesion (c) and the angle of internal friction (Φ) of the soil, these are the soil shear strength parameters. Direct shear test of clay was conducted with marble powder and sand, and clay, sand and marble powder altogether in various percentages. Angle of internal friction ϕ increases and cohesion declines when clay soil is mixed with sand and also when clay, sand and MP are added together. Thus angle of internal friction for clay can be improved by addition of sand and MP in certain percentages.

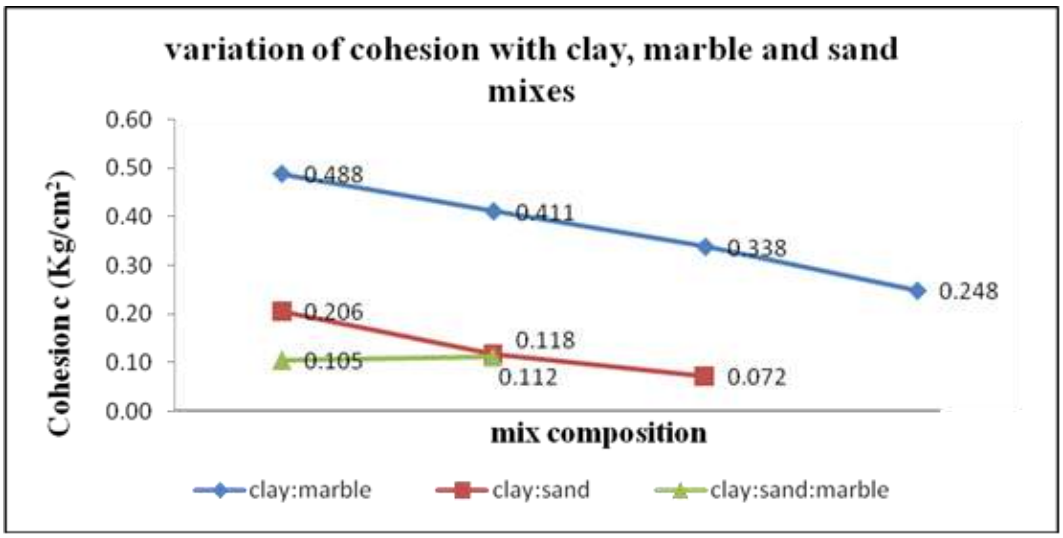

Fig 6. Variation of c with Clay, MP and Sand mix compositions.

V. CONCLUSION

- The addition of marble powder to clay: (a) reduces the liquid limit (LL), (b) raises the plastic limit (PL) and shrinkage limit (SL) and (c) reduce the plasticity index (PI) of soil, and hence swelling potential. The reduction of plasticity index was an indication of improvement of soil property. Thus marble powder can be utilized as additives in soil stabilization.
- The maximum dry density of mix compositions of clay increases with increasing percentage of marble powder and sand in clay and optimum moisture content decreases. This occurs due to the reason that the void spaces between the clay particles are occupied by marble powder and sand particles thus make mix compact.
- An increment was observed in CBR values of clay treated with marble powder and sand in both soaked and un-soaked condition. The improvement in CBR value may be attributed to better compaction and packing of the mix particles with addition of sand and marble powder. Thus, clay mixed with sand and marble powder can be effectively used in the construction of sub-grades of roads.
- The coefficient of permeability k (cm/sec) decreases with the increase in marble powder is due to marble powder is non-plastic and having colloidal fractions which forms gel. On addition of sand permeability increase as it provides more space to flow.
- In Direct shear test, angle of internal friction ϕ increases and cohesion decreases with increase in marble powder and sand compositions. Thus internal friction of clay can be improved by adding marble powder and sand this results in increasing shear strength of the soil.

VI. REFERENCES

1) Eskioglou, Panagiotis Ch. (1996). *Influence of soil type on stabilization with marble dust for forest road construction.* Department of Forestry and Natural Environment, Thessaloniki.
2) Sabat, Akshaya Kumar and Nanda, Radhikesh P. (2005). *Effect of marble dust on strength and durability of rice husk ash stabilized expansive soil*. Internat. J. Civil & Structural Engg., 1(4) : 939- 948.
3) Baser O (2009) *Stabilization of expensive soils using waste marble dust*. MSc Thesis in Civil Engineering, Middle East Technical University, Ankara.
4) AK Mishra, R Mathur, YV Rao, AP Singh and P Goel, *A New Technology for Marble Slurry Waste Utilisation*. in Roads, Journal of Scientific and Industrial Research, 2010, 69, 67-72.
5) NA Joulani, *Effect of Stone Powder and Lime on Strength, Compaction and CBR Properties of Fine Soils*, Jordan Journal of Civil Engineering, 2012, 6(1), 1-16.
6) R.P. Arora, N.K. Ameta and Kapil K. Samar (2014), "*Enhancement of Engineering characteristics by use of marble slurry in udaipur region*" research paper, International Journal of Agricultural Engineering.
7) Muthu Kumar M, Tamilarasan V S (2015), "*Experimental Study on Expansive Soil with Marble Powder*". International Journal of Engineering Trends and Technology (IJETT) – Volume 22 Number 11 - April 2015.
8) "*Soil Mechanics and Foundation Engineering*", by Dr. K.R. Arora.
9) Altmeyer, W.T. (1955), "*Discussion of Engineering properties of expansive clays*", PocASCE,