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# Effect of Marble Dust On Index Properties of Black Cotton Soil

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***Abstract*: This paper represents the results of a laboratory study undertaken to investigate the effect of marble dust powder on the index properties of black-cotton soil. The black-cotton soil features a poor supporting capacity and enormous 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 gauge the feasibility of commercial waste like marble dust as soil stabilization material. To investigate the effect of marble dust on index properties of black-cotton soil a series of laboratory experiments are conducted on black-cotton soil samples mixed with 0% to 10% of marble dust by weight of dry soil. The test results showed a big change in consistency limits of samples containing marble dust. The liquid limit would decrease from 67.49% to 52.01%. The plasticity index decreased from 37.16% to 10.43%. Also the differential free swell decreased from 60% to 14%, showing appreciable decrease in swelling behaviour. From this laboratory investigation it's concluded that the waste like marble dust generated from stone industries features a potential to switch the characteristics of expansive clay like black-cotton soil. There is significant improvement within the index properties of the black-cotton soil on addition of marble dust into it. The expansive behaviour of the clay has reduced to an excellent extent.**

***Keywords*: Marble dust, Black-cotton soil, Index properties.**

## 1. Introduction

The black cotton soil is expansive clay. The construction on expansive soil always creates a problem for civil engineers because of its swelling and shrinkage properties. When the black cotton soil comes in contact with water then excessive swelling occurs 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. The black cotton soil contains high percentage of montmorillonite mineral which imparts expansive behaviour to it. Disposal of waste materials generated from different industries causes many problems like environment pollution within the nearby locality, scarcity of land for disposal, etc. Industrial waste like furnace slag, fly-ash, silica-fume, rice husk ash and stone dust, etc., are considered as alternative materials for soil stabilization. From cutting and polishing of marble stone, the marble dust is generated. The amount of marble slurry generated is extremely substantial, being within the range of 5-6 million tons once a year. This project envisages the effect of marble dust powder on the index properties of black-cotton soil.

### *A. Marble dust*

Marble may be a rock resulting from the transformation of a pure limestone. The purity of marble is liable for its color and appearance; it's white if the limestone consists solely of calcite. Marble is employed for construction and decoration; marble is durable, features a noble appearance, and is consequently in great demand. Quartz, muscovite, tremolite, actinolite, micro line, talc, garnet, osterite and biotite are the main mineral impurities whereas $SiO_2$, limonite, $Fe_2O_3$, manganese, $3H_2O$ and $FeS_2$ are the main chemical impurities related to marble. The most impurities in raw limestone which may affect the properties of finished cement are magnesia, phosphate, leads, zinc, alkalis and sulfides.

## 2. Literature Review

### *A. Related Research: An Overview*

Singh and Vasikar (2013) investigated stabilization of Black cotton soil using lime. They concluded that an addition of 4% lime decreases the liquid limit by 12.1%, while addition of 6 % lime show a decrease of only 17.1%. It is observed that swelling pressure of Black cotton soil mixed with 4% and 6% lime decreased by 40% and 80% respectively. MDD is found to decrease by 2.4% and 5.6% at 4% and 6% lime content respectively.

Kumari Pratima et al. (2015) investigated swelling behavior of expansive soil mixed with lime and fly ash as admixture. They found that liquid limit of stabilize samples initially decrease with the addition of lime up to 6% and then increases. Free swell index of samples decreases with increasing lime content and the value of Free swell index becomes 0 at 8% of lime addition. The OMC of BC soil increases with increasing percentage of fly ash, however it decreases at 35% of fly ash and again increases at 40% fly ash. MDD decreases with increasing percentage of fly ash, however it decreases at 35%

of fly ash. OMC of BC soil increases with increasing percentage of lime and MDD decreases with increasing percentage of lime.

Nadgouda and Hegde (2010) investigated the Effect of Lime Stabilization on Properties of Black Cotton Soil. The results of their work indicated that liquid limit of soil decreased from 59.8% to 53.2% with increase in lime content up to 4.5% after that it goes on increasing with increase in lime content. Plasticity index of soil decreased from 25.9% to 15.1%. DFS decreases gradually with increase in lime content. MDD remains constant with variation in lime content whereas the OMC decreases with increasing percentage of lime.

Singh and Pani (2014) studied evaluation of lime stabilized fly ash as a highway material. They concluded that dry unit weight of compacted specimen decreased from 1.142 to 1.255 kJ/m3 with change in compaction energy from 118.6 kJ/m3 to 2483 kJ/m3, whereas the OMC is found to decrease from 30.2% to 24.2%. The highest unsoaked and soaked CBR values were found to be 25.39% and 1.546% at compaction energy of 2483 kJ.

Choudhary et al. (2015) studied the effect of lime on compaction characteristics of soil-fly ash mixtures. The results of their work indicated that OMC of the soil fly ash lime mix increases with increases with increase in percentage of lime and 20% fly ash and the MDD of the soil fly ash lime mix decreases with increase in percentage of lime.

Rajak and Pal (2015) investigated CBR values of soil Mixed with fly ash and lime. They concluded that the MDD value of soil decreases with increase in lime and fly ash content. The OMC value of the soil increases with increase in fly ash and lime content. The CBR value of the soil increases as increase in percentages of fly ash and lime.

Manjularani et al. (2015) investigated Augmenting the properties of Black cotton soil using additives they found that the MDD increases with decreasing in OMC up to 50% fly ash addition, thereafter MDD decreases with increase in OMC. Addition of 1 to 5% lime to optimum fly ash treated soil, MDD increase up to 3% lime addition, thereafter MDD decreases with increase in OMC.

Naik and A.S (2012) studied Geotechnical Characteristics of Black Cotton Soil Mixed with Fly ash: An Experimental Evaluation. They found that the index parameters of the study soil improve with the addition of fly ash. The liquid limit and plasticity index decreases with increase in percentage of fly ash. The plastic limit and shrinkage limit increases with the addition of fly ash from 10% to 60%. With respect to the compaction parameters, the maximum dry density is found to increase from 1.72 g/cc for FBC-10 mix to 2.07 g/cc for FBC-30 mix. However further addition of fly ash the MDD value is observed to decrease. The optimum moisture content decreases from 15% for FBC-10 mix to 5% for FBC-30 mix.

Rajput and Yadav (2015) studied the effect of fly ash on geotechnical properties of Black cotton soil. They found that LL decreased from 55.2% to 36.3% as fly-ash content increased from 0% to 50% similarly, Plasticity index decreased from 27.1% to18.1% and DFS decreased from 52% to 14% respectively. It has been observed that the optimum moisture content increased from 19.3% to 24.1% and maximum dry density decreased from 1.63% to 1.52% and maximum CBR value obtained at 20% fly-ash.

Raut et al. (2014) studied Stabilization of Expansive Soils Using Fly ash and Murrum. They concluded that as the percentage of murrum and fly ash increases the MDD and unconfined compressive strength increases up to a certain proportion and afterwards value decreases. The maximum MDD and unconfined compressive strength were found for proportion of 7.5 % murrum and 5% fly ash. As there is increase in percentage of Murrum additive, the plasticity of the clay murrum mixture decreases, and the MDD value increases and the corresponding OMC value decreases. As there is increase in percentage of fly ash additive, the plasticity of the clay fly ash mixture increases, and the MDD value decreases and the corresponding OMC value increases. As there is increase in percentage of murrum and fly ash combination as additive, the plasticity of the clay murrum fly ash mixture decreases and MDD value increases, the corresponding OMC value decreases but the values are small as compared to clay- murrum mix case. It has been observed that the strength of the Clay mixed with 7.5 % of murrum and 5 % fly ash combination as optimum combination to improve its properties.

## 3. Experimental Programmes

The purpose of this experimental study is to determine the change in engineering characteristics of black cotton soil on addition of marble dust in the black cotton soil. The various geotechnical properties and its values are determined for original black cotton soil and their variation on addition of different percentage of marble dust. Marble dust is used as stabilizer in the prepared samples and its percentage is varied from 0% to 10% by dry weight of soil. In this experimental study, the improvement in geotechnical properties of black cotton soil is monitored. The tests were conducted in the Geotechnical laboratory of Civil Engineering Department, St. Aloysius Institute of Technology.

### *A. Materials used*

Materials used in the laboratory research are black cotton soil and marble dust.

#### *1) Black cotton soil*

The soil sample is collected from St. Aloysius Institute of Technology, Jabalpur (MP). The black cotton soil collected from the site is brought to the laboratory for testing. Before testing it is assured that the soil is free from any organic matter, polythene, etc. The soil collected is oven dried for testing purpose. Black cotton soil is classified as clay of high plasticity (Gs = 2.58 with 95% fines) with expansive behaviour.
Physical characteristics of clay sample is presented in table 1.

Table 1
Geotechnical properties of black cotton soil

| S. No. | Properties | Values |
|---|---|---|
| 1. | Soil classification | CH (Clay of high plasticity) |
| 2. | Liquid Limit (LL) | 67.49% |
| 3. | Plastic Limit (PL) | 30.33% |
| 4. | Plasticity Index (PI) | 37.16% |
| 5. | Specific gravity (G) | 2.4 |
| 6. | Differential Free Swell (DFS) | 60% |
| 7. | Optimum Moisture Content (OMC) | 18.74% |
| 8. | Maximum Dry Density (MDD) | 1.69 g/cc |

Table 2
Summary of test results

| S. No. | Sample | Experimental results | | | | | |
|---|---|---|---|---|---|---|---|
| | | LL (%) | PL (%) | PI (%) | DFS (%) | OMC (%) | MDD (g/cc) |
| 1. | Unstabilized BC soil | 67.49 | 30.33 | 37.16 | 60 | 18.74 | 1.69 |
| 2. | BC soil + 2% Marble Dust | 62.73 | 41.28 | 21.45 | 55 | - | - |
| 3. | BC soil + 4% Marble Dust | 56.85 | 40.25 | 16.6 | 40 | - | - |
| 4. | BC soil + 6% Marble Dust | 55.65 | 39.68 | 15.97 | 25 | - | - |
| 5. | BC soil + 8% Marble Dust | 52.01 | 41.58 | 10.43 | 14 | - | - |
| 6. | BC soil + 10% Marble Dust | 52.78 | 41.69 | 11.09 | 14 | - | - |

*2) Marble dust*

The stabilizing material marble dust was purchased from Marble City located in Jabalpur district of Madhya Pradesh. A laboratory research was conducted on black cotton soil and marble dust mix in different proportions.

*B. Laboratory tests*

A series of laboratory test were conducted on black cotton soil mixed with different proportion of marble dust. Marble dust is added in 2%, 4%, 6%, 8% and 10% by weight of dry soil. Various soil samples mixed with different percentage of marble dust was prepared. Following tests were conducted on prepared samples as per relevant IS code of practice:

- Specific gravity test
- Wet sieve analysis
- Liquid Limit
- Plastic Limit
- Differential Free Swell (DFS) test
- Modified proctor compaction test

## 4. Results and Discussion

A series of laboratory tests were conducted on black cotton soil mixed with different proportion of marble dust i.e. 0%, 2%, 4%, 6% and 10% by dry weight of soil. Test results are summarized in Table 2.

*A. Discussion*

*1) Liquid limit*

Figure 1 shows the variation of liquid limit for different proportion of marble dust.

Figure 1 shows that liquid limit of black cotton soil decreases from 67.49% to 52.01% with increase in marble dust content up to 8% after that further increase in marble dust content there is no significant change in liquid limit.

*2) Plasticity index*

Figure 2 shows that plasticity index of black cotton soil decreases from 37.16% to 10.43% with increase in marble dust content up to 8% after that slight change observed with increase in marble dust content.

*3) Differential free swell*

DFS of normal black cotton soil was found as 60%. Figure 3 shows that DFS decreases from 60% to 14% gradually with increase in marble dust content up to 10%.

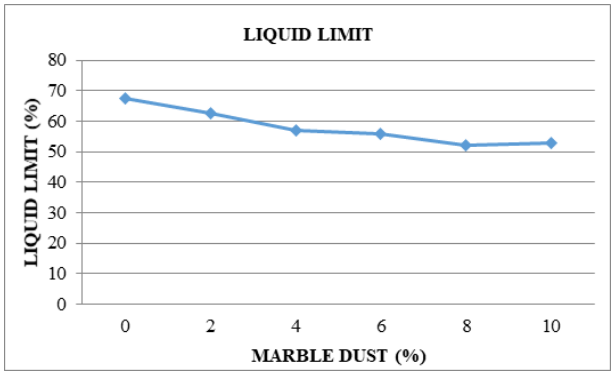


Fig. 1. Variation of liquid limit with increasing % of marble dust

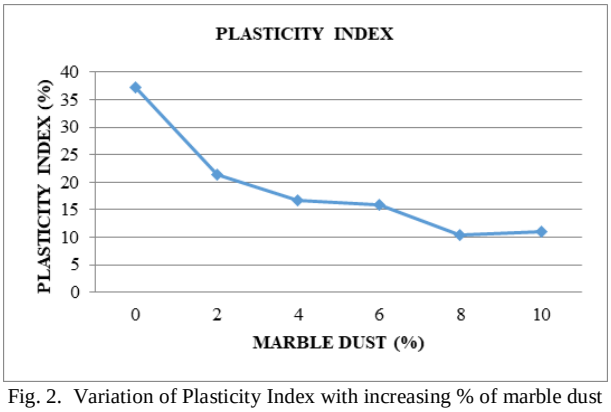


Fig. 2. Variation of Plasticity Index with increasing % of marble dust

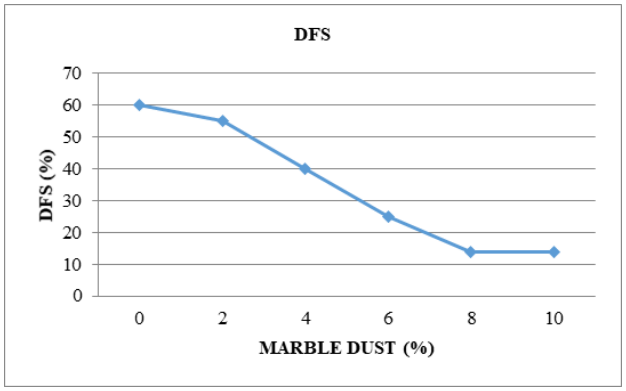


Fig. 3. Variation of DFS with increasing % of marble dust

## 5. Conclusion

From the test results obtained from series of experiments conducted on black cotton soil mixed with different proportion of marble dust (2%, 4%, 6%, 8% and 10%) the following conclusion can be drawn.

BC soil mixed with marble dust:

- Liquid limit of soil decreases from 67.49% to 52.01% with increase in marble dust content up to 8% after that there is no significant change with increase in marble dust content.
- Plasticity index soil decreases from 37.16% to 10.43% with increase in marble dust content up to 8% after that slight change is observed with increase in marble dust content.
- Differential free swell of soil decreases from 60% to 14% with increase in marble dust content up to 8% after that with further increase in marble dust content there in no change observed in DFS.

Therefore, it can be concluded that the optimum quantity of marble dust is found as 8% if the soil is stabilized with marble dust.

From the above laboratory investigation, it can be concluded that the industrial waste like marble dust has a potential to modify the characteristics of expansive clay like black cotton soil and to make it suitable in many geotechnical applications.

## 6. Future Scope of the Work

- Similar tests can be conducted with different combinations of other waste materials obtained from different industries.
- An economized comparison can be done among soil stabilized with different industrial wastes.
- Other properties like triaxial, shear, consolidation characteristics, swelling pressure may be studied for expansive soil containing different industrial wastes.
- Durability aspects of expansive soil with different combination of wastes.

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