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# Influence of Waste Marble Powder on Characteristics of Clayey Soil

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**Abstract:** ***Soil stabilization is came in the picture when we handle a soil which is weak in strength or show unusual behavior of excessive swelling and shrinking with in and out of water respectively. Clay is also shown similar kind of behavior. In India, it found in the Indian Deccan plateau which covers about 0.8x10$^6$ km$^2$ (approx. 20% surface area) area [1].There are many ways to stabilize the soil with different types of materials like cement, lime, geopolymers etc. but the authors choose Waste Marble Powder (WMP) which is the waste generated from the marble industry as the stabilizer for there search work. WMP has Calcium Oxide (CaO) as the major constituent in its composition which has binding properties itself. This waste is approximately 40% share of the total marble handled. The disposal of the waste marble is a big problem for the marble industry. To solve this entire problem, the best solution is to use the marble waste for good cause like soil stabilization. The authors added the marble waste in the soil as 10%, 20% and 30% by weight and compare the properties of parent soil with the stabilized soil. In this research work, the authors include the index properties like liquid limit, plastic limit and engineering properties like Compressibility and Permeability and California Bearing Ratio (CBR) for the comparison. With the increase in the percentage replacement OMC has been decreasing and MDD has been increasing. The value of CBR is also shows a progressive improvement with change in percentage of marble dust.***

**Keywords:** Marble, Clay, Stabilization, index properties, engineering properties, swelling

## 1. Introduction

### 1.1 Clay

Clay is an expansive soil which creates always a problem in design and construction of civil engineering structures for civil engineers. When clay soil comes in contact with the water swelling occurs in the soil and shrinks when water content decreases in the soil because of which structures are severely damaged. In India, the predominant states are Tamilnadu, Karnatka, Gujrat, Andhra Pradesh, Madhya Pradesh and Maharashtra [2]. It also found in some areas of Punjab at 2 - 2.5 m depth from the surface level. In the engineering terms, it is the fine grained soil which having particle size below 2 micron. The behavior of the soil extensively depends upon the water content. Plasticity Index is the main parameter to classify the fine grained soil. The water molecules are dipolar and attracted towards the clay surface. The phenomenon is known as adsorption. The behavior of clay soil depends largely upon the amount of different clay minerals illite, kaolinite and montmorillinite present in the soil. Among three, montmorillinite has the maximum ability to swell. These clay minerals impart cohesion and plasticity. The study of clay mineral is essential for understanding the behavior of clayey soils [12].

### 1.2 Waste Marble Powder

*Marble* is a shining stone which is recoginsedfor its uniform and smooth texture, colours, moderate hardness, and its ability to be quarried into big blocks, shiny and smooth polished surface which gives a silky feel. In geological terms, it is a metamorphic rock which is made by the metamorphism of the limestone under extreme thermal and pressure energy. The main states which are reported for the marble existence are Rajasthan, Haryana, Gujarat, Jammu & Kashmir, Madhya Pradesh, Uttar Pradesh, Maharashtra, Andhra Pradesh, Sikkim and West Bengal. Rajasthan alone has 95% processing capacity of the country [13].

*Waste marble powder (WMP)* is the by-product of the marble industry which is generated during cutting and grinding of marble. The waste generation is approximately 40% of the total marble handled per annum. It has relevance because annually about 68 million of marble is manufactured all over the world. The waste is produced from the industries in the form of both solid and slurry. The solid waste is generated on the mine sites or at the processing units and slurry is in the semi- liquid form generates during sawing and polishing operations. The disposal of marble waste in the open ground creates serious threats for the public health and for the environment. Besides it, a lot of space is also occupied which should be used for other purposes.. If marble waste mix with the surface water sources it contaminates the water and cause diseases. It may also percolate through the soil and affects the ground water. It also causes clogging of soil by lowering its permeability and also reduces the productivity of the soil.

## 2. Literature Review

**2.1 Er. Muthukumar and Er.Tamilarasan V S (2015)** adds the marble dust in the soil by percentage weight in proportion of 5% to 25% with an interval of 5%. He concluded that with increase in percentage of marble powder increases, the Liquid limit value decreases constantly with 5 to 25% proportion of marble powder from 70% to 55%, plastic limit value was increased by 25% approx., it was noticed that the Optimum moisture Content (OMC) of clay increased from 18% to 24% and maximum dry density (MDD) increases up to 10% and then starts decreasing with the addition of Marble powder. The initial increase in the UCS value was expected, the decrease in the UCS values after the addition of 15% [3].

**2.2 Ravi Shankar Mishra and Brajesh Mishra (2015)** conducted a soil stabilization using quarry dust as replacement with soil in percentage of 20, 30 and 40 and compare it with soil stabilize by the cement and lime. He observed that OMC increases from 23% to 25.1% with increase in the percentage of quarry dust and MDD decreases from 1.83gm/cc to 1.71gm/cc. UCS increases up to 30% with optimum value of 19.60kg/m2 and then decreases for 40% replacement. Plastic and liquid limits are also increased with increase in the percentage replacement but in very small range. Free swell index significantly decreases from 85% to 45% [4].

**2.3 Chayan Gupta and Dr. Ravi Kumar Sharma (2014)** conducted a research on the already stabilized soil (with fly ash – sand) by replacing soil with different proportion of marble dust from 0% to 20% in interval of 4% which shows 15% replacement gives optimum results. The mix gets MDD at proportion of soil-sand-fly ash-marble dust as 52.36%-22.44%-13.20%-12%. California Bearing Ratio (CBR) value in soaked condition increased by 200% with the addition of sand, fly ash and marble dust in the above mentioned proportion [5].

## 3. Tests Performed

Specific Gravity test [6]
Liquid Limit (LL) test [7]
Plastic Limit (PL) test [8]
Standard Proctor Test[9]
California Bearing Ratio (CBR) test[10]
Permeability test[12]

## 4. Properties of Materials and Methodology

### 4.1 Clay

Clay which is used for the research work is brought from a dry pond in Lehri village about 20km from Talwandi Sabo, Bathinda, Punjab.
Liquid Limit – 31.70 %
Plastic Limit – 17.70%
Plasticity Index – 14%
Type of Clay -Low Compressibility type.
Specific Gravity – 2.66
OMC – 18.00%
MDD – 1.738 gm/cc
Fineness Modulus - .057

**Table 1:** Particle Size Distribution of Parent Soil

| *IS sieve (mm)* | *Mass of soil retained* | *% retained* | *Cum% retained* | *% finer* |
|---|---|---|---|---|
| 4.75 | - | - | - | 100 |
| 2.00 | - | - | - | 100 |
| 1.00 | - | - | - | 100 |
| .600 | - | - | - | 100 |
| .425 | .64 | .13 | .13 | 99.87 |
| .300 | .70 | .14 | .27 | 99.73 |
| .212 | 2.12 | .42 | .69 | 99.31 |
| .150 | 2.48 | .49 | 1.18 | 98.82 |
| .075 | 22.40 | 4.48 | 5.66 | 94.34 |
| Pan | 471.66 | 94.34 | 100 | |

### 4.2 Waste Marble Powder

The waste marble powder is brought from the Makrana, Rajasthan through a marble dealer of BhuchoMandi, Punjab. The marble is named as makrana marble which is a calcite type of marble.

**Table 2:** Components of WMP

| Compound | mass % |
|---|---|
| calcium oxide (CaO) | 50-56 |
| Silica | .33-1.20 |
| Alumina | 0.42-.86 |
| iron oxide | .10-.28 |
| magnesium oxide | .8-1.8 |

Specific gravity – 2.65
Fineness Modulus - .692

**Table 3:** Particle Size Distribution of WMP

| *IS sieve (mm)* | *Mass of soil retained* | *%retained* | *Cum % retained* | *% finer* |
|---|---|---|---|---|
| 4.75 | - | - | - | 100 |
| 2.00 | - | - | - | 100 |
| 1.00 | - | - | - | 100 |
| .600 | - | - | - | 100 |
| 0.425 | 3.59 | 0.72 | 0.72 | 99.28 |
| 0.3 | 55.45 | 11.09 | 11.81 | 88.19 |
| 0.212 | 87.79 | 17.56 | 29.37 | 70.63 |
| 0.15 | 70.97 | 14.19 | 43.56 | 56.44 |
| 0.075 | 128.15 | 25.63 | 69.19 | 30.81 |
| Pan | 154.05 | 30.81 | 100 | |

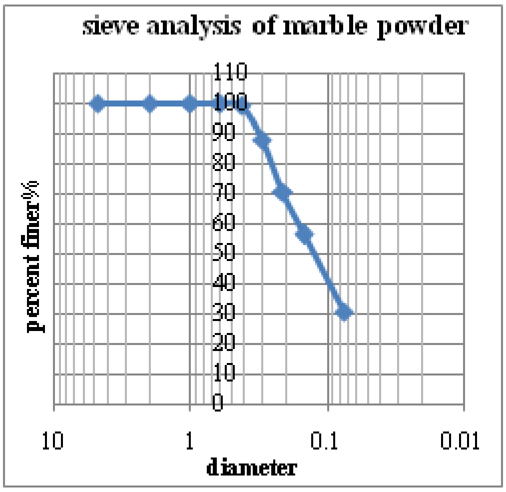


**Figure 1:** Particle Size Distribution curve for WMP

## 4. Methodology

- First of all some previous researches are studied to check out expected outcomes with the use of marble dust. From the study we can also conclude about the possible percentage of the waste replacement with which we can observe some significant results and also the trends which are followed in the results.
- Select the source for the soil and marble waste used for the research work.
- Make a rough estimate of quantities for all materials and procure them accordingly.
- Lab testing of characteristics of the waste marble powder according to the requirement in the study.

- Prepare the soil sample for the various tests of soil as per the instructions given the respective test code.
- Trying the marble waste in the soil as replacement in interval of 10% up to 30%.
- Following lab tests are performed to check the change in the properties of soil by replacement -: Plastic limit test, Liquid limit test, Plasticity index, Optimum Moisture Content (OMC) and Maximum Dry Density (MDD), Permeability test, California Bearing Ratio (CBR) test.
- Show the all results in tabular and graphical forms to understand it better.

## 5. Results and Discussions

### 5.1 Effect of WMP on Liquid Limit

**Table 4:** Effect of WMP on Liquid Limit

| S.No. | WMP % | LL % |
|---|---|---|
| 1. | 0 | 31.70 |
| 2. | 10 | 28.10 |
| 3. | 20 | 26.40 |
| 4. | 30 | 25.00 |

As per shown in the table LL decreases with increase in the percentage of WMP. Due to the coarser particles of WMP surface area of the mix (marblepowder + soil) is decreased. However, it requires less water content to reach its liquid limit.

### 6.2 Effect of WMP on plastic limit

**Table 5:** Effect of WMP on plastic limit

| *S. No.* | *WMP %* | *PL* |
|---|---|---|
| 1. | 0 | 17.69 |
| 2. | 10 | 18.10 |
| 3. | 20 | 18.78 |
| 4. | 30 | 19.26 |

### 6.3 Effect of WMP on plasticity Index

**Table 6:** Effect of WMP on plasticity Index

| S. No. | WMP % | PI % |
|---|---|---|
| 1. | 0 | 14 |
| 2. | 10 | 10 |
| 3. | 20 | 7.62 |
| 4. | 30 | 5.74 |

### 6.4 Effect of WMP on OMC and MDD

**Table 7:** Effect of WMP on OMC and MDD

| *S.No.* | *WMP %* | *OMC %* | *MDD gm/cc* |
|---|---|---|---|
| 1. | 0 | 18.00 | 1.738 |
| 2. | 10 | 17.20 | 1.795 |
| 3. | 20 | 16.80 | 1.805 |
| 4. | 30 | 14.10 | 1.884 |

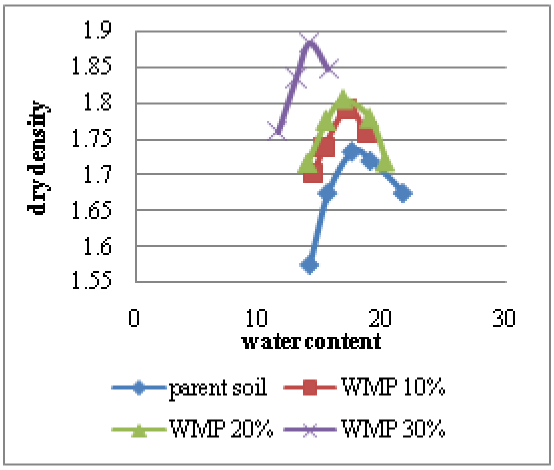


**Figure 2:** Effect of WMP on OMC and MDD

The reason behind increase of MDD is due to the occupation of the void spaces of waste marblepowder by the clay soil particles and cementitious effect of CaO present in the WMP and decrease of OMC is due the increase of the coarser particles in the mix.

### 6.5 Effect of WMP on CBR

**Table 8:** Effect of WMP on CBR

| S.No. | WMP % | CBR |
|---|---|---|
| 1. | 0 | 2.46 |
| 2. | 10 | 4.78 |
| 3. | 20 | 5.53 |
| 4. | 30 | 6.07 |

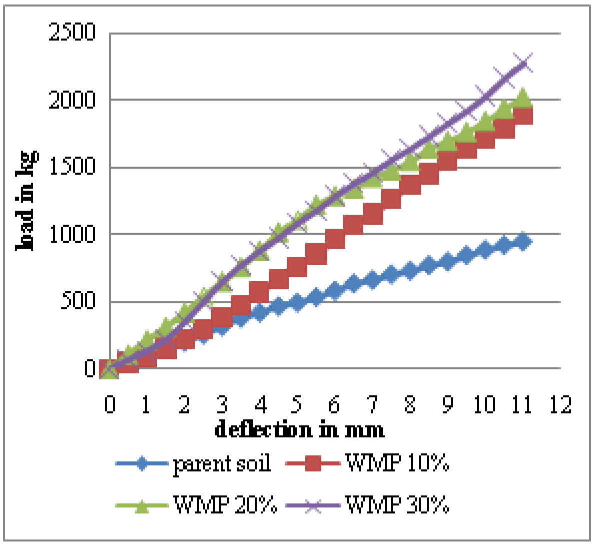


**Figure 3:** Effect of WMP on CBR

The reason behind the increase in CBR value is both due to coarser particles as well as lime present in the waste marble powder which behaves as cementatious material. Due to this reason the bond between clay particles and waste marble powder becomes strong and the load bearing capacity has been increased.

### 6.6 Effect of WMP on Permeability

**Table 10:** Effect of WMP on Permeability

| S. No. | WMP % | Coefficient of Permeability (mm/sec) |
|---|---|---|
| 1. | 0 | $3*10^{-4}$ |
| 2. | 10 | $4*10^{-4}$ |
| 3. | 20 | $2*10^{-4}$ |
| 4. | 30 | $2*10^{-4}$ |

By the addition of marble dust more compact structure of soil is gained with fewer pores and pores are filled with cementitious products formed during the reaction. This may be a valid reason for the decrease in the permeability of the soil mix by replacement of soil with WMP. 10% replacement of soil with WMP shows an increase in the permeability because coarser particles in WMP which predominates at the situation. At 20% replacement of soil with WMP shows a decrease in the permeability because with the increase in amount of WMP, lime content also increases which may be predominates in the situation and the soil mix is gotten more compact.

## 6. Conclusion

This study is carried out to keep in mind the best possible utilization of the waste marble powder in soil stabilization by replacing the soil with waste marble powder in the proportion of 10%, 20% and 30%. The study shows that inclusion of waste marble powder makes it a good alternative for the soil stabilization.

On the basis of research work conducted, following conclusions are come out: -

- Liquid limit of the stabilized soil is decreased from 31.70% for parent soil to 28.10%, 26.40% and 25.00% with partial replacement of soil with marble powder as 10%, 20% and 30% respectively.
- Plastic limit of the stabilized soil is increased from 17.69% for parent soil to 18.10%, 18.78% and 19.26% with partial replacement of soil with marble powder as 10%, 20% and 30% respectively.
- Plasticity index of the stabilized soil is decreased from 14 for parent soil to 12.10, 7.62 and 5.74 with partial replacement of soil with marble powder as 10%, 20% and 30% respectively.
- OMC of the stabilized soil is decreased from 18.00% for parent soil to 17.30%, 16.80%, and 14.10% with partial replacement of soil with marble powder as 10%, 20% and 30% respectively.
- MDD of the stabilized soil is increased from 1.735gm/cc for parent soil to 1.795gm/cc, 1.805gm/cc, and 1.884gm/cc with partial replacement of soil with marble powder as 10%, 20% and 30% respectively.
- CBR of the stabilized soil is increased from 2.46 for parent soil to 4.78, 5.53 and 6.07 with partial replacement of soil with marble powder as 10%, 20% and 30% respectively.
- From the above study it is clear that the waste marble powder is being used as a soil stabilizer.

## 7. Future Scope

In my present research work I can't perform all tests which are possible to do on soil. So there is a vast scope of study with the same material. In my research work I can perform liquid and plastic limit test, standard proctor test for OMC and MDD, UCS test, CBR test and permeability test. There are many more tests for the determination of consolidation properties of clayey soil which are not included by me in my study and there are more tests for the shear strength determination like direct shear test, triaxial test under different load conditions to determine more accurate values. In my research work I can include only marble dust for replacement. As per the literature review, we may use two or more wastes simultaneously for the study and find out the optimum values of them by replace constant value of one waste and vary others or vary all the wastes and with many more other combinations. We may find out all the index and engineering properties of the waste itself.

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