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Improving the Mechanical Properties of Fine Soil using Marble Waste

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***Abstract*—**In past many researchers used industrial waste to improve soil stabilization as low cost material and to save environment. Keeping this in mind, an attempt is made to evaluate the use of Marble Waste Powder (MWP) to stabilize the spacious clay. Marble industry is producing substantial amount of slurry with fairly good engineering characteristics. In this study, the marble waste slurry has been added to the soil to reduce the permeability of the dam cores. MWP was mixed with the soil with different varying proportions. Laboratory experiment include atterberg limits, liquid limit, hydrometer test, falling head permeability test, moisture density relation test, sieve analysis were performed on the treated and untreated soils. The result revealed that addition of 10-15% of MWP to the soil significantly improve in the density and strength and at the same time reduction in the permeability and plasticity of the stabilized soil with respect to varying moisture conditions is also very much improved..

***Keywords*—** Marble waste powder, stabilization, expansion soil, properties, dam core

I. Introduction

Construction of any structure requires stable ground for its foundation to rest on it and with least possible movement to enhance the life span and utility of the structure. Expansive soil is also called black cotton soil, because of its color and suitability for cotton crops. Expansive clay is the type of soil with most movement compared to sand and gravel because it undergoes heave when it absorbs water and undergoes hogging when it loses water. So that to improve the engineering properties, the expansive soil should be enhanced with soil stabilization method.[1]

Construction on expansive soils has always been a problem for geotechnical engineers so as construction on the weaker soils that inhibit excessive seepage thus making the structures even weaker and less durable. On the other hand the industrial waste disposal has become a major problem all across the globe. The sustainable solution for which is the reuse of the industrial waste rather than disposing it off as it creates more and more health hazards as a result. On the other hand if the disposed material improves the engineering properties of the soils it is an extra edge for the soils.

II. Background

Soil Stabilization is in practice for centuries now, it is required when the soil available for construction is not suitable for the intended purpose. It is used to reduce the permeability and compressibility of the soil mass in the earth embankment and to increase its shear strength [2]. Cohesive soils are most commonly used in dam cores due to their low permeability characteristics but these soil show a quite high degree of loss of strength on wetting. Due to their low strength flat slopes angles are usually required to resist the geostatic stresses. This cause an increase in the size of the core and hence the cost. If the soil is stabilized to increase the strength with a reduction in permeability economical dam cores can be designed. The marble powder classified as Dolomite is a natural agglomerate of Calcium magnesium carbonate, white in colour has a rock forming material that contains extraordinary affinity for water absorption and dispersion.

III. Litrature Review

Marble industry is producing huge quantity of powdered marble waste as increasing in demand for marble product in the construction industry rises the generation of MWP. During the process of cutting marble rocks, the dust of the marble and water mixes together and become waste marble mud where around 25% marble is resulted in dust. The waste produced during the cutting and grinding of marble is very fine but non-plastic (rock flour) and almost well graded.[4]-[7] The particle size of the powdered waste depends on the strength of marble, type of the cutter or grinders and the pressure applied during cutting and grinding. Hard marble and low cutting produces finer particles and vice-versa.[8] The marble powder although non plastic contains an appreciable colloidal fraction that forms a gel which significantly reduces the permeability and allows deformation without cracking which is desirable for dam cores.[9]

This paper aims to study the use of MWP in different proportion with soil in order to enhance the engineering properties like strength, permeability and plasticity. The current world is facing the shortage of naturally suitable materials for construction, the flip side of this problem is the excessive environmental pollution as a result of this industrialization, the by products are so gigantic in size that they are required to be utilized or quickly being properly disposed. One of the biggest source of pollution is Carbon dioxide, which is causing the depletion of the ozone layer, cement industry alone is generating 10 percent of the total Carbon dioxide produced globally.[10] Researchers focus mainly now on decreasing the pollution sources, by changing fuels, so is the case for construction industry, there are efforts made to utilize the by products like Polyethene, rice husk, baggase ash and marble dust to improve the properties of soil and concrete and the results are fruitful so far. The industrial by products are used as a partial replacement with the conventional material, so they can be called as admixtures, so that the natural resources are sustained for long now.[11] The marble waste can be used in other industries like ceramics, white cement, bricks, infiltration plants and tiles. Other areas of utilization are clinker production and filler materials along with usage in bitumen made pavements.

Okagbue and Onyebi replaced a portion of soil with Marble dust and found a considerable increase in the engineering properties of the soil, after the tests the plasticity of the soil was reduced by 20 percent to about 33 percent and the CBR increased by 27 percent to 55 percent.

Cai et al. investigated the use of lime with soil through Scanning Electron Microscope and found that there was a reaction between lime and the soil, which changed the soil fabric permanently causing an improvement in strength properties of the soil.Al-Mukhtar et al. proved the phenomenon and termed the reaction between the soil and lime as Pozzolanic reaction, that occur micro structural level, not visible with naked eyes. Marble dust decreased the swelling potential of the soil and increased the Unconfined Compressive strength of the soil. In extreme conditions lime was helpful against the freeze and thaw action.

Wishwanthan et al. found that lime and fly ash class F can be used as good stabilizers for sandy and silty bases for highways.

Abdullah Demirbas and Ismail Zorluer found that addition of the lime and fly ash showed an increase in strength after 28 days of curing, because the reactions are slower in the start, an estimated of 3.5 times in strength occurred later on.

Hassini concluded that the impermeable layers cycled much at landfills by performing experiments about freezing and thawing to quantify shear strength and permeability, it was found that 10-15% of grain loss did not had any effect on the strength of the soil.

Zorluer mixed marble dust in variable proportions with soil and then compacted it according to Standard Proctor Compaction test, he also checked for swelling potential in consolidation test, and found that marble dust improved the soil quality against swelling, also the mixing of marble dust with the soil showed an increase in unconfined compressive strength.

Altug SAYGILI found that after mixing clayey soils with different marble dust proportions the engineering properties of soils are substantially improved, the samples were classified into two classes as a result of their plasticity, it was found that high plasticity samples showed better performance in direct shear test and swelling test while the low plasticity test showed better performance in unconfined compressive strength test.

IV. PROBLEM STATEMENT

Marble industry is producing tons of waste each day which is of no use and causes a lot of health hazards and environmental issues it should be used properly to improve soil properties.

V. OBJECTIVES

The objective of the study is soil improvement for increasing the strength and control the seepage under dams, with the aim to cope with abundant production of marble waste to use in improving the soil properties and improve environment.

SCOPE: The results are applicable to cohesive fine grained soils with medium plasticity and the waste comprised of the fine marble powder type.

VI. EXPERIMENTAL PROFRAMME

SOIL SAMPLE COLLECTION:

The soil samples were collected from the site of Jalozai small dam, 25km from main GT road on Pabbi-Cheratroad. Samples were collected from 2.5m depth pit-hole. Soil was stiff clay and dark brown in colour as shown in Figure 1.

Figure 1: The Expansive Soilat the Borrow Area

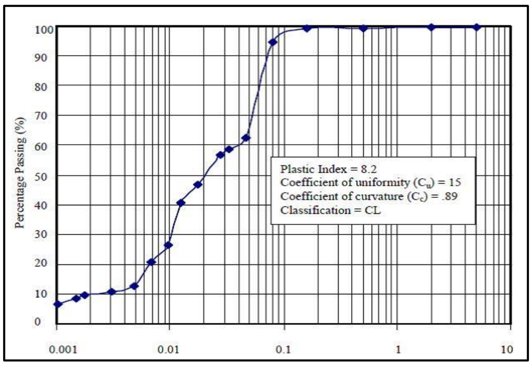
MARBLE WASTE POWDER:

Marble waste was obtained from factories at Warsak Road Pirbala at about 30km from Peshawar. Then the marble stone were crushed into powder as shown in Figure 2.

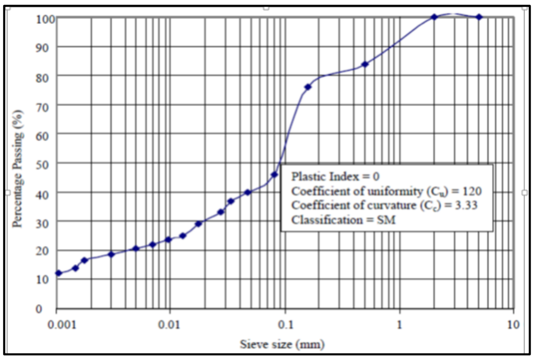
Figure 2: The Marble Sample as Sold and Powder

PREPARATION AND TESTING

A laboratory testing program was conducted on soil mixed with MWP. Laboratory experiments included atterberg limits (liquid and plastic limit), permeability test, hydrometer test, falling head permeability test, moisture density relation test, sieve analysis. Classification and gradation curves for soil marble powder are shown in the Figure 3.



Soil (Marble Powder-0%)



Marble powder

Figure 3: Gradation curve for Soil and marble powder

Marble slurry (white marble) was mixed with the soil and the gradation curves for the different mix ratios (5, 10 and 20%) were drawn and shown in the Figure 4. The Coefficient of uniformity (Cu) and the coefficient of curvature (Cc) were calculated for each gradation curve. The values were then plotted with respect to varying percentages of the marble slurry and are shown in the Figure 5.

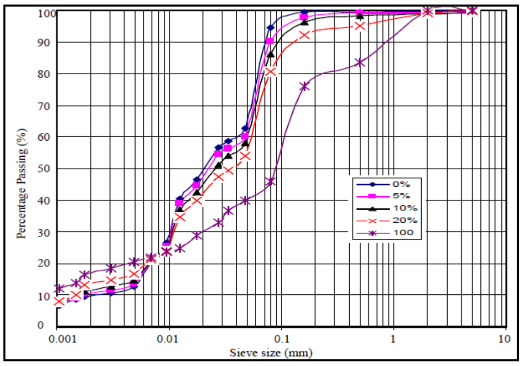


Figure 4: Gradation curve of soil mixed with varying percentage of marble powder

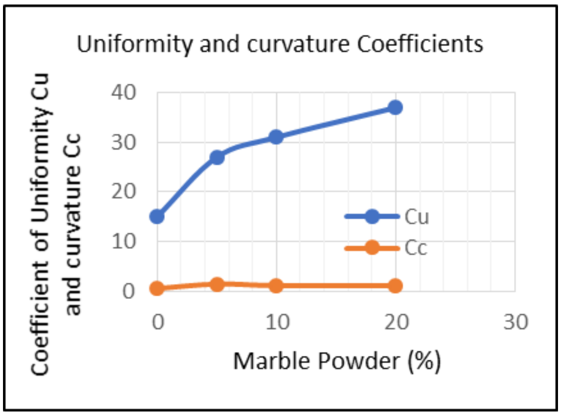


Figure 5: Variation of Cu and Cc of soil mixed with varying percentage of marble powder

The moisture density relationship of the soil- marble powder mixtures, standard proctor compaction test (using 2.5 kg rammer) was performed. The curves were plotted as shown in the Figure 6. The maximum dry density and the optimum moisture content for different mixes were determined.

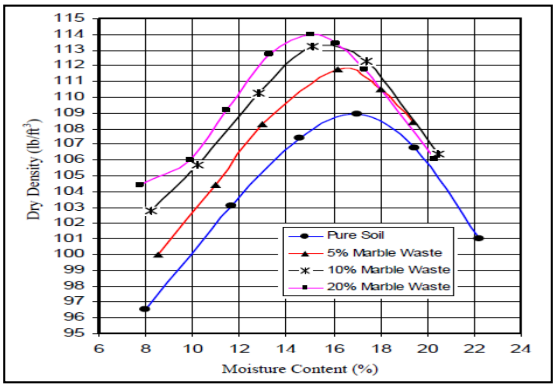


Figure 6: Moisture density curve of soil mixed with varying percentage of marble powder

In order to study the effect of marble slurry percentage on the maximum dry density and the optimum moisture content, curves were plotted and shown in the Figure 7 and Figure 8.

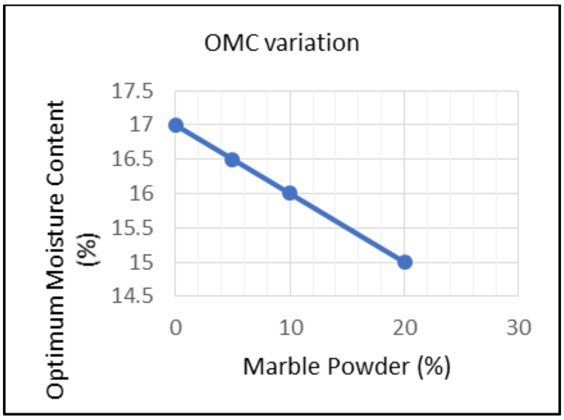


Figure 7: Variation in Optimum Moisture Content with varying Percentage of Marble powder

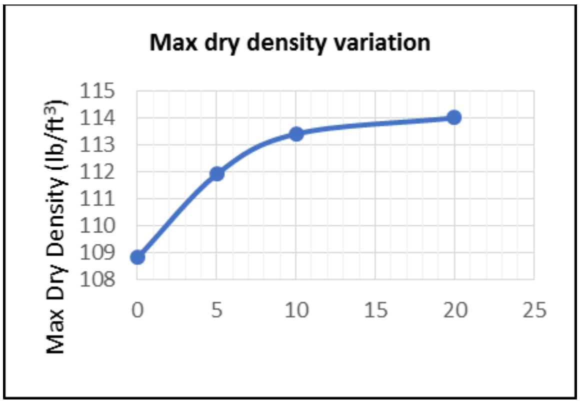


Figure 8: Variation in max dry density mixed with varying Percentage of Marble powder

Different soils-marble powder mixtures were compacted in the permeability test moulds, in three layers using static compaction. The compaction was made at optimum moisture content achieving the maximum dry density as determined in the compaction tests. The permeability value for each mix ratio was determined. The curve of permeability values versus marble powder is plotted and shown in the Figure 9

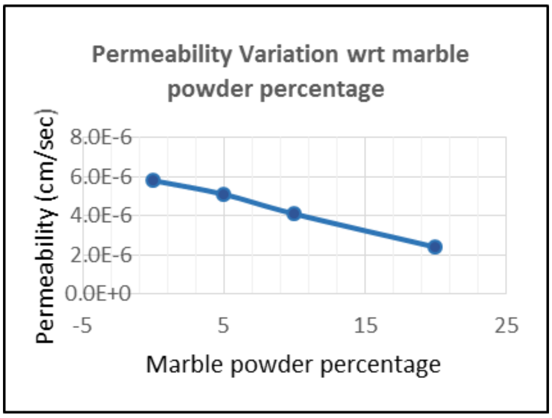


Figure 9: Variation in Permeability of Soil mixed with varying percentage of marble powder

VII. Results and Discussion

Based on size distribution and atterberg limits the soil was classified as poorly graded lean clay of medium plasticity as per USCS standards, it was designated by CL. On the other hand, the marble powder was classified as well graded with non-plastic properties with particle size comparable to that of silt and sand with approximately 13% of particles smaller than 0.001mm (gradation curve shown in Figure 3) according to USCS, classified as SM. Results showed that the addition of marble powder improved the gradation of the soil from poorly graded to nearly well grade with the maximum dry density increased with the increase in the percentage of the marble slurry. The optimal economical dose of marble powder was about 10%. For compaction, the optimum moisture content (OMC) decreased with the increasing percentage of marble powder. Being classified as uniformly graded, it helped in improving structure of the soil having more voids initially to comparatively lesser voids later on, the coefficient of permeability decreased with increasing percentage of the marble slurry.

Conclusion and Recommendations

Overall the study met its desired results of confirming the addition of marble waste to the soil as a 10-15% replacement of soil is feasible for improving the mechanical properties of the soil, by being able to utilize a waste material which is hazardous for health of the near living community mostly causing the breathing problems. Based on the experimental results obtained from this study, finding new utilization areas for waste marble powder will decrease environmental pollution and by the utilizing these wastes material in problematic soils have great contribution to the economy and conservation of resources. Marble powder waste is an excellent material for mechanical stabilization of plastic/ cohesive soils. The soil stabilized with marble powder will give more stable and economical dam cores.

The limit of the marble powder for the maximum improvement in properties ranges from 10-15% however the type of soil and the marble powder will affect the upper limit in other cases.

Depending on the requirement of stabilization, the mix may require to be designed for each project. The results are representative of the white marble slurry and may not be applied to all types of the marble wastes.

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CONFLICT OF INTEREST

All the authors declares that there is no conflict of interest.

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