Improvement of Subgrade Soils by Using Marble Dust-(Libya, Case Study)

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Abstract—**the practice of using waste materials to modify the properties of poor soils has become increasingly important in geotechnical engineering. In recent years, much research has been devoted to the effect of this waste material on soil properties. This study aims to address the influence of marble dust powder on the performance of subgrade. Thus, soils mixed with different percentages of marble dust were tested. The CBR test and modified proctor have been used to evaluate the performance of the soils mixed with marble dust. The statistical analysis illustrated that marble dust significantly enhanced the properties of the soils. The study concludes that an addition of 10% of marble dust to untreated (control) soils yields the most satisfactory results among other percentages of marble dust. The study recommends the use of marble dust in geotechnical construction.**

Index Terms: **Marble dust; Subgrade; CBR; Waste materials**

I. INTRODUCTION

Subgrade properties specify the thickness of pavement layers [1]. In preparation of subgrade for road construction, using a wide range of normal materials is, generally, inescapable because of financial and natural contemplations [2]. In this way, distinguishing and treatment of poor subgrade soils is a fundamental goal [3]. Replacement of poor soil is one of the usual options [4, 5]. Nevertheless, it is expensive and unrealistic in the road projects because of the massive volume of these works [6, 7].

Enhancement of poor soils utilizing lime, Portland concrete, and different synthetic concoctions is a successful solution [8-10]. Notwithstanding, utilizing these admixtures increase the total amount of budget. As of late, using industrial by-products in the improvement of poor soils is popular as it improves the environment and diminishes the expense. marble dust is one such waste materials [11-13]. The marble dust is produced from the cutting and sharpening of marble stone [14].

The measure of marble slurry created each year is in the variety of 5-6 million tons [15]. The marble dust powder has a huge amount of lime content and had been suggested by numerous specialists, which helps in Stabilization [16]. Several studies[13, 15, 17] examined the enhancement of red tropical soils by the addition of marble dust powder in different percentages. Plasticity was decreased by 20 % and compressive strength and CBR improved by 30 to 46% and 27 to 55% separately [18]. The greatest value of compressive strength and CBR was attained at 8% marble dust. Another study [19] has examined the impact of marble dust addition in various percentages (10,20,30,40,50%) on the properties of dark cotton soil. The results showed that the liquid limit possible decline from 57.67% to 33.9% and the shrinkage limit improved from 8.06% to 18.39%. However, this study has not investigated the effect of these percentages on the strength of the poor soils.

The production of a cheaper and more robust soil layer by using these wastes can help the civil engineer to ensure the economy in the infrastructure project and address environmental degradation [20]. This paper highlights the feasibility of using marble waste and mixing it with soil to achieve the economy and preserve the environment. This research provides a laboratory-oriented study to examine the impacts of marble powder on the properties of the weak subgrade utilizing CBR testing approach and modified proctor test. Several CBR tests and modified proctor tests were executed on a number of untreated models and soil treated with various percentages of marble dust (5%, 10%, 15%, 20%, and 25% by total weight of soil). This study aims to provide the optimum content of marble dust that yields the highest value of CBR and maximum dry density. Statistical analysis is used to show the significance of adding different percentages of marble dust.

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II. MATERIALS

The materials used in this research are clay soil and marble powder.

A. *The untreated Soil*

The soils used in this study were brought from near El-Marj military airport. The soils have the following properties:

- The sieve analysis for untreated soils is shown in figure 1.

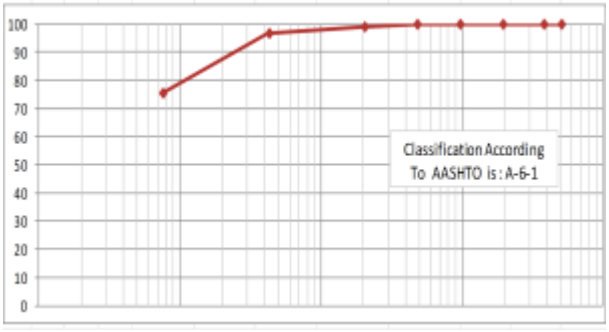

Figure 1 Sieve Nnalysis and Classification of Clayey Soil

- Atterberg Limits for untreated soils were obtained as follows:
  - Liquid Limit 39.21%.
  - Plastic Limit 22.36%.
  - Plasticity Index 16.85%.
- According to the AASHTO classification method, the untreated soils were classified as A-6, which means the soil is clayey soils
- Optimum moisture content (OMC) = 1.2%, Maximum dry density (MDD) = 15.7kN/m^3, CBR = 3.65%, UCS= 56.87 KN/m^3

B. *Marble dust*

The marble dirt shown in figure 2, had been produced from reducing and sharpening of marble stones. The main constituent of marble dirt is calcium carbonate (90 %) which assists in the stabilization of the soil. Figure 3 illustrates the sieve distribution of marble powder.

Figure 2 Marble Dust Used in this Study

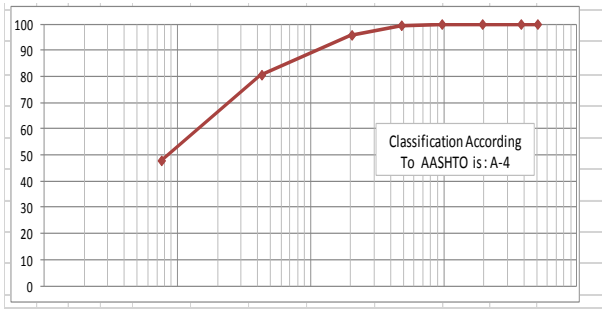

Figure 3 Sieve Analysis Classification of Marble Dust

III. METHOD

Besides the tests achieved to ascertain the properties of materials utilized (control soil and modified soil), a progression of tests was done utilizing the CBR method (according ASTM D1883) to evaluate the potential strength of soil (untreated and treated). The modified proctor test was conducted according to ASTM D1557 on treated and untreated soils to determine the optimum moisture content at which a given soil type will become most dense and achieve its maximum dry density. To set up the samples for testing, five percentages of marble powder (5%, 10%, 15%, 20% and 25% by the weight of soil) were added to the soils. Also, a sample was made for the control sample without including marble dust. The CBR test and modified proctor test were employed on all samples to determine the optimum value of CBR. All measurements were repeated three times and the average value was recorded.

IV. RESULTS AND DISCUSSIONS

A. *California Bearing Ratio (CBR)*

The California bearing ratio test was done on the 3 soil samples with 5 various portions of marble powder. Marble dusts were mixed to soil in various percentages (5,10,15,20,25%) respectively. The results of the CBR test are illustrated in figure 4. The figure proved that the addition of percentages of marble dust improves the CBR of the soils. The maximum value of CBR attained was 12.15 % (soils blended with 25% of marble dust). The lowest value recorded was when the soil is untreated with marble dust (CBR was 3.65%%). This enhancement in the MDD value was due to the gradual formation of cementitious mixtures (calcium silicate hydrate) owing to the reaction between the calcium carbonate present in the marble powder, soil, and water

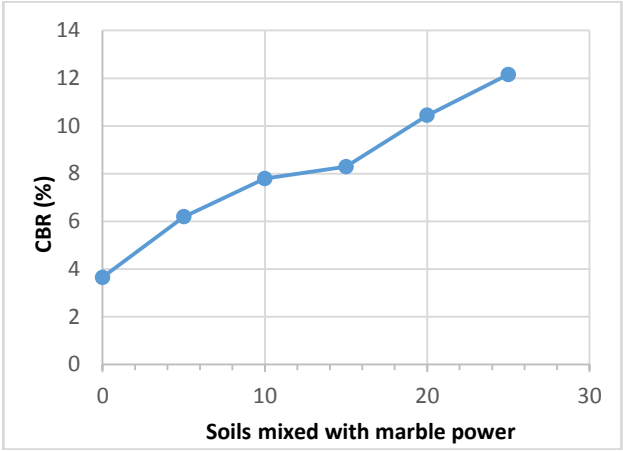

Figure 4 The CBR Values of Untreated and Treated Samples with Different Percentages of Marble Dust

B. *Maximum Dry Density (MDD)*

The standard proctor test was operated on the soil sample with five percentages of marble dust powder. Marble dust was blended with the soil in diverse portions (5,10,15,20 and 25%) respectively. The maximum value of MDD was attained 1.74 g/cm3 as 10% of marble dust. While MDD of untreated soils was 1.6 g/cm3. Figure 5 presents the results of the test for all samples. The Dry density for all different samples increases as the water content increases till it reaches a maximum value of dry density and then it starts slightly to decrease.

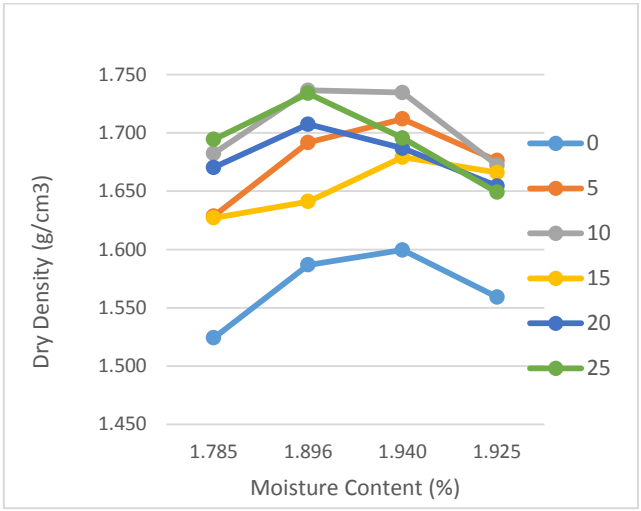

Figure 5 Effect of Marble Dust on Dry Density

Figure 6 presents the MDD for different samples. The MDD increases as the percentages of marble dust percentage (MDD for untreated soils is 1.6 g/cm^3 while MDD for soil mixed with 10 % of marble is 1.74 g/cm^3). The results also showed that by increasing marble percentages of more than 10%, the MDD starts to decrease. This due to soil particles become large-sized clusters, causing a texture change. This process develops a flock formation. This increase in the void ratio reflects the lower in MDD.

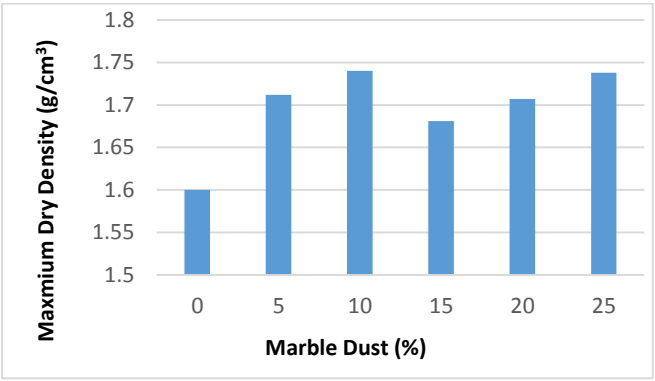

Figure 6 Effect of marble dust on MDD

C. *Statistical Analysis*

Statistical analysis was done to exhibit the significance of the addition of marble powder in the soils on the MDD and CBR. ANOVA test was used in this study to analyze the results statistically.

The statistical analysis shown in Table 1, states that P-value is smaller than 0.05 and F-stat is larger than F-Critical, which indicates that adding various percentages of marble dust powder to the soils significantly enhances the soil properties.

This result agrees with previous research conducted [16] where the soils were observed to be more improved when mixed to marble dust, however, the previous studies have not revealed in-depth the influence of using various percentages of marble dust on the stability of the soils.

Table 1. The Output from Statistical Analysis ANOVA Test on Influence of Marble Dust Content on CBR and MDD

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	354.05	2	177.02	5.498	0.0161	3.682
Within Groups	482.97	15	32.198			
Total	837.02	17				

V. CONCLUSION

In this paper, the effect of using different percentages of marble dust in soft soils is studied. The experiment involved utilizing different marble dust percentages: 5%, 10%, 15%, 20%, and 25%, by the weight of soils. A comparative assessment was made to evaluate these different marble dust percentages to the untreated (control) soils. Based on the findings of this study, we conclude that:

- It was shown that adding marble dust to soft soils significantly increased the maximum dry density (MDD) when the result compared to untreated soils. soils mixed with 10% of the marble dust provided the highest value of MDD and thus is less prone to deformation. However, the statistical analysis proved that the portions of the marble dust added to the soils were not significant.

- The statistical analysis illustrated that adding marble dust to soils significantly enhanced the CBR when it is compared to untreated soils. Therefore, the soils have a much larger bearing ratio when subjected to heavy loads. The results illustrated that as the percentages of the marble dust increase, the CBR values increase. Also, these increments proved to be so significant. The soils modified with 25% marble dust yielded the highest value of the CBR.

- Adding marble dust to soils not only reduces the accumulation of waste materials at landfills and protect the environment, but it may also be an efficient method of improving the long-term performance of weak soils.

However, it is recommended to mentioned that the limitations of this research are those types of soil and marble dust that impacted and influenced the interpretation of the findings of the research. The results of this study are valid only on the types of soils and marble dust obtained from the region of Al-marj, Libya.

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BIOGRAPHIES

Dr. Ahmed Salama Eltwati received his bachelor's degree in civil engineering from Benghazi University in 2007, and his master's degree in Highway & Transportation Eng. (Civil Engineering) from Universiti Teknologi Malaysia in 2010. Then, he pursued his Ph.D. study in Highway Engineering at Universiti Teknologi Malaysia and got his Ph.D. in 2015. He has 3 years of site experience in infrastructure and building work from 2006 to 2009. He has published several indexed journal paper in ISI. He has been working as cooperated lecturer in University of Benghazi since 2016. Currently, he is lecturer in Materials Science department in Star Bright University. His research interest focuses on the development of rut and fatigue prediction models for flexible pavement and study of recyclable materials in asphalt concrete.