POTENTIAL OF GRANITE DUST TO IMPROVE THE ENGINEERING PROPERTIES OF SOFT SOILS FOR ROAD CONSTRUCTION

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Abstract

Soft soils such as clayey soils, mostly if the soils comprise swelling elements may produce great loss to highway pavement, particularly if the soils are exposed to water. The chemical additives may improve the engineering properties of soil. In this paper, granite waste dust was utilized to evaluate the possibility to develop the strength of clayey soils. This research investigates the effect of deposited granite dust on the properties of soft soils. The Atterberg limits, particle size distributions, dry density, bearing capacity and shear strength of the soil were evaluated. The natural soil was treated with different percentages of granite dust (0%, 4%, 8%, 12%, 16%, and 20% by total weight of soil). The findings display a great improvement in the maximum dry density (MDD), optimum water content, direct shear strength and CBR with intensifying the amount of granite dust. The MDD and CBR were improved from 1.59 kg/cm³ and 3.6 % to 1.88 kg/cm³ and 17% respectively. The best results obtained for CBR values were when the soils mixed with 9 % granite dust. Although these findings indicate a great enhancement in the characteristics of clayey soils, the superior performance established is not sufficient if the soils utilized in the base course for roads with high traffic volume. However, this modified material can be suitable for the subbase course and subgrade.

Keywords: *Clayey Soil; Geotechnical Properties, Stabilization; CBR; Strenght*

Research Highlights

- The findings revealed that the geotechnical properties of clayey soils are enhanced considerably by the adding of deposited granite dust.
- The results have shown that mixing the clayey soil with the granite dust m improved the maximum dry density. Adding content of 8% of the granite powder to the untreated soil attains the best results.
- There is a great development in the strength of modified soil made with granite dust. The result showed that the values of CBR of treated soil increased as the percentage of the granite powder in the sample increased. The optimum granite dust content was 8%.
- The direct shear test showed that there was a noticeable indication of shear stress enhance as shear strain. Also, the study found that normal stress gets higher as the shear stress elevates. The shear strength of modified soils with granite dust is 3 times better than untreated soils

Graphical Abstract

Fig. 1: The effect of granite dust on CBR, MDD, and OMC

Fig. 2: The relationship between shear stress vs. shear strain on treated soil and natural soil

Research Objectives

The flexible pavement is highly dependent on the performance of underlying layers, particularly the subgrade (1-3). Several studies have recently been done to enhance the engineering properties of clayey soils. Therefore, this research aimed to improve the properties of subgrade. This experiment investigates the effect of granite dust on high-plasticity clay soil. The parameters examined were bearing capacity, MDD, OMC, particle size distribution, and shear strength. The performance of these parameters with a changing amount of the granite powder was utilized to evaluate the efficiency or otherwise of granite powder in enhancing the engineering properties of soft soils.

Several CBR tests, standard proctor tests, and direct shear tests were done on several soil samples mixed with different contents of granite dust (0%, 4%, 8%, 12%, 16%, and 20% by total weight of soil). This research aims to obtain the optimum content of granite dust that produces the best values of CBR, MDD and shear strength

Methodology

The materials used in this project were deposited granite powder and clayey soil. The granite dirt was obtained from a local factory. The natural soil utilized in this experiment was obtained from near the military airport of Elmarj. In preparing the soil for the tests, several preliminary tests were done. The preliminary tests were sieve analysis, Atterberg limits, and chemical analysis of soil. From the AASHTO Classification System, the natural soil is classed as A-6 (very plastic clayey soils). The liquid limit, plastic limit, and plasticity index of soil were 39.3%, 22.4%, and 16.9% respectively. According to the chemical analysis, the main constituents of granite dust are SiO_2 (silica) (72.9%), Al_2O_3 (alumina) (15.3%), and K_2O (4.53%).

To prepare the samples for testing, various amounts of granite powder (4%, 8%, 12%, 16% and 20% by the weight of soil) were blended to the soils. The direct shear experiment was conducted on several samples with changing the amount of granite dust. The degree of loading was kept at 0.5 mm/min. The specimens were subjected to various rates of standard stresses. The CBR test was executed to determine the bearing capacity of the natural and modified soils. The Proctor compaction experiment was performed to ascertain the dry density of soils and OMC. Figure 1 exhibits the results of MDD, OMC, and CBR for all samples. While Figure 2 manifests the result of direct shear strength.

Results

The MDD of the soft soil improved with the heightening of the content of granite powder in soil. It is revealed in Figure. 1 that the highest value of MDD is 1.88 gm/cm³, which characterizing the treated soil with 9 % granite powder. On the other hand, the MDD of the natural soil 1.599 gm/cm³. Therefore, it can be concluded that the MDD of soil was increased by about 16 %.

Figure1 shows that as the percentages of granite dust in the soil elevate, the ratios of CBR increase. The highest ratio of CBR reached was 15.8 %, that is corresponding to the treated soil with 8.00% granite powder. The lowest value recorded was when the soil is untreated with granite dust (CBR was 3.65%).

From Figure 2, the shear stress rises as shear strain escalates. the rise of the shear stress was extremely reliant on the rise of its normal stress. From Figure2, the untreated soil achieved its greatest shear strength with 18.33, 39.23, and 75.36 kPa subjected to stresses of 50, 100, and 200 kPa, respectively. On the other side, the soil mixed with 8% of granite dust powder attained its highest shear strength with 50.2, 118.72, and 221.76 kPa for stresses of 50, 100, and 200 kPa, correspondingly

Findings

The improvement in MDD and CBR indicates that waste powder operates as a greasy film on the exterior side of soil grains, reducing the absorption of water, and this eases the compaction, thus improving the connecting of soil grains along with MDD and CBR. Also, it can be concluded that mixing soil with 9% of granite dust powder improved the shear strength nearly 3 times higher than untreated soil. This result is consistent with previous researches (4-12) done on soils mixed with igneous rock i.e. marble dust. However, the previous studies have not investigated using other types of igneous rock such as granite

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Ahmed Salama Eltwati received his master's degree in Highway & Transportation Eng. 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 Scopus/ISI indexed journals. Currently, he is the dean of the faculty of aeronautics in the Bright

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