©2017 Published in 5th International Symposium on Innovative Technologies in Engineering and Science 29-30 September 2017 (ISITES2017 Baku - Azerbaijan)

Usage of Fly Ash and Granite Dust for Soil Stabilization

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Abstract

Industrial wastes materials are serious problem for environmental pollution. Furthermore these wastes are composed in large quantities. In recent years lots of researches have been done to solve this problem. According to these researches, waste materials can be used in many areas as a material or additive material. One of the areas is soil stabilization. Soil properties are improved with this additive wastes.
In this study, laboratory tests were conducted on granular soil specimens amended with fly ash and granite dust. The specimens were prepared with granular soil and fly ash-granite at different ratios. They were compacted standard Proctor compaction energy and, than were cured 1, 7, 28 and 56 days. After cure, unconfined compressive tests were conducted to investigate the effect of fly ash-granite dust on granular soil strength. Moreover California bearing ratio test were performed to specimens with additive materials. Addition of fly ash-granite dust increased soil strength. As a result, fly ash-granite dust can be used with granular soil for increasing strength.

Key words: Fly ash, Granite dust, Soil stabilization

1. Introduction

Usage of waste materials as a recycling material is important because of these materials cause to environmental pollution. These wastes have harmed to soil, ground water and also have formed visual pollution. Especially industrial wastes are formed serious problem due to very large quantities and it is difficult to store these wastes. In the developing countries, distinct rules of waste disposing are initiated to prevent the environment pollution. Also, many scientists research about usability of wastes in many areas. This case is positive effects on environment by means of recycling, regains to economy and reducing environmental pollution. Wastes materials were began to be used in soil stabilization like usage in many areas. Because these waste materials increase some parameters of soil like strength and decrease some parameters like settlement, permeability.

Fly ash is the main by-products of coal combustion for electrical energy production. Fly ash is one of the waste materials that are generated by the coal industry in very large quantities. However, a small part (25% – 30%) of the fly ash can be used in many areas. Its utilization is not limited and it is added to cement and concrete products, construction materials as a light weight aggregate, infiltration barrier, underground, void filling, water and environmental improvement, and is used in geotechnical stabilization as an additive material, structural fill, cover material, unpaved roads, highway base structures, roadway and pavement etc. There are a lot of studies

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about fly ash used in the stabilization of soils. In the some previous studies [1, 2, 3, 4, 5, 6] it was indicated that the engineering properties of fly ash amended soils have been improved. Generally, fly ash was used together with different additive materials like cement, lime or industrial wastes like marble dust, cement kiln dust, etc.

The granite dust occurs with sawing process of granite blocks. This dust is carried by cooling water to sedimentation pond. Sediment dust is taken from pond, is used in soil stabilization. Granite dust was used in road construction as a stabilization material [7]. According to this study, added granite dust improved soil strength. Granite dust was mixed with base soil at 3%, 5%, 8%, 10% and 15% by dry soil weight. They said that strength increased in specimens with the increase in additive amount. But, the highest strengths were in the specimens with 8% and 10% granite for different base materials. Jagmohan et al. [8] researched effect of granite dust on index properties of lime stabilized black cotton soil. Granite dust was mixed with lime stabilized clay soil in different ratio (10%, 20%, 30%). Liquid and plasticity index decreased and shrinkage limit increased with added granite dust. Moreover, granite dust addition to stabilized clay soil decreased its swelling behavior. In the study‘s Ogbonnaya et al. [9], potential effect of granite dust on geotechnical properties of expansive soils was researched. Liquid limit and plasticity index decreased. Max. dry density increased and optimum water content decreased. CBR, angle of shear resistance increased and cohesion decreased.

In this study, laboratory tests will be conducted on granular soil specimens amended with fly ash and granite dust. The specimens will be prepared with granular soil and fly ash-granite dust at different ratios. They will be compacted standard Proctor compaction energy and, than will be cured 1, 7, 28 and 56 days. After curing, unconfined compressive tests will be conducted to investigate the effect of fly ash-waste boron on granular soil strength. Furthermore, California Bearing Ratio (CBR) tests were performed to these mixing specimens.

2. Material and Method

The granular soil (SG) used in this study was obtained from Afyonkarahisar Municipality, Turkey. This material was used in road construction. It had 28 % particles passing the US No. 10 sieve (<2 mm), 8% passing US No. 200 sieve (<0.075 mm). Unit weight is 18,74 kN/m^3. It was classified as well graded gravel (GW) according to the Unified Soil Classification System (USCS) and A-1 according to the American Association of State Highway and Transportation Officials (AASHTO). The fly ash was obtained from Soma-B Power Plant in Manisa, Turkey. It is F class according to ASTM C 618 [10] and W class according to TS EN 197-1 standard [11]. Approximately, 80 % of the particles are finer than the U.S. No. 200 sieve size. Some chemical compounds of the waste fly ash are shown in Table 1.

Granite dust was obtained from Çimstone plant in İzmir, Turkey. Granite dust is taken from sedimentation pond, is dried and is sieved from sieve of no: 200. Then it was mixed granular soil at different ratios. Granite dust chemical compounds are shown in table 1.

Table 1. Chemical compounds of used materials

	SiO_2	Fe_2O_3	Al_2O_3	CaO	MgO	SO_3	P_2O_5	Ti_2O_2	Na_2O	B_2O_2	LOI
Fly ash	48.28	7.19	27.72	10.51	2.51	3.16	0.27	1.28	-	-	-
Granite dust	89,30	0,23	0,19	0,58	0,46	0,06	-	-	0,37	-	8,26

Soil identification tests were performed according to TS 1900-1[12] standard. The distribution of the particle sizes was determined by sieving. For the sieve analysis, the granular soil was washed above the 0.075-mm sieve and dried in the drying oven. Then, it was sieved by a sieve set. For the standard Proctor compaction tests, water was added to the dried granular soil material and mixed. The wet specimen was compacted in the compaction mold (diameter: 105 mm height: 115.5 mm). For the standard Proctor test, the compaction process was performed in three layers of approximately equal mass, each layer being given 25 blows from 2.5 kg rammer dropped from a height of 305 mm above the specimen. The maximum dry density and optimum water content were determined from the relationships between the dry density and the water content of these processes for every test separately. For the sample preparation, the granular soil was mixed with granite dust and fly ash at different ratios and the dry weights of the materials were used for the mixtures. The percentage of additives was obtained from literature [1, 2, and 6]. All of the specimens were compacted with standard Proctor compaction energies and optimum water contents. The compositions of the mixtures are given in Table 2.

Table 2. Mixing ratios of Specimens

	Mixing Ratio
SG	-
5GD-10FA	SG + 5% Granite Dust + 10% Fly Ash
10GD-20FA	SG + 10% Granite Dust + 20% Fly Ash
15GD-30FA	SG + 15% Granite Dust + 30% Fly Ash

2.1. Unconfined compressive strength test

The unconfined compressive strength (qu) is a measure of the strength of the mixtures. It shows the effects of the additive materials to granular soil strength. The unconfined compressive strength test followed the procedures outlined in the TS 1900-2 standard [13]. A strain rate of 1 % / min was maintained during this test. The specimens that were mixed with the granular soil, granite dust and fly ash, were compacted in a standard Proctor mold. After compaction, the specimens were extruded with a hydraulic jack from the compaction mold. Two specimens were prepared from this mold separately for a mixture ratio. The specimens were sealed in a plastic wrap three times and covered with a wet cloth for controlling humidity. The cloth was wetted every day, and then, the specimens were cured 1, 7, 28, and 56 days. Duplicated specimens were tested for the unconfined compressive test as quality control, and the averages of these two tests were reported as the results.

2.2. California bearing ratio test

The California bearing ratio test (CBR) is a penetration test for the determination of the mechanical strength of the highway base materials. The CBR tests were performed according to TS 1900-2 [13] standard. The specimens were compacted at the optimum water content using the standard Proctor effort at the CBR mold. They were prepared in the mold using three layers, each layer being given 61 blows using the 2.5 kg rammer. The surface area of the plunger is 19.35 cm^2 with the rate of penetration of the 1.27 mm/min. After compaction, curing was not applied to the specimens, and the CBR tests were performed at bottom and top surface of the specimen. The averages of these two values were used for the evaluation of the test results.

3. Results

Unconfined compressive test results can be seen in figure 3a, 3b and table 3. The strength values increased in all specimens with the increase cure time (Figure 3a). But the strength of specimens with 15GD-30FA decreased at the end of 7 day cure. Than the strength values increased again at 28 and 56 day cure. The highest strength values were obtained in 5GD-10FA mixture ratio (Figure 3b). After this ratio, the strength values decreased in 10GD-20FA and 15GD-30FA.

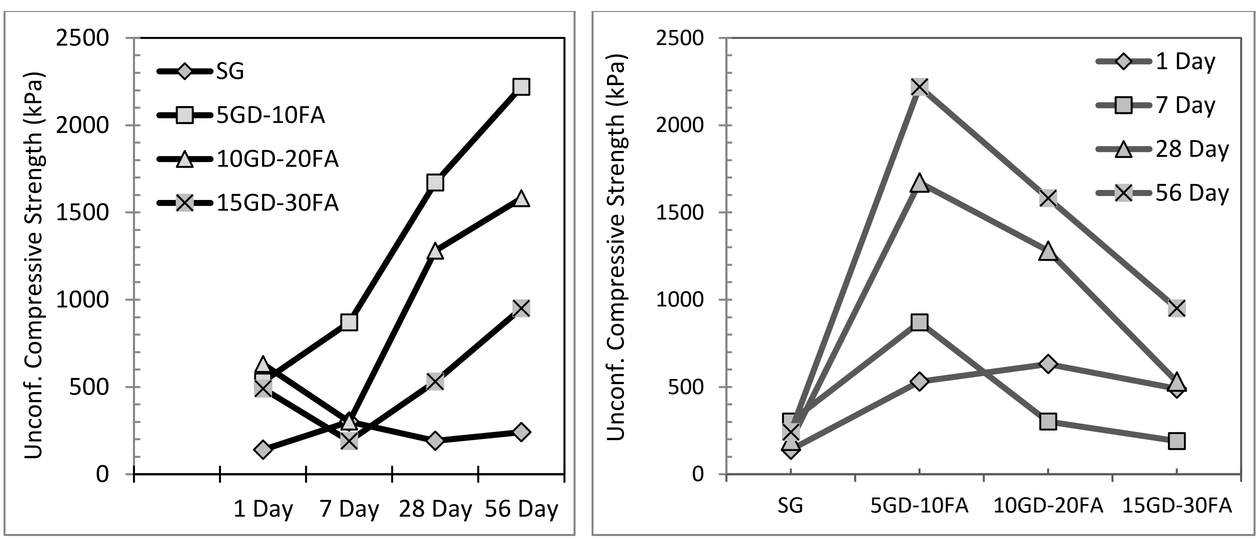

Figure 3 a) Unconfined compressive strength – cure time, b) Unconfined compressive strength - additive ratio

Table 3. Unconfined compressive strength values (kN/m^2)

Strength (kPa)	1 Day	7 Day	28 Day	56 Day
SG	140,5	300,8	190,9	240,9
5GD+10FA	530,7	870,4	1671,0	2220,1
10GD+20FA	630,9	300,6	1280,4	1581,0
15GD+30FA	490,9	190,4	530,0	950,1

The Effect of additive on CBR strength is presented in figure 4. The highest CBR value was seen in the 5GD-10FA specimen (128%). Other CBR values are 102% in the 10 GD-20FA and 120% in the 15 GD-30FA.

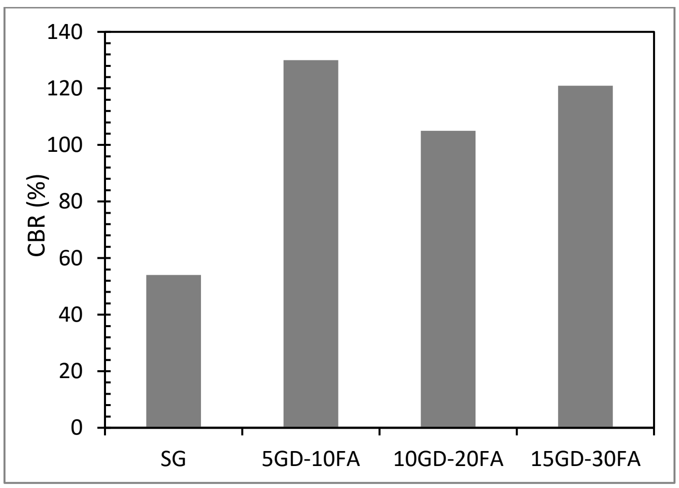

Figure 4. California Bearing Ratio – Additive Ratio

4. Discussion

The strength values increase in the cure time in all the specimens. The increases show linear trend like seen figure 3a, and this is an expected situation. Because, reaction occurs from pozzolanic property of additives and continues depending on the time. [1, 2, 3, and 5]. When reaction stops, the strength will be maximum value. But, the strength of specimens with 15GD-30FA decreased at the end of 7 day cure. Than the strength values increased again at 28 and 56 day cure. This decrease may be from experimental mistake.

Mixing ratio of additive materials is important. As you can see from Figure 3b, the highest strength values were obtained in 5GD-10FA mixture ratio. After this ratio, the strength values decreased in 10GD-20FA and 15GD-30FA. Consequently optimum mixing ratio is 5% GD –

10% FA for test materials in this study. Similar results have been seen in previous studies [1, 2, 3, 5, and 7]

The highest CBR value was seen in the 5GD-10FA specimen (figure 4). When an additive of more than these amounts was added, a decrease in the CBR values can be observed. In the studies performed with fly ash by Arora and Aydilek [3], and Cetin et al. [4], and in the study performed with granite dust by Ogbonnaya [9] the results similar to this study was obtained regarding the connection between CBR and the increase in additive. In our study, fly ash and granite dust have been used together in the different mixing ratio.

Conclusions

Because industrial wastes are a major and serious problem, their use in soil stabilization has affirmative effect for the environment. Because it is cheap as an additive material and it is decreased pollution. In this study, it is investigated the beneficial reuse of granite dust and fly ash in soil stabilization. Tests were performed on granular soil mixtures amended with granite dust and fly ash. For unconfined compression tests, specimens were prepared with standard Proctor compaction energy and, than were cured 1, 7, 28 and 56 days. Then, unconfined compressive strength tests were performed after cure time in these specimens. CBR tests were made granite dust and fly ash can be used as an additive material in soil stabilization. 5GD-10FA can be explained as a suitable mixing ratio.

Acknowledgements

This study was supported from Commission of Scientific Research Projects (AKÜ-BAP) with the project, 17.KARIYER.89

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