Effect of Marble Dust on Consolidation Characteristics of Clay Soils

Ismail ZORLUER
Department of Construction Education, AKU, Afyonkarahisar, Turkey
izorluer@aku.edu.tr

Ismail MURATOGLU
Department of Construction Education, AKU, Afyonkarahisar, Turkey

Abstract : The usage of waste materials as an additive material has became widespread, in soil stabilization. This case was positive effects on environment by means of recycling, regains to economy and reducing environmental pollutions. In this study, marble dust had been used as an additive material in clay soil. Marble dust is a waste of the marble industry and despite its recycling in various industries, there is still a significant amount of marble dust left as waste.
In this study, soil specimens were sampled from different locations in the ANS campus of Afyon Kocatepe University. These specimens were mixed with waste marble dust at ratios of 5%, 10% and 15%. Geotechnical experiments were carried out on specimens. Test results shows that marble dust have affected consolidation characteristics of clay soils. Especially, swelling index and consolidation index of specimens were decreased. This decrease is important in point of swelling potential of clay soils.

Introduction

Marble dust is a waste of the marble industry and despite its recycling in various industries, there is still a significant amount of marble dust left as waste. Marble dust has been used as an additive for soil stabilization. Okagbue and Onyeobi (1999) showed that the geotechnical parameters of red tropical soils are substantially improved by adding marble dust: plasticity is reduced by 20 to 33% and strength and CBR increased by 30 to 46% and 27 to 55%, respectively.

The effect of marble dust on the swelling potential of Na-bentonite and Meşelik clays and unconfined compressive strength was investigated by Zorluer (2003, 2006). Specimens were mixed with marble dust at different percentages (3,5,8,10%) of dry soil weight, and compacted at standard proctor compaction energy. For swelling tests, specimens were obtained using oedometer floating ring from compacted mixtures and then tests were carried out with oedometer. Swelling potential reduced from 25.6% to 21% at 5-8% marble dust additive. For compression test, specimens were sampled with coring tube from compacted mixtures. Unconfined compressive tests were performed to these specimens and were cured for 1, 7 and 28 days. At the end of 28 days of curing time, strength increased from 20.1 to 57.3 N/cm^2.

Waste marble dust was used as an additive material by Zorluer and Taspolat (2009) in landfill liner. Mixtures of kaolinite-bentonite were mixed with waste marble dust for design of landfill liner. This process was performed at marble dust ratio of 5%, 10% and 15%. Freezing-thawing tests were carried out in these mixtures. At the end of the tests, it was observed that waste marble dust increased strength of liner in conditions of freezing and thawing.

The objective of this study was to investigate use of marble dust as an additive in clay soils. For this purpose, soil specimens were sampled from 3 locations at ANS campus of Afyon Kocatepe University. These specimens were mixed with waste marble dust (proportions of 5, 10 and 15% dust to dry soil by weight). Index properties of the specimens were determined by liquid limit, plastic limit, sieve, hydrometer and buoyancy analysis tests. Standard proctor and odeometer tests were carried out in these specimens.

Materials

Afyonkarahisar region is known as one of the most important marble production and processing centre in Turkey. Yearly production of marble is about 80,000 m^3 in this region. About 24,000 m^3 marble dust occurs

from this production. Marble dust is minimum sized marble waste that occurs with sawing of marble blocks and plates. This dust is carried by water to sedimentation ponds. Sediment dust is removed from the pond to wasteland, but this forms serious problems for the environment. Waste marble dust is used in very small quantities despite being used in widely variable industries, such as construction, ceramics and cement, paint, agriculture and fertilizer; as a result, a lot of marble dust ends up as waste (2003). The marble dust used in this study, was obtained from a marble processing factory in Afyonkarahisar-Turkey. It was dried and sieved, resulting in marble dust grains smaller than 300 microns. Table 1 are shown chemical compound percentage (%) of marble dust.

SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	P_2O_3	K_2O	Na_2O	SO_3	Mn_2O_3	LOI[a]
0.01	0.85	0.04	55.30	0.24	-----	0.20	0.03	-----	-----	43.51

Table 1. Chemical Compound Percentage of Marble Dust (%)

Afyon Kocatepe University Campus area was formed clay. Clay specimens were sampled from three points at campus area. These points were named as BH1, BH2 and BH3. Properties of specimens are in the table 2. Soil classification and definition tests were applied according to the TS 1900 standard.

Specimen	Gs	w_l	w_p	I_p	class
BH1	2,65	59,5	25,6	33,9	CH
BH2	2,72	37,2	20,4	16,8	CL
BH3	2,76	29,4	21,6	7,8	CL
Gs:Specific Gravity, w_l: Liquid limit, w_p: Plastic Limit, I_p: Plasticity index					

Table 2. Geotechnical Properties of Clay Specimens

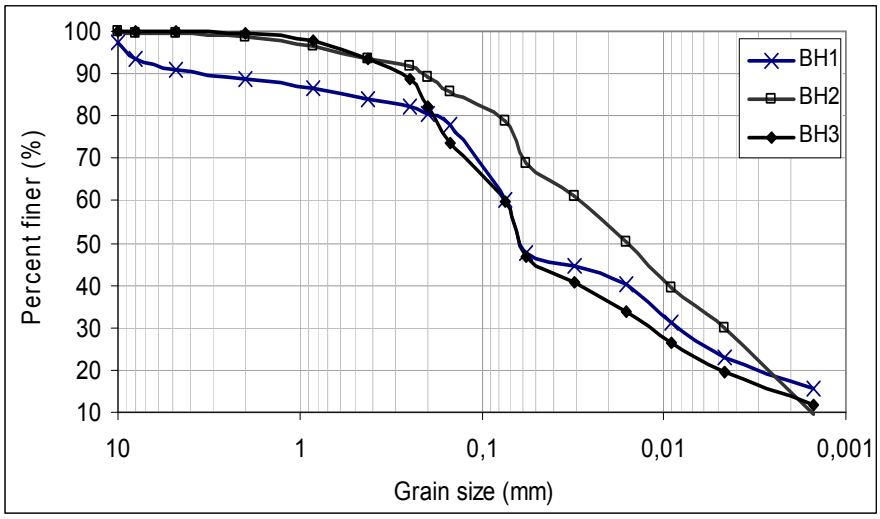


Figure 1. Grain size distribution curves of specimens.

Experimental Study and Results

Standard proctor test was performed on clay specimens. Compaction characteristics of clay soils were determined from this Proctor test. Maximum dry density and optimum water contents were obtained from figure 2. The specimens were mixed with waste marble dust at ratio of 5%, 10% and 15%. These ratios were obtained

from other studies (Okagbue&Onyeobi, 1999; Zorluer, 2003, 2006, 2009). Then, these mixtures were compacted with optimum water content at the standard compaction mold.

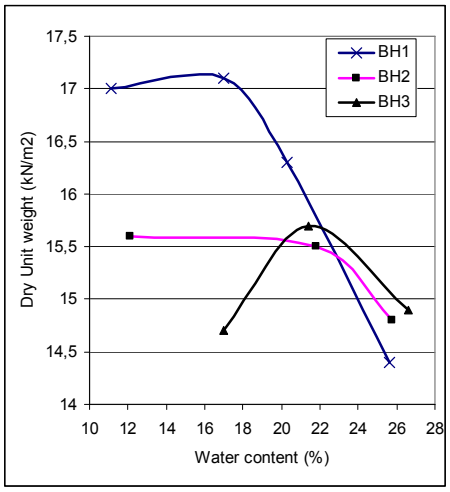
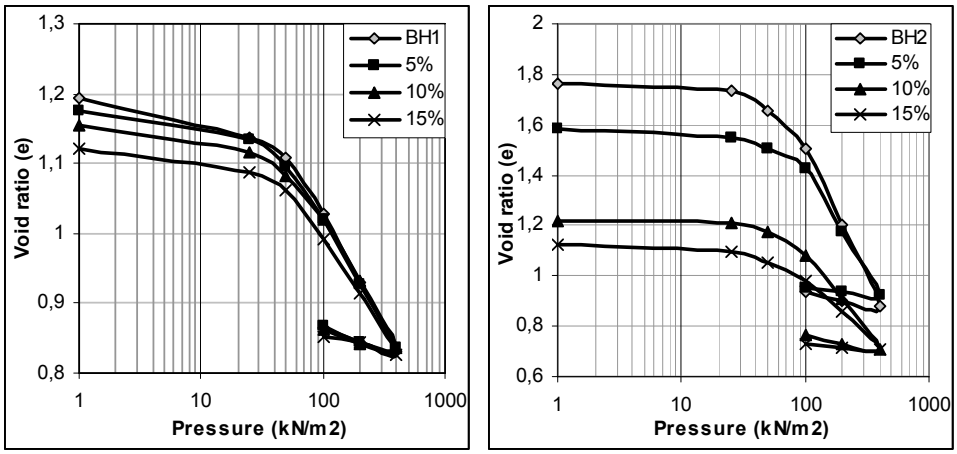
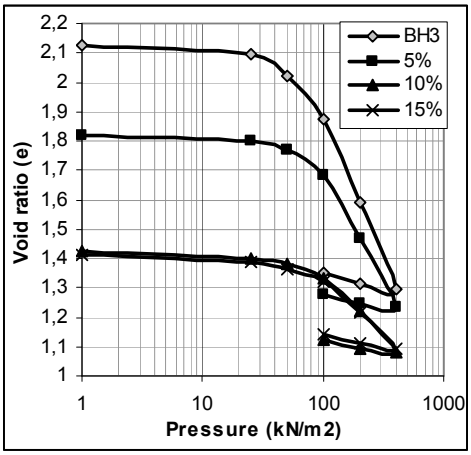


Figure 2. Compaction curves of soil specimens

For consolidation tests, specimens were sampled from compacted mixtures using odeometer ring. Consolidation tests were carried out on these specimens. e-log p graphs were plotted from consolidation tests results (fig. 3 a, b, c). In addition, compression index (c_c) and expansion index (c_e) were obtained from figure 3.



a b

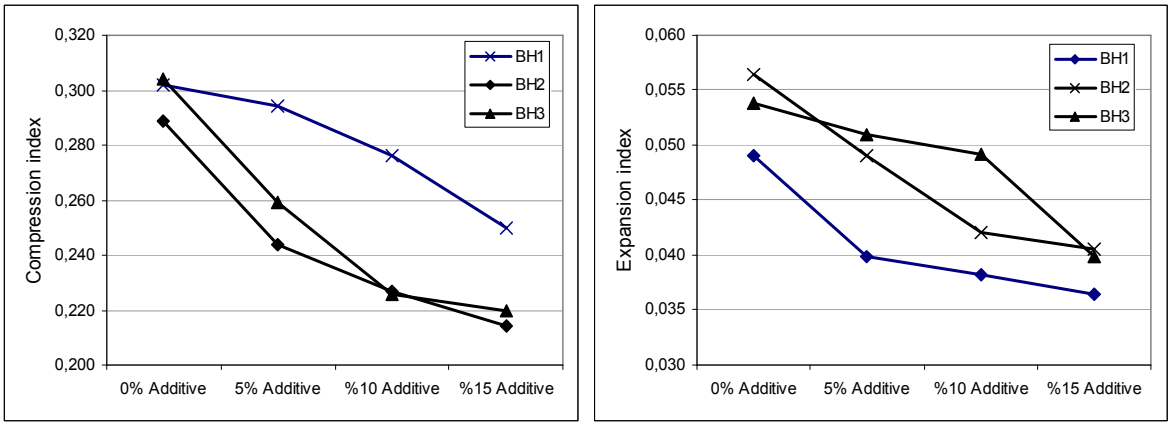


c

Figure 3. (a, b, c) e-log p curves of specimens

Discussion

Compression index (c_c) is the slope of the linear portion of the e-log p plot and dimensionless. It was seen that c_c has decreased with marble dust increasing for all specimens (fig 4 a). For example, this decreasing is from 0,304 to 0,220 for BH3. Similarly, void ratios of specimens have decreased with marble dust increasing (fig 3). Consolidation settlement of soils is fewer when soil voids decreased.



a b

Figure 4. Change of compression and expansion indices with increasing marble dust.

Decreasing of expansion index (c_e) is same with other studies (Zorluer, 2003). The findings show that the expansion index of specimens decreases when the amount of the added marble dust increases (fig 4.b). Therefore, swelling potential reduces when the amount of the added marble dust increases. This case shows that marble dust can be used at stabilization of swelling soils. Also, at the other study of Zorluer (2003), swelling potential was reduced by adding marble dust. Besides, swelling potential values was measured from swell pressure test.

Conclusion

Marble dust affects the properties of clay like strength, swelling potential, freeze-thaw strength. This case was expressed at previous studies. In this study, consolidation characteristic of clay were affected from waste marble dust. Compression index (c_c) and expansion index (c_e) of specimens decreases when the amount of the added marble dust increases. Furthermore, void ratio decreases with increasing of marble dust. This result shows that consolidation settlement reduced when marble dust mixed to clay soil. Use of marble dust in soil stabilization, provide the protection of the environment. In addition, it is gained an economical material for soil stabilization.

References

Okagbue, C.O. Onyeobi, T.U.S. (1999). Potential of marble dust to stabilize red tropical soils for road construction**.** Engineering Geology, 53. 371-380.

Zorluer, I. (2003). Effect of waste marble dust to swelling potential of clay soils. XI. National Clay Symposium. Izmir, Turkey. 475-482.

TS 1900-1 (Turkish Standard) (2006) Methods of testing soils for civil engineering purposes in the laboratory - Part 1: Determination of physical properties Ankara, Turkey.

TS 1900-2 (Turkish Standard) (2006) Methods of testing soils for civil engineering purposes in the laboratory – Part 2: Determination of Mechanical Properties Ankara,Turkey.

Zorluer, I. (2006). The Effect of waste marble dust on unconfined compression strength of clay soils. GAP V, Engineering Congress. Sanlıurfa, Turkey, 1042-1046.

Zorluer, I. & Taspolat, L.T. (2009). Reuse of waste marble dust in the landfill layer. First International Symposium on Sustainable Development. Sarajevo, Bosnia and Herzegovina. 301-305.