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THE EFFECT OF ASPHALT WASTE AND AFŞIN-ELBISTAN FLY ASH ON THE ENGINEERING FEATURES OF SANDY-CLAY SOILS

ASFALT ATIĞI VE AFŞİN-ELBİSTAN UÇUCU KÜLÜNÜN KUMLU-KİL ZEMİNLERİN MÜHENDİSLİK ÖZELLİKLERİ ÜZERİNDEKİ ETKİSİ

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ABSTRACT

In this experimental study, the impact of asphalt waste (AW) generated after the Kahramanmaraş earthquake on the geotechnical features of sandy-clay soils was examined. Afşin Elbistan fly ash (AEFA), which is widely produced in the region, was also added, and its effect was determined. After determining the engineering characteristics of the sandy-clay soil, mixtures were prepared by adding AW at the rates of 5,10,15,20% by weight. Mixtures were prepared by adding 5,10,15,15,20% AW at a constant rate of 15% AEFA. Atterberg limit, standard proctor, unconfined compressive strength (UCS), shear box, and California bearing ratio (CBR) tests were conducted on the samples. According to the results of the Proctor test, it is seen that the dry density increases and the optimum water content decreases as the proportion of AW mixed into soil increases. It was found that UCS improved with the addition of AW. It was observed that the internal friction angle increased with the addition of AW, and the cohesion increased with the addition of AEFA. As a result, it was determined that the use of AW and AEFA as 15% AW and 15% AEFA by dry weight in Sandy clay soil affects improving soil geotechnical properties. It is also concluded that the disposal of earthquake and industrial by-product waste will contribute to the environment and economy.

Keywords: Asphalt waste, Afşin-Elbistan fly ash, soil stabilization, sandy clay soil, Kahramanmaraş earthquake.

ÖZET

Bu deneysel çalışmada, Kahramanmaraş depremi sonrasında oluşan asfalt atığının (AW) kumlu-kil zeminlerin geoteknik özellikleri üzerindeki etkisi araştırılmıştır. Bölgede yaygın olarak üretilen Afşin Elbistan uçucu külü (AEFA) de ilave edilerek etkisi belirlenmiştir. Killi-kumlu zeminlerin mühendislik özellikleri belirlendikten sonra ağırlıkça %5,10,15,20 oranlarında AW ilave edilerek karışımlar hazırlanmıştır. Karışımlar, %15 AEFA sabit oranında %5,10,15,15,20 AW eklenerek hazırlanmıştır. Numuneler üzerinde atterberg limiti, standart proktor, serbest basınç dayanımı (UCS), kesme kutusu deneyi ve Kaliforniya taşıma oranı (CBR) testleri yapılmıştır. Proctor testi sonuçlarına göre, zemine karıştırılan AW oranı arttıkça kuru birim hacim ağırlığın arttığı ve optimum su içeriğinin azaldığı görülmüştür. UCS'nin AW ilavesi ile arttığı gözlemlenmiştir. AW eklendiğinde iç sürtünme açısının artığını ve AEFA eklenmesi ile kohezyonun artığı görülmüştür. Sonuç olarak, AW ve AEFA'nın kumlu- kil zeminlerde kuru ağırlıkça %15 AW ve %15 AEFA olarak kullanılmasının zemin geoteknik özelliklerinin iyileştirilmesinde etkili olduğu belirlenmiştir. Ayrıca deprem ve endüstriyel yan ürün atıklarının bertarafının çevreye ve ekonomiye katkı sağlayacağı sonucuna varılmıştır.

Anahtar Kelimeler: Asfalt atıkları, Afşin-Elbistan uçucu külü, zemin stabilizasyonu, kumlu kil zeminler, Kahramanmaraş depremi.

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INTRODUCTION

With the population growth in big cities in the last decade, existing buildings have become insufficient. Therefore, the need for new buildings and new construction sites is increasing rapidly. Construction sites with engineering features that are not suitable for new buildings are being put into use. Structures built on weak soil areas that are not sufficient in terms of engineering properties cause serious problems in the future (Güllü et. al., 2023; Abed et. al., 2023; Bilgen & Altuntas, 2023). Weak soil refers to soil that has poor engineering properties, making it less capable of supporting heavy loads or structures. The weakness of soil can result from various factors, including its composition, structure, and moisture content. Weak soils pose challenges in construction and civil engineering projects because they may require special foundation design or soil improvement techniques to provide the necessary support for structures (Seferoğlu et. al., 2020; Canakci et. al., 2018; Aksoy & Yıldırım, 2023). Engineers often use methods such as soil stabilization, compaction, or the addition of reinforcing materials to improve the engineering characteristics of weak soils. Additionally, understanding the characteristics of weak soils is crucial for designing foundations that can withstand the potential challenges posed by these soil types. Soil stabilization is a process used to improve the engineering features of soil. The primary goal is to enhance the soil's strength, durability, and load-bearing capacity, making it more suitable for construction activities and infrastructure development. There are various methods of soil stabilization, and the choice of technique depends on the specific characteristics of the soil and the requirements of the project. Today, there are many soil stabilization methods including chemical, physical, mechanical, thermal, electrokinetic, and biological (Canakci et. al., 2016; Güllü et. al., 2017; Güllü et. al., 2019; Cinar, 2023).

Since some of the soil stabilization methods are very costly, improving the geotechnical features of the soil with various additives, whose properties are less costly, has been preferred recently. The main reason for this is the emergence of serious environmental problems due to the increase in industrial by-products and waste materials in the developing world. Also, a lot of waste material is produced after major earthquake disasters. Some of the products used as additives in soil stabilization are; blast furnace slag, fly ash, bottom ash, rice husk ash, construction demolition waste, and marble dust (Çelik & Cankci, 2015; Cıınar et. al., 2019; Sidhu et. al., 2024). These wastes are generally preferred due to their easy availability, continuous production, high tonnage, and low cost. As a result of the earthquake, various construction demolition wastes were produced. One of these wastes is asphalt waste from bituminous mixtures.

In this study, it was aimed to improve the geotechnical features of low-strength Sandy clay soil by mixing asphalt waste (AW) and Afşin Elbistan fly ash (AEFA) in different proportions. In 2023, there were very large earthquakes in the Kahramanmaraş province of Turkey. After the February 6, 2023 Kahramanmaraş earthquakes, it was reported that more than 350 million tons of construction demolition waste will be generated (Doğdu & Alkan, 2023). The earthquake zone consists of 11 cities and many districts. Not only buildings but also roads were affected by the earthquake. Therefore, these roads need to be repaired. 21.5 million tons of these wastes will consist of bituminous mixtures and wood waste (Doğdu & Alkan, 2023). The use of these wastes in soil improvement is both environmentally friendly and sustainable. Road damages from the earthquake are shown in Figure 1.

Figure 1. Road damages caused by the earthquake in Kahramanmaraş and Hatay.[URL1; URL 2]

AEFA refers to the fly ash (FA) generated as a byproduct of coal combustion at the Afşin Elbistan Power Plant in Turkey. FA is a fine, powdery material composed of spherical particles that are collected from the flue gas of coal-fired power plants during the combustion process. It is one of the coal combustion products and is typically composed of inorganic mineral matter. The Afşin Elbistan Power Plant, located in the Afşin-Elbistan district of Turkey's Kahramanmaraş Province, is a major coal-fired power station. FA produced at such power plants can vary in its chemical and physical characteristics based on the type of coal burned, combustion conditions, and the collection methods used. FA can be utilized in soil stabilization and as a component in the construction of embankments, road bases, and foundations. It can be used in waste stabilization and solidification processes to immobilize hazardous contaminants in certain waste materials. Utilizing FA in these ways helps to reduce the environmental impact of coal combustion by finding beneficial applications for the resulting byproducts. In previous studies (Temiz et. al., 2021) Chemical analyses of the samples taken from the 1st and 2nd units of the Afşin-Elbistan Thermal Power Plant were carried out. According to the determined chemical analysis results, it is classified as W according to TS EN 197-1 because the reactive CaO ratio (53.44%) is over 10%. According to ASTM C618 standards, it was out of class because the total value of SiO_2+Al_2O_3+Fe_2O_3 (30.69%) was below 50% and the SiO_2 ratio (18.27%) was below 25%. Since AEFA does not comply with standards, it is not used in sectors with substantial use, such as concrete production. Since it does not comply with standards, its area of use is decreasing and it poses serious environmental hazards due to high tonnage production. Its use in soil stabilization will be both an environmentally friendly and sustainable solution.

Seferoğlu et al. (2020) tried to use recycled asphalt pavement as an alternative to natural aggregate in their study. They investigated the use of recycled asphalt pavement materials in road pavement layers. Recycled asphalt pavement was substituted for natural aggregate at different rates (0%, 15%, 30%, 45%, 60%, 100%). Laboratory tests such as bitumen content, modified proctor, sieve analysis, and California Bearing Ratio (CBR) were performed on the prepared mixtures and some properties of the mixtures were compared with natural aggregate. The increase in the ratio of recycled asphalt pavement in the mixtures caused the maximum dry density (MDD) to decrease. In addition, the optimum moisture content (OMC) values of the mixtures decreased with the increase in the recycled asphalt pavement ratio. It was observed that the MDD of the mixtures can be achieved if recycled asphalt pavement 1 material is used at a maximum rate of 5% and recycled asphalt pavement 2 material is used at a maximum rate of 15-20%. In terms of bearing capacity, recycled asphalt pavement material utilization rates can be increased by using various additives (pozzolanic cement, fly ash, etc.) by considering other specification criteria.

Korkmaz et al. (2023) used ladle slag (LS), electric arc furnace slag (EAF), recycled asphalt pavement (RAP), and recycled concrete aggregate (RCA) instead of natural soil used as backfill material in road construction. Experiments were carried out to determine the specific gravity, shear strength parameters, particle diameter distribution, permeability coefficients, compaction parameters, and unsoaked/soaked CBR values of waste materials mixed at different rates. Results of the test indicate that the average internal friction angle of RAP was found to be 34 degrees and the permeability coefficient was found to be 1.99×10^{-3} cm/s. In addition, the dry CBR values allowed in the highway technical specifications were found to be suitable for the sub-base layer.

Lima et al. (2023) conducted experiments with different proportions (0-80%) of RAP incorporated into sedimentary soil. Tests were performed on the mixtures to evaluate their mechanical strength, compaction features, and expansion after curing for up to 28 days. The results showed that the addition of RAP increased the splitting tensile strength and unconfined compressive strength of the mixtures.

Hakan, (2010) added FA to cohesive soils at ratios of 0 to 25 %. In the study, FA added to cohesive soil increased plasticity. In this experimental study, it was determined that MDD, OMC, and unconfined compressive stress (UCS) increased. The optimum FA content was found to be between 15% and 20% by weight.

In the study of Çimen & Keleş, (2020), FA was added to high plasticity clay at 5 to 30 wt%, and compression tests, atterberg limits tests, UCS tests, and swelling pressure tests were carried out. The same series of experiments were then repeated, keeping the lime content constant at 6 wt%. In the experiments, it was found that plasticity index, liquid limit value, and swelling pressure decreased with increasing additive content, while plastic limit value, MDD, OMC, and UCS increased. The optimum FA ratio was found to be 15 wt%.

Literature review shows that there are limited studies for AW, while for AEFA there are studies for FA in different regions. It has been observed that AW is not used to enhance the characteristics of sandy-clay soils and non-standard AEFA is not used in soil improvement.

In this study, 5, 10, 15, 20% AW, and 15% AEFA were kept constant and 5, 10, 15, 20% AW was added to the Sandy clay soil, and its effect on the engineering features of the soil was investigated. After the mixtures were prepared, consistency limits, standard proctor test, shear box test, UCS, and CBR test were performed. The primary aim of this study is to minimize environmental pollution and improve the geotechnical properties of weak soils by using the large quantities of asphalt waste generated after earthquakes. It is also aimed to utilize the high tonnages of AEFA produced. The main feature that distinguishes this study from other studies is the disposal of AW, which is earthquake waste. AEFA is used as a binary mixture to improve soil properties.

MATERIAL AND METHOD

Material

The Sandy clay soil used in the study was taken from the Kahramanmaraş Sütçü İmam University Avşar Campus. Sieve analysis and consistency limit tests were performed to determine the natural soil properties. Asphalt waste was taken from a road in the Onikişubat district of Kahramanmaras that was damaged in the earthquake. The waste was grinded and sieved through a 2 mm sieve to be used in the experiments. After the ground asphalt waste was separated from the large pieces, the part taken to be used in the experiment was sieve analyzed, and the result was found to be SW. Afşin Elbistan Fly Ash was collected from the Afşin Elbistan Thermal Power Plant. Table 1 presents the physical characteristics of clay, AEFA, and AW and Table 2 illustrates the chemical components of AEFA.

Table 1. Physical Properties of The Sandy-Clay, AEFA, and AW.

Parameters	Sandy-Clay	AEFA	AW
Liquid limit (%)	47.0		
Plastic limit (%)	23.0		
Plasticity Index, %	24.0		
Maximum Dry Density (kN/m^3)	1.5	11.52	18.75
Optimum Moisture Content, %	24.5	20	11
Specific Gravity, %	2.80	2.75	2.51
Finer Component (% Passed No. 200 Mesh, %)	47.5		2
USCS Classification	SC		SW

Table 2. Chemical Components of AEFA

Chemical Composition (%)	AEFA
Al_2O_3	8.40
CaO	54.30
Cl	0.01
Fe_2O_3	2.36
K_2O	0.45
MgO	1.54
Na_2O	0.09
P_2O_5	0.54
SO_3	11.20
SiO_2	18.50
TiO_2	0.25
LOI	2.36

Method

Before starting the experimental work, AW was taken from the field and crushed. The AW and soil samples were then dried in an oven for 24 hours. AEFA was added to the soil at the rates of 5%, 10%, 15%, and 20% by weight, taking into account the studies in the literature. Then, similarly, 5%, 10%, 15%, and 20% AW were added while keeping 15% AEFA constant (Cinar, 2024). Consistency limits, standard Proctor test, shear box test, UCS, and CBR test were performed on the prepared specimens. The tests were performed first on natural soil, then on natural soil + AEFA (5, 10, 15, 20%) as a binary mixture, and then on natural soil + 15% AEFA + AW (5, 10, 15, 20%) as a ternary mixture.

In the study, firstly, a consistency limits test was performed. Consistency limits tests are laboratory tests used to determine the moisture content at which a soil exhibits specific consistency states. These tests are crucial in soil mechanics and geotechnical engineering to classify soils based on their plasticity and to understand their behavior under different moisture conditions. The two primary consistency limits determined by these tests are the liquid limit (LL) and plastic limit (PL). These two limits, along with the natural water content of the soil, are used to calculate the plasticity index (PI) of the soil, which is a measure of its plasticity. The plasticity index is calculated as follows: PI= LL−PL

The consistency limits and plasticity index are key factors in the classification of soils according to systems such as the AASHTO (American Association of State Highway and Transportation Officials) or the Unified Soil Classification System (USCS) classification system. Various soil types (e.g., sand, silt, clay,) and their engineering properties can be assessed based on these consistency limits, helping engineers make informed decisions about soil suitability for construction projects. Consistency limits tests were conducted in accordance with ASTM D4318-10 standard.

The standard proctor test is a laboratory test used to determine MDD and OMC of soil. It is an especially important test for the placement of soil backfill materials at the appropriate density and moisture content. This test is used to evaluate the workability properties and bearing capacity of the soil. The standard proctor test in this study was performed according to ASTM D698-12.

Samples were prepared with MDD and OMC values determined from the standard proctor test, and UCS was carried out according to ASTM D2166-16 standard. The prepared samples were carefully removed from containers with a diameter of 50 mm and a length of 100 mm. The length to diameter ratio of the samples must be between 2 and 2.5. Before the experiment starts, device information is entered so that the axial deformation rate is 1.2% per minute. Loading continues until the deformation rate in the samples reaches 15% and the test device automatically stops when fracture occurs.

The specimens for the CBR test were prepared at MDD and OMC values. The specimens were placed in the CBR mold and compressed layer by layer according to ASTM D1883-21. The percentage CBR value obtained by proportioning the load applied as a result of the piston sinking 2.5 mm and 5 mm into the specimen to the load specified in the standard was determined as the CBR value. The higher of the two values is considered as the final CBR value.

The shear box test is a test performed to evaluate the shear resistance of the soil and to understand the durability of the soil. This test is used to evaluate the bearing capacity, durability, and behavior of the soil, especially in soil engineering and construction projects. The prepared mixtures were placed in a 60x60x25 mm test mold. The test was performed at a loading rate of 0.002 mm/sec and in accordance with ASTM D3080M-11 standards.

RESULTS AND DISCUSSION

In this study, AW was added to the Sandy clay soil at 5%, 10%, 15%, and 20% by weight. Then, similarly, 5%, 10%, 15%, and 20% AW were added while keeping 15% AEFA constant. Consistency limits, standard Proctor test, shear box test, CBR, and UCS tests were performed on the prepared specimens.

Consistency limits test results are illustrated in Figure 2. The Sandy clay soil LL value was 47%, PL value was 23% and PI value was 24%. According to the PL, the value increased as the waste ratio increased. Therefore, it was seen that the plasticity index decreased as the AW waste ratio increased. The main reason for this is that AW holds more water due to its larger grain size. It was also found to increase workability by reducing the plasticity index. (Bhatt & Suman, 2022) The lowest plasticity index was determined in a 15% AW mixture. In the literature, Bhatt & Suman, (2022) found similar results in their study. In the ternary mix, the LL value decreased as the waste ratio increased, the PL value increased and the PI decreased until the mixture with 15%GB addition and then increased. In the consistency limits experiment, it was observed that the 15% AW mixture gave the best results in both binary and ternary mixtures. An increase in the PL of soil usually has an impact on the durability and stability of the soil. A decreasing PI can mean that soils generally tend to be more durable and stable. This property is important in soil engineering projects, as a lower PI can often be associated with better bearing capacity of soils and less tendency to deform.

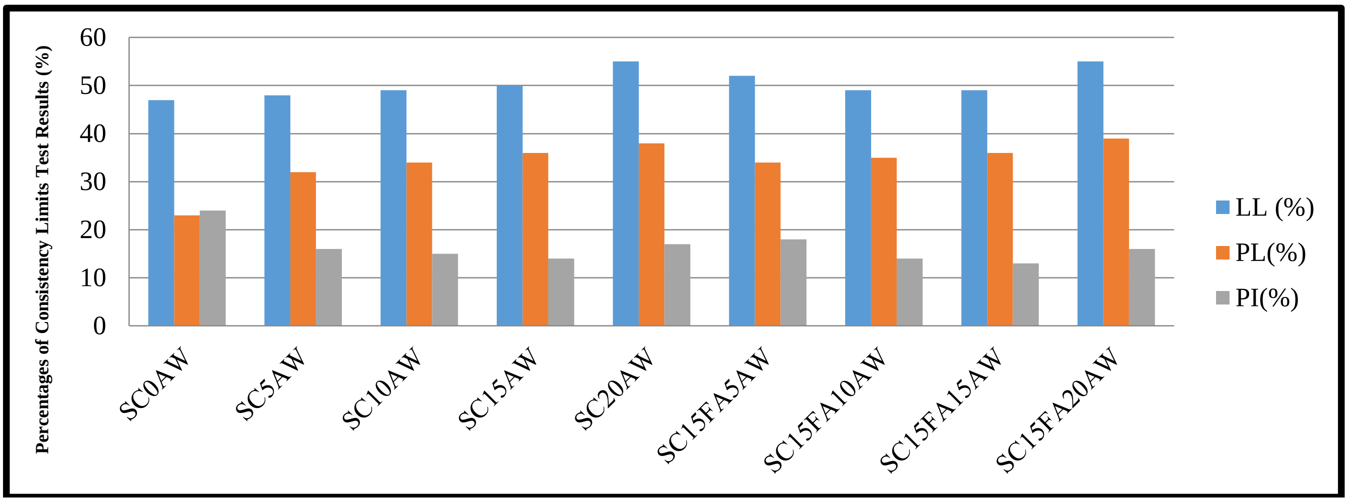
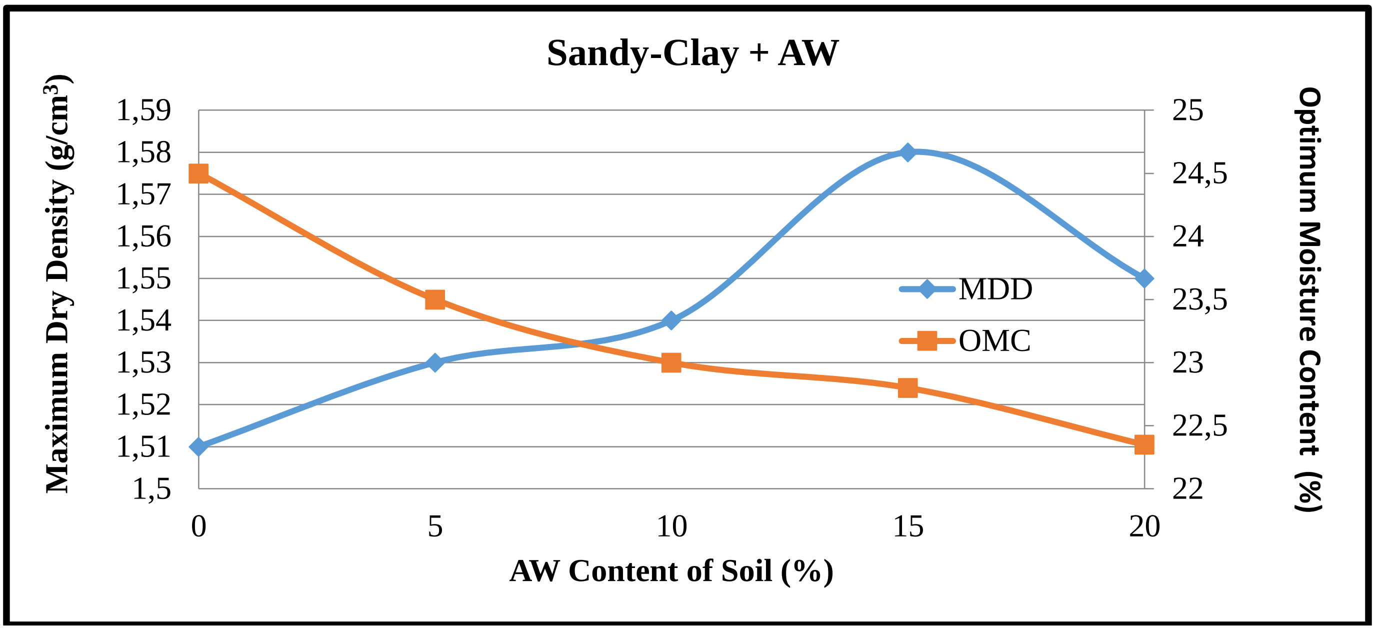
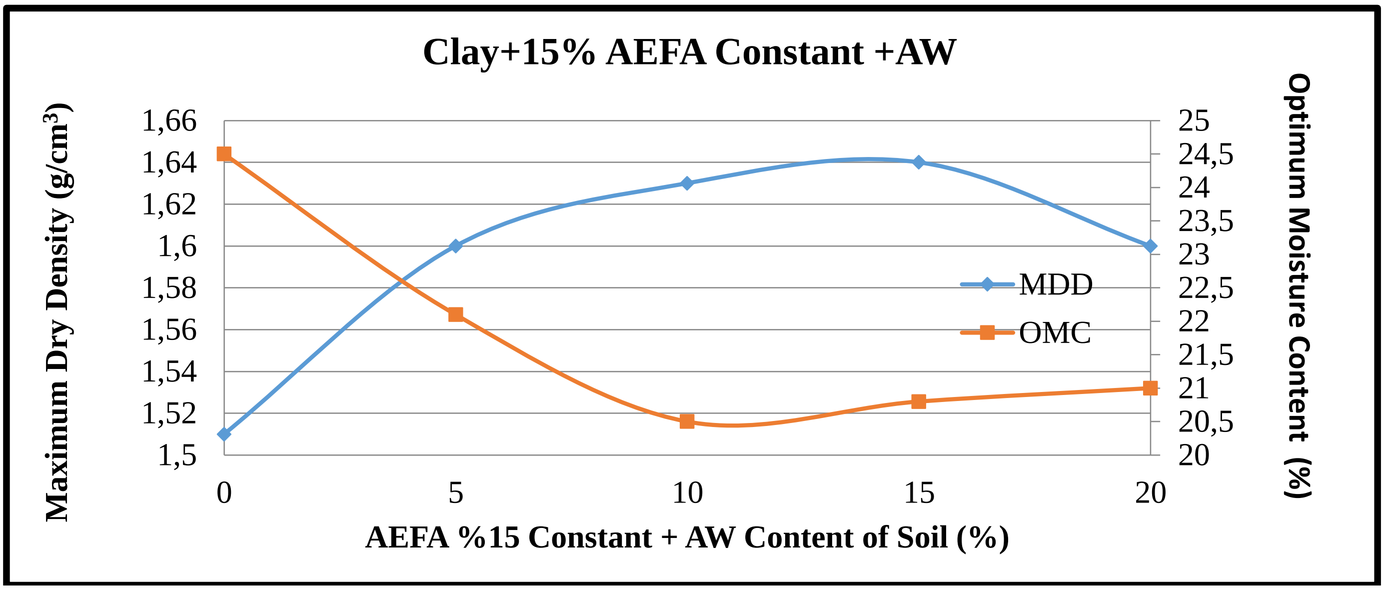


Figure 2. Changes in The LL, PL, and PI by Adding AW and AEFA to The Sandy Clay Sample.

The standard proctor test was performed on natural soil and binary and ternary mixture samples respectively and the MDD and OMC were found. The experimental results are illustrated in Figure 3. When Figure 3a binary mixture and Figure 3b ternary mixture figures are analyzed, it is seen that the MDD increases and the OMC decreases as the proportion of AW mixed into the natural soil increases. This is due to the filler effect on the natural soil with the increase in AW. When Figures 3a and 3b are observed, the highest value of MDD was found in the AW mixture with 15% addition. Also in Figure 3b, higher MDD was obtained in mixtures with AEFA addition. The reason for this is that AEFA has a smaller particle structure and is considered to hold the soil particles. Similar results have been observed in previous studies. (Cinar, 2024a)



a.



b.

Figure 3. Standard Proctor Compaction Test Result of **a**. Sandy-Clay + AW and **b.** Sandy-Clay + AW+ AEFA

UCS test results are shown in Figure 4. Three of each specimen were prepared for the UCS test. The tests were performed for curing times of 7 and 28 days. Since the natural soil is sandy clay soil, the compressive strength was found to be 255 kPa for 7 days curing time and 278 kPa for 28 days curing time. It was seen that the compressive strength increased with the addition of AW waste. The highest values of 390 kPa and 548 kPa were obtained in the 15% AW mixture. Compared to the natural soil strength value, a 41% increase was observed for 7 days of curing time and a 97% increase was observed for 28 days of curing time. Since the natural soil is a Sandy clay soil, the clay in the soil holds the soil together, but with the increase in the addition of AW, brittle behavior was observed (Hakan, 2010; Çimen&Keleş, 2020). With the effect of AEFA in ternary mixtures, it was seen that the UCS test results were better than the specimens made with AW only. The highest values of 430 kPa and 580 kPa were obtained from a 15% AW + 15% AEFA mixture for 7 and 28 days of curing time. In addition, when compared with the natural soil compressive strength value, an increase of 35% and 109% was observed. The main reason for this increase is considered to be because AEFA is a pozzolanic material. In the literature, Lima et al found similar results.

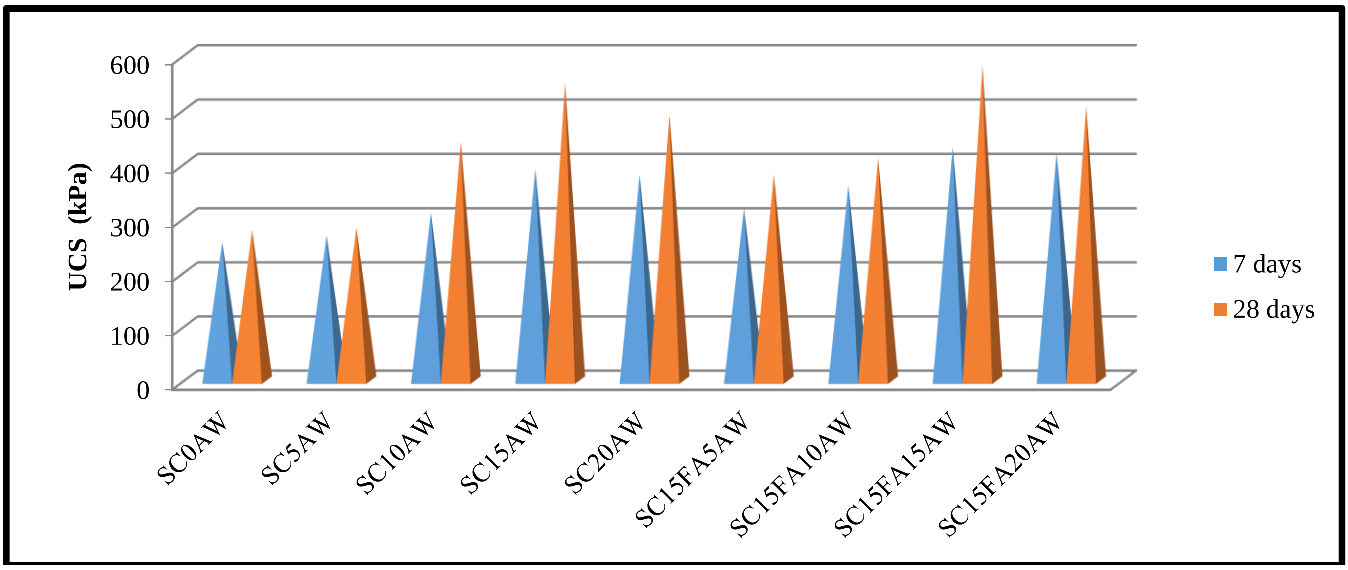


Figure 4. UCS test result of sandy-clay, AW, and AEFA for 7 and 28 days curing time

The shear box test helps in determining the shear strength parameters of soils, such as the angle of internal friction (φ) and the cohesion (c). These parameters are crucial for analyzing the stability of soil masses and designing retaining walls, foundations, and other geotechnical structures. The cohesion values and internal friction angle of the mixtures are shown in Table 3. The cohesion value and internal friction angle of the natural soil were found to be 40 and 19.3 kPa, respectively. Table 3 shows that the angle of internal friction increases as the AW ratio increases. The cohesion value also increased as the amount of waste increased. When compared with the angle of internal friction of the natural soil, the highest increase was calculated as 15% in the SC20AW mixture. However, in ternary mixtures (sandy clay, 15% AEFA, and AW), the angle of internal friction decreased as the AW ratio increased. It is also seen that cohesion increases significantly. It was determined that the main reason for the increase in the angle of internal friction when AW was added was due to the coarser grain size of AW. The reason for the decrease in the ternary mixture with the addition of AEFA is that AEFA grains have a finer and spherical structure, which reduces the angle of internal friction and increases cohesion (Lima et. al., 2023).

Table 3. Shear strength parameters of sandy-clay, AW, and AEFA

	c (kPa)	**ø (Deg.)**
SC0AW	19.3	40
SC5AW	22	42
SC10AW	25	45
SC15AW	28	44
SC20AW	28.5	46
SC15FA5AW	35.8	42
SC15FA10AW	70	43
SC15FA15AW	70.5	32
SC15FA20AW	74	32

Since the highest results in the UCS test and other tests were obtained with 15% AW admixture in binary and ternary mixtures, sandy-clay soil, 15% AW waste + Sandy-clay soil, and 15% AW waste+15% AEFA + Sandy-clay soil specimens were prepared for CBR tests soaked and unsoaked during 28 days curing time. According to the test results, the unsoaked and soaked penetration values were found to be 3.45% and 2.34% for natural soil, 21.5% and 15.46% for 15% AW mixture and 28.5% and 20.14% for 15% AW waste + 15% AEFA. When the literature was searched, Look, (2007) conducted a study according to the previous CBR test results. According to Look, (2007), according to CBR percentages, it was evaluated whether it can be used as road sub-base material or not. According to the study, CBR results <1% is extremely weak, 1%-2% is very weak, 2%-3% is weak, 3%-10% is medium, 10%-3% is moderate, 10%-30% is strong (can be used as sub-base material), >30% is very strong (suitable for use as sub-base-foundation- material). According to the results of Look, (2007), 15% AW and 15%

AW+10%AEFA mixtures can be used as natural soil sub-base material when added (Cinar, 2024b; Ibrahim et. al., 2023).

Table 4. CBR results of sandy-clay, AW, and AEFA

	CBR (%) Unsoaked	CBR (%) Soaked
SC0AW	3.45	2.34
SC15AW	21.5	15.46
SC15FA15AW	28.5	20.14

CONCLUSION

To determine the geotechnical properties of the sandy-clay soil, the effect of mixtures prepared by adding asphalt waste and Afşin Elbistan fly ash at different ratios was investigated. The results of the consistency limits, standard proctor, shear box, unconfined compressive, and CBR tests are given below.

- The liquid limit and plastic limit values of the binary mixture increased as the AW ratio increased. Therefore, it was observed that the plasticity index also decreased as the proportion of AW increased. In the ternary mix, the LL and PL values increased as the waste ratio increased, and the PI decreased for the 15% GB mix. In the consistency limits experiment, it was observed that the 15% GB mixture gave the best results for both the binary and ternary mixtures.
- According to the results of the standard Proctor test, it is seen that the MDD increases and the OMC decreases as the proportion of AW mixed into the sandy-clay soil increases. It was also observed that MDD increased in binary and ternary mixtures up to 15% AW mixtures and then decreased.
- Unconfined compressive tests were performed for 7 days and 28 days curing times and the compressive strength was found to be 255 and 278 kPa since the natural soil is sandy clay soil. It was observed that the unconfined compressive strength increased with the addition of AW. The highest value was obtained in a 15% waste mixture with 390 and 548 kPa. Compared to the natural soil strength value, an increase of 97% was observed. With the effect of AEFA in the ternary mixtures, it was observed that the unconfined compression test results were better than the binary mixture specimens. The highest values of 430 and 580 kPa were obtained from a 15% AW + 15% AEFA mixture. In addition, an increase of 108% was observed when compared with the natural soil compressive value. When the 7 and 28-day samples were compared, it was seen that the 28-day curing time was higher.
- According to the shear box test, it was observed that the angle of internal friction increased with the addition of AW. However, in ternary mixtures, the angle of internal friction decreased with the addition of AW waste. The finer and spherical structure of AEFA grains decreased the angle of internal friction and increased the cohesion.
- According to the CBR test results, it was found as 3.45% for natural soil, 21.5% for 15% AW mixture, and 28.5% for 15% AW+15% AEFA. According to the natural soil result, the increase was found to be 523% for the mixture with the addition of AW and 726% for the 15% AEFA + 15% AW mixture. When 15%AW and 15%AW + 10% AEFA mixtures were added, it was seen that the natural soil could be used as highway sub-base material.

As a result, it was found that waste asphalt can be added up to 15% by dry weight in sandy clay soil. It was determined that the use of 15% asphalt waste and 15% Afşin Elbistan fly ash as a binary mixture has an improving effect on soil geotechnical properties. It is also concluded that the disposal of earthquake wastes and industrial by-product wastes will contribute to the environment and economy.

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