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THE EFFECT OF FERROCHROME WASTE AND POLYPROPILEN FIBER ADMIXTURE ON THE STRENGTH OF ADOBE

ABSTRACT

In this study, the effect of polypropylene fiber on the strength and durability of adobe with ferrochrome addititive is investigated. For this purpose, 0%, 5%, 10%, and 15% of polypropylene fiber by weight of adobe is used instead of straw. The compressive strength test and disintegration experiment of adobe blocks under water attact was performed. Besides, tension and mudding experiments were performed on the soil to be used in the adobe. According to the results of the experiment, it is observed that there is an increase in the strength and durability of the adobe compared to those produced with usual procedures.

Keywords: Adobe, Polypropylene Fiber, Ferrochrome, Straw, Compression Strength

FERROKROM ATIĞI VE POLİPROPİLEN LİFİN KERPİÇ DAYANIMI ÜZERİNE ETKİSİ

ÖZET

Bu çalışmada, polipropilen lifin ferrokrom atığı katkılı kerpicin dayanım ve dayanıklılığı üzerine etkisi incelenmiştir. Bu amaçla kerpiç ağırlığının %0, %5, %10 ve %15'i miktarlarında saman yerine ikame edilmek suretiyle polipropilen lif kullanılmıştır. Polipropilen lifli kerpiç bloklar üzerinde basınç dayanımı ve kerpiç blokların su etkisiyle dağılma deneyleri yapılmıştır. Ayrıca kerpiç blokların üretiminde kullanılan toprak üzerinde çekme ve çamurlaşma deneyleri gerçekleştirilmiştir. Deney sonuçlarına göre polipropilen lif ve ferrokrom atığı katkılı kerpiç blokların standard kerpiç bloklara göre dayanım ve dayanıklılık değerlerinde belirli oranlarda artmalar tespit edilmiştir.

Anahtar Kelimeler: Kerpiç, Polipropilen Lif, Ferrokrom, Saman, Basınç Dayanımı

1. INTRODUCTION (GİRİŞ)

As it is known, soil is one of the foremost materials used by human beings for sheltering. Today most of the people living in the world are staying in soil made houses. This is because soil as a structure material can be easily obtained at huge amounts and structure made of soil is more useful in several aspects than that made of other materials. Soil structure, in places and periods where there is no other facility, is used compulsorily. With increase in prosperity of the public, it has become a material which can be given up when the conditions allow. Yet, recently social and economic conditions have again made the useful properties of soil come to fore.

Soil structure provides for construction of house, office and service buildings with use of ample sources in country in an easy and efficient way, opportunity for use of customs and traditions of public, efficient energy saving, lowering the use of materials in construction sector which are necessary for development to the least, the dweller with the most convenient living conditions in every season, benefit form the solar energy with easy and the most efficient methods, use of every equipment required by the civilization in the structure. For these reasons, soil structure, today gained the qualities of "Contemporary Structure". Certainly, soil structure as other types of structure, has negative aspects. These aspects may be totally eliminated or drawn down to the minimum by taking necessary precautions and applying the provisions [1 and 6].

In the Iran Earthquake, thousands of adobe structures collapsed, thousands of people were killed. In this earthquake, due to weakness of adobe (powdering of adobe to dust) the number of deaths reached serious values. The study, here, also aims at lessening the powdering of adobe [2].

Adobe is one of the cheap and quick ways of sheltering. It provides a comfortable life at ultimate level. It is the only material at minimum cost which does not require foundation of production facility. It provides the one who builds his or her home with the opportunity of using his or her capabilities. Mass production is possible and provides considerable reduction in cost and energy saving in material production and transportation. It provides the use of own sources. Construction of house gets easier; offices, coops, and sheds can be constructed. In the rural areas which are obligatory for development of agricultural production and handicrafts, it provides conditions for civilized life. In rural areas, it helps benefit from known construction techniques and develop it. A building with sufficient strength can be constructed. Adobe has significant contributions to prevention of environmental pollution [1, 4, and 6].

Şimşek and Erol, in their study, investigated the reuse of fly ash produced from thermal power plants, both for preventing environmental pollution and revealing the mechanical properties of it in the adobe which is used as a construction material in rural areas. By weight, 5%, 7%, 10% fly ash, cement and depending on the clay content of soil 7 kg of straw are mixed and from this mixture adobes are produced. Compressive strength and water resistance of these adobes are compared according to their admixtures. From the results it is seen that adobe with fly ash gave better results that those with cement and straw [3 and 4].

Kafesçioğlu produced the alker (gypsum plaster adobe) which is also known as contemporary adobe. In his study he used 100 kg soil, 22 liters water, 2 kg lime and 10 kg gypsum are used to produce alker, which is mixed in mixer 3 minutes and placed in the form then become ready to be used in the construction after 20 minutes. It is a water resistant material. It is observed that with the applied pressure,

adobe is two times as strong as brick and concrete. The experts have the opinion that with these bricks up to 4 floor masonry structures can be constructed [1].

Balaban and Şen used different admixtures to increase the water resistance and compressive strength of adobe. The primary stabilizing admixtures used for this purpose are Portland cement and emulated asphalt. It is found that the adobe soil with cement and emulated asphalt, when compressed, depending on the ratio of admixtures, the resistance of press adobe increases [5].

Potacıoğlu found that addition of cement to adobe material has increased primarily the compression strength, resistance to water and durability to freezing. In this way, important superiorities are obtained compared to very small increase in cost. With this material important superiorities are obtained in the lifetime of the structures. With this material, it is stated that there is a significant increase in the lifetime of structures [5 and 7].

2. RESEARCH SIGNIFICATION (ÇALIŞMANIN ÖNEMİ)

It is known that the adobe which has low strength and low durability in the case of water attact is a traditional structural material. Because of its poorly properties, researchers performed lots of investigations in order to improve engineering properties of the adobe.

As it is known, adobe consists of clay and straw that works as fiber. Generally, pozzolon (gypsum, fly ashes, etc.) is used as an addititive in the improvement investigations of durability and strength of the adobe. However, there is not enough research on fiber which works as a reinforcement in the adobe.

For this purpose, polypropylene fiber is used instead of straw, and ferrochrome dust is used as pozzolon in this study. It is considered that the investigation of effect of using these addititives will be very appropriate for improving durability and strength of the adobe.

3. EXPERIMENTAL STUDY (DENEYSEL ÇALIŞMA)

3.1. Material (Malzeme)

The polypropylene fiber to be used in the mud of adobe is taken from Beksa and Polyfibers factories. Ferrochrome dust is obtained from Elazığ Eti boron ferrochrome mine. For soil, the clayey soil taken from 0.5 m depth from foundation level in Ankara Beşevler is used. Water from Ankara drinking water network is used. In the mixture, polypropylene is used in place of straw, 0%, 5%, 10%, and 15% by weight. The numbers of samples to be used in the tests are given in Table-1.

Table 1. Prepared samples
(Tablo 1. Hazırlanan numuneler)

Adobe Additives	Mixture Ratios (%)	For Compression Strength	For Water Resistance
Polypropylene Fiber	0	3	6
	5	3	6
	10	3	6
	15	3	6
Ferrochrome (constant)	71.45 kg/m^3		
		Total	36 unit

3.2. Method (Yöntem)

3.2.1. Preparation of Experiment Samples (Deney Numunelerinin Hazırlanması)

In this study, 71.45 kg/m^3 constant by weight ferrochrome dust is used. Besides, 7 kg/m^3 polypropylene fiber is used in 5% of the sample. The fiber amount to be used in other samples is determined fiber amount used in the 5% of the sample. According to TS 2514, the amount of water to be used in 1 m^3 of adobe is accepted as 500 liters [8]. From each ratio 9 adobes are made. In this study, it is evaluated whether ferrochrome dust can be used in adobe with polypropylene fiber or not. In the mathematical calculations, the mixing ratios of materials in the adobe are determined. From these calculations, the numbers of samples given in Table 2 are computed.

Table 2. Material amount table as a whole
(Tablo 2. Malzeme miktarları tablosu)

Amount of material for one sample(g)	Polypropylene fiber(g)	Ferrochrome Dust(g)	Water (liters)	Soil(g)	Total Fiber+ Ferrochrome + Soil (g)
5 %	45.36	462.99	3.24	8817.65	9326
10 %	90.72	462.99	3.24	8772.29	9326
15 %	136.08	462.99	3.24	8726.93	9326

Normally, when polypropylene is used in concrete, selection of fiber is based on the maximum aggregate diameter. Therefore, the type of fiber to be used in a concrete containing aggregate size of maximum 20 mm is F19: 900 g/m^3. But, since the maximum size of clay in the adobe is 3-5 mm, it is accepted that this type of fiber is unsuitable. Straw used in normal adobe production is exists in different dimensions and distributed homogeneously. Dimension of straw in the adobe generally varies between 3 mm and 25 mm, although greater straws are seldom come encountered. Therefore, M12: 600 g/m^3–12 mm (1/2"), M19: 900 g/m^3–19 mm (3/4"), F19: 900 g/m^3–19 mm (3/4") types of propylene fibers are mixed at equal weights by mass and fibers to be used are obtained.

3.2.2. Experiments About Adobe (Kerpiç Deneyleri)

3.2.2.1. Compression Strength Experiment (Basınç Dayanımı Deneyi)

In compliance with TS 2514, adobes are placed, maximum 1.5 cm apart, one on top of other in a pattern frame. In between adobes is filled with mortar which is made of (1) part cement, (3) part washed fine sand (0.2 mm–1.0 mm). By positioning the frame vertical, the outer faces of adobes are smoothed by covering by maximum 3 mm mortar parallel to the opposite faces. Compression test is applied after 7 days to the sample prepared this way. The sample which is rested for 7 days is removed from the pattern frame and ultimate load under press machine is determined.

3.2.2.2. Disintegration of Adobe Blocks by the Effect of Water (Su Etkisi Altında Kerpiç Blokların Dağılma Deneyi)

Adobe sample, 12x18x30 cm, is immersed to the half in a container which is filled with water. The dispersion time of the immersed part is determined. Results are compared to topic 12.1.3 in TS 2514.

3.2.3. Experiments About Soil of Adobe (Kerpiç Toprağı Üzerinde Yapılan Deneyler)

3.2.3.1. Tension Experiment (Çekme Deneyi)

After the sample is prepared according to TSEN 2514, it is placed to the instrument measuring the tension resistance given in Figure 8 (TS 2514). Sample is loaded until breaking by the dry sand of 1 mm diameter flowing from the silo given in Figure 8 in TSEN 2514.

Load increment is continuous and maximum at a rate 750 g per minute. The tension strength of mud is the arithmetic average of the experiment results which are different by at most 10%. And it is expressed by g/cm². The area of the cross-section of the sample used in the calculations is 5 cm^2 [8].

3.2.3.2. Mudding Experiment (Çamurlaşma Deneyi)

A sample prepared and dried according to TS 2514 Item 2.1.3. is hung such that the bottom 5 cm part is in the water as in Figure-11 in TS 2514. The time between the placing the bottom part in the water and breaking off this part from the sample is measured. If the sunken part separates from the main part in less than one hour, this sample is accepted to become is mud. If this time is longer than one hour, it is hard for this sample to be mud. If separation occurs in 45 minutes or less, from the mud the sample is taken should not be used for producing adobes [8].

4. FINDINGS AND COMMENTS (BULGULAR VE YORUMLAR)

The results of the experiments in this method are expressed in tables and figures and reliability is checked by variation method.

4.1. Experiments About Adobe (Kerpiç Deneyleri)

4.1.1. Compression Strength Experiment (Basınç Dayanımı Deneyi)

As stated in Chapter 3.2.2.1, results of compression strength experiment about adobe are given in Table 3 and Figure 1.

Table 3. Compression strength experiment results
(Tablo 3. Basınç dayanımı deneyi sonuçları)

Polypropylene Fiber and Clayey Soil Ratio	Number of Samples Used	Compression Strength Kg/cm^2			Average Compression Strength Kg/cm^2	Standard Deviation
		1	2	3		
Witness Sample (5% Ferrochrome Added)	3	12.6	13.9	14.5	13.67	0.971
5%	3	25.5	26.1	25.4	25.66	0.378
10%	3	28.9	30.0	27.0	28.63	1.517
15%	3	31.5	29.2	32.3	31.00	1.609

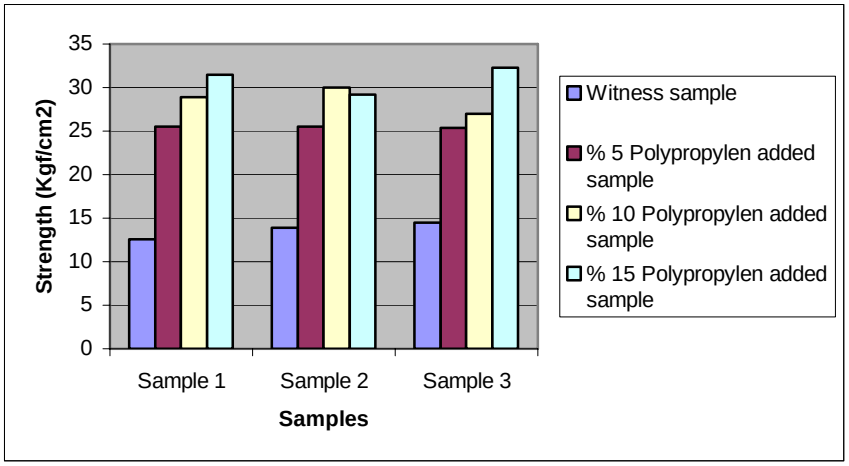

Figure 1. Compression strength experiment distribution
(Şekil 1. Basınç dayanımı testi dağılımı)

4.1.2. Disintegration of Adobe Blocks by the Effect of Water Experiment (Su Etkisindeki Kerpiç Blokların Dağılma Deneyi)

As stated in Chapter 3.2.2.2, results of disintegration under effect of water experiment are given in Table 4 and Figure 2.

Table 4. Disintegration by the effect of water experiment results
(Tablo 4. Su etkisi altında dağılma deneyi sonuçları)

Disintegration by water effect experiment	Sample 1 (min)	Sample 2 (min)	Sample 3 (min)	Sample 4 (min)	Sample 5 (min)	Sample 6 (min)
Witness Sample	55	50	59	47	60	46
5% Addition	91	87	95	88	85	100
10% Addition	95	92	105	98	110	108
15% Addition	105	115	98	103	109	112

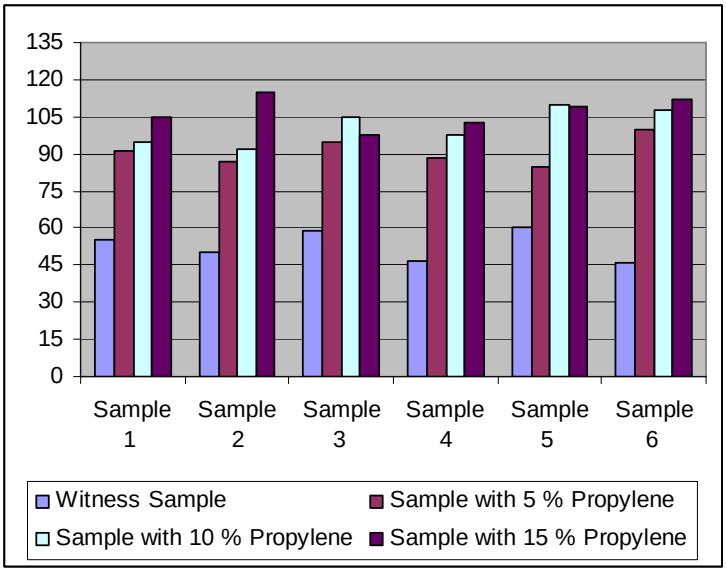

Figure 2. Disintegration by water effect graph
(Şekil 2. Su etkisiyle dağılma grafiği)

4.2. Experiments About Soil of Adobe (Kerpiç Toprağı Üzerinde Yapılan Deneyler)

4.2.1. Tension Experiment (Çekme deneyi)

As stated in Chapter 3.2.3.1, results of tension experiment about soil of adobe are given in Table 5 and Figure 3.

Table 5. Tension experiment results
(Tablo 5. Çekme Deneyi sonuçları)

Tension Failure Value	Sample 1	Sample 2	Sample 3
Obtained Value (g/cm^3)	138.6	150.4	145.3

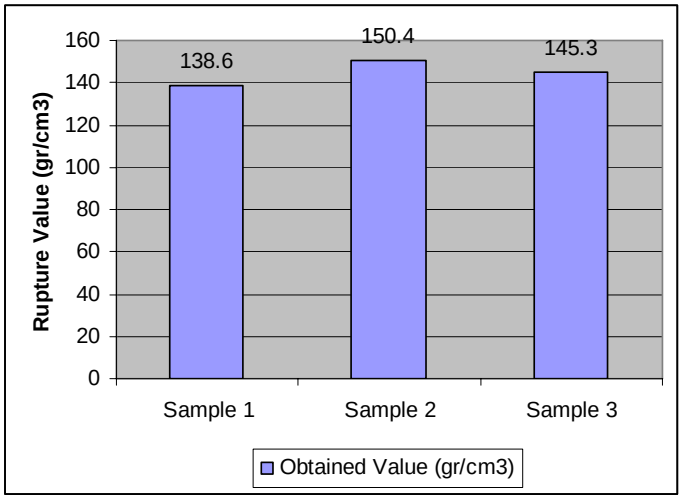

Figure 3. Tension experiment distribution
(Şekil 3. Çekme deneyi dağılımı)

4.2.2. Water Absorption (Mud) Experiment (Su Emme (Çamurlaşma) Deneyi

As stated in Chapter 3.2.3.2, results of water absorption of soil of adobe experiment are given in Table 6 and Figure 4.

Table 6. Water absorption (Mud) experiment results
(Tablo 6. Su emme (Çamurlaşma) deney sonuçları

Water Absorption Experiment	Sample 1	Sample 2	Sample 3
Time Elapsed (min)	72	68	65

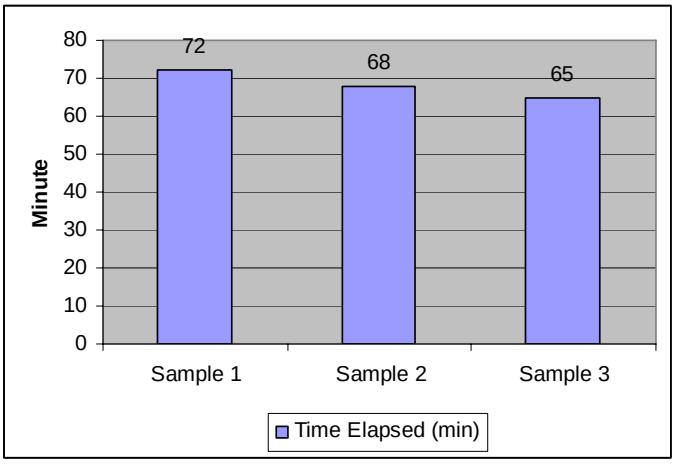

Figure 4. Water absorption (Mud) experiment distribution
(Şekil 4. Su emme (Çamurlaşma) deneyi dağılımı)

4.3. Examination of the Experiments by One-Tail Variance (Deneylerin Tek Yönlü Varyans Analiziyle Incelenmesi)

The mathematical expression: $Y_{ij} = \mu + T_j + E_{ij}$ is used to test the reliability of the results of the compression strength and disintegration by water effect (mud) experiments about adobe and tension strength and water absorption (mud) experiments about soil of adobe. The results are as followings [8].

Result of compression of adobe experiment: Sum of squares general; $SS_{general}$=133.352, Sum of squares between trials; SS_{trials}=129.876, Sum of squares of errors; SS_{error}=3.476, Mean of sum of squares general; $MSS_{general}$=43.155, Mean of sum of squares of errors; MSS_{error}=1.158. From these, $F_{calculated}$ is found to be 26.384. Since $F_{calculated}$=26.384 < F_{table}=$_{.95}F_{3,8}$=4.07, it is found that polypropylene fibers increase the compression strength of adobe.

Result of disintegration of adobe blocks by water effect experiment: Sum of squares general; $SS_{general}$=467.957, Sum of squares between trials; SS_{trials}=453.279, Sum of squares of errors; SS_{error}=14.678, Mean of sum of squares general; $MSS_{general}$=146.692, Mean of sum of squares of errors; MSS_{error}=4.892. From these, $F_{calculated}$ is found to be 37.587. Since $F_{calculated}$=37.587 < F_{table}=$_{.95}F_{3,8}$=4.07, it is found that polypropylene fibers increase the resistance of adobes to disintegration by water effect.

Result of tension strength of adobe experiment: Sum of squares general; $SS_{general}$=678.955, Sum of squares between trials; SS_{trials}=657.081, Sum of squares of errors; SS_{error}=21.874, Mean of sum of squares general; $MSS_{general}$=219.729, Mean of sum of squares of errors; MSS_{error}=7.291. From these, $F_{calculated}$ is found to be 35.678. Since $F_{calculated}$=35.678 < F_{table}=$_{.95}F_{3,8}$=4.07, it is found that polypropylene fibers increase water absorption durability of soil of adobe.

Result of tension strength of adobe experiment: Sum of squares general; $SS_{general}$=320.483, Sum of squares between trials; SS_{trials}=308.860, Sum of squares of errors; SS_{error}=13.623, Mean of sum of squares general; $MSS_{general}$=103.716, Mean of sum of squares of errors; MSS_{error}=4.541. From these, $F_{calculated}$ is found to be 18.436. Since $F_{calculated}$=18.436 < F_{table}=$_{.95}F_{3,8}$=4.07, it is found that polypropylene fibers increase water absorption durability of soil of adobe.

5. CONCLUSION AND SUGGESTIONS (SONUÇ VE ÖNERİLER)

At the end of the compression strength test of adobe, the compression strengths of samples are 13.9 kg/cm^2, 25.4 kg/cm^2, 27.0 kg/cm^2, and 31.5 kg/cm^2 respectively. Since the polypropylene fibers can undergo stress more than straw, as the content of polypropylene fibers increases the compression strength of adobe increases.

At the end of the disintegration of adobe by water effect experiment, the durations of the samples in the water are 55 min, 91 min, 105 min, and 109 min, respectively. Since polypropylene fibers have more adherence than straw, as the content of polypropylene fibers increases the disintegration value of adobe in the water increases.

The results of the tension test of soil of adobe experiment are 138.6 g/cm^3, 150.4 g/cm^3, and 145.3 g/cm^3 respectively. The average of these values is 144.76 g/cm^3. According to TS 2514, this soil is among the lubricious soil class as shown in Table 1 in the standard.

The results of the water absorption of soil of adobe experiment are 72 min, 68 min, and 65 min respectively. The average of theses values is 68.3 min. According to TS 2514, since this value is greater than 45 min it is found that this soil is appropriate for adobe production.

Providing a more durable material than straw, addition of polypropylene fiber to the soil, universal construction material, will be effective in increasing the durable life of adobe.

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