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A RESEARCH ON THE PRODUCTION OF SILICA FUME ADOBE

ABSTRACT

In this research the use of silica fume in the mix proportion of adobe as a component and the strength of silica fume adobe is investigated. For this purpose, some amount of cement is added to the adobe, and 0%, 5%, 10% and 15% silica fume by weight of cement is added to the adobe mixture. Three samples from each of the percent classes are prepared. With these prepared samples, strength tests, water resistance tests, and wind resistance tests are conducted. According to the test results, the addition of silica fume to the adobe can be said to increase the strength and water resistance of adobe. According to the results of the wind resistance test, no significant change is observed in the samples that were painted with plastic paint. In the samples painted with lime, very fine visible cracks were formed and partial disintegrations were observed.

Keywords: Adobe, Silica Fume, Strength, Durability, Concrete

SİLİS DUMANLI KERPİÇ ÜRETİMİ ÜZERİNE BİR ARAŞTIRMA

ÖZET

Bu araştırmada, belirli oranlarda silis dumanı katkılı kerpicin fiziksel ve mekanik özellikleri incelenmiştir. Bu amaçla, çimentonun ağırlığının %0, %5, %10 ve %15 oranlarında silis dumanı eklenerek kerpiç karışımı hazırlanmıştır. Her bir orana ait üçer numune hazırlanmıştır. Önceden hazırlanmış bu numuneler üzerinde dayanım testi, suya karşı direnci ve rüzgâr direnci testleri yapılmıştır. Test sonuçlarına göre silis dumanı katkılı kerpicin suya karşı direncinde ve dayanım özelliklerinde artış sağladığı gözlenmiştir. Rüzgâr dayanım testinin sonuçlarına göre plastik boyayla boyanan numuneler üzerinde herhangi bir değişiklik gözlenmiştir. Kireçle boyanan örneklerde çok az görülebilecek parçacıkların ayrıldığı gözlenmiştir.

Anahtar Kelimeler: Kerpiç, Silis Dumanı, Dayanım, Dayanıklılık, Beton

1. INTRODUCTION (GİRİŞ)

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 [1].

Erol (2000) studied the production of adobe with the addition of fly ash, and compared the strength and water resistances of the produced adobes according to their admixture types. As a result, the strength of fly ash adobes is found out to be greater than cement and straw added adobes [2].

Durmuş has investigated the addition of rice husk to adobes, and proposed the rice husk adobes as a suitable structural masonry unit [3].

Kılıçkale has conducted similar researches and investigated the properties and pozzolanic activities of fly ash, silica fume, clinker slag, and rice husk. As a result, he determined that all the given admixtures had to some extent pozzolanic activities, but the more active admixtures had been the silica fume and rice husk [4].

Ekinci reported that, silica fume addition to cement pastes increases the strength, reduces the production time of the cement, and increases the water requirement in the paste [5].

In his research, in 1993, Başyiğit determined that addition of silica fume and fly ash to concretes demonstrates an increase in the strength of the concrete [6].

Çelik et. al. in their study in 2001, discussed that the addition of silica fume increases the setting time of cement [7].

Erdoğdu et. al. has investigated the addition of silica fume in different amounts to concrete. With low (9%) silica fume ratio the strength of concrete semmed to increase 50% in the early days of concrete production [8].

Tokgöz et. al. in their study in 2004 investigated the strength of silica fume adobe and stated that the addition of silica fume to adobe increases the strength [9].

2. RESEARCH SIGNIFICATION (ÇALIŞMANIN ÖNEMİ)

Adobe is a structural material that is produced by the molding of a soil paste including water and drying of it in the open air. The basic material of adobe is soil. Adobe is used to build human and animal shelters especially in villages and small towns. According to the researches done, when producing adobe, the addition of admixtures to the soil may improve the physical properties of the adobe. The most important benefit that is desired by the addition of admixtures to adobe paste is to increase the water resistance and strength of adobe. In this study, the aim is to increase the strength of adobe by the addition of silica fume to the adobe paste.

3. EXPERIMENTAL STUDY (DENEYSEL ÇALIŞMA)

3.1. Material (Malzeme)

In the experiments clay soil obtained from Çorum Bağlar region construction sites is used. Clay is obtained from the site according to the regulations of "Turkish Standard 1901 - Methods of and Obtaining of Disturbed and Undisturbed Samples for Civil Engineering Purposes" [10]. Animal bait straw and Portland cement (PÇ 42.5) according to "TS EN 197-1 - Compositions and conformity criteria for

common cements ” standard is used as binding materials in adobe production [11]. Silica fume is obtained from Antalya Etibank Electrometallurgy Facilities [12]. As for the mix water, Çorum provincial drinking water is used The properties of soil used in production of adobe was determined in accordance with TS 1900 procedure and is given in Table 1.The chemical and physical properties of silica fume is presented in Table 2 respectively.

Table 1. The properties of adobe soil
(Tablo 1. Kerpiç toprağının özellikleri)

Properties	Value
Specific gravity (gr/cm^3)	2.72
Liquid limit (%)	56
Plastic limit (%)	30
Plasticity index (%)	26
Moisture content(%)	37.5

Table 2. The chemical and physical properties of silica fume
(Tablo 2. Silis dumanının fiziksel ve kimyasal özellikleri)

Physical properties	Value
Specific gravity(gr/cm^3)	2.19
Moisture (%)	0.63
Retained on no. 30 sieve (%)	0.00
Retained on no.200 sieve (%)	15.60
Retained on no.325 sieve (%)	30.95
Chemical composition	
SiO_2 (%)	93.75
Al_2O_3 (%)	0.82
Fe_2O_3 (%)	0.67
MgO (%)	1.23
CaO (%)	0.80
SO_3	0.21
Loss on ignition (%)	0.69
Insoluble residue (%)	0.42

3.2. Method (Yöntem)

The guidelines of “TS EN 537 - Cement Treated Adobe Bricks” are used in this experimental study. As a result of the analysis made on the soil, it is found that the soil was suitable for adobe production. Silica fume of 0%, 5%, 10% and 15% by weight of Portland cement (PÇ 42.5) is added to the cement and three samples of 12x12x12 cm dimensions from each of the silica fume percentage classes are prepared [13].

3.2.1. Strength Experiment (Dayanım Deneyi)

Adobe samples were prepared according to the regulations of TSEN 537; two layers of blocks and a layer of mortar in between. The top and bottom faces of the test samples were capped with smooth surfaced glasses to enable the smoothness of the sample surface. Then, the samples were waited for 2 days in a fully damp environment, and then for 5 days in 20±5 °C, and 55% relative humidity. The dimensions of the sample surfaces that were subjected to compressive stress were measured with a precision of 0.1 mm and the gross area of the sample surfaces were determined. Later on, in the press machine, the compressive strength test is conducted by increasing the load (P) until the samples failed. The strength of the samples (in kgf/cm^2) was computed by dividing the failure load to the surface area [13].

3.2.2. Water Resistance Experiment (Su Direnci Deneyi)

According to the regulations of TSEN 537 adobe samples were placed in water to their half height, and the disintegration of the portion of the samples in contact with water was determined [13].

As a result of the observations witness sample has shown disintegration at the end of 59 minutes. 5%, 10%, and 15% silica fume added samples have shown disintegration at the end of 63, 65, and 63 minutes, respectively.

3.2.3. Wind Resistance Experiment (Rüzgar Direnci Testi)

Adobe samples were painted with plastic paint and lime. Painted samples were waited for 1 day. These samples were wrapped with cardboards and subjected to artificial wind produced by an electrical ventilator. It is observed that whether the paints dropped off the surfaces of the samples or not.

As a result, the samples painted with plastic paint have not shown significant change, on the other hand, in the samples painted with lime visible small fine cracks have occurred, and paint has outworn. Paints in all samples, especially the 10% silica fume samples, have dropped off at least partially.

4. FINDINGS AND COMMENTS (BULGULAR VE YORUMLAR)

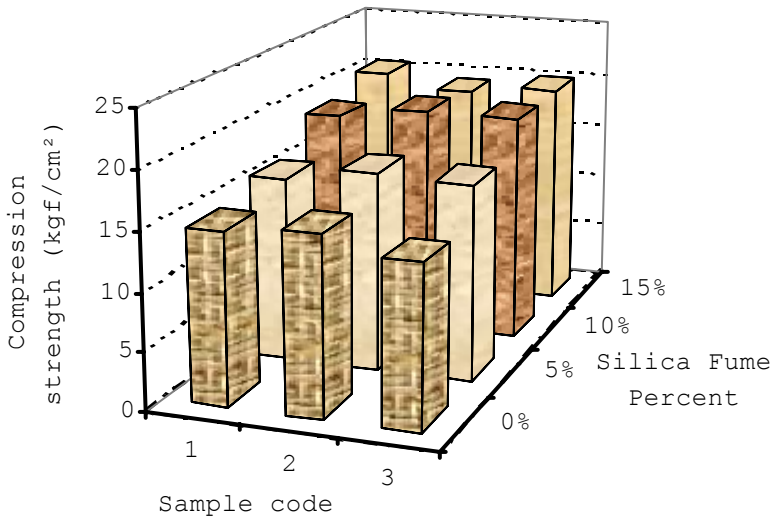
The results of the experiments in this method are expressed in tables and figures and reliability is checked by one-tail variation method.

4.1. Strength determination (Dayanım Tespiti)

The experimental results obtained from the tests are demonstrated in Table 3 and Graph 1.

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

Sample Code	Witness sample 0% (kgf/cm²)	5% silica fume (kgf/cm²)	10% silica fume (kgf/cm²)	15% silica fume (kgf/cm²)
1	14.758	16.048	18.858	20.437
2	15.439	17.283	19.947	19.216
3	13.968	17.045	19.887	19.925



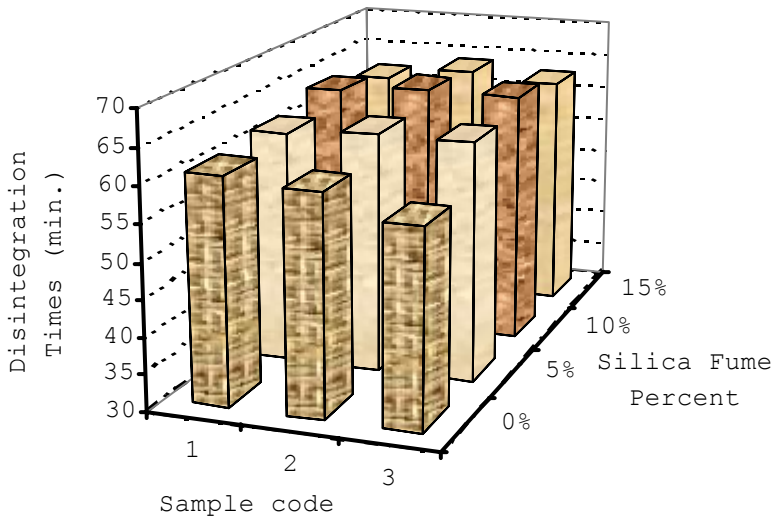
Graph 1. Compressive Strength of Silica Fume Adobes
(Grafik 1. Silis Dumanlı Kerpiçlerin Basınç Dayanımları)

4.2. Water Resistance Determination (Su Direnci Tespiti)

The experimental results obtained from the tests are demonstrated in Table 4 and Graph 2.

Table 4. Disintegration times of the samples under the effect of water
(Tablo 4. Su etkisi altıdaki kerpiç numunelerin dağılma zamanları)

Sample No	Witness sample (0%) (min.)	5% silica fume (min.)	10% silica fume (min.)	15% silica fume (min.)
1	61	62	64	62
2	60	63	65	64
3	57	63	65	63



Graph 2. Disintegration times of the samples under the effect of water
(Grafik 2. Su Etkisi altıdaki kerpiç numunelerin dağılma zamanları)

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

The mathematical expression $Y_{ij} = \mu + T_j + E_{ij}$ is used to test the reliability of the results of the compression strength and water resistance experiments about adobe. The results are as followings.

Result of compression of adobe experiment: Sum of squares general; $SS_{general}$=56.922, Sum of squares between trials; SS_{trials}=53.481, Sum of squares of errors; SS_{error}=3.441, Mean of sum of squares general; $MSS_{general}$=17.827, Mean of sum of squares of errors; MSS_{error}=0.430. From these, $F_{calculated}$ is found to be 41.458. Since $F_{calculated}$=41.458 < F_{table}=$_{.95}F_{3,8}$=4.07, it is found that silica fume increases the compression strength of adobe.

Result of water resistance experiment: Sum of squares general; $SS_{general}$=57, Sum of squares between trials; SS_{trials}=45, Sum of squares of errors; SS_{error}=12, Mean of sum of squares general; $MSS_{general}$=15, Mean of sum of squares of errors; MSS_{error}=1.5. From these, $F_{calculated}$ is found to be 10. Since $F_{calculated}$=10 < F_{table}=$_{.95}F_{3,8}$=4.07, it is found that silica fume addition increases the water resistance of adobe.

5. CONCLUSIONS (SONUÇLAR)

At the end of strength test, the strength of the samples is found to be 14.721 kgf/cm². When silica fume of 5%, 10%, and 15% by weight of cement is added, the strengths become 16.792, 19.564, and 19.859 kgf/cm², respectively. It is obvious that silica fume addition has increased the strength of adobe.

The disintegration time for the witness sample in water resistance test is found to be 59 minutes. When silica fume of 5%, 10%, and 15% by weight of cement is added, the disintegration times become 63, 63, and 65 minutes, respectively. It is obvious that silica fume addition has increased the water resistance of adobe.

In the wind resistance tests, the samples that are painted with plastic paint have shown no significant change, but the samples painted with lime have shown fine cracks, and partial drop-offs.

Because of the limited content of this study, the percentage of silica fume was kept constant as 5%,10% and 20% respectively. It can be useful to research the influence of different percentage lime silica fume on mechanical properties of adobe. The optimization can be made by testing more percentage of lime, silica fume addition.

Silica fume used in production of adobe are obtained as by-product and the utilization of these waste materials which are not utilized effectively in the other areas is possible. The utilization of industrial waste materials both provides a significant contribution for country economy and solution of the environmental pollution problems.

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