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A Study on the Production of Adobe with the Addition of Silica Fume

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Abstract

In this study, usability and resistance of silica fume in the manufacture of adobe by mixing silica fume in certain proportions with the material used in the manufacture of adobe was investigated. For this purpose, a certain amount of cement with no or some silica fume content was added to adobe. Three bricks were prepared with each of the cement added mixtures containing 0, 5, 10, and 15% ($w_{silica\ fume}/w_{cement}$) silica fume. The prepared samples were tested to determine compressive strength, water resistance, and wind resistance. For the wind resistance tests, the bricks were painted with either plastic paint or lime. The results of the experiments showed that the silica fume substitution can be said to increase compressive strength and water resistance. However, the wind resistance values were not changed in the samples painted with plastic paint. The samples painted with lime showed visible capillary cracks, and partial spills occurred.

Keywords: Silica Fume, Adobe

1. Introduction

Adobe is a construction material which is prepared by kneading soil with water and drying in the open air. The main material is the soil. Adobe is used in the making of human and animal shelter. It has been shown that, during the manufacture of adobe, the inclusion of some binding agents to the soil exerted improving effects on some mechanical properties of the brick. The most important benefits expected from inclusion of a variety of binding substances in adobe soil are to improve resistance to water and pressure (1). This study aimed at improving the strength of adobe by using silica fume, which is an industrial waste.

1.1. Literature Review

Ekinci has stated that the addition of silica fume increased the strength of cementitious systems and shortens the preparation time of mortar, and together with silica fume addition the regular water requirement increased (2).

Çelik et al., in their study in 2001, has mentioned that silica fume delayed the setting time of cement (3).

Erdoğdu and coworkers studied the substitution of silica fume at different ratios. They have found that the silica fume addition at the low dosages as 9% provided increase in strength of concrete at early ages in the order of 50% (4).

2. Material and Method

2.1 Material

2.1.1. Soil, Cement, Straw, Silica Fume, Mixture Juice

In experimental studies, clayey soil obtained from Çorum Bağlar location construction field in accordance with the "TS 1901" disturbed sampling methods of drilling strategies in construction engineering has been used (5). Animal feed, straw haymaker and PC 42.5 type cement in accordance with TS 19 have been used as binding material.

2.2. Method

In the study, TS 537 standard has been applied for the walls with adobe blocks with cement addition. Based on the analyses made on the soil, the soil was determined to be suitable for adobe production. Three samples of 12x12x12 size for each of 0, 5, 10, and 15% substitution in PÇ 42,5 cement were prepared.

2.2.1. Determination of Compressive Strength

Adobe samples were prepared in accordance with “TS 537” by stacking two blocks and placing a mortar layer in between. The top and bottom surfaces of the test sample were headed with the same mortar using a straight edge glass. Following the placements of heads, the samples were kept in a saturated humidity location for the first two days and then in a location with 55% relative humidity at 20±5 ^{o}C temperature for five days, totaling to seven days. The gross area of the surface at which pressure will be applied was determined by measuring the dimensions of the surface at 0,1 mm precision. Then the experiments were performed by increasing the pressure (P) in pressure test pres until the samples were broken. By dividing the measured value with the surface area, the compressive strengths were determined as kgf/cm^2 (6).

2.2.2. Determination of Water Resistance Values

The adobe samples were immersed in water to half of their height in a container according to “TS 537”, and the disintegration times of the sections in contact with water were recorded in minutes (6).

The control sample was observed to start to disintegrate in 59 minutes. The disintegration times for the samples with 5, 10, and 15% silica fume supplementation were found to be 63, 65, and 63 minutes, respectively.

2.2.3. Determination of Wind Resistance

The adobe samples were painted with plastic paint and lime. The painted adobes were kept for one day. Then whether a spill occurred or not was observed when these samples were faced to wind for 36 hours by using a ventilator and enclosing the samples with cardboard boxes.
As a result, no change was observed with the samples painted with plastic paint. However, the visible capillary cracks were observed with the samples painted with lime, and the paint showed some visible wear. Pronounced in the samples with 10% silica fume substitution, partial disintegrations (spills) were observed in all the samples.

3. Results and Discussion

The results of the experiments defined in methods section are given as tables and figures, and the reliability was tested by using one-way variance analysis.

3.1. Determination of Compressive Strength

The data obtained from the experiments made as in Section 2.2.1 are shown in Table 1 and Figure 1.

Table 1. Compressive strength values of adobe samples with silica fume supplementation

Experiment No	Control sample (0% silica fume) (kg_f/cm^2)	Sample with 5% silica fume (kg_f/cm^2)	Sample with 10% silica fume (kg_f/cm^2)	Sample with 15% silica fume (kg_f/cm^2)
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

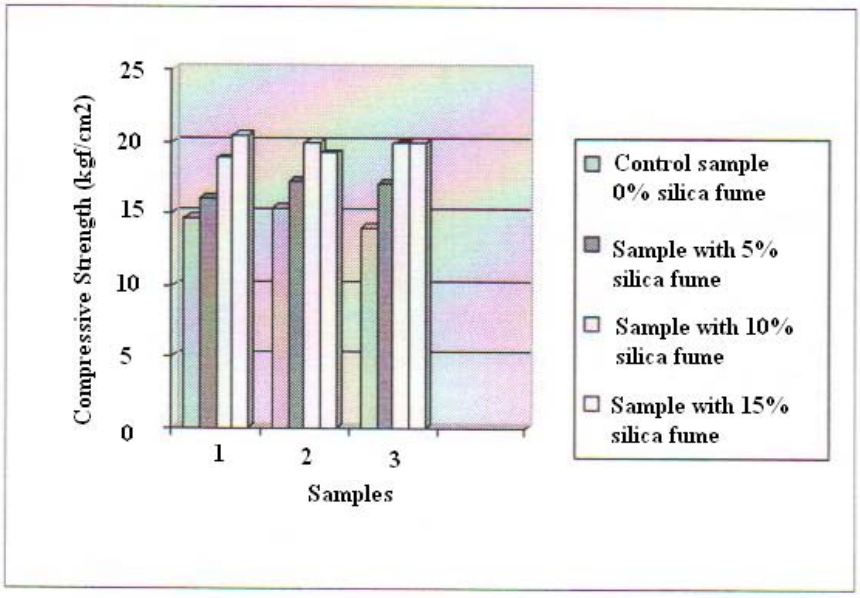


Figure 1. Distribution graph of the compressive strength values of adobe samples with silica fume supplementation

3.2. Determination of Water Resistance Values

The data obtained from the experiments made as in Section 2.2.2 are shown in Table 2 and Figure 2.

Table 2. Water resistance data of adobe samples with silica fume supplementation

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

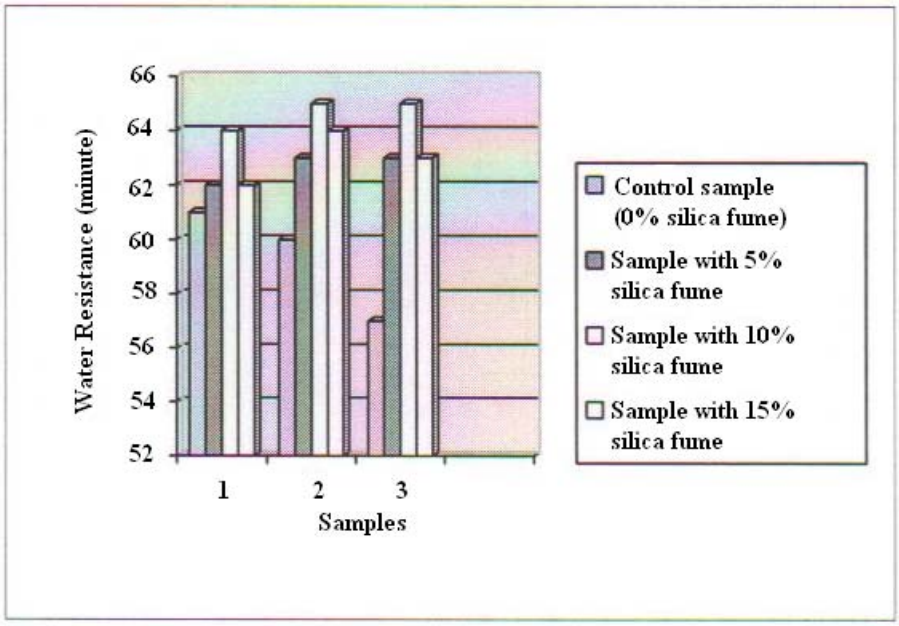


Figure 2. Distribution graph of the water resistance values of adobe samples with silica fume supplementation

3.3. Evaluation of the Experimental Results

Mathematical model equation for the evaluation of the reliability of the results obtained in compressive strength and water resistance experiments was established as(7):

$Yij=\mu+\tau j+\Sigma ij$

and the following results were obtained.

The result of compressive strength experiment: the general sum of the squares as $SS_{General}=56.922$, the interexperimental sum of squares as $SS_{Experiment}=53.481$, the sum of squares of error as $SS_{Error}=3.441$, the general mean of squares as $S_{mGeneral}=17.827$, and the mean of squares of error as $S_{mError}=0.430$ were calculated. Based on the data obtained from these values, $F_{calculated}=41.458$ was found.

Thus, because $F_{calculated}=41.458 > F_{Table}={}_{95}F_{3,8}=4.07 \rightarrow F_{calculated} > F_{Table}$, it was understood that the silica fume supplementation increased the compressive strength of adobe sample.

The result of water resistance experiment: the general sum of the squares as $SS_{General}=57$, the interexperimental sum of squares as $SS_{Experiment}=45$, the sum of squares of error as $SS_{Error}=12$, the general mean of squares as $S_{mGeneral}=15$, and the

mean of squares of error as S_{mError}=1.5 were calculated. Based on the data obtained from these values, $F_{calculated}$=10 was found.
Thus, because $F_{calculated}$=10 > F_{Table}=$_{95}F_{3,8}$=4.07 → $F_{calculated}$ > F_{Table}, it was understood that the silica fume supplementation increased the water resistance of adobe sample.

4. Conclusion

As a result of compressive strength experiment, the control sample value was found to be 14.721 kg/cm^2. Upon the substitution of cement with 5, 10, and 15% silica fume, the values were found to be 16.792, 19.564, and 19.859 kg/cm^2, respectively. The compressive strength was observed to increase in 5, 10, and 15% silica fume supplemented samples as compared to the control sample.
As a result of water resistance experiment, the control sample value was found to be 59 min. Upon the substitution of cement with 5, 10, and 15% silica fume, the values were found to be 63, 65, and 63 minutes, respectively. Based on these values, the supplementation with 5, 10, and 15% silica fume was observed to increase the water resistance values.
As a result of wind resistance experiment, no significant change occured with the samples painted with plastic paint. However, in the sample painted with lime, visible capillary cracks were formed, and partial spills occured.

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