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Investigation of the Physical and Mechanical Properties of Glycerin Added PVA Fiber Screened Cement Composites

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Keywords

Fiber, PVA fiber, Cement, Glycerin, Engineered cement composites.

Abstract

Concrete, in its simplest definition, is a building material obtained by combining water, cement and aggregate in certain proportions. The basic chemical components of concrete consist of these three materials. However, it has been an important issue to develop concrete against many effects other than its existing mechanical and physical properties, thanks to its economic and easy accessibility. Fibers that have been added to concrete in order to improve the tensile stresses of concrete since the past have been expanding their range today. PVA fiber reinforced concrete, known as engineered cementitious composite (ECC), improves the low tensile stress of concrete and accordingly provides high toughness. ECC concrete is a material developed with a micromechanical mix design. However, the use of ECC concrete is limited due to its disadvantage in terms of easy accessibility and economy. In this study, the physical and mechanical properties of 1 drop of glycerin added PVA fiber and 2 drops of glycerin added PVA fiber concretes were investigated. The physical and mechanical properties of the samples were investigated by adding 2% PVA 1 drop of glycerin fiber and PVA 2 drops of glycerin fiber into the concrete mix design prepared with the micromechanical design. According to the findings, an increase was observed in water absorption, porosity and electrical resistivity tests compared to the control sample and commercial PVA fiber samples; A decrease was observed in the charpy experiment.

1.Introduction

The desire to expand the usage areas of concrete, which is one of the building materials, has led to the need for development in concrete technology [1]. This development has emerged in the direction of improving the weak properties of concrete [2]. The most common method used to improve the weak properties of concrete is to add steel, glass, polypropylene, etc. into the concrete. to add fibers [3]. The most important feature that should be provided in fibrous concretes is that the fibers are uniformly dispersed and that this homogeneity is maintained even after the concrete is mixed and put into molds [4]. Although concrete is known as a brittle material due to its high compressive strength, these fibers added to the concrete enable the concrete to resist tensile stresses and give the concrete ductility [5]. In a study [6]; By adding 0.5%, 1% and 1.5% steel, polypropylene and glass fiber into the concrete mortar mixture, 3 pieces of each series were produced and compared with the produced fiber-free control sample. According to the results obtained, it was stated that all fibrous series had higher toughness and deflection values compared to the control sample. At the same time, the best results among the fibrous series were observed in the samples produced with steel fibers. In another study [7]; The fiber fraction added to the mortar and the water/cement ratio were changed and compared with the control sample and the mechanical properties on the concrete samples were examined. It was stated that with the addition of glass fiber to the control sample with a water/cement ratio of 0.34, the fracture energy increased 109 times. In fibroconcrete with a water/cement ratio of 0.36, this increase was observed as 66 times. According to the findings, it was stated that with the addition of fiber to the bare matrix, it became more tough and ductile by increasing the fracture toughness. In another study [8]; The effect of polypropylene fibers on the adherence behavior between concrete and reinforcement was investigated. Fibers were added into the mortar at the rates of 0.25%, 0.50% and 1% and were produced with vertically positioned Ø10 diameter reinforcement. The stripping of the reinforcement was observed by applying the tensile test to the reinforced concrete sample. According to the findings, it was stated that the reinforced concrete samples with polypropylene fiber had lower tensile stresses compared to the control samples. In another study [9]; Polypropylene fiber concrete was used in the tension region of the beam and it was designed without stirrups, supported by steel and glass fiber reinforcements (GFRP). The behavior of the designed beams under the bending effect has been investigated. As a result, it was stated that GFRP reinforced beams greatly improved the bending performance. In another study [10]; The physical and mechanical properties of the samples produced by adding 2%, 4% and 6% by volume polyvinyl alcohol (PVA) fibers into the mortar were compared with the control sample. As a result, with the increase of fiber fraction, multiple crack formation was observed in concrete mortar samples, indicating that ductility increased and crack widths decreased.

When the literature studies are examined, it is clearly seen that fiber concrete improves the width of the usage areas and the building elements. However, among the studies, no study was found in which the physical and mechanical properties of the fibers were examined by increasing the moisture retention with the addition of glycerin into the fibers. In this study, the physical and mechanical properties of the samples were investigated compared to the control concrete, with the addition of glycerin, which is thought to be a solution to the problem of agglomeration of fibers, in the concrete mix design by using it in the fiber.

2. Testing process

2.1. Test specimens and properties

In use in the experiment; 42.5 Portland made is PVA fiber with added water, silica sand, fly ash, superplasticizer, drinking water and glycerin. It is designed by mixing cement, silica sand, fly ash and chemical content.

The cement used as hydraulic binder in the mortar mixture prepared to be used in the experiment is CEM I-42.5/R type Portland Cement (PÇ) and complies with TS EN 197-1 [11] standard. 42.5 Portland cement has a Blaine fineness of 3312 cm2/g and a specific gravity of 3.1. Class F fly ash was used as the pozzolanic binder. The chemical components of cement and fly ash are presented in Table 1. Silica sand of 50 µm size was used as aggregate.

The water used in sample preparation was used from the campus network of Afyon Kocatepe University.

The high-performance plasticizer concrete additive used to increase the workability in the prepared fresh concrete mix is Sika Viscocrete SF-18 brand and 0.77% of the binder weight in the mortar was used in the fresh concrete mix. In order for the high-performance plasticizer concrete additive to enter the reaction faster, it was added to the mortar mixture by mixing it with water at the same time. The chemical composition of the concrete additive is presented in Table 2.

Table 1. Chemical components of cement and

Component, %	Cao	SiO_2	Al_2O_3	Fe_2O_3	MgO	Na_2O	K_2O	SO_3	KK
PÇ	63.6	19.6	4.72	3.27	1.91	0.34	1.06	4.72	2.69
Fly Ash	6.66	47.4	19.8	11.8	4.76	0.57	2.62	1.86	2.76

Table 2. Technical properties of the superplasticizer additive

Chemicak Structure	Modyfied polimer polycarboxylate based
Density	1.10±0.02 kg/l, 20°C
pH	3 – 7
Freezing Point	-10 °C
Percentage of Manageable in Water	Max. 0.1%, chloride free (TS EN 934-2)

Different proportions of glycerine added PVA fibers used in the mortar mixture are presented in Figure 1.

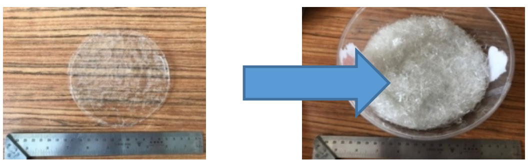

Figure 1. Appearance of glycerin-doped PVA fiber

2.2 Testing system and manufactured specimen

How to design in use in ready-to-use ashes in the experiment and using volatile, superplasticizer and different (1 drop/2 drop) glycerin doped PVA fiber.

Prismatic samples of 30.5x2.5x2.5cm were prepared to be used in the experiments. Experimental studies were carried out on 18 (2+4+6+6) batch mortar mixes in total. Of these samples, 2 (1+1) are control samples and 4 (2+2) are commercial PVA fiber samples, the others are PVA fiber samples with glycerin additive. The mixture design of the mortars used in the experiments is given in Table 3.

In the table, W is water; C, cement; FA stands for fly ash. In the mortars prepared to be used in the experiment, first of all, binders (cement and fly ash) and aggregate (silica sand) were put into the planetary mixer and dry mix was made for about 1 minute. After the dry mixture was made, some of the water was added to the mixture and mixed some more. The remaining water was added to the mixture at the same time by mixing with water so that the concrete admixture could react more quickly, and the mixture was mixed for about 3-4 minutes until the mixture became homogeneous.

Table 3. Mixture designs

	Quantities (kg/m^3)			
Components	%0	%2 PVA	%2PVA1G	%2PVA2G
Cement	96.34	96.34	96.34	96.34
Silica sand	77	77	77	77
Fly ash	115.67	115.67	115.67	115.67
Superplasticizer	1.25	1.25	1.25	1.25
Water	75.67	75.67	75.67	75.67
Fiber	0	9.34	9.34	9.34
TOTAL	365.93	367.1	368.27	369.43
W/(C + FA)	0.36	0.36	0.36	0.36
FA/C	1.2	1.2	1.2	1.2

Prepared test mortars were poured into pre-oiled molds. The test samples in the molds were removed from the molds after 24 hours and placed in the curing pool with lime-saturated water at room temperature (20±2 oC) to be cured for 28 days. The 28-day test samples were subjected to water absorption, porosity, electrical resistivity and charpy tests. Experiments were started from physical properties. The test samples were kept in the oven for 24 hours and the oven dry weight was taken. Afterwards, the samples were kept in the curing pool for 24 hours and saturated with water. The values obtained by weighing the water-saturated test samples on Archimedes balance were noted and electrical resistivity test was performed. The electrical resistivity values (R) are in accordance with the ASTM C 1760 [12] standard and were determined by the two-plate method with the help of a test resistor (ohm-meter) (Figure 2). In order to distribute the current evenly over the entire area, the two side areas to be measured are covered with wet felt. The electrical resistivity values of the mortars were also determined by the equation (1) given below.

$$\delta = R.A/L \qquad (1)$$

In the equation, δ is the electrical resistivity (kohm.m); R resistor (kohm); A represents the sample surface area (m2) and L represents the distance between the plates (m).

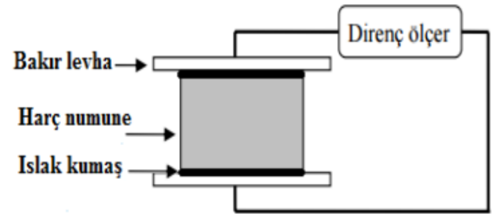

Figure 2. Resistivity test setup

Afterwards, the samples were placed in an oven to be kept for 24 hours. At the end of 24 hours, the drying-dry values of the samples were noted and the water absorption and porosity values were determined. The experiments were continued with the bending test, which is one of the mechanical properties. The experiment was carried out on samples of 3x5x2,5 mm dimensions, with 3-point bending type and 4 cm support span, according to TS EN 12390-5[13] standard. has been carried out. The capacity of the bending press used in the experiment is 20kN. The 3-point flexural strength of the mortars was determined by equation (2).

$$\sigma = 3.F.L / 2.b.d^2 \quad (2)$$

In the equation, σ is the flexural strength of the rock (kgf/cm2), F is the load causing fracture (kgf), L is the distance of the test sample between the supports (cm), b is the width of the test sample (cm), d is the thickness of the test sample (cm).

For the Charpy test, a U notch with a width of 1.5 mm and a height of 10 mm was drilled on the 3x5x2.5 sized samples (Figure 3). Charpy test is based on finding the required energy of the sample under dynamic loading by using potential differences. The value obtained by dividing this potential energy by the fracture area is called the fracture toughness. The fracture toughness of the samples was determined by equation (3).

$$Ç=U/A=(G(h0-h1))/A \quad (3)$$

In the equation, Ç, is fracture toughness (kN/m), U, potential energy (j, Nm), A, cross sectional area (m 2), G, pendulum weight (kN), h0, the initial height of the pendulum (m) ve h1, pendulum height after impact (m) symbolism.

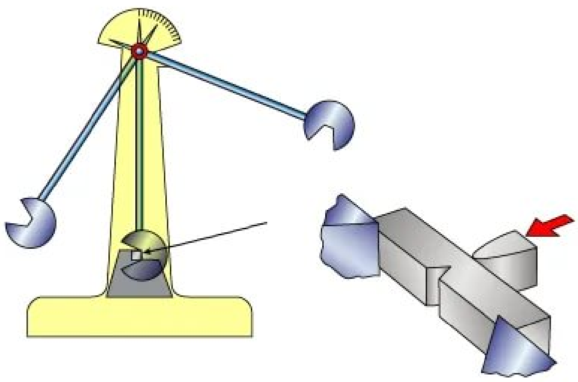

Figure 3. Charpy experimental setup

3. Experiment Results and Evaluation

3.1 Test Results of Mechanical Properties

3.1.1 Tensile Strength Test Results

The flexural strength values of glycerin added PVA fiber samples synthesized at different rates are presented in Figure 4. The flexural strength value of the control sample is 17.01 Pa. Compared to the control sample, an increase of approximately 7% was observed in the PVA fiber concrete, while a decrease of 67% and 50% was observed in the PVA1G and PVA2G fiber samples, respectively. When the glycerine added PVA fiber samples were evaluated among themselves, it was determined that the bending strength increased as the fiber content increased. With the increase of fiber content, an increase in the flexural strength was observed, although the load transfers also increased. The observed reductions are that a more fluid concrete is produced due to the increase in glycerine added into the fiber.

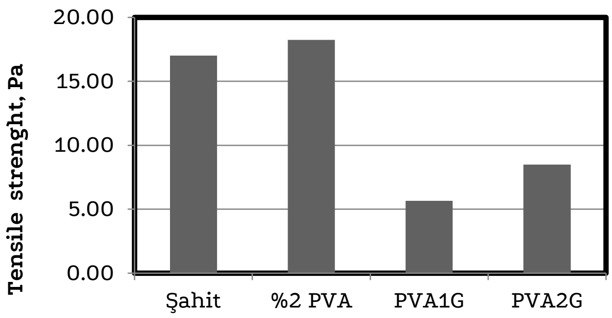

Figure 4. Flexural strength values of mortars

3.1.2 Charpy Test Results

Fracture toughness values of glycerin-doped PVA fibers synthesized at different rates are presented in Figure 5. The fracture toughness value of the control sample is 40.58MPa. An increase of approximately 0.5% was observed in the PVA fiber concrete compared to the control sample. Although it was observed that there was a decrease of 68% and 52%, respectively, in the PVA1G and PVA2G fiber samples, it was determined that the fracture toughness increased as the fiber content increased among themselves. It was observed that the fracture toughness increased with the increase in the amount of fiber and the increase in the absorbed energy. The observed reductions, on the other hand, are that a more fluid concrete is produced due to the increase in glycerin added into the fiber, as in the bending strength.

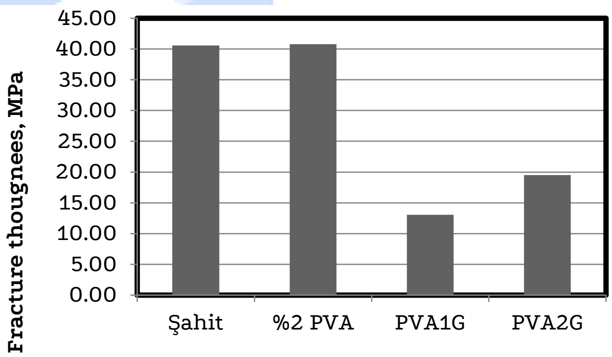

Figure 5. Fracture toughness values of mortars

3.2 Experimental Results of Physical Properties

3.2.1 Vacancy Rate and Water Absorption Test Results

The porosity and water absorption graphs of glycerin-doped PVA fibers synthesized at different rates are presented in Figure 6 and Figure 7. When the graphs were examined, it was observed that the control sample and the samples with PVA fiber had close values, while the water absorption values of the PVA1G and PVA2G samples increased by approximately 67% and 49%, respectively. The reason for this increase is due to the moisture retention of the glycerine added into the fiber. It was determined that there was an increase of approximately 21% in the porosity values in the PVA1G sample. The reason for this increase is the formation of gaps depending on the orientation of the fibers.

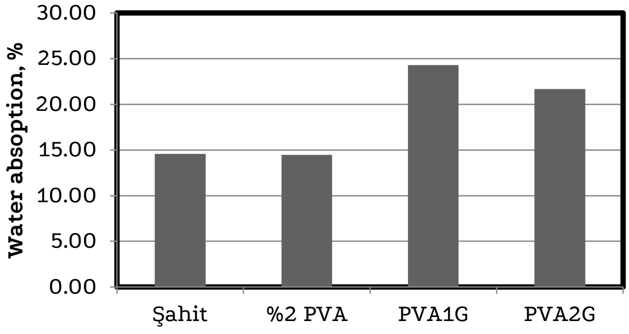

Figure 6. Water absorption values of mortars

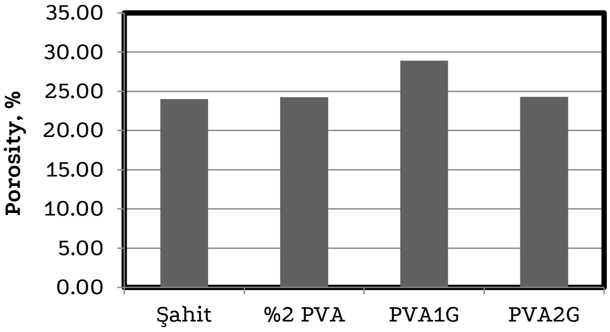

Figure 7. Apparent porosity values of mortars

3.2.2 Electrical Resistivity Experiment Results

The electrical resistivity test was applied to obtain information about the void structure and dimensions of the samples. The current is carried by spreading in the sample with the help of pore water. Therefore, the mixture design of the samples affects the electrical resistivity test results. The electrical resistivity test results are given in Figure 8. When the results are examined, it is observed that the electrical resistivity values of the control sample and the PVA fiber samples are close, while an increase of 113% and 88% is observed in the PVA1G and PVA2G samples, respectively. Thanks to this observed increase, it is expected that concrete samples will be more resistant to durability problems. problems.

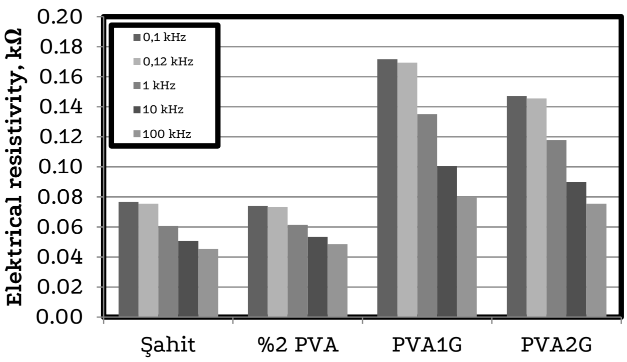

Figure 8. Electrical resistivity of mortars

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Declaration of Conflict of Interests

The authors declares that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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