International Journal of Engineering and Science Applications
p-ISSN: 2406-9833, e-ISSN: 2656-3053, Vol. 6 No. 1 May 2019

IJEScA

Combination of Silica Fume and Fly Ash in Concrete with Sulfuric Acid-Curing

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ABSTRACT

Concrete needs as material in construction require innovation, one of which is in building materials. Innovation concrete is expected to have adequate strength quality, and good durability in certain environmental conditions. This study aims to determine the optimum content of the combination of silica fume and fly ash in acidic medium. In this study, the focus was on testing characteristics of concrete, such as compressive strength, split strength, and beam flexural strength. Silica fume used was constant with a value of 9%, and the variation in the content of fly ash was 0%, 9% and 11% of the weight of cement. The results of this study indicated that the variation of 9% SF + 11% FA was the optimum composition for the compressive strength with a different percentage between normal curing and sulfuric acid-curing of 3.31%. The variations of 9% SF + 9% FA was the optimum composition for the split strength and the beam flexural strength with a different percentage of 7.91% and 8.91%, respectively.

Keywords: c*oncrete; fly ash; silica fume; and combination*

1. INTRODUCTION

The concrete supplier industry has grown as needed in the construction sector. This need is what makes researchers and academics challenged to design and innovate about concrete-forming materials. At present, the composition of concrete requires variations or substitute materials in part or in full on cement material. On the other hand, many researchers also use substitute materials or variations on coarse and fine aggregate materials. All materials used must keep to the standards used, namely SNI. By Bapedal, fly ash can be categorized as toxic waste (B3) which is mostly the result of waste from coal combustion. The amount of waste that continues to grow every year is a problem and a threat to the environment and the local community.

Silica fume is a very smooth, round shape and 1/100 times smaller than cement. Silica fume has an important role, in terms of its chemical properties, silica fume can fill the cavities between cement, whereas in terms of its mechanical properties, silica fume can react with calcium released by cement, which contains high SiO_2.

2. METHODOLOGY

B.1. Theory

Fly ash is a material that has a high cement content and is included in the pozzolanic type. There are two types of fly ash categorized by ASTM C168-86, namely Class

F is fly ash from combustion of anthracite or bituminous type of coal and class C is lignite or subbituminous type of ash fly ash, which has high calcium content. Fly ash used comes from PT. Makassar Tene, Parangloe Industry, Makassar.

Silica fume used in this study is a product of PT. Sika Indonesia. It was in the form of powder, grayish, in a pack of 20kg/bag, has a density of 0.60 kg/L, and dosage usage ranging from 3% to 10% of the weight of cement.

Sulfuric acid is a very strong mineral (inorganic) acid, which is soluble in water and soil. Sulfuric acid H_2SO_4 is an aggressive acid that is often found in water and soil, which can also damage concrete.

Several studies have been reported in the preparation of concretes mixed with other materials. Dewi *et al.* [2] investigated the use of hazardous and toxic substances carbide and fly ash waste as ready-made concrete mixtures. The composition used was 25% fly ash and 2.5%; 5%; 10% and 15% carbide waste. The results showed that carbide and fly ash wastes can increase the compressive strength of concrete at the age of 28 days. The best composition was a mixture of 25% fly ash and 10% carbide waste with the compressive strength of 18.59 MPa. Dermawan and Ashari [3] used sandblasting and fly ash waste at the concrete with the age of 28 days. Nugraha [4] examined Self Compacting Concrete (SCC) using silica fume added to the mixture. Rusyandi *et al.* [5] conducted a study of geopolymer concrete by utilizing fly ash and sandblasting waste (Silica Fume) as the main ingredients for forming concrete.

B.2. Mixing Design of Concrete

Mixing design of concrete was based on SNI code with a plan compressive strength (f 'c) of 30 MPa with variation of silica and fly ash as follows: 9% silica fume + 0% fly ash, 9% silica fume + 9% fly ash, and 9% silica fume + 11% fly ash. The specimens used were in the form of cylinders (D = 15 cm and H = 30 cm) and beams with concentrations of 15 cm x 15 cm x 60 cm. The concrete was tested for the concrete compressive strength with ages of 7, 14, 21 and 28 days; the concrete tensile strength with a concrete age of 28 days, and beam bending with a concrete age of 28 days. The treatment of specimens was carried out using air (normal) and water containing sulfuric acid with a pH of 5.0.

Table 1. Composition of concrete at variation of 9% Silica fume + 0% fly ash

Material	**Weight (kg/m^3)**
Coarse aggregate	1145.98
Fine aggregate	518.67
Cement	452.36
Water	198
Silica fume	44.74

Table 2. Composition of concrete at variation of 9% Silica fume + 9% fly ash

Material	**Weight (kg/m^3)**
Coarse aggregate	1145.98
Fine aggregate	518.67
Cement	407.62
Water	198
Silica fume	44.74
Fly ash	44.74

Table 3. Composition of concrete at variation of 9% Silica fume + 11% fly ash

Material	Weight (kg/m^3)
Coarse aggregate	1145.98
Fine aggregate	518.67
Cement	397.68
Water	198
Silica fume	44.74
Fly ash	54.68

Tables 1, 2, and 3 show the composition of concrete at variations of 9% Silica fume + 0% fly ash, 9% Silica fume + 9% fly ash, and 9% Silica fume + 11% fly ash, respectively.

3. RESULT AND DISCUSSION

The compressive strength, split tensile strength and flexural test for normal curing and sulfuric acid-curing can be seen in Table 4 and Table 5, respectively.

Table 4. Compression Strength for normal curing (NC)

Normal Curing		
Combination	**Age of concrete (days)**	**Actual Compression Strength of concrete (MPa)**
9%SF + 0%FA	7	19.52
	14	26.89
	21	29.05
	28	31.51
9%SF + 9%FA	7	20
	14	27.18
	21	29.9
	28	33.1
9%SF + 11%FA	7	20.5
	14	28.03
	21	30.2
	28	34.14

Table 5. Compression Strength for sulfuric acid-curing (SAC)

Sulfuric Acid-Curing		
Combination	**Age of concrete (days)**	**Actual Compression Strength of concrete (MPa)**
9%SF + 0%FA	7	19.41
	14	26.19
	21	28.76
	28	31.02
9%SF + 9%FA	7	19.9
	14	26.73
	21	29.24
	28	32.06
9%SF + 11%FA	7	19.99
	14	25.88
	21	29.54
	28	33.01

The compressive strength of the concrete treated with sulfuric acid-curing is less than that treated with normal curing. But there is an increase in each composition as given in Fig. 1 and Fig. 2.

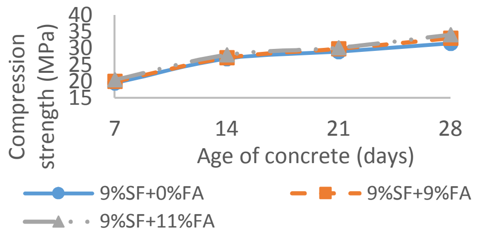

Fig. 1. Compressive strength for normal curing

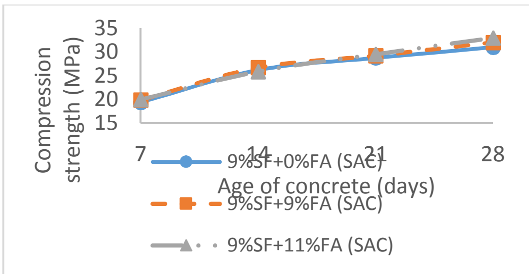

Fig. 2. Compressive strength for sulfuric acid-curing

Both figures show that there is an increase in the compressive strength at each age in both immersion treatments.

Fig. 3 shows the comparison of the compressive strength between normal curing and sulfuric acid-curing for the concrete consisting of 9% SF + 0% FA.

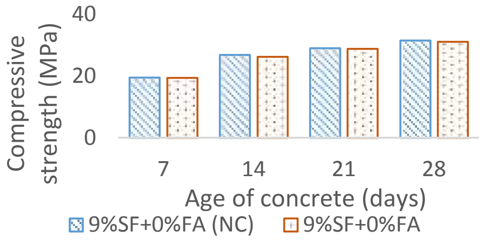

Fig. 3. Comparison of the compressive strength of 9% SF + 0% FA between NC and SAC

The compressive strength of the concrete treated with sulfuric acid-curing is less than that treated with normal curing for 28 days in the concrete with a composition of 9% SF + 0% FA. The difference of the compressive strength between the two treatments was 1.56%.

The comparison of the compressive strength between normal curing and sulfuric acid-curing for the concrete consisting of 9% SF + 9% FA is given in Fig. 4.

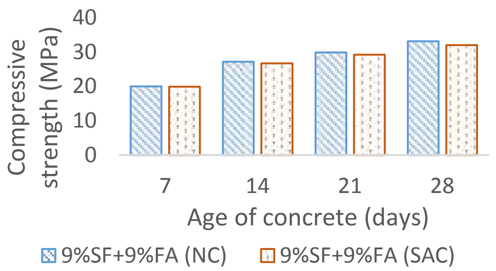

Fig. 4. Comparison of the compressive strength of 9% SF + 9% FA between NC and SAC

It can be seen that the compressive strength of the concrete treated with sulfuric acid-curing for 28 days is less compared to that with normal curing in the concrete with a composition of 9% SF+9% FA is 3.14%.

Fig. 5 shows the comparison of the compressive strength between normal curing and sulfuric acid-curing for the concrete consisting of 9% SF + 11% FA.

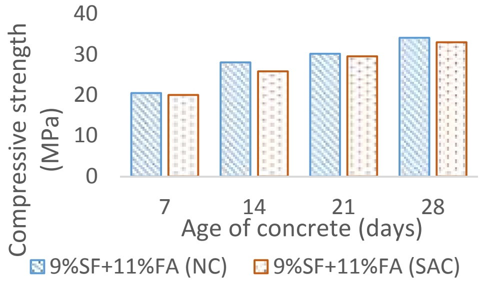

Fig. 5. Comparison of the compressive strength of 9% SF + 11% FA between NC and SAC

The compressive strength for the concrete treated with sulfuric acid-curing is less than that treated with normal curing for 28 days in the concrete with a composition of 9% SF+9% FA. The difference between the two treatments was 3.31%.

Fig. 6 is the comparison of the split tensile strength with a variation in the concrete composition.

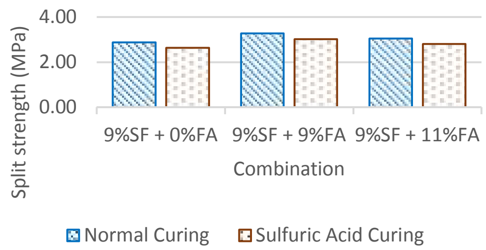

Fig. 6. Comparison of split tensile strength in each composition

The split tensile strength is different between the concrete treated with normal curing and sulfuric acid-curing in each composition. The difference between the two treatment of immersion was 8.20% for the composition of 9% SF + 0% FA; 7.91% for compositions 9% SF + 9% FA; and 7.75% for the composition of 9% SF + 11% FA.

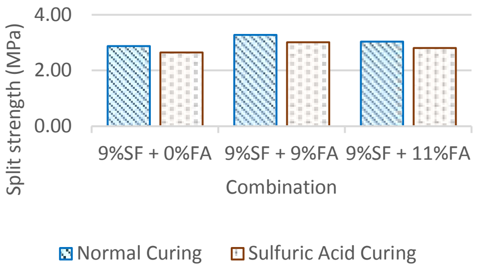

Fig. 7. Comparison of flexural strength in each composition

The flexural strength the concrete treated with normal curing is different with that treated with sulfuric acid-curing in each composition. The difference of the flexural strength between the two treatment of immersion was 11.32% for the composition of 9% SF + 0% FA; 8.32% for the composition of 9% SF + 9% FA; and 9.09% for the composition of 9% SF + 11% FA.

4. CONCLUSIONS

The optimum condition in the compressive strength on the cylindrical concrete was in the composition of 9% SF + 11% FA while the optimum conditions in the split tensile strength of the flexural strength were in the composition of 9% SF + 9% FA. The result proved that the combination of silica fume and fly ash can be used in the mixture concrete, especially concrete which was in contact with sulfuric acid.

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