Engineering and Technology Journal e-ISSN: 2456-3358
Volume 09 Issue 04 April-2024, Page No.- 3685-3691
DOI: 10.47191/etj/v9i04.02, I.F. – 8.227
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Effect of Silica Fume Addition on Mechanical Properties of Concrete in Peat Swamp Water Environment

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ABSTRACT: Hydraulic Portland cement, water, fine and coarse aggregate, and additional ingredients can be added or left out to create concrete. Making and maintaining concrete requires water as a reagent in the cement mixture so that a chemical reaction occurs when it undergoes the hydration process, which is the process where the cement begins to bind the ingredients that make up the concrete and then hardens and forms a solid mass. The need for water in concrete care is to soak it during the hardening process, however, not all types of water can be used. Peat swamp water is water that collects or flows within the peat swamp ecosystem. Peat swamps are a type of swamp formed from organic material accumulated over thousands of years. Silica fume is a material that contains SiO2 greater than 85% and is a very smooth, round material with a diameter of 1/100 the diameter of cement. The swamp water used in this research was taken from Jl. Rappokalling, Tallo District, Makassar City, South Sulawesi. Mix Design uses the Indonesian National Standard (SNI) 03-2834-2000 method with a planned concrete quality (f'c) of 25 MPa. Compressive strength tests were performed on concrete that was 7 and 28 days old for split tensile strength, and on the 28-day old concrete for modulus of elasticity. The concrete's compressive strength ratings after 28 days in variations of immersion in normal water and peat swamp water are 25,842 MPa and 20,749 MPa. From the test results, it was found that the average split tensile strength value of concrete for variations in normal water immersion and peat swamp water was 2.545 MPa and 1.886 MPa. From the results of the modulus of elasticity test, it was found that the average concrete in normal water immersion and peat swamp water variations was 19893.961 MPa, and 17109.75 MPa.

KEYWORDS: Water, Peat, silica fume, Concrete

INTRODUCTION

The increase in the implementation of construction affects the development of the world of building materials technology. Especially in the field of construction, when using large amounts of concrete, it is necessary to make high-quality concrete from cheap and easily available raw materials. Concrete is one of the most frequently used construction materials in building various kinds of buildings. Concrete is a mixture of cement and water that is used in the production of concrete. It is a mixture of cement, water and water that is used in the production of concrete. Water is required to soak the concrete during the hardening process, however not all types of water are suitable for this purpose. The water must be pure and free from organic components, acids, bases, salts, oils, or elements that damage the mortar or any metal present in the wall. Concrete is often cured using the same water used for mixing. The problem is that not all concrete building projects in Indonesia are located in areas free from the influence of swamp water. Swamp water contains many ionic and non-ionic compounds, acidic elements such as sulfate, chloride and nitrate that exceed the normal conditions of water in general. Research has been conducted to improve the performance and quality of concrete at low cost without compromising its quality, mostly through the use of swamp water, as technology advances. Wet soil that is constantly inundated with water is naturally called swamp water.

Research by Ikhsan Hidayat, From tests that have been carried out by adding silica fume with variations from 0% to 25% with an increase of 5%, the largest result in the compressive strength test is 70.21 Mpa at 15% so that it is stated that the addition of silica fume below 20% can increase the compressive strength of concrete.[1].

By substituting 12.5% metakaolin and silica fume, it gives an improvement to the workability of fresh concrete that reaches the requirements and also gives an improvement to the flexural strength when the concrete is 28 days old with 0% to 15% SF content with values of 5.17Mpa to 6.09 Mpa.[2]. The addition of silica fume in modulus testing ranging from 0% to 25% created the highest results at 15% as much as 7.30 Mpa. For the tensile strength test, the highest figure of 4.78 Mpa was also obtained at 15%. [3]. PCC control concrete was stronger after soaking, but OPC control concrete showed lower compressive strength. The porosity of PCC-K concrete decreased, but the porosity of OPC-K concrete increased after

150 days. The use of peat water mixed with quicklime can in the long term improve the compressive strength and porosity of OPC and PCC concrete exposed to peat water.[4]. The pressure strength of 10% porous concrete with fly ash in peat water immersion reached 6.89 MPa and the pressure strength of 20% porous concrete reached 7.85 MPa. The models immersed in PDAM water and peat swamp water experienced crack patterns due to the stress distribution of the test specimens during the grip installation procedure. The results showed that the crack pattern occurred at the side end.[5]. The compressive strength development tests of HVFA and HVFA-HS concrete showed that they developed slower than ordinary concrete at days 7 and 14, but at 28 days, their compressive strength increased. The chloride ion penetration test also showed that using silica fume in HVFA concrete created a lower absorption rate.[6]. In terms of compressive, split tensile and flexural strength of concrete, partial replacement of crushed marble stone as coarse aggregate has an impact of 50%, and substitution of silica fume as cement has an impact of 0% to 15%. The value of silica fume substitution was highest in the 10% variation, but the strength of concrete decreased if the percentage of silica fume substitution was higher.[7]. The results showed that the use of silica fume and coral shard ash in concrete can have an impact on the strength of concrete. The highest 28-day compressive strength was 31.989 MPa, the highest split tensile test value was 3.491 MPa, and the highest elastic modulus value was 3.3486.8743 MPa. The maximum modulus of elasticity and compressive strength occurred at 5% variation, and the maximum split tensile strength occurred at 7.5 percent variation.[8]. Through testing, the compressive strength figure obtained with the addition of 8% sika fume is 592 kg / cm². Compared to the addition of consol fume obtained 570 Kg / cm². When the variation becomes 7% the compressive strength value in the sika fume mixture is 509 Kg / cm² while mixing Consol Fume is 503 Kg / cm². And for concrete without the addition of 473 Kg/cm².[9]. This protective layer is resistant to both chlorides and sulfates, according to research findings; silica added to type I cement improves resistance to chlorides but not to sulfates, while type II cement added to type I cement improves resistance to sulfates but not to chlorides.[10]

RESEARCH METHODOLOGY

1. Location of Research Materials

The location of the peat swamp water collection is located in Rapokalling, Tallo District, Makassar City, and South Sulawesi.

Figure 1. Location of Peat Swamp Water Intake

2. Trial Mix

In order to know whether the calculation of the composition of the mixture that has been calculated can reach the value of the compressive strength of the plan, a trial mix is carried out using 7 days as a test age factor. The planning compressive strength number is 25 MPa with the number of test objects used, namely 3 cylinders. The following is the Trial mix test data:

Table 1. Trial Mix Testing Results

Age of Concrete (Day)	P (kN)	Actual Pressure Concrete Strength (MPa)	Concrete Age Factor	28-Day Conversion Concrete Compressive Strength (MPa)
7	300	16,977	0,65	26,118
	290	16,411		25,247
	300	16,977		26,118

3. Proces of Making Specimens

In making the test material, it will be processed if the compressive strength obtained from the trial process has reached the planning concrete quality. The test specimens were made as many as 24 samples which consisted of 12 test materials with normal water immersion and 12 test specimens for immersion with peat swamp water.

4. Material Characteristics

Table 2. Specification of Coarse aggregate Characteristics

No.	Testing	Results	Interval	Description
1	Water Content	0,888	0.5% - 2.0%	Qualified
2	Sludge Content	0,402	0.2% - 1.0%	Qualified
3	SSD Specific gravity	2,650	1.60 - 3.20	Qualified
4	Absorption	0,929	0.20% - 2.00%	Qualified
5	Solid Volume Weight	1605,714	1400 - 1900 kg/m3	Qualified
6	Loose Volume Weight	1540,357	1400 - 1900 kg/m3	Qualified
7	Modulus of Fineness	7,041	5,50 - 8,50	Qualified

Table 3. Specification of Fine Aggregate Characteristics

No	Testing	Results	Interval	Description
1	Water Content	3,306	3.0% - 5.0%	Qualified
2	Sludge Content	1,523	0.2% - 6.0%	Qualified
3	SSD Specific gravity	2,593	1.60 - 3.20	Qualified
4	Absorption	1,211	0.20% - 2.00%	Qualified
5	Solid Volume Weight	1504,710	1400 - 1900 kg/m3	Qualified
6	Loose Volume Weight	1415,094	1400 - 1900 kg/m3	Qualified
7	Modulus of Fineness	2,734	2,20 - 3,10	Qualified
8	Organic Substances	3,306	3.0% - 5.0%	Qualified

5. Concrete Curing

The test material is put into a soaking bath for the curing process to prevent it from evaporating too much.

a. Giving a code to each test specimen so that it is easy to sort when curing.

b. Putting the test material into the soaking bath

c. Lifting the test material and then drying it at the time one day before testing.

Figure 2. Specimens

DATA PROCESSING AND RESULT

A. MECHANICAL PROPERTIES

1) Concrete Pressure Strength

Testing the compressive strength of concrete begins when the test samples are 7, and 28 days old. This is

Done to determine the highest compressive strength of concrete with a compressive load (P) in units of kN. Below are the results of the compressive strength testing

Table 2. Compressive Strength Test Results of Normal Water variation + Silica fume 10%

Code	Age of Concrete (Day)	P (kN)	Actual Concrete Compressive Strength (MPa)	Average (MPa)
BKT 1	7	300	16,977	16.788
BKT 2		300	16,977	
BKT 3		290	16,411	
BKT 4	28	460	26,031	25,842
BKT 5		470	26,597	
BKT 6		440	24,889	

Table 3. Compressive Strength Test Results of Peat Swamp Water variation +Silica fume 10%

Code	Age of Concrete (Day)	P (kN)	Actual Concrete Compressive Strength (MPa)	Average (MPa)
BKT 1	7	220	12,449	13,393
BKT 2		240	13,581	
BKT 3		250	14,147	
BKT 4	28	380	21.504	20,749
BKT 5		360	20,372	
BKT 6		360	20,372	

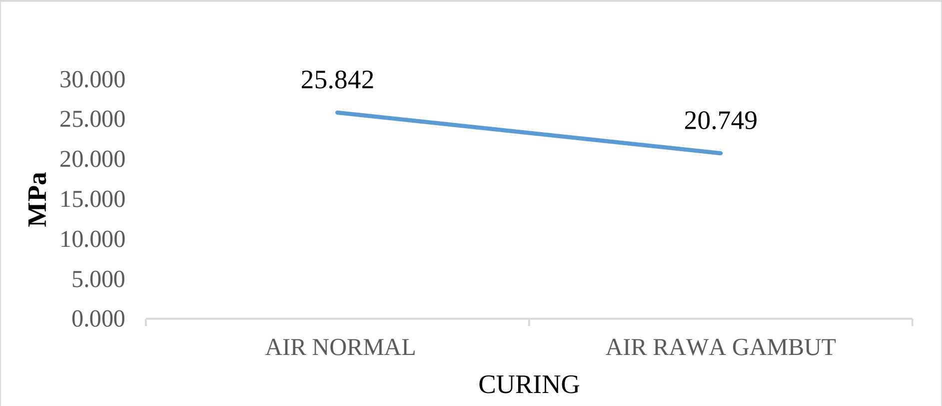

Figure 3. Graph of Concrete Compressive Strength Test Result

Figure 3 shows that the value of the compressive strength of concrete at the age of 28 days increases in normal water immersion, namely 25.842 MPa, while in peat swamp water immersion it decreases, namely 20.749 MPa, so that it meets the quality plan f'_c 25 MPa, namely normal water immersion.

2) Tensile Strength of Concrete

The split tensile strength test was conducted on the 28th day using a compressive testing machine to determine the highest tensile load of the concrete, expressed in kN.

Table 4. Concrete Split Tensile Strength Test Results (f_t) with 10% Silica Fume

Curing Type	Age of Concrete (Day)	Maximum Load (kN)	Split Tensile Strength (MPa)	Average (MPa)
Normal Water	28	180	2.545	2.545
		170	2.404	

		190	2.687	
Peat Swamp Water	28	110	1.556	1.886
		140	1.980	
		150	2.121	

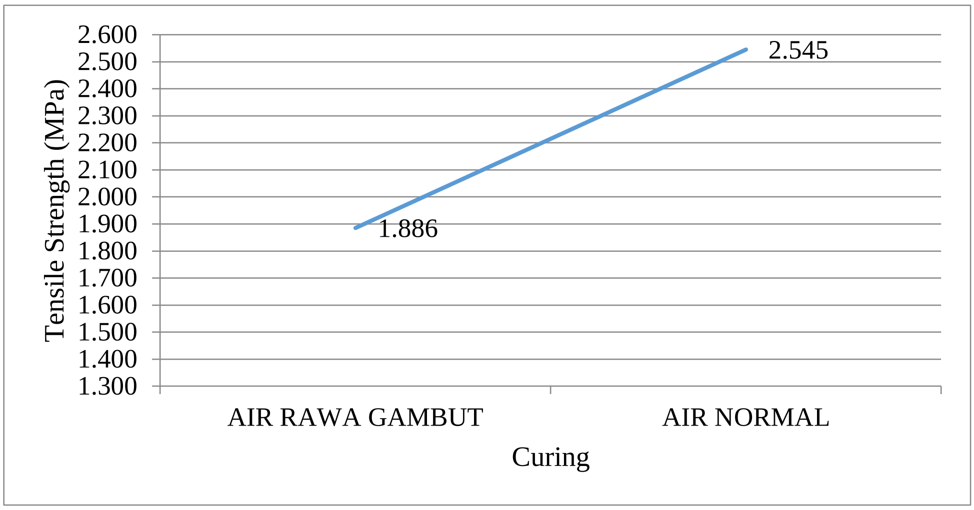

Figure 4. Graph of Tensile Strength Test Results

Figure 4 shows the graph of the relationship between normal water immersion and raw water immersion with the addition of silica fume by 10% in the tensile strength of the split there is a process of decreasing in peat swamp water immersion. From the results of the split tensile strength test obtained in normal water immersion of 2.545MPa, in peat swamp water of 1.886 Mpa.

3) Modulus Elasticity of Concrete

A compressive testing machine was used to compare the stresses and strains in the concrete after the specimens had been in it for 28 days. Readings from a vertical dial gauge were obtained in increments of 50 kN.

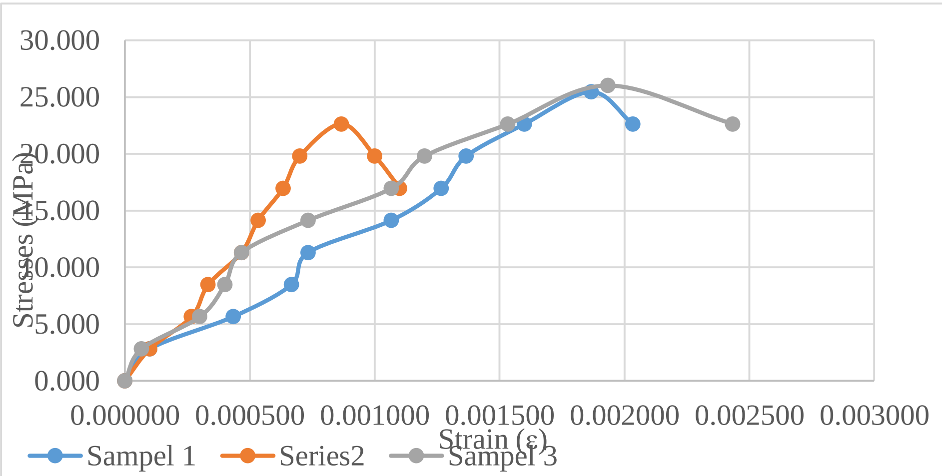

Figure 5: Test data graph of Modulus Elasticity of Concrete Normal Water + 10% silica fume

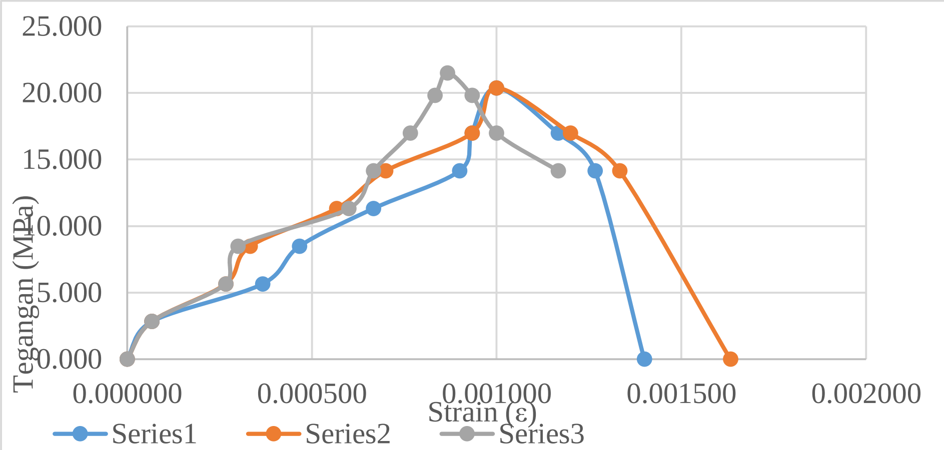

Figure 6: Test data graph of Modulus Elasticity of Concrete Peat Swamp Water + 10% silica fume

B. RELATIONSHIP OF MECHANICAL PROPERTIES OF CONCRETE

1) Relationship of Concrete Pressure Strength / Concrete Split Tensile Strength

Table 5. Relationship between split tensile strength and compressive strength

Curing	Compressive Strength (MPa)	Split Tensile Strength (MPa)	Relationship Percentage %
Normal Water	25.842	2.545	9,848
Peat Swamp Water	20.749	1.886	9,090

From table 7, the percentage value of the correlation between pressure strength and split tensile strength in normal water immersion variations and peat swamp water has decreased the correlation between pressure strength and split tensile strength but is still within the limits of normal concrete. The percentage has complied with the predetermined standard of 7%-11%. (Agus Setiawan: 2016).

2) Relationship between Concrete Pressure Strength and Modulus Elasticity of Concrete

The stress to strain ratio was calculated using the relationship between the modulus of elasticity of concrete (E) and the compressive strength (f'c). Based on the findings of the concrete compressive strength (f'c) test at the age of 28 days in normal water immersion is 25.842 MPa, while in peat swamp water immersion it has decreased to 20.749MPa and concrete modulus of elasticity (E) test data obtained for normal water immersion is 22873.046 MPa and for peat swamp water immersion 21424.86 MPa.

Tabel 6. Relationship between Concrete Pressure Strength and Modulus Elasticity of Concrete

Curing	f'c (MPa)	E (MPa)	Theoritical Elastic Modulus 4700 $\sqrt{\mathbf{f'c}}$ (MPa)
Normal Water	25,842	19893,961	23892,463
Peat Swamp Water	20,677	17109,75	21371,827

CONCLUSIONS

a. The addition of 10% silica fume in normal water soaking will increase the compressive strength of concrete with an increase of 3.310% at 7 days and 3.368% at 28 days, but decreases in peat swamp water soaking with a decrease of 17.584% at 7 days and 17.004% at 28 days. In addition, the split tensile strength test decreased in the peat swamp water immersion process by 1.886 MPa and increased in normal water immersion by 2.545 MPa. and the modulus of elasticity showed a decrease in peat swamp water immersion by 22873.046 MPa and an increase in normal water immersion by 21424.86 MPa.

b. From the percentage of correlation between compressive strength and split tensile strength in the variation of normal water immersion and peat swamp water, the relationship between compressive strength and split tensile strength has decreased but is still within the limits of normal concrete and for the relationship between compressive strength and modulus of elasticity has decreased.

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