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COMPARISON OF CONCRETE PERFORMANCE WITH FIBERGLASS SUBSTITUTION AS A SAND REPLACEMENT

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ABSTRACT

Fiberglass, with its superior mechanical properties and corrosion resistance, has been proposed as a partial or total replacement for sand in concrete mixes. Although research on the use of glass powder as a sand substitute has been widely conducted, specific studies examining the use of fiberglass as a fine aggregate replacement in concrete are limited. Therefore, this study will focus on a comparative analysis of the performance of concrete with fiberglass substitution as a sand replacement material, considering various mechanical and durability aspects. With the aim of knowing the effect of the addition of fiberglass powder into the concrete mixture. in this study the method of calculating mix design using the SNI 03-2834-2000 method. in this research, the results obtained with the addition of fiberglass in the concrete mixture at certain variations cannot increase the compressive strength of Hybrid concrete at the age of 7 days, 14 days and 28 days. The optimum value of the 7-day concrete compressive strength test is in the 2% variation of fiberglass addition, which is 12.14 MPa because it does not decrease significantly. The optimum value of the 14-day concrete compressive strength test is also in the 2% variation of 15.01 MPa, and for the optimum value of the 28-day concrete compressive strength test is also in the 2% variation of 18.38 MPa.

Keyword: *Concrete, Fiberglass, Compressive Strength.*

1. INTRODUCTION

The use of alternative materials in concrete mixtures has been a focus of research to improve performance and sustainability in construction. One promising approach is substituting fine aggregates, such as sand, with materials that possess suitable physical and mechanical characteristics. Fiberglass, with its superior mechanical properties and corrosion resistance, has been proposed as a partial or complete replacement for sand in concrete mixtures.

Previous studies have explored various substitute materials for sand in concrete. Aditya [1] investigated the use of onyx sand waste as a sand substitute and found an increase in compressive strength and reduced water absorption in paving blocks. Additionally, Tumingan et al. [2] examined the utilization of pond ash as a sand replacement, showing decreased porosity and increased concrete compressive strength.

Natural materials have also been studied as substitutes. Bunyamin et al. [3] analyzed the substitution of oyster shells as a partial replacement for cement and fine sand, resulting in improved concrete tensile strength. Similarly, Simatupang et al. [4] examined the feasibility of using white soil as a fine aggregate substitute and found that the resulting concrete met the required standards.

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Furthermore, research by Diana et al. [5] indicated that the addition of bamboo leaf ash as a cement substitute material could enhance concrete performance. However, specific studies on the use of fiberglass as a replacement for sand in concrete remain limited. Therefore, this study aims to compare the performance of concrete with fiberglass substitution as a sand replacement, focusing on compressive strength, durability, and other mechanical properties.

Studies by Sudjati et al. [6] investigated the effect of using glass powder as a fine aggregate substitute on concrete mechanical properties. The results showed that glass powder usage could enhance compressive strength up to a certain percentage before it decreased due to higher glass powder content. Additionally, research by Fakhri [7] explored the use of glass powder as a partial sand replacement in concrete and bondcrete, demonstrating an increase in concrete tensile strength with up to 10% glass powder incorporation.

Wijaya Kusuma et al. [8] evaluated the utilization of glass waste as a partial volume replacement for sand and fly ash (20%) as a cement substitute. Their results indicated that the optimal percentage of glass waste replacement for sand was 18.44%, which provided the best sulfate resistance and maximum compressive strength of 21.07 MPa. Additionally, research by Sudjati et al. [6] suggested that substituting glass powder up to 30% could improve concrete compressive strength to 34.79 MPa.

Although research on the use of glass powder as a sand substitute has been widely conducted, specific studies examining the use of fiberglass as a fine aggregate replacement in concrete are still limited. Therefore, this research will focus on a comparative analysis of the performance of concrete with fiberglass substitution as a sand replacement material, considering various mechanical and durability aspects with the aim of finding out how effective the partial replacement of sand with fiberglass powder is in concrete mixtures.

2. LITERATURE REVIEW

2.1. Concrete

Concrete is a mixture of Portland cement or other hydraulic cement, fine aggregate, coarse aggregate, and water, with or without additives, that forms a solid mass. Concrete is produced by mixing fine aggregates such as sand and coarse aggregates such as crushed stone, with the addition of cement and water to support chemical reactions during the hardening and curing process. The strength and durability of concrete are influenced by various factors, including mix ratio, material quality, casting method, finishing techniques, temperature, and maintenance conditions during hardening.

The compressive strength of concrete is much higher than its tensile strength, and concrete has brittle properties. The tensile strength of concrete only ranges from 9% to 15% of the compressive strength. In its use as a structural component of buildings, concrete usually works together with other materials to overcome its weaknesses, especially in parts that receive tensile forces, because concrete can only withstand compressive forces. When concrete is used in conjunction with steel, it is known as reinforced concrete, which is designed to strengthen the structural capabilities. In its development, reinforced concrete is often placed in areas of the structure where both can serve to resist compressive forces, thus increasing the overall strength of the structural component.

2.2. Fiberglass

Fiberglass is a fiber made from molten glass that is drawn into thin strands with diameters ranging from 0.005 mm to 0.01 mm, resulting in fine fibers. These fibers are then spun into yarn or woven into fabric-like structures, which are later impregnated with resin to create a strong and corrosion-resistant material. Fiberglass is a type of composite fiber material that offers several advantages, such as high strength while remaining lightweight. Although it is not as strong or as light as carbon fiber, fiberglass is more flexible and has a relatively more affordable price in the market [9]

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in this study, the type of fiberglass used is fiberglass mat, which is first decomposed with varying additions of 0%, 0.1%, 0.2%, and 0.3% of the cement weight. Fiberglass mat refers to white-colored fibers arranged in a random pattern. Its primary function is to reinforce resin, particularly in sheet production, to prevent cracking or breaking easily. Additionally, fiberglass mat is applied as a coating to increase the thickness of fiberglass layers.

3. RESEARCH METHOD

This research employs an experimental method aimed at analyzing the effect of using limestone as a partial replacement for cement in concrete. The research process begins with designing the concrete mix, which includes sand, cement, water, gravel, and additional limestone (calcite) as a partial substitute for gravel. These materials are thoroughly mixed to form a concrete mixture ready for the molding process. Afterward, the concrete is cast, further processed, and tested to evaluate its characteristics, such as compressive strength and other quality parameters, to compare the performance of this new composition against standard concrete.

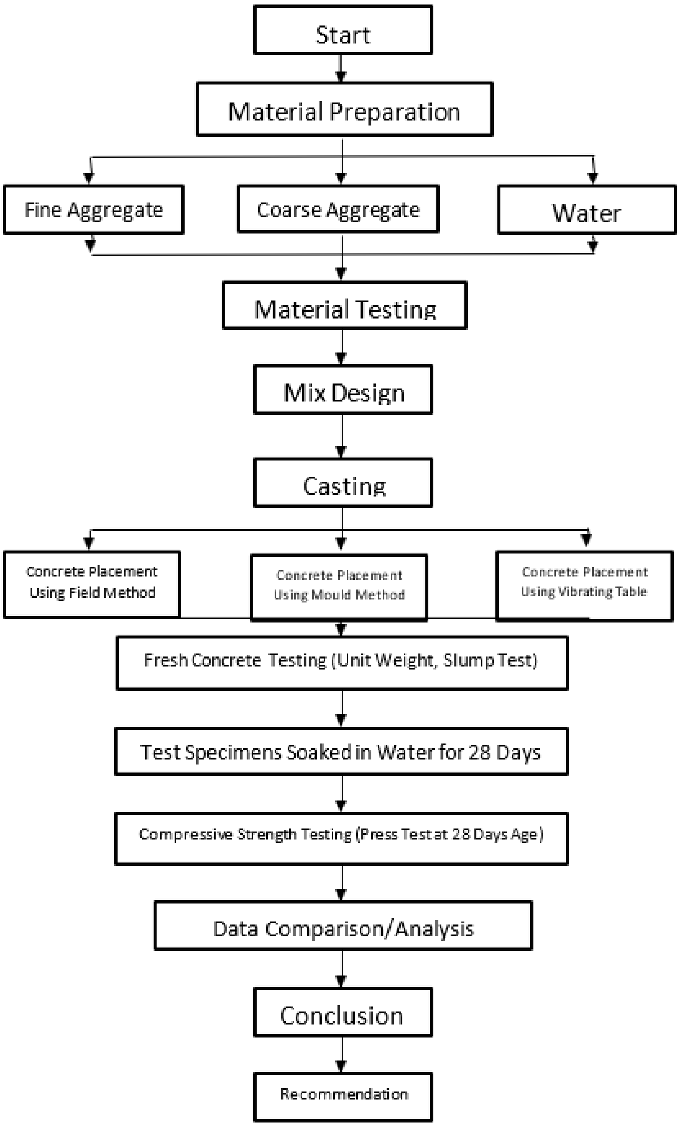

Figure 1. Research Flow

The calculation method used in the concrete mix design is based on SNI 03-2834-2000.

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4. RESULT AND DISCUSSION

4.1. Fiberglass Requirement

During the mixing process, fiberglass is added as a partial replacement for sand in the concrete mixture. To create cylindrical test specimens, the required amounts for six samples with different fiberglass addition variations are as follows:

1. 2% addition = 0.51 kg
2. 4% addition = 1.02 kg
3. 6% addition = 1.53 kg

Table 1. Mix Design

Percentage of Additive Material		
Mold	Percentage of Addition	Fiberglass
	2%	0.51
Silinder X6	4%	1.02
	6%	1.53
	Total	3.06

Source: Test Results (2024)

4.2. Compressive Strength Test of Concrete

Table 2. 7-Day Compressive Strength of Concrete

Mix Percentage	Age	Test Item Number	Weight (Kg)	Compressive Strength Fc' (Mpa)	Average (Mpa)
0%	7 Day	1	12.12	13.35	13.10
	7 Day	2	12.15	13.35	
	7 Day	3	12.19	11.83	
	7 Day	4	12.17	12.34	
	7 Day	5	12.14	13.36	
	7 Day	6	12.11	14.36	
2%	7 Day	1	12.22	12.74	12.14
	7 Day	2	12.04	11.86	
	7 Day	3	12.12	12.54	
	7 Day	4	12.11	11.66	
	7 Day	5	12.05	11.34	
	7 Day	6	12.12	12.72	
4%	7 Day	1	12.01	11.07	10.62
	7 Day	2	12.00	11.93	
	7 Day	3	12.1	10.01	
	7 Day	4	12.14	10.36	
	7 Day	5	12.21	9.88	

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Mix Percentage	Age	Test Item Number	Weight (Kg)	Compressive Strength Fc' (Mpa)	Average (Mpa)
6%	7 Day	6	12.14	10.47	10.29
	7 Day	1	12.02	10.92	
	7 Day	2	12.17	10.47	
	7 Day	3	12.01	10.36	
	7 Day	4	12.19	9.87	
	7 Day	5	12.23	9.92	
	7 Day	6	12.02	10.22	

Source: Test Results (2024)

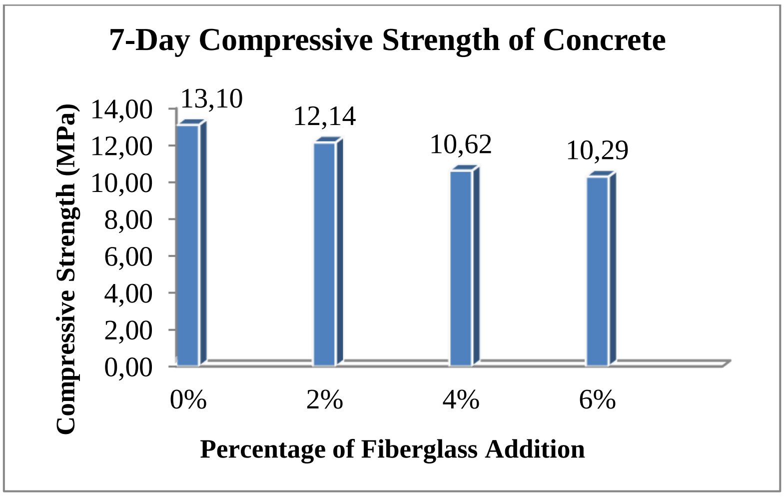

Figure 2 7-Day Compressive Strength of Concrete

Based on the table above, the optimum 7-day concrete compressive strength is found in normal concrete, with a value of 13.10 MPa. Meanwhile, for the fiberglass mixture, each addition variation consistently experiences a significant decrease in compressive strength.

Table 3. 14-Day Compressive Strength of Concrete

Mix Percentage	Age	Test Item Number	Weight (Kg)	Compressive Strength Fc' (Mpa)	Average (Mpa)
0%	14 Day	1	12.13	17.06	16.51
	14 Day	2	12.11	15.50	
	14 Day	3	12.1	15.34	
	14 Day	4	12.21	16.51	
	14 Day	5	12.21	17.21	
	14 Day	6	12.29	17.45	

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Mix Percentage	Age	Test Item Number	Weight (Kg)	Compressive Strength Fc' (Mpa)	Average (Mpa)
2%	14 Day	1	12.02	16.00	15.01
	14 Day	2	12.04	13.66	
	14 Day	3	12.06	15.64	
	14 Day	4	12.13	16.75	
	14 Day	5	12.15	14.66	
	14 Day	6	12.21	13.34	
4%	14 Day	1	12.11	16.45	13.96
	14 Day	2	12.07	17.66	
	14 Day	3	12.22	10.72	
	14 Day	4	12.03	16.87	
	14 Day	5	12.13	11.74	
	14 Day	6	12.01	10.34	
6%	14 Day	1	12.07	14.59	11.53
	14 Day	2	12.24	14.17	
	14 Day	3	12.12	9.71	
	14 Day	4	12.11	10.75	
	14 Day	5	12.20	10.73	
	14 Day	6	12.25	9.24	

Source: Test Results (2024)

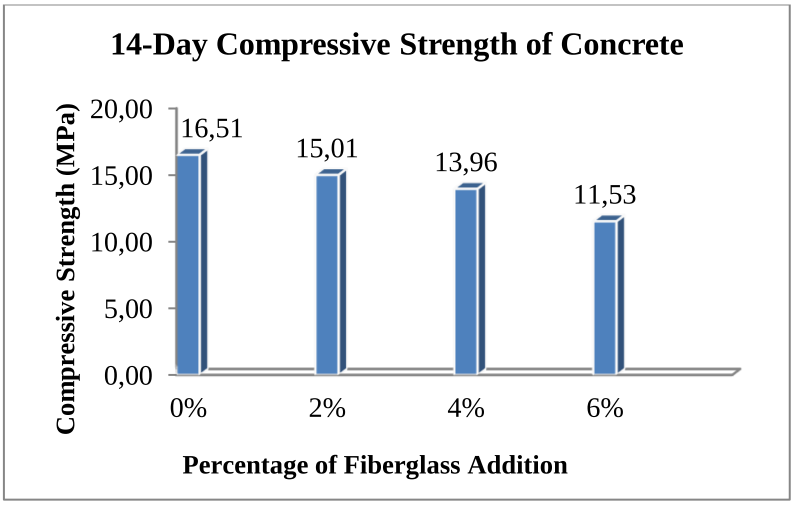

Figure 3. 14-Day Compressive Strength of Concrete

And for the 14-day concrete compressive strength, the results are almost similar to the 7-day compressive strength but are slightly higher. The optimum compressive strength is 16.51 MPa in normal concrete (0% variation).

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Table 4. 28-Day Compressive Strength of Concrete

Mix Percentage	Age	Test Item Number	Weight (Kg)	Compressive Strength Fc' (Mpa)	Average (Mpa)
0%	28 Day	1	12.31	21.46	20.33
	28 Day	2	12.21	19.55	
	28 Day	3	12.22	21.39	
	28 Day	4	12.24	19.45	
	28 Day	5	12.05	20.70	
	28 Day	6	12.11	19.40	
2%	28 Day	1	11.89	17.57	18.38
	28 Day	2	11.92	18.50	
	28 Day	3	11.83	19.64	
	28 Day	4	11.89	16.72	
	28 Day	5	12.05	20.40	
	28 Day	6	11.94	17.42	
4%	28 Day	1	11.65	17.66	16.08
	28 Day	2	11.54	16.74	
	28 Day	3	11.78	14.23	
	28 Day	4	11.76	15.22	
	28 Day	5	11.64	16.41	
	28 Day	6	11.67	16.24	
6%	28 Day	1	12.06	14.22	12.18
	28 Day	2	12.17	10.22	
	28 Day	3	11.95	10.55	
	28 Day	4	11.98	12.26	
	28 Day	5	11.74	14.15	
	28 Day	6	12.02	11.66	

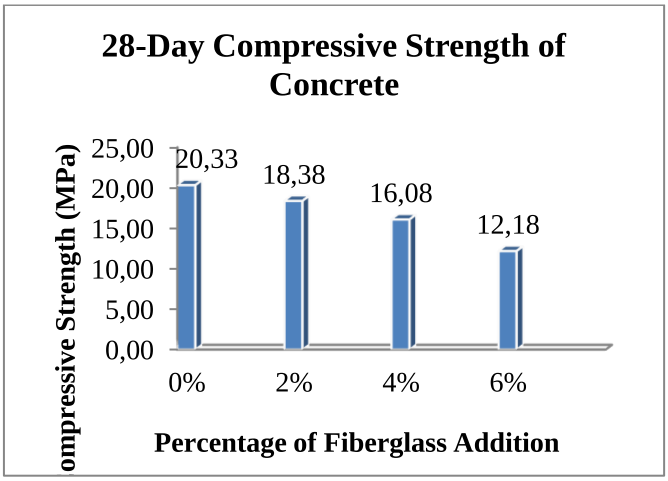

Figure- 4 28-Day Compressive Strength of Concrete

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At 28 days, the normal concrete achieved the planned compressive strength of 20 MPa. However, the concrete with fiberglass variations did not reach the target strength. This is because the fiberglass additive was unable to effectively bond with other particles, making the fiberglass-modified concrete insufficiently strong as a concrete mixture. To enhance the strength of fiberglass-mixed concrete, the addition of an additive is necessary to improve the bonding between fiberglass particles and other concrete components.

5. CONCLUSION

The addition of fiberglass in the concrete mixture at certain variations does not increase the compressive strength of Hybrid concrete at the ages of 7 days, 14 days, and 28 days. The optimum compressive strength test value at the age of 7 days is at a 2% fiberglass addition variation, which is 12.14 MPa, as it does not experience a significant decrease. The optimum compressive strength test value at the age of 14 days is also at a 2% variation, reaching 15.01 MPa, and the optimum compressive strength test value at the age of 28 days is also at a 2% variation, reaching 18.38 MPa.

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