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THE EFFECT OF ADDITIONAL VERMICULITE ON COMPRESSIVE AND FLEXURAL STRENGTH OF CONCRETE

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ABSTRACT

Concrete is one of the building materials that is used the most. The majority of the volume of concrete is made up of aggregates, which have a significant impact on the characteristics, mix proportions, and economics of concrete. The space created by the absence of fine aggregate can be filled with vermiculite. Vermiculite is a rich mineral that is widely recognized for its exfoliating properties and for expanding quickly when heated. Vermiculite typically has a temperature resistance of up to 1200°C. It is a system of low-density, non-structural building products. In addition to being lighter in weight and odorless, vermiculite offers increased workability, improved fire resistance, and improved resistance to cracking and shrinking also reduces the cost of construction. In this research, vermiculite is employed at varying concentrations of 12%, 24%, and 36%. Vermiculite samples from PT.IPI Sunijaya, cement with the Dynamix brand, fine aggregate from the Galunggung area, and coarse aggregate from Cimalaka. The design of this research followed ACI 1991, with a design quality of 15 MPa. The maximum variant on compressive strength and flexural strength of concrete is using 36% of vermiculite because vermiculite has a high capacity for water absorption, adding it to concrete boosts both the compressive strength and flexural strength of the material. Vermiculite will therefore absorb excess water in the mixture and dry out the mortar while keeping the completed product's firmness owing to the granules. This is why it is added to and blended with concrete. Vermiculite particles can be used to patch cracks and holes in concrete.

Keywords Compressive Strength; Flexural Strength; Vermiculite
Paper type Research paper

INTRODUCTION

Concrete is one of the most often utilized construction materials worldwide. The majority of the volume of concrete is made up of aggregates, which have a significant impact on the characteristics, mix proportions, and economics of concrete. Vermiculite can be used to fill the gap left by a lack of fine aggregate [1]. Vermiculite use improves concrete's resistance to shrinkage and cracks, fire resistance, and environmental impact while also lowering building costs [2]. Magnesium-iron-aluminum silicates that are hydrated makeup vermiculite. Biotite or phlogopite undergoes weathering or hydrothermal modification to become vermiculite. Vermiculite is a rich mineral that is widely recognized for its exfoliating properties and for expanding quickly when heated. Vermiculite typically has a temperature resistance of up to 1200°C. Vermiculite expands when heated to 650–950 C. The expansion process is known as exfoliation [3]. It is a system of low-density, non-structural building products. The use of vermiculite in concrete as a substitute and replacement for lightweight aggregates in lightweight concrete will tend to decrease the compressive strength of the concrete [4]. In addition to being lighter in weight and odorless, it also offers increased workability, improved fire resistance, and improved resistance to cracking and shrinking. Thermally insulating materials are used to increase comfort within the space and lower the energy needed for cooling during the summer. Mostly, it is of an inert chemical type. Typically, it is manufactured by simply combining exfoliated vermiculite as the aggregate with cement and water [2].

In a study [5] entitled "Incorporation of Expanded Vermiculite Lightweight Aggregate in Cement Mortar," it was found that the use of vermiculite as a substitute for fines aggregate in concrete can increases the strength of concrete and its resistance to high temperatures. And [6] entitled “Mechanical and Thermal Properties of Lightweight Concretes with Vermiculite and EPS Using Air-Entraining Agent” showed that lightweight concrete with vermiculite substitution can absorb more

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water than concrete using EPS substitution. Only mortar and lightweight concrete were utilized as test materials in the two researches mentioned above. The modifications made with an additional 12%, 24%, and 36% vermiculite, which were tested for compressive and flexural strength, were the differences and updates from the experiments.

METHOD

Vermiculite at various concentrations of 12%, 24%, and 36% is used in this study. Cement with the Dynamix brand, vermiculite samples from PT.IPI Sunijaya, fine aggregate from the Galunggung region, and coarse aggregate from Cimalaka. ACI 1991 was employed in this study's design, with a design quality of 15 MPa. Creating concrete specimens with mold sizes of 150 mm in diameter and 300 mm in height for testing the compressive strength and 100 mm x 100 mm x 500 mm for evaluating the tensile strength of concrete. After being formed, concrete was tested for flexural strength at 28 days after it was tested for compressive strength at 7, 14, 21, and 28 days .

(A) (B)

Figure 1. (a) manufacture of concrete specimen of flexural strength test
(b) manufacture of concrete specimen of flexural strength test

In this study, there were as many pieces of concrete as were needed to test the concretes compressive strength and flexural strength with 32 cylinders of concrete (for testing concretes compressive strength). and 8 concrete blocks (used to evaluate the flexural strength of concretes). The steps of this research are shown on Figure 1.

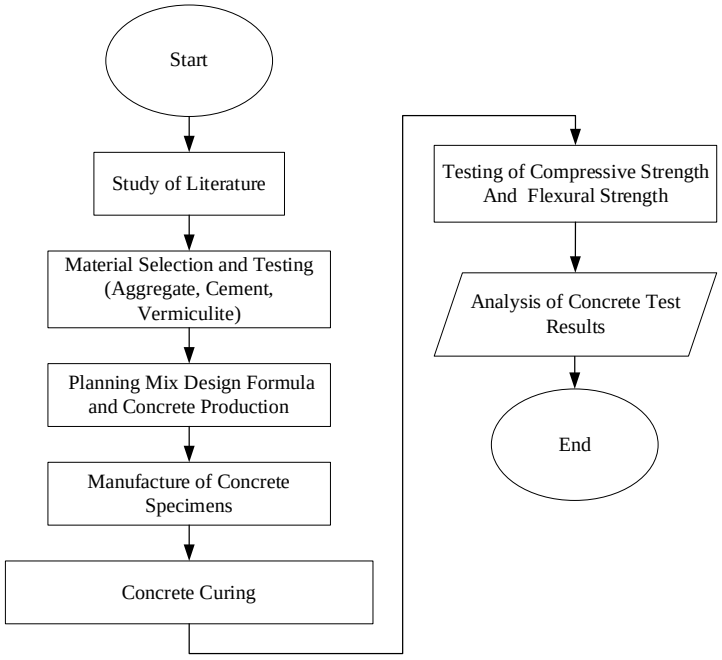

Figure 2. Methodology of The Research

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Vermiculite

Vermiculites are naturally occurring minerals that have glistening flakes that mimic mica. Vermiculites typically produced by modification of micaceous minerals such as Vermiculite, Hydrobiotite, and Phlogopite. These processes include weathering, hydrothermal activity, percolating groundwater, or a combination of these three. It contains hydrated magnesium and aluminum silicates.[7]. Vermiculite showed in Figure 3.

Figure 3. Vermiculite

Compressive Strength of Concrete Test

The most important mechanical property of concrete is compressive strength. The quality of the concrete itself has a strong relationship with the compressive strength of the concrete. The definition of concrete's compressive strength is the amount of load per unit area that, if applied more than the capacity of the concrete specimen, causes it to be crushed [8]. Concrete compressive strength testing is shown in Figure 4.

Figure 4. Concrete Compressive Strength Testing

Flexural Strength of Concrete Test

Flexural strength is the capacity of concrete placed on two supports to withstand pressure perpendicular to the axis before the concrete breaks [9]. Following flexural strength tests on beams with two-point loading, the failure flexural load was used to derive the average ultimate flexural tensile stress—concrete flexural strength testing shown in Figure 5.

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Figure 5. Flexural Strength of Concrete Testing

RESULT

Cement, coarse aggregate, fine aggregate, and water are proportionately created in this mixture (mix design). based on AASHTO 1993 with a quality goal of fc' 15 MPa (quality target modified to account for lean concrete production requirements). To get the amount of vermiculite added to the concrete mixture, multiply the percentage addition (12%, 24%, and 36%) by the total volume of the mixture, and then multiply that result by the vermiculite's specific gravity. **Error! Reference source not found.** provides specifics of the mixture's proportions employed in this investigation.

TABLE I. MIX DESIGN OF 15 MPA CONRETE

Mix Design	Cement (kg/m^3)	Coarse Aggregate (kg/m^3)	Fine Aggregate (kg/m^3)	Water (kg/m^3)	Vermiculite (%)	Slump (cm)
Variant 0	302,129	937,497	595,010	210,485	0%	7,5 - 10
Variant 1	302,129	937,497	595,010	210,485	12%	7,5 - 10
Variant 2	302,129	937,497	595,010	210,485	24%	7,5 - 10
Variant 3	302,129	937,497	595,010	210,485	36%	7,5 - 10

Vermiculite Content Testing

The results of a few tests were completed about vermiculite that originates from PT.IPI Sunijaya is shown in Table 1 and Table 2 below.

TABLE 1 VERMICULITE PHYSICAL TESTING

No	Test	Hasil
1	Specific Weight	0,80%
3	Weight Content	0,19 kg/liter
6	Water Absorption Rate	106,90%
7	Sieve Size	Maximum Size 4,75 mm

TABLE 2 VERMICULITE CHEMICAL CONTENT TESTING

No	Chemical Content	Result
1	SiO_2	41,60%
2	Al_2O_3	13,38%
3	Fe_2O_3	6,29%
4	FeO	<0,001%
5	MgO	24,60%
6	H_2O	2,73%

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Compressive Strength of Concrete Testing

The concrete specimens are tested for compressive strength at 7, 14, 21, and 28 days of age. Additionally, when the concrete specimen has been cured, this compressive strength test is also conducted. Table 3 and **Error! Reference source not found.** is the ratio of the compressive strength of normal and vermiculite concrete.

TABLE 3 COMPRESSIVE STRENGTH OF NORMAL AND VERMICULITE CONCRETE

(Days)	Variants of Vermiculite			
	Compressive Strength of Concrete			
	0%	12%	24%	36%
7	6,64	7,44	8,53	9,41
14	9,74	10,24	11,23	12,17
21	12,74	12,94	13,83	14,27
28	14,84	15,24	16,18	16,58

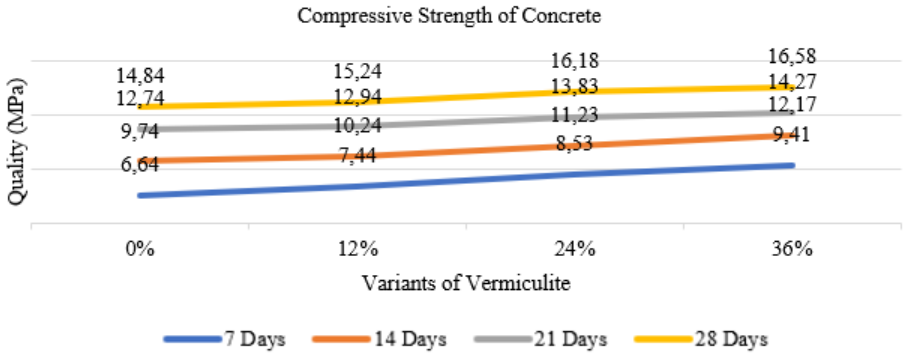

Figure 6. Compressive Strength of Normal and Vermiculite Concrete

Vermiculite has a significant impact on the outcomes of compressive strength tests on concrete specimens. The compressive strength of the concrete increases with the amount of vermiculite added, as can be observed and the maximum value of compressive strength of concrete is adding 36% of vermiculite in 14 days of curing. This is possible because vermiculite's primary property is its ability to absorb large amounts of water. As a result, when vermiculite is added to and mixed with concrete, it will absorb the excess water present in the mixture and dry out the mortar while maintaining the solidity of the final product thanks to granules. Vermiculite particles can be used to fill any cracks or holes in concrete.

Flexural Strength of Concrete Testing

After the concrete has been in place for 28 days, it may be tested for flexural tensile strength. In the previous concretes compressive strength test, vermiculite significantly affects the flexural tensile strength test findings on concrete specimens. The concrete's flexural strength may be inferred from the fact that it gets stronger the more vermiculite is put into it. The increase in flexural strength occurs with an increase in the percentage of vermiculite and the curing time [10]. in Table 4 and **Error! Reference source not found.** results of the strong flexure tests on the water-cured concrete. However, there is a tendency for the flexural strength of the concretes to increase.

TABLE 4 FLEXURAL STRENGTH OF NORMAL AND VERMICULITE CONCRETE WITH TWO CURING METHODS

Flexural Strength of Concrete	
Variants	MPa
0%	2,00
12%	2,33
24%	2,72
36%	2,86

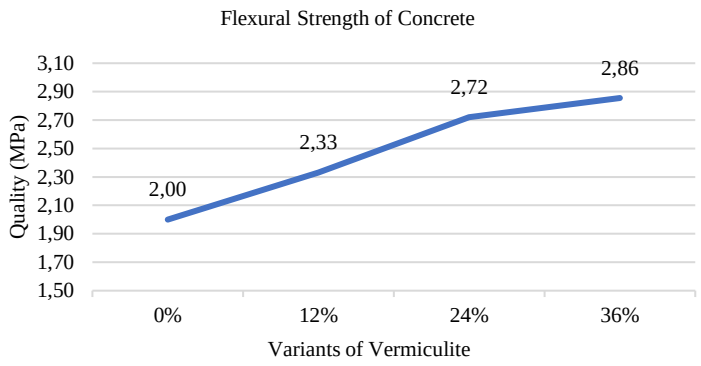

Figure 7. Comparison of Flexural Strength of Normal and Vermiculite Concrete with Two Curing Methods

CONCLUSION

The compressive strength and flexural strength of concrete increase with the addition of vermiculite because vermiculite's ability can absorb a lot of water is one of its main characteristics. Because of this, when vermiculite is added to and blended with concrete, it will absorb excess water in the mixture and dry out the mortar while preserving the firmness of the finished product due to granules. Concrete fractures and holes can be filled using vermiculite particles.

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