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The Effect of Adding Fly ash Waste and Additive Sikacim Concrete On The Compressive Strength Of CLC Type Lightweight Bricks

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Abstract

This study aims to determine the results of compressive strength testing between ordinary lightweight bricks compared to lightweight bricks with fly ash waste additives and sikacim concrete additives. The method used is the experimental method. In this study, test objects were made by adding fly ash waste and sikacim concrete additive as a mixture of lightweight brick material. Then the lightweight brick is tested for compressive strength at the age of 14 and 28 days, which is possible that the lightweight brick has reached the maximum compressive strength value. The data analysis used to determine whether or not the use of fly ash waste additives and sikacim concrete additives affects the compressive strength of lightweight bricks is regression analysis. In this study, 3 variations of test objects were made where each variation consisted of 5 test objects that had different mixture compositions, namely 0%, 25%, and 50%. The results of the comparison of the compressive strength of ordinary lightweight bricks with a mixture of fly ash waste and sikacim concrete additives for 14-day-old lightweight bricks, at 0% composition is 3.70 Mpa, and at the age of 28 days it increases to 4.43%. The compressive strength value at the age of 14 days for the 25% composition has increased to 4.38 Mpa and the 28-day old has increased compressive strength to 5.05 Mpa. While the 50% composition at the age of 14 days decreased by 16.15%, namely 3.09 Mpa, and those aged 28 days decreased by 17.60%, namely 3.65 Mpa.

Keywords: sikacim concrete, compressive strength, fly ash waste, lightweight bricks

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1. INTRODUCTION

Along with the times, the growth and development of the building industry in Indonesia is increasing. Almost in every city, there are many construction projects such as office buildings, houses and others. With so many projects, the need for building materials, especially wall coverings, will also increase. wall is one part that functions as a cover layer in a building. (Ardiyana, 2017).

According to SNI 03-0349-1989, concrete bricks are building materials in the form of stones whose hardening is not burned and made of mixed materials in the form of sand, cement, water and in the manufacture can be added with other materials (*additives*). Currently, material innovations are increasingly diverse and are present to answer all problems in the field. One of them is the innovation of wall masonry materials, namely lightweight bricks which are starting to be commonly used as an alternative to red bricks and concrete blocks. The faster workmanship, easy implementation, and neatness produced are the advantages of lightweight bricks. Its much larger size and lighter weight are the reasons why lightweight bricks are considered more efficient to use for construction projects today. (Wiku, 2022)

Lightweight bricks have a lighter weight than other types of bricks, which is the reason consumers choose brick alternatives as building walls, so as to reduce the existing foundation load. However, lightweight bricks are not able to withstand earthquakes well when they have to be supported by other constructions. Selection of good lightweight bricks and proper construction planning, lightweight bricks as an alternative to construction walls can withstand earthquakes and can make the weight of building construction lighter. (Eko. Dkk, 2021)

Along with the development of time and technology, there have been many innovations or alternative building materials that facilitate workmanship, are environmentally friendly, provide comfort effects, durability, speed in application, this can also be found in lightweight bricks with *foam* technology. In the manufacture of lightweight bricks or often also called lightweight concrete there are several ways that are done, for example by creating gas / air bubbles in the cement mixture, the use of lightweight aggregates such as burnt clay or pumice. (Lilik, 2015).

Lightweight bricks are made using materials similar to those used to make concrete where aggregate is the main material while cement is the binding agent. However, modern construction projects are growing so rapidly that the demand for cement is increasing in almost all parts of the country. In an effort to minimize the use of cement, new innovations are needed, such as the addition of coal *fly ash waste* to the lightweight brick mixture as a partial substitute for cement. (Wiku, 2022)

Innovation in the use of *fly* ash (*fly ash waste*) can be used as a mixture for making lightweight bricks. Making lightweight bricks generally still uses cement as a mixture. *Fly ash waste was* chosen as one of the additives in making lightweight bricks. According to (Mira, 2018) The use of *fly ash waste* material as a cement substitute forming material is based on the properties of this material which have similarities to the properties of cement. The similarity of these properties can be viewed from two main properties, namely physical and chemical properties. Physically, *fly ash waste* material is similar to cement in terms of its grain fineness.

According to (Mulyati and Reza, 2018) Other chemical additives that can be used for lightweight beta mixes are commonly found on the market, namely Sikacim

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Concrete *Additive* or *SikaCim* Concrete *Additive*. Based on the product description listed and previous research references, these additives can harden the process with high early and late strength in lightweight concrete bricks reducing water (*water reducer*) and *superplasticizers* which are very effective for producing high quality concrete in hot climates. Research conducted by Rini Rahmayanti, et al (2023) states that the addition of fly ash waste can increase the compressive strength value of lightweight bricks. Similar research was also conducted by Anggy Guspita, et al (2023) on the utilization of fly ash waste to increase the compressive strength of lightweight bricks. In connection with this, researchers were inspired to try to utilize *fly ash waste* and combine it with sikacim concrete *additive to* be used as an alternative mixture for making lightweight bricks. The purpose of this study is to determine the results of compressive strength testing between ordinary lightweight bricks and lightweight bricks with fly ash waste and sikacim concrete additives.

2. LITERATURE REVIEW

Definition of Lightweight Concrete Brick

Lightweight concrete bricks were first developed in Sweden in 1923 as an alternative building material to reduce deforestation. It was then developed by Joseph Hebel in Germany in 1943. Through Hebel's products, lightweight bricks got the nickname *Aerated Lightweight Concrete* (ALC). Lightweight concrete bricks or often called hebel and celcon bricks are quite light, smooth and have a good level of cracking. This lightweight concrete brick was created in order to lighten the structural load of a construction building. Lightweight concrete bricks are bricks that weigh much less than bricks in general. (Arman. A and Andi Setiawan 2019)

Lightweight concrete bricks were created with the aim of lightening the structural load of a construction building, accelerating implementation, and minimizing the remaining material that occurs during the wall installation process. In addition, it is important to note that there are a number of different types of concrete that can be used in the construction industry, such as concrete batching plants, concrete pumps, concrete pumps, concrete pumps, concrete pumps, and concrete pumps. In Suryani & Munasir (2015) there are those who define lightweight bricks as bricks with a density between 2000 kg/m3 or lower.

Cellular Lightweight Concrete (CLC) Brick

CLC type lightweight brick is a lightweight brick with natural hardening process. CLC lightweight brick is a conventional type of concrete where the coarse aggregate has been replaced with air bubble foam. The equipment used in this type of production is standard, so the production can be easily done with only sand, foam, cement and water. The desired specific weight can be set between 350 kg/m3 to 1800 kg/m3 and strength values between 1.5 and more than 30 N/mm2. This type of CLC lightweight brick is similar to ordinary concrete, that is, the strength increases over time.

The mixture of CLC includes cement, fine sand, water and special foam which once hardened produces a strong lightweight concrete containing millions of cells or fine air bubbles of consistent size and evenly distributed. CLC has a density between 400 kg/m³ to 1800 kg/m³. However, for structural work, a good density of CLC to use

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ranges from 1200 kg/m³ to 1400 kg/m³. The advantages that can be obtained from the use of CLC include:

1. Provides excellent heat and sound insulation. For example, a 125 mm CLC wall provides four times better insulation than a 230 mm brick wall.
2. The form is stable even when exposed to additional water. Whereas in lightweight concrete with the use of alumina powder, the concrete will expand again when exposed to additional water.
3. The advantage for remote areas is that it only requires cement to manufacture. Unlike aerated concrete which still uses alumina powder in its manufacture.

Lightweight brick is composed of several elements, where each constituent material has certain characteristics, and provides lightweight properties to lighten the structural load of a construction building. In short, the constituent elements of lightweight bricks can be seen in table 2.1 below:

Table 2.1. Ingredients of lightweight bricks

No.	Ingredients	Characteristics
1	Cement	is hydraulic because it contains calcium silicate and calcium sulfate
2	Fine aggregate	as a filler material in the manufacture of concrete bricks. The strength of concrete is affected by the quality of sand used,
3.	Water	Water serves for the cement reaction to start the bonding as well as being a lubricant between the aggregate grains so that they can be easily worked and compacted.
4.	Foam Agent	so that many pores are formed so that lightweight bricks have a light weight
5.	Fly ash waste	coal combustion waste in steam power plant furnaces that is fine, round and pozolanic in nature
6.	Sikacim Concrete	Water reducers and superplasticizers are highly effective for producing high-quality concrete in hot climates.

Compressive Strength

The definition of compressive strength or perforated lightweight brick is analogous to the compressive strength of concrete. Referring to SK SNI M-14-1989-F about testing the compressive strength of concrete. What is meant by concrete compressive strength is the amount of load per unit area that causes the concrete test specimen to crumble when loaded with a certain compressive force produced by a press machine. (Department of Public Works, 1989: 4).

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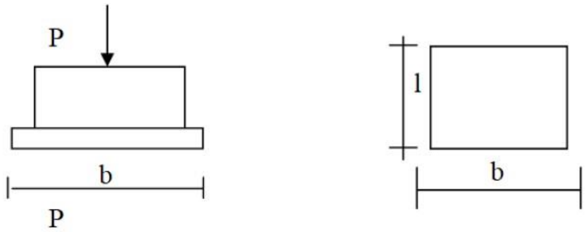

$$f'c = \frac{P}{A} \quad \text{.......persamaan (1)}$$

Keterangan : *f'c* = kuat tekan (Mpa)
P = beban (Kg)
A = luas penampang (Cm^2)
Dimana A = l x b (Cm^2)

Figure 2.1. Compressive Strength Equation

Based on the above formula, it can be seen that the compressive strength of concrete will be higher if the compressive cross-sectional area is larger, and also the cement water factor also determines the compressive strength. For this reason, it is necessary to find the optimum value of the cement water factor (fas) which produces the maximum compressive strength.

In order to obtain a high compressive strength, an aggregate that has been tested through an aggregate test is required so that its compressive strength is not lower than that of the paste. The most important thing to consider when choosing a concrete batch plant is the quality of the concrete, the quality of the mix and the quality of the concrete itself. The amount of cement can determine the compressive strength of lightweight bricks, but the amount of cement intended to increase the compressive strength of lightweight bricks must be considered the value of the cement water factor produced by the concrete mixture.

From some of the above definitions, the final conclusion can be drawn that the compressive strength of lightweight bricks is the strength resulting from compressive testing by a compressive testing machine which is the overall compressive load when the test object is broken divided by the size of the nominal area of lightweight bricks or the amount of load per area.

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3. METHODS

The purpose of this research is to analyze the comparison of compressive strength of ordinary lightweight bricks with lightweight bricks mixed with *fly ash waste* and Sikacim Concrete *Additive*. The research stages are shown in Table 3.1. as follows:

Table 3.1 Research Stages

No.	Stages	Description
1.	I	Preparation and planning of lightweight brick making using mixtures.
2.	II	Light brick making.
3.	III	Testing the compressive strength of lightweight bricks
4.	IV	Obtain the results of the light brick compressive strength test and enter them into the research report data.

In this research, the method used is the experimental method. This research is intended to test the effect of a treatment on the object of research. In this study, the test objects were made by adding *fly ash waste* and sikacim concrete *additive* as a mixture of lightweight brick material. Then the lightweight brick is tested for compressive strength at the age of 14 and 28 days, which is possible that the lightweight brick has reached the maximum compressive strength value.

A sample of 30 test pieces with a comparison dose as shown in Table 3.2 below:

Table 3.2 Comparison Measures of Test Objects

Sample Code	Composition				Number of Test Objects
	%	*Fly ash waste* %	Sand %	Sikacim Concrete *Additive* %	
A	100	0	100	1	5
B	75	25	100	1	5
C	50	50	100	1	5
					15

Data analysis used to determine the effect or not the comparison of the use of additives in the form of *fly ash waste* and Sikacim Concrete *Additive* Substances on the compressive strength of lightweight bricks is by regression analysis.

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4. RESULTS AND DISCUSSION

In this study, 3 variations of test specimens were made where each variation consisted of 5 test specimens that had different mixture compositions. After calculating the material requirements for each variation, a recapitulation is obtained as shown in the table below:

Table 4.1 Recapitulation of material requirements

No.	Material Type	Sat.	Variable Volumes		
			0%	25%	50%
1	Sand	Kg	16.6	16.6	16.6
2	Cement	Kg	8.05	6.0375	4.025
3	Water	Kg	3.55	3.550	3.550
4	*Fly ash waste*	Kg	0	2.0125	4.025
5	Foam	gr	500	500	500
6	Sikacim Concrete	%	1	1	1

From Table 4.1 above, it is known that the proportion of material in variation 1 only uses cement without *fly ash waste* and Sikacim Concrete *Additive*. In variation 2 and variation 3, the proportion of cement was gradually reduced and replaced with *fly ash waste* which increased by 25% and 50% respectively and Sikacim Concrete *Additive* with a fixed proportion of 1% of the total weight of the material.

For the slump test, it was found that the data from the *slump* test on each variation of medium lightweight bricks made the *slump* value decrease along with the partial substitution of cement with *fly ash waste* and the addition of SikaCim Concrete *Additive to* reduce the use of 15% water. This makes the workability of fresh lightweight bricks lower than normal lightweight bricks.

The results of this research observation show that as the proportion of partial substitution of cement with *fly ash waste* increases, the absorption of water by *fly ash waste is* greater and the use of SikaCim Concrete *Additive* does not play a role in the level of *workability of* fresh lightweight bricks to be higher. For more details of the *Slump* value can be seen in Figure 4.1 as follows:

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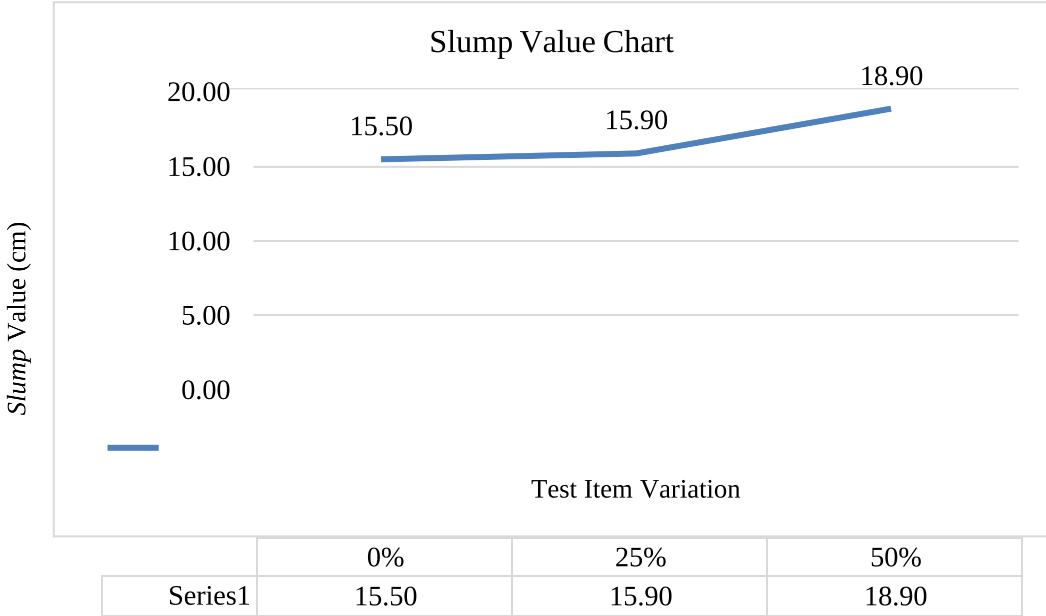

Figure 4.1 Graph of Slump Value

After going through the *curing* or treatment process, it will produce the weight per specimen in each substitution. For 14-day-old specimens, the average weight of 0% substitution reached 5786.40 grams, while for 25% substitution the weight increased by 0.60% to 5821.20 grams, and for 50% substitution the weight increased by 3.30% to 5978.60 grams.

At the age of 28 days the average weight of the test objects at 0% substitution reached 5025.80 gr, while for 25% substitution the weight decreased by 6.19% as much as 4714.60 gr, and for 50% substitution the weight increased by 21.5% as much as 6106.60 gr. For more details can be seen in Figure 4.2 below:

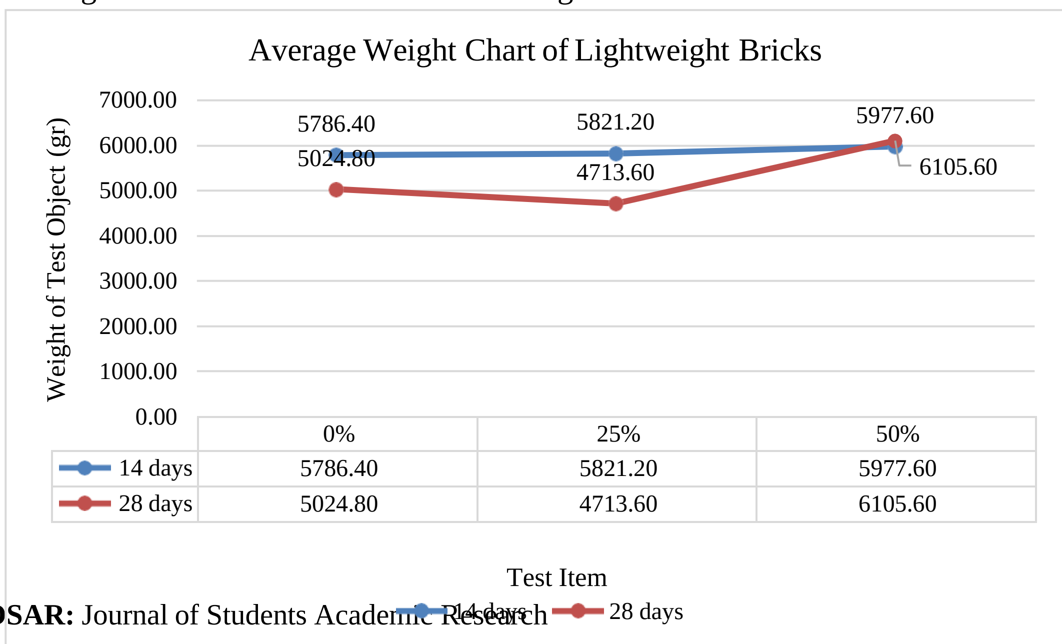

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Figure 4.2 Graph of Average Weight of Lightweight Brick

After the test specimens go through the *curing* or treatment process, the test specimens are tested for compressive strength with a compressive tester. This test is carried out on all test specimens aged 14 and 28 days. This test aims to determine the strength value of lightweight bricks based on the amount of load given per surface area. The test was carried out using a press tester located at the Civil Engineering Laboratory of Balitar Islamic University. The results of the compressive strength test on the specimens can be seen in Table 4.3 below:

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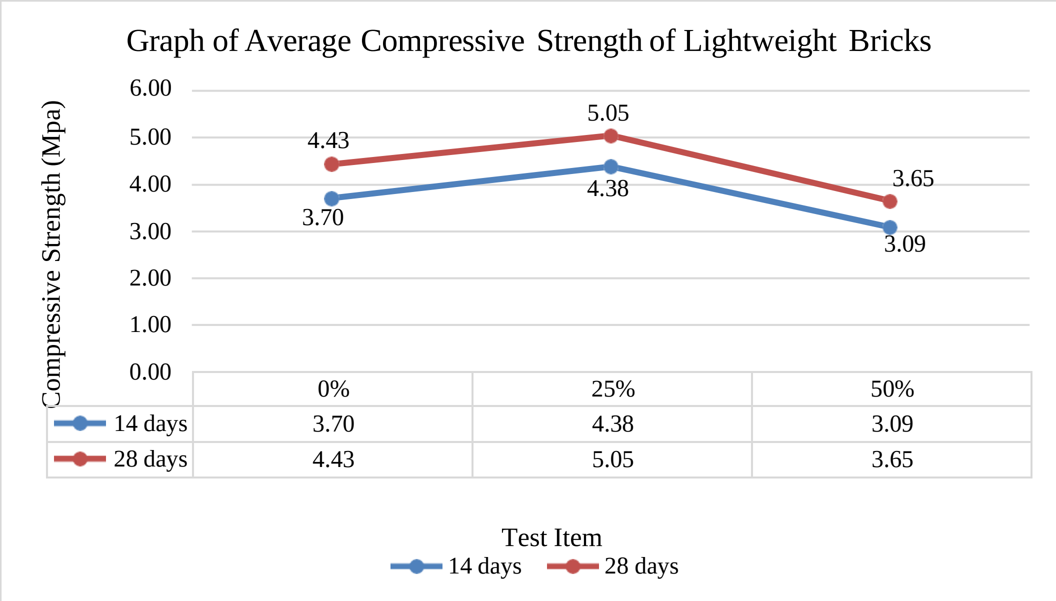

Figure 4.3 Graph of Average Compressive Strength of Lightweight Brick

In the table above, it can be seen that after the compressive strength test was carried out on 28-day-old test specimens, the average result at 0% substitution reached 4.43 Mpa, while for 25% substitution the compressive strength value increased by 13.86% by 5.05 Mpa, and for 50% substitution the compressive strength value decreased by 17.60% by 3.65 Mpa. This is in accordance with the results of research conducted by Rini Rahmayanti (2023) which states that the optimal value of the strength of lightweight bricks is at a percentage of 30%. And decreased when the percentage of substitution was 50%.The amount of *fly ash waste* too much fly ash is no longer helping cement in the binding process between materials, so as to improve the quality of lightweight bricks, but instead the opposite. In line with the results of Anggy Guspita's research, et al (2023) which states that the level of fly ashwaste mixture that is too much, namely at a mixture concentration of more than 30%, causes a decrease in the quality of lightweight bricks. Fly ash waste has a lower pozzolonic ability than cement, so the content of fly ash waste only fills the empty spaces between particles, and not binds particles.

From the test results of the average compressive strength of the lightweight bricks, regression analysis is then carried out, until the following results are obtained.

Table 4.2 Results of R Square Analysis

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.473[a]	.223	-.553	31.15716	1.447

a. Predictors: (Constant), Compressive Strength

b. Dependent Variable: Mixed Percentage

The R square value is 0.223, meaning that the percentage mixture variable is able to influence the compressive strength variable by 22.3%,

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while the remaining 77.7% influence is influenced by other variables besides the percentage of the mixture.

Table 4.3 Anova Test Results

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	279.231	1	279.231	.288	.687[a]
	Residuals	970.769	1	970.769		
	Total	1250.000	2			

a. Predictors: (Constant), Compressive Strength

b. Dependent Variable: Mixed Percentage

The ANOVA table obtained a calculated F value (2.888) and a significance value (p) of 0,687. Because p> 0.05, it is concluded that the percentage of mixture does not simultaneously affect the compressive strength variable.

Table 4.3 T-Statistic Results

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	93.175	128.383		.726	.600
	Compressive Strength	-18.310	34.141	-.473	-.536	.687

a. Dependent Variable: Mixed Percentage

The significance value of the t-statistic on the percentage mixture variable is obtained (p=0.687), then the percentage mixture variable has no significant effect (p>0.05) on the compressive strength. Or in other words, the use of flyash mixture and sikacim concrete additive does not have a significant effect on the compressive strength of lightweight bricks. The compressive strength value of lightweight bricks obtained with the existing mixture variations has met the minimum compressive strength according to SNI-8640-2018 which is 1.80 Mpa.

The average compressive strength value of lightweight bricks obtained in this study is also in accordance with the results of research conducted by Rini Rahmayanti (2023), that the results of the compressive strength of lightweight bricks have met the standard compressive strength value, as well as the results of research conducted by Narmadi (2020).

6. CONCLUSION

The results of the comparison of the compressive strength of ordinary lightweight bricks with a mixture of *fly ash waste* and Sikacim Concrete *Additive* substances at 25% composition aged 14 days increased compressive strength by 18.39%, namely 4.38 Mpa and aged 28 increased compressive strength by 13.86%, namely 5.05 Mpa, while the composition of 50% aged 14 days decreased by 16.15%, namely 3.09 Mpa, and aged 28 days decreased by 17.60%, namely 3.65 Mpa.

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