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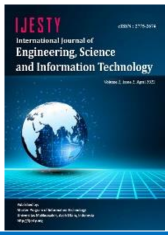

The Effect of Plastiment-VZ on the Compressive Strength and Flexural Strength of Lightwieght Concrete Using Aluminium Powder

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Abstract

One of the approaches to producing lightweight concrete is by adding the aluminum powder to the cement mixture to create air bubbles in the concrete as such enabling pores to appear in the concrete. Aluminum powder can reduce the weight of lightweight concrete despite its tendency to reduce compressive strength. The compressive strength of concrete can be increased by certain methods, one of which is by the addition of Plastiment-VZ admixture. This study aims to investigate the effect of the use of Plastiment-VZ admixture on the compressive strength and flexural strength of lightweight concrete. The normal concrete compressive strength is designed to the range of 0.7 MPa – 5.0 MPa. The concrete testing specimens were in the form of a cube of 15 cm x 15 cm x 15 cm for the compressive test and beams with dimensions of 15 cm x 15 cm x 60 cm for the flexural test. The test results of the compressive strength obtained for normally aerated concrete (0% of Plastiment-VZ) is 6.31 MPa; and for the variation of 0.2% is 6.52 MPa, for 0.4% is 6.8 MPa, and for 0.6% is 8.04 MPa. The highest increase in strength occurred at 0.6% variation, which is 27.46% above normally aerated concrete. The degrees of flexural strength of the concrete produced from each variation of 0%; Based on the findings, it can be concluded that Plastiment-VZ has a significant effect on increasing the compressive strength and flexural strength of lightweight concrete. The more quantity of Plastiment-VZ is used, the higher the compressive strength and flexural strength are produced; even though, the optimum level for the use of Plastiment-VZ for aerated concrete has not been found.

Keywords: Aluminium Powder, Plastiment-VZ, Aerated Concrete, Compressive Strength, Flexural Strength.

1. Introduction

Lightweight concrete has a weight less than normal concrete and it reduces the total weight of a construction building. The use of lightweight concrete is mostly applied in the partition walls and other non-structural elements. There are many types of lightweight concrete; one of which is the aerated lightweight concrete. The method in use to obtain aerated lightweight concrete is by adding aluminum powder into the cement mixture to create air bubbles; thus, enabling air pores to appear in the concrete [1].

Aluminium powder act as an additive material potentially to create air bubbles. When the aluminium powder paste reacts with calcium hydroxide (Ca(OH)2) present in cement plus water, hydrogen gas will be produced. The hydrogen gas exerts air bubbles and magnifies the volume of the concrete mixture [2]. Aluminium powder is able to reduce the specific gravity of lightweight concrete despite its tends to reduce the compressive strength of lightweight concrete The same method of making lightweight concrete by adding aluminium powder was also carried out by Kusuma [3] in the form of an experimental study by adding aluminium powder into a mixture of non-sand concrete and the addition of gypsum powder which was molded using a cylindrical specimen with an aluminium powder content of 0%; 0.3%; 0.5%; and 0.7% of the weight of cement. Kusuma [3]mentions that the greater the quantity of aluminium powder is added, the smaller is its impact on the compressive strength of the concrete. Aluminium powder is not able to work alone to develop lightweight concrete. Therefore, it is necessary to put more additives to allow lightweight concrete to expand so as to reach the expected specifications. The nature of aluminium powder is to aerate rather than to expand the concrete. The chemical reaction between aluminium powder and cement releases air bubbles (aeration) and concrete hardens quickly. In this study, Plastiment-VZ additive was used to slow down the setting time of the concrete so as to help improve workability during the bonding process. In addition, Plastiment-VZ also reduces the mixing water and increases the compressive strength of concrete with its age increament [3].

Based on the previous study by [3] who conducted an experimental study by adding Plastiment-VZ to normal concrete using a content of 0.20%; 0.40%; and 0.60% of the weight of cement, where the compressive strength test was carried out at the age of 7 days, 14 days and 28 days, the test results showed that the compressive strength of normal concrete at the age of 7 days is 18.21 MPa. The study concludes that the concrete added with Plastiment-VZ of 0.60% results in a compressive strength of 12.83 MP where there is a delay in achieving the strength of the concrete at an early age, which was 29.54% below normal concrete, but its strength increases with age. This is indicated by the obtained compressive concrete strength of 24.25 MPa at the age of 14 days and 32.08 MPa at the age of 28 days [4] [5].

Plastiment-VZ act as a water reducer and retarder has a dual function; firstly, to reduce the mixing water needed to produce concrete with a certain consistency; and secondly to inhibit the setting time of the concrete in order to improve the workability of the concrete which will affect the strength of the concrete. In other study, the addition of Plastiment-VZ and Sikament-NN can improve the characteristics of concrete in rigid pavement [6]. Muqtadi [7] studied the behavior of styrofoam concrete without admixtures other than Plastiment-VZ added materials. The test results show that with the addition of Plastiment-VZ the compressive strength graph has increased in comparison to that of the Styrofoam concrete without Plastiment-VZ.

Mohammadi et al [8] concludes that increasing the percentage of aluminium powder content will cause a decrease in the specific gravity of the cement weight. In addition, in light of the compressive strength, minislump values and workability, it shows that 0.0934% is the optimal percentage to achieve an optimum compressive strength of 10.1 MPa and an average of 7.35 MPa. In this study the percentage of AP is fixed at 0.0934% in use for all specimens.

By considering the afore-stated reasons, the addition of aluminium powder with an AP percentage of 0.0934% to lightweight concrete using Plastiment-VZ admixture constitutes a typical mixture that needs researching. This study seeks to determine the value of the compressive strength and the flexural strength of aerated lightweight concrete against addition of Plastiment-VZ.

2. Literature Review

2.1. Lightweight Concrete

The term of lightweight concrete is referred to the concrete with density in range of 1140 kg/m^3 to 1840 kg/m^3 [9]. The lightweight concrete can be obtained by making concrete from lightweight aggregates, making air bubbles, or adding materials that have a small specific gravity. Tjokrodimuljo [1] summarized the the method used to manufacture the lightweight concrete includes: making air bubbles by adding aluminium powder to the cement mixture to enable air pores to appear in the concrete; using aggregates that have a smaller unit weight, such as burnt clay and pumice; and the manufacture of concrete without the use of fine aggregate is called as 'non-sand concrete'.

According to [10], admixture materials constitute the materials in the form of powder or liquid, which are added to the concrete mixture during stirring in a certain amount of quantity to change some of its properties. In general, the added materials used in concrete can be divided into two parts; namely chemical admixtures and mineral additives [11]. The addition of liquid chemical additives in large quantities must be considered as part of the mixing water [10]. In addition, plastiment-VZ is a type D additive, which is an additive that has a dual function; to reduce the amount of needed mixing water in order to produce concrete with a certain consistency and to inhibit the initial setting of the mix.

2.2. Plastiment-VZ

According to [12], Plastiment-VZ is a plasticizer and water reducer for concrete admixture in the form of liquid and has the effect of slowing down the setting time (set retarder). Plastiment-VZ is used as a general admixture in concrete mixtures where the condition of the bearing requires high quality concrete such as the followings: high temperature; fine-surfaced concrete; pumped concrete; ready mix concrete; areas where large quantities of concrete will be placed (mass concrete); and high strength concrete is required.

In addition, the main function of Plastiment-VZ as a *retarder and water reducer*, Plastimen-VZ also provides the properties and advantages of extending the *setting* time in hot weather, accelerating the hardening of concrete after setting, increasing the workability without increasing the amount of water, reducing the water use without reducing workability, increasing concrete strength, reducing shrinkage and cracking, and lengthening the control of reduced *slump* value [12].

The recommended level of Plastiment-VZ [12] is 0.15% - 0.40% by weight of cement. The effective percentage depends on the type of cement and fine aggregate. In general, the levels to be used ranges from 0.15% to 0.25% for concrete which has a low absorption capacity of fine aggregate. This level can be increased up to 0.6% to overcome the difficulty of cement and aggregate quality, high temperatures and the difficulty in placement. In this study, the level used will be made up to a maximum level of 0.6%. The characteristics and information of Plastiment-VZ products can be depicted in Table 1 below.

Table 1. Plastiment-VZ Characteristics: Source [12]

Technical Data	
Chemical base	*Polyhydroxy carbon salts*
Packaging	Drum of 240 kg, large quantity shipping
Shape / color	Liquid / transparent yellow
Age and storage	Minimum 1 year if stored in its original sealed packaging
Storage Condition	Store in a dry, cool and shady place
Specific gravity	1.18 ± 0.01 kg/L
Total chloride ion content	< 0.1% w/w

2.3. Aluminium powder

According to [13], aluminium powder or paste for AAC (Autoclave Aerated Concrete) concrete is a product of dry milling process. Aluminium powder has advantages such as high aluminum content, fast gas generation rate, easy dispersion, and long storage time, and its particle size distribution can be controlled or adjusted based on different formulas. In this study, However, the material to be used was the aluminium powder obtained from chemical stores. Aluminium powder has a silver color with fine grains. The specific gravity of aluminium powder is lighter than that of cement. From the results of examinations in the laboratory, the average specific gravity of aluminium powder from the chemical shop is 2.73. Meanwhile, cement has an average specific gravity of 3.12.

2.4. Concrete Mix Design and Slump Flow Test

Determining the concrete filler and the proportional ratio of cement, water, sand and concrete filler additives aims to produce concrete with a certain minimum strength. To get the right proportions, the trial-error method is employed in this research. Calculation of the concrete mix is carried out based on absolute volume which refers to [10] which is formulated in the form of an equation for the material that composes concrete with a volume of 1 m^3.

Slump flow test is determined on the basis of the average base diameter of the mortar from the stated mortar mass as the original base diameter [14]. According to [15] the flow requirement must be produced at 110 ± 5 and shall be determined in accordance with [16]. The flow calculation is determined by the following formula.

$$\text{Flow} = (A / \text{Base diameter}) \times 100\% \qquad (1)$$

Where:

A = *Average mortar diameter – Base diameter (mm)*
Dia. base = *Diameter of the mortar base when the mold is removed (mm)*
Flow = *mortar flow (%)*

2.5. Compressive and Flexural Strength Testing

Compressive strength is the ability to accept compressive forces per unit area. The compressive strength identifies the quality of a single component of the concrete structure. The higher the strength of a structure, the better the quality of the resulting concrete [11]. The concrete specimen in use for the compressive strength test is a cube specimen with dimensions of 150 mm x 150 mm x 150 mm. The tests were carried out at the age of 7 days, 14 days and 28 days. After the maximum load was obtained from the compressive strength test in the laboratory using a compression testing machine, the compressive strength result was then calculated using the following formula as in [14].

$$f'c = P/A \qquad (2)$$

where:

$f'c$ = *compressive strength of concrete (MPa or N/mm^2)*
P = *axial compressive force (N)*
A = *cross-sectional area of the specimen (mm^2)*

Meanwhile, according to [17] flexural strength of concrete is the ability of concrete beams laid in two places to withstand forces in a direction perpendicular to the axis, which is given until the concrete beam failed. The flexural strength of concrete is stated in the unit of Mega Pascal (MPa). In this study, the concrete specimen used is a beam having width, height and length of 15 cm, 15 cm and 60 cm, respectively. The test is carried out by placing the beam on a steel base or cylindrical shaped pillar, then it is loaded at two points or every 1/3 of the span. The flexural strength of the concrete is calculated using the formula in equation (3) as follows:

$$\sigma = PL/bh^2 \qquad (3)$$

where,

σ = *Flexural Strength (MPa)*
P = *Maximum load that the flexural beam can withstand (N)*
L = *Length of beam cross section (mm)*
b = *Width of beam cross section (mm)*
h = *Height of beam (mm)*

3. Method

The research was carried out in a number of stages comprising the material testing, concrete mix design, concrete material admixture stirring, slump flow test, production and maintenance of concrete specimens, compressive strength test and flexural strength test. Experimental works were carried out by using the Plastiment-VZ produced by Sika Indonesia Co. Ltd. added in a mixture of fresh concrete combined with aluminium powder by 0.0934% of the weight of cement as an additive to make air bubbles in the concrete. Plastiment-VZ was added by 0.2%; 0.4%; and 0.6% of weight of cement. Plastiment-VZ has been mixed first with mixing water prior being stirred into a concrete mixture in accordance with [16], while for the material to make air bubbles, it is not allowed to be mixed with other materials. Aluminium powder was added to the mix by gradual stiring at the end of the mixing procedure.

The mixing procedure complies with [18] on the *Procedure for Mixing Mortars* using a mixer. After mixing, a *flow* test was carried out in accordance with [19] using a *flow table* instrument and 1 set of minislumps. After obtaining a flow value of 110 ± 5%, the subsequent step is casting, compacting and finishing according to [20] and [14] procedures. The finishing surface on the fresh concrete is conducted using a scraper, but since the volume of fresh concrete continues to increase and there is an excess of volume in fresh concrete, the smooth surface is perpetrated again using a grinder after the concrete has hardened. All specimens were tested on day 28 to see the concrete compressive strength and the flexural strength. The compressive strength and flexural strength tests were conducted on to each of the 12 specimens .

This research involved a four stage of testing, namely testing the physical properties, the *slump flow* test, the compressive strength test, and the flexural strength test. The compressive strength test used a specimen having a cylindrical shape with a diameter of 150 mm and height of 300 mm. The flexural strength test sample used a beam-shaped with a length of 600 mm, width of 150 mm and height of 150 mm. The *mix design* calculation was in accordance to [10] and it was done by *trial and error* approach.

3.1. Variation and Number of Specimen

According to [16], it stated that the number of specimens is usually three or more; the specimens are provided for each test age and test conditions unless otherwise specified. In this study, three variations of percentage Pl-VZ and one normally aerated concrete with 0% Pl-VZ will be made and each variation would have 3 specimens each. As shown in Table 2.

Table 2. Compressive Strength and Flexural Strength Design

Code of specimens	Variation of specimens	Compressive strength	Flexural strength
AP-PL_0	AP 0.0934% + Pl-VZ 0%	3	3
AP-$PL_{0.2}$	AP 0.0934% + Pl-VZ 0.2%	3	3
AP-$PL_{0.4}$	AP 0.0934% + Pl-VZ 0.4%	3	3
AP-$PL_{0.6}$	AP 0.0934% + Pl-VZ 0.6%	3	3
	Total of specimens	12	12

where:
AP = Aluminium powder
Pl-VZ = Plastiment-VZ
AP-PL_0 (BAN)= Sampel Aluminium powder0.0934% + Plastiment-VZ 0%
AP-$PL_{0.2}$ = Sampel Aluminium powder0.0934% + Plastiment-VZ 0.2%, etc.

3.2. Material Testing

Material testing aims to determine the characteristics of the material that meets the quality requirements in order that the material can be used in research. The material inspection stages include fine aggregate inspection, cement inspection, and aluminium powder inspection. The materials used in this research are:

- The fine aggregate in use was the sand taken from Kreung Mane River.
- The cement is type I portland cement of Semen Padang of 50 kg bag packaging.
- The Plastiment-VZ added material is the product of PT. Sika Indonesia
- Aluminium powder was purchased at a chemical store.

3.3. Concrete mix design

Calculation of the concrete mixture is made based on the absolute volume formulated in the form of an equation, where the total volume of the material that composes the concrete must be equal to 1 m^3. The calculation steps start from determining the cement water factor, the ratio of the cement volume and fine aggregate, the levels of AP and Plastiment-VZ in comparison to the weight of cement. After determining these initial values, the volume of each material is subsequently calculated by employing the absolute volume equation. The initial variable that can be obtained from the equation is the cement weight. All the material volume formulas must be related to the cement weight (Ws). Once Ws is obtained, the other variables are then mathematically substituted to find their respective volumes. The next stage is to calculate the weight of each material out of the weight formula based on the absolute volume and the adjustment to the aggregate moisture. And, the final stage is to perform the trial batch adjustment and proceded to check the flow and the fresh concrete density. If the trial batch does not match, the new trial mix will be recalculated so as that the expected mix is obtained. The ratio of the cement volume and the sand volume is determined as 1: 2. Water cement ratio (w/c) is determined according to [18] for mortar with an additional air of 0.46. The required flow value range is 110 ± 5% according to [19]. The designed f'c value is in the range of 0.7 – 5 MPa. The fine aggregate uses fine graded sand (zone IV). In order to determine the right mix design, the trial and error approach is employed.

3.4. Slump flow test and Manufacturing of Concrete Specimens

The flow test was carried out in accordance with [19]. This test aims to determine the workability of fresh concrete based on the fresh concrete spreadability the unit of diameter. The slump flow test is conducted after the stirring stage is complete. Fresh concrete that meets the slump flow requirements can be cast into a concrete mold. The test is executed by dropping the flow table 25 times in 15 seconds. The flow value is obtained by measuring the diameter of the mortar using a caliper for 4 times, calculated using the equation (1) as referred to in [20].

The stage of the manufacturing of concrete specimens complies with the [14] and [16] which consists of pouring, compaction (hand tamping) and the final stage (finishing). After the slump flow test, fresh concrete was stirred with a shovel to avoid segregation, then the concrete mix was poured into the mold using a blunt shovel. Concrete pouring is carried out in no more than 2 minutes 30 seconds after the mixing of mortar [20]. Pouring is attempted not far from the storage place for 24 hours. The storage area must be flat, rigid, and protected from vibration [16].

The mold can be opened when the concrete reaches the age of 24 ± 8 hours after molding. Concrete that has been hardened is to be immeresed in a tub containing clean water at a temperature of 23°C ± 1.7°C till the age of the concrete reaches the age of 28 days. The testing of the specimens follow [16] on the curing of concrete specimens for the compressive and the flexural strength test.

3.5. Compressive and Flexural Strength Testing

At this stage, after the specimen immersion, the specimen is to be dried by wiping its surface with a towel. The specimen must be tested in humid conditions. The permissible test time tolerance after the transfer from the immersion place for the age of 28 days is ± 20 hours. Subsequently, the specimen can be tested for compressive strength with a compression testing machine. The testing procedure is in accordance with [15]. The concrete compressive strength is obtained by dividing the value of maximum load with the cross-sectional area of the specimen as shown in Equation (2). Meanwhile, the flexural test is carried out by placing the beam on two supports. Then the beam is given a pressure with a concentrated load at two points in every one-third of the span in the middle of the beam. This testing procedure is stipulated in [17]. The concrete flexural strength is obtained from Equation (3).

4. Results and Discussion

4.1. Slump flow test results

The results of the slump flow test show that the obtained value of the slump flow is still within the required limits for the use of w/c 0.46. The addition of Plastiment-VZ to fresh concrete will produce a thicker fresh concrete texture that is relatively easier to mix than the normally aerated concrete. However, an excessive additonal amount of water will produce the value of mortar flow exceed the specified range. The results of the average slump flow test of fresh concrete; namely concrete without the addition of Plastiment-VZ or normally aerated concrete (NAC) is an average flow value of 111.42%; addition of 0.2% Plastiment-VZ is an average flow value of 112.20%; addition of 0.4% is an average flow value of 113.63%; and the addition of 0.6% is average flow value of 113.74%. The visual details of the test results can be seen in the Table 3.

Table 3. Average Slump Flow of Aerated Concrete

No	Variations	Dia. Base (mm)	Dia. mortar average (mm)	*Average Flow* %	Remarks
1	NAC	100	211.42	111.42	Met
2	AP-PL 0.2%	100	212.20	112.20	Met
1	AP-PL 0.4%	100	213.63	113.63	Met
2	AP-PL 0.6%	100	213.74	113.74	Met

Figure 1 shows that that the distribution value of fresh mortar increases along with the increase in Plastiment-VZ levels, as shown by the increasing trend of the graph. The range of slump *flow* values in terms of the normally aerated concrete and the three variations of the slump flow test has met the criteria for mortar flow as required in the [20], with the value of 110 ± 5%.

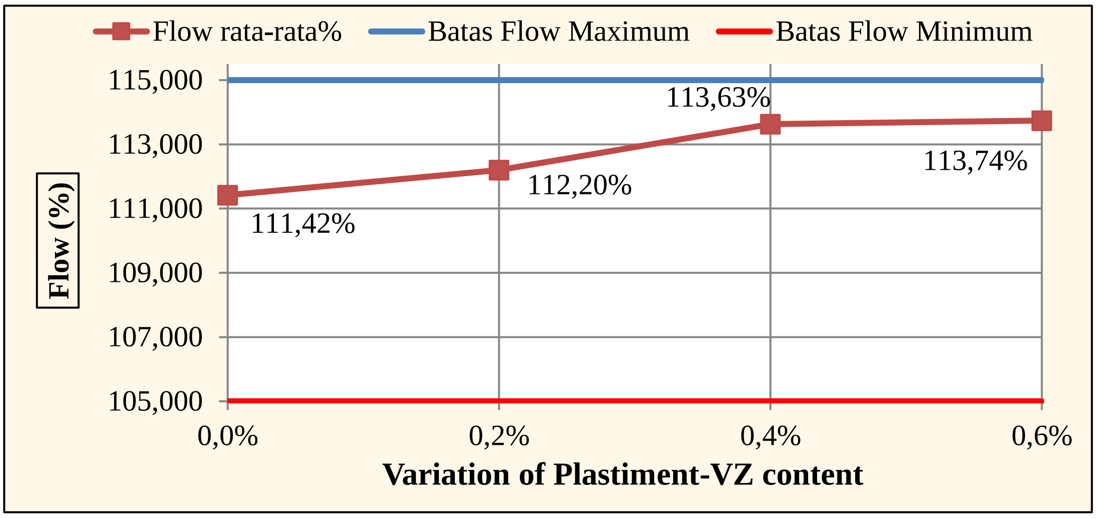

Fig 1. Slump flow chart

The difference in the flow values that are not far among variations is due to the presence of control over the adding of additional water at the variations of 0.2%; 0.4%; and 0.6% when the stirring was carried out; not adding additional water as a whole yields a flow value of 110 ± 5%. In other words, the quantity of additional water used in the variations of 0.2% to 0.6% was not the same and was not added as a whole during stirring. In contrast to the NAC variation (without Plastiment-VZ), the added water was stirred as a whole in the mortar mixture. The reduction of mixed water was due to the addition of Plastiment-VZ to the mixture, enabling to increase workability without increasing the amount of water. The average reduction of water used in the aerated concrete mixture with w/c of 0.46 for the variation of 0.2% was 30.45 g or 3.70% of the total mixed water; for the variation of 0.2% was 43.60 g or 5.30%; and for the variation of 0.6% is 64.49 g. or 7.85% by weight of the total mixed water. The average water reduction for each variations is shown in Table 4 and Figure 2. The largest of the average water reduction in the mixture occurred in the Plastiment-VZ 0.6% variation, which was 64.49 gr or 7.85% of the total weight of the mixed water. It may conclude that the mixed water is significantly reduced by the addition of the Plastiment-VZ in the fresh concrete.

Table 4. Average Water Reduction of Fresh Concrete

No	**Variations**	**Mixed water (gr)**	**Added water 15% (gr)**	**Unused water average (gr)**	**% Reduced water average**
1	NAC	717.00	107.55	0.00	0.00
2	AP-PL0.2%	716.14	107.42	30.45	3.70
3	AP-PL0.4%	715.28	107.29	43.60	5.30
4	AP-PL0.6%	714.42	107.16	64.49	7.85

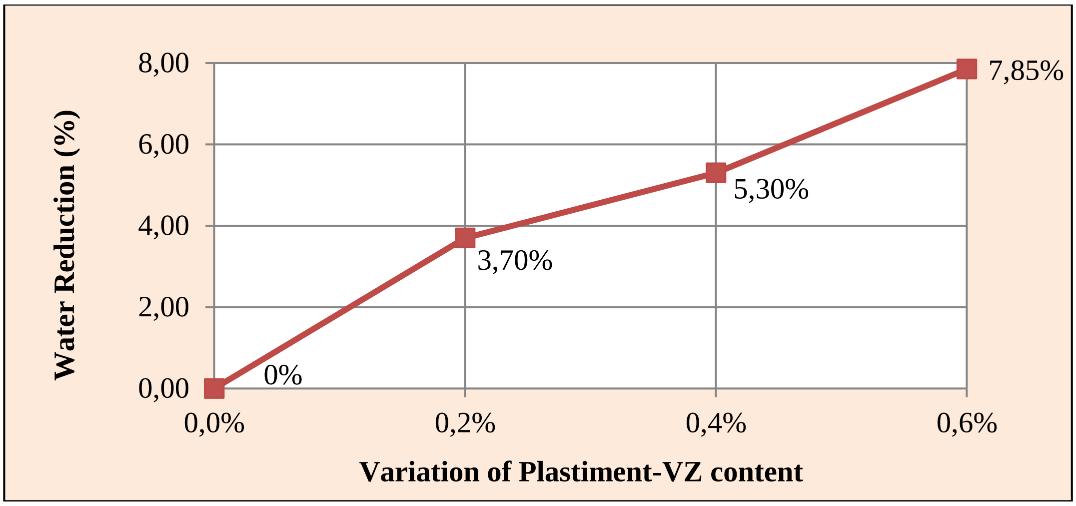

Fig 2. Water Reduction Chart

4.2. Density and Compressive Strength of Aerated Lightweight Concrete

Before the specimens is tested to obtain the compressive strength of the concretes, all the specimens are weighted to measure the density of each specimen. Based on the findings, all of the speciments were found to meet the requirements of the lightweight concrete properties (1140 kg/m3 to 1840 kg/m3) despite mixed with varying percentage of Plastiment-VZ. Meanwhile, the average density of the specimens is about 1771.86 1840 kg/m^3. The concrete compressive strength testing was then performed using the adopted method as elaborated in the previous section. The concrete compressive strength is a function of the working load and the cross-sectional area of a standard concrete specimen. In the testing method, the load is continuously applied untill the specimen is cracked or failled. The result of the density dan compressive strength is shown in Table 5 and Figure 3, respectively.

Table 5. Average Compressive Strength Result of Lightweight Aerated Concrete

No	Variations	Average weight of concrete (kg)	Density of concrete (kg/m^3)	Force (N)	Cross Section Area (mm^2)	Concrete Strength (MPa)
1	NAC	5.98	1771.85	142000.00	22500	6.31
2	AP-PL0.2%	6.03	1786.67	146666.67	22500	6.52
3	AP-PL0.4%	5.95	1762.96	153000.00	22500	6.80
4	AP-PL0.6%	5.96	1765.93	181000.00	22500	8.04

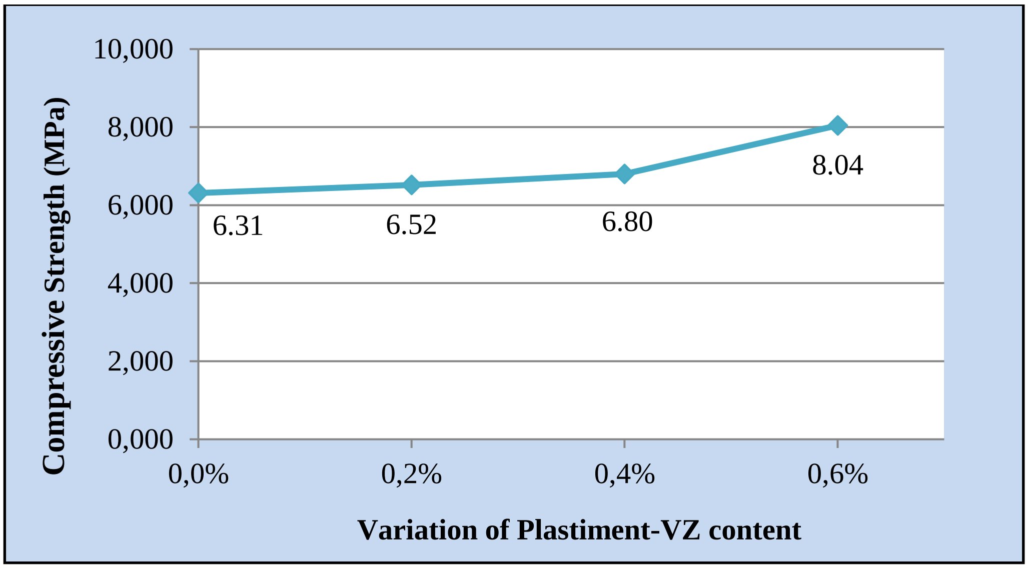

Fig 3. Compressive Strength of Aerated Lightweight Concrete

Based on the Figure 3, the maximum average compressive strength of concrete at 28 days with the addition of Plastiment-VZ is 8.04 MPa for the variation of added Plastiment-VZ 0.6% (AP-PL0.6%), while the minimum compressive strength is obtained at 6.31 MPa for the added Plastiment-VZ 0% (NAC). It was found that the usage of Plastiment-VZ in aerated lightweight concrete mixed with AP has a significant effect as it is able to increase the compressive strength of lightweight concrete, improve workability and reduce mixing water. The use of Plastiment-VZ was able to increase the compressive strength by 3.29%, 7.75%, and 27.46% against normal aerated lightweight concrete at each variations of 0.2% (AP-PL0.2%), 0.4%(AP-PL0.4%), and 0.6%(AP-PL0.6%) respectively. The compressive strength of the mix is greatly influenced by the addition of the Plastiment-VZ; showing a trend of increase in the compressive strength with the increment of Plastiment-VZ in the mix. From the overall results of the compressive strength test for each of variations, the designed compressive strength (f'cr) of 0.7-5 MPa has been reached. In addition, in the normal aerated concrete, the recommended Plastiment-VZ content is up to 0.6% of weight of cement. However, the lightweight concrete above has not found to reach the optimum variation of Plastiment-VZ use for aerated lightweight concrete that uses AP as an additional material of 0.0934% of the cement weight, because the graph has not shown any decline.

4.3. Flexural strength of lightweight aerated concrete

Concrete flexural strength test constitutes a comparison between the maximum flexural moment that a beam can withstand and the inersia of the cross section of the beam. Before being tested, the beam is removed from the immersion tub, dried with a towel till the surface is saturatedly dry, then the weight is measured and a bearing line is drawn on each side of the beam. From the results of the flexural strength test at the age of 28 days, it was found that the average flexural strength was 5.13 MPa for the NAC specimen, 5.55 MPa for AP-PL0.2% variation, 5.60 MPa for AP-PL0.4% variation, and 6.13 MPa for AP-PL0.6% variation. The maximum flexural strength was at 0.6% variation and the minimum flexural strength was at NAC variation as shown in Table 6**.** The relationship between the variations of the Plastiment-VZ and concrete flexural strength is shown in Figure 4

Table 6. Average Flexural Strength of Aerated Lightweight Concrete

No	Varia-tions	Average Concrete Weight (kg)	Average Concrete Density (kg)	Force (N)	Length (mm)	Width (mm)	Height (mm)	Flexural Strength (MPa)
1	NAC	22.16	1641.23	28866,67	600	150	150	5.13
2	0.20%	22.87	1694.32	31200.00	600	150	150	5.55
3	0.40%	22.95	1700.00	31500.00	600	150	150	5.60
4	0.60%	23.09	1710.62	34500.00	600	150	150	6.13

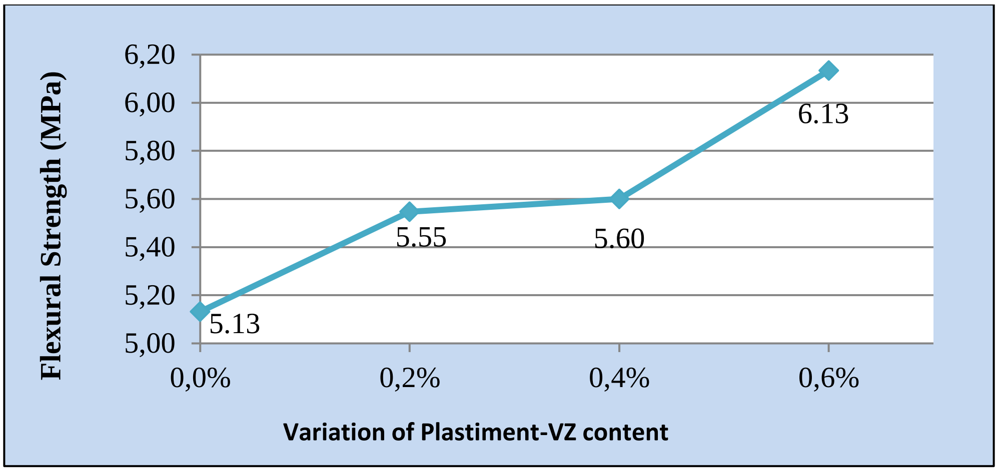

Fig 4. Flexural Strength of Aerated Lightweight Concrete

The calculation result of increase percentage in flexural strength of aerated lightweight concrete in Figure 4 shows that Plastiment-VZ is able to enhance the flexural strength of aerated lightweight concrete above NAC (normally aerated lightweight concrete). The flexural strength of the aerated lightweight concrete is found to be positively correlated with the addition of Plastiment-VZ; showing an increment of flexural stress with the addition of Plastiment-VZ in the mix.. The increase happened to reach 8.08%; 9.12% and 19.52% for each variations of 0.2%; 0.4% and 0.6% against normal aerated concrete (0%). In the flexural test, the entire specimens experienced fractures in the middle of the span after being subjected to lateral loads.

5. Conclusion

From the results of the research that has been carried out, it is found that the compressive strength of the light weight concrete with Pl-VZ has increased compare to normal aerated lightweight concrete. The increase that occurred was 3.29%; 7.75% and 27.46%. The maximum compressive strength was obtained in the 0.6% variation (AP-PL0.6%) with a value of 8.04 Mpa. Meanwhile, the compressive strength of normally aerated concrete (NAC) was 6.31 MPa. Similar to the compressive strength, the flexural strength test also experienced an increase in the flexural strength value in the variations of 0.2%; 0.4% and 0.6% for normal aerated lightweight concrete where the values are 8.08%; 9.12% and 19.52% consecutively. The highest flexural strength was obtained at a variation of 0.6% (AP-PL0.6%) at 6.13 MPa and the lowest was NAC (0%) at 5.13 MPa.

It can be concluded that the addition of Plastiment-VZ is able to increase the compressive strength and flexural strength of lightweight concrete that uses aluminium powder as an air bubble maker. The greater the level of addition of Plastiment-VZ is, the higher the compressive strength and flexural strength is obtained. However, the maximum level Plastiment-VZ that can be used for aerated concrete is not yet known because the graph is still increasing and has not shown any decrease. Besides having a good effect on inhancing the compressive strength and flexural strength of lightweight concrete, Plastiment-VZ is also able to improve workability and reduce mixing water up to 7.85% of the total weight of mixing water when using 0.6% Plastiment-VZ.

References

[1] K. Tjokrodimuljo, *Building Material*. Yogyakarta: Biro Publisher, 2017.

[2] and J. J. E. Pahlevi, Boby Dean, Triwulan, “Cement-Substitution Fly Ash and Lime (Ca(OH)2) for Lightweight Concrete Mixture Using Aluminium powder as an Expanding Material, Surabaya.,” 2013.

[3] C. W. Kusuma, “The Effect of Aluminium powder Addition Variation on Compressive Strength of Non-Sand Concrete with Gypsum Powder Added Material,” 2017.

[4] N. Allain-Bonasso, F. Wagner, S. Berbenni, and D. P. Field, “A study of the heterogeneity of plastic deformation in IF steel by EBSD,” *Mater. Sci. Eng. A*, 2012, doi: 10.1016/j.msea.2012.03.068.

[5] A. Teleman *et al.*, “Altered Growth and Cell Walls in a of Arabidopsis Fucose-Deficient Mutant,” *Plant Physiol.*, 2012, doi: 10.1104/pp.110.160051.

[6] S. . Megasari and W. Winayati, “An Analysis of Concrete Characteristics with the Combination of Plastiment-VZ and Sikament-NN Added Mate-rials on Rigid Pavement Works in Riau Provinc,” pp. 117–124, 2017, doi: 10.21063/spi3.1017.117-124.

[7] K. Muqtadi, “The Impact of Use and an Analysis of Sand-Substitute Styrofoam with Plastiment-VZ Added Materials Effect on the Value of Concrete Compressive Strength,” *J. Tek. Sipil dan Lingkung.*, vol. 2, no. 2, 2014.

[8] M. D. M Mohammadi, AA Shirzadi Javid, “Introducing a Method to Determine Nonautoclaved Aerated Concrete Air Content Based on Packing Theory,” *J. Mater. Civ. Eng.*, vol. 30, no. 3, 2018.

[9] 2013 SNI 2847:2013, “Structural Concrete Requirements for Buildings,” Jakarta, 2013.

[10] 2012 SNI-7656-2012, “Procedure for Selection of Mixtures for Normal Concrete, Heavy Concrete and Mass Concrete,” Jakarta, 2012.

[11] C. Technology, *Concrete Technology*. Yogyakarta: ANDI Publisher, 2004.

[12] P. S. Indonesia, “Plastimen-VZ. Version 01.01.,” 2018. .

[13] Zhanqiu Metallic Pigment Co Ltd., “Aluminium powder/Paste for AAC. Version 2018,” 2018. .

[14] SNI 03-6825-2002, “The method of testing the compressive strength of Portland cement mortar for civil works,” 2002.

[15] SNI 1974-2011, 2011, “The Method of Testing a Concrete Compressive Strength with Cylindrical Test Object,” Jakarta, 2011.

[16] 2011 SNI-2493-2011, “The Procedure for Manufacturing and Treating Concrete Test Objects in the Laboratory,” Jakarta, 2011.

[17] 2011 SNI-4431-2011, “How to Test Normal Concrete Flexural Strength with Two Loading Points,” Jakarta, 2011.

[18] ASTM C305, “Standard Practice for Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency,” *ASTM lnternational*, pp. 1–3, 2011.

[19] ASTM, “Standard Test Method for Compressive Strength of Hydraulic Cement Mortars,” *ASTM C 1437-0*, 2007.

[20] ASTM, “Standard Test Method for Flow of Hydraulic Cement Mortar,” *ASTM C 109 M*, 2013.