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The Effectiveness of Added *Admixture Additon Superfluid L* with the Reduction of Cement and Water Contents on Concrete Characteristics

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ABSTRACT

Concrete is a complex-composite material. Semen Portland or other hydraulic types of cements, fine aggregates, coarse aggregates, and water, with or without additional substance, are the major materials in making concretes. In this time, the concrete cost more expensive, despite of many infrastructure development that caused higher concretes demand, the increased of concretes cost also caused by the cements high-price as a result of higher PPN value 11% for cement production cost. Cement is highly affected the concrete cost, it is because cement is the major material in forming the concrete that is more expensive than other types of materials. Therefore, it is important to reduce the cement content to press the cost of concrete. This study done by utilizing the variation of added admixture additon superfluid L to reduce the use of cement and water contents by using trial and test method, and slump that was planned 10±2 cm. The reduction of cement for about 5% and 10% from the total weight of cement also there are 4 added variation of content of admixture additon superfluid L, they are 0.5%, 1.0%, 1.5%, dan 2.0% from the cement weight with FAS still about 0,5. According to the test of concrete characteristics such as compressive strength testing, porocity testing, and elastic modulus testing, generally by having more PSA and admixture additon superfluid L, the quality of concrete getting lower from the view of compressive strenght, porocity,or even elastic modulus. There was concrete mixture configuration while it was 28 days, the most effective variation of reduction cement and water content, also the added admixture additon superfluid L 0,5% that possess compressive strenght value around 26,328 MPa ; porocity value around 11,11% ; elastic modulus value about 21950,49 MPa and poisson rasio value around 0,21179.

Key Words: *water content; cement content; admixture; concrete characteristics.*

INTRODUCTION

The infrastructure development in Indonesia has been more intensively handled by the government, almost the whole part of construction area. Infrastructure development cannot be separated by an essential component called concrete. Concrete is a complex-composite material [1]. Semen *Portland* or other hydraulic types of cements, fine aggregates, coarse aggregates, and water, with or without additional substance, are the major materials in making concretes [2]. Moreover, in formulating the mixture that can be inserted in the mold and be desirably molded, some concrete-forming materials were entirely mixed by specific contexture. If this combination were slighted until it became hardened, it will happen due to long chemical processes in which cements and water were involved, or, in other words, the concrete mixture will be hardened over the times [3]. Nowadays, concrete becomes the mostly used material because of its strength, desirably formed, economic treatment, easily used compare to the other construction materials, even it is durable and resistant to weather or fire [4].

In this time, the concrete cost more expensive, despite of many infrastructure development that caused higher concretes demand, the increased of concretes cost also caused by the cements high-price as a result of higher PPN value 11% for cement production cost [5]. That condition automatically makes the concrete production cost in *batching plant* becomes higher and made the owner of *batching plant* looks for some solutions to reduce the cements need, so that it can cut down the concrete production cost. Then, in keeping the *water cement factor* that possess significant effect on the caliber and quality of produced concrete, it needs to minimalize and keep the contents of water and cements [6]. Beside to keep the *water cement factor*, the reduction of water content was intended to decrease the problem of bledding and *segregation*. In making the less of water needs, keeping the concrete *workability* is a must, so that concrete still can be processed easily during the moulding. Regarding the explanation that has been previously mentioned, it is important to do a study for solving those problems by adding *admixture (superplasticizer)* in the concrete mixture. Admixture addition superfluid L is kind of superplacticizer type F that used for additional chemical subtances in concrete mixture to reduce the cements and water needs, still by watching the strenght and *workability* of concrete. *Admixture additon superfluid L* possesses some advantages as follows; increasing the greater workability than normal *plasticizer*, considering as a concrete with low cement water factors, considering as concrete with maximal 15% of cement needs, and reducing maximal 40% of water needs. The use of *superplasticizer* intended to change or increase the concrete's quality to become more suitable with the specific demand and job, for instance accelerate and postpone the setting, make the work capability becomes possible and increase compressive strenght[7].

This study aimed to know the effectiveness of added *admixture additon superfluid L* on 28 days of concrete's characteristics in reducing the use of cement and water contents.

METHODOLOGY

This study applied an experimental research method by employing some steps as follows:

Material

This study used material namely Cement PCC type 1 merk Semen Gresik, whereas the water came from PDAM, grit from Lumajang as fine aggregates, crushed rock from Mojokerto as coarse aggregates, and *admixture additon superfluid L* from PT. Additon Karya Sembada.

Material Analysis

There were two kinds of materials analysis, fine and coarse aggregates. Then, the analysis of materials themselves did by following the ASTM standards as the followings:

Table 1: ASTM Table of Materials Testing

Material Analysis	Material Type	
	Fine Aggregate	Coarse Aggregate
Included humidity test	ASTM C 556 – 89	ASTM C 556 - 89
Inflirtation of water test	ASTM C 128 - 93	ASTM C 128 - 93
Volume weight test	ASTM C 29/ C 29M - 91	ASTM C 29/ C 29M - 91a
Specific gravity test	ASTM C 128 - 78	ASTM 127 – 88 - 93
Mud rate test	ASTM C 117	-
Organic material rate test	ASTM C 40 - 92	-
Sieved analysis	ASTM C 136-95a	ASTM C 136-95a

The Plant of *Job Mix Design*
Job Mix Design was planned by applying *Department of Environment* (DoE) method in which it fits the SNI 03-2834-2000 [8].

The Trial of Concrete's Mixture
The *trial* of concrete's mixture is a process in making the concrete based on the calculated value that was previously taken *(Job Mix Design)* that aims to know the suitability between the result of normal concrete *slump* with *slump* value on concrete *mix design*. In the *trial* of concrete mixture, this study used ASTM 192 - 90a.

The Admixture of Wet Concrete
In the process of wet concrete admixture, this study applied the rules of ASTM 192 - 90a.

Concrete Slump Test
The *slump* value for normal concrete used 10 ± 2cm. This study also applied the rules of ASTM 143 - 90a specifically for concrete *slump* test [9].

Produce Cylinder Concrete Specimen
There are 63 test specimens used in this study, with the spesification of 45 cylinders size 15 x 30 cm and 18 cylinders size 10 x 20 cm. There are 9 various of the mixtures, such as: normal concrete without the reduction of water and cement, also added *admixture*; concrete with 5% PSA variation and added 0.5%, 1.0%, 1.5%, 2.0% of *admixture additon superfluid L*; also concrete with 10% PSA variation and added 0.5% , 1.0% , 1.5% , 2.0% of *admixture additon superfluid L*. Each modification did the test 3 times, they are the test of compressive strenght of three test specimens, the porosity of two test specimens, and elastic modulus ot two test specimens.

Maintenance of Test Specimen
The aim of *curing* is to produce concrete that has strenght and characteristics established by mix design [10]. This technique referred to the SNI standard 2493:2011 [11].

Testing Hard Concrete
The testing of hard concrete can be done by using several tests such as compressive strenght of concrete, porocity concrete test, and elastic modulus concrete test.
a. Compressive Strenght of Concrete
The testing for compressive strenght concrete used the rules of ASTM C 39-94
This following formula was applied to determine the compressive strenght of concrete: [12]

$$f'c = \frac{P}{A} \tag{1}$$

Notes:
f'c = Compressive strenght of concrete (N/mm²)
P = Maximum load (N)
A = Surface area of cylinder test specimen (mm²)

b. Porocity of Concrete
The testing of concrete porocity used the rules of ASTM C 642 - 06
There was the formula used to calculate the concrete porocity: [13]

$$\text{Porocity} = \frac{B-C}{B-A} x100\% \quad (2)$$

Notes:
A = The sample weight under water (gram)
B = The sample weight in SSD condition (gram)
C = The sample weight dry oven (gram)

c. Elastic Modulus Concrete
The testing of elastic modulus concrete used the rules of ASTM C 469 - 02
This following formula was used to calculate the elastic modulus concetrate: [14]

$$Ec = \frac{S_2 - S_1}{\varepsilon_2 - \varepsilon_1} \quad (3)$$

Notes:
Ec = Elastic modulus concrete (MPa)
S_1 = The stress while the strain of curve value is ε_1 (MPa)
S_2 = The stress in elastic load (MPa)
ε_1 = Strain of 0.00005 (m^3)
ε_2 = Strain in $P_{elastic}$

RESULT AND DISCUSSION

This following information is the test result and analysis that had been done to determine parameter of the study about the effectivenes of *admixture additon superfluid L* on compressive strenght, porocity, and elastic modulus concrete by reducing the contents of water and cement.

Material Testing

To know the distribution of particle size both fine and croase aggregates, the material testing was conducted by using grain as fine aggregates and crushed rock as croase aggregates. This test included humidity, inflirtation of water, volume weight test, specific gravity test, mud rate, organic material rate, and filtered analysis. Table 1 shows the result of material testing:

Table 2: Results of Fine Aggregate and Coarse Aggregate Material Tests

Material Test	**Fine Aggregate**	**Coarse Aggregate**	**Results**
Specific gravity test (gr/cm³)	2.67	2.80	Comply
Included humidity test (%)	2.68	1.73	Comply
Inflirtation of water test (%)	1.29	1.09	Comply
Volume weight test (kg/m³)	1358.2	1484.3	Comply
Organic material rate test (Color)	Yellowish clear	-	Comply
Mud rate test (%)	1.30	-	Comply

The results of the sieving analysis can be presented in Figures 1 and 2.

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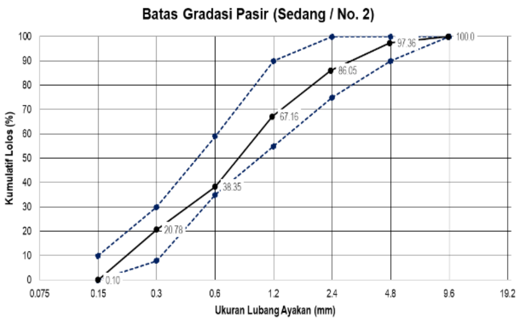

Figure 1: Graph of Fine Aggregate Sieve Analysis

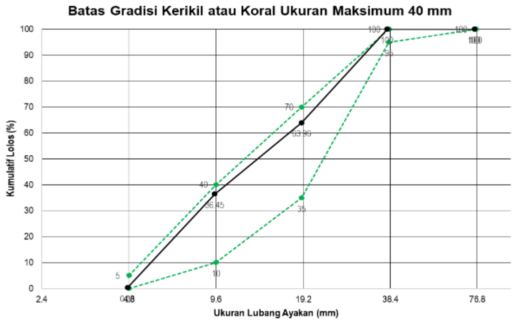

Figure 2: Graph of Coarse Aggregate Sieve Analysis

Job Mix Design

After the material testing, than the calculation of *job mix design* was implemented to know the contexture of concrete by using *Department of Environment* (DoE) technique with determined cement-water factor for about 0,4. Table 2 shows the result of *job mix design*:

Table 3: Job Mix Design Calculation Results

	Concrete Variations	Water (kg)	Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)
Composition 1 mix	Normal	7.02	15.13	21.25	39.17
	PSA 5%	6.67	14.37	21.25	39.17
	PSA 10%	6.32	13.62	21.25	39.17

From the table above, the result of various amount on the used of *admixture additon superfluid L* from the weight of normal cement, for instance: the content of 0.5 % was 0.065 liter; content of 1.0 % was 0.129 liter; content of 1.5 % was 0.194 liter; and content of 2.0 % was 0.259 liter.

Concetrate Slump Test

After having the mixture based on *job mix design*, than the process of wet concrete slump test was conducted. Slump testing aims to know the *workability* (workability during the production process) form the concrete mixture and achieve homogen water-used [15]. The result of wet concrete slump test provided in the figure 5:

Figure 3: Concrete Slump Test Process

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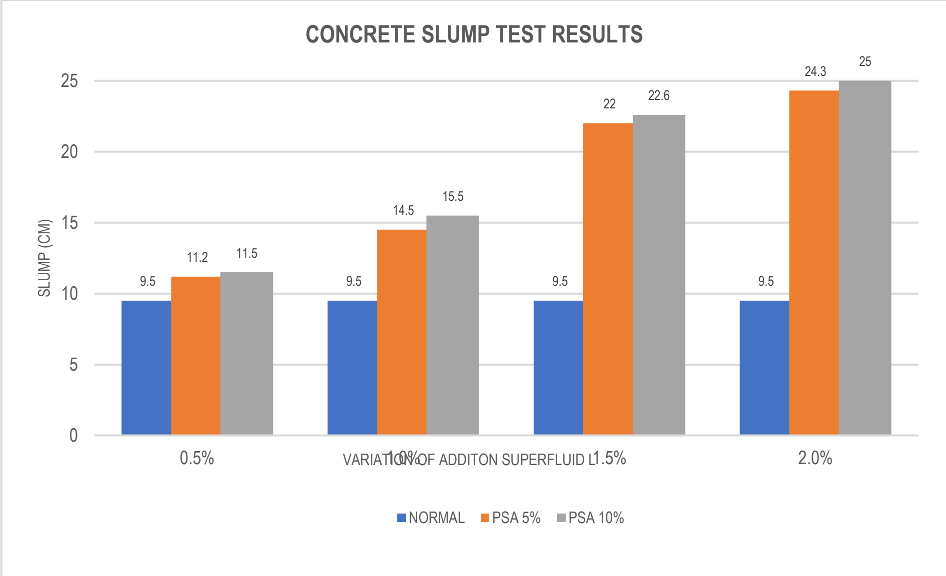

Figure 4: Concrete Slump Test Results

Based on the slump test result as shown in the graphic above, it can be seen that the slump value in concrete had increased in each percentage of PSA and admixture additon superfluid L, that case was caused by the added admixture that possess a liquid properties or makes the concrete admixture liquid even more watery. As a result of a higher slump value, the workability of concrete also increased so that it can make the concrete inserted to the mold.

Compressive Strenght Testing

This testing was conducted after the concetrate were about 28 days and already had curing process. The result of compressive strenght testing was reported in the table 4.


Figure 5: Concrete Compressive Strength Testing Process

Table 4: Concrete Compressive Strength Test Results

Variations of PSA	Rate of Additon Superfluid L (%)	Compressive Strength (Mpa)			Average (Mpa)
		1	2	3	
Normal	0	24.905	27.798	24.673	25.792
5%	0.5	24.843	30.884	23.258	26.328
	1.0	22.929	26.893	27.176	25.666
	1.5	18.332	24.090	28.223	23.548
	2.0	15.496	15.796	22.567	17.953

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10%	0.5	25.087	23.864	24.911	24.620
	1.0	20.608	24.345	28.308	24.420
	1.5	20.393	20.976	27.227	22.865
	2.0	13.078	16.673	21.848	17.200

The graph showing the compressive strength test results of concrete is shown in Figure 6 and can be used to interpret the data from Table 4:

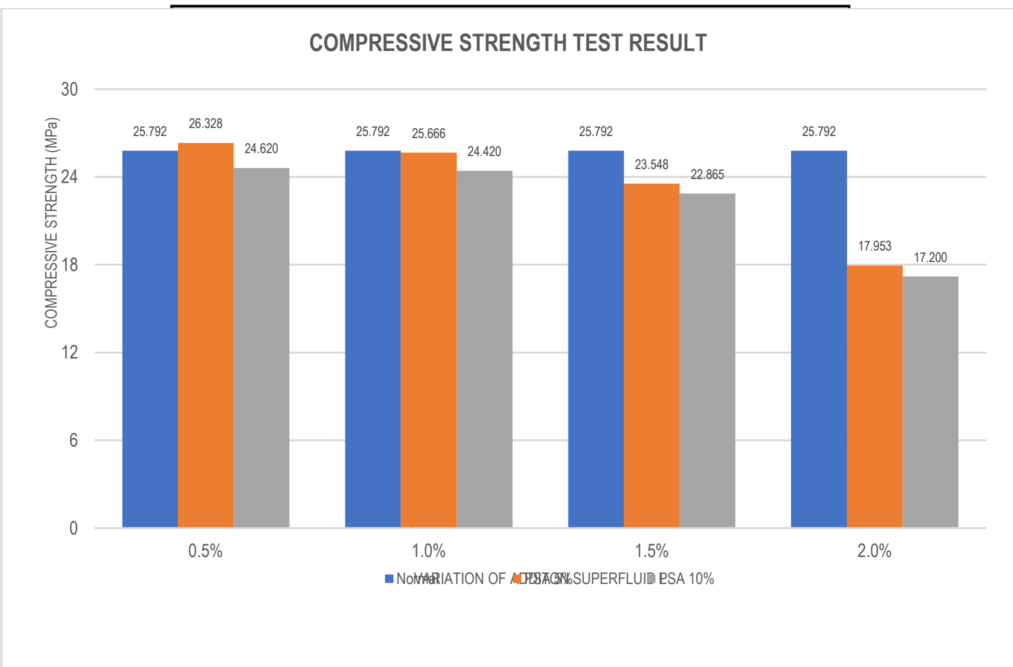

Figure 6: Concrete Compressive Strength Test Results

It can be concluded that the result of compressive strenght testing had derivation in each various reduction of cement and water, also the added *admixture additon superfluid L*. The added *admixture additon superfluid L* in the mixture of concrete has possitive effect on the concrete itself, whereas the concrete slump value getting bigger, in other words, the concrete workability become better, however, the reduction of cement and water has negative effect on the concrete in which compressive strenght concentrate became lower. This situation caused by the reduction of cement and water that affect the pasta in concetrate mixture became lower, and finally leave many cavities or the concrete had a bigger porocity and make compressive strenght concetrate became lower. Therefore, it was suggested to add *admixture additon superfluid L* without the reduction of pasta in concrete mixture, because *admixture additon superfluid L* will be optimally increased the compressive strenght concrete if working together with suitable pasta. Furthermore, the result of this study was where the added *admixture additon superfluid L* only can increase the concrete workability, Indeed it could not optimally increase compressive strenght concrete because concrete porocity getting bigger as an effect of the less pasta.

Concrete Porocity Testing

Porocity Testing was conducted after the concerete soaked for about 28 days. After having a *curing* process, the test specimen was pondered while it was under water, after it was in the oven, and while it was in SSD condition. The result of porocity testing can be seen in the figure 8:

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Figure 7: Concrete Porosity Testing Process

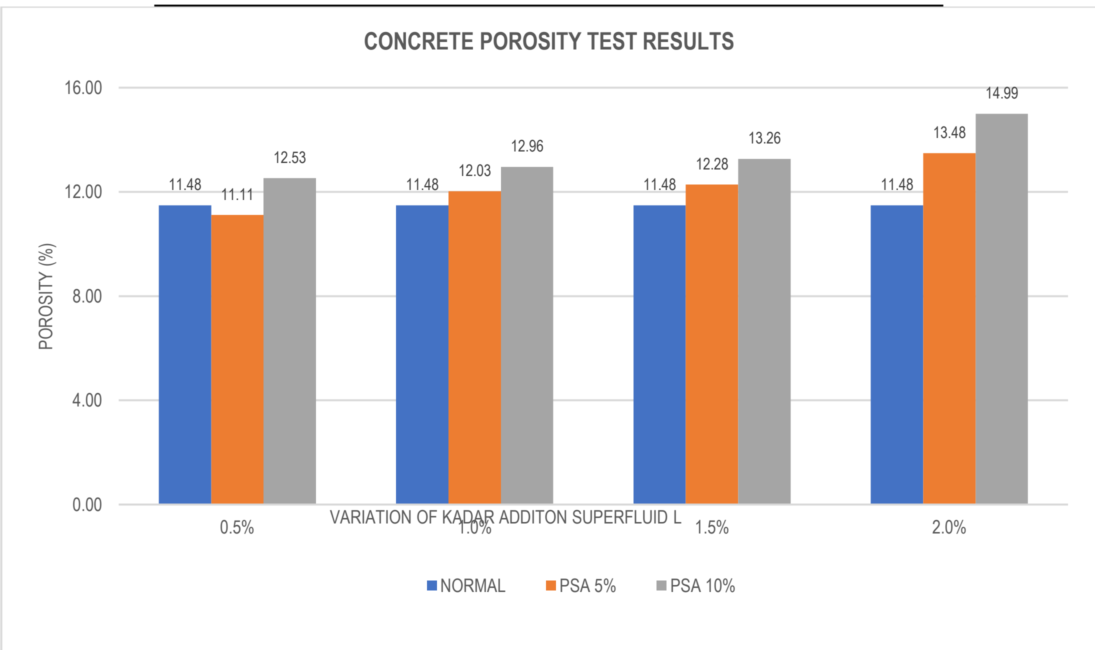

Figure 8: Concrete Porosity Test Results

It can be concluded that the more PSA percentage and the more added *admixture additon superfluid L* increase the concetrate porosity value. Porosity happened because a lack of pasta that caused by the process of the reduction of cements and water in which it caused the cavity in concetrate.

Elastic Modulus Concrete Testing

Figure 9: Concrete Elasticity Modulus Testing Process

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Elastic modulus test results can be presented in table 5:

Table 5: Modulus of Elasticity Test Results

Variatios of PSA	Rate of Additon Superfluid L (%)	Elastic Modulus (Mpa)
0%	0	21027.25
5%	0.5	21950.49
	1	20499.14
	1.5	18540.39
	2	16337.05
10%	0.5	19976.25
	1	19496.36
	1.5	17723.96
	2	16154.34

The elastic modulus graph in Figure 10 is the result of testing the elastic modulus from table 5:

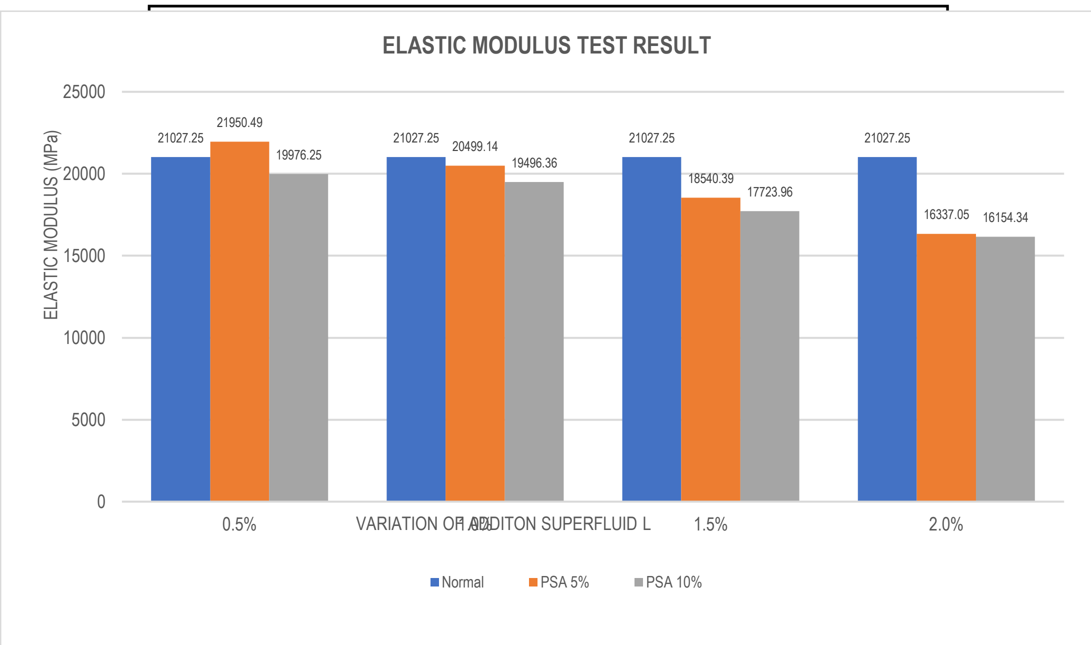

Figure 10: Elastic Modulus Test Results

It can be said that the more PSA percentage, the more added *admixture additon superfluid L* is, indeed the elastic modulus concrete value become lower.

The Calculation of *Poisson Ratio*

The relation between axial strain and lateral strain known from the data for the change of longitudinal/axial lenght and direction (L) and the change of lateral/axsial direction (r) [16]. By using the fitur of linier regresion analysis in *Microsoft Excel* program to reage the double point of axsial-lateral strain to the x and y-axis, the axsial and lateral strain curve can be formed. Then, the value of poisson ratio can be determined by using function equation from regresion equation. Table 6 showed the calculation of *poisson ratio*:

Table 6: Calculation Results of Concrete Poisson Ratio Value

Variation of PSA	**Rate of Additon Superfluid L (%)**	***Poisson Ratio***
0%	0	0.21840
5%	0.5	0.21179
	1	0.22112
	1.5	0.23596
	2	0.24282
10%	0.5	0.22727
	1	0.23086
	1.5	0.23919
	2	0.24534

According to the table 6, it clearly stated that the result of *poisson ratio* was contradictory with the result of elastic modulus concrete, where the value of elastic modulus concrete become bigger, the value of *poisson ratio* become lower.

CONCLUSION

The result of this study showed that concrete had lower quality with the growing reduction percentage of cement and water (PSA), and added admixture additon superfluid L. In this case, it can be known from the result of compressive strenght and elastic modulus concrete that become lower, while the result of porocity testing become higher. Therefore, for knowing the effectiveness of admixture additon superfluid L, it did not need to reduce the cement or water. Moreover, doing the substitution of cement and water reduction with suitable material as the glue between aggregates inside concrete. For the variation of concrete mixture, the most effective one is concrete with PSA 5% and admixture additon superfluid L 0.5%.

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