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The Compressive Strength Of Fly Ash Foamed Concrete With Polypropylene Fiber

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Abstract—Lightweight concrete is widely used for various structural applications because its lighter than normal concrete. Foamed concrete is made to produce low-density concrete by introducing air bubbles or foam into it. In the presence of air bubbles, the density of concrete only reaches 300-1700 kg/m^3 [1]. The addition of fly ash can reduce the pores that cause the entry of acids. In addition, the modulus of elasticity in the polypropylene fiber mixture prevents cracked so it can make foamed concrete more ductile than foamed concrete without fibers and can make concrete stronger. The manufacture of foamed concrete specimens was planned by the SNI Module 3 specifications [4] and was equipped with ASTM [2], [3]. The foaming agent content in foamed concrete was 0.8 % where the polypropylene fiber variations are 0 %, 0.15 %, 0.2 %, and 0.3 % with 25 % fly ash as a cement substitute. The compressive strength test results show that the addition of fibers to foamed concrete increases the compressive strength of concrete where the maximum compressive strength produced by foamed concrete with polypropylene fibers is 0.3% and the lowest compressive strength is produced by foamed concrete without fibers.

Keywords—Foamed Concrete, Polypropylene Fiber, Foaming Agent, Fly Ash, Compressive Strength.

I. Introduction

Foamed concrete is a type of lightweight concrete and includes cellular concrete. Foamed concrete is made to produce low-density concrete by inserting air bubbles or foam into it. The air bubbles that are introduced into the concrete come from a hydrolyzed protein-based material or soap resin called a foaming agent.

In general, foamed concrete has a maximum compressive strength of 15 MPa because the use of foamed concrete is still aimed at non-structural concrete only. Many innovations in foamed concrete technology are being developed, one of which is the addition of natural waste and fiber to concrete. Fly ash is solid waste that is generated from burning coal. Currently, coal fly ash is used in cement factories as a mixture for concrete. In addition, one of the uses or benefits of fly ash is as a cement raw material.

II. Literature Review

2.1 *Foamed Concrete*

Foamed concrete is lightweight concrete containing approximately 20% foam bubbles in the concrete mix [6]. Foamed concrete does not contain coarse aggregates, only fine sand, and is very lightweight. Foamed concrete material consists of cement, water, and foaming agent, so it has an air content of more than 25% which distinguishes it from the air content in air-entrained concrete. The basic ingredients of foamed concrete are a blend of sand, cement, water, and a foaming agent with protein or synthetic ingredients [1].

2.2 *Fly Ash*

Fly ash is an additive that is quite popular today to be used as a substitute for some cement in the mixture. Fly ash is a waste material from burning coal. The use of fly ash as an additive in concrete mixes and cement mixtures has been around since the 1930s.

The definition of fly ash as a pozzolanic material is a material containing silica or silica + alumina compounds independently, with very little or no binding ability (non-cementitious) in a very fine form that can react with calcium hydroxide to form a material that has binding properties (cementitious).

2.3 *Foaming Agent*

The foaming agent is also defined as an air-entraining agent. An Air entraining agent is an organic material. When a foaming agent is added to water it will produce hollow bubbles in the cement paste mixture. The properties of foamed concrete are highly dependent on the quality of the foam. Protein foam weights about 80 gr/L. The protein-based foaming agent is derived from animal protein from horns, blood, bones of cattle, pigs, and other remains of animal carcasses. Synthetic foam has a density of about 40 gr/L. The synthetic foaming agent is a purely chemical product, very stable at concrete densities above 1000 kg/m^3, and provides good strength. Shelf life is about 1 year in sealed condition. Synthetic foam has a finer bubble size compared to protein but generally gives lower strength to foamed concrete, especially at specific gravity below 1,000 kg/m^3 [5].

2.4 *Fresh Mortar Testing*

2.4.1 Slump Test

The slump test is used to determine the consistency or stiffness of the fresh concrete mix to determine the level of workability of concrete. The stiffness in a concrete mix indicates how much water is used. The slump test aims to determine whether the concrete mixture is deficient, excess, or sufficient in water.

2.4.2 Setting Time

The setting time is also known as the initial setting time in fresh concrete testing. Bonding time is the time it takes for concrete to start in a plastic state, easy to form and work with until the concrete becomes non-plastic. The purpose of this test is when the concrete begins to bind so that after that time has passed, the concrete must not be disturbed again or change its position again.

2.5 *Compressive Strength Test*

Compressive strength is the ability of concrete to accept compressive forces per unit area. The compressive strength test is carried out to determine the strength of the concrete that is expected to result in as planned. Testing the compressive strength of cylindrical specimens is guided by the ASTM C 39-03 standard 'Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens' [3].

$$f_c' = \frac{P}{A} \qquad (1)$$

where FC is the compressive strength (MPa), *P* is the maximum load (failure load) applied to the specimen (N), and *A* is the cross-sectional area of the specimen resisting the load (mm^2).

III. Methodology

This research was conducted at the Concrete and Materials Laboratory, Department of Civil Engineering, Faculty of Engineering, Sriwijaya University. The test specimens are cylinders of 100 x 200 mm. Variations of polypropylene fibers are 0.15, 0.2, and 0.3% with 25 % fly ash as a cement substitute, the ratio of the binder: fine aggregate: water is 1: 1.5: 0.45.

The materials used in this study consisted of fly ash from PLTU Tanjung Enim, South Sumatera, fine aggregate from Tanjung Raja, foaming agent, and polypropylene fiber. The tools used are cylinder and block molds, concrete mixer for mixing concrete mix, Abrams cone for testing the slump of fresh concrete, Vicat apparatus for testing the setting time, and Universal Machine Test for testing the compressive strength and flexural strength of the test object.

Table I. The proportion of the mixture of heavy concrete and foamed concrete.

Sample	Foaming Agent (%)	Polypropylene Fiber (%)	Binder		Sand (%)	Water Ratio (%)
			Portland Cement (%)	*Fly Ash* 25 % (%)		
N	0	0	25,42	8,48	50,85	15,25
NP - 0,15	0	0,15	25,42	8,48	50,85	15,25
NP - 0,2	0	0,2	25,42	8,48	50,85	15,25
NP - 0 ,3	0	0,3	25,42	8,48	50,85	15,25
NF	0,8	0	25,42	8,48	50,85	15,25
NFP - 0,15	0,8	0,15	25,42	8,48	50,85	15,25
NFP - 0,2	0,8	0,2	25,42	8,48	50,85	15,25
NFP - 0,3	0,8	0,3	25,42	8,48	50,85	15,25

Material testing includes testing the physical properties of fine aggregates and testing the analysis of chemical compounds of fly ash. Before the mixing work is carried out, all materials are weighed according to the proportions. Put the cement, fly ash, and sand into the mixer, then add the water. When the mixture is homogeneous, enter the polypropylene fiber into the mixer. Stirring when the fiber is inserted about 3-5 minutes.

While waiting for a homogeneous mixture, foam is made with a mixture of foaming agents and water. Then the foam that has been finished is mixed with the mixture and then again stirred in the mixing bath for about 2-4 minutes. If it looks mixed evenly then the stirring is complete and ready to be put into the mold

Fresh mortar tests carried out are setting time and slump test. Setting time is the binding time of the cement mixture with water when the mixture is still fresh until it becomes rigid. The initial setting time of cement was tested by using a 1 mm diameter Vicat needle that penetrated the cement paste as deep as 25 mm at 30 seconds after the needle was released. According to the ASTM C-191 standard, the initial setting time should not be less than 45 minutes, and the final setting time should not be more than 375 minutes [2].

Fresh concrete mix as soon as possible is introduced into the Abrams cone gradually, as many as 3 layers with the same height. Each layer was compacted by stabbed by dropping freely, carried out 25 times for each layer. Then slowly lift the Abrams cone. Then the height of the drop is measured against the top of the Abrams cone.

The compressive strength test of foamed concrete is carried out using the Universal Testing Machine. For testing the flexural strength of foamed concrete, it is carried out using the Universal Testing Machine and reading data on the value of flexural strength and deflection using a data logger available in the laboratory. Before the test object is tested, the weight of the test object is weighed first to get the weight of the test object.

IV. Result

The results of testing the chemical compound fly ash as a mortar material. The results of the fly ash test showed that the type of fly ash was class F with $SiO2 + Al2O3 + Fe2O3 = 87.54\%$ with CaO content = 3.75%.The results of testing the chemical compound fly ash as a mortar material. The results of the fly ash test showed that the type of fly ash was class F with $SiO2 + Al2O3 + Fe2O3 = 87.54\%$ with CaO content = 3.75%.

Table II. The slump test results have different values for each composition.

Sample	***Slump Test* (cm)**
N	8,20
NP - 0,15	7,80
NP - 0,20	6,70
NP - 0,30	5,15
NF	12,65
NFP - 0,15	11,40
NFP - 0,20	10,70
NTFP - 0,30	10,05

The results of the slump test can be seen that the role of the foaming agent in the concrete mixture affects the slump value. And the more polypropylene fiber content can reduce the slump value of a mixture

Table III. The results of the setting time test with various variations of the test object.

Sample	***Initial Setting* (waktu pengikatan awal) (menit)**	***Final Setting* (waktu pengikatan akhir) (menit)**
N	75	120
NP - 0,15	70	115
NP - 0,2	65	110
NP - 0 ,3	60	105
NF	105	180
NFP - 0,15	90	175
NFP - 0,2	90	170
NTFP - 0,3	85	160

The setting time test results show that the addition of foaming agent into the mixture makes the concrete setting time longer, and the greater the polypropylene fiber content, the faster the required bonding time.

Table IV. The results of testing the specific gravity of concrete.

Sample	**Spesific Gravity (kg/m^3)**			
	7 days	**14 days**	**21 days**	**28 days**
N	1980	2020	2040	2050
NP - 0.15	2130	2140	2160	2180

NP - 0.2	2200	2210	2220	2220
NP - 0.3	2250	2260	2240	2250
NF	1650	1630	1630	1640
NFP - 0.15	1660	1640	1650	1660
NFP - 0.2	1680	1690	1650	1660
NFP - 0.3	1720	1710	1700	1710

The table above shows that the lightest specific gravity is foamed concrete, due to the effect of adding a foaming agent to produce concrete with a light density.

The results of testing the compressive strength of concrete without a foaming agent and foamed concrete with variations of polypropylene fiber for 7, 14, 21, and 28 days.

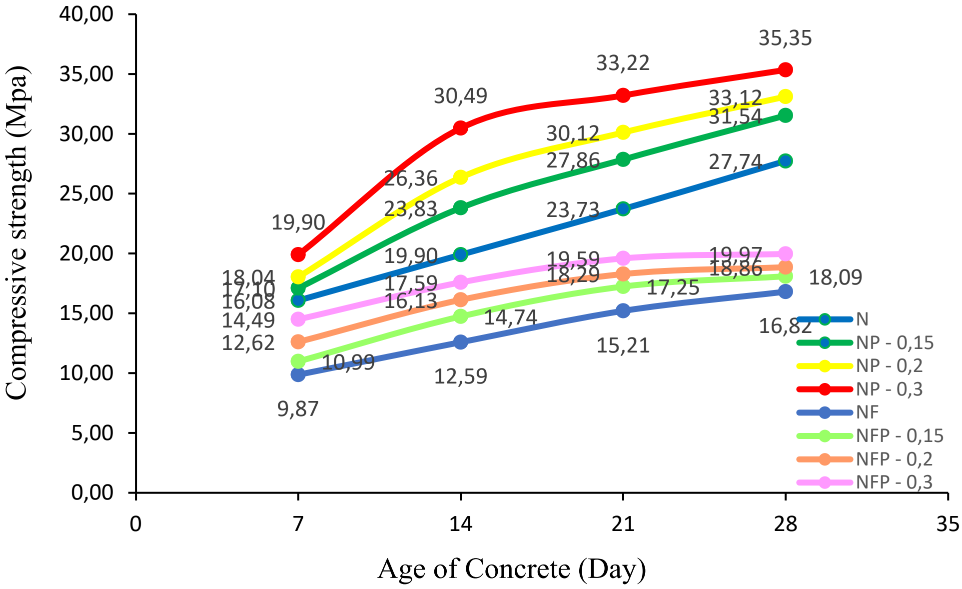

Fig. 1. Relationship of compressive strength with the age of concrete

Based on the results of the compressive strength test, it can be seen that the composition of NP - 0.3 is concrete with 0.3% polypropylene fiber, producing a compressive strength of 35.35 MPa at 28 days. Compared to N, which is concrete without fiber, the compressive strength at the age of 28 days is 33.12 MPa. Thus, it is concluded that the increasing percentage of polypropylene fiber in the mixture can increase the compressive strength of concrete.

The relationship of the compressive strength test of concrete without foaming agent and foamed concrete aged 28 days with variations in the percentage of polypropylene fibers.

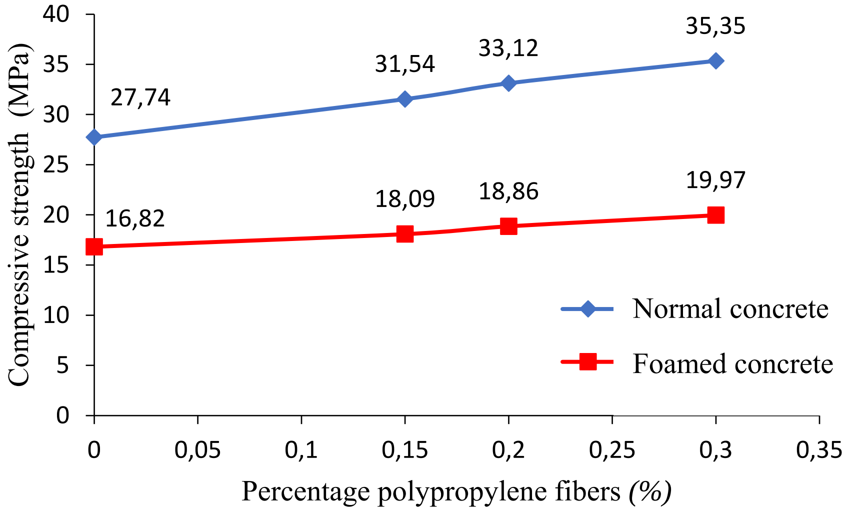

Fig. 2. Relationship of compressive strength with percentage polypropylene fibers

At 0.15% fiber variation, the compressive strength of foamed concrete is 18.09 MPa, which is greater than that of foamed concrete without fiber, which is 16.82 MPa. With this, it can be concluded that as the percentage of fiber increases, the compressive strength of concrete without a foaming agent and foamed concrete increases.

The results of the specific gravity test obtained from the weight versus volume of the compressive strength test object which produces a graph of the relationship between the compressive strength of concrete with variations in fiber and specific gravity at the age of 28 days and the compressive strength of foamed concrete with variations in polypropylene fiber with specific gravity at the age of 28 days.

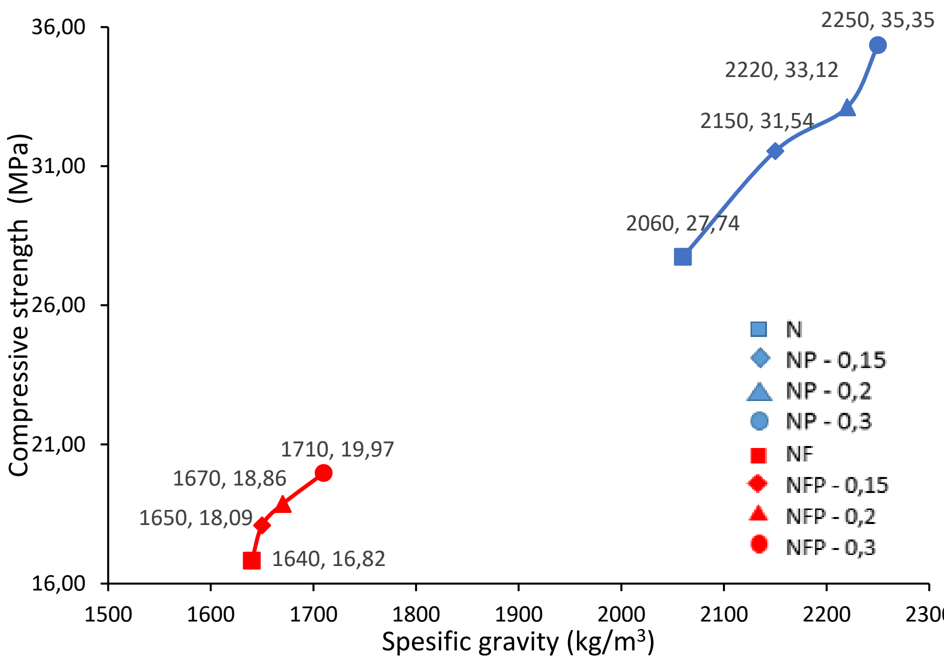

Fig. 3. Relationship of compressive strength with specific gravity

The specific gravity of foamed concrete with variations in polypropylene fibers is lighter than the density of concrete without a foaming agent. For example, the density of NFP – 0.3 or foamed concrete with 0.3% polypropylene fiber is 1710 kg/m^3 and the density of N or concrete without foaming agent is 2060 kg/m^3. And the lightest specific gravity is NF or foamed concrete without fiber variations with a value of 1650 kg/m^3.

V. Result

Based on the results of research conducted at the Laboratory of Materials and Concrete, Department of Civil Engineering, Faculty of Engineering, Sriwijaya University, it can be concluded that the results of the research on the mechanical properties of foamed concrete compared to concrete without a foaming agent on variations in polypropylene fibers are as follows:

1. In the table of concrete specific gravity, foamed concrete with variations of polypropylene fibers produces a lighter density than concrete without a foaming agent with variations in fiber at the age of 28 days. The value of the specific gravity of foamed concrete with 0.2% fiber variation is 1690 kg/m^3 and the specific gravity of concrete without foaming agent with 0.2% fiber variation is 2220 kg/m^3. This is because the addition of a foaming agent into the mixture that fills the voids of the concrete with foam bubbles makes the concrete lighter.
2. Based on the value of compressive strength at the age of 28 days, the compressive strength of concrete without a foaming agent and foamed concrete continues to increase as polypropylene fibers increase. For the value of the compressive strength of concrete without the foaming agent, the ratio of the foaming agent with polypropylene fiber is 0: 0 the result is 29.38 MPa, for 0: 0.15 is 31.54 MPa, 0: 0.2 is 33.12 MPa and for volume 0: 0.3 is 35.35 MPa. For the compressive strength of foamed concrete, the ratio of the foaming agent with polypropylene fiber is 0.8 : 0 the result is 16.82 MPa, for 0.8: 0.15 is 18.09 MPa, 0.8: 0.2 is 18.86 MPa and for volume 0,8: 0.3 is 19.97 MPa.

References

[1] Aldridge, D. (2005). Introduction to foamed concrete: What, why, how? Proceedings of the International Conference on the Use of Foamed Concrete in Construction, 1–14.

[2] ASTM C 191. (2008). Standard Test Method for Time of Setting of Hydraulic Cement by Vicat Needle. ASTM International, 04(C), 1–6. www.astm.org,

[3] ASTM Standard C39/C 39M. (2016). Test Method for Compressive Strength of Cylindrical Concrete Specimens. ASTM International, 04(October), 1–7. https://www.astm.org/Standards/C39.htm

[4] Badan Standarisasi Nasional. (2002). Tata cara mengevaluasi hasil uji kekuatan beton SNI 03-6815-2002. 32. http://sispk.bsn.go.id/SNI/DetailSNI/179

[5] Brady, K. C., Watts, R. A., & Jones, I. R. (2001). Specification for foamed concrete. www.iceni.com/unlock.htm

[6] McCarthy, A., & Jones, M. R. (2005). Preliminary views on the potential of foamed concrete as a structural material. In Magazine of Concrete Research. https://doi.org/10.1680/macr.2005.57.1.21