Mechanical Properties of Foamed Concrete with Additional Pineapple Fiber and Polypropylene Fiber

IOP Conf. Series: Journal of Physics: Conf. Series **1198** (2019) 082018 doi:10.1088/1742-6596/1198/8/082018

Mechanical Properties of Foamed Concrete with Additional Pineapple Fiber and Polypropylene Fiber

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Abstract. Foamed concrete is classified into lightweight concrete having a density range of 300-1,800 kg/m^3. Foamed concrete is made by adding air bubbles into the concrete. The air bubbles can make affects decrease strength of concrete. To increase compressive strength and flexural strength can be added by pineapple fiber and polypropylene fiber that have high tensile strength. Percentage of pineapple fiber and polypropylene fiber used 0%, 0.2%, 0.4% of weight volume and with a pineapple fiber length 10 mm, 20 mm, 30 mm and 12 mm for polypropylene fibers. The maximum compressive strength was obtained in the mixture with a percentage of 0.4% fiber polypropylene fiber with a 12 mm fiber length of 8.38 MPa. The mimimum compressive strength is obtained in a mixture of 0% fiber. The maximum flexural strength is obtained in the mixture with a percentage of 0.4% fiber of polypropylene fiber with a 12 mm fiber length of 3.23 MPa. The minimum flexural strength is obtained in the mixture of 0% fiber. The result of this research showed that there was an increase of compressive strength and flexural strength of foamed concrete with added by pineapple fibers and polypropylene fibers.

1. Introduction

Foam concrete is classified into lightweight concrete made by adding air bubbles into theconcrete and depending on the amount of foam inserted into the mixture. Lightweight concrete weight lighter than normal concrete, in general lightweight concrete has a density of 300-1,800 kg/m^3[1, 2]. Lightweight concrete is the incorporated foaming agent that serves to produce bubbles in the concrete therefore it becomes lightweight. However, the advantages of lightweight concrete are mainly on the weight, so that when used in high-rise project can reduce the weight of the building itself, which further impact to the calculation of foundation. Lightweight concrete encourage the use in the construction world because it can reduce the weight of the building [3, 4].

Foamed concrete is produced by inserting the foaming agent into a concrete mixture. The existence of foam concrete can reduce the weight of the building so as to create an earthquake resistant building. But the problem is that it has a low compressive strength [5, 6].

Lightweight autoclave aerated concrete (AAC) concrete is a cellular concrete in which the air bubbles present are caused by chemical reactions, the AAC mixture generally comprises quartz sand, lime, a little gypsum, water, and aluminum paste as a chemical developer or filler. Foam concrete forming materials are the cement, water, sand, foaming agent, and fly ash as a substitute for part or substitution of cement [7, 8].

Natural fiber is beneficial to the environment because it can reduce agricultural waste [7]. Natural fiber comes from plants one of which is pineapple fiber. Added fiber comes from pineapple leaves and has abundant availability so it can be used for concrete. The addition of natural and synthetic fibers is expected to reduce the crack so that the concrete is more ductile. Polypropylene fiber is one type of synthetic fiber. Polypropylene fibers have more contribution to flexural, splitting and shrinkage

properties in foamed concrete [7, 9]. Pineapple fiber is taken from the pineapple leaves. The pineapple fiber is composed of cellulose and non cellulose obtained by removal of the outer layer of the leaf mechanically.

Based on previous research, in this study discussed the influence of percentage of pineapple fiber and polypropylene fiber to the mechanical properties of foamed concrete so that the quality of concrete can be improved.

2. Material and Methodology

Percentage of fiber used 0%, 0.2%, and 0.4% of total weight volume. The length of pineapple fiber is used 10 mm, 20 mm, and 30 mm while the polypropylene fiber is 12 mm. Stages of research conducted in the laboratory are material testing, mix foam concrete planning, mixing mixed foamed concrete, slump flow test, setting time test, test object molding, specimen treatment, weight measurement testing, compressive strength testing, flexural strength, and scanning electron microscope (SEM). The natural fiber used is pineapple fiber. Here is the technical data of pineapple fiber that has been tested at Textile testing laboratory of the Ministry of Industry Bandung.

Fibre diameter	: 215 micron–nominal
Tensile strength	: 25.5 N/Tex
Producent area	: Blitar, Indonesia

The synthetic fibers used are polypropylene fibers. Here is the technical data of polypropylene fiber:

Base	: Polypropylene fibres
Colour	: Natural
Specific Grafity	: 0.91 g/cm 3
Length	: 12 mm
Diameter	: 18 micron – nominal
Tensile strength	: 300 – 440 MPa
Elastic Modulus	: 6,000 – 9,000 N/mm 2
Water absorption	: Nil
Packaging	: 0.6 kg/bag

Pineapple and polypropylene fibers used in this study can be seen in Figure 1. below:

(a) (b)

Figure 1. (a). Pineapple fiber (b). Polypropylene fiber

Pineapple fiber treatment refers to previous research where at this stage, pineapple fiber obtained, purchases in Blitar, East Java. The pineapple rinse is cleaned and then dried. After drying the pineapple fiber brushed for fiber picking. Treatment of soaking with NaOH solution with 5% concentration took 6 hours. Once soaked, the fibers are rinsed with water equates until clean and dried. After the drying is done the cut to size is mixed on the specimen.

The specimens used were 100x200mm diameter cylinders for compressive strength of 28 days concrete. The test specimens are 100x100x350mm beam for flexural strength of 28 days. Target weight was 1.000 kg/m^3. Foaming agent used synthetic type with dosage of 1 kg foaming agent: 30 liters of water. The type of foaming agent used is gel-shaped. Preparation of foam with mixture of foaming agent and water using snow tube and wind compressor until pressure in snow tube 35-40 Psi and after that foam removed from snow tube. After foam is formed, weighted and mixed into fresh concrete.

The next stage of cement and fly ash is stirred first until homogeneous and then sand is then fed in a uniform mixture and then added with water. After the average was input pineapple fiber or polypropylene fiber into the mixer according to the composition of the plan. Stirring takes about 1 – 2 minutes. Once mixed evenly then stirring mixing is complete and ready to put in the mold. The treatment of specimens based on ASTM C - 192 was performed at room temperature for 24 hours after removal from the mold. Then after 24 hours, the specimen is removed from the mold. Planning of mixed foamed concrete composition based on ACI 523.3R-3 "Guide for Cellular Concrete Above 50 pcf, and for aggregate concrete above 50 pcf with Compressive Strengths Less Than 2,500 Psi". Material used in the form of Portland type 1 cement, fly ash, fine aggregate escaped strain no. 16, Water, pineapple fiber and polypropylene. Foaming agent with a ratio of 1 Liter foaming agent compared with 30 Liter of water. The mixed compositions for cylindrical and beam test objects can be seen in Table 1.

Tabel 1. Mix propotion of foamed concrete (based on the volume, m^3)

Mix design code	Percent of fiber	Lenght of fiber	Cement	Fly ash	Sand	Foam	Water	*Foam solution Foaming agent*	Water
	(%)	(mm)	(kg)	(kg)	(kg)	(liter)	(liter)	(gr)	(liter)
FC0-0	0	0	408.05	45.34	453.39	500	204.02	806.45	24.19
FCN0.2-10	0.2	10	408.05	45.34	453.39	500	204.02	806.45	24.19
FCN0.4-10	0.4	10	408.05	45.34	453.39	500	204.02	806.45	24.19
FCN0.2-20	0.2	20	408.05	45.34	453.39	500	204.02	806.45	24.19
FCN0.4-20	0.4	20	408.05	45.34	453.39	500	204.02	806.45	24.19
FCN0.2-30	0.2	30	408.05	45,34	453.39	500	204.02	806.45	24.19
FCN0.4-30	0.4	30	408.05	45.34	453.39	500	204.02	806.45	24.19
FCP0.2-12	0.2	12	408.05	45.34	453.39	500	204.02	806.45	24.19
FCP0.4-12	0.4	12	408.05	45.34	453.39	500	204.02	806.45	24.19

3. Results and Discussion

Testing of foam concrete in this research consists of density, compressive strength, flexural strength, scanning electron microscope (SEM).

3.1. Density

From Figure 2, it can be seen that the maximum density is in the concrete mixture of FCP0.4-12 with the percentage of 0.4% polypropylene fiber with 12 mm fiber length (LP12) of 1,191 kg/m^3, while the minimum density is in concrete mixture with 0% fiber of 1,027 kg/m^3.

In pineapple fibers for fiber length 30 mm the maximum density of 1,195 kg/m^3occurs in amixture of FCP0,4-30 with a percentage of 0.4% and a minimum density fiber in the FCN0.2-30 mixture of 1,192 kg/m^3. At 20 mm long pineapple fiber has a maximum density of 1,163 kg/m^3 (FCN0.4-20) while the minimum density is 1,035 kg/m^3 (FCN0.2-20). In a mixture of FCN0.4-10 with a fiber length of 10 mm the maximum density of 1,165 kg/m^3 while the minimum density is 1,061 kg/m^3 (FCN0.2-10). In polypropylene fibers the maximum type weight of 1,192 kg/m^3 occurs in the mixture of FCP0.4-12 and the minimum in the FCP0.2-12 mixture of 1,156 kg/m^3.

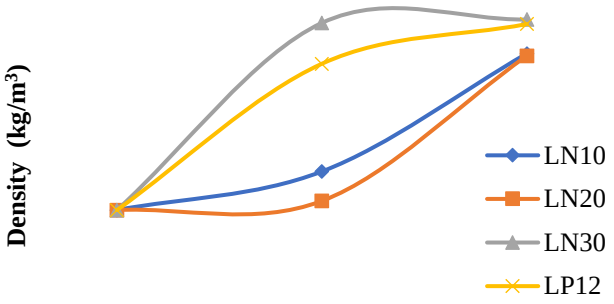


Figure 2. Density at age 28 days

3.2. Compressive strength

The results of the compressive strength test of the 28-day concrete age can be seen in Figure 3. which explains the value of compressive strength is increasing with the addition of pineapple fiber percentage and polypropylene. The value of compressive strength increases due to the presence of the fibers the bond between the concrete is stronger so that more solid. The more fiber percentage then the bond between the concrete increase. The compressive strength of pineapple fiber is smaller compared to polypropylene fiber because the value of tensile strength of pineapple fiber is smaller than polypropylene fiber.

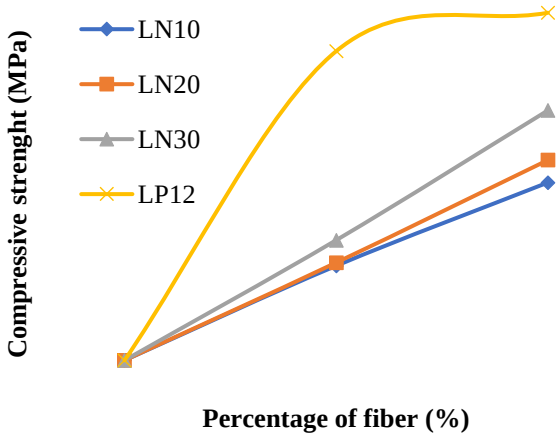


Figure 3. Compressive strength at age 28 days

Figure 3 shows the maximum compressive strength values found in the mixture of FCP0.4-12 with a mixture of 0.4% fiber and a 12 mm fiber length (LP 12) of 8.38 MPa. The minimum compressive strength is obtained in the FC0-0 mixture with a percentage of 0% fiber of 2.85 MPa. In pineapple fiber for 30 mm fiber length the maximum compressive strength of 6.83 MPa occurs in the mixture of FCP0.4-30 with a percentage of 0.4% and a minimum compressive strength fiber in the FCN0.2-30 mixture of 6.04 MPa. In pineapple fibers with a length of 20 mm has a maximum compressive strength value of 5.68 MPa (FCN0.4-20) while a minimum compressive strength of 4.76 MPa (FCN0. 2-20). In the FCN0.4-10 mixture with a 10 mm fiber length the maximum compressive strength is 4.41 MPa while the minimum compressive strength is 4.36 MPa (FCN0.2-10). In polypropylene fiber the maximum compressive strength of 8.36 MPa is found in the mixture of FCP0.4-12 with the percentage of fiber 0.4% and minimum compressive strength at mixture of FCP0.2-12 equal to 7.77 MPa.

3.3. Flexural strength

The result of strength test of flexural strength of 28 days concrete can be seen in Figure 4. The strength of flexural strength is increasing with the addition of pineapple fiber and polypropylene percentage. Flexural strength value increased due to the existence of the fiber bond between the concrete. The more fiber percentage applied then the bond between the concrete was more and more. Flexural strength of pineapple fiber is lower compared to polypropylene fiber because the value of tensile strength of pineapple fiber is lower than polypropylene fiber.

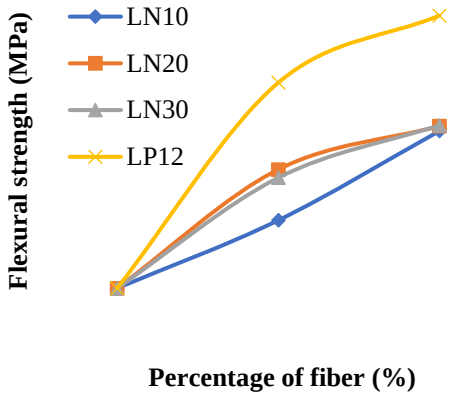


Figure 4. Strength flexural at age 28 days

From Figure 4, it can be concluded that the maximum flexural strength value is found in the mixture of FCP0.4-12 with a mixture of 0.4% fiber and 12 mm fiber length (LN 12) of 3.23 MPa. The minimum compressive strength is obtained in the FCN0-0 mixture with a percentage of 0% fiber of 0.50 MPa. In pineapple fibers for 30 mm length the maximum flexural strength of 2.03 MPa is found in the mixture of FCP0.4-30 with the percentage of 0.4% and minimum fibers in the FCN0.2-30 mixture of 2.02 MPa. In pineapple fibers with a length of 20 mm has a maximum flexural strength value of 1.95 MPa (FCN0,4-20) while the minimum of 1.45 MPa (FCN0.2-20). In a mixture of FCN0.4-10 with a maximum strength of 10 mm of a maximum flexural fiber of 1.54 MPa while a minimum of 0.98 MPa (FCN0.2-10). Maximum flexural strength polypropylene fibers of 3.23 MPa are obtained in the mixture of FCP0.4-12 with a 0.4% fiber percentage and a minimum on the FCP0.2-12 mixture of 2.49 MPa.

3.4. Scanning electron microscope (SEM)

The microstructural testing is SEM (Scanning Electron Microscopy) testing. The result of SEM foamed concrete testing with magnification 1,000 x can be seen in Figure 5 - 7. Figure 5 is the result of SEM FCN0-0 test with 0% fiber. There is a bubble but without the fibers scattered on the mixture. There is also a micro crack that occurs in the bubble. The amount of bubble in the mixture is still high. Figure 6.a - 6.d show that there was the fiber and also bubble. There was micro crack on the bubble. Strong bonds occur between concrete mixture and fiber so that the fibers are not pulled out of the concrete mixture. Fiber breaks due to loading. Figure 7 is the result of SEM test with 0.4% pineapple fiber and polypropylene fiber and showed a very small amount of bubble and a very small bubble diameter this is due to the addition of fibers.

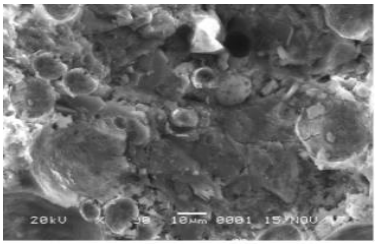
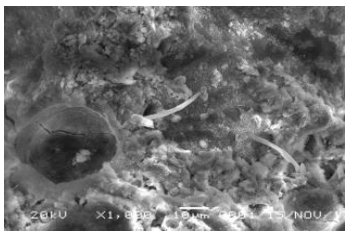
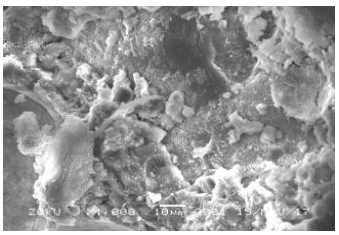


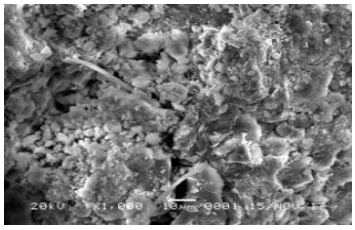
Figure 5. SEM 0% fiber (FCN0-0)



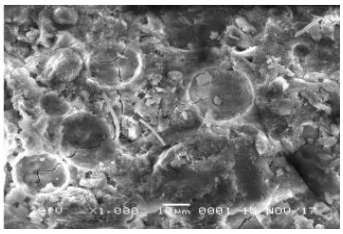
(a). FCN0.2-10



(b). FCN0.2-20

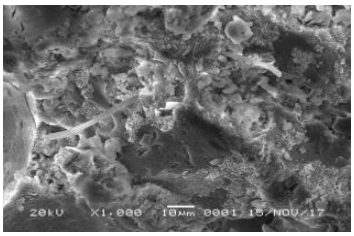


(c). FCN0.2-30

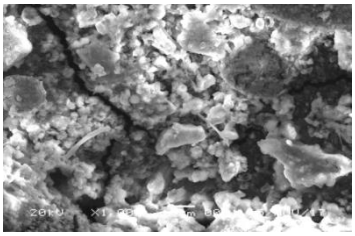


(d). FCP0.2-12

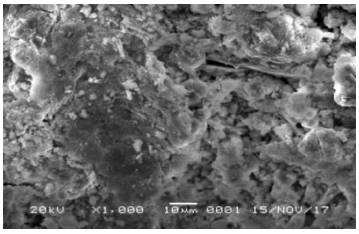
Figure 6. SEM 0.2% fiber



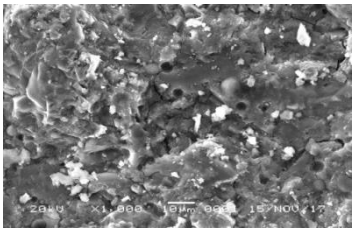
(a). FCN0.4-10



(b). FCN0.4-20



(c). FCN0.4-30



(d). FCP0.4-12

Figure7. SEM 0,4% fiber

4. Conclusion

The conclusion can be drawn from the research results of mechanical properties of foamed concrete with additional pineapple fiber and polypropylene fiber which have been done as follows:

1. Testing of pineapple fiber and polypropylene fiber used in addition to foam concrete showed an increase in compressive strength and flexural strength with increasing percentage of added fiber. Percentage of pineapple fiber and polypropylene fiber used 0%, 0.2%, 0.4% of total volume weight and with a fiber length of 10 mm, 20 mm, 30 mm, and 12 mm for polypropylene fibers. Maximum density is obtained in concrete with a percentage of 0.4% polypropylene fiber with a fiber length of 12 mm (LP 12) of 1,191 kg/m^3, meanwhile the minimum density is in concrete with 0% fiber of 1,027 kg/m^3. The maximum compressive strength was obtained in the mixture with a percentage of 0.4% fiber polypropylene fiber with a 12 mm fiber length of 8.38 MPa. The minimum compressive strength is obtained in a mixture of 0% fiber. The maximum flexural strength is obtained in the mixture with a percentage of 0.4% fiber polypropylene fiber with a 12 mm fiber length of 3.23 MPa. The minimum flexural strength is obtained in the mixture of 0% fiber 0.5 MPa. The result of this research is increase of compressive strength and flexural strength of foamed concrete with added pineapple and polypropylene fiber.
2. The SEM test shows a strong bond between the fibers with the foam concrete mixture, the presence of fiber can prevent micro crack that can prevent the concrete is broken into two parts.
3. Fiber pineapple and polypropylene fiber can increase the strength of concrete for nonstructural element and also structural element such as beams and columns.

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