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Experimental Study of Porous Concrete with Addition of Fiber Variations

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ABSTRACT

Porous concrete is concrete without fine aggregate and consist of coarse aggregate, cement and water. To improve the mechanical properties of the porous concrete, one of which is with addition of fiber. The fiber material used in this study was obtained from the natural fibers of coconut fibers and artificial fibers that is polypropylene fibers. This study aimed to determine the effect of the natural fibers of coconut fiber and the artificial fibers of polypropylene fibers to characteristics of porous concrete with addition of fiber variations. Characteristics testing of porous concrete which include the percentage of pore volume, volume weight, compressive strength and split tensile strength. This research is conducted in the civil engineering's laboratory of structures and materials , UKI-Paulus makassar, with a cylindrical specimen with diameter 15 x 30 cm as much 84 specimens with the add ition of fiber 0%, 0.1%, 0.2%, and 0.3 % of the weight of porous concrete. The testing of compressive strength and split tensile strength for porous concrete specimens on age 7, 21, 28 days. Porous concrete test results with the addition of polypropylene fibers showed the largest pore volume is 22.836%. While porous concrete with the addition of coconut fiber, the largest percentage of the pore volume is 25.607%. Weight volume of concrete with the addition of polypropylene fiber highest 1894.787kg / cm3. For weight volume of concrete with the addition of coconut fiber highest is 1823.473kg / cm3. For concrete strength testing, porous concrete value's with the addition of polypropylene fiber is obtained 13.966 MPa for compressive strength and split tensile strength is obtained 1.793 MPa, while the compressive strength and split tensile strength in the porous concrete with the addition of coconut fiber is obtained 12.096 MPa and 1,911MPa, respectively. With fiber addition into a porous concrete, compressive strength's value is decreased but the split tensile strength's value increased with an increased volume of fibers and transform a brittle concrete material becomes more ductile material.

Keywords: Porous concrete, polypropylene fiber, coconut fiber

1. INTRODUCTION

Porous concrete also known as pervious concrete or porous concrete is a type of concrete that has a cavity on its structure, allowing the liquid to flow through the cavity contained in the concrete [1, 2]. According to ACI 522R-10 Report on the pervious concrete, porous concrete can be described as a concrete formed from portland cement, coarse aggregate, fine aggregate slightly or not at all, and water. In accordance with the functions, porous concrete is concrete pavement that is easy to pass the water it is required the pores in concrete, in which the pore volume to be achieved is between 25 ± 5% of the volume of the concrete so easily

traversed by water [3]. The process of making porous concrete as well as concrete manufacturing in general, that the material after mixed according to the composition and the added water according to the water to cement ratio factor (fas). Faktor non water-cement concrete sand ranges of 0.36 and 0.46 while the value factor optimum cement water about 0.40. In non sand concrete admixture should be added to increase workability. With the water-cement factor optimum value would have resulted with a maximum compressive strength of concrete non sand [4, 5]. Porous concrete is not a concrete type that is commonly used in a construction because it is hollow [6]. Applications of hollow concrete is still limited, even in Indonesia itself is still less to apply. Hollow character possessed by porous concrete making concrete of this type have a lower compressive strength of the solid concrete type that is normally used, thus making porous concrete more suitable when used for applications that do not require high compressive strength value.

2. METHODOLOGY RESEARCH

In this study, the specimens using a cylinder diameter of 15 cm and height 30cm. Specimen for porous concrete without the addition of fiber (BRN) as many as 12 samples, porous concrete with the addition of polypropylene fibers (BRSP) variation of 0.1%, 0.2%, dan0,3% as many as 36 samples, porous concrete with the addition of coconut fiber (BRSK) variation of 0.1%, 0.2%, and 0.3% were 36 samples. Compressive strength testing amounts to 63 samples for age 7, 21.28 days, and 21 samples for testing the split tensile strength of concrete age 28 days. Thus the total sample was 84 samples. This research was conducted at the Laboratory of Structures and Materials, Department of Civil Engineering, Faculty of Engineering, Christian Indonesia Paulus University of Makassar. Testing tools used for the compressive strength and split tensile strength are Universal Testing Machine with capacity 2000 KN as shown in Figures 1 and 2.

Fig. 1 Compressive strength testing

Fig. 2 Tensile Strength testing

Research flowchart shown in Figure 3

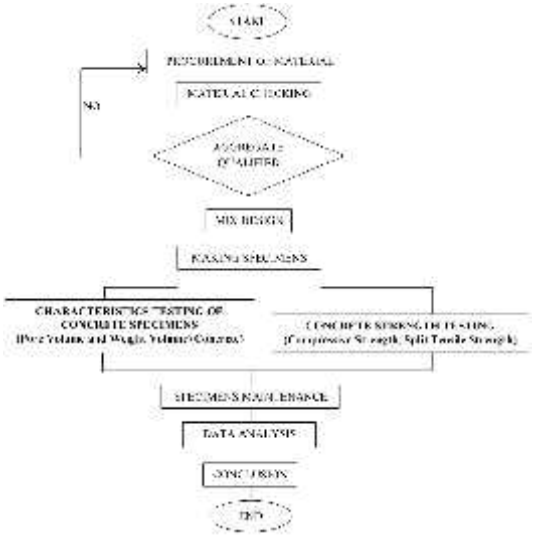

Fig. 3 Research Flowchart

In this study begins with the collection of data characteristic of the formation of hollow concrete material obtained from laboratory testing, then the process of designing the composition of the mixture, manufacture, maintenance and testing of the specimen based on the parameters that determine the characteristics of hollow concrete. Then analyze the data that have been obtained from the test results specimen of laboratory test. Result data tests were analyzed to determine the pore volume, weight volume, compressive strength and split tensile strength of porous concrete with variation of additional fiber.

Pore volume to be achieved ranged between 15-30% of concrete volume so easily be passed by water. Percentage of pore volume be calculated by the following formula:

$$V_p = \frac{(V_s - V_{po})}{V_s} \qquad (1)$$

Where,

Vp = The percentage of pore volume (%)

Vs = Cylinder volume (liter)

Vpo = Pore volume (liter)

and to get the *Vpo* use the following formula,

$$"V_{po} = \frac{(W_a - W_w)}{\gamma_w} \qquad (2)$$

Where,

Wa = weight of cylinder sample in air (Kg)

Ww = weight of cylinder sample in water (Kg)

¥*w* = weight volume of water (1 kg / liter)

Weight volume of concrete or concrete density is ratio between the cylinder concrete weight volume in air with a cylinder volume expressed in kg / m3. Weight volume of concrete is calculated by the following formula:

$$W_c = \frac{W_a}{V_s} \qquad (3)$$

Where,

Wc = volume weight of concrete (kg / m3)

Wa = weight of cylinder specimen in air (kg)

Vs = Cylinder volume (m3)

Compressive strength values of concrete can be calculated by the following equation:

$$f'_c = \frac{P}{A} \qquad (4)$$

Where,

f'c = Compressive strength of concrete cylinder [MPa]

P = Maximum load [N]

A = Area section of specimen [mm]

The compressive strength and split tensile strength of concrete is not comparable, every correction in compressive strength only accompanied improvement with only a small increase its tensile strength values. According to ASTM C496-86 approximate values obtained from the test results repeatedly obtaining power from 0.5 to 0.6 times of √f'c, so for normal concrete used 0,57√f'c. Vertical tension can be calculated by,

$$f_{spv} = \frac{2P}{\pi LD}\left[\frac{D^2}{r(D-r)}\right] - 1 \qquad (5)$$

Horizontal tension can be calculated by,

$$f_{sp} = \frac{2P}{\pi LD} \qquad (6)$$

Where,

fsp = split tensile strength [MPa]
P = maximum load [N]
L = length of cylinder [mm]
D = diameter of cylinder [mm]
r = distance from compressive load to speciment [mm]

3. RESULT AND DISCUSSION

Results test of aggregate are shown in table 1 show that coarse aggregate which checked have been qulified from standard interval so that it can be used for research

Table 1. Characteristics of Aggregate Summary of Examination

NO	CHARACTERISTICS	RESULTS	INTERVAL ASTM	INFORMATION
1	WATER CONTENT	0592	**0.5% -2.00%**	Qulified
2	SLUDGE CONTENT	0520	**0.2% - 1:00%**	Qulified
3	WEIGHT VOLUME SOLID	1.460	**1.40 - 1.90 Kg / ltr**	Qulified
4	WEIGHT VOLUME LOOSE	1.432	**1.40 - 1.90 Kg / ltr**	Qulified
5	SPECIFIC GRAVITY SSD	2.558	**1.60% - 3.20%**	Qulified
6	ABSORPTION	1,576	**0.20% - 2.00%**	Qulified

For porous concrete pore volume value of the test data analysis results obtained:

Wa BR = 10,640 kg

Ww BR= 6.567 kg

γ w = 1 kg / liter

Vs = 5.299 ltr

$$V_p = \frac{(W_a - W_w)}{\gamma_w} = \frac{(1.6 - 6.5)}{1} = 4{,}073 \text{ ltr}$$

$$V_p = \frac{(V_s - V_{po})}{V_s} \times 100\% = \frac{5.299 - 4.073}{5.299} \times 100\% = 22.836\%$$

For further calculations can be seen in Table 2.

Table 2. Percentage of average pore volume results

Variation	Pore Volume Percentage (%)
BRN (0%)	22.836
BRSP (0.1%)	19.538
BRSP (0.2%)	17.279
BRSP (0.3%)	15.681
BRSK (0.1%)	18.607
BRSK (0.2%)	17.726
BRSK (0.3%)	15.160

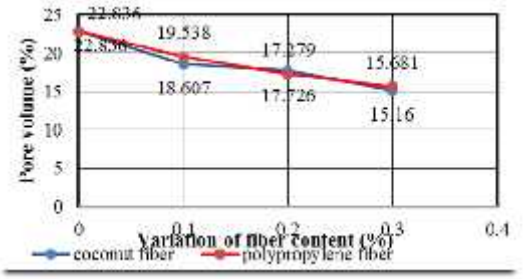

Fig. 4 Percentage of pore volume - variations of fiber content

Based on the percentage graph of volume pore in figure 4, porous concrete with the addition of polypropylene fiber and coconut fiber with variations 0.1% to 0.3% can reduce the value of pore volume porous concrete with average 24%.

Weight volume of concrete or concrete density is the ratio between the weight of the air volume in the concrete cylinder with a cylinder volume. The calculation of data analysis:

Weight of porous concrete (W) = 10,640 kg

Cylinder volume (V) = 0, 00529875 m3

Weight volume of concrete = $\frac{W}{V}$

$$= \frac{10.640}{0.005529875}$$

= 2008.021 kg/m3

For further calculations can be seen in Table 3

Table 3. Results hollow concrete volume weight average

Variation	Volume weight of porous concrete (kg/m^3)
BRN (0%)	1968.263
BRSP (0.1%)	1894.787
BRSP (0.2%)	1873.429
BRSP (0.3%)	1863.883
BRSK (0.1%)	1888.716
BRSK (0.2%)	1844.051
BRSK (0.3%)	1814.642

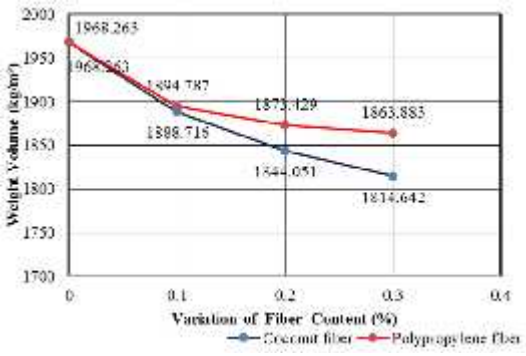

Figure 5. Weight volume of concrete – variation of fiber content

Based on the volume weight graph shown in figure 5, that the porous concrete with the addition of polypropylene fiber and coconut fiber variations 0.1% to 0.3% weight decreased volume with a value of an average weight loss of 5.3% of porous concrete normal.

The results of the compressive strength of porous concrete at 28 days showed that porous concrete compressive strength value's 13.966 MPa, while the value of the highest compressive strength of porous concrete with the addition polypropylene fibers at 0.1% is 9.814 MPa and porous concrete fibers with the addition of coconut fiber in variations as big as 8869 Mpa. The value of concrete compressive strength of each specimen are shown in table 4.

Table 4. Results of average compressive strength

Variation	f'_c of 7 days (MPa)	f'_c of 21 days (MPa)	f'_c of 28 days (MPa)
BRN (0%)	12.833	13.399	13.966
BRSP (0.1%)	7.549	7.926	9.814
BRSP (0.2%)	7.738	8.021	8.304
BRSP (0.3%)	6.794	7.738	7.926
BRSK (0.1%)	7.642	8.208	9.869
BRSK (0.2%)	7.076	8.303	8.680
BRSK (0.3%)	7.887	7.359	8.114

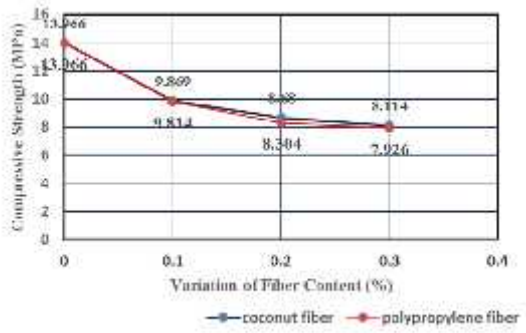

Fig. 6 Strong press - the variation of fiber content

In figure 6 shows that the compressive strength at 28 days decreased by 43.4% .of the normal porous concrete to variation of 0.3% and the addition of polypropylene fibers for porous concrete fiber with addition of coconut fiber variation 0.3% 41.9 %.

The results of the tensile strength values sides hollow concrete at 28 days showed that in normal porous concrete tensile strength values divided by 1, 321 Mpa, while the value of the highest split tensile strength of porous concrete with the addition polypropylene fibers on a variation of 0.3% for 1,793 Mpa and porous concrete fibers with the addition of coconut fiber in a variation of 0.3% as big as 1,109 Mpa. Value split tensile strength concrete of each specimen are shown in Table 5.

Table 5. Results of average compressive strength

Variation	f'_c 28 days (MPa)
BRN (0%)	1.321
BRSP (0.1%)	1.604
BRSP (0.2%)	1.699
BRSP (0.3%)	1.793
BRSK (0.1%)	1.478
BRSK (0.2%)	1.573
BRSK (0.3%)	1.609

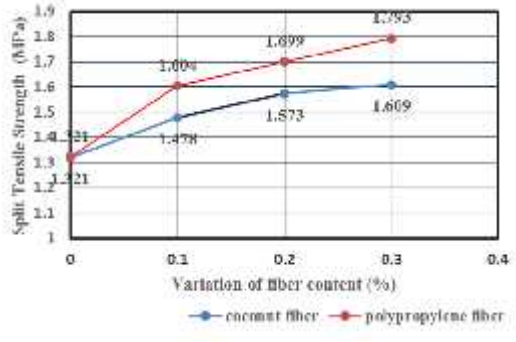

Fig. 7 Split Tensile strength - variation of fiber content

In figure 7 shows that the value of a strong root split at 28 days increased by 43.4% .of the normal porous concrete to variation of 0.3% and the addition of polypropylene fibers for porous concrete fiber coconut with addition variation 0.3% is 41, 9%.

4. CONCLUSION

From the research results, it can be concluded that porous concrete fibers with the addition of either fiber polypropylene and fiber coconut ,the value of the pore volume is reduced from normal porous concrete. The more the addition of fiber, the smaller the pore volume porous concrete. Similiar with the volume weight of the concrete, the more the addition of fiber, the smaller the volume weight of the concrete. For the compressive strength, the more the addition of the fiber strength of concrete produced getting smaller. Different things happen at the split tensile strength where the concrete with addition of polypropylene fibers an increase in split tensile strength along with the increased variation of polypropylene fibers. Similar with porous concrete with the addition of coconut fiber, split tensile strength values increases.

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