

EFFECT OF COMPRESSIVE STRENGTH OF CONCRETE WITH PARTIAL SUBSTITUTION OF FINE AGGREGATES WITH WASTE BAMBOO FIBERS

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ABSTRACT

Concrete consists of cement, sand, gravel and water, with cement being the main binder that affects its quality. However, the increasing cost of raw materials and the environmental impact of lime mining and sand dredging are challenges in construction. To address this, the study proposed the use of bamboo fiber as an environmentally friendly and economical additive. This study tested the variation of 0%, 10%, and 15% pulung bamboo fiber waste on the compressive strength of concrete. The results showed that normal concrete without bamboo fiber had a compressive strength of 452 kN (fc' 26.08 MPa). The addition of 10% bamboo fiber decreased the compressive strength to 404 kN (fc' 23.32 MPa), while the addition of 15% decreased it further to 393 kN (fc' 22.68 MPa). The more bamboo fiber added, the more the compressive strength of the concrete decreased.

Keywords: Waste, Wulung Bamboo, Compressive Strength, Normal Concrete, Variety Concrete

INTRODUCTION

Concrete is a key material in construction because it is easy to use, relatively inexpensive, and can be shaped as needed. Concrete has high compressive strength, making it a top choice for structures such as buildings, dams, and flyovers. However, its disadvantages are its low tensile strength and brittle nature. To ensure the quality and durability of concrete, research and testing is required to determine the optimal mix composition to suit the needs of the construction project. Careful testing of concrete ensures structural strength and adaptation to the environment, guaranteeing construction safety. Concrete consists of cement, sand, gravel and water, with cement being the main binder that affects its quality. However, the increasingly expensive and environmentally damaging production of concrete, such as lime mining and sand dredging, is a challenge in construction. To address this, the research proposed the use of bamboo as an additive, with the hope of producing concrete that is cheaper, more economical, and still has a compressive strength suitable for building construction. This research was conducted because of the alternative source of bamboo, which is considered an environmentally friendly admixture that can reduce environmental impact. In the current era, materials for concrete materials must look for sustainable and suitable ones because one day crops or concrete materials derived from the earth are difficult to find and will cause damage to the environmental ecosystem. Therefore, the material that will be used for substitution this time is bamboo material as a fine aggregate mixture in making concrete. With the bamboo material as a fine aggregate mixture, it is hoped that it can reduce damage to the ecosystem, can affect

the price of concrete more economically and is environmentally friendly to the surrounding nature.

METHODS

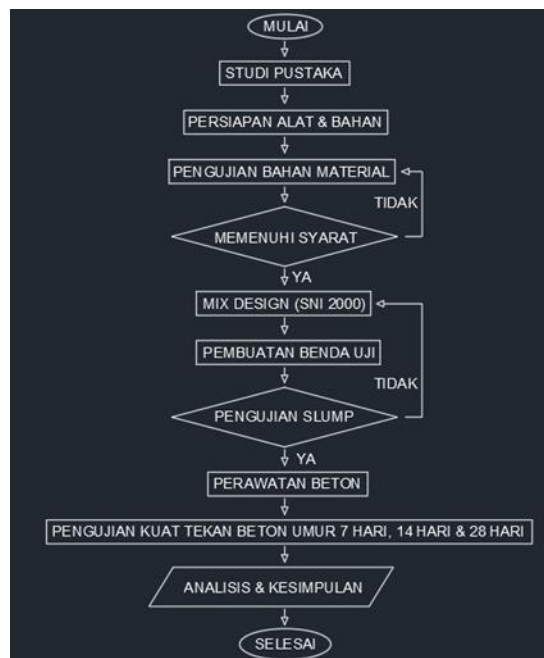
This study was conducted through an experimental approach. The objective of this study was to identify the causal relationship between the dependent and independent variables. The dependent variable was a variation of normal concrete with a concrete grade of $f'c$ 25 MPa or equivalent to K-300, while the independent variable was a concrete sample containing wulung bamboo fiber waste as a partial replacement of fine aggregate at 10% and 15%.

Table 1: Total number of samples

No.	Sampel Benda Uji (Limbah Serat Bambu Wulung)	7 hari	14 hari	28 hari	Jumlah Benda Uji
1.	Uji Kuat Tekan Ukuran 15 x 30 cm, Variasi 0 %	3	3	3	9
2.	Uji Kuat Tekan Ukuran 15 x 30 cm, Variasi 10 %	3	3	3	9
3.	Uji Kuat Tekan Ukuran 15 x 30 cm, Variasi 15 %	3	3	3	9
Jumlah					27

Source: Processed Research Data, 2024.

In this research, the initial stage of preparing materials such as sand, gravel, cement, water and also waste bamboo fiber. Furthermore, testing was carried out in the laboratory of PT Pionir Beton Plant Karawang, then carried out the mix design process using the Microsoft Excel software application and carried out the trial mix process, if the slump test results were according to plan, it would be continued with the process of making sample test objects which were molded using cylinders of size $\varnothing 15 \times 30$ cm. After the concrete is unloaded from the cylinder mold for 24 hours, the concrete is immediately soaked (curing) until the specified day. After the concrete is ready on the specified day, the concrete will be tested for compressive strength and get the results to be analyzed so that conclusions are obtained.



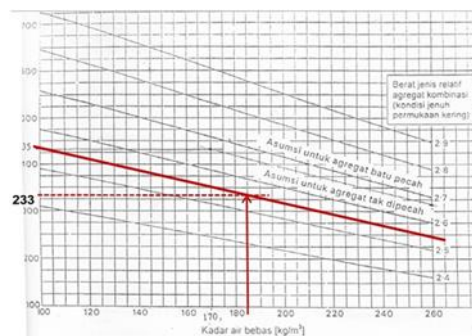
Source: Processed Research Data, 2024.

Figure 1. Research Flow Chart

RESULTS AND DISCUSSION

The tests carried out in this study include aggregate inspection such as specific gravity analysis, gradation analysis and wear testing of coarse aggregate / crushed stone using a Los Angeles machine. The concrete batching plant is designed to meet the needs of customers in the construction industry and to meet the needs of customers in the construction industry. Normal Concrete Quality Mix Design f_c' 25 (Mpa) or equivalent K-300. The provisions of the normal concrete plan, as follows:

1. Planned concrete quality = f_c' 25 (Mpa);
2. Concrete is used indoors / non-corrosive;
3. Standard Deviation = 7 Mpa;
4. Slump height set = 10 ± 2 cm;
5. Test piece (cylinder) = 15 x 30 cm in diameter;
6. Type of cement = Portland cement;
7. Maximum aggregate grain = 40 mm;
8. Specific gravity of sand (SSD) = 2.50 kg/m³;
9. Specific gravity of split (SSD) = 2.60 kg/m³;
10. Planned concrete = 33.2 MPa
 $(f_c'r = f_c' + (1.64 \times S) = 25 + (1.64 \times 7) = 33.2 \text{ Mpa})$
11. Free cement water factor = 0.475
12. Free water content:
 Free water content for unbroken aggregate sand 175 kg/m³
 Free water content for split aggregate 205 kg/m³
 Free water content = $(2/3 \times 175) + (1/3 \times 205) = 185 \text{ kg/m}^3$
13. Water content of cement = $185 / 0.475 = 389.5 \text{ kg/m}^3 \approx 390 \text{ kg/m}^3$
14. Aggregate combined fine aggregate percentage = $(32\% + 40\%)/2 = 36\%$
15. Coarse aggregate percentage = $100\% - 36\% = 64\%$
16. Specific gravity of combined aggregate = $(36\% \times 2.500) + (64\% \times 2.600) = 2.564$



Source: Processed Research Data, 2024.

Figure 2: Weight content graph of normal concrete

The concrete content weight is sought using the graph above according to the specific gravity and free water content.

Concrete content weight = 2335 kg/m³

Normal concrete planning K-300

Aggregate content = $2335 - 390 - 185 = 1760 \text{ kg/m}^3$

Total fine aggregate = $36\% \times 1760 \text{ kg/m}^3 = 633.6 \text{ kg/m}^3$

Total coarse aggregate = $64\% \times 1760 \text{ kg/m}^3 = 1126.4 \text{ kg/m}^3$

Cylindrical test specimens with a diameter of 15 cm and a test specimen height of 30 cm with the number of test specimens for each variation of 6 test specimens. Then the volume of the slinder test object is:

Volume = Cross-sectional Area x height = $(1/4 \times \pi \times d^2) \times tinggi = (1/4 \times 3.14159 \times 15 \text{ cm} \times 15 \text{ cm}) \times 30 \text{ cm} = 5301.4376 \text{ cm}^3 \approx 0.0053 \text{ m}^3$.

From the calculation results, the recapitulation of concrete mix planning can be seen in Table 2 below:

Table 2 Recapitulation of Concrete Mix Planning

Keterangan	semen	air	Agregat	
	(kg)	(kg)	Halus (kg)	Kasar (kg)
Proporsi campuran Teoritis	2,07	0,98	3,36	5,97
Setiap m ³	390,0	185	633,6	1126,4
Setiap campuran Uji: 0,0159 m ³	0,0159 x 390,0 = 6,20	0,0159 x 185 = 2,94	0,0159 x 633,6 = 10,07	0,0159 x 1126,4 = 17,90

Source: Processed Research Data, 2024.

Bamboo Fiber Waste Requirement

For the use of sand substitution materials using bamboo fiber by 10% and 15%. The weight of rolled bamboo fiber can be seen below:

1. The weight of bamboo fiber needed as a 10% sand substitute
= 10% pulung bamboo fiber. sand weight. cylinder volume
= 0.34 kg
2. The weight of bamboo fiber required as a 15% sand substitute
= 15% pulung bamboo fiber. sand weight. cylinder volume
= 0.51 kg

Concrete Slump Test Results

Table 3 Data of Concrete Slump Test Results

Variasi Campuran	Nilai Slump	Satuan
Beton f'c 25 Mpa.	11	cm
Beton f'c 25 MPa variasi 10% limbah serat bambu pulung	9	cm
Beton f'c 25 MPa variasi 15% limbah serat bambu pulung	8	cm

Source: Processed Research Data, 2024.

Results of Concrete Compressive Strength Testing

Testing the compressive strength of concrete refers to SNI 1974-2011 on the Procedure for Testing the Strength of Concrete Pressures with Cylindrical Test Objects.

Calculation of concrete compressive strength using the formula:

Compressive Strength = P/A (1)

Where:

The compressive strength of concrete is expressed in units of MPa or N/mm²

P : Axial compressive force (N)

A : Cross-sectional area (mm²)

Based on SNI 1974-2011 establishes procedures for testing the compressive strength of concrete with cylindrical test objects for testing the compressive strength of concrete. The following concrete compressive strength test results are carried out on test specimens aged 7 days, 14 days, and 28 days. Tests are carried out with a concrete press test tool, which uses readings on the tool with units of kN and digital displays, as shown in Table 4 through Table 6 and in Figure 3 below.

Table 4 Recapitulation of 7-day Cylindrical Concrete Compressive Strength Test Results

No	Benda Uji	Tanggal Pembuatan	Tanggal Pengujian	Umur Benda Uji (hari)	Berat Benda Uji (kg)	Aktual Kuat Tekan kN	Rata-rata Kuat Tekan kN	Rata-rata Kuat Tekan kN
1	fc'25	30/11/2024	07/12/2024	7	12,268	286,3	289	66,72%
2	fc'25	30/11/2024	07/12/2024	7	12,27	291,8		
1	10% SBW	30/11/2024	07/12/2024	7	12,268	189,2	193	44,56%
2	10% SBW	30/11/2024	07/12/2024	7	12,246	197,4		
1	15% SBW	30/11/2024	07/12/2024	7	12,244	184,5	182	42,02%
2	15% SBW	30/11/2024	07/12/2024	7	12,252	180,2		

Source: Processed Research Data, 2024.

Table 5 Recapitulation of the results of the compressive strength test of 14-day-old cylindrical concrete

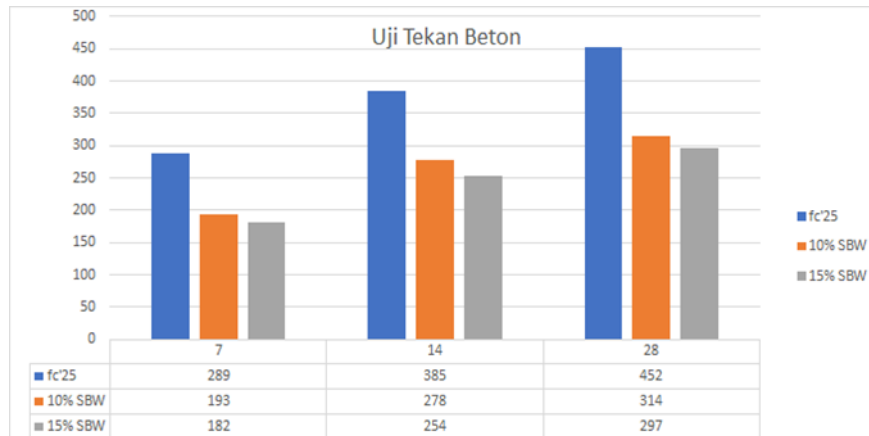
No	Benda Uji	Tanggal Pembuatan	Tanggal Pengujian	Umur Benda Uji (hari)	Berat Benda Uji (kg)	Aktual Kuat Tekan kN	Rata-rata Kuat Tekan kN	Rata-rata Kuat Tekan kN
1	fc'25	30/11/2024	14/12/2024	14	12,3	384	385	88,88%
2	fc'25	30/11/2024	14/12/2024	14	12,294	385,8		
1	10% SBW	30/11/2024	14/12/2024	14	12,278	279,4	278	64,18%
2	10% SBW	30/11/2024	14/12/2024	14	12,286	277,2		
1	15% SBW	30/11/2024	14/12/2024	14	12,268	241,6	254	58,64%
2	15% SBW	30/11/2024	14/12/2024	14	12,274	266,1		

Source: Processed Research Data, 2024.

Table 6 Recapitulation of the results of compressive strength testing of 28-day-old cylindrical concrete

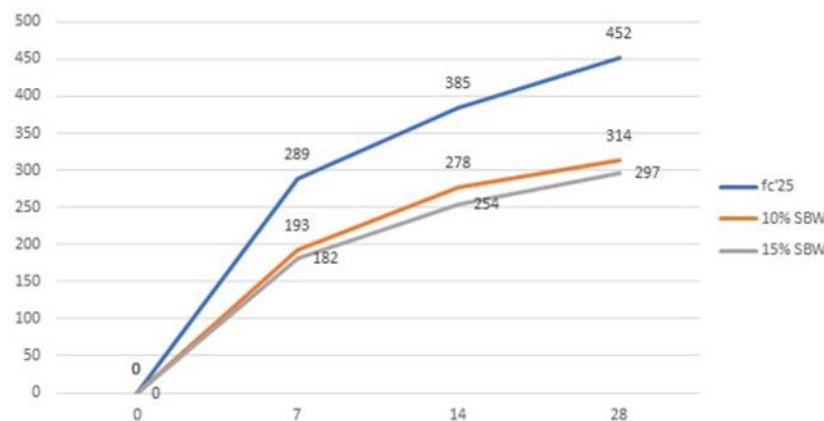
No	Benda Uji	Tanggal Pembuatan	Tanggal Pengujian	Umur Benda Uji (hari)	Berat Benda Uji (kg)	Aktual Kuat Tekan kN	Rata-rata Kuat Tekan kN	Rata-rata Kuat Tekan kN
1	fc'25	30/11/2024	28/12/2024	28	12,312	456,3	452	104,35%
2	fc'25	30/11/2024	28/12/2024	28	12,306	447,2		
1	10% SBW	30/11/2024	28/12/2024	28	12,302	318,4	314	72,49%
2	10% SBW	30/11/2024	28/12/2024	28	12,298	310,3		
1	15% SBW	30/11/2024	28/12/2024	28	12,302	289,7	297	68,56%
2	15% SBW	30/11/2024	28/12/2024	28	12,3	304,3		

Source: Processed Research Data, 2024.



Source: Processed Research Data, 2024.

Figure 3: Diagram of Normal, Variation 1 and Variation 2 Concrete Press Test Bricks



Source: Processed Research Data, 2024.

Figure 4: Graph of Normal, Variation 1 and Variation 2 Concrete Press Tests.

CONCLUSIONS

Based on the results of the research that has been carried out and the discussion in the previous chapter which includes variations in the use of pulung bamboo fiber waste with a percentage of 0%, 10%, and 15%, the conclusions that can be drawn are as follows:

- 1) The results of the compressive strength test on normal concrete at the age of 28 days reached 452 kN (fc' 26.08 MPa). This shows that normal concrete has very good strength and in accordance with the standards expected for structural concrete;
- 2) In variation 1 with 10% pulung bamboo fiber waste, there was a decrease in compressive strength, where the result reached 404 kN (fc' 23.32 MPa). This decrease indicates that the addition of pulung bamboo fibers affects the concrete matrix thereby reducing the resulting compressive strength;
- 3) For variation 2 with the addition of 15% pulung bamboo fiber waste, the compressive strength test results further showed a decrease, with the strength reaching 393 kN (fc' 22.68 MPa). This indicates that the more bamboo fiber added, the more significant the negative effect on the compressive strength of the concrete.

From these data, it can be concluded that pulung bamboo fiber has a reducing effect on the compressive strength of concrete, and the proportion of bamboo fiber addition needs to be carefully considered to optimize the balance between compressive strength and the ecological benefits of using waste materials.

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