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Utilization of sawdust on the compressive strength of concrete with variations of cement

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ABSTRACT

The construction process requires building materials so that the buildings made can last a long time and cannot be planned. Concrete is the most widely used material in the manufacture of buildings; therefore, a strong and quality concrete material can produce strong concrete according to the plan. As a replacement for each kind of cement, this research aimed to see how bayur sawdust affected concrete strength and find out which amount of sawdust, ranging from 0% to 2.0% of the cement weight, had the maximum compressive strength. The test object is a cylinder with a diameter of 15 cm and a height of 30 cm with 54 specimens. The cement used in this research is 2 (two) Indonesian Cement Manufacturers and 1 (one) Chinese Cement Manufacturer. The results of research conducted from the use of sawdust fibre concrete as much as 0%, 1.0%, and 2.0% of the weight of each (brand) cement, namely the average compressive strength value of Cement Manufacturing Indonesia 1, which is 21.14 MPa, 17.90 MPa, and 22.40 MPa. The average compressive strength of Cement Manufacturer Indonesia 2 is 20.63 MPa, 17.53 MPa, and 21.36 MPa. The average compressive strength of Cement Manufacturers in China is 21.72 MPa, 19.50 MPa, and 23.01 MPa. This study's compressive strength test data showed that the composition between China Factory Cement and 2% sawdust had the most optimal value because it produced the largest compressed concrete, which was 23.01 MPa.

ABSTRAK

Proses konstruksi bangunan memerlukan bahan bangunan yang kokoh agar bangunan yang dibuat dapat bertahan lama dan dapat memikul beban yang telah direncanakan. Beton merupakan bahan yang paling banyak dipakai dalam pembuatan bangunan, oleh sebab itu material penyusun beton yang kuat dan berkualitas dapat menghasilkan kuat tekan beton yang sesuai dengan rencana. Tujuan penelitian ini adalah untuk mengetahui pengaruh serbuk kayu bayur sebagai bahan pengganti sebagian dari variasi setiap semen terhadap kuat tekan beton dan mengetahui nilai kuat tekan beton terbesar dari variasi serbuk kayu sebesar 0%, 1.0%, dan 2.0% terhadap berat setiap variasi semen yang digunakan. Benda uji berbentuk silinder berdiameter 15 cm dan tinggi 30 cm dengan benda uji sebanyak 54 buah. Semen yang digunakan dalam penelitian ini yaitu 2 (dua) Semen Pabrikan Indonesia dan 1 (satu) Semen Pabrikan China. Hasil penelitian yang dilakukan dari penggunaan beton serat serbuk kayu sebanyak 0%, 1.0%, dan 2.0% dari berat setiap (merk) semen yaitu didapat nilai kuat tekan rata-rata dari Semen Pabrikan Indonesia 1 yaitu 21.14 MPa, 17.90 MPa, dan 22.40 MPa. Hasil rata-rata kuat tekan dari Semen Pabrikan Indonesia 2 yaitu 20.63 MPa, 17.53 MPa, dan 21.36 MPa. Hasil rata-rata kuat tekan dari Semen Pabrikan China yaitu 21.72 MPa, 19.50 MPa, dan 23.01 MPa. Data pengujian kuat tekan beton pada penelitian ini menunjukkan komposisi antara Semen Pabrikan China dengan serbuk kayu 2% memiliki nilai yang paling optimal karena menghasilkan kuat tekan beton terbesar yakni 23.01 MPa.

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1. Introduction

Good and strong building materials are needed to make buildings that last a long time and can carry the planned loads. Concrete is the most widely used material in the manufacture of buildings, so a strong and quality concrete constituent material is needed to produce the planned compressive strength of concrete. Concrete is a mixture of coarse aggregate, fine aggregate, cement and water. Portland cement is the main choice compared to using other binding materials as a constituent of concrete. Portland cement is a type of cement that is relatively expensive and widely circulated in the market. The development of science and technology has made many cement producers innovate to produce good quality cement at low prices.

Research to develop materials and methods of making quality concrete is very important. Along with the development of science and technology, many studies have been carried out to improve the properties of concrete, namely load-bearing strength and durability [1-13]. Fibre-reinforced concrete is one of the developments in concrete technology by adding fibre to the concrete mix. The fibre materials are steel (steel), plastic (polypropylene), glass (glass), carbon, and fibres from natural materials, such as palm fibre or other fibre materials. Wood sawdust was used in this study to improve the properties of concrete, especially in terms of strength, because the fibres make the concrete more resistant to cracking. The addition of fibre increases ductility but does not significantly increase the compressive strength of concrete [14]. Wood sawdust is waste obtained from cutting wood using a machine or manually. Through the mineralization process of immersion in a 5% lime solution, Wood sawdust will form calcium carbonate as an adhesive substance (tobermorite). Wood mineralized with cement will glue the aggregate grains to form a denser mass.

This study focuses on determining the ratio of the compressive strength of concrete using variations of cement and the effect of sawdust on the compressive strength of concrete with variations of cement brands. The wood powder used is bayur wood powder with a strong class III. The compressive strength of the concrete to be designed is 20 MPa. The percentage of use of sawdust in the concrete mixture is 0%, 1.0%, and 2.0%. The cement brand was taken randomly with price variations in the field, and this research is comparatively destructive.

2. Research Methodology

2.1. Material

The materials used in this study are as follows:

a. Coarse Aggregate

In this case, the material, the coarse aggregate used in concrete mixing, must first be tested for physical properties. The following tests were performed:

1) Density (based on SNI 1969:2008)
2) Filter analysis (based on SNI ASTM C136:2012)
3) Moisture content (based on SNI 1971:2011)
4) Aggregate resistance with LAA engine (based on SNI 2417:2008)
5) Aggregate resistance with sulfate solution (based on SNI 3407:2008)
6) Fill weight and air voids in the aggregate (based on SNI 4804:1998)
7) Sludge content (based on SNI ASTM C117:2012)

b. Fine Aggregate

In this scenario, the material, fine aggregate used in concrete mixing, must first be examined for physical qualities. The following tests were performed [1]:

1) Density (based on SNI 1970:2008)
2) Filter analysis (based on SNI ASTM C136:2012)
3) Moisture content (based on SNI 1971:2011)
4) Sludge content (based on SNI ASTM C117:2012)

c. Mix Design

In this study, the planned concrete quality is fc' 20 MPa at the age of 28 days of concrete. The test object is made after the calculation of the mixed plan is complete, and the material is in good condition.

d. Test Object Manufacturing Equipment

The tools used for the manufacture of test objects are:

1) Cylindrical mould;
2) Shieve shaker machine;
3) A set of sieves;
4) Los Angeles machine;
5) Scales;
6) A set of slump test equipment;
7) Measuring cup;
8) Concrete mixer;
9) Cylindrical concrete mould 15 cm in diameter and 30 cm in height.
10) Complementary tools include a ruler, rubber hammer, tray, cup and spoon of cement.
11) Mechanical testing machine ctm (compression testing machine) is used for testing the compressive strength of concrete.
12) The test specimens are cylindrical concrete with a diameter of 15cm and a height of 30cm as many as 54 specimens, and the age of concrete is 7 and 28 days.

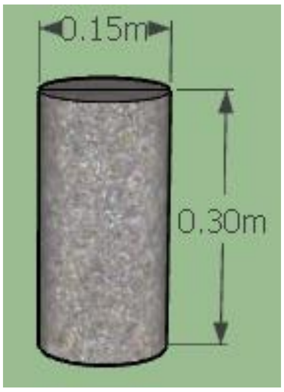

Figure 3. The shape of the concrete cylinder test object [15].

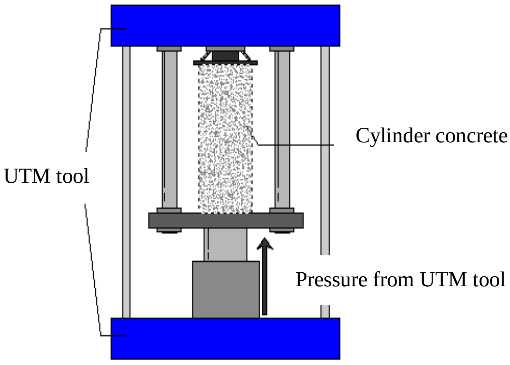

Figure 4. Testing the compressive strength of concrete.

Table 1. Number of test objects [15]**.**

Cement variation	Powder variety	Code	Age of test object	Amount
A	0.00 %	BN A	7 and 28 days	18
	1.00 %	SK 1 A		
	2.00 %	SK 2 A		
B	0.00 %	BN B	7 and 28 days	18
	1.00 %	SK 1 B		
	2.00 %	SK 2 B		
C	0.00 %	BN C	7 and 28 days	18
	1.00 %	SK 1 C		
	2.00 %	SK 2 C		

e. Concrete Compressive Strength Test

After treatment, the specimens were removed after the specified days (7 and 28 days). Then tested using a compression testing machine.

3. Results and Discussion

3.1. Test Results of Concrete Composition Materials

Table 2 describes about material test results.

Table 2. Material test results [15].

Test	Test object	Result
Water content	Coarse aggr.	1.6
	Fine aggr.	3.6
Density	Coarse aggr.	2.61
	Fine aggr.	2.33
Absorption	Coarse aggr.	0.47
	Fine aggr.	5.45
Aggregate filling weight	Coarse aggr.	1,402.67 km/m3
Sludge levels	Coarse aggr.	0.8
	Fine aggr.	7.73
Aggregate analysis	Coarse aggr.	7.03
	Fine aggr.	2.996
Aggregate wear	Coarse aggr.	19.12 %

3.2. Wood Powder Test

Table 3 describes about wood powder moisture content test results.

Table 3. Wood powder moisture content test results [15].

Object	I	II
Mass of sawdust before oven (gr.)	300	300
Mass of sawdust after oven (gr.)	272	270
Moisture content of sawdust (%)	10.29	11.11
Average (%)	10.70	

3.3. Concrete Mix Proportion

Table 4 describes about proportion of concrete mix.

Table 4. Proportion of concrete mix [15].

Material	3 Cylinder
Cement (kg)	9.47
Water (kg)	4.59
Gravel (kg)	17.68
Sand (kg)	13.08
Total (kg)	44.83

3.4. Analysis of Calculation of Compressive Strength of Concrete

Based on SNI 1974:2011 and it is known that the compressive strength (fc') is 20 MPa, the following equation can calculate it:

$$fc' = \frac{P}{A} \quad (1)$$

So that,

$20 = \frac{P}{0,25.3,14.150.150}$

P = 353250 N

P = 353.25 kN

Calculation above shows that the maximum load value is 353.25 kN.

3.5. Concrete Compressive Strength Test

3.5.1. Slump

This study used a slump of 15-17.5 cm following SNI 7656-2012. In addition, the selected slump value can facilitate workability so that the target compressive strength can be achieved.

3.5.2. Concrete compressive strength test results

Table 5. Normal concrete [15].

Code	Age (Day)	Pressing force (N)	Compressive strength (N/mm^2)	Average (N/mm^2)
BN28A	28	392.900	22.245	
BN28A	28	371.000	21.005	21.14
BN28A	28	356.200	20.167	
BN28B	28	367.000	20.778	
BN28B	28	343.800	19.465	20.63
BN28B	28	382.100	21.633	
BN28C	28	386.400	21.877	
BN28C	28	384.900	21.792	21.72
BN28C	28	379.400	21.481	

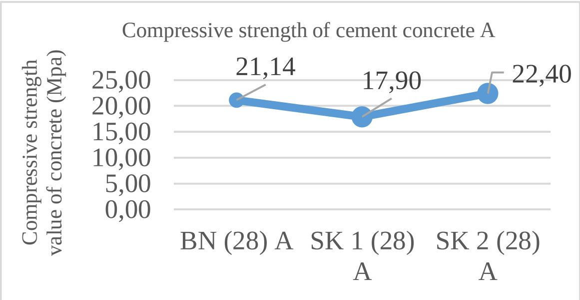

Figure 6. Graph of the relationship of cement A with sawdust. [15]

Table 6. 1% wood powder concrete [15].

Code	Age (Day)	Pressing force (N)	Compressive strength (N/mm^2)	Average (N/mm^2)
SK1A	28	319.400	18.084	
SK1A	28	307.500	17.410	17.90
SK1A	28	321.600	18.208	
SK1B	28	301.700	17.081	
SK1B	28	308.600	17.472	17.53
SK1B	28	318.400	18.027	
SK1C	28	342.700	19.403	
SK1C	28	337.100	19.086	19.50
SK1C	28	353.400	20.008	

Table 7. 2% wood powder concrete [15].

Code	Age (Day)	Pressing force (N)	Compressive strength (N/mm^2)	Average (N/mm^2)
SK2A	28	380.900	18.084	
SK2A	28	387.100	17.410	22.40
SK2A	28	418.900	18.208	
SK2B	28	372.600	17.081	
SK2B	28	377.700	17.472	21.36
SK2B	28	381.400	18.027	
SK2C	28	395.800	19.403	
SK2C	28	400.600	19.086	23.01
SK2C	28	422.700	20.008	

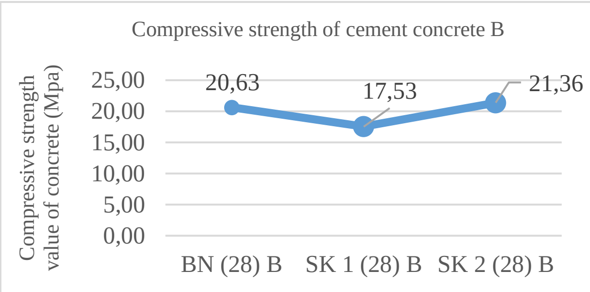

Figure 7. Graph of the relationship of cement B with sawdust. [15]

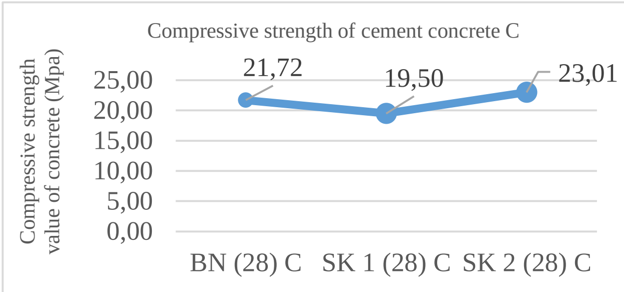

Figure 8. Graph of the relationship of cement C with sawdust. [15]

The average compressive strength of concrete obtained from the three brands of cement made by China or cement C or SK 2 C has a higher compressive strength value than the other 2 (two) cement brands, namely 23.01 Mpa. Meanwhile, Cement Manufacturer Indonesia 1 is cement A or SK 2 A, which is 22.40 MPa and cement Manufacturer Indonesia 2 is cement B or SK 2 B, which is 21.36 MPa. The average compressive strength of concrete obtained by Cement Manufacturer Indonesia 1 as cement A or SK 2 A as the second-highest can also be considered effective because the average compressive strength obtained is the second largest in this study whole.

The difference in the value of the compressive strength of concrete that occurs is influenced by several factors. The factors are the binding ability of each brand of cement, the humidity of the concrete, and the number of air voids in the concrete so that the cracking process becomes faster and the loading process automatically stops. Based on the previous two graphs, it can be concluded that all cement brands experienced a decrease in the value of the compressive strength of concrete when mixed with sawdust, as much as 1%. Too little or too much fibre content does not produce a good effect on concrete [16]. This study concluded that the mixture of Cement C and 2% sawdust has the most optimal value because it produces the greatest compressive strength of concrete, followed by Cement A with the largest 23.01 MPa, followed by Cement A with 2% sawdust, i.e. 22.40 MPa.

3.6. Crack Pattern

Further analysis of the effect of sawdust on fibre concrete can be shown in typical conditions of concrete collapse due to the loading that occurs in fibre concrete due to the use of sawdust with a Universal Testing Machine (UTM) machine.

(a) (b) (c)

Figure 9. Documentation of the failure pattern of cylindrical concrete (a) normal, (b) 1% sawdust concrete, and (c) 2% sawdust concrete. [15]

Figure 9 shows the failure pattern due to continuous loading of the entire test object, namely normal concrete, concrete with 1% sawdust, and concrete with 2% sawdust. The crack pattern is a failure pattern parallel to the vertical (columnar) axis. The failure pattern is visually in the form of cracks from the top surface of the concrete that continues to the middle or concrete base.

4. Conclusions

Based on the results of testing the compressive strength of cement, cement made by China as cement C has a superior compressive strength value compared to cement from Indonesian Manufacturer 1 as cement A and cement from Indonesian Manufacturer 2 as cement B. The result can be seen from the value of the compressive strength of concrete under normal concrete conditions or not mixed with sawdust, which results in the compressive strength of cement C 21.72 Mpa, cement A 21.14, Cement B 20.63 Mpa. The effect of Kayu Bayur powder is as much as 2% can increase the compressive strength of concrete in all cement brands. The result is indicated by the compressive strength value, which exceeds the design compressive strength value of 20 MPa. These results indicate that the mixture of Cement C with 2% sawdust has the most optimal value because it produces the greatest concrete compressive strength of 23.01 Mpa.

References

[1] Anugraha, R. B., & Mustaza, S. (2010). Beton ringan dari campuran Styrofoam dan serbuk gergaji dengan semen Portland 250, 300 dan 350 kg/m3. *Jurnal Aplikasi Teknik Sipil*, vol. 8, no. 2, pp. 57-66.

[2] Royani, I. F., Basuki, A., & Sunarmasto, S. (2014). Kajian kuat tekan, kuat tarik, kuat lentur dan redaman bunyi pada panel dinding beton ringan dengan agregat limbah plastik pet dan limbah serbuk kayu. *Matriks Teknik Sipil*, vol. 2, no. 4, pp. 641–648.

[3] Boni, L. O. M. I., Nasrul, N., & Talanipa, R. (2019). Pemanfaatan limbah gergaji sebagai bahan subtitusi pasir sabulakoa terhadap campuran mortar. *Stabilita*, vol. 7, no. 1, no. 31–38.

[4] Fauzi, M. F., & Nursyamsi, N. (2014). Pemanfaatan limbah serbuk kayu (sawdust) sebagai subtitusi agregat halus pada campuran beton. *Jurnal Teknik Sipil USU*, vol. 3, no. 2, pp. 1-7.

[5] Hepiyanto, R., & Arif, S. (2019). Pengaruh Variasi penambahan abu serbuk gergaji kayu pada pasta semen terhadap uji bahan semen. *Rang Teknik Journal*, vol. 2, no. 1, 117 – 122.

[6] Istighfar, I., Kurniawandy, A., & Ermiyati, E. (2019). analisa perbandingan kuat tekan beton semen PCC dan semen tipe 1 terhadap pemakaian sikament. *JOM Bidang Teknik dan Sains*, vol. 1, no. 1, 1-15.

[7] Masril, M., & Putra, H. (2021). Analisa pengaruh substitusi serbuk kayu surian dengan agregat halus terhadap rencana kuat tekan beton. *Ensiklopedia of Journal*, vol. 3, no. 2, pp. 69-80.

[8] Saifuddin, M. I., Edison, B., & Fahmi, K. (2013). Pengaruh penambahan campuran serbuk kayu terdahap kuat tekan beton. [*Disertasi*]. Riau: Universitas Pasir Pengaraian.

[9] Salain, I. M. A. K. (2012). Pengaruh jenis semen dan jenis agregat kasar terhadap kuat tekan beton. *Teknologi dan Kejuruan: Jurnal teknologi, Kejuruan dan Pengajarannya*, vol. 32, no. 1, pp. 63-70.

[10] Siswadi, S., Rapa, A., & Puspitasari, D. (2009). Pengaruh penambahan serbuk kayu sisa penggergajian terhadap kuat desak beton. *Jurnal Teknik Sipil Universitas Atma Jaya Yogyakarta*, vol. 7, no. 2, pp. 144–151.

[11] Widari, L. A. (2021). Pengaruh penggunaan abu serbuk kayu terhadap kuat tekan dan daya serap air pada paving block. *Teras Jurnal*, vol. 5, no. 1,pp. 51-59.

[12] Fuad, I. S., Perwira, A., & Jayusman, H. (2020). Pengaruh pemakaian semen dan pasir yang berbeda terhadap kuat tekan beton. *Jurnal Desiminasi Teknologi*, vol. 8, no. 1, pp. 8-12.

[13] Wiyono, S., Zulhendri, Z., Alfajrizal, M., & Puri, A. (2018). Kajian perbandingan penggunaan berbagai merek semen dengan dan tanpa perawatan terhadap kuat tekan dan kuat lentur beton pada perkerasan kaku. *Jurnal Saintis*, vol. 18, no. 2, pp. 33-42.

[14] Tjokrodimuljo, K. (1996). *Teknologi Beton*. Yogyakarta: Penerbit Nafiri.

[15] Darwis, Z., Kuncoro, H. B. B., & Delpiero, A. X. (2021). Analisis pendahuluan: Pemanfaatan serbuk gergaji pada kuat tekan beton dengan variasi semen. [*Private Document*].

[16] Nugraha, P. (2007). *Teknologi Beton: Dari Material, Pembuatan, ke Beton Kinerja Tinggi*. Yogyakarta: Andi.