

ANALYSIS OF LIGHTWEIGHT BRICK WASTE FOR PARTIAL SUBSTITUTION OF FINE AGGREGATE ON CONCRETE COMPRESSIVE STRENGTH

Ihsan Taqwa¹, Yonas Prima Arga Rumbyarso², Lydia Darmiyanti³

^{1,2,3}Department of Civil Engineering, Krisnadwipayana University
Email : Ihsantaqwa29@gmail

ABSTRACT

The construction industry in Indonesia is experiencing a significant increase, fueled by government infrastructure development. Concrete is the material of choice as it is easy to use, economical and strong. However, excessive sand mining has a negative impact on the environment, including land degradation and pollution. The increase in construction has led to an increase in construction waste, which, if managed properly, can be profitable. Effective waste management is crucial to address environmental concerns and the utilization of waste lightweight bricks offers a cost-effective and efficient solution. Studies related to the use of waste lightweight bricks as a partial replacement for sand in concrete are highly relevant. The results of compressive strength testing on normal concrete at the age of 28 days obtained based on data analysis and discussion that has been presented in the previous chapter regarding the use of waste lightweight brick powder fibers with variations of 0%, 5%, and 10% are 439 kN (f'c 24.85 Mpa), while variation 1 of 10% lightweight brick powder waste reaches 344 kN (f'c 19.48 Mpa), and variation 2 of 15% lightweight brick powder waste reaches 308 kN (f'c 17.44 Mpa).

Keywords: Concrete, Concrete Compressive Strength, Waste Lightweight Brick Powder

INTRODUCTION

The construction industry in Indonesia has experienced significant growth, driven by government infrastructure development. Concrete is the material of choice because it is easy to use, economical, and strong (Pribadi, G., Darmiyanti, L., & Martinus, M., 2023). However, excessive sand mining has negative impacts on the environment, including land degradation and pollution. Increased construction leads to increased construction waste, which if managed properly, can be profitable (Abdillah, S. R., Zulfikar, S., & Prima, Y., 2023). Effective waste management is crucial to addressing environmental issues and the utilization of lightweight brick waste offers an economical and efficient solution. Studies related to the use of lightweight brick waste as a partial substitute for sand in concrete are very relevant.

METHODS

This study uses an experimental method with a series of laboratory tests to evaluate and compare the results. The testing process in the study includes material analysis, preparation of a concrete mix plan, concrete viscosity testing through slump tests, making test samples, concrete curing, and concrete compressive strength testing. The implementation of the study is divided into several stages of implementation, including:

- 1) At this stage, the equipment and materials used in the implementation of the study are provided;
- 2) At this stage, testing is carried out on the concrete components such as:
 - a) Specific gravity testing on aggregates;
 - b) Testing to pass through the sieve.
- 3) Called the concrete mix planning stage (mix design) based on the SK SNI 03-2834-2000 method.
- 4) Making test objects or test object samples, the samples used in this test object consist of several comparison variations:
 - a) Normal concrete variation without the addition of plastic bottle waste;
 - b) Concrete variation with the addition of 3% plastic bottle waste;
 - c) Concrete variation with the addition of 6% plastic bottle waste.
- 5) Slump test refers to SNI 1972-2008;
- 6) Concrete treatment (curing) is carried out by immersion in water;
- 7) Concrete compressive strength testing is carried out after the concrete is 7 days, 14 days, and 28 days old;
- 8) At this stage, the data obtained from the test results will be analyzed to obtain the relationship between the variables studied;
- 9) The last stage is drawing conclusions, at this stage the data that has been analyzed must be drawn into a conclusion related to the research objectives.

Research Flow Chart

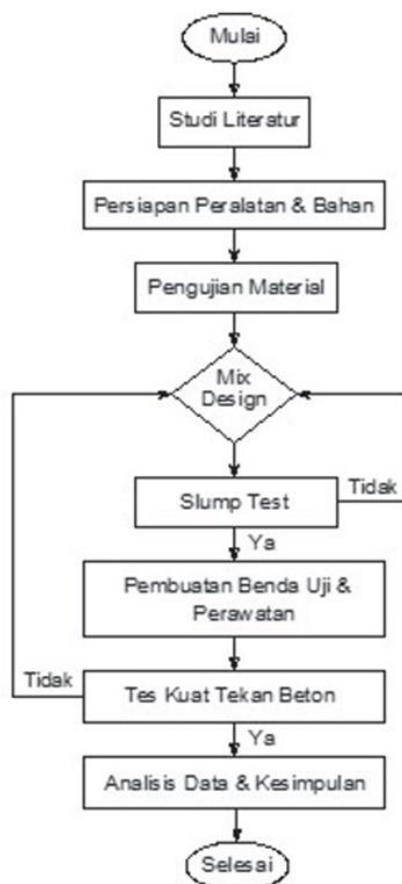


Figure 3. Research Flowchart

Before starting the research, it is necessary to prepare the tools and materials so that the process runs smoothly. The tools used must first be cleaned from dust or dirt that sticks. For example, the concrete cylinder must be cleaned to avoid bolts that get stuck or stuck when opening and removing. The walls of the concrete cylinder also need to be lubricated so that the concrete that has been poured and dried does not stick to the walls. Similar preparations are needed for other tools such as scales, ovens, and mixers. Materials need to be available in full from the beginning to the end of the research, including sand, crushed stone, water, and cement, to ensure there are no shortages. In addition, materials must be stored in a place protected from direct exposure to the weather to maintain their quality.

- 1) Slump testing on concrete is a measurement of the decrease in the height of the concrete that occurs immediately after the slump mold is lifted, according to SNI 1972-2008. This test assesses the water balance in the concrete mixture, with a target decrease of around $10 \text{ cm} \pm 2$;
- 2) The concrete molding process is in accordance with SNI 2493-2011 which describes how to make and maintain concrete test objects in the laboratory. This process involves the formation of cylindrical concrete that will be tested for compressive strength;
- 3) Concrete treatment is also regulated by SNI 2493-2011, which includes methods for maintaining concrete characteristics through the curing or treatment process;
- 4) The purpose of this test is to determine the compressive strength of the concrete sample that has been made, for application in the field according to established procedures. The compressive strength of concrete is measured based on the magnitude of the load per unit area that can cause the concrete test object to break when pressed with a compressive strength testing machine.

RESULTS AND DISCUSSION

The results of the material inspection, including aggregate test analysis, fresh concrete, and hardened concrete, were obtained from the Concrete Technology Laboratory of Krisnadwipayana University, Jakarta. The results of the testing and analysis are then presented in this chapter as graphs and tables.

Table 1 Results of Sand Gradation Testing

Lolos Ayakan		Berat Tak Lolos (gr)	Jumlah Tak Lolos (gr)	Jumlah Prosentase		Tidak Lolos Kumulatif (%)
SNI (mm)	ASTM			Tak Lolos (%)	Lolos (%)	
9,52	3/8 in	0	0	0,00	100,00	0,00
4,75	NO.4	30	30	3	97	3
2,36	NO.8	70	100	10	90	10
1,18	NO.16	142	242	24,2	75	24,2
0,6	NO.30	128	370	37	63	37
0,3	NO.50	133	503	50,3	49,7	50,3
0,15	NO.100	277	780	78	22	78
0,075	NO.200	220	1000	100	0	0
Jumlah		1000		100		202,5
Modulus Kehalusan						2.025
Hasil analisis uji modulus Kehalusan = $202.5 / 100 = 2.025$ Sesuai spek SNI-S-04-1989-F nilai modulus pasir 1,50-3,80						

There are 2 (two) methods for testing mud and sand clay content: volume and weight.

Table 2 Average Content of Sand Mud

No	Uraian	Hasil	
1	Mangkuk	1	2
2	Sebelum dicuci, berat kering (A) gram	500	500
3	Setelah dicuci, berat pasir kering (B) gram	492,3	491,6
4	Kandungan lumpur $((A) - (B) / A) \times 100 \%$	1,54	1,68
	Kandungan lumpur rata-rata (%)	1,61	
Temuan pengujian : 1,61% kandungan lumpur			
Nilai kadar pasir < 5% adalah nilai maksimum yang diperbolehkan oleh spesifikasi SNI-S-04-1989-F.			

The results of the specific gravity and absorption test of concrete sand for concrete mixtures are shown in Table 3 below.

Table 3 Results of Specific Gravity & Absorption Test of Sand

Berat Jenis dan Penyerapan Pasir Bogor				
No.	Uraian	Satuan	Rumus	Percobaan
1	Bobot pasir kering mutlak (BK)	Gr	-	473,1
2	Bobot partikel pasir (SSD)	Gr	-	500
3	Bobot piknometer ditambah Air ditambah Pasir(BT)	Gr	-	970
4	Bobot Piknometer ditambah Air (B)	Gr	-	667
5	Bobot jenis curah	-	$BK / (B + SSD - BT)$	2,317
6	Bobot jenis SSD	-	$SSD / (B + SSD - BT)$	2,538
7	Bobot jenis semu	-	$BK / (B + BK - BT)$	2,668
8	Daya serap air	%	$(SSD - BK) / BK * 100$	5,686

Table 4 to Table 6 shows the split analysis for the split stone used in this test, which has a maximum size of 4 cm.

Table 4 Split Sieve Analysis Results Test

Berat Jenis dan Penyerapan Pasir Bogor				
No.	Uraian	Satuan	Rumus	Percobaan
1	Bobot pasir kering mutlak (BK)	Gr	-	473,1
2	Bobot partikel pasir (SSD)	Gr	-	500
3	Bobot piknometer ditambah Air ditambah Pasir(BT)	Gr	-	970
4	Bobot Piknometer ditambah Air (B)	Gr	-	667
5	Bobot jenis curah	-	$BK / (B + SSD - BT)$	2,317
6	Bobot jenis SSD	-	$SSD / (B + SSD - BT)$	2,538
7	Bobot jenis semu	-	$BK / (B + BK - BT)$	2,668
8	Daya serap air	%	$(SSD - BK) / BK * 100$	5,686

Table 5 Results of Specific Gravity and Split Absorption Tests

Uji Analisis Berat Jenis dan Daya Serap Air Split				
No	Keterangan	Satuan	Rumus	Hasil Uji Analisis
1	Bobot agregat kering mutlak (BK)	gr	-	4895,5
2	Bobot split (SSD)	gr	-	5000
3	Bobot split di dalam air (BA)	gr	-	3047
4	Bobot jenis curah	-	$BK / (SSD - BA)$	2,507
5	Bobot jenis SSD	-	$SSD / (SSD - BA)$	2,560
6	Bobot jenis semu	-	$BK / (BK - BA)$	2,648
7	Daya serap air	%	$(SSD - BK) / BK * 100$	2,135

Table 6 Split Wear Test Results

Uji Analisis Berat Jenis dan Daya Serap Air Split				
No	Keterangan	Satuan	Rumus	Hasil Uji Analisis
1	Bobot agregat kering mutlak (BK)	gr	-	4895,5
2	Bobot split (SSD)	gr	-	5000
3	Bobot split di dalam air (BA)	gr	-	3047
4	Bobot jenis curah	-	$BK / (SSD - BA)$	2,507
5	Bobot jenis SSD	-	$SSD / (SSD - BA)$	2,560
6	Bobot jenis semu	-	$BK / (BK - BA)$	2,648
7	Daya serap air	%	$(SSD - BK) / BK * 100$	2,135

For the use of sand substitute materials using lightweight brick powder waste of 10% and 15%.

The specific gravity of rubber seeds can be seen below,

1. The specific gravity of lightweight brick powder needed as a substitute for sand is 10% = 10% lightweight brick powder. weight of sand. cylinder volume = 0.17 kg
2. The specific gravity of lightweight brick powder needed as a substitute for sand is 15% = 15% lightweight brick powder. weight of sand. cylinder volume = 0.34 kg

Table 7 Concrete Slump Test Analysis

Desain Campuran	Nilai Slump	Satuan
Beton f'c 25 Mpa.	8	cm
Beton f'c 25 MPa variasi 10% limbah serbuk bata ringan sebagai substitusi pasir	10	cm
Beton f'c 25 MPa variasi 15% limbah serbuk bata ringan sebagai substitusi pasir	11	cm
Rata-rata	9,7	cm



Figure 4. Normal Concrete Slump Test

Table 8 Compressive Strength Analysis Test of 7-Day-Old Cylinder Concrete Load

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	28 Mei 2024	4 Juni 2024	7	10,84	263		
2	fc'25	28 Mei 2024	4 Juni 2024	7	11,11	274	265	59,95%
3	fc'25	28 Mei 2024	4 Juni 2024	7	11,7	259		
1	10% BR	7 Juni 2024	14 Juni 2024	7	11,7	194		
2	10% BR	7 Juni 2024	14 Juni 2024	7	11,84	220	207	46,83%
3	10% BR	7 Juni 2024	14 Juni 2024	7	11,83	207		
1	15% BR	13 Juni 2024	20 Juni 2024	7	11,54	210		
2	15% BR	13 Juni 2024	20 Juni 2024	7	11,6	228	206	46,61%
3	15% BR	13 Juni 2024	20 Juni 2024	7	11,5	180		

Table 9 Compressive Strength Analysis Test of 14-Day-Old Cylinder Concrete Load

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	28 Mei 2024	11 Juni 2024	14	11,91	366		
2	fc'25	28 Mei 2024	11 Juni 2024	14	12,14	371	371	83,94%
3	fc'25	28 Mei 2024	11 Juni 2024	14	11,8	376		
1	10% BR	7 Juni 2024	21 Juni 2024	14	11,7	296		
2	10% BR	7 Juni 2024	21 Juni 2024	14	11,81	302	297	67,19%
3	10% BR	7 Juni 2024	21 Juni 2024	14	11,91	293		
1	15% BR	13 Juni 2024	27 Juni 2024	14	11,51	236		
2	15% BR	13 Juni 2024	27 Juni 2024	14	11,81	265	262	59,28%
3	15% BR	13 Juni 2024	27 Juni 2024	14	11,7	286		

Table 10 Compressive Strength Analysis Test of 28-Day-Old Cylinder Concrete Load

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	28 Mei 2024	25 Juni 2024	28	11,84	444	439	99,32%
2	fc'25	28 Mei 2024	25 Juni 2024	28	12	438		
3	fc'25	28 Mei 2024	25 Juni 2024	28	11,6	435		
1	10% BR	7 Juni 2024	5 Juli 2024	28	11,7	357	344	77,83%
2	10% BR	7 Juni 2024	5 Juli 2024	28	11,83	346		
3	10% BR	7 Juni 2024	5 Juli 2024	28	11,81	328		
1	15% BR	13 Juni 2024	11 Juli 2024	28	11,54	295	308	69,68%
2	15% BR	13 Juni 2024	11 Juli 2024	28	11,6	307		
3	15% BR	13 Juni 2024	11 Juli 2024	28	11,5	322		

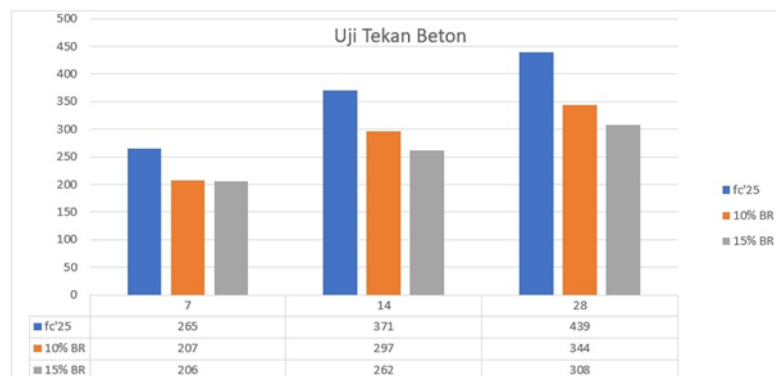


Figure 5. Normal Concrete Compression Test Bar Diagram, Variation 1 & Variation 2

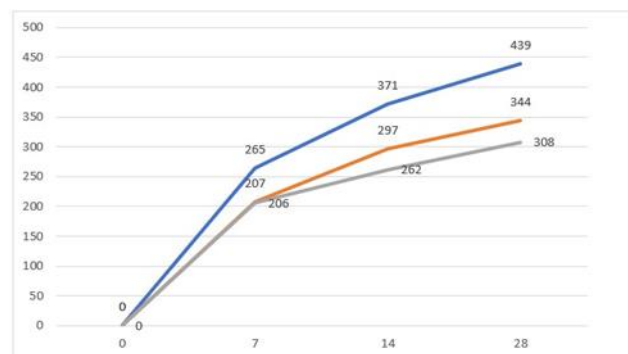


Figure 6. Normal Concrete Compression Test Graph, Variation 1 & Variation 2

CONCLUSIONS

The results of the compressive strength test on normal concrete at the age of 28 days were obtained based on data analysis and discussion that have been presented in the previous chapter regarding the use of lightweight brick powder waste with variations of 0%, 5%, and 10%, namely 439 kN (f'_c 24.85 Mpa), while variation 1 lightweight brick powder waste 10% reached 344 kN (f'_c 19.48 Mpa), and variation 2 lightweight brick powder waste 15% reached 308 kN (f'_c 17.44 Mpa).

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