

THE EFFECT OF CONCRETE COMPRESSIVE STRENGTH TESTING USING RUBBER SEED SUBSTITUTION AS A PARTIAL REPLACEMENT OF FINE AGGREGATE

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ABSTRACT

The idea of environmental conservation has influenced the development of more environmentally friendly construction technologies, with the integration of natural materials such as rubber seed waste into construction materials. The construction industry faces challenges from production waste and material requirements that increase with population growth. Utilizing waste as an alternative material not only reduces pollution but also helps conserve non-renewable natural resources, such as replacing sand with rubber seeds in concrete mixes. The results of compressive strength testing on normal concrete at the age of 28 days reached 440 kN (f'_c 24.91 Mpa), while variation 1 of 5% rubber seed waste reached 310 kN (f'_c 17.55 Mpa), and variation 2 of 10% rubber seed waste reached 276 kN (f'_c 15.63 Mpa). The compressive strength of concrete using rubber seed waste as a fine aggregate substitution with a 5% variation obtained an average compressive strength at the age of 7, 14, and 28 days of 8.72 MPa, 15.06 MPa and 17.55 MPa. The compressive strength of concrete using rubber seed waste as a substitute for fine aggregate with a 10% variation obtained the average compressive strength at the age of 7, 14, and 28 days of 7.81 MPa, 12.63 MPa, and 15.63 MPa. It does not meet the SNI 1974-2011 standard that the compressive strength of f'_c 25 concrete plan at the age of 7 days is 60% with a value of 15.06 MPa, the age of 14 days is 84% with a value of 21.06 MPa, the age of 28 days is 100% with a value of 24.91 MPa.

Keywords: Concrete, Compressive Strength, Rubber Seeds.

INTRODUCTION

The idea of environmental conservation has influenced the development of more environmentally friendly construction technologies, with the integration of natural materials such as rubber seed waste into construction materials. The construction industry faces challenges from production waste and increasing material needs as the population grows.

Utilizing waste as an alternative material not only reduces pollution but also helps conserve non-renewable natural resources, such as replacing sand with rubber seeds in concrete mixes.

METHODS

An experimental design combining independent and dependent variables was used to conduct this investigation. The independent variable of this study included the use of rubber seed residue as a partial replacement for split concrete. In this study, standard concrete with a strength of 25 MPa, or equivalent to K-300, was the dependent variable.

Table 1. Total Test Cylinder Samples

No	Sampel Silinder Uji	Total Sampel Tergantung Pada Usia Pengujian (Hari)			Jumlah
		7	14	28	
1	Beton Standar f_c 25 MPa atau K-300	3	3	3	9
2	Penambahan limbah biji karet sebagai pengganti sebagian pasir dengan variasi 5 % penambahan limbah biji karet	3	3	3	9
3	Penambahan limbah biji karet sebagai pengganti sebagian pasir dengan variasi 10 %	3	3	3	9
Total Sampel Uji					27

The research instruments include digital weighting, cylindrical concrete molds, concrete mixers, concrete compressive strength testing tools, Los Angeles abrasion machines, analysis shieve, rubber hammers, ovens, Abram cones, 16 mm diameter and 600 mm long 1 stick, slump test base plate, meter, cart, cement scoop.



Figure 3. Concrete Load Compressive Strength Test Equipment

Research Flowchart

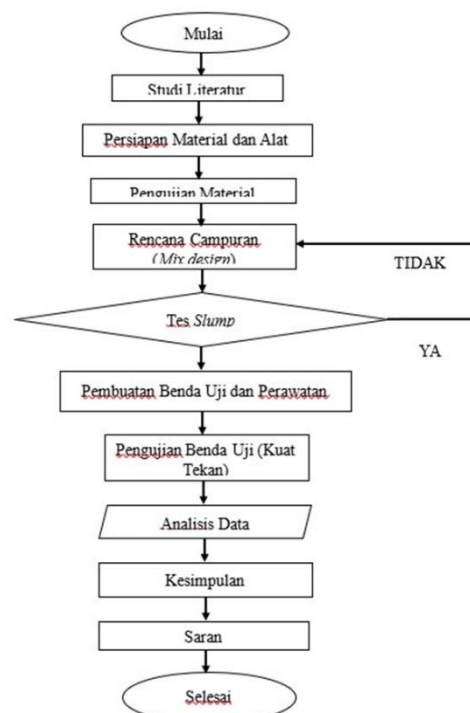


Figure 4. Research Flowchart

In addition to functioning as a data search procedure for the concrete mix design process, testing is carried out to ensure that the quality of the material meets the relevant standards for each test.

Among the experiments carried out include: aggregate density and absorption experiments, sieve passing tests, aggregate sieve tests, aggregate water content tests, aggregate specific gravity and porosity tests.

Job design mix, Table 2 below shows the volume of each test cylinder sample.

Table 2 Concrete f'c 25 MPa for 1 Cylinder

No	Material	Volume	Satuan
1	Semen	2,412	Kg
2	Pasir	3,592	Kg
3	Split	5,476	Kg
4	Air	0,928	Kg

To make concrete, first calculate and record the material requirements according to the mix design and the number of test objects to be made. Weigh all materials based on these calculations, prepare a concrete mixer in a flat place and close to the drain. Add water and cement alternately into the mixer, followed by sand. After mixing, add split stone and replacement material. Let the mixture stir for about 5 minutes until evenly distributed. Pour the concrete mixture into a tray plate to facilitate slump testing.

For slump testing, first wet the abram cone and other equipment. Install the cone with the larger opening at the bottom on the base plate. When filling, the operator holds the mold from the steps and fills it with freshly mixed concrete from the mixer. Divide the concrete into three layers, stab each layer at least 25 times with a skewer without touching the base plate. After compacting, lift the Abram cone vertically and carefully within 5 ± 2 seconds, then measure the reduction in concrete height using a meter. Calculate the slump value by dividing the reduction in height by the height of the concrete after settlement. Record and document the slump test results.

To make the concrete test specimen, clean the excess concrete from the inside of the cube mold and lubricate it with oil using a brush. Pour fresh concrete from the mixer into the mold using a cement trowel. Fill the mold with three layers of concrete, piercing each layer at least 25 times if the sample diameter is 150 cm. Fill the mold to the top and smooth the top surface with a cement trowel. Repeat this step for the next mold until all are filled.

RESULTS AND DISCUSSION

This chapter summarizes the analysis of compressive strength testing between ordinary concrete and concrete with rubber seed waste. In addition to splitting wear testing with the Los Angeles abrasion machine for aggregates, this study also uses gradation and specific gravity analysis. The compressive strength of concrete is measured using a compression test machine on new concrete mixtures and samples that have been produced.

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

Table 3 Results of Sand Gradation Tests

Lolos Ayakan		Berat Tak Lolos	Jumlah Tak Lolos	Jumlah Prosentase		Tidak Lolos Kumulatif
				Tak Lolos	Lolos	
SNI (mm)	ASTM	(gr)	(gr)	(%)	(%)	(%)
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 4 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) x 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 5 below.

Table 5 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	%	$(SSD - BK) / BK \times 100$	5,686

For the experiment, the mixture proportion with the shrinkage number was added. The mixture shrinkage number is around 10% - 20%, taken 15%, so that the mixture proportion with the shrinkage number is obtained as follows:

Table 6 Mixture Proportion with Shrinkage Number

	Semen (kg)	Air (kg)	Agregat	
			Halus (kg)	Kasar (Kg)
<u>Rasio campuran :</u> <u>Secara teori</u>	1	0,55	2,09	3,45
Setiap m3	390	185	696,15	1088,85
Setiap campuran uji: 0,0159 m3	0,0159 x 390 = 6,20	0,0159 x 185 = 2,94	0,0159 x 696,15 = 11,07	0,0159 x 1088,85 = 17,31
Proporsi campuran dengan angka penyusutan 7,5%	1	0,55	2,09	3,45
Setiap m3	420	199	748	1170
Setiap campuran uji: 0,0159 m3	0,0159 x 425,5 = 6,67	0,0159 x 212,75 = 3,38	0,0159 x 809,5 = 12,87	0,0159 x 1266,2 = 20,13

Rubber Substitute Material

For the use of sand substitute materials using rubber seeds of 5% and 10%. The specific gravity of rubber seeds can be seen below,

- 1) The specific gravity of rubber seeds needed as a substitute for sand is 5%
= 5% rubber seeds. weight of sand. cylinder volume
= 0.17 kg
- 2) The specific gravity of rubber seeds needed as a substitute for sand is 10%
= 10% rubber seeds. weight of sand. cylinder volume
= 0.34 kg

The concrete samples were tested for compressive strength after 7, 14, and 28 days using a compression test machine. This tool uses a digital display to show the value in kN. In addition to Table 7 to Table 9, the data from the concrete compressive strength test can be seen in Figures 5 and 6 below.

Table 7 Test Analysis of Compressive Strength of Concrete Cylinder Loads at 7 Days

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	Hasil Kuat Tekan (N/mm ²)(Mpa)
1	fc'25	27 Mei 2024	3 Juni 2024	7	11,85	265			15,00
2	fc'25	27 Mei 2024	3 Juni 2024	7	12,1	274	266	60,18%	15,51
3	fc'25	27 Mei 2024	3 Juni 2024	7	11,7	260			14,72
Rata-Rata									15,06
1	5% BK	6 Juni 2024	13 Juni 2024	7	11,8	154			8,72
2	5% BK	6 Juni 2024	13 Juni 2024	7	11,85	176	154	34,84%	9,96
3	5% BK	6 Juni 2024	13 Juni 2024	7	11,85	132			7,47
Rata-Rata									8,72
1	10% BK	13 Juni 2024	20 Juni 2024	7	11,55	123			6,96
2	10% BK	13 Juni 2024	20 Juni 2024	7	11,7	160	138	31,22%	9,06
3	10% BK	13 Juni 2024	20 Juni 2024	7	11,6	130			7,36
Rata-Rata									7,81

Table 8 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	Hasil Kuat Tekan (N/mm ²)(Mpa)
1	fc'25	27 Mei 2024	10 Juni 2024	14	11,95	367			20,78
2	fc'25	27 Mei 2024	10 Juni 2024	14	12,16	372	372	84,16%	21,06
3	fc'25	27 Mei 2024	10 Juni 2024	14	11,9	377			21,34
Rata-Rata									21,06
1	5% BK	6 Juni 2024	20 Juni 2024	14	11,6	251			14,21
2	5% BK	6 Juni 2024	20 Juni 2024	14	11,8	262	266	60,18%	14,83
3	5% BK	6 Juni 2024	20 Juni 2024	14	11,9	284			16,08
Rata-Rata									15,06
1	10% BK	13 Juni 2024	27 Juni 2024	14	11,5	224			12,68
2	10% BK	13 Juni 2024	27 Juni 2024	14	11,8	231	223	50,45%	13,08
3	10% BK	13 Juni 2024	27 Juni 2024	14	11,4	213			12,06
Rata-Rata									12,63

Table 9 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	Hasil Kuat Tekan (N/mm ²)(Mpa)
1	fc'25	27 Mei 2024	24 Juni 2024	28	11,85	445			25,19
2	fc'25	27 Mei 2024	24 Juni 2024	28	12,1	439	440	99,55%	24,85
3	fc'25	27 Mei 2024	24 Juni 2024	28	11,7	436			24,69
Rata-Rata									24,91
1	5% BK	6 Juni 2024	4 Juli 2024	28	11,6	316			17,89
2	5% BK	6 Juni 2024	4 Juli 2024	28	11,8	289	310	70,14%	16,36
3	5% BK	6 Juni 2024	4 Juli 2024	28	11,7	324			18,34
Rata-Rata									17,55
1	10% BK	13 Juni 2024	13 Juli 2024	28	11,5	263			14,89
2	10% BK	13 Juni 2024	13 Juli 2024	28	11,6	277	276	62,44%	15,68
3	10% BK	13 Juni 2024	13 Juli 2024	28	11,8	288			16,31
Rata-Rata									15,63

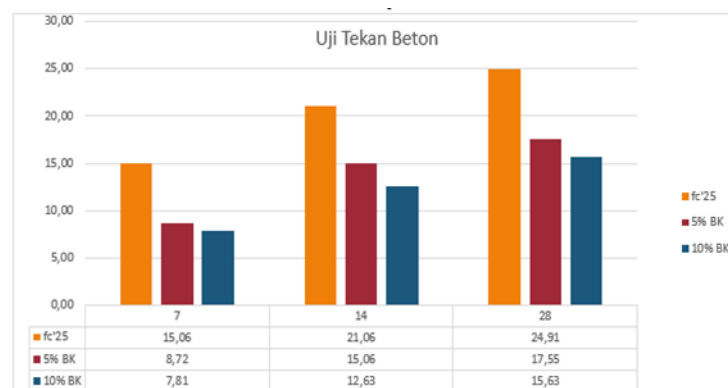


Figure 5. Normal Concrete Compression Test Bar Diagram, Variation 1 and Variation 2

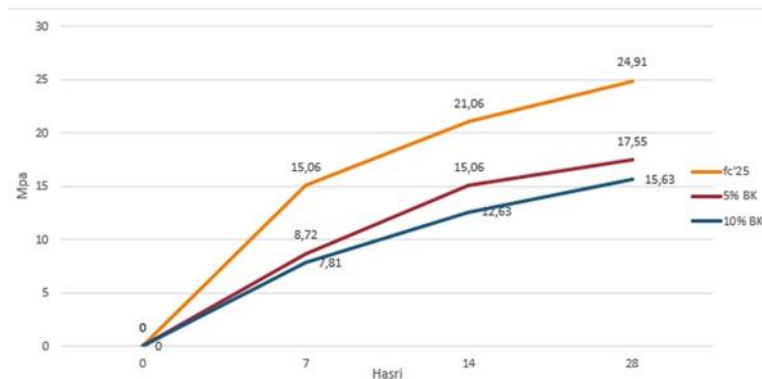


Figure 6. Normal Concrete Compression Test Graph, Variation 1 and Variation 2

CONCLUSIONS

The results of the compressive strength test on normal concrete at the age of 28 days reached 440 kN (f'_c 24.91 Mpa), while variation 1 of 5% rubber seed waste reached 310 kN (f'_c 17.55 Mpa), and variation 2 of 10% rubber seed waste reached 276 kN (f'_c 15.63 Mpa). The compressive strength of concrete using rubber seed waste as a substitute for fine aggregate with a variation of 5% obtained an average compressive strength at the ages of 7, 14, and 28 days of 8.72 MPa, 15.06 MPa and 17.55 MPa. The compressive strength of concrete using rubber seed waste as a substitute for fine aggregate with a variation of 10% obtained an average compressive strength at the ages of 7, 14, and 28 days of 7.81 MPa, 12.63 MPa, and 15.63 MPa. It does not meet the SNI 1974-2011 standard that the design compressive strength of f'_c 25 concrete at 7 days is 60% with a value of 15.06 MPa, at 14 days is 84% with a value of 21.06 MPa, at 28 days is 100% with a value of 24.91 MPa.

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