Evaluation of the strength of coconut shell aggregate concrete block for parking area

IOP Conf. Series: Earth and Environmental Science **277** (2019) 012002 doi:10.1088/1755-1315/277/1/012002

Evaluation of the strength of coconut shell aggregate concrete block for parking area

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Abstract. The development of green technology requires the utilization of waste products and processing of them into cheap and environmentally friendly materials. The idea was applied in the concrete block (conblock) production. The usage of coconut shell waste for the concrete mixed material will reduce the cost and produce an environmentally friendly road conblock for pavement, which also quickly absorbs runoff into the soil so that pavement is more durable.The purpose of this research was to evaluate the compressive strength of concrete obtained by the addition of fine aggregate mixture and a coarse aggregate of coconut shell. The test specimens used were cubes with a size of 15x15x15 cm consisting of 5 samples for each variation of coconut shell and powder content (0%, 20%, 25%, and 30%) and tested at 28 days. The average yield of compressive strength and absorption at 28 days were 18.5 MPa and 22% for 0% variation, 11.4 MPa and 16% for 20% variation, 7.6 MPa and 14% for 25% variation, and 6.7 MPa and 12% for 30% variation. The results inform that the concrete given a mixture of fine and coarse aggregate coconut shell has decreasing compressive strength and absorption.

1. Introduction

The fast development of the era and technology nowadays bring to the consequence that the use of waste to be processed into a mixture of materials that are environmentally friendly is obligatory. By utilizing the products of waste origins, we can save costs while reducing the environmental pollution that results from the production of waste.

Production of construction materials for road pavements that are environmentally friendly is currently intensified, in the hope that it can help in absorbing surface water into the soil. Therefore not all road pavements should use cast concrete or asphalt because these materials do not allow surface water to be absorbed quickly into the soil, consequently will cause damage to the pavement. For this reason, conblock is used as an alternative to road pavement (Figure 1). Conblock is a composite of building materials made from a mixture of Portland cement, water, stone, fine aggregate and coarse aggregate.

One of the household wastes that we often find in Indonesia is coconut shells, which is usually only used to replace firewood. This research reported the utilization of coconut shell waste into additional material in making conblock which is expected to be useful as one alternative additive in conblock production.

Figure 1. Pavement of parking area made of conblock.

2. Material and Methods

2.1. Definition, quality requirements and classification of conblock

2.1.1. *Definition and quality requirements.* Concrete brick (paving block) is a composition of building materials made from a mixture of Portland cement or similar hydraulic adhesive materials, water, and aggregate with or without other additives that do not reduce the quality of the concrete brick. Paving blocks have to meet the requirements shown in Table 1 [1,2].

Table 1. Physical properties.

Quality	Uses	Compressive strength (MPa)		Wear Resistance (mm/minute)		Maximum water absorption (%)
		Average	Min	Average	Min	
A	Road	40	35	0.090	0.103	3
B	Parking	20	17.0	0.130	0.149	6
C	Pedestrians	15	12.5	0.160	0.184	8
D	Parks and other uses	10	8.5	0.219	0.251	10

2.1.2. Classification. Based on Indonesian National Standard (SNI 03-2403-1991), the classification of conblock (concrete block) is shown in Table 2 [3,4].

2.2. Concrete forming material

2.2.1. Cement. In this study, the cement used was a type of composite Portland cement (PCC). Portland cement composite is a hydraulic bonding material that is milled together with portland cement slag and cast with one or more inorganic materials or the result of mixing of portland cement powder with other inorganic powder ingredients. Inorganic materials include blast furnace slag, pozzolan, a silicate compound, limestone, with a total content of inorganic materials 6%-35% of the mass of composite Portland cement. This composite Portland cement can be used for general construction such as concrete work, masonry, gutters, roads, wall fences and the construction of special building elements such as precast concrete, prestressed concrete, concrete panels, concrete brick (paving blocks) etc [5,6].

Table 2. Conblock classification.

Classification Type	Description
Based on the form	The form of a paving block is generally divided into two types, namely: • Paving blocks in rectangular shapes • Paving blocks in many facets
Based on thickness	There are three types of paving block thickness, namely: • Paving blocks with a thickness of 60 mm, for light traffic loads. • Paving blocks with a thickness of 80 mm, for moderate to heavy traffic loads. • Paving blocks with a thickness of 100 mm, for super heavy traffic loads.
Based on strength	The class of Paving block based on concrete quality is: • Paving block with concrete quality I with a value of fc '350 - 400 kg/cm^2. • Paving block with concrete quality II with a value of fc '250 - 300 kg/cm^2. • Paving block with concrete quality III with a value of fc '170 - 200 kg/cm^2

2.2.2. Aggregate. Coarse aggregates have granules with a size greater than 4.75 mm. Coarse aggregates are always synonymous with gravel or broken stone. Gravel is a natural disintegration of stone or in the form of broken stone obtained from the stone-breaking industry and has grain sizes between 5 mm-40 mm [7].

Fine aggregates are called sand, either in the form of natural sand obtained directly from rivers or excavated soil, or from the result of breaking rocks. Aggregates with grains smaller than 1.2 mm are called fine sand, whereas grains smaller than 0.075 mm are called silt, and those smaller than 0.002 mm are called clay [8].

2.2.3. Water. The function of water in concrete mixes is to help chemical reactions that cause the binding process to take place and as a lubricant between aggregate and cement mixtures to make it easy to work while maintaining workability [9].

2.2.4. Coconut shell. Coconut shells are wastes (residual processing) from households or industries that use coconut as the main ingredient. Its presence in Indonesia is abundant, and its use is mostly limited to firewood [10].

Visually the coconut shell when melted is in the form of hard flakes. The advantages of coconut shell as concrete-mixture materials are [11]:

1. The strength and tenacity of the coconut shell are high because it has a high modulus of elasticity, so it will produce concrete with a high modulus of elasticity.
2. As a result of the residual coconut fiber texture of the coconut shell surface, the bond with cement paste will be stronger.

2.3. Formulation of modified test specimens

The test specimens used were cubes with a size of 15x15x15 cm consisting of 5 samples for each variation of coconut shell and powder content of 0%, 20%, 25%, and 30% as shown in Table 3.

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Table 3. Matrix test specimens.

Cement kg	Gravel kg	Coconut Shell		Fine Aggregate kg	Coconut Powder		Water kg	Number of Samples
		%	kg		%	kg		
560	1,250	0	0	834	0	0	269	5
560	1,000	20	250	667	20	167	269	5
560	938	25	312	626	25	208	269	5
560	875	30	375	584	30	250	269	5

2.4. Compressive strength test

The compressive strength is the ability of concrete to accept the compressive force of broad unity. Concrete compressive strength identifies the quality of a structure. The higher the level of the desired structural strength, the higher the quality of the concrete produced. For testing the compressive strength of concrete, a test object in the form of a concrete cube with a size of 15x15x15 cm is pressed with a load until it collapses. When it is pressed, there is compressive stress on the concrete (σ_c) equal to the load (P) divided by the cross-sectional area of concrete (A):

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

with:

σ_c = concrete compressive stress (kg/cm²)
P = the maximum load(kg)
A = concrete cross-sectional area (cm²)

2.5. Water absorption test

Measurement of absorptive capacity is the percentage of the difference between wet weight and dry weight, in accordance with the provisions stated in the Indonesian National Standard (SNI 03-0691-1996). For the wet weight, the sample was soaked for 24 hours and then measured.

$$\text{Water Absorption} = \frac{\text{Wb}-\text{Wk}}{\text{Wk}} \times 100\% \quad (2)$$

with:
Wk: dry sample weight (gram)
Wb: wet sample weight (gram)

Figure 2. Compressive strength testing process in test objects.

3. Results and discussion

The compressive strength test results on the concrete paving press testing machine at 28 days (Figure 2) of all combination of coconut shell and powder are shown in Table 4.

Table 4. Compressive strength and percentage of absorption at 28 days[a].

% of coconut shell and powder	Strength (MPa)	Water absorption (%)
0	18.5	0.22
20	11.4	0.16
25	7.6	0.14
30	6.7	0.12

[a] results are average of 5 samples

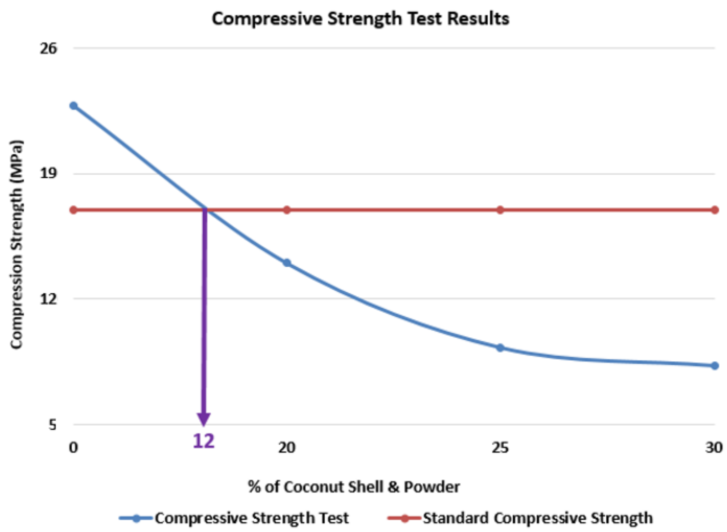

Figure 3. Optimum point of compressive strength substitution of coconut shell and powder.

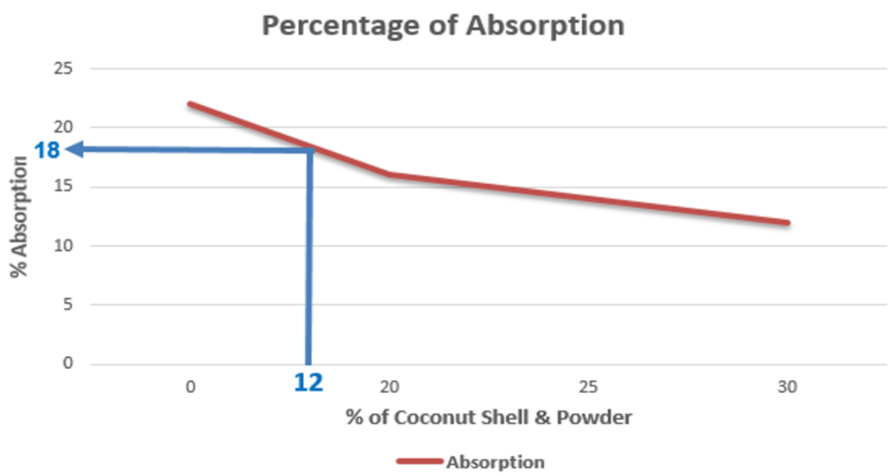

Figure 4. Optimum water absorption.

Figure 3 shows the optimum point of compressive strength substitution of coconut shell and powder. The average compressive strength test at 28 days intersects with the minimum standard of compressive strength of the conblock, which shows the optimum value of a combination of the mixture with coconut shell and powder is 12%.

The average percentage uptake value of each variation of 0%, 20%, 25% and 30% coconut shell aggregate and powder was 22%, 16%, 14% and 12%, respectively (Table 4). To obtain optimal absorption values, the optimum coconut shell and powder content from Figure 3 was used. Figure 4 shows that at the optimum percentage replacement (12%), the water absorption value was 18%.

4. Conclusion

The results show that normal paving block had 18.5 Mpa compressive strength, while substitutions of 20%, 25%, and 30% coconut shells and powders resulted in compressive strengths of 11.4 MPa, 7.6 MPa, and 6.7 MPa respectively. Absorption testing shows that the average water absorption values were 22%, 16%, 14% and 12% for coconut shell and powder contents of 0%, 20%, 25% and 30%, respectively. The optimum substitution of the coconut shell and powder percentage was 12%, which gave a higher water absorption (18%) compared to other mixed compositions.

Acknowledgments

Thanks to the Chancellor and Vice Chancellor of the University of Kadiri for the financing and they're supporting for the research. Thank also to Mr. Edy Gardjito, Mr. Bambang Subiyanto, and Mr. Hery Lilik Sudarmanto for all their help.

References

[1] Badan Standardisasi Nasional 1996 *SNI 03-0691.1996 Bata Beton (Paving Block)* (Jakarta: BSN)
[2] Limantara A D, Winarto S, Gardjito E, Subiyanto B, Raharjo D, Santoso A, Sudarmanto H L and Mudjanarko S W 2018 *AIP Conf. Proc.* **2020** 020029
[3] Badan Strandarisasi Nasional 1991 *SNI 03-2403.1991 Pemasangan Blok Beton Terkunci Untuk Permukaan Jalan* (Jakarta: BSN)
[4] Mudjanarko S W, Rasidi N, Utomo W M, Alimudin A, Suprianto D and Limantara A D 2018 *Int. J. Eng. Technol.* **7** 311–5
[5] Badan Strandarisasi Nasional 2004 *SNI 15-7064.2004 Semen Portland Komposit* (Jakarta: BSN)
[6] Limantara A D, Widodo A, Winarto S, Krisnawati L D and Mudjanarko S W 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **140** 012104
[7] Badan Strandarisasi Nasional 1998 *SNI 03-4804.1998 Metode Pengujian Bobot Isi dan Rongga Udara dalam Agregat* (Jakarta: BSN)
[8] Badan Strandarisasi Nasional 2013 *SNI 2847.2013 Persyaratan Beton Struktural untuk Bangunan Gedung* (Jakarta: BSN)
[9] Badan Strandarisasi Nasional 2002 *SNI T-03-3449.2002 Tata Cara Rencana Pembuatan Campuran Beton Ringan dengan Agregat Ringan* (Jakarta: BSN)
[10] Akbar F, Ariyanto A and Edison B *e-Journal Mahasiswa Teknik* **1** 1–11.
[11] Sawant R M, Khan J, Khan J and Waykar S 2015 *Int. J. Civ. Eng. Technology* **6** 46–54