

Comparative Study of Concrete Hollow Blocks with and Without Rice Husk Powder as Partial Replacement to Cement

Shobana K-Assistant Professor, ³S.Beulah-Assistant professor

Department of Civil Engineering

Nehru Institute of Technology

nitpraveenkumar@nehrucolleges.com - Corresponding Author

Abstract. Rapid development leads to a high demand and increased price for the basic construction materials like cement. This led the researchers to look for possible partial cement replacement by investigating the potential use of rice husk in making concrete hollow blocks. The researchers created concrete hollow blocks (CHB) at three different percentage of rice husk (RH) powder addition from 0%, 5%, and 10%. This study was intended to evaluate which works best in terms of compressive strength and density. The researchers created a total of 36 samples but only 12 were tested at ASTEC Materials Testing Corporation. Cost analysis, compression testing, and measuring of dimensions are the methods used to gather data. Results from the testing show that the mean compressive strength of the normal CHB (0%) is 76 psi compared to only 53 psi and 39 psi for CHB with 5% and 10% RH, respectively. The density of the normal CHB is 1.4319 g/cm³ while 1.2497 g/cm³ and 1.2822g/cm³ for CHB with 5% and 10% RH, respectively. In the cost analysis, the normal CHB costs ₱11.58 per piece, for CHB with 5% RH is ₱11.48, and for CHB with 10% RH is ₱11.37. Since the compressive strength of the normal CHB is greater than that of the CHB with pulverized rice husk, the researchers have concluded that a CHB unit is stronger and more resilient than a CHB with pulverized rice husk. Likewise, the mean density of the normal CHB is also greater than that of CHB with rice husk powder, it can be established that a CHB unit is more compact and rigid than the alternative. However, the addition of rice husk powder decreases the cost of CHB, therefore, CHB with RH is a more economical buildingmaterial.

1. Introduction

A building aims to give shelter for any human and his activities. A man's basic needs include food, clothing and shelter [1]. It is critical that he owns a shelter, and this basically involves construction. In the Philippines, house designs are usually adequate in space and furnishings, convenient for day-to-day operation, comfort, childcare provision and creation. However, due to poverty, inadequacy of houses exists. Apparently, many families find shelter in shanties and other forms of temporary housing outside their homes. The cost of materials used in construction may be a primary reason for this [2].

The construction industry is the top contributor to the growing economy of the Philippines. According to Philippine Statistics Authority [3], the gross domestic product from the industry increased to 240,706.14 million pesos in the second quarter from 181,395.89 million pesos in the first quarter of 2017. The industry grew by 6.3 percent in the second quarter of 2017. This was driven by

the increase in public and private construction which helped sustain tourism, business process outsourcing and public-private relationships that results in more construction facilities. The increase in construction projects signifies that more construction materials will be needed. There are many materials to choose from in building construction. One can either go with cement, brick, wood or concrete blocks [4].

The main material used in the construction industry is concrete block. The typical mixture is made up of Portland cement, water, sand, and gravel. It is compacted by high pressure and vibration that makes it very strong and resilient to severe load.

When compared to other traditional construction materials, concrete blocks cost considerably high to a residential construction. In addition, deterioration of the mortar used to hold the blocks together will occur over time [5]. Consequently, leaks take place and must be resolved once they are detected. Waterproofing is also obliged since the blocks are permeable and the mortar used is not leak-proof.

Due to increasing demands for reliable and durable construction materials, polluted environment exists as well. Requirements of durable concrete are met by proven supplementary cementitious materials [6]. For instance, rice husk ash is high in its pozzolanic activity. Thus, it enriches the strength and durability of concrete. Moreover, rice husk ash is widely available as a raw agricultural waste. Its production process has a great impact on its quality. Conversion of ash into active pozzolanic material, one must follow controlled conditions of production and processing[7].

Today, local builders face a problem, in terms of construction materials cost. Due to increased price, primary binder, such as cement, has become more expensive as well and could hinder low-cost housing[5-7].

Due to rapid urbanization, the advancement in technology has led to waste accumulation, which contribute to the pollution in the environment. Philippines, mainly an agricultural country produces wastes such as rice husk and straw, coconut shell and bagasse [8]. The waste that the researchers are concerned with is risk husk. Its estimated annual production is more than 2 million tons. Environmental sustainability is now becoming the priority of industries such as construction and manufacturing. To meet that urgency, the integration of these agricultural wastes in the production of materials such as construction supplies started to arise as reported by previous studies[7,9-11]

The rice husk (or hull) is the outermost layer that serves as a hard-protective covering of grains of rice [7]. It is separated from the rice grains during the milling process. It was long considered a waste from the process and is often dumped and burned. However, due to its easy collection, cheaper cost and high silica content, it is used as an admixture with cement and steel. Concrete hollow blocks are produced with sand and cement as constituents, but raw materials can be added in the mixture to manufacture another locally-made concrete blocks. For instance, rice husk in its powdered form can be used as an additive to produce a cheaper alternative.

Corresponding to the situations mentioned, the researchers decided to utilize pulverized rice husk as a partial cement replacement in concrete hollow block mix. This study aimed to produce a useful concrete hollow blocks with pulverized rice husk as a partial cement replacement. The researchers intended to determine which concrete hollow block mixture is more economical and performs better in terms of density and compressive strength.

2. Methodology

Research Design

An experimental method was done for the researchers to compare the three: CHB with 5%

rice husk as partial replacement of to cement, CHB with 10% rice husk as partial replacement of to cement and the commercially available CHB (which is composed of Portland Cement Type II, sand, water). The design of the comparative research is to observe the differences of objects or specimens that contains similar characteristics. The goal of the comparative study is to test and analyze properties of the objects being examined and find the best option between the objects.

Subjects, Study site and Sample

The researchers did not make use of any respondents. The subjects of this study are the concrete hollow blocks created by the researchers and tested by ASTEC Materials Testing Corp. Three types of hollow blocks were created and tested: CHB with 5% rice husk powder replacement, CHB with 10% rice husk powder replacement, and Normal CHB (without rice husk powder). The site of A.L.C. Construction, where the researchers made the hollow blocks, is located at Blumentritt Road, Sampaloc, Manila. ASTEC Materials Testing Corp., a testing laboratory where the researchers tested the hollow blocks, is in Pinyahan, Quezon City. The researchers only created 12 samples per subgroup.

Data measure

Two criteria were used to test the hollow blocks, these are: density and compressive strength of the blocks. The researchers used different devices to measure the criteria set. The said devices are Mechanical Weighing Scale with Pan, Mixer, Manual CHB molder, Measuring Tape, Electronic Platform Scale and Hydraulic Pressure Testing machine.

Mixture

For normal CHB, 8 kilograms of cement, 108 kilograms of sand and water was used. For CHB with 5% Rice Husk Replacement, 0.4 kilograms of rice husk powder, 7.6 kilograms of cement, 108 kilograms of sand and water was used. For CHB with 10% Rice Husk Replacement, 0.8 kilograms of rice husk powder, 7.2 kilograms of cement, 108 kilograms of sand and water was used.

Laboratory testing of Blocks

The testing of the blocks was administered by 2 employees of ASTEC Materials Testing Corp. Using a tape measure, the employees measured the length, width, height and thickness of each hollow block. The weight of the block was measured by placing the blocks in the electric platform scale. Next the blocks were tested on Hydraulic Pressure Testing Machine

Mode of data analysis

Since the sample groups have 4 data, the researchers used t-test to analyze the gathered data. But first, because the samples are not paired, f-test is used to check if the variances are equal or not. T-test assess whether the means of two sample groups are statistically different from each other. This analysis is appropriate when the sample size is less than thirty ($N < 30$). The researchers used t-test to compare the mean compressive strength and mean density of the hollow blocks with rice husk and the hollow blocks without rice husk. This test determines which hypothesis to accept. On the other hand, f-test assesses the equality of variances. It is most often used when comparing statistical models that have been fitted to a data set, to identify the model that best fits the population from which the data were sampled. The software used to perform the tests is Microsoft Excel.

3. Result and Discussion

Strength Analysis

In this study, the equipment used in measuring the compressive strengths of both blocks is a hydraulic pressure testing machine. Table 1 shows the compressive test result of the hollow blocks.

Table 1. Gross Compressive Strength of tested CHB

Types	Sample No.	Load (N)	Compressive Strength Gross (Psi)
Normal CHB	1	26,350	79
	2	24,570	74
	3	22,560	68
	4	27,330	82
CHB with 5% RH	5	18,420	56
	6	18,150	55
	7	15,450	47
	8	18,310	55
CHB with 10% RH	9	11,740	35
	10	10,920	33
	11	10,440	31
	12	18,030	55

Four samples of traditional concrete hollow block are randomly chosen to determine the average compressive strength. The average dimension of these blocks is 40.6 cm x 14.7 cm x 18.9 cm. In addition, four sample blocks per mixture are tested. As stated, two mixtures were prepared; the first one is comprised of 95% cement, 5% pulverized rice husk, and the second one is composed of 90% cement, 10% pulverized rice husk. The age of the blocks is 6 days. The average dimension of these blocks is 40.3 cm x 14.7 cm x 19.8 cm. Evidently, all of the samples have different compressive strengths. The average compressive strength of the first four samples is 75.75 Psi or 0.515 MPa. The second four samples have compressive strength of 53.25 Psi or 0.363 MPa on average, and 38.5 Psi or 0.26 MPa for the third four samples. The values are low, as these blocks are categorized as non-load bearing blocks, which are designed only for constructing walls that basically function as partitions..

Density Analysis

Table 2 summarizes the measurements for each block. Table 3 shows the calculated volume and density of each block. Thus based on the values in Table 3, the results showed that the mean density of the normal CHB is also greater than that of CHB with rice husk powder, it can be concluded that a CHB unit is more compact and rigid than the alternative.

Table 2. Dimensions of tested CHB

Type	Sample No.	Length (cm)	Width (cm)	Height (cm)	Face Shell Thickness (cm)	Web Thickness (cm)	Received Weight (g)
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Normal	1	40.6	14.7	19.6	3.8	3.5	11,420
CHB	2	40.6	14.7	18.5	3.6	3.5	10,755
	3	40.6	14.7	18.7	3.7	3.5	11,135
	4	40.6	14.7	19.1	3.8	3.5	10,930
	5	40.3	14.7	20.4	3.8	3.8	10,385
CHB with 5%	6	40.3	14.7	20	3.8	3.5	10,280
	7	40.3	14.7	20.3	3.7	3.8	10,455
	8	40.3	14.7	19.6	3.8	3.7	10,135
CHB with 10 %	9	40.4	14.7	19.7	3.6	3.7	10,340
	10	40.4	14.7	20	3.7	3.7	10,550
	11	40.4	14.7	19.2	3.7	3.7	10,120
	12	40.3	14.7	19.7	3.8	3.8	10,010

Table 3. Volume and Density of tested CHB

Type	Sample No.	Volume (cm ³)	Density (g/cm ³)
Normal	1	8079.5120	1.4135
CHB	2	7378.1700	1.4577
	3	7583.9720	1.4682
	4	7873.4020	1.3882
	5	8449.6800	1.2290
CHB with 5%	6	8198.8000	1.2538
	7	8276.7160	1.2632
	8	8090.4880	1.2527
CHB with 10%	9	7887.4860	1.3109
	10	8140.0000	1.2961
	11	7814.4000	1.2950
	12	8159.7400	1.2268

Cost Analysis

Table 4 shows the cost analysis comparison between the three tested CHB. Based on Table 4, the results showed the cost of materials of Normal CHB and CHB with rice husk powder. The type with the highest cost per piece is Normal CHB (₱11.58) and the lowest cost per piece is CHB with 10% rice husk powder (₱11.37).

Table 4. Cost Analysis

Items	Quantity	Normal CHB	Quantity	CHB with 5% RH	Quantity	CHB with 10% RH
Sand	108 kg	₱71.00	108kg	₱71.00	108kg	₱71.00
Cement	8 kg	₱50.00	7.6kg	₱47.50	7.2kg	₱45.00
Rice Husk	-	-	0.4kg	₱1.20	0.8kg	₱2.40
Labor		₱18.00		₱18.00		₱18.00
Total	12 pcs	₱139.00	12 pcs	₱137.70	12pcs	₱137.40



Price per piece	₱11.58	₱11.48	₱11.37
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Table 5 shows the profit analysis comparison between the three tested CHB. If the blocks are sold at

₱15, CHB with 10% RH yields the highest profit per piece (₱3.63). To better show the differences in profit, the researchers assumed an order of 5000 pieces of hollow blocks. With this, the profit difference between the three types range from ₱500 to ₱600. For the transportation cost, the researchers created a situation wherein there is 20 periods. In one period, there is one order of materials. The materials are delivered by trucks (capacity: 16,000 kg). Assuming in one order, the truck will be fully filled with 16,000 kg of the raw material. Since the dimensions of the normal CHB and CHB with rice husk is almost exactly the same, the storage costs are equal. This cost was not considered in this study.

Table 5. Profit for 5000 CHB

Item	Normal CHB	CHB with 5% RH	CHB with 10% RH
Price per piece	₱11.58	₱11.48	₱11.37
SRP per piece	₱15.00	₱15.00	₱15.00
Profit per piece	₱3.42	₱3.53	₱3.63
Average of Order (5000 CHB)	₱17,083.33	₱17,625.00	₱18,166.67

4. Conclusion

In the strength of the materials, higher compressive strength of a member means higher resistance towards lateral or axial forces. Since the compressive strength of the normal CHB is greater than that

of the CHB with pulverized rice husk, the researchers have concluded that a concrete hollow block unit is stronger and more resilient than a concrete hollow block with pulverized rice husk. In the density of the material, a highly dense hollow block means it is built firmly or solidly. It is important for the hollow blocks to be hard and unyielding as they are the fundamental units of any building. Since the density of the normal CHB is greater than that of the CHB with pulverized rice husk, the researchers have concluded that a concrete hollow block unit is more compact and rigid than a concrete hollow block with pulverized rice husk. In the cost analysis, the normal CHB costs ₱11.58 per piece, for CHB with 5% RH is ₱11.48, and for CHB with 10% RH is ₱11.37. Since the compressive strength of the normal CHB is greater than that of the CHB with pulverized rice husk, the researchers have concluded that a CHB unit is stronger and more resilient than a CHB with pulverized rice husk. Likewise, the mean density of the normal CHB is also greater than that of CHB with rice husk powder, it can be concluded that a CHB unit is more compact and rigid than the alternative. However, the addition of rice husk powder decreases the cost of CHB, therefore, CHB with RH is a more economical building material.

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