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Comparative Analysis of the Compressive Strength of Concrete Hollow Blocks Containing Different Treatments of Rice (*Oryza sativa*) Husk

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Abstract: Concrete hollow blocks (CHB) have proven their significance in the modern construction of various human architecture. Rice husk is an organic waste product and a major by-product of the agricultural biomass and rice milling industry. In the Philippines, utilizing this agricultural waste may potentially solve a disposal problem and serve as an economically and structurally viable partial replacement for cement in the production of CHBs. The aim of this study is to compare the compressive strength of CHBs containing untreated rice husk and powdered rice husk. The CHBs were produced by modifying the specifications of Aquino et al. (2021), replacing 15% of the weight of the cement with the different treatments of rice husk. A total of nine concrete hollow blocks were submitted for compressive strength testing, following the specifications of ASTM-C140. These comprised three control CHBs, three containing untreated rice husk, and three containing powdered rice husk. The results of the study found that adding untreated rice husk as a partial replacement for cement produces a CHB with a higher value of compressive strength as compared to commercially available CHBs in the Philippines. This implies that using CHBs containing untreated rice husk as a building material may produce more structurally stable buildings while also reducing the overall cost of production. However, due to the lack of data regarding the effects of untreated rice husk on the other mechanical properties of CHBs, it cannot be conclusively stated that its addition is beneficial for the overall quality of the CHBs produced.

Keywords: concrete hollow blocks; rice husk; compressive strength

1. INTRODUCTION

In recent ages, concrete hollow blocks (CHB) have demonstrated their structural stability and relevance in the current building of varied human architecture. Thorat et al. (2015) report that it is a frequent and regular choice due to its benefits, such as its simplicity as a building element, significant strength comparable to conventional blocks or bricks, and adaptability to achieving various architectural formations. Furthermore, research results from Hasan et al. (2021) indicate that masonry walls made from concrete hollow blocks have greater compressive strength compared to walls made of bricks. Additionally, as per Ignacio et al. (2020), sand and cement are the primary ingredients utilized in making concrete hollow blocks, and an array of raw materials can be added to the mixture as an additive to create a less expensive alternative and accessible material to the masses.

In the study of Nidoy (2016), rice (*Oryza sativa*) husk is an organic waste product and a vital by-product of the agricultural biomass and rice milling industries. Stuecker et al. (2018) report that the temperature and geography of the Philippines carry an excellent feeding ground for numerous sorts and varieties of rice, diversifying and presenting a vast range. Ganiron et al. (2017) also report that utilizing agricultural waste, such as rice husk, in the Philippines may potentially solve a disposal problem and serve as an economically and structurally viable alternative material in the production of concrete hollow blocks. There already exist many studies regarding rice husk and its use in increasing the mechanical properties of concrete hollow blocks, such as those of Carig et al. (2015), Jaya (2020), Aquino et al. (2021), and many others. However, these studies generally focus on turning them into ash and analyzing its effects on the mechanical properties of various concrete and masonry products. As such, this study will focus on two other various treatments of rice husk and their effect on the compressive strength of concrete hollow blocks.

In the Philippines, utilizing this agricultural waste may potentially solve a disposal problem and serve as an economically and structurally viable partial replacement for cement in the production of concrete hollow blocks. This study aims to compare the compressive strength of concrete hollow blocks containing different treatments of rice husks, such as powdered rice husk and untreated rice husk, compared to standard concrete hollow blocks. The study achieved this by producing concrete hollow blocks that contain untreated rice husk or powdered rice husk as a partial replacement for cement and then determining if there was a significant difference between the compressive strength of regular concrete hollow blocks as compared to hollow blocks that contain untreated rice husk or powdered rice husk as a partial replacement.

2. METHODOLOGY

2.1 Collection of Samples

The following materials were collected to produce the samples necessary to accomplish the study. One sack of rice husk, which equates to roughly 10 kilograms, was collected from Rexford Rice Mill located at Barangay San Antonio, Kaimito Street, Binan, Laguna. 0.9 kilograms of the rice husk was separated and labeled as untreated rice husk, while another 0.9 kilograms of rice husk was pulverized using a high-power blender and labeled as powdered rice husk. The 20 kilograms of Portland cement, along with 110 kilograms of sand, were procured from Grandma's Construction Supply, located at Barangay Tagapo, City of Santa Rosa Laguna. Table 1 provides a summary of the procured materials.

Table 1

Summary of the Materials Procured

Material	Amount
Rice Husk	10 kg
Powdered Rice Husk	0.9 kg
Untreated Rice Husk	0.9 kg
Cement	20 kg
Sand	110 kg

2.2 Production of Concrete Hollow Blocks

The procedure of the production of hollow blocks followed the protocol defined by Aquino et al. (2021), with modifications. The production of the hollow blocks took place at Grandma's Construction Supply, located at Barangay Tagapo, City of Santa Rosa Laguna. The cement and the aggregates were proportioned to meet the standard by-weight ratio of 1:6. Fifteen percent (15%) of the weight of the cement was partially replaced with the treatments of the rice husk. The dry materials were then pre-proportioned according to these parameters. The proportion for the dry ingredients of the hollow blocks with untreated rice husk was 0.9 kilograms of untreated rice husk, 5.1 kilograms of cement, and 36 kilograms of sand, while the proportion for the dry ingredients of the hollow blocks with powdered rice husk was: 0.9 kilograms of powdered rice husk, 5.1 kilograms of cement, and 36 kilograms of sand. Table 2 provides a summary of the pre-proportion of the dry materials.

Table 2

Summary of the Pre-proportion of Dry Materials

Materials	4" CHB		
	Untreated Rice Husk	Powdered Rice Husk	Control
Cement	5.1 kg	5.1 kg	6 kg
Sand	36 kg	36 kg	36 kg
Untreated Rice Husk	0.9 kg	0 kg	0 kg

Powdered Rice Husk	0 kg	0.9 kg	0 kg

Water was then incrementally added to the mixture and mixed until everything was well incorporated. The resulting mixture was then transferred to a mold on a semi-automatic vibrating table-type machine to be thoroughly compacted. The motorized vibrating of the mold caused the concrete to settle down, and more of the mixture was then raked across the mold until it was level. A stripper head was placed over the mold to bear on the leveled material. The mold was then lifted by the lever, which produced four pieces of four-inch hollow blocks simultaneously. Each hollow block was removed from the mold into the pallet to rest and dry. The process was repeated until all mixtures were transformed into hollow blocks. All the treatments were then left to cure for exactly twenty-one (21) days.

2.3 Testing of Compressive Strength

The concrete hollow blocks were sent to the Associated Services and Testing Center Materials Testing Corporation located at Barangay Balibago, City of Santa Rosa, Laguna, to conduct the compressive strength test. The compressive strength test was performed by qualified laboratory technicians using a universal testing machine (UTM) specifically configured to determine the compressive strength of a material, as per the specifications of the ASTM C-140 (American Society for Testing and Materials, 2022). A higher value, measured in megapascals, indicates a better quality of concrete hollow blocks produced in terms of compressive strength. A total of nine concrete hollow blocks were submitted for compressive strength testing. These comprised three control concrete hollow blocks, three containing untreated rice husk, and the final three containing powdered rice husk.

2.4 Data Analysis

The data acquired from the compressive strength test was processed using various statistical analysis tools. One-way analysis of variance (ANOVA) was used to determine if there is a significant difference between the compressive strength of hollow blocks containing different rice husk treatments, while Dunnet's multiple comparisons test was used to determine which of these experimental groups were significantly different compared to the control group.

3. RESULTS AND DISCUSSION

The three samples of concrete hollow blocks containing untreated rice husk indicated compressive strengths of 2.97 MPa, 2.88 MPa, and 2.20 MPa, averaging a compressive strength of 2.68 MPa. The three samples of concrete hollow blocks containing powdered rice husk indicated compressive strengths of 1.50 MPa, 1.57 MPa, and 1.79 MPa, averaging a compressive strength of 1.62 MPa. The three samples of the control hollow block that does not contain any rice husk indicated compressive strengths of 2.33 MPa, 1.25 MPa, and 1.00 MPa, averaging a compressive strength of 1.53 MPa. Table 3 shows a comprehensive summary of the compressive strength values obtained for each of these samples.

Table 3

Compressive Strength Values of Produced 4" Concrete Hollow Blocks

Samples	4" CHB		
	Untreated Rice Husk	Powdered Rice Husk	Control
1	2.97 MPa	1.50 MPa	2.33 MPa
2	2.88 MPa	1.57 MPa	1.25 MPa
3	2.20 MPa	1.79 MPa	1.00 MPa
Average	2.68 MPa	1.62 MPa	1.53 MPa

The ANOVA results indicated that the compressive strength values differed significantly across the three treatments, $F\ (2,6) = 5.310$, $p = .047$. This demonstrates that, as compared to regular concrete hollow blocks, the addition of the untreated rice husk or the powdered rice husk has a significant effect on the resulting compressive strength of the produced concrete hollow blocks. Table 4 shows the results of the analysis of variance.

Table 4

ANOVA on Compressive Strength Values

Source of Variation	*SS*	*df*	*MS*	*F*	*p*	*F crit*
Between Groups	2.477	2	1.239	5.310	0.047	5.143
Within Groups	1.400	6	0.233			

The results of Dunnet's multiple comparisons ended up with a Dunnet critical value of $D_{crit} = 1.13$. The difference between the mean compressive strength of the control hollow blocks and the hollow blocks containing untreated rice husk was calculated to have a value of 1.16, while the difference between the mean compressive strength of the control hollow blocks and the hollow blocks containing powdered rice husk was calculated to have a value of 0.09. This indicates that the compressive strength of the concrete hollow blocks containing untreated rice husk is significantly different from the control concrete hollow blocks, while the compressive strength of the concrete hollow blocks containing powdered rice husk is not significantly different from the control concrete hollow blocks. This coincides with the general behavior of the effect of aggregate size on compressive strength, as it usually increases the concrete's strength as the aggregate's size increases, as indicated in the studies of Ajamu & Ige (2015), Musa & Saim (2017), Ogundipe et al. (2018), Yu et al. (2019), Fazli et al. (2021), and Fabien et al. (2022). Table 5 provides a summary of the results of the multiple comparisons test.

Table 5

Dunnet's Multiple Comparisons

Comparison	*Abs. Mean Diff*	*D crit*
Control vs. Untreated Rice Husk	1.16	1.13
Control vs. Powdered Rice Husk	0.09	1.13

A definitive comparison between this study and the other well-researched rice husk ash studies, such as those of Carig et al. (2015), along with Aquino et al. (2021), is still uncertain. This is because despite using the same methodology, such as using the same cement-to-sand ratio of 1:6, the difference lies in the curing period used for the compressive strength test. The curing period implemented in the study was 21 days, while the other two studies used 28 days. With that, however, Carig et al.'s (2015) and Aquino et al.'s (2021) concrete hollow blocks with 15% RHA replacement yielded a compressive strength of 3.64 and 2.36 MPa, respectively. Meanwhile, the researchers' concrete hollow blocks with 15% untreated and powdered rice husks gave an average compressive strength of 2.68 and 1.62 MPa, respectively. Despite these discrepancies, the raw data suggests that there is a good reason why rice husk ash stands as the better treatment method for increasing compressive strength. Additionally, the compressive strengths of the produced concrete hollow blocks were higher than the compressive strength of commercially available concrete hollow blocks in the Philippines, which typically have compressive strength values of about 1.0 MPa, as stated by Dolores et al. (2020).

4. CONCLUSIONS

Based on the results of the study, the researchers found that adding untreated rice husk as a partial replacement for cement produces a concrete hollow block with significantly higher values of compressive strength as compared to commercially available concrete hollow blocks and concrete hollow blocks containing powdered rice husks. The average compressive strength of a concrete hollow block containing untreated rice husks is 2.68 MPa, while the average compressive strengths of the concrete hollow block containing powdered rice husks and the regular concrete hollow block are 1.62 MPa and 1.53 MPa, respectively. This would imply that using concrete hollow blocks containing untreated rice husk as a building material would produce more structurally stable buildings. Since the overall amount of cement used in the production of the concrete hollow blocks was reduced by 15%, it also implies that the overall cost of production may be lowered. However, since this study limits itself only to comparative analysis of the compressive strength of the concrete hollow blocks produced, it cannot be conclusively stated that the addition of untreated rice husk is beneficial for the overall quality of the concrete hollow blocks produced. This is because there is a lack of data regarding the effects of the untreated or powdered rice husk on the other mechanical properties of the concrete hollow blocks produced.

The researchers would recommend preparing more samples for each of the different treatments of rice husk in the hopes of studying the effects of the curing period and replacement percentage on the overall compressive strength of the concrete hollow blocks to be produced. In light of this, the researchers would also recommend comparatively analyzing different mechanical properties besides compressive strength, such as density, drying shrinkage, and water absorption, so that there may be a more holistic understanding of the effects of different treatments of rice husk to the quality of the concrete hollow block as a whole. The researchers would also like to recommend conducting a deterioration analysis to determine if the addition of an organic material, such as rice husk, will degrade the integrity of the concrete hollow blocks over an extended time. Additionally, the researchers would also recommend conducting a petrographic analysis to observe the reactions that took place in the concrete hollow blocks and provide a definitive reason as to why the addition of untreated rice husks increases the compressive strength of the produced concrete hollow blocks. The researchers would also recommend conducting the study in a laboratory setting to eliminate further any external factors that may influence the results of the study.

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