Compressive Strength of Ash Horse Manure and Musa acuminata (Lakatan Banana) Fiber as Additive Ingredients in Concrete Hollow Blocks

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Abstract

Concrete Hollow Blocks is widely utilized in the construction industry to build structure. Hence, this study investigates the impact of incorporating ash horse manure and M. acuminata (Lakatan Banana) fibers as alternative reinforcement materials in concrete hollow blocks, aiming to assess their influence on compressive strength and determine optimal combinations for producing durable building materials. In line with this, the researchers conducted quantitative research using a true experimental design. The methodology included rigorous experimentation with varied ratios of reinforcement material. To obtain necessary data, the study employed mean and ANOVA as data analysis. The compressive strength varies among different variations of the mixing design ratio, with Variation D, incorporating an equal amount of M. acuminata (Lakatan Banana) fiber and ash horse manure, demonstrating the highest mean strength. Although the observed differences are not statistically significant according to the ANOVA results, the inclusion of both ash horse manure and M. acuminata (Lakatan Banana) fibers led to a remarkable 98.04% enhancement in the compressive strength of concrete hollow blocks, with the combination of these additives proving to be the most effective. However, the observed compressive strengths were relatively low overall, suggesting the need for further research exploring alternative approaches, mixing design ratios, incorporated fibers, and additional engineering property tests.

Keywords: *Concrete Hollow Blocks; Compressive Strength; Banana Fiber; Ash Horse Manure*.

I. INTRODUCTION

Concrete is one of the most widely used materials to build structures and buildings in the construction industry. Khaskheli et al., (2022) noted that the reason for this is that concrete is easy to make and shape. According to Khan & McNally (2023), in the construction sector, concrete stands as a vital foundation, renowned for its durability, versatility, and affordability. Its widespread utilization is rooted in its ability to conform to various shapes and sizes while providing exceptional strength and resilience. It is a common material used in the construction industry that possesses required materials mainly cement, gravel, sand, coarse aggregate, and water. Shwetha et al (2022) proved that concrete blocks are substitutes for conventional bricks and stone. However, concrete has been shown to have many weaknesses and risks. According to the study of Ahmed et al., (2020), the standard concrete has low tensile strength, impact resistance, and is prone to cracking. The study of Mugume et al., (2021) also stated the weaknesses of standardized concrete, having low capacity to resist compressive loading, post-cracking capability, fracture resistance, and brittleness. This leads to the concrete having more compressive stress-induced damage which commonly leads to cracks in the concrete.

A concrete's production and manipulation highlights its suitability for a wide range of construction applications. One potential application involves the production of concrete hollow blocks. The process of creating concrete blocks is a mixture of cement, gravel, sand, and water, which results in a gray block with a rough surface texture. It is laid up one by one and retained together with a fresh cement mortar to be used for the construction of the wall's desired length and height (Winarno, 2019). Hasan, Islam, & Partha (2023) noted that concrete hollow blocks (CHB) are among the most essential materials used in building and construction projects worldwide and have emerged as a competitive alternative to conventional building materials like bricks.

On the other hand, Pavlendova et al. (2019) stated that adding horse manure fibers in making concrete has better compressive and flexural strength values. This was further supported by the study of Aggarwal et al. (2023), where it was found that adding horse manure significantly improved many of the engineering properties of the concrete, notably compressive strength and tensile strength. The material acts as reinforcement within the concrete matrix, enhancing its load-bearing capacity and resistance to bending forces. This can result in stronger and more durable concrete structures.

However, despite its strengths and benefits, plain concrete is a brittle material. According to Kiruthigasri and Sathishkumar (2020), metal bars are most commonly reinforced in concrete to further improve its strength and other variables of the concrete, however, utilization of metal reinforcement is quite costly. Furthermore, using natural fibers to make concrete is easily accessible and environmentally safe. Meanwhile, the researchers found that there are also limited studies that utilized ash horse manure as an additive in making concrete hollow blocks. Taking into account that one of the agricultural wastes of Baguio City is horse manure due to the presence of horses in the area, it is also important to consider using this waste. When horse manure undergoes combustion, it transforms into ash, containing minerals and elements present in the original material, influenced by factors like the horse's diet and bedding type. The result of ash composition includes calcium, potassium, phosphorus, sulfur, and trace elements (Chastain, 2022). While, Bharathi et al. (2021) stated that banana fibers are chemically composed of cellulose, lignin, extractives, ashes, and moisture. Furthermore, there are no studies that utilized both ash horse manure and banana fiber as reinforcement ingredients in making CHB. Since these two variables have different chemical components, it is a must to venture into the study to know if the compressive strength of the CHB will increase or decrease. Additionally, based on the study of Afraz and Ali (2021), it was recommended to use various mix design ratios, such as water-cement ratio and fiber length, to implement construction planning.

Therefore, the primary objective of this study is to investigate the impact of incorporating ash horse manure and Musa acuminata (Lakatan Banana) fibers as alternative reinforcement materials specifically in concrete hollow blocks. M. acuminata (Lakatan Banana) will be utilized due to their abundance in the locality. Furthermore, it will use a different mixing design ratio. The study aims to assess the influence of various factors on the compressive strength of these blocks. By thoroughly examining the variables including the composition of the material, the curing processes, and the manufacturing methods, the research seeks to determine their impact on the structural integrity of the blocks. Through comprehensive testing and analysis, the study aims to provide valuable insights into the highest conditions for producing blocks with high compressive strength. This research is essential for informing industry practices and ensuring the development of durable and reliable building materials for construction projects. The research involves exploring various mix design ratios, encompassing different concentrations of ash horse manure and M. acuminata (Lakatan Banana) fibers. By systematically varying these proportions, the study intends to determine the optimal combination and concentration of these additives that yield the highest compressive strength in hollow concrete blocks.

II. RESEARCH QUESTIONS

This study seeks to determine the compressive strength of ash horse manure and *M. acuminata* (Lakatan Banana) fibers in terms of compressive strength and effectiveness as concrete hollow blocks. More specifically, it sought to answer the following questions:

- *What is the Compressive Strength of Standardize Hollow Blocks and Hollow Blocks Infused with ash Horse Manure and Banana fiber?*
- *Is there a Significant Difference among the Variations of the Mixing Design ratio in Terms of their Compressive Strength?*

- *Ha: There is a Significant Difference between the Variations of the Mixing Design ratio in Terms of their Compressive Strength.*

III. METHODS

- *Research Design*

The researchers conducted quantitative research. Quantitative research uses scientific and statistical techniques to generate and test hypotheses (Brown and Meissel, 2022). Furthermore, this research involved experimental technique. According to Zubair (2023), experimental research includes manipulating one or more independent variables and applying them to one or more dependent variables to figure out their impact on the latter. Specifically, the study employed a true experimental study. True experimental is the most reliable experimental design since it depends on the statistical hypothesis to support or refute the hypothesis (Zubair, 2023). This approach was an effective way to test the compressive strength of CHB. True experimental was utilized to allow the researchers to test whether ash horse manure and M. acuminata (Lakatan Banana) fibers were effective in increasing the compressive strength of hollow blocks.

- *Data Analysis*

For the compressive strength value of the mixing design variations to be calculated, the formula below was be used. The compressive strength test formula was adapted from the study of Aggarwal et al (2023). The specimen's measured compressive strength will be computed by dividing the highest load that the specimen could withstand during the test, determined by the cross-sectional area derived from the average dimensions of the section, with the value indicated to the closest N/mm2 (Aggarwal et al., 2023).

Furthermore, the researchers utilized mean as a statistical tool, which involves summing up all the numbers in a dataset and dividing this sum by the total count of numbers (Frost, 2023). This statistical measure serves as a representative value, providing insight into the central tendency or typical value of the dataset, commonly used as a point of reference for comparison (Frost, 2023). Employing the mean enabled the researchers to effectively compare various samples of hollow blocks, serving as a guiding method for conducting comparisons among different datasets.

Moreover, the study employed a one-way analysis of variance (ANOVA). A one-way ANOVA compares the means of two or more groups for one dependent variable. Furthermore, it is customary to be used when there are two or more biological conditions or group treatments being considered (Bürger, 2023).

IV. RESULTS AND DISCUSSION

Table 1 Compressive Strength Test Result and Average

Variations	Trials			Average (MPa)
	Trial 1	Trial 2	Trial 3	
A	0.00	0.76	0.78	0.51
B	0.62	0.92	1.19	0.91
C	0.31	0.79	0.94	0.68
D	0.81	0.93	1.30	1.01

Based on the data above, Variation D, incorporating both M. acuminata (Lakatan Banana) fiber and ash horse manure in equal amounts, exhibits the highest compressive strength among all variations, with an average of 1.01 MPa, indicating a synergistic enhancement effect resulting from the combination of both additives. The analysis of the compressive strength data suggests that the incorporation of M. acuminata (Lakatan Banana) fiber and ash horse manure indeed contributes to the enhancement of the mechanical properties of the concrete hollow blocks. Variation D consistently outperforms the other variations, indicating a synergistic effect between the two additives. This can be attributed to the reinforcing nature of the banana fiber, which enhances the compressive strength of the concrete (Sharma et al., 2021), while the ash horse manure likely acts as a pozzolan, reacting with calcium hydroxide to form additional cementitious compounds (Sahu &Tiwari, 2022), thereby improving.

Meanwhile, for Variation A, representing the standard hollow blocks, the compressive strength remains consistently low throughout the testing period, with an average of 0.51 MPa, indicating minimal enhancement. This is supported by the study of Mugume et al (2021), where they highlighted the limitations of standardized concrete, which include reduced ability to withstand compressive loading, limited post-cracking performance, lower fracture resistance, and inherent brittleness. Also, Variation B, incorporating a greater amount of M. acuminata (Lakatan Banana) fiber, demonstrates a notable improvement in strength, with an average of 0.91 MPa, showcasing the reinforcing effect of the banana fiber on the concrete. Studies have demonstrated that incorporating banana fibers in concrete mixtures can lead to enhanced mechanical characteristics, such as compressive strength, tensile strength, and flexural strength (Afraz & Ali, 2021). Different percentages of banana fibers, ranging from 0.5% to 2.5%, have been investigated in various research works, showcasing positive outcomes in terms of durability, long-term compressive performance, and resistance to cracking and spalling (Afraz & Ali, 2021). The utilization of natural fibers like banana fibers presents a sustainable and effective approach to improving the overall performance of concrete structures (Sharma et al., 2021).

Lastly, variation C, incorporating a greater amount of ash horse manure, shows a moderate increase in strength compared to the standard blocks, with an average of 0.68 MPa, suggesting a potential pozzolanic effect of the ash horse manure. The incorporation of ash horse manure in the blocks leads to improvements in mechanical properties, such as stiffening and strengthening, as evidenced by various tests like confined compressive tests and uniaxial compression tests (Sahu & Tiwari, 2022).These findings underscore the potential of incorporating M. acuminata (Lakatan Banana) fiber and ash horse manure as additive ingredients to improve the compressive strength and durability of concrete hollow blocks, with Variation D showing the most promising results.

Table 2 ANOVA Result of Compressive Strength

Sources	SS	df	MS	F	P value
Between Groups	0.46	3	0.15	1.35	0.33
Within Groups	0.91	8	0.11		
Total	1.31	11	0.12		

The analysis of variance (ANOVA) results reveals the comparison of compressive strength among different variations of the mixing design ratio. Across four variations labeled A, B, C, and D, each with three samples, the mean compressive strengths vary. Variation A, representing the controlled hollow blocks, shows a mean compressive strength of 0.51 MPa, while Variation B, incorporating M. acuminata (Lakatan Banana) fiber, exhibits a higher mean strength of 0.91 MPa. Variation C, incorporating ash horse manure, shows an intermediate mean strength of 0.68 MPa, and Variation D, incorporating both M. acuminata (Lakatan Banana) fiber and ash horse manure, displays the highest mean strength of 1.01 MPa. The ANOVA indicates that while there are differences in mean compressive strengths among the variations, the observed variance is not statistically significant at the 0.05 significance level ($p = 0.33$), suggesting that the differences may be due to random variation rather than true differences in performance.

This suggests that while there are variations in the average compressive strengths of the different formulations, these differences are not significant enough to confidently conclude that one variation consistently outperforms the others. However, it is worth noting that Variation D, incorporating both M. acuminata (Lakatan Banana) fiber and ash horse manure, exhibits the highest mean compressive strength.

However, while there are observed differences in compressive strength among the variations of the mixing design ratio, the ANOVA results do not provide sufficient evidence to conclusively state that one variation is significantly superior to the others. However, the trends in the mean compressive strengths suggest that formulations incorporating both M. acuminata (Lakatan Banana) fiber and ash horse manure, such as Variation D, tend to exhibit higher strengths on average.

Table 3 Kruskal-Wallis Result

	x^2	df	p
Trial 1	3.00	3	0.39
Trial 2	3.00	3	0.39
Trial 3	3.00	3	0.39
Average	3.00	3	0.39

After conducting the Kruskal-Wallis test, the test statistic (χ^2) value of 3.00 for each trial and the average, along with degrees of freedom (df) of 3, indicated that four groups were compared in each instance. However, the resulting p-values of 0.39 for all trials and the average were higher than the designated significance level (0.05). This means that there isn't enough evidence to accept the alternative hypothesis. Therefore, based on the test and under the alternative hypothesis, which suggests significant differences between groups, there isn't sufficient statistical evidence to assert differences in ranks or distributions among the groups in each trial and their average. Consequently, the study will not conduct Dwass-Steel-Critchlow-Fligner test (DSFC), as there are no significant differences among the values above.

V. CONCLUSION AND RECOMMENDATIONS

- The inclusion of ash horse manure and M. acuminata (Banana Lakatan) positively impacts the compressive strength of the concrete hollow block, resulting in enhanced strength. Therefore, they can be utilized as additive reinforcement materials in concrete hollow blocks.
- While there were differences in compressive strength among the various concrete hollow blocks tested, the values obtained were relatively low. As such, the addition of ash horse manure and M. acuminata (Banana Lakatan) did not have a significant effect on the compressive strength of the blocks. Hence, further studies and tests are suggested to achieve and ensure optimal results.
- It is recommended to explore a different approach and methodology in the study, as this may lead to new valuable insights and discoveries in enhancing concrete properties.
- A study with varied mixing design ratio to gain insights into how different ratios influence the strength and durability of concrete hollow blocks..
- A study investigating additional engineering property tests such as the tensile strength test and flexural strength test to achieve a more comprehensive understanding of the material's behavior.
- A study with different incorporated fibers or additives, as this could provide valuable insights into their respective impacts on the properties of concrete hollow blocks.
- It is advised to compare the concrete hollow blocks from this study, with their specific mixing design ratio, to a hollow block using a standard mixing design ratio usually employed in the construction industry.

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