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Regression Modeling of the Compressive Strengths of Interlocking Hollow Blocks with Rice Husk Ash as Partial Replacement to Cement

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ABSTRACT –

In order to arrest the incidence of global warming brought about by the emission of greenhouse gases notably carbon dioxide (CO2) into the atmosphere, the use of materials that can substitute the material responsible for greenhouse gases is being promoted worldwide. One of these is Rice Husk Ash (RHA) which has been found suitable by researchers to partially replace Portland cement in the production of concrete. It has been demonstrated by numerous researchers that adding rice husk ash to cementitious materials, also known as pozzolanic materials, such as blast furnace slag, silica fume, metakaolin (MK), fly ash (FA), and rice husk ash (RHA), among others, improves the various properties of concrete and lowers construction costs using hollow blocks with contemporary design and interconnecting keys (protrusions and grooves). Furthermore, it is relative that the most effective replacement of rice husk ash is 10% which has a significant increase of more than 34% compared to the controlled variable in terms of compressive strength. The optimum percentage of replacement of rice husk ash is attained at 10%. The best regression modeling is y=-2784x^3+497.6x^2-14x+2.312, where x is the % of RHA replacement and y is the Compressive Strength, having 100% accuracy.

Keywords: Interlocking Hollow Blocks, Rice Husk Ash, Compressive strength, Regression Modelling,

I. INTRODUCTION:

The construction industry is one of the most established and prominent worldwide. An extensive range of construction procedures, modern designs, and materials serves the industry's and society's various needs, which involves using cutting-edge strategies and methods to produce and enhance building materials that are more affordable, reliable, and acceptable.

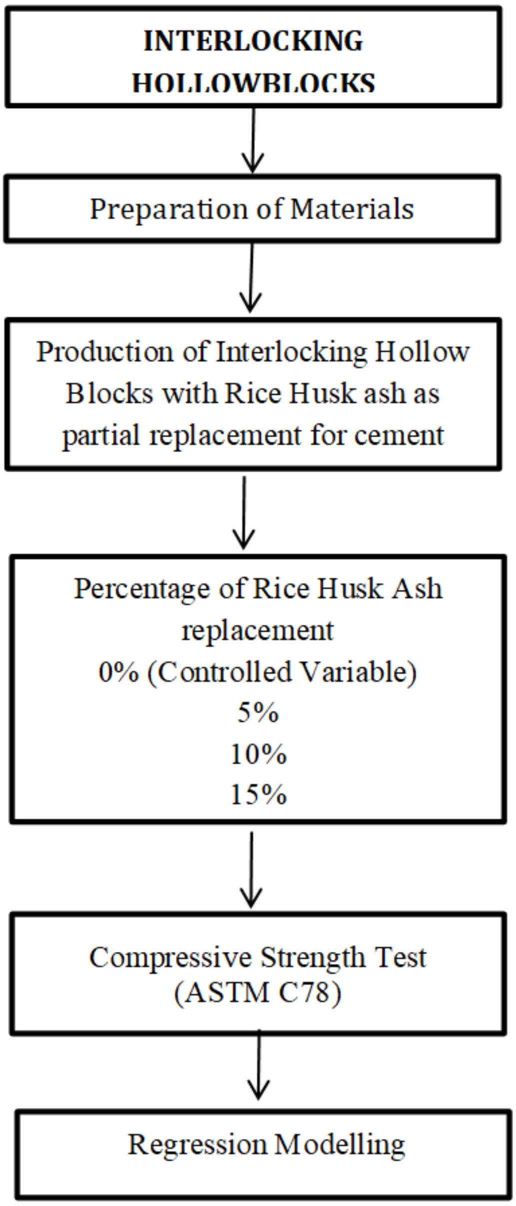
Concrete Hollow Blocks, or CHB as they are more often known, are essential elements in the building business. This is one of the most frequently utilized walling materials in the Philippines. CHB is used in all types of buildings and can be used for both load-bearing and non-load-bearing walls. It may be rectangular or segmented and have an end shape to provide interlock at joints. The standard hollow block has three void cells ranging from 4-6 inches thick.

The utilization of rice husk as an additive or admix to concrete is because the rice plant is one of the plants that absorb silica from the soil and assimilates it into its structure during growth. Rice husk is the outer covering of the grain of rice plants with a high concentration of amorphous silica, generally more than 80-85%. Thus, using rice husk ash in concrete on a large scale will help lessen the adverse environmental effects of myriad activities in the construction domain by reducing the rate at which cement is produced.

One of the various solutions to cut construction cost is to reduce the pricing of construction materials. Hollow Blocks is one of the significant components in construction, so the promotion of high-end and low-cost hollow blocks will become a staple for future construction. The increase in agricultural waste, especially rice husks, which the experts think may be utilized as building material to decrease the problem, is another element contributing to this problem. Therefore, the project's main end users are Marinduque's construction and agricultural businesses. The increase in agricultural waste, especially rice husks, which the experts think may be utilized as building material to decrease the problem, is another element contributing to this problem.

The product employed was a mix of alternative materials to partially replace cement in Interlocking Hollow Blocks (ILHB) production, making them more affordable when they hit the market.

II. METHODOLOGY



III. RESULTS AND DISCUSSIONS

3.1 Design of Mold

The mold of the interlocking hollow blocks was fabricated using the commonly used mold for ordinary concrete hollow blocks. The mold was modified to have interlocking keys (protrusions and grooves).

Figure 1: Modified Design of ILHB Molder

Figure 2: Interlocking Hollow Blocks sample

3.2 Compressive Strength

Figure 3: Compressive Strength Test Set – up

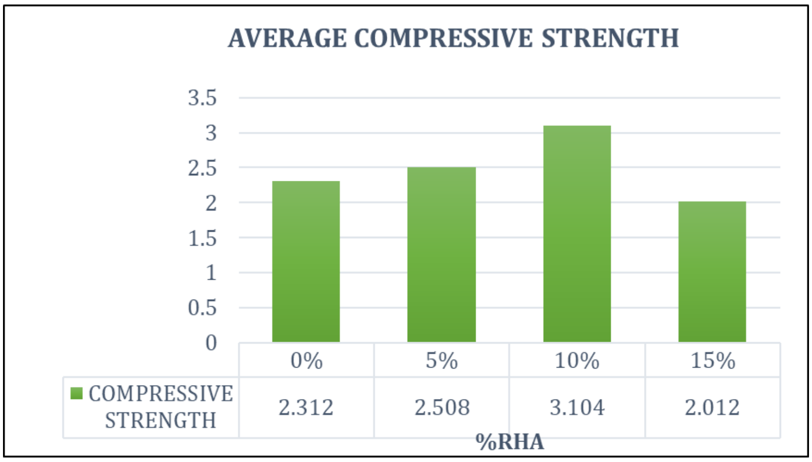


Figure 4: Average Compressive Strength

Table 1: Comparisons between the Controlled samples and the ILHB with RHA

PERCENTAGE	COMPRESSIVE STRENGTH (MPA)	CONTROLLED VARIABLE (0%)	REMARKS
5	2.51	2.31	Passed
10	3.10	2.31	Passed
15	2.01	2.31	Passed

To study the axial load-bearing capacity of the ILHB-RHA, four (4) groups were made corresponding to the percentage of RHA-cement replacement, with five specimens in each group for compressive strength. The width of the ILHB-RHA is 94 mm, with a thickness of 398 mm. The compressive strength of ILHB-RHA was tested using the Universal Testing Machine. According to the test of American Standards of Testing Materials (ASTM) C140, all the specimens have a curing time of 28 days to attain the highest compressive strength of concrete.

Based on the results, the controlled variable has an average compressive strength of 2.312 MPa. Thus, the compressive strength of ILHB-RHA with a replacement of 5% has an average value of 2.508 MPa, the ILHB-RHA with 10 % replacement has an average value of 3.104 MPa, and the ILHB-RHA with 15% replacement has an average value of 2.012.

Thus, based on the result of the testing procedures, the ILHB-RHA with 10 % replacement has the highest compressive strength, which is higher than the controlled variable, with an increase of more than 10% of compressive strength compared to the controlled variable. According to Fapohunda et al. (2017), the construction and qualities of concrete with rice husk ash (RHA) as a partial replacement for Portland cement up to 10% cement replacement with RHA results in strength development compared to control specimens. There is a relative increase in compressive strength when the replacement relief is at 10%

3.3 Paired Sample T – Test

Table 2: Paired Samples Test for Compressive Strength

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	CS_0percent - CS_5percent	-.196	1.15336	.51580	-1.62808	1.23608	-.380	4	.723
Pair 2	CS_0percent - CS_10percent	-.792	.98060	.43854	-2.00957	.42557	-1.81	4	.145
Pair 3	CS_0percent - CS_15percent	.3000	1.16166	.51951	-1.14239	1.74239	.577	4	.595

Based on the results of Paired Samples T-test that were evaluated, the mean difference between the paired proportions of 0% and 5% of RHA replacement for cement is -0.196, while the mean difference of 0% and 10% of RHA replacement for cement is -0.792, and the mean difference of 0% and 15% of RHA replacement for cement is 0.3. Therefore, this study can conclude that the ILHB-RHA replacement of 10% has effectiveness in the treatment administered, because the mean value is less than the t-value we can say that the t-value is greater than the critical (t-value > Critical value). The mean difference of -0.792 is statically significantly different from zero. Additionally, the pair of 0% and 5%, 0% and 10%, and 0% and 15% are accepted based on the null hypothesis. There is no significant difference between the means of the compressive strength of the interlocking Hollow blocks with Rice Husk ash replacement and the controlled variable.

3.4 Quantile-Quantile Plot

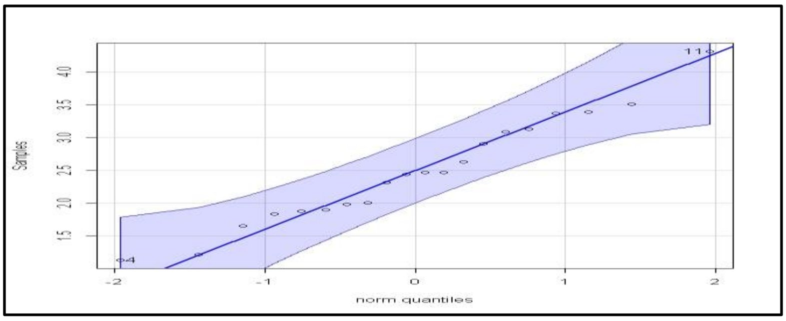


Figure 5: Q-Q Plot for Compressive Strength

This may be inferred that the errors are normally distributed using the Quantile-Comparison (Q-Q) Plot since the points are near the straight line.

3.5 Box Plot

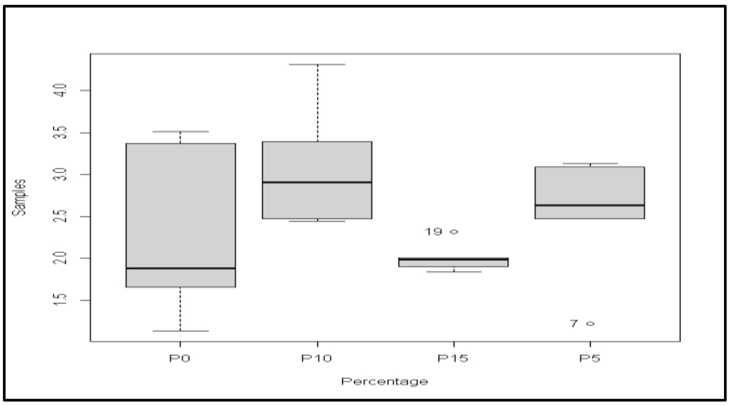


Figure 6: Box Plot for Compressive Strength

The Box Plot shows that the average compressive strength of (15%) is less variable than the other proportions. The compressive strength of concrete containing RHA at 10% cement replacement with RHA will result in strength development comparable to the control specimens. However, when the replacement of rice husk ash reaches 15%, the compressive strength fails compared to the controlled variable (Fapohunda, Akinbile, et.,al., 2017).

3.6 Determine the Best Regression Model Based on the Observed and Predicted Values

3.6.1 Linear Regression

Table 3: Model Summary of Linear Regression

R	R square	Adjusted R square	Std Error of the Estimate
0.085	0.007	-0.489	0.562

Based on the Linear Regression, the coefficient of determination of compressive strength is 0.7 %. Thus, the model partially predicts the outcome.

3.6.2 Quadratic Regression

Table 4: Model Summary of Quadratic Regression

R	R square	Adjusted R square	Std Error of the Estimate
0.811	0.658	-0.026	0.467

The compressive strength's coefficient of determination is 65.8% according to the quadratic regression. Hence, the model only partially predicts the result.

3.6.3 Cubic Regression

Table 5: Model Summary of Cubic Regression

R	R square	Adjusted R square	Std Error of the Estimate
1.000	1.000	-	-

According to the cubic regression, the compressive strength's coefficient of determination is 100%. Therefore, the model accurately predicts the outcome.

3.6.4 Compound Regression

Table 6: Model Summary of Compound Regression

R	R square	Adjusted R square	Std Error of the Estimate
0.145	0.021	-0.468	0.220

Compound regression yields a coefficient of determination for compressive strength of 2.1%. Therefore, the model can only forecast the result somewhat.

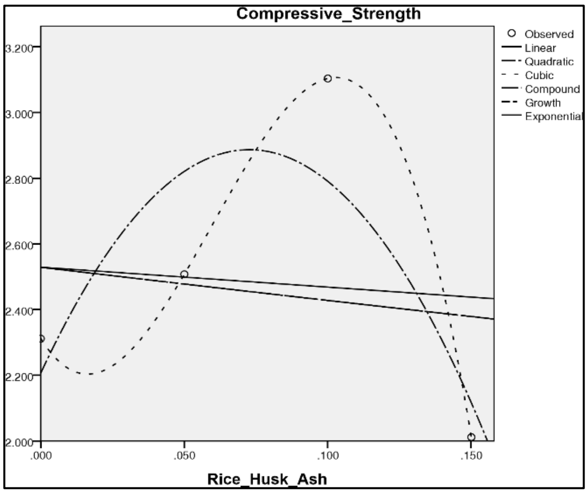


Figure 7: Graph of Compressive Strength

The graph shows that the Cubic Regression has perfectly predicts the outcome. Therefore, the Cubic Regression is the best regression model having a coefficient of determination (R2) of 100%.

Best Regression Model:

y=-2784x^3+497.6x^2-14x+2.312

x = % of RHA replacement

y=Compressive Strength

Table 7: Comparative Analysis of the Observed Value and Predicted Model

COMPARATIVE ANALYSIS OF THE OBSERVED VALUE AND PREDICTED MODEL			
of RHA replacement	**Observed Value**	**Predicted model**	**Standard Error of Estimate**
15%	2.01	2.01	0%
10%	3.10	3.10	0%
5%	2.51	2.51	0%
0%	2.31	2.31	0%

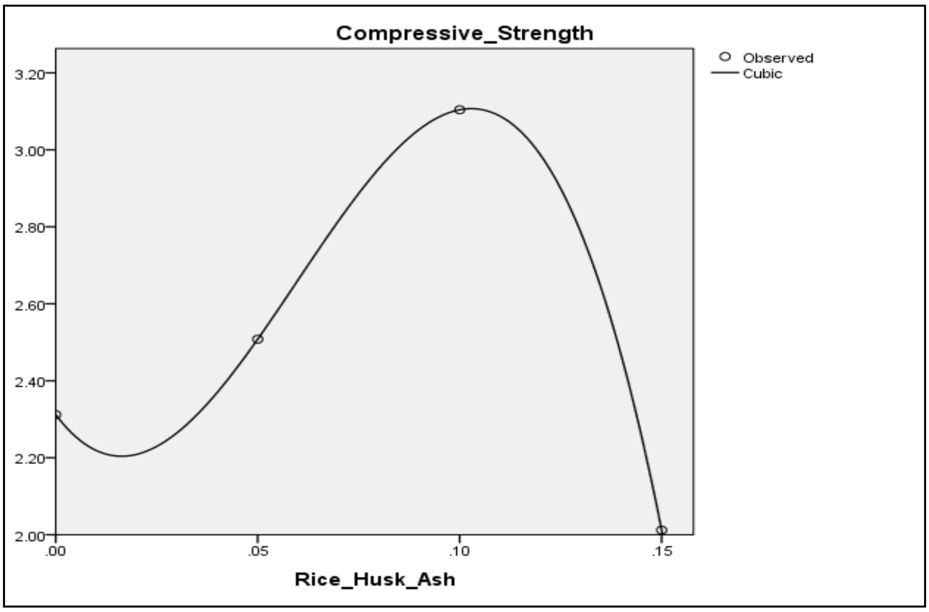


Figure 8: Graph of the Regressed Compressive Strength

The dependent variable(%RHA) was regressed on predicting the compressive strength of the ILHB. The independent variable significantly predicts the compressive strength, F (0,3), $p<0.01$ which indicates that the factor under the study has a significant impact on the %RHA. Moreover, the R2= 1 (coefficient of determination) which means it is 100% accurate.

IV. CONCLUSIONS AND RECOMMENDATIONS

Based on regression modeling, the best regression modeling is the cubic regression. Because among the other used regression analysis, the cubic regression is the only one that has a 100% coefficient of determination (R2) and is accurate. Thus, it is safe to conclude that it is the best regression modeling in terms of comparing the observed and predicted values of the parameters in compressive strength.

The best regression modeling is $y=-2784x^3+497.6x^2-14x+2.312$, where x is the % of RHA replacement and y is the Compressive Strength, having 100% accuracy.

The most effective proportion of RHA as a partial replacement to cement used in ILHB is 10 % in terms of compressive strength with a 34% increase relative to the controlled variable (0%).

Based on regression modeling used, there is a significant difference between the means of results of interlocking hollow blocks with RHA replacement and controlled variables in terms of compressive strength, the 10% has a significant difference compared to the controlled (0%).

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