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# A Comparative Study on the Compressive Strength of Concrete Using Rice Husk Ash and Waste Paper as Partial Replacement for Fine Aggregates

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***Abstract:***
Waste materials has been used in different occasions to develop a sustainable concrete that is more economical and eco-friendlier. Particularly in the Philippines, rice husk ash is in abundance due to rice being one of the major produce of the country. Paper waste is also in question with it being one of the highest components of global waste. With these considered, the researchers evaluated and created a comparison on the compressive strength of concrete mixed with rice husk ash (RHA) and wastepaper to standard concrete. The researchers replaced 5% of the usual aggregates with these said waste materials. The other materials used for this study are Portland Cement Type 1, sand, gravel, RHA, old newspaper as the wastepaper, and water. Following a ratio of 1:2:3, the concrete mixture of both the experimental and the controlled samples were molded into cylindrical PVC molds measuring 152x302mm creating 18 samples; 9 samples for the experimental concrete mixture and 9 samples for the controlled concrete mixture. These samples were tested on the 7, 14, and 21 curing age marks, with 3 samples of each category being tested for each age mark. The statistical treatment of ‘t-Test for two independent means was applied on the results gathered through the Universal Testing Machine (UTM) with the significance level of 95% or 0.05 as recommended by ASTM International, specifically ASTM C39/C39M. The mean of the individual results was taken and compared. With the results of this study, the null hypothesis is rejected for the 7, 14, and 21 day marks due to having a weaker compressive strength – which is 8.58 MPa out of 22.50 MPa for the 14 day mark and 10.02 MPa out of 24.75 to 25 MPa for the 21 day mark – than the standard controlled concrete.

***Keywords**: Rice Husk Ash, Wastepaper, Aggregate, Compressive Strength.*

## I.INTRODUCTION

Humankind has relied on the natural environment for its needs since the dawn of civilization. However, ever since the dawn of civilization, anthropogenic activities, such as the incineration of waste, has been causing - especially since the Industrial Revolution - a rapid depletion in the earth’s supporting capacity. Noting on the incineration of waste, this practice is a main contributor to global warming thus several nation-states have innovated concrete through the

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incorporation of industrial and agricultural waste [1]. Among the types of waste, paper waste and rice husk ash (RHA) are part of the top contributors to environmental damage. However, RHA has the potential to be an eco-friendly replacement for fine aggregates because it can be a substitute for Portland Cement [2]. Additionally, paper can be used as an effective building material called "papercrete", a more durable and cheaper concrete compared to the standard concrete blocks [3]. Other studies promote the use of agricultural waste as partial replacement for aggregates to increase the quantity of compressive strength for mortar and self-compacting concrete since it showed significant results, specifically its effect on the pozzolanic and the micro-filling property [4]. Moreover, RHA as an agronomic waste is one of the commonly used materials for concreting purposes and is widely used by other previous researchers [5], and the use of newspaper as papercrete creates a good insulation property [6].

The objective of this study is to propose a workable concrete mix design that has wastepaper and RHA and to compare the results of the compressive strength between the standard and the experimental concrete with 5% partial replacement of wastepaper and RHA. With this, the study can provide thorough findings with the utilization of these two waste materials in making concrete for the field of engineering and the construction industry. Further benefits to the said field and industry are the widening of variety in terms of purpose and the possible production of a sustainable concrete. Moreover, this study supplies the lack of research focused on the use and the outcome of wastepaper and RHA as a single quantity. Hence, the researchers will analyze the combination of wastepaper and RHA as replacements for fine aggregates in concrete making.

Being that this study focuses on tackling paper waste and rice husk ash, the researchers settled on the following limitations. The study utilized newspaper and RHA as 5% replacements for sand and cement, respectively, using a ratio of 1:2:3 for the concrete mix. Holcim cement was used as the binder of the aggregates. A total of 18 samples were casted using PVC pipes (152 x 302 mm). This study is partial to the comparison of the compressive strengths of the standard and the experimental concrete after the 7th, 14th and 21st day of curing. Consequently, three (3) samples were tested for each curing day. ASTM C-39, 2004 standard was used to examine the compressive strength of the experimental samples.

## II.LITERATURE REVIEW

### *A.Utilization of Rice Husk Ash and Effect on the Properties of Concrete*

Rice husk is a common agricultural waste in the Philippines because of its high production of rice. There are many studies conducted around rice husk and RHA. Most notably, it is inferred that the compressive strength and workability of the concrete develops, and the water permeability decreases when RHA is used as a substitute for cement [7]. The controlled concrete mixture and the modified concrete mixture using 100% recycled aggregates and replacement of cement with 10% RHA using 1:2:4 ratio and water-cement (w/c) ratio of 0.5, were prepared to create 30 cubes and 30 cylinders to check the compressive and tensile strengths of normal and modified concretes at 7, 14 and 28 days. Results revealed that 10% RHA has improved the compressive and tensile strength at all three curing periods [8]. Additionally, a study indicated that a setup with 4% RHA showed a better performance of increasing slightly the compressive strength during the 28th day in comparison to the 8% RHA replacement that showed a compressive strength lower than the controlled [9].

### *B.Utilization of Wastepaper and Effect on the Properties of Concrete*

Paper waste has been one of the contributors to the overall global pollution. It is worth noting that some paper mill companies use a furnace to burn and get rid of their paper waste causing the release of toxic waste adding further to existing pollution. Moreover,

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discarding wastepaper in croplands and landfills decreases the soil's fertility – thus its capacity to provide produce – and endangers the health of surrounding communities [10]. However, wastepaper, mainly newspaper as papercrete, can be advantageous as a structural material for its good insulation property and fire resistance surges [6]. Correspondingly, a study on the concrete mix containing paper waste investigated the compressive strength, the density, the slump value, and the water absorption at 10% and 15% wastepaper replacement. It was discovered that there is a rise in the compressive strength and density, while water absorption increased within 20% of the wastepaper [12].

## III.METHODOLOGY

For this study, the materials used are Portland Cement Type 1, sand, gravel, RHA, old newspaper, and water. The researchers followed the American Institute Concrete (ACI) proportion mix in creating the concrete. The ratio used is 1:2:3 for the concrete mix corresponding to 1 part of cement, 2 parts of sand, and 3 parts of gravel. PVC pipes were used as the cylindrical molds with dimensions of 152 x 302 mm. There are 18 samples made: 9 experimental concrete samples and 9 standard concrete samples. Consequently, all samples were cured for 7, 14, and 21 days. The American Society for Testing and Materials (ASTM C-192/C-192M) was followed for the making and the curing procedures. All samples were tested using the Universal Testing Machine (UTM).

The creation of the samples started by mixing the fine aggregates with the partial replacement of RHA and the coarse aggregates consisting of gravel and wastepaper. After the mixture is thoroughly mixed, water was added. The wet concrete was then transferred into the PVC mold using a trowel or a shovel. While setting the concrete, the mixture was tamped 25 times using a steel rod to prevent air entrapment, gaps, and bubbles to transpire. Lastly, the final layer of the concrete was added. After the concrete has been completely set, the researchers cured all samples. Consequently, the concrete was removed from the molds and was tested after 24 hours as prescribed as the allotted time per curing period

The compressive strength results were gathered using the Universal Testing Machine (UTM) and will be compared with the standard ASTM C-39/C-39M to analyze the compressive strength of the experimental and standard samples. Additionally, the statistical treatment used is T-test for two independent means. The null hypotheses assumed that the compressive strength of the experimental sample is equal to the compressive strength of the standard sample while the alternative hypothesis assumed that the compressive strength of the experimental sample is not equal to the compressive strength of the standard sample. In addition, the alpha value used was 0.05. The equation used for the statistical treatment is as indicated below.

$$t = \frac{X_1 - X_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (1)$$

In the equation, $X_1 - X_2$ is the arithmetic mean that corresponds to the compressive strength of the sample, $n_2$ and $n_2$ is the total number of samples, and is the standard deviation of the samples.

## IV.RESULTS

For the compressive strength test results, the maximum stress that the experimental concrete samples were able to withstand was approximately 6.77 MPa to 7.69 MPa for 7 days, 7.88 MPa to 9.62 MPa for 14 days, and 8.34 MPa to 11.34 MPa for 21 days. Table 1 shows the specified results of the test

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TABLE I: EXPERIMENTAL AND CONTROL – COMPRESSIVE STRENGTH

| Curing Periods | No. of Samples | STANDARD CONCRETE | | | EXPERIMENTAL CONCRETE | | |
|---|---|---|---|---|---|---|---|
| | | Max. Force | Max. Stress | | Max. Force | Max. Stress | |
| | | (kN) | (kN/mm$^2$) | (MPa) | (kN) | (kN/mm$^2$) | (MPa) |
| 7 days | 7A | 145.984 | 0.00800 | 8.00 | 123.53 | 0.00677 | 6.77 |
| | 7B | 186.484 | 0.01022 | 10.22 | 124.672 | 0.00683 | 6.83 |
| | 7C | 232.344 | 0.01274 | 12.74 | 140.266 | 0.00769 | 7.69 |
| 14 days | 14A | 275.875 | 0.01512 | 15.12 | 143.656 | 0.00788 | 7.88 |
| | 14B | 210.391 | 0.01153 | 11.53 | 150.547 | 0.00825 | 8.25 |
| | 14C | 266.813 | 0.01463 | 14.63 | 175.406 | 0.00962 | 9.62 |
| 21 days | 21A | 309.875 | 0.01699 | 16.99 | 189.578 | 0.01039 | 10.39 |
| | 21B | 345.156 | 0.01892 | 18.92 | 206.906 | 0.01134 | 11.34 |
| | 21C | 309.094 | 0.01694 | 16.94 | 152.063 | 0.00834 | 8.34 |

TABLE II: T-TEST RESULTS FOR THE COMPRESSIVE STRENGTH OF SAMPLES BASED ON CURING AGE

| Curing period | Setup | Mean | T-value | P-value | Decision | Remarks |
|---|---|---|---|---|---|---|
| 7 days | Controlled | 10.32 | 2.30060 | 0.04140 | Reject $H_0$ | Significant |
| | Experimental | 7.10 | 2.30060 | 0.04140 | Reject $H_0$ | Significant |
| 14 days | Controlled | 13.76 | 4.16700 | 0.00700 | Reject $H_0$ | Significant |
| | Experimental | 8.58 | 4.16700 | 0.00700 | Reject $H_0$ | Significant |
| 21 days | Controlled | 17.62 | 6,90730 | 0.00120 | Reject $H_0$ | Significant |
| | Experimental | 10.02 | 6.90730 | 0.00120 | Reject $H_0$ | Significant |

For the hypothesis testing, Table 2 shows the results of the t-test of two independent sample means for 7, 14, and 21-day curing period, respectively.

The null hypotheses states that the compressive strength of the experimental sample, denoted as $\bar{X}_1$, is equal to the compressive strength of the standard sample, denoted as $\bar{X}_2$. Conversely, the alternative hypothesis states that the compressive strength of the experimental sample is unequal to the compressive strength of the standard sample. On the 7, 14, and 21-day marks, a fluctuation on the experimental sample mean can be observed. The experimental sample means did not surpass the controlled sample means, in which the experimental sample got 7.10 MPa, 8.58 MPa and 10.02 MPa compared to the controlled sample means of 10.32 MPa, 13.76 MPa and 17.62 MPa from the 7, the 14, and the 21 day marks respectively. With the results considered, the calculated test statistics for the three curing periods rejects the null hypothesis. Therefore, there is a significant difference between the compressive strength of the standard concrete and experimental concrete at a significant level of 0.05. Considering the standards of the American Society for Testing and Materials (ASTM C39/C39M), the experimental concrete must achieve strengths equal or higher 65%, 90%, and 99% for 7, 14, and 21 days, respectively. Because of these requirements, the experimental concrete specimens failed to equal or surpass the standard compressive strengths of concrete, which are

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7.10 MPa out of 16.37 MPa for 7 days, 8.58 MPa out of 22.50 MPa for 14 days, and 10.02 MPa out of 24.75MPa for 21 days.

## V.CONCLUSION

In this study, the compressive strength of nine experimental concrete samples with the usual aggregates replaced with rice husk ash and wastepaper in the form of old newspaper were evaluated and compared with 9 samples of the controlled standard concrete samples. These samples were tested on three different curing ages of 7, 14, and 21 days with three samples from the experimental and controlled samples tested for each age. As shown by the results of the experiments, the compressive strength of the standard concrete samples on all three curing ages despite the gradual increase of the compressive strength of experimental samples. Therefore, the compressive strength of the experimental concrete samples gained a lower compressive strength than that of the standard concrete samples. Furthermore, the researchers stipulated that a flaw must have occurred in the mixing of the concrete for it to produce such low results. In addition, after the samples were tested in the Universal Testing Machine, the researchers found out that the wastepaper did not blend properly with the concrete because it corrodes too easily. Thus, concluding that the concrete mix design with 5% replacement of RHA and wastepaper does not produce a strong compressive strength.

The researchers highly recommend the thorough preparation of the materials and the experimentation. Moreover, the researchers advise the changing of the percentage of the replaced aggregates followed by a trial-and-error method in experimenting with different percentages of the replaced aggregates tested on its 3-day mark. Aside from the recommendations related to this study, the researchers encourage the development of studies using other waste materials as partial replacements.

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