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RESEARCH ARTICLE

ANALYTICAL MODELS FOR PREDICTION OF MECHANICAL PROPERTIES OF RICE HUSK ASH CONCRETE

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ABSTRACT

In this paper, mathematical models were developed using stress strain relations to predict the compressive strength of concrete produced with partial replacement of cement with rice husk ash. The water absorption property was also predicted but based on the assumption that the amount of water absorption in concrete is dependent on the volume fraction of rice hush ash used as partial replacement. Both the compressive strength and water absorption compared favourably with the experimental values and both decreased with increase in rice husk content. The coefficient of correlations were very high for both the compressive strength and water absorption (0.934, 0.946) showing that the proposed model can be used as a tool in the prediction of mechanical properties of concrete produced with replacement of cement with rice husk ash.

INTRODUCTION

Projects where concrete is being made use of as a structural material are hardly achievable by both urban and rural dwellers because of increasing cost of cement as one of the construction materials. As a result, any material that can be used a partial replacement for cement in concrete production will go a long way to making concrete production cost effective [1-8]. The use of ash obtained from some agricultural wastes has been shown to improve the mechanical properties of concrete [9]. Rice husks is an agricultural waste. Even though it is used as fuel in some areas of the world are a source of environmental pollution. Careful use of this agricultural waste can profer solutions to human problems such as housing development and others rather than being a source of environmental pollution. Rice husk ash is highly pozzolanic and very suitable for use as Portland cement in concrete production. Rice husk ash is indeed a partial replacement material for cement in concrete production. However, the failure which is associated with the use of its concrete can be traced to missing knowledge concerning material properties and techniques of its concrete production. The objective of this paper is to develop analytical models to predict the mechanical properties of risk husk ash concrete. It is believed that research into this prediction will promote maximum utilization of concrete made from this agricultural wastes as partial replacement for cement.

Model Development

From Hooke's law, the generalized 2-dimensional stress-strain relationship is given by

$$\varepsilon_x = \frac{1+v}{E}\left(\sigma_x(1-v) - v\sigma_y\right) \quad (1)$$

The material is strained in the longitudinal direction, implying that $\sigma_y = 0$

Equation (1) now transforms to:

$$\varepsilon_x = \frac{1+v}{E}\left(\sigma_x(1-v)\right) \quad (2)$$

From equation (2),

$$\varepsilon_x .E = (1+v)(1-v)\sigma_x \quad (3)$$

From Hooke's law,

$$\sigma = E.\varepsilon \quad (4)$$

$$\Rightarrow \sigma_c = (1+v)\ (1-v)\sigma_{cc} \quad (5)$$

$$\{\varepsilon_x .E = \sigma_c \ and\ \sigma_x = \sigma_{cc}\ \}$$

From equation (5),

$$\sigma_{cc} = \frac{\sigma_c}{(1+v)(1-v)} \quad (6)$$

Expansion of the denominator of equation (6) transforms equation (6) to

$$\sigma_{cc} = \frac{\sigma_c}{1-v^2} \quad (7)$$

where

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σ_{cc}, σ_c = compressive strength of rice husk ash concrete and mortar respectively.

v = poisson's ratio of rice husk ash concrete = 0.30 for low strength concrete [10].

Using rice husk ash as partial replacement for cement reduces the compressive strength of concrete. The reduction of strength of cement- rice husk ash mortar is given by

$$\sigma_c = \sigma_{cu} - \lambda\sigma_{cu} \quad (8)$$

Therefore,

$$\sigma_c = \sigma_{cu}(1-\lambda) \quad (9)$$

Substitution of equation (8) for σ_c in equation (6) gives

$$\sigma_{cc} = \frac{\sigma_{cu}(1-\lambda)}{1-v^2} \quad (10)$$

where

$1-\lambda$ represents the volume percentage of cement in the cement-rice husk mortar. Since the total volume percentage is equal to unity.

That is,

$$C + \lambda = 1 \quad (11)$$

where

C, λ = volume percentage of cement and rice husk ash respectively.

The compressive strength of concrete made from rice husk ash as partial replacement is predicted using equation (10). The water absorption of the concrete is predicted based on the assumption that the water absorption is dependent on the volume percentage of the rice husk ash only.

Let

W_A represents the water absorption and

M_a water absorption coefficient

From the assumption that water absorption depends only on the amount of rice husk ash present in the concrete, and using equation (11),

$$\Rightarrow W_A = M_a(1-\lambda) \quad (12)$$

Equation (12) is used to predict the water absorption of concrete made from rice husk ash as partial replacement.

RESULTS AND DISCUSSION

The proposed analytical models were verified using experimental data obtained from literature [11].

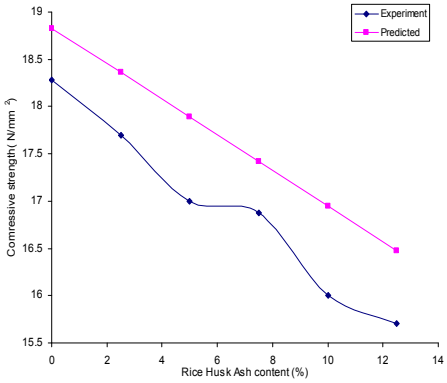

Figure 1: Relationship between compressive strength and Rice husk ash content (%) for 7 days

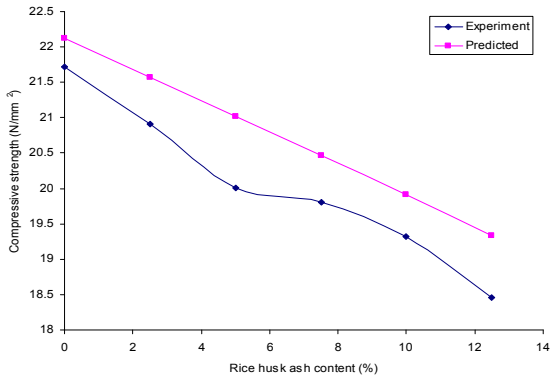

Fig. 2: Relationship between compressive strength and Rice husk ash content (%) for 14 days

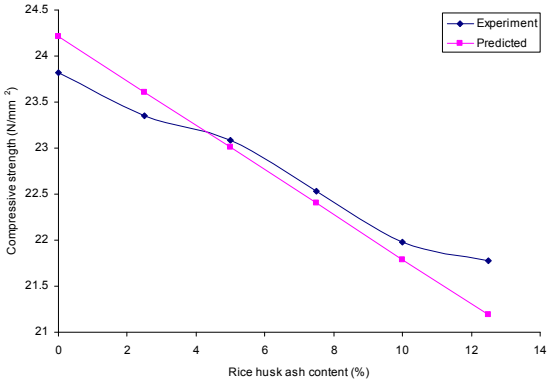

Fig. 3: Relationship between compressive strength and Rice husk ash content (%) for 28 days

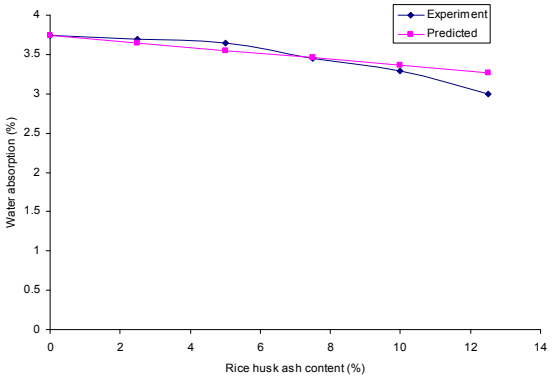

Fig. 4: Relationship between water absorption and Rice husk ash content (%) for 7 days

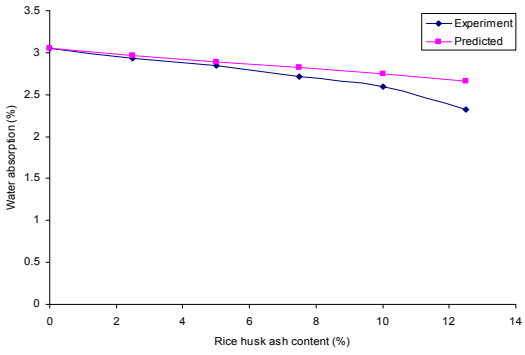

Fig. 5: Relationship between water absorption and Rice husk ash content (%) for 14 days

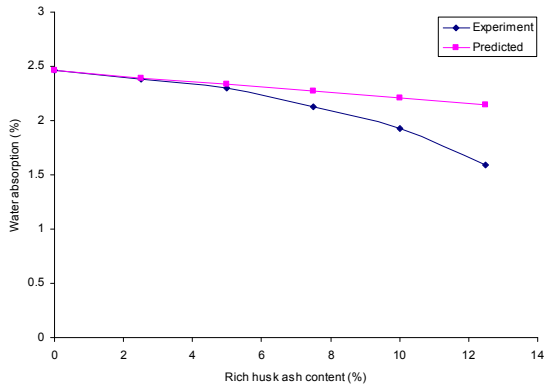

Fig. 6: Relationship between water absorption and Rice husk ash content (%) for 28 days

The results of the experimental data and analytical models for compressive strength at age 7, 14 and 28 days are as shown in Figures 1-3. Figures 1-3 illustrate the relationship between compressive strength against rice husk ash content for 7, 14 and 28 days investigation. The curves agree closely with a very high correlation coefficient of 0.9467. F-statistic test was also conducted and the result showed that both the experimental and predicted results have the same variance, showing good reliability of the proposed model. The predicted curve showed that compressive strength decreases with increase in rice husk ash content. This trend may be due to the fact that the partial replacement of cement with rice husk ash resulted in the reduction in the quantity of cement in the mix available for the hydration process leading to reduction in the formation of stable strength producing cementitious compounds. The little disparity between the experimental and predicted results may be due to imperfections in the assumption made in the model development. Typical results for the experimental and analytical models at ages 7, 14, 14 and 28 days are presented in Figures 4-6. The results agree closely with correlation coefficient of 0.946. F-statistic test also showed that both the experimental and predicted values have the same variance, indicating good reliability of the model. Both the experimental and predicted curves show that the use of rice husk ash as partial replacement decreases the water absorption of concrete. This trend may be attributed to the fact that the porosity of concrete increased with increase in rice hush ash content. The little difference between the experimental and predicted results may be due to imperfections in the assumption made in the derivation of the model.

Conclusions

The following are the main conclusions drawn from the study:

(i) The 2-dimensional stress strain relationship gave a very high correlation coefficient showing the effectiveness of the model in the prediction of mechanical properties of concrete made from rice husk as partial replacement for cement.

(ii) The compressive strength of concrete made form rice husk ash as partial replacement decreases with increase in rice husk content.

(iii) The water absorption decreases with increase in rice husk content.

REFERENCES

1. Onyekan, G.L. and Kamiyo, O.M. Effect of Nigerian Rice Husk Ash on some Engineering Properties of Sandcrete blocks and concrete, research Journal of Applied Sciences 3 (5): 345-351, 2008.
2. Mehta, P.K. and Pitt, N. Energy and Industrial Materials from crop residues. In Resources Recovery and Construction, 2, Elsevier scientific publishing company, pp: 23-38, (1996).
3. Okpala, D.C., Rice Husk Ash (RHA) as partial Replacement of cement in concrete. Proceedings of 1987 Annual Conference of Nigerian Society of Engineers, Port Harcourt, PP: 83-90 1987.
4. Yogenda, M.R. and Jagadish, K.S. Pozzolanic properties of Rice Husk Ash, Burnt Clay and Red mud. J. Building and Environment, 23: 303- 308, 1988.
5. Zhang, M.H. and Malhotra, V.M. High performance concrete incorporating rice husk ash as a supplementary cementing material. ACI Material J., PP: 629- 636, 1996.
6. Sampalo, J., Coutiaho, S.J. and Sampalo, M.N. Portuguese rice husk ash as a partial cement replacement. Technical Report, Department of Civil Engineering, EFUP, Universidade do porto, Portugal, 2002.
7. Musa, A. and Alhaji Mohammed M. (2005). Effect of Rice Husk Ash on cement stabilized laterite. A final year project, Department of Civil Engineering, Federal University of Technology, Minna, Pp. 1-10.
8. Paya, J., Wolley, G.R., Goumans, J.M. and Wainwright, P.J. Studies on crystalline rice husk ashes and activation of their pozzolanic properties, Pergamon, Amsterdam, PP: 493-503.
9. Falade, F. Effect of Sawdust Ash on the strength of Laterized concrete. West Indian J. Eng., 15 (1): 71-84, 1990.
10. Neville, A.M., 1996. Properties of concrete, Longman Ltd., England.
11. Udogu, A.H. The Effect Rice Husk Ash on the Mechanical Properties of Concrete. A Final year thesis, Department of Civil and Environmental Engineering, University of Port Harcourt, 2008.

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