

## INVESTIGATION OF COMPRESSIVE STRENGTH OF CONCRETE CONTAINING RICE-HUSK-ASH

R. B.Y. B. Uduweriya<sup>1</sup>, C. Subash<sup>1</sup>, M. M. A. Sulfy<sup>1</sup> and Sudhira De Silva<sup>2</sup>

<sup>1</sup>Graduate Student, Department of Civil and Environmental Engineering,  
Faculty of Engineering, University of Ruhuna  
Email: uduweriya@gmail.com  
Tel: +94-(0)77-2666601

<sup>2</sup>Senior Lecturer, Department of Civil and Environmental Engineering,  
Faculty of Engineering, University of Ruhuna, Hapugala, Galle, Sri Lanka  
Email: sudhira@cee.ruh.ac.lk  
Tel: +94-(0)91-2245765~7

### ABSTRACT

The rice husk ash (RHA) is a pozzolanic material that can be blended with the Portland cement in concrete to obtain a better performance of normal concrete. This paper proclaims an experimental investigation on utilization of RHA for the concrete as it is a byproduct of brick-kilns in Sri Lanka. The results of three different replacement percentages of RHA in concrete (10%, 20% and 30% by mass of cement) were compared with the concrete that does not contain RHA. Those samples were tested for compressive strength, tensile strength, surface water absorption and the durability aspects. A comparative study on chemical composition and physical properties was carried out and the experimental results were discussed. A significant improvement on the compressive strength at early stage is identified and optimum strength was achieved at the 20% RHA replacement by mass of cement. The strength of the concrete with different sizes of RHA particles was compared to identify the effects of particle size of RHA. Around 50% of the RHA collected from the brick-kiln can be utilized for the concrete after proper grinding.

*Keywords* –Rice husk ash, compressive strength, brick-kiln, surface water absorption

### 1. INTRODUCTION

In the present situation, concrete is one of the most widely used construction material in the world. The most common form of concrete is Ordinary Portland Cement (OPC) concrete, which consists with coarse aggregate, fine aggregate, cement and water.

In most of the countries, different cementitious materials such as Fly-Ash, Ground Granulated Blast-furnace Slag (GGBS), Silica Fume and Rice Husk Ash (RHA) to achieve high performance, good quality and low cost concrete mixtures. In here, rice husk is a byproduct of de-husking operation of paddy rice that is produced in about 115 million of tons in all over the world annually. The total amount of rice produced in Sri Lanka in year 2002 is 2.79 million metric tons <sup>[1]</sup>. The total amount of rice needed in Sri Lanka over the year 2010 and 2020 are estimated at 3.46 and 3.83 million metric tons respectively <sup>[2]</sup>. Approximately 20 kg of rice husk are obtained for 100 kg of rice. Rice husks contain organic substances and 20% of inorganic material <sup>[3]</sup>. Therefore considerable amount of rice husk is wasted annually and it may increase with the time.

Rice husk ash (RHA) can be used as a highly reactive pozzolanic material to improve the microstructure of the interfacial transition zone (ITZ) between the cement paste and the aggregate in high-performance concrete. The utilization of rice husk ash as a pozzolanic material in cement and concrete provides several advantages, such as improved compressive strength and durability properties, reduced materials cost due to cement savings and environmental benefits related to the disposal of waste materials and reduced carbon dioxide emissions <sup>[4]</sup>.

From 1980 to 1996, the world's annual consumption of Portland cements increased around 2 million tons to 1.3 billion tons. This was associated with major environmental problems since the cement manufacturing is the third largest CO<sub>2</sub> producer and for over 50% of all industrial CO<sub>2</sub> emissions (for every 1.0 ton of cement produced, 1.0 to 1.25 tons of CO<sub>2</sub> is released in the air) and 1.6 tons of natural resources is consumed to produce 1.0 ton of cement <sup>[5]</sup>.

The reaction of the rice husk ash with the cement is dependent on several factors. Burning duration, burning temperature and the particle size of the ashes are the most significant. The optimum

temperatures are around 600 °C for 2-3 hrs burning and 400 °C for 4 hrs burning. There is an optimum temperature for each burning time and burning at higher temperatures beyond a certain limit does not necessarily help to produce quality ash <sup>[6]</sup>.

The grinding process would affect the water absorption capacity of concrete. Longer the grinding time, it may lower the water absorption rate <sup>[3]</sup>. With the proper grinding process, the RHA can be converted to the ultrafine particles. Therefore, of ultrafine RHA in to concrete to reduce permeability, water absorption of concrete and many beneficial effects on concrete performance <sup>[4]</sup>.

This paper proclaims an experimental investigation on possibility of utilization of RHA from the byproduct of brick-kilns in Sri Lanka. In the present investigation, rice husk has been blended with Ordinary Portland Cement (OPC) at various percentages and experiments were carried out to investigate the mechanical properties. The results were compared with conventional OPC concrete.

## 2. MATERIALS AND METHODS

### 2.1 Rice Husk Ash

RHA for the experiment was obtained from the brick-kiln that used rise husk as a fuel. The burning temperature was within the range of 600 °C to 850 °C. The fully burnt ashes and the partially burnt ashes are separated by 10 minutes sieving. The ash passing 300 mm sieve size are considered as fully burnt ashes and it may be around 60% of the ashes collected from the brick-kiln. The particle size of the RHA is limited to 75 µm and fineness of the RHA was increased by the grinding process. The particle size distribution of 75 µm passing RHA is as shown in Fig 1. The average particle size is 18 µm and specific gravity is 2.16. Since the RHA is finer than cement it can be expected to have micro-filler effect as well as the pozzolanic reaction <sup>[7]</sup>.

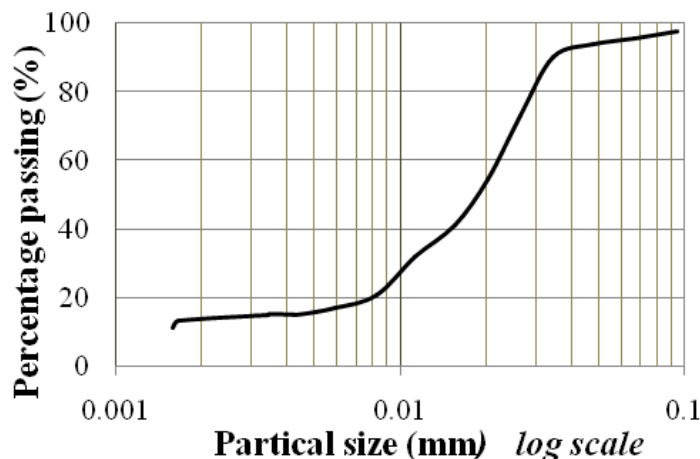


Fig 1: Particle Size Distribution for RHA obtained from 75µm Passing

### 2.2 Fine and coarse aggregates

The fine aggregates that used for the experiment were natural river sand passing from 4.75 mm sieve. The specific gravity of the sand was tested according to BS 812: Part 2: 1995. The specific gravity of fine aggregate was observed as 2.65.

The coarse aggregate that used for the experiment were crushed granite with maximum size of 20 mm. The specific gravity of the coarse aggregate was tested according to BS 812: Part 2: 1995. The specific gravity was observed as 2.65 for coarse aggregates.

Table 1 - Water Absorption in Aggregates

Type of aggregate	Water absorption
Fine aggregate	1.30 %
Coarse aggregate	0.31 %

### 2.3 Compressive strength of concrete

The Compressive strength of the concrete was measured by preparing cubes of 150x150x150 mm mould size. Concrete with 0.75 W/C ratios was used for the experiments. Mechanical vibrator was used to compact the concrete during casting. The moulds were removed after 24 hours and placed in the curing tank until the testing dates. The specimens were tested after 3, 7, 14, 28, 56, and 91 days with the loading rate of 0.3 N/mm<sup>2</sup>/s. The average value of compressive strength was obtained by testing of three specimens.

### 2.4 Split tensile test

Split tensile test for the concrete was carried out according to the BS 1881:Part117:1983. Concrete cylinders of 150 mm diameter and 300 mm height were casted by using concrete with W/C ratio of 0.75. Mechanical vibrator was used to compact the concrete during casting. The moulds were removed after 24 hours and placed in curing tanks until the testing dates. The specimens were tested after 91 days with the loading rate of 0.03 N/mm<sup>2</sup>/s. The average value of tensile strength was obtained by testing of three specimens.

### 2.5 Surface water absorption test

The surface water absorption test was carried out with a concrete cube of 150x150x150 mm size. The W/C ratio of 0.75 was used for concrete mixture. The test was conducted after 28 days and the variation of the results were discussed as percentage deviation with reference to the control sample. All cubes were subjected to oven dry under 100 °C before testing. The surface water absorption of concrete was tested at 10, 30 and 60 min after the water head was released to the concrete surface.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Compressive strength of concrete

The compressive strength of concrete cubes containing different amount of RHA (75µm passing) was tested according to BS 1881: Part 116:1983. The variation of compressive strength of concrete with days is shown in Fig. 2.

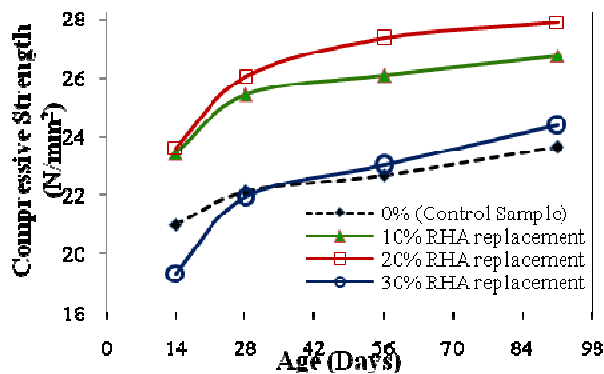


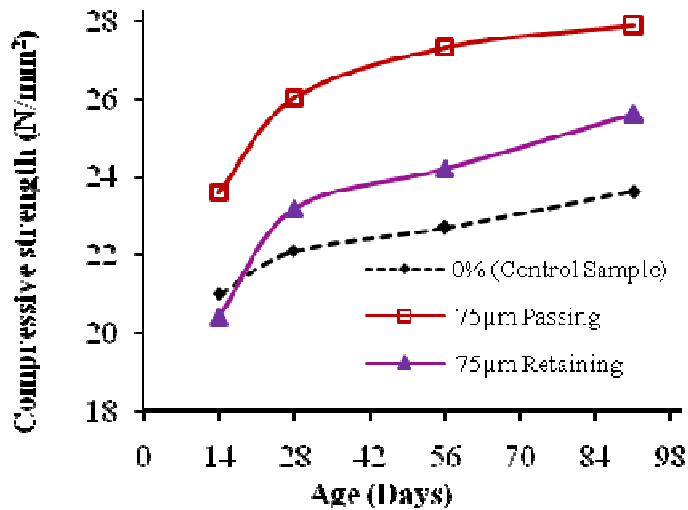
Fig 2: Variation of Compressive Strength of Concrete

Table 2: *Compressive Strength of Concrete with Difference Percentage of RHA*

Replacement	Average Compressive Strength (N/mm <sup>2</sup> )			
	14 days	28 days	56 days	91 days
0%(Control)	21.00	22.10	22.69	23.63
10% of RHA	23.40	25.41	26.07	26.75
20% of RHA	23.60	26.04	27.33	27.87
30% of RHA	19.33	21.95	23.01	24.38

The maximum strength is achieved with 20% replacement of RHA for the cement in concrete. The maximum increment is around 17.9% than the control sample. Therefore 20% of RHA can be identified as the optimum percentage to replace the cement in concrete.

The effect of the particle size also tested during this experiment. The sieve sizes of 75  $\mu\text{m}$  and 150  $\mu\text{m}$  passing RHA mixed concrete specimens were compared with control sample. The variation of compressive strength of concrete containing different two sizes of particle sizes of RHA is shown in Fig. 3.

Fig 3: *Variation of Compressive Strength of Concrete*

The compressive strength development of concrete with 150  $\mu\text{m}$  passing was lower than RHA passing 75  $\mu\text{m}$ . However, the strength development rate is almost equal in both cases. Therefore, it can be concluded that when the fineness of the RHA increases the strength development of the RHA mixed concrete also increased. Similar results have been obtaining in previous studies as well. <sup>[7, 8]</sup>

### 3.2 Splitting tensile strength

The tensile strength of the concrete was tested according to the BS 1881: Part 117: 1983 by using the concrete cylinder. The experimented results are as follows.

Table 3: *Results of Splitting Tensile Strength*

Sample No.	Replacement (%)	Splitting Tensile Strength (N/mm <sup>2</sup> )
1	0	1.86
2	10	2.60
3	20	3.01
4	30	2.56

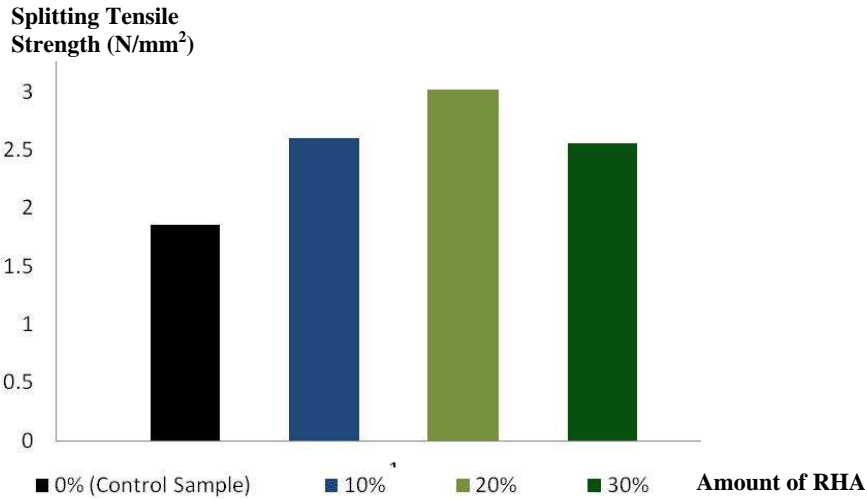


Fig 4: Variation of Splitting Tensile Strength

Fig 4 shows that significant increment in the tensile strength in concrete containing RHA. The maximum tensile strength is resulted with 20% replacement. Therefore tendency of cracking of concrete containing RHA can be considered as low compared to the normal concrete.

### 3.3 Surface water absorption test

The result of surface water absorption test is shown in Table 4. Around 15% reduction in water absorption was observed with the 20% replacement of fly ash. Around 11% reduction in water absorption with 20% replacement of RHA and around 10% reduction with combination of same amount of RHA and Fly Ash were observed.

Table 4: Surface water absorption test results

Time (min)	Control Sample	Percentage water absorption compared to control sample		
		Fly-Ash 10 and RHA10	RHA 20	Fly-Ash 20
10	100	88.24	91.18	86.76
30	100	91.11	88.89	86.67
60	100	88.57	85.71	82.86
Average	<b>100</b>	<b>89.31</b>	<b>88.59</b>	<b>85.43</b>

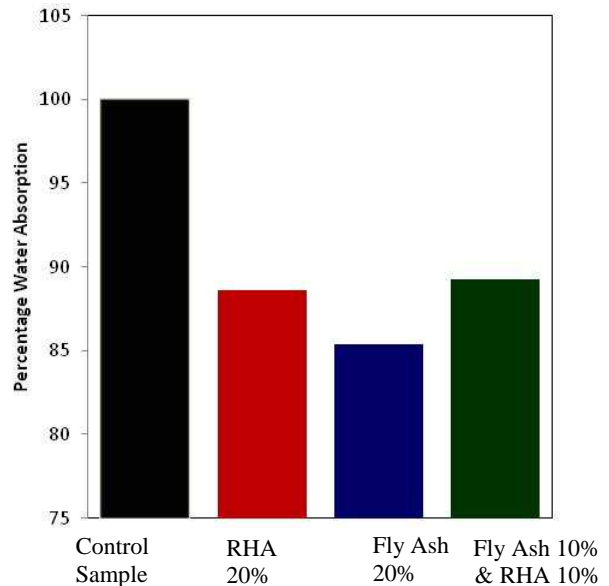


Fig 5: Surface water absorption test results

The concrete containing RHA has shown a considerable reduction in surface water absorption in concrete. Further addition of fly ash has given better result than the 20% RHA replacements. It may be due to higher fineness of fly ash than the RHA particles. However, according to the degree of replacement of RHA, the rate of water absorption can be different. Therefore, number of experiments consisting with different percentage of RHA is required to find out the optimum level of RHA to minimize the surface water absorption of concrete.

## 4.0 CONCLUSIONS

- It is possible to use the RHA that is produced as waste material from the land molded burnt clay brick production process in Sri Lanka to improve the properties of concrete.
- 20% replacement of RHA by mass of cement shows about 18% increment of compressive strength of concrete.
- There is considerable increment in splitting tensile strength with 20% replacement of cement by RHA.
- There is a significant reduction of workability in fresh concrete with the increase amount of RHA content in concrete. The Fly Ash can be used with the RHA to increase the workability of concrete.
- The performance of the concrete would depend on the fineness of the RHA. The finesses of RHA would increase the compressive strength of the concrete.
- The addition of RHA for the concrete decreases the water absorption of concrete. There was around 11% reduction in surface water absorption with the 20% of RHA replacement compared to control specimen.

## 5.0 REFERENCES

- 1) Reddy D. V., and Alvarez, B. S. M., "Marine Durability Characteristics of Rice Husk Ash-Modified Reinforced Concrete", Fourth LACCEI International Latin American and Caribbean Conference for Engineering and Technology (LACCET'2006), June 2006.
- 2) Thiruchelvam S., "Efficiency of Rice Production and Issues relating to Cost of Production in the Districts of Anuradhapura and Polannaruwa", J. Natn.Sci.Foundation Sri Lanka 2005 33(4), October 2005, pp. 247-256
- 3) Tashima M. M., De Silva C. A. R., Akasaki J. L., and Barbosa M. B. "The Possibility of Adding the Rice Husk Ash (RHA) to the Concrete", Civil Engineering Department, FEIS/UNESP, Brazil.
- 4) Saraswathy V., Song H.W., "Corrosion Performance of Rice Husk Ash Blended Concrete", 2006.
- 5) James R., Mihelcic., and DamT. V., "Development of Appropriate and Sustainable Construction Materials", Michigan Technological University, Southern University and A&M College, May 23, 2005.
- 6) Yamamoto Y., and Lakho S. M., "Production and Utilization of Active Rice Husk Ash as a Substitute for Cement", proceeding of the Japan Society of Civil Engineers, No 322, June 1982.
- 7) Habeeb G. A., Fayyadh M. M., "Rice Husk Ash Concrete: the Effect of RHA Average Particle Size on Mechanical Properties and Drying Shrinkage", Australian Journal of Basic and Applied Sciences, vol.3, No.3, 2009, pp.1616-1622.
- 8) Cordeiro G.C., Filho R.D.T., Fairbairn E.M.R., "Use of ultrafine rice husk ash with high-carbon content as pozzolan in high performance concrete", Materials and Structures (2009) Vol. 42, September 2008, pp. 983-992.
- 9) Mehta, P. K., and Paulo J. M. M., "Concrete Microstructures, Properties and Materials", Third Edition, New Delhi, Tata McGraw-Hill Publishing Company Limited, 2006, pp. 257-307.
  - a) Mehta P. K., U.S Patent No. 4105459(Aug.1978), and 5346548(Sep.1994); also in Malhotra, V.M., ed "Advanced in Concret Technology", CANMET, Ottawa, Canada, 1994.
  - b) Mehta, P. K., and Folliard K. J., ACI, SP-154, American Concrete Institute, Detroit, 1995.
  - c) Zhang, M. H., and Malhotra V. M., *ibid*.
- 10) De Pádual P. G. L., Tavares L. R. C., Bezerra A. C. S., Aguilar M. T. P., and Cetlin P. R., "Concretes Made With Rice Husk Ash Obtained At Low Temperature", Proceedings of the 11<sup>th</sup> International Conference on Non-conventional Materials and Technologies (NOCMAT 2009), Bath, UK, September 2009.
- 11) Dong D. V., Huu P. D., Lan N. N., "Effect of Rice Husk Ash on Properties of High Strength Concrete", The 3rd ACF International Conference- ACF/VCA., 2008.
- 12) Sensale G. R., "Strength development of concrete with rice-husk ash", Cement & Concrete Composites 28 (2006), September 2005. pp. 158-160.
- 13) Di Campos. M. S., Barbosa N. P., Savastano Jr. H., "Swine Deep Bedding Ashes as A Mineral Additive for Cement Based Mortar", Vol. 65, March/April 2008, pp. 109-115.