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Supplementary Cementing Materials
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Influence of Rice Husk Ash in Mechanical Characteristics of Concrete

Mauro M. Tashima, Carlos A. R. Silva, Jorge L. Akasaki and Michele B. Barbosa

Synopsis: Concrete is the most used material in civil construction. Relatively to its use, the cost of the using concrete is even greater, mainly because of the manufacturing cost of the cement Portland, its main component.
The use of mineral additives in concrete has been intensified a lot during the last decades. Among this additives, the fly ash is, definitely, the most used, due to its great availability and low cost. However, other pozzolans has recently attracted a special attention: the Rice Husk Ash (RHA).
In the present work, how different grades of RHA added to the concrete can influence its physic-mechanical properties was studied. Concrete specimens was molded with 5% e 10% of ash, replacing the cement, and measured its to axial compressive strength, splitting tensile, water absorption and elasticity modulus.
The obtained results confirm the viability of adding RHA to the concrete.

Keywords: rice husk ash; mechanical characteristics; concrete

Paper XII.08 - p. 780-790 ISBN 85-98576-08-5

Mauro M. Tashima is a MS student from UNESP – Ilha Solteira.

Carlos A. R. Silva recieved his MS (2004) from UNESP – Ilha Solteira.

Jorge L. Akasaki is an assistant Professor of Civil Engineering at UNESP – Ilha Solteira. He received his MS (1995) and his Ph.D. (1999) from the University of São Paulo.

Michele B. Barbosa is a MS student from UNESP – Ilha Solteira.

INTRODUCTION

Rice husk is an agro-waste material which is produced in about 100 million of tons. Approximately, 20 Kg of rice husk are obtained for 100 Kg of rice. Rice husks contain organic substances and 20% of inorganic material. Rice husk ash (RHA) is obtained by the combustion of rice husk. The most important property of RHA that determines the pozzolanic activity is its amorphous phase content. RHA is a highly reactive pozzolanic material suitable for use in lime-pozzolan mixes and for Portland cement replacement. RHA contains a high amount of silicon dioxide, and its reactivity related to lime depends on a combination of two factors, namely the non-crystalline silica content and its specific surface.

Research on producing rice husk ash (RHA) that can be incorporated to concrete and mortars are not recent. In 1973, Metha [1] investigated the effect of pyroprocessing on the pozzolanic reactivity of RHA. Since then, a lot of studies has been developed to improve the mechanical and durability properties of concrete. Since then, a lot of researches have been developed to improve the mechanical and durability properties of concrete Costenaro and Libório [2], Payá [3].

The potential reactivity of aggregate was investigated by Hasparyk [4]. The results show that adding percentage over 12% of RHA, the expansion is reduced in acceptable levels.
In this paper, the RHA obtained by uncontrolled combustion was added to concrete. Mechanical properties (axial compressive strength, splitting tensile strength, water absorption and elasticity modulus) were verified. The samples were tested at 7, 28 and 91 days of age.

EXPERIMENTAL METHODS

Materials

Rice Husk Ash (RHA)– Rice husk was burnt approximately 48 hours under uncontrolled combustion process. The burning temperature was within the range 600 to 850^{0}C. The

Paper XII.08 - p. 780-790 ISBN 85-98576-08-5

ash obtained was ground in a ball mill (Figure 1) for 30 minutes and its appearance color was grey (Figure 2).

Their physical and chemical characteristics were determined according to the Brazilian ABNT Standards (Table 1). In addition, X-ray diffraction was used to verify the presence of crystalline silica in RHA and a laser diffraction particle size analyzer was used to determine the particle size distribution of RHA.

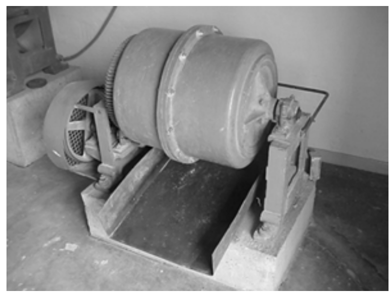

Figure 1–A ball mill.

Figure 2–RHA sample after 30 minutes of grounding.

Paper XII.08 - p. 780-790 ISBN 85-98576-08-5

Table 1−Physical and chemical properties of RHA.

Blaine Specific Surface (cm^2/g)		16196
Specific Gravity (g/cm^3)		2.16
Mean Particle size (μm)		12.34
Passing # 325 (%)		96.6
Chemical Components	SiO_2	92.99
	Fe_2O_3	0.43
	Al_2O_3	0.18
	CaO	1.03
	MgO	0.35
	$S\hat{O}_3$	0.10
	$Al_2O_3 + Fe_2O_3$	0.61
	$SiO_2 + Al_2O_3 + Fe_2O_3$	93.50
	Na_2O	0.02
	K_2O	0.72

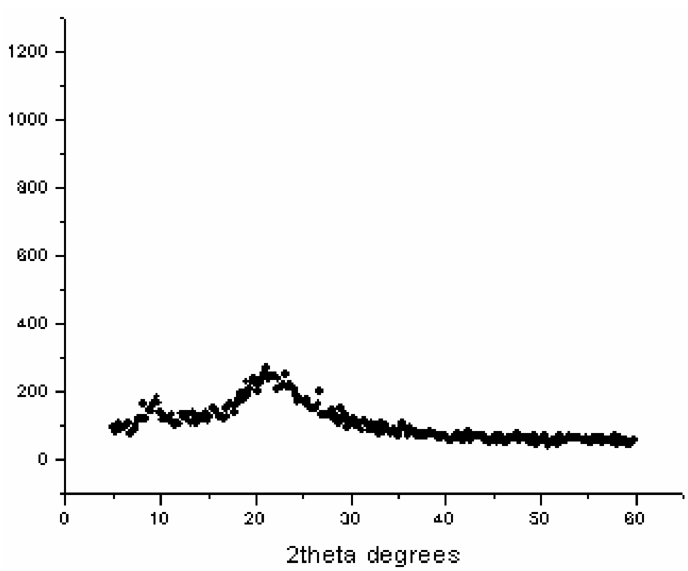

Figure 3−X-ray diffractograms of RHA sample.

According to the chemical characteristics, the RHA has high levels of SiO_2, approximately 93%, and the specific gravity is $2.16g/cm^3$. Figure 3 shows x-ray diffractogram for the RHA sample, which denotes that the RHA presents an amorphous structure.

Paper XII.08 - p. 780-790 ISBN 85-98576-08-5

According to the Figure 4, the average particle size distribution was 13.34µm. Thus the RHA is finer than cement and should be expected to work not only a pozzolanic role, but also a microfiller effect.

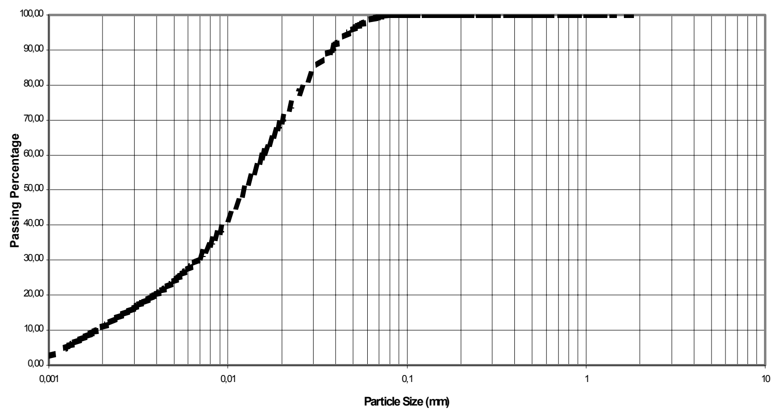

Figure 4–Particle size distribution of RHA after 30 minutes in a ball mill.

<u>Cement</u>–The cement type used in this research was high early strength or Type III cement. All their characteristics were according to Brazilian Standard NBR- 5733. Physical and chemical properties of cement were listed in Table 2.

Table 2– Physical and chemical properties of cement.

Blaine Specific Surface (cm^2/g)		6916
Specific Gravity (g/cm^3)		3.08
Initial Setting Time		1:48
Compressive Strength (MPa)	3 days	33.4
	7 days	38.8
	28 days	45.0
Chemical Components	SiO_2	23.89
	Fe_2O_3	2.72
	Al_2O_3	8.91
	CaO	51.27
	MgO	4.48
	SO_3	3.55
	Na_2O	0.18
	K_2O	0.96

Paper XII.08 - p. 780-790 ISBN 85-98576-08-5

Aggregates–The fine aggregate used is a natural sand with fineness modulus of 2.25 and specific gravity 2.58g/cm^3. The coarse aggregate (basalt rock) has maximum size of 19mm and specific gravity 2.96g/cm^3.

Superplasticizer–A superplasticizer of third generation for concrete was used. This superplasticizer is suitable for the production of high performance concrete. It facilitates extremely high water reduction, high flowability as well as internal cohesiveness. It was the Viscocrete 5 from Sika Brazil.

Composition of Concrete Mixtures

Table 3 shows the used mixture proportions of concrete. Two dosages of RHA, 5% (mixture E) and 10% (mixture F) in substitution to the cement, and a control mixture (mixture D) were used. The slump test was fixed in 120 ± 20mm, therefore, for the mixtures D and E, the dosage of superplasticizer was 0.2% of binder mass. For the mixture F, the dosage of superplasticizer was 0.3%.

Table 3–Composition of the concrete mixtures.

Cement	Sand	Coarse aggregate	W/C	Cement (kg/m3)		
				Mixture D	Mixture E	Mixture F
1	1.33	2.27	0.42	490.0	465.5	441.0

After that, 10x20cm cylindrical specimens have been molded and tested to the simple compressive strength, splitting tensile strength, water absorption by immersion and elasticity modulus. The tests have been accomplished with ages of 7, 28 and 91 days, with curing in moist room.

RESULTS AND DISCUSSION

Water Absorption

The water absorption is shown in Table 4 and Fig. 5. The results reveal that higher substitution amounts results in lower water absorption values, this occurs due to the RHA being finer than cement. Adding 10% of RHA to the concrete, a reduction of 38.7% in water absorption is observed when compared to mixture D.

Paper XII.08 - p. 780-790 ISBN 85-98576-08-5

Table 4−Water absorption test (%).

Mixture	7 days	28 days	91 days
D – control	2.67	1.76	1.54
E – 5% RHA	2.64	1.64	1.35
F – 10% RHA	2.35	1.38	1.11

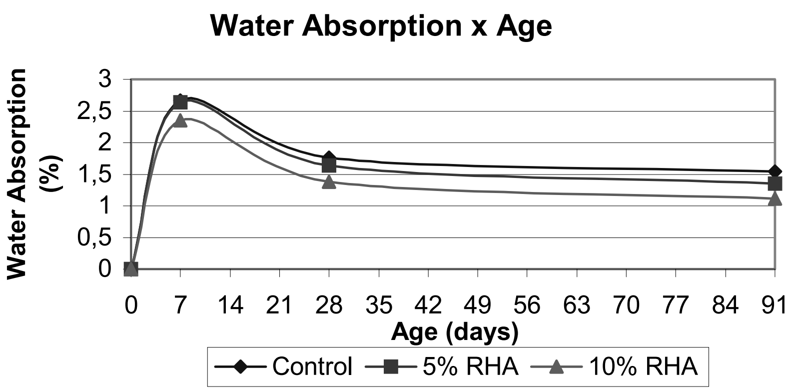

Figure 5−Results of water absorption test.

Axial Compressive Strength

The axial compressive strength is shown in Table 5 and Fig. 6. The addition of RHA causes an increment in the compressive strength due to the capacity of the pozolan of fixing the calcium hidroxide, generated during the reactions of hydrate of cement. All the replacement degrees of RHA increased the compressive strength. For 5% of RHA, 25% of increment was verified when compared with mixture D.

Table 5−Axial compressive strength (MPa).

Mixture	7 days	28 days	91 days
D – control	45.9	48.1	58.3
E – 5% RHA	52.9	60.4	62.0
F – 10% RHA	45.8	54.2	60.9

Paper XII.08 - p. 780-790 ISBN 85-98576-08-5

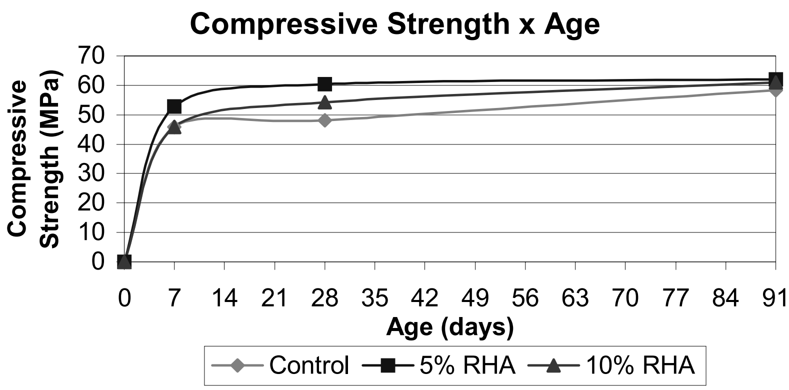

Figure 6–Results of axial compressive strength.

Splitting Tensile Strength

The results of splitting tensile strength are shown in Table 6 and Fig. 7. All the replacement degrees of RHA studied, achieved similar results in splitting tensile strength. According to the obtained results, may be verified that there is no interference of adding RHA in the splitting tensile strength.

Table 6–Splitting tensile strength (MPa).

Mixture	7 days	28 days	91 days
D – control	4.85	5.37	5.41
E – 5% RHA	4.94	5.79	5.9
F – 10% RHA	4.82	5.78	5.4

Paper XII.08 - p. 780-790 ISBN 85-98576-08-5

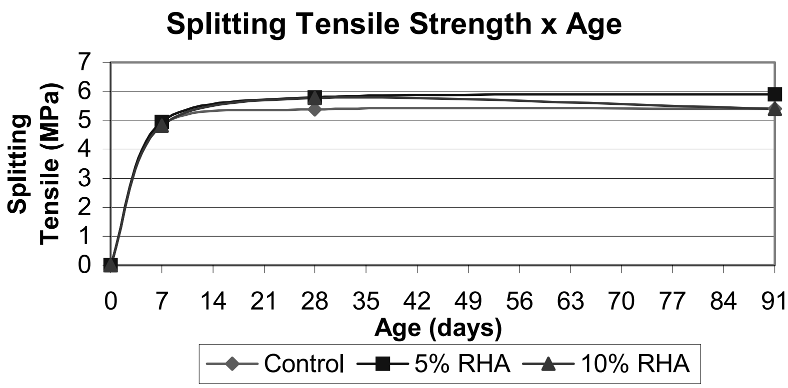

Figure 7–Results of splitting tensile strength.

<u>Elasticity Modulus</u>

The elasticity moduli are shown in Table 7 and Fig. 8. All the samples studied have a similar results in elasticity module. A decreasing in the module is verified when the levels of RHA are increased.

Table 7–Elasticity modulus (GPa).

Mixture	7 days	28 days	91 days
D – control	38.08	40.85	45.04
E – 5% RHA	40.72	40.76	41.84
F – 10% RHA	40.23	40.21	40.03

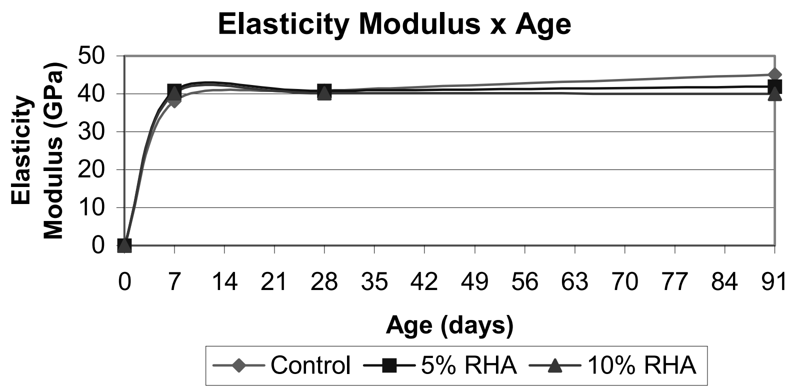

Figure 8: Results of elasticity modulus test.

CONCLUSION

The use of RHA in civil construction, besides reducing the environmental polluters factors, may bring several improvements for the concrete characteristics.

Adding RHA to concrete , a decreasing in water absorption was verified. A reducing of 38.7%, for 10% of RHA at 28 days, was observed when compared to the control sample. An increment of 25% in axial compressive strength was obtained when added 5% of RHA for 28 days. Moreover, a reducing on the use of Portland cement was verified, obtaining the same control sample axial strength.

According to the results of splitting tensile test, all the replacement degrees of RHA studied, achieved similar results. Then, it may be realized that there is no interference of adding RHA in the splitting tensile strength. All the samples studied have a similar results in elasticity module. A decreasing in the module is pointed out when the levels of RHA are increasing.

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Paper XII.08 - p. 780-790 ISBN 85-98576-08-5

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