Use of Rice Husk Ash in Cement Mortar

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Abstract

This research deals with the effects of using rice husk ash (RHA) as a partial weight of cement replacement materials in cement mortar mixes. This work is based on an experimental study of mortar made with ordinary Portland cement (OPC) and 5%, 10%, 15% and 20% (OPC) replaced by RHA. The rice husk ash used was produced by burning the rice husk at 500˚ C, then grinding it to a fineness of 11200 cm^2/gm (Blaine). The tests which were performed evaluate the action of this material were: normal consistency, setting time, compressive strength, flexural strength and porosity. The results show that addition of RHA show better results for 15% replacement level than OPC at 90 days.

الخلاصة

يتناول هذا البحث دراسة تاثير استخدام رماد قشور الرز كإحلال جزئي من وزن السمنت في خلطات مونة السمنت . يعتمد هذا العمل على الدراسة العملية لمونة السمنت المعمولة من السمنت البورتلاندي الاعتيادي مع إحلال جزئي من مادة رماد قشور الرز بالنسب 5%, 10%,15%و 20% من وزن السمنت . استخدم رماد قشور الرز الناتج من حرق قشور الرز عند درجة حرارة 500˚ م وطحن لنعومة مقدارها 11200سم^2/ غم باستخدام طريقة بلين . الفحوصات التى استخدمت لتقييم تأثير هذه المادة هي : الليونة القياسية , زمن التجمد , مقاومة الانضغاط , مقاومة الانثناء والمسامية لمونة السمنت. تشير النتائج الى ان اضافة رماد قشور الرز بنسبة 15% تظهر نتائج افضل من السمنت البورتلاندي الاعتيادي بعمر 90 يوم .

Introduction

Rice husk is the outer jacket of the grain of white rice with high concentration of silica. Generally this silica concentration is more than (80-88)%. After burning rice husk contributes 20% of its weight to rice husk ash [**Anwar 2001**]. According to Tashima RHA is a high pozzolanic material[**Tashima 2004**].

A large number of researches have been conducted towards the utilization of waste materials. For the development work the utilization of blended cement is growing rapidly. Pozzolans from industrial and agricultural byproducts are receiving more attention due to their uses in concrete production which improve the concrete property, and reduce the negative environmental effects. According to Metha [**Metha 1979**] when rice husk is burnt at temperatures lower than 700˚ C, rice husk ash with cellular microstructure is produced and contains high silica content in form on non-crystalline or amorphous silica and can be used as supplementary cementitious materials. Some other researchers wrote that the lower boundary of the temperatures is 500˚ C [**Hana 1984**].

. [**Ganesan et al 2007**] concluded that concrete containing 15% of RHA showed an atmost compressive strength and loss at elevated contented more than 15% .

[AL – Abdaly 2007] studied the effect of addition Rice Husk Ash (RHA) in two percentages (5, 7.5)% by weight of cement on the mechanical properties and drying shrinkage of high strength concrete . He found that the addition of RHA to concrete causing a deficiency by about (16 -34) % for compressive strength , (11-16)% for splitting tensile strength , (4- 11) % for modulus of elasticity and (7- 43) % for drying shrinkage . This reduction was observed for two percentages of RHA (5, 7.5)% .

[**Mahmud et al 2004**] studied the use of RHA to produce high strength concrete and the studied the effect of addition or replacement of RHA compared with silica fume on fresh and hardened mechanical properties .In this investigation OPC , RHA

,SF and asulphonated naphthalene formaldehyde based super plasticizer was used as chemical admixture with varying amounts to maintain workability . The results showed that the addition of RHA up to 15% leads to increase the compressive strength , increasing the amount above these values decreases the strength of the concrete . The optimum addition level of RHA to produce HSC approximately 10% and the optimum cement replacement with RHA is about 5%.

Experimental Work

Materials and Mixes

Cement

Ordinary Portland (cement) brought from Kufa cement plant was used throughout the present study. This cement conforms to the Iraqi standard specification (IQS No.5 - 1984). The chemical composition and physical properties of this cement are presented in Tables (1 and 2).

Table (1): Chemical composition of the cement

Oxides	% by weight	Limits of Iraqi specification IQS No.5/1984
CaO	61.94	—
SiO_2	20.80	—
Al_2O_3	5.52	—
Fe_2O_3	4.00	—
Mgo	1.85	≤ 5.00
SO_3	2.5	< = 2.5 if C_3A < 5% < = 2.8 if C_3A > 5%
Free lime	0.97	—
L.O.I	3.3	≤ 4.00
C_3S	41.48	—
C_2S	28.34	—
C_3A	7.86	—
C_4AF	12.17	—
L.S.F	0.88	0.66- 1.02

Table (2) Physical properties of cement

Physical properties	Test Results	Limits of Iraq specification IQS NO.5/1984
Fineness,Blaine,cm^2/gm Setting time vicats method Initial hrs :min Final hrs :min	3000 2:10 3:30	≥ 2300 ≥ 00:45 ≤ 10:00
Compressive strength Mpa 3day 7day	 20.0 28.0	 ≥ 15:00 ≥ 23:00

Sand

The sand used was natural sillicious sand with maximum size of 2.36mm (100% passed 2.36mm sieve). Sieve analysis and other properties of this sand are listed in Table (3).

Table (3): Grading and other properties of sand

Sieve Size mm	Cumulative Passing %	Limits of Iraqi Specification No.45/1984
9.5	100	100
4.75	100	90 -100
2.36	100	85 -100
1.18	88	75 -100
0.6	67	60 - 75
0.3	32	12 - 40
0.15	8	0 - 10
Sulfate content as SO_3	0.4 %	≤ 0.5 %
Fine materials	0.9 %	≤ 5 %
Fineness modulus FM	2.05	----

Rice Husk Ash (RHA)

Burning of rice husks according to [**Habeeb 2000, Hana 1984**] was carried out in a furnace with controlled temperature in order to establish the optimum burning temperature and burning time. The produced ash was burnt at a temperature of 500° C°, for two hours. The ash was grounded by Los Angles machine and to produce finer ash it will be grounded by small mill. The chemical composition of this (RHA) is given in Table (4).

Table(4) : Chemical properties of RHA

Oxides	CaO	SiO_2	Al_2O_3	Fe_2O_3	K_2O	Na_2O	MgO	SO_3	MnO	Cl	L.O.I
Percentage	1.31	87.5	0.5	0.24	3.3	1.2	0.4	1.7	O.O7	0.53	3.05

Mix Proportion and Curing

Ordinary Portland cement (OPC) was replaced by different amount of RHA (0%, 5%, 10%, 15% and 20%) in dry condition. Sample prepared with only (OPC) called the controlled samples. The mix designation are in Table (5). Cement mortar used in proportion of (1:3) (cement : sand) and w/c = 0.56

Table (5) : : Mix constituents and designation

Mix Designation	OPC %	RHA %
A0	100	0
A5	95	5
A10	90	10
A15	85	15
A20	80	20

The mortar was mixed in laboratory at (22 ± 2) c˚. After casting all specimens were covered by polyethylene for 24 hours and then demolded and placed in a water bath (22 ± 2) c˚ until the time of test.

Testing Procedures

Normal Consistency

This test was performed according to (B.S 12 : 1971). The test was used to estimate the w/c ratio for cement mortar which make vicat needle of normal consistency capable to penetrate a distance of about (5-7) mm from the base of the mold.

Initial and Final Setting Time

Vicat apparatus was used to estimate initial and final setting time of cement at normal consistency. This test was performed according to B.S 12 1971.

Compressive Strength Test

Compressive strength of cement mortar specimens was conducted on (70.7 mm) cubs according to B.S 1881- part 4 - 1989, by using 200 KN capacity testing machine. The compressive strength of the mortar specimens was tested at the ages of 7, 28 and 90 days.

Flexural Strength Test

The center point loading method was used in making flexural tests on the prism specimens. This test was performed according to ASTM C348- 86, 1989 using (40 × 40 × 160) mm prism specimens. The specimens was tested at the age of 7, 28 and 90 days. Flexural strength can be calculated from the following equations:

$$F_t = \frac{3PL}{2bd^2}$$

Where:

F_t = flexural strength (N/mm^2)
P = maximum applied load (N)
L = effective length (mm)
b = width of prism (mm)
d = depth of prism (mm)

Porosity

Cube specimens with (70.7)mm were used for the mortar porosity test. This test was conducted at 7, 28 and 90 days age of water curing. These specimens were dried in an oven at (105 ± 5) c˚ for 72 hours. Then the specimens were immersed in water for (24 hours), moreover we need a third weight for specimens which presented the submerged weight. The porosity can be determined from the following equation:

$$\text{Porosity } \% = \frac{Wsat - Wdry}{Wsat - Wsub} \times 100\%$$

Where:

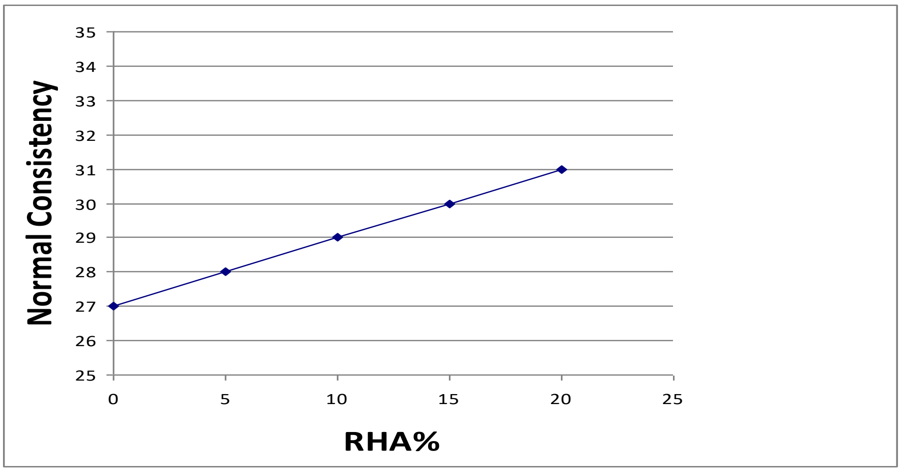
Wdry: The average weight of three dry specimens (g)
Wsat: The average weight of three saturated specimens (g)
Wsub: The average weight of three submerged specimens (g)

Saturated specimens submerged in water and measured their weights with a hydrostatic scale.

Result And Discussion

Consistency and Setting Time

The percentage of cement replacement level by RHA against standard consistency graph shown in Fig (1). It was observed that the water demand for standard consistency linearly increases with an increase of cement replacement level by RHA. The specific surface area of RHA is higher than the cement and the ashes are hygroscopic in nature, so needs more water [**Metha 1979**].



Fig(1): Normal consistency verses % 0f RHA

Initial and final setting times are presented in Fig (2) . The inclusion of RHA increased both setting times .

Compressive Strength

Compressive strength of mortar specimens are shown in Table (6) and Fig (3). Comparison of the data for curing time of 7 and 28 days shows that the compressive strength of OPC mortar is higher than the others but at later age (90 days), the samples having 5%, 10% and 15% RHA show better results than the OPC one. The increase in strength may be due partially to the pozzolanic reaction and the presence of reactive silica in RHA as reported by many researchers [**Ganesan 2007 and Al-Khalaf 1984**] .

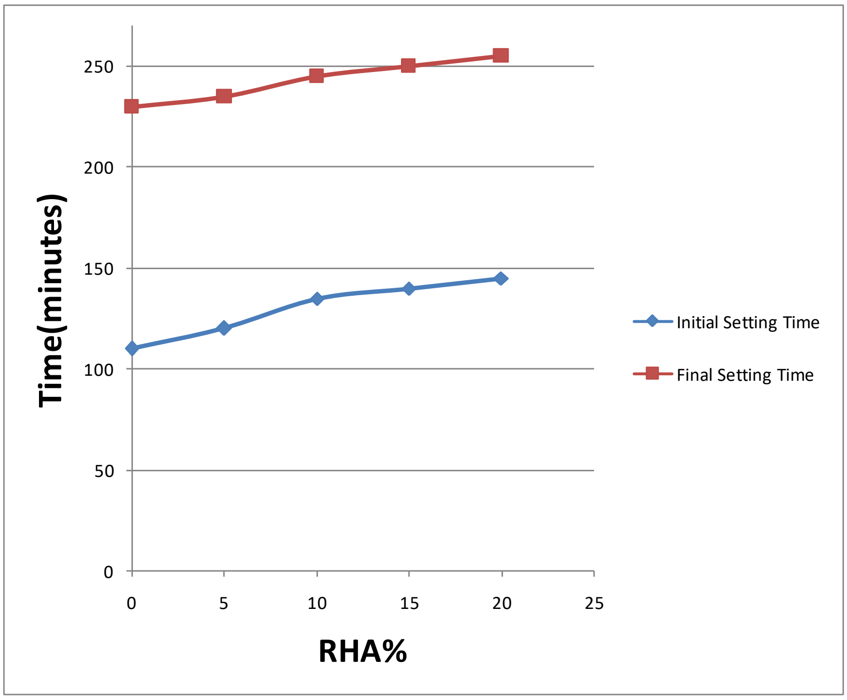
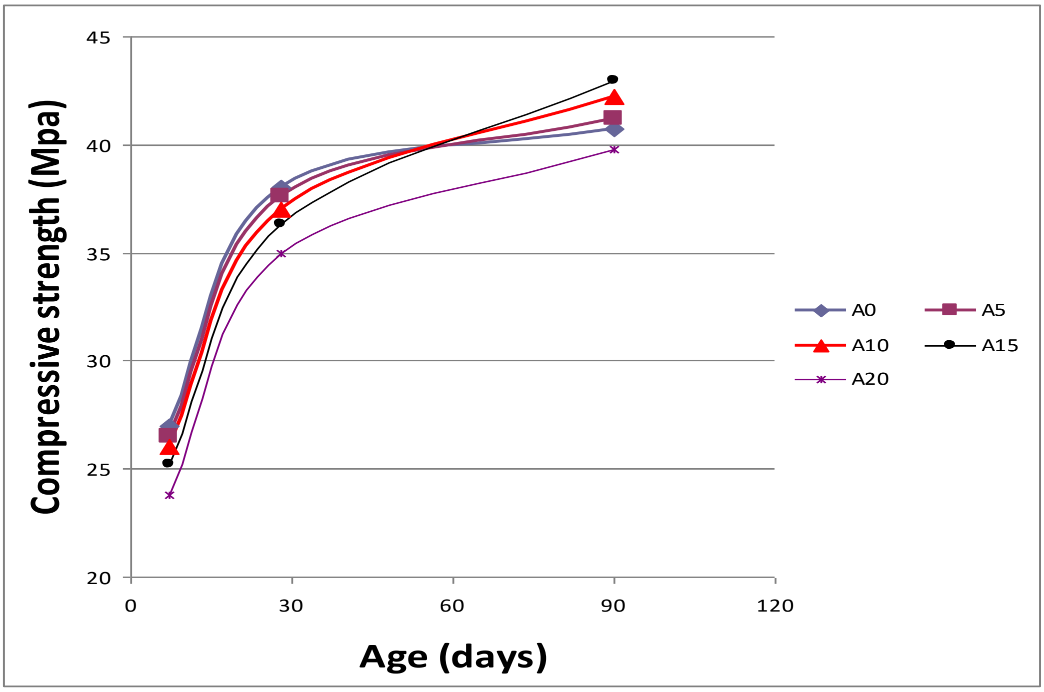


Fig (2) :Initial and final setting time verses % of RHA

Table (6) : Compressive strength at different ages

Mix designation	Compressive strength MPa		
	7 days	28 days	90 days
A0	27.0	38.0	40.7
A5	26.5	37.6	41.2
A10	26.0	37.0	42.2
A15	25.2	36.3	43.0
A20	23.8	35.0	39.8



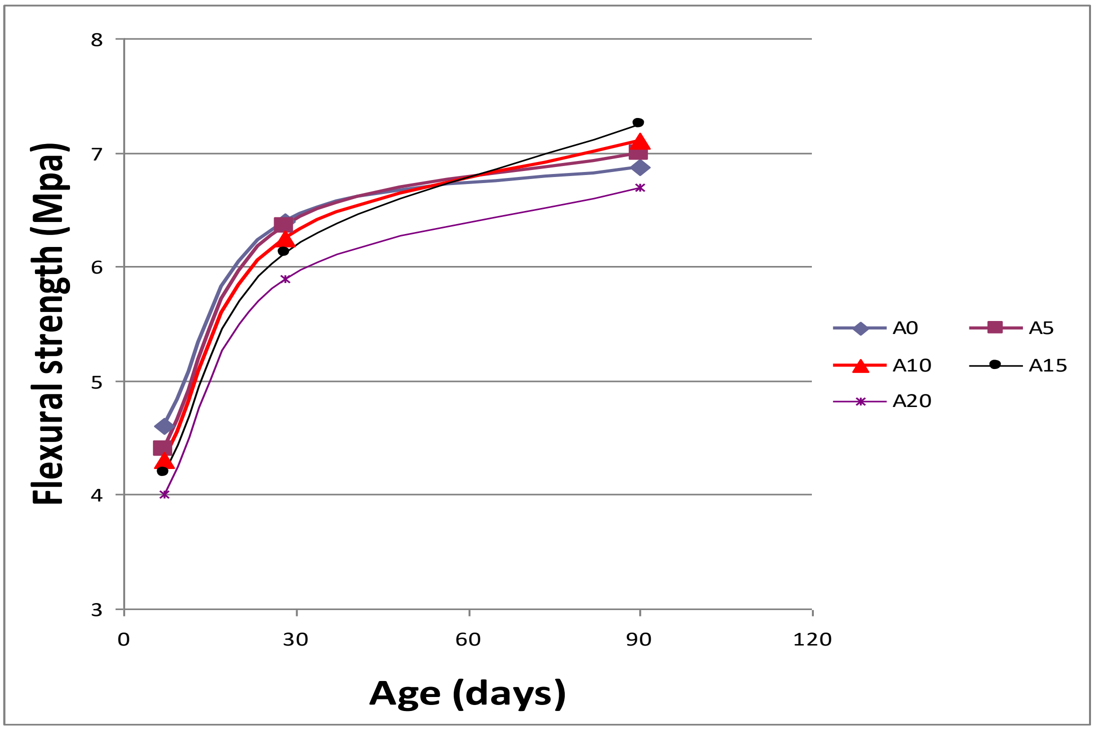
Fig(3): Compressive strength development of cement mortar

Flexural Strength

Table (7) and Fig (4) demonstrates the experimental value of flexural strength at 7, 28 and 90 days age for cement mortar specimens. From this Fig it can be seen that the influence of RHA in flexural strength is similar to that of compressive strength.

Table (7) : Flexural strength at different ages

Mix designation	Flexural strength MPa		
	7 days	28 days	90 days
A0	4.6	6.4	6.87
A5	4.4	6.35	7.0
A10	4.3	6.25	7.1
A15	4.2	6.13	7.25
A20	4.0	5.9	6.7



Fig(4): Flexural strength development of cement mortar

Porosity

The results of the porosity of cement mortars at different days (7, 28 and 90 days) are shown in Table (8) . It can be seen that the porosity of mortar containing 5%, 10% and 15% of rice husk ash is lower than that of the controlled specimens at all ages. At 20% cement replacement level by RHA, the porosity of mortars increased with that of the controlled one in all ages. The porosity of cement mortar reduced with an increase of age. This is due to the increase of hydration of cementitious materials

Table (8) : Porosity at different ages

Mix designation	Porosity %		
	7 days	28 days	90 days
A0	19.0	15.9	14.7
A5	18.7	15.7	14.5
A10	18.4	15.6	14.4
A15	18.8	15.4	14.2
A20	19.3	16.0	14.8

Conclusions

1- The water demand for standard consistency linearly increases with an increase of cement replacement level by RHA.

2- The addition of RHA to cement paste at all replacement level causes increase in the initial and final setting time.

3- The use of RHA significantly improves the cement mortar strength at the 15% replacement level at the age of 90 days .

4- The use of RHA at the 5% .10% and 15% replacement level decrease the porosity of cement mortar in comparison with controlled mortar samples at ages 7, 28,and 90 days . But at 20% cement replacement level by RHA , the porosity of mortars increased with that of the controlled one in all ages.

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