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Development of Mechanical Properties of Self Compacting Concrete Contain Rice Husk Ash

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Abstract**—**Self-compacting concrete (SCC), a new kind of high performance concrete (HPC) have been first developed in Japan in 1986. The development of SCC has made casting of dense reinforcement and mass concrete convenient, has minimized noise. Fresh self-compacting concrete (SCC) flows into formwork and around obstructions under its own weight to fill it completely and self-compact (without any need for vibration), without any segregation and blocking. The elimination of the need for compaction leads to better quality concrete and substantial improvement of working conditions. SCC mixes generally have a much higher content of fine fillers, including cement, and produce excessively high compressive strength concrete, which restricts its field of application to special concrete only. To use SCC mixes in general concrete construction practice, requires low cost materials to make inexpensive concrete.

Rice husk ash (RHA) has been 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 self compacting concrete. Mechanical experiments of RHA blended Portland cement concretes revealed that in addition to the pozzolanic reactivity of RHA (chemical aspect), the particle grading (physical aspect) of cement and RHA mixtures also exerted significant influences on the blending efficiency.

The scope of this research was to determine the usefulness of Rice husk ash (RHA) in the development of economical self compacting concrete (SCC). The cost of materials will be decreased by reducing the cement content by using waste material like rice husk ash instead of.

This paper presents a study on the development of Mechanical properties up to 180 days of self compacting and ordinary concretes with rice-husk ash (RHA), from a rice paddy milling industry in Rasht (Iran). Two different replacement percentages of cement by RHA, 10%, and 20%, and two different water/cementicious material ratios (0.40 and 0.35), were used for both of self compacting and normal concrete specimens. The results are compared with those of the self compacting concrete without RHA, with compressive, flexural strength and modulus of elasticity. It is concluded that RHA provides a positive effect on the Mechanical properties at age after 60 days.

Base of the result self compacting concrete specimens have higher value than normal concrete specimens in all test except modulus of elasticity. Also specimens with 20% replacement of cement by RHA have the best performance.

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Keywords**—**Self compacting concrete (SCC), Rice husk ash (RHA), Mechanical properties.

I. Introduction

THE development of self-compacting concrete started in Japan (Tokyo University) in the mid 80-ies with the aim to reduce durability problems in complicated and heavily reinforced concrete structures due to lack of skilled workers and a poor communication between designers and construction engineers [1].

The concept of self-compacting concrete was proposed in 1986 by Professor Hajime Okamura (1997), but the prototype was first developed in 1988 in Japan, by Professor Ozawa (1989) at the University of Tokyo [2,3]. This new concrete was deliberately designed to be able to fill every corner of the form and encapsulate all reinforcement with maintained stability only under the influence of gravitational forces, without segregation or bleeding. This makes SCC particularly useful wherever placing is difficult, such as in heavily-reinforced concrete members or in complicated work forms [4]. To fulfill notion request, concrete need to has special properties in fresh state. On the other word, the flow ability of concrete has to void segregation. These properties of the fresh concrete can be realized by high enough mix design. In this mix design, a proportion of aggregate is replaced by powder material while the water contends is kept constant [5]. Self-compacting concrete with a similar water cement ratio will usually have a slightly higher strength compared with traditional vibrated concrete, due to the lack of vibration giving an improved interface between the aggregate and hardened paste. The strength development will be similar so maturity testing will be an effective way to control the strength development whether accelerated heating is used or not [6]. The tensile strength may be safely assumed to be the same as the one for a normal concrete as the volume of paste (cement + fines + water) has no significant effect on tensile strength. Increasing the paste volume could decrease the E-value. Because SCC often has higher paste content than traditional vibrated concrete, some differences can be expected and the E-value may be somewhat lower but this should [6].

II. Materials Properties

A. Cement

In this research ordinary Portland cement manufactured by Tehran Cement Plant was applied with specific surface 3415

cm^2/g and specific gravity $3.15gr/cm^3$ were used. Chemical composition of ordinary cement is reported in Table I.

B. Rice Husk Ash

The Rice husk ash is from Guilan Research Park and treated by Grinding; its chemical composition is given in Table I.

TABLE I
CHEMICAL COMPOSITION RAW MATERIAL

Materials	SiO_2	AL_2O_3	Fe_2O_3	CaO	MgO	SO_3	LOI
RHA	91.2	0.94	0.37	2.15	0.88	-	-
Cement	18.1	5.58	2.43	62	2.43	3.1	4.4

C. Fine Aggregate

The fine aggregates consisted of river sand with maximum size of 4.75 mm, with a modulus of fineness Mx = 2.97; normal grading. Specific gravity was 2.59, and absorption value was 4.7%.Also the sieve analyses of fine aggregates are given in Table II.

D. Coarse Aggregate

Coarse aggregate is from river gravel with a maximum size of 12.5 mm and normal continuous grading. The specific gravity of the coarse aggregates was 2.71, absorption value was 5.1%. Also the sieve analyses of the coarse aggregates are given in Table II.

TABLE II
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

Sieve	Percentage passed (%)	
	Fine aggregates	Coarse aggregates
1/2in	100	100
3/8in	100	51.2
#4	100	0.9
#8	81.2	-
#16	60.3	-
#30	38.7	-
#50	19.2	-
#100	3.7	-

E. Admixture

A complex retarding super-plasticizer super viscos1 was used. Its water reduction rate 30% and the dosage of the admixture is 1% + justify amount.

III. MIX DESIGN

Self-compactability can be largely affected by the characteristics of materials and the mix proportion. A rational mix-design method for self-compacting concrete using a variety of materials is necessary. Okamura and Ozawa have proposed a simple mix-proportioning system assuming general supply from ready-mixed concrete plants [7]. The coarse and fine aggregate contents are fixed so that self-compactability can be achieved easily by adjusting the water powder ratio and super plasticizer dosage only.

In this investigation, with first by try and error, different mix design of SCC were casted and tested to find out the fresh properties such as value of slump flow, L-box and V-funnel and hardened concrete properties such as 28 days compressive strength, flexural strength ,and modulus of elasticity. Fresh properties amount are in acceptable limited from European Specifications and Guidelines for Self Compacting Concrete [5].

For the experiments, six series of self compacting concrete with six series of ordinary concrete were mixed: Two different replacement percentages of cement by RHA, 10%, and 20% with mix have no RHA and two different water/cementicious material ratios (0.40 and 0.35), were used for both of self compacting and ordinary concrete specimens. The mixture proportions according to water/Binder ratio adopted and are reported in Tables III and IV.

TABLE III
MIX DESIGN (KG/M3)

Mix	Gravel	Sand	Water	Cement	RHA	W/B
SCC(0%RHA)	770	970	184	460	0	0.4
SCC(10%RHA)	770	970	184	414	46	0.4
SCC(20%RHA)	770	970	184	368	92	0.4
OC(0%RHA)	1043	700	184	460	0	0.4
OC(10%RHA)	1043	700	184	414	46	0.4
OC(20%RHA)	1043	700	184	368	92	0.4

TABLE IV
MIX DESIGN (KG/M3)

Mix	Gravel	Sand	Water	Cement	RHA	W/B
SCC(0%RHA)	770	1000	161	460	0	0.35
SCC(10%RHA)	770	1000	161	414	46	0.35
CC(20%RHA)	770	1000	161	368	92	0.35
OC(0%RHA)	1043	750	161	460	0	0.35
OC(10%RHA)	1043	750	161	414	46	0.35
OC(20%RHA)	1043	750	161	368	92	0.35

IV. EXPERIMENTAL EXAMINATION

In this study, all of concrete specimens were made and covered with plastic sheet and burlap for the first 24 hours to prevent moisture loss. After 24 hours, the specimens were demodeled and placed in the water with 22±2 °c for all times of test. Specimen’s dimensions are shown in Table V.

TABLE V
SPECIMEN’S DIMENSION

Type of test \ Dimensions	Length (cm)	Wide (cm)	Height (cm)
Compressive strength	10	10	10
Flexural strength	45	10	10
Modulus of elasticity	10	10	10
Porosity	10	10	10

V. Results and Discussions

A. Compressive strength

For compressive strength the specimens were test at different ages from7 to 180 days. The results are shown in Fig. 1. According to results SCC mixes show higher compressive strength than normal concrete. This difference is around 31% to 41% of normal concrete compressive strength.

However mixes containing rice husk ash indicate lower compressive strength until 60 days rather than samples with no replacement, but by increasing the rate of pozzolanic reactions of rice husk ash in the matrix, strength of composite mixes goes up.

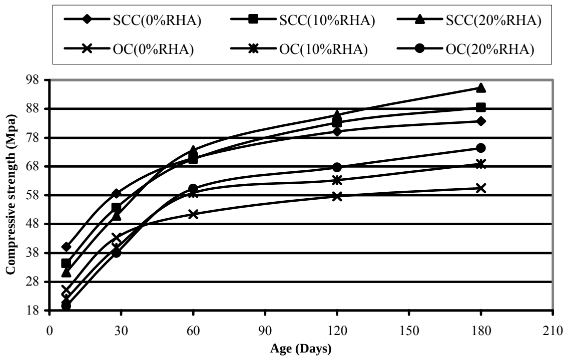

Fig. 1 Compressive strength ($^{Water}/_{Binder}$=0.40)

Also, increasing the amount of rice husk ash replacement in matrix shows a greater effect on strength of normal concrete than SCC mixes.

The mixes containing 20% rice husk ash have the highest compressive strength than the others. In addition water to binder ratio has more impact on normal concrete rather than self-compact concrete. Moreover, by increasing the amount of replacement, water to binder ratio rises up.

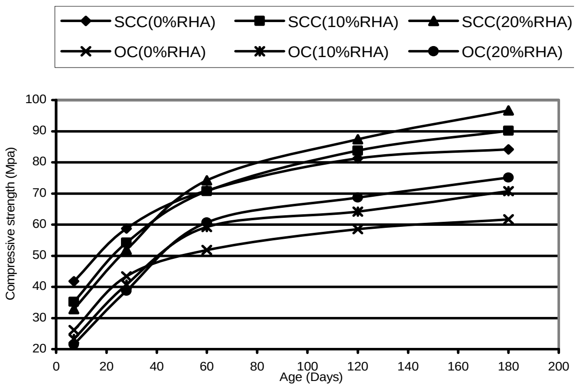

Fig. 2 Compressive strength ($^{Water}/_{Binder}$=0.35)

B. Flexural Strength

All cases of study, tested at 28, 60, 120 and 180 days age, and test results have been shown in Figs. 3 and 4.

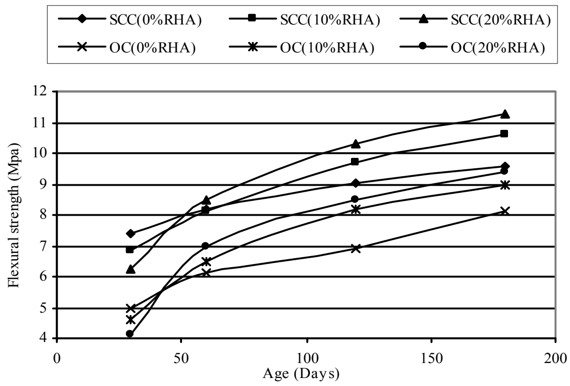

Fig. 3 Flexural strength ($^{Water}/_{Binder}$=0.40)

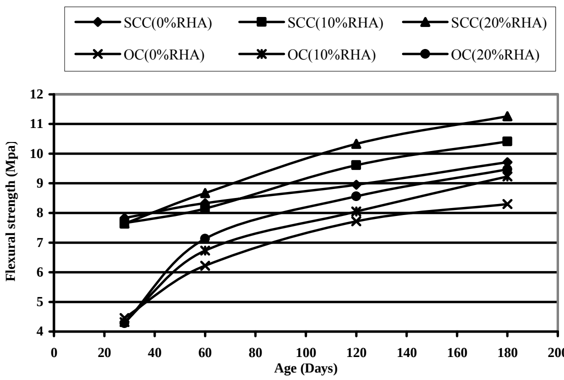

Fig. 4 Flexural strength ($^{Water}/_{Binder}$=0.35)

According to results, SCC mixes show the strength about 12% to 20% more than normal concrete.

In flexural strength like compressive one, mixes containing rice husk ash indicate lower compressive strength until 60 days rather than samples with no replacement and by increasing the rate of pozzolanic reactions of rice husk ash in the matrix, strength of composite mixes goes up.

Also the mixes containing 20% rice husk ash have the highest flexural strength in all cases.

Moreover, by increasing the amount of replacement, flexural strength rises up. This increase is grater in normal concrete than SCC.

In addition by increasing the amount of replacement in self-compact concrete, effect of water to binder ratio is more considerable than normal concrete. By increasing the amount of replacement, water to binder ratio increases.

C.Modulus of Elasticity Test and Result

All cases of study tested at 28, 60, 120& 180 days age. The results are shown in Fig. 3.

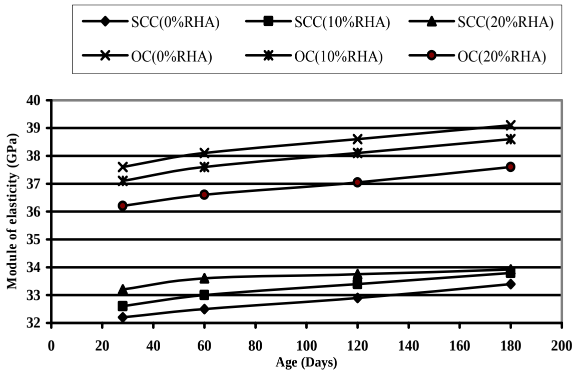

Fig. 5 Modulus of elasticity

According to results, by aging and hardening of concrete mixes, the module of elasticity like compressive and flexural strength increases. Normal concrete mixes show bigger module of elasticity around 9% to 17% more than of SCC ones. Also by increasing the amount of rice husk ash in the matrix, module of elasticity of all mixes reduced.

Results show, water to binder ration has no impact on module of elasticity in all cases.

VI. Conclusion

Base on experimental research for 12 self compacting concrete mixes, the following conclusions can be drawn:

1. SCC mixes show higher compressive and flexural strength and lower module of elasticity rather than normal concrete.
2. Replacement up to 20% of cement with rice husk ash in matrix causes reduction in utilization of cement, and expenditures, also can improve quality of concrete at the age of more than 60 days.
3. Results indicate that pozzolanic reactions of rice husk ash in the matrix composite were low in early ages, but by aging the specimens to more than 60 days, considerable effect have been seen in strength.
4. According to our study, addition of pozzolans like rice husk ash to the concrete, can improve the mechanical properties of specimens.

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