

Study of Strength Properties of Self Compacting Concrete with Rice Husk Ash and Lime-Stone Powder as Admixtures

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ABSTRACT: Self-compacting concrete(SCC) is a relatively recent development in the construction industry. It is characterized by deformability and segregation resistance. It flows under its own weight while remaining homogeneous in composition. This study presents the effect of replacing cement content with rice husk ash (RHA) and limestone powder (LP) on workability (slump flow, V-Funnel, L-Flow), and mechanical strength (compressive, split tensile and flexural strength) properties of SCC. First SCC is made by replacing cement with Rice husk ash in percentages of 10, 15, 20, 25, and 30 and by taking the optimum percentage of Rice husk ash, limestone powder is blended to mix in percentages like 10, 15, 20, and 25 as a partial replacement to cement. Test results shows that SCC mix with 15% of RHA in combination with 10% of LSP as cement replacement gave good workability and strength results.

KEYWORDS: Self compacting concrete, Admixtures, Rice husk ash, lime stone powder.

I. INTRODUCTION

Self compacting concrete (SCC) is the one that can be placed in the form and can go through obstructions by its own weight and without the need of vibrations. SCC involves the use of limited aggregate content, low water to binder (w/b) ratio, and use of super plasticisers (18). SCC, due to its high fluidity and resistance to segregation, can be pumped over longer distance (4), and its strength and durability can be improved by incorporating supplementary cementitious materials(SCM'S). SCM's are fillers and powders without cementitious value but when they are finely divided react with cement in the presence of moisture and form compounds possessing cement like properties (7). SCM's usually replace part of cement and include flyash (FA), silica fume (SF), ground granulated blast furnace slag (GGBS) and rice husk ash (RHA) (1,5,6).

Ricehusk, obtained from rice processing mills when properly burnt at temperature lower than 700⁰c generates rice husk ash (RHA) containing reactive amorphous silica content (6). The silica content in RHA is approximately 90% and is most suited for use as pozzolan to improve the microstructure of the interfacial transition zone (ITZ) between the cement paste and the aggregate in SCC. The use of RHA in concrete as SCM is a sustainable environmental solution; it saves energy and natural resources by reducing cement consumption and CO₂ generation (13) and its utilisation generally improves the properties of the blended cement concrete (6). Flow of concrete mixes increased with increase (3.5-4.5%) in quantity of super plasticiser (SP) where as decreased with increase in quantity (0-10%) of RHA, and compressive strength of all mixes with RHA were comparable to control mix (15). Slump flow time increased with increase in (0-100%) in RHA content (21). SCC mixes containing RHA (10-20%) showed lower compressive strength until 60 days than the mixes with no replacement, but beyond 60 days the strength of composite mixes goes up due to increase in the rate of pozzolanic reactions of RHA in matrix (2). Excellent compressive strength and reduced porosity was achieved in 15% RHA containing self consolidating high performance concrete (SCHPC) with low w/b ratios (0.30-0.50) due to micro filling ability and pozzolanic activity of RHA (19). Similar conclusions were also made by Memon, Shaikh, and Akbar (2010), Chik, Bakar, Johari, and Jaya(2011), Rahman, Muntohar, Pakrashi, Nagaratnam, and Sujana (2014) on increased compressive strength in 10, 15, and 20% RHA concrete mixes, respectively, due to improved workability and sufficient self-compactability. Improvement in the compressive strength of SCC mixes

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containing metakaolin (MK) and RHA (1:1) was also observed (12). The strength improvement of SCC blended with 15% RHA was higher than that of normal SCC which further decreased with increase in percentage of RHA after 20%. With the increase (2.5 and 5%) of RHA, the mixes had improved passing and filling ability, and also increased the compressive strength of concretes at all ages due to micro filling ability and pozzolanic activity of RHA which produced extra C-S-H gel and thus improved the microstructure (16). Increased strength values in 20% RHA concrete compared to control, 10, 30% RHA concrete mixes were observed (17).

Lime stone powder (LSP) is a potentially valuable resource produced during stone crushing operations, and it is most common additive for improving the flowability of SCC (8, 9). The addition of LSP reduces initial and final setting times of concrete while increasing the total shrinkage only slightly compared to conventional concrete (22). The lime stone filler acts as a viscosity enhancer, increasing the workability (23, 24). Incorporation of raw rice husk ash with FA, LSP and SF as partial ordinary Portland cement (OPC) replacement individually and in blends showed reduced compressive strength values compared to control mix (44.7Mpa) after 90 days (3). Decreased compressive strength with increase in percentage of RHA (0-100%) could be improved by addition of LSP (21). Higher 28 days strength is observed in RHA-SCC mixes compared to shell lime powder (SL)-SCC mixes due to the presence of silica in RHA that reacts better with lime in cement compared to that of calcite contents of SL (14).

Therefore, RHA and LSP have proved to be SCM's that contributes in higher strength and improved performance characteristics. However, to date limited research has been carried out on using combination of RHA and LSP as cement replacement in SCC. Hence the aim of this project is to ascertain the suitability of using RHA and LSP as partial replacement for cement in SCC.

II. MATERIAL AND METHODS

A. MATERIAL

i. Cement

The cement used was ordinary Portland cement 53(OPC53). All properties of cement were determined by referring IS12269-1987. The specific gravity of cement is 3.12. The initial and final setting times were found as 55 minutes and 258 minutes respectively. Standard consistency of cement was 32%.

ii. Aggregate

Coarse aggregate

The coarse aggregate with maximum size of 12.5 mm was used, and the specific gravity value and fineness modulus of the coarse aggregate were 2.88 and 4.72 respectively.

Fine aggregate:

The sand which was locally available and passing through 4.75mm IS sieve is used. The specific gravity of fine aggregate was 2.66 and its fineness modulus is 3.22.

iii. Water

Locally available potable water is used in the entire work.

iv. Rice husk ash (RHA)

The RHA used in the study was obtained from Sri Rayalaseema green energy ltd. Kurnool. Specific gravity of RHA is 2.14. The chemical composition of RHA is given in Table 1.

v. Lime stone powder (LSP)

The LSP used in the study was obtained from lime stone mines, Banaganapalli, Kurnool. Specific gravity of LSP is 2.67. The chemical composition of LSP is given in Table 1.

Table 1. Chemical composition of RHA and LSP.

Composition (%)	RHA	LSP
Silicon dioxide (SiO ₂)	8.9	2.84
Aluminum oxide (Al ₂ O ₃)	1.2	2.37
Ferric oxide (Fe ₂ O ₃)	0.54	-
Magnesium oxide (MgO)	0.36	0.42
Calcium oxide (CaO)	1.82	52.98
Sodium oxide (Na ₂ O)	1.26	-
Potassium oxide (K ₂ O)	2.37	-
Sulphur trioxide (SO ₃)	0.78	2.1

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vi. Super plasticizer

Master Glenium sky 8233 procured from BASF Secunderabad, is used as high range water reducing admixture. Specific gravity of super plasticizer is 1.08. Glenium stream 2 procured from BASF secunderabad, is used as viscosity modifying agent (VMA).

B. MIXPROPORTIONING

Ten concrete mix proportions were made. First was the control mix (with 0% RHA) and next 5 mixes contained RHA with varying percentage (10, 15, 20, 25, 30) as the partial replacement to cement. Fresh and hardened properties of all the above mentioned mixes were studied and optimum mix containing RHA (15%) is obtained. Keeping this optimum percentage of RHA constant, another 4 mixes containing LSP with varying percentage (10, 15, 20, 25) as replacement of cement were casted. Parameters kept constant are the amount of fine aggregate, coarse aggregate, water, SP content, W/B ratio, VMA content. For each mix cube (150*150*150mm) specimens, cylinder (300*150mm) specimens, beam (500*100*100mm) specimens were casted and cured in water tank. The specimens were tested after 7 and 28 days of curing period. Mix proportions are shown in Table 2.

C. TEST METHODS

i. Fresh concrete properties

A concrete mix can only be classified as SCC if the requirement of all three characteristics i.e., filling ability, passing ability and segregation resistance are fulfilled. To fulfil these requirements basic tests are conducted i.e., slump flow test and V-funnel test for filling ability, L-box for passing ability. All these tests were performed in accordance to the methods mentioned in EFNARC (2005). Acceptance criteria for SCC as per EFNARC (2005) are shown in Table 3.

ii. Mechanical properties

Compressive strength (cube 150*150*150mm), split tensile strength (cylinder 150*300mm) and flexural strength (beam 500*100*100mm) was determined at the age of 7 and 28 days for all mixes.

Table 2-Mix proportions of various SCC mixes.

M i x	Replacement%	Cement(Kg/m ³)	RHA(Kg/m ³)	LSP(kg/m ³)	Water(lit/m ³)	C.A(Kg/m ³)	F.A(Kg/m ³)	S.P(lit/m ³)	VMA(lit/m ³)
C M	0	5 0 0	0	0	2 0 0	7 0 0	9 1 0	4 . 6 2	0 . 2 5
RHA-1	1 0	4 5 0	5 0	0	2 0 0	7 0 0	9 1 0	4 . 6 2	0 . 2 5
RHA-2	1 5	4 2 5	7 5	0	2 0 0	7 0 0	9 1 0	4 . 6 2	0 . 2 5
RHA-3	2 0	4 0 0	1 0 0	0	2 0 0	7 0 0	9 1 0	4 . 6 2	0 . 2 5
RHA-4	2 5	3 7 5	1 2 5	0	2 0 0	7 0 0	9 1 0	4 . 6 2	0 . 2 5
RHA-5	3 0	3 5 0	1 5 0	0	2 0 0	7 0 0	9 1 0	4 . 6 2	0 . 2 5
LSP-1	15+10	3 7 5	7 5	5 0	2 0 0	7 0 0	9 1 0	4 . 6 2	0 . 2 5
LSP-2	15+15	3 5 0	7 5	7 5	2 0 0	7 0 0	9 1 0	4 . 6 2	0 . 2 5
LSP-3	15+20	3 2 5	7 5	1 0 0	2 0 0	7 0 0	9 1 0	4 . 6 2	0 . 2 5
LSP-4	15+25	3 0 0	7 5	1 2 5	2 0 0	7 0 0	9 1 0	4 . 6 2	0 . 2 5

Table 3. Fresh concrete properties of various SCC mixes.

M i x	Slumpflow(mm)	T 5 0 c m (s e c)	V - funnel time(sec)	L - box ratio
EFNARC guidelines	5 5 0 - 8 5 0	2 - 5	7 - 2 5	0 . 8 - 1
C M	6 6 0	4	1 6	0 . 8 5
R H A - 1	6 5 0	4	9	0 . 9 8
R H A - 2	6 3 5	5	1 4	0 . 9 2
R H A - 3	6 2 0	5	1 8	0 . 8 9
R H A - 4	6 0 6	6	2 0	0 . 8 5
R H A - 5	5 9 2	7	2 4	0 . 8 0
L S P - 1	6 8 0	3	1 1	0 . 9 2
L S P - 2	6 9 4	3	1 2	0 . 8 9
L S P - 3	6 8 6	4	1 4	0 . 8 3
L S P - 4	6 6 0	5	1 9	0 . 8

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III. RESULTS AND DISCUSSION

A. FRESH CONCRETE PROPERTIES

The results of fresh concrete properties of all mixes are shown in Table3. The table shows the properties such as slump flow, T50 cm slump flow time, V-funnel flow time, L-box ratio of all the mixes. In terms of slump flow, all SCC mixes exhibited satisfactory results in the range of 550-850mm, which is an indication of good deformability. All other fresh properties of SCC mixes were in good agreement to that of values given by European guidelines. Lowest workability was obtained by mix containing maximum percentage of RHA i.e., 30%. Workability decreased with increase in RHA content. Where as highest workability was obtained by mix containing 75% of cement, 15% RHA, 10% LSP.

3.2. Hardened concrete properties

The hardened concrete properties of all mixes after 7 and 28 days of water curing are given in the Table4.

Table4-Hardened concrete properties

Mix	Compressivestrength(Mpa)		Splittensilestrength(Mpa)		Flexuralstrength(Mpa)	
	7 d a y s	2 8 d a y s	7 d a y s	2 8 d a y s	7 d a y s	2 8 d a y s
C M	2 6 . 6 6	3 8 . 6 3	1 . 5 3	3 . 1 2	2 . 6 5	4 . 3 1
R H A - 1	2 7 . 2 4	4 0 . 5 9	1 . 5 5	3 . 2 0	2 . 6 6	3 . 5 6
R H A - 2	2 8 . 3 3	4 1 . 7 7	1 . 8 5	3 . 7 1	2 . 6 2	4 . 1 8
R H A - 3	3 1 . 9 7	4 1 . 0 3	2 . 0 7	3 . 5 5	2 . 7 1	3 . 8 8
R H A - 4	2 8 . 0 9	4 0 . 3	1 . 7 9	3 . 2 8	2 . 7	3 . 8 9
R H A - 5	2 3 . 1 7	3 6 . 7 4	1 . 8 0 5	2 . 9 3	2 . 0 0	3 . 3 7
L S P - 1	2 7 . 4 8	3 9 . 1 1	1 . 5 8	3 . 6 0	2 . 6 2	3 . 2 5
L S P - 2	2 8 . 1 2	3 7 . 3 3	1 . 5 3	3 . 2 5	2 . 6 5	2 . 8 4
L S P - 3	2 7 . 2 4	3 4 . 5	1 . 4 8	2 . 8 3	2 . 4 8	2 . 7 4
L S P - 4	2 6 . 9 8	3 3 . 9 2	1 . 4 2	2 . 7 5	2 . 3 4	2 . 7 0

i. Compressive strength

Compressive strength test results of all mixes are shown in Table4. Maximum compressive strength was obtained by RHA-2 mix i.e., SCC mix with 85% of cement and 15% of RHA, and it gradually decreased with further increase in RHA content. Where as the mixes with both RHA and LSP as cement replacements shown less compressive strength results. However LSP-1 mix i.e., mix with 10% of LSP, 15% of RHA and 75% of cement shown higher 28days compressive strength results than that of control mix.

ii.. Split tensile strength

Split tensile strength test results of all mixes are shown in Table4. Maximum split tensile strength was obtained by RHA-2 mix i.e., SCC mix with 85% of cement and 15% of RHA, and it gradually decreased with further increase in RHA content. Where as the mixes with both RHA and LSP as cement replacements shown less split tensile strength results. However LSP-2 mix i.e., mix with 15% of LSP, 15% of RHA and 70% of cement shown equal split tensile strength results as that of control mix.

iii. Flexural strength

Flexural strength test results of all mixes are shown in Table4. RHA-2 mix i.e., SCC mix with 85% of cement and 15% of RHA, shown equal flexural strength results as that of control mix. Where as the mixes with both RHA and LSP as cement replacements shown less flexural strength results.

IV. CONCLUSIONS

- Fresh properties results showed that with increase in amount of RHA workability decreased. However by using LSP in combination with RHA as cement replacement gave good workability results.

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- Maximum compressive and split tensile strengths at 7 and 28 days were obtained by mix containing 15% of RHA as cement replacement. Where as flexural strength of this mix (15% RHA) was same as that of control mix.
- Using LSP in combination with RHA as cement replacement resulted in to lower strength values. However SCC mix containing 75% of cement, 15% of RHA, 10% of LSP gave higher compressive strength (28days) than that of control mix.

REFERENCES

1. Agarwal,S.K., & Deepali,G. (2006). Utilization of industrial wastes and un processed micro fillers for making cost effective mortars. *Construction and Building Materials*,20,999-1004.
2. Ahmadi,M.A., Alidoust,o., Sadrinejad,I., &Nayeri,M. (2007). Development of mechanical properties of self compacting concrete contain rice husk ash. *International journal of computer and Information Engineering*,1,259-262.
3. Atan,M.N., &Awang,H. (2011). The compressive and flexural strengths of self-compacting concrete using raw rice husk ash. *Journal of Engineering Science and Technology*, 6,720-732.
4. Bartos,J.M. (2000). *Measurement of key properties of fresh self compacting concrete*. Paris: CEN/PNR Workshop.
5. Binici,H., Huseyin,T., &Mehmet,M.K.(2007). The effect of fineness on the properties of blended cements incorporating ground granulated blast furnace slag and ground basaltic pumice. *Construction and Building Materials*, 21,1121-1128.
6. Chindaprasirt,P., Kanchanda,P., Sathonsaowaphak,A., &Cao,H.T. (2007). Sulfate resistance of blending cements containing fly ash and rice husk ash. *Construction and Building Material*, 21,1356-1361.
7. Detwiler,R.J. (1997). Micro structure of durable concrete. *In proceedings of 6th international colloquium on concrete in developing countries, Lahore Pakistan* (pp.459-468).
8. Domone PL. Self compacting concrete: ananalysis of 11 years of case studies. *Cem Concr Compos* 2006;28:197-208.
9. Domone PL. A review of the hardened mechanical properties of self compacting concrete. *Cem Concr Compos* 2007; 29:1-12.
10. EFNARC. (2002). *Specifications and guidelines for self compacting concrete*.
11. EFNARC. (2005). *Specifications and guidelines for self compacting concrete*.
12. Kannan,V., &Ganesan,K. (2013). Chloride and chemical resistance of self compacting concrete containing rice husk ash and metakaolin. *Construction and Building Materials*, 51,225-234.
13. Karim,M.R., Zain,M.F.M., Jamil,M., Lai,F.C., &Islam,M.N. (2012). Strength of mortar and concrete as influenced by rice husk ash: a review. *World Applied Sciences Journal*, 19,1501-1513.
14. Khadir,S.M., Nayak,G.P., Aziz,T., Saurav,S., &Pai,B.H.V. (2014). Evaluation of properties of self compacting concrete specimens having rice husk ash and shell lime powder as fillers. *American Journal of Engineering Research (AJER)*,3,207-211.
15. Memon,S.A., Shaikh,M.A., &Akbar,H. (2008). Production of low cost self compacting concrete using rice husk ash. In *Proceedings of 1st International conference on Construction in developing countries (ICCID-1), Pakistan*(pp.31-41).
16. Memon,S.A., Shaikh,M.A., &Akbar,H. (2010). Utilization of rice husk as has viscosity modifying agent in self-compacting concrete. *Construction and Building Materials*, 25,1044-1048.
17. Muthadi,A., &Kothandaraman,s. (2013). Experimental investigation of performance characteristics of rice husk ash blended concrete. *Journal of Material in Civil Engineering*, 8, 1115-1118.
18. Okamura,H., &Ouchi,M. (2003). Self-compacting concrete. *Journal of Advanced concrete Technology*.1,5-15.
19. Safiuddin,Md, West,J.S.,& Soudki,K.A. (2010). Hardened properties of self consolidating high performance concrete including rice husk ash. *Cement and Concrete Composites*, 32,708-717.
20. Safiuddin,Md, West,J.S.,& Soudki,K.A. (2012). Properties of freshly mixed self compacting concretes in incorporating rice husk ash as a supplementary cementing material. *Construction and Building Materials*, 30,833-842.
- 21.Sua-iam,G.,& Makul,N. (2013). Utilization of lime stone powder to improve the properties of self compacting concrete incorporating high volumes of untreated rice husk ash as fine aggregate. *Construction and Building Materials* ,38,455-464.
22. ValcuendeM, MacroE, ParraC, SernaP. Influence of lime stone filler and viscosity-modifying admixture on the shrinkage of self-compacting concrete. *Cem Concr Res* 2012;42:583-92.
23. FelekogluB. Utilisation of high volume of lime stone quarry wastes in concrete industry (Self compacting concrete cases). *Resour Conserv Recycl* 2007;51:770-91.
- 24.YahiA, TanimuraM, ShimoyamaY. Rheological properties of highly flowable mortar containing lime stone filler-effect of powder content and W/Cratio.*Cem Concr Res* 2005;35:532-9.