Importance of High Strength Concrete Using Silica Fume and Rice Husk Ash

Pawan Kumar, Dr. D.P.Gupta, Dr. Arvind Dewangan, Er. Rahul Sikka

Abstract— **Maintenance, repair and rehabilitation of existing cement concrete structures involve a lot of problem leading to significant expenditure. In the recent past, there has been considerable attention for improving the properties of concrete with respect to strength and durability, especially in aggressive environments .High strength concrete (HSC) appears to be better choice for a strong and durable structure. Suitable addition of mineral admixtures such as silica fume (SF) and rice husk ash (RHA) in concrete improves the strength and durability of concrete due to considerable improvement in the microstructure of concrete composites, especially at the transition zone. Very few studies have been reported on the use of SF and RHA for development of high strength concrete and also durability characteristics of these mixes have not been reported . In order to make a quantitative assessment of different cement replacement levels with SF and RHA on the strength and durability properties for M70 grades of HSC trial mixes and to arrive at the maximum levels of replacement of cement with SF and RHA, investigations were taken. Requirement of proper curing is essential otherwise micro cracks will appear on the surface of concrete.**

This paper reports on the performance of HSC trial mixes having different replacement levels of cement with SF and RHA. The strength and durability characteristics of these mixes are compared with the mixes without SF and RHA. Compressive strengths of concrete at7day, 14 days and 28days were obtained by using varoius replacement of cement with SF and RHA.

Keywords:- High strength concrete (HSC), strength and durability, silica fume (SF), rice husk ash (RHA), replacement of cement, Superplasticizer.

Test for compression of concrete cubes

The compression test is carried out as per IS516.

- Apparatus

Testing Machine — The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified in 5.5. The permissible error shall be not greater than ± 2 percent of the maximum load. The testing machine shall be equipped with two steel bearing platens with hardened faces. One of the platens (preferably the one that normally will bear on the upper surface of the specimen) shall be fitted with a ball seating in the form of a portion of a sphere, the centre of which coincides with the central point of the face of the platen. The other compression platen shall be plain rigid bearing block. The bearing faces of both platens shall be at least as large as, and preferably larger than the nominal size of the specimen to which the load is applied. The bearing surface of the platens, when new, shall not depart from a plane by more than 0-01 mm at any point, and they shall be maintained with a permissible variation limit of 0-02 mm. The movable portion of the spherically seated compression platen shall be held on the spherical seat, but the design shall be such that the bearing face can be rotated freely and tilted through small angles in any direction.

- Procedure —

Specimens stored in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting fins removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing. The dimensions of the specimens to the nearest 0-2 mm and their weight shall be noted before testing.

- Placing the Specimen in the Testing Machine — The bearing surfaces of the testing machine shall be wiped clean and any loose sand or other material removed from the surfaces of the specimen which are to be in contact with the compression platens. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom I he axis of the specimen shall be carefully aligned with the centre of thrust of the spherically seated platen No packing shall be used between the faces of the test specimen and the steel platen of the testing machine As the spherically seated block is brought to bear on the specimen, the movable portion shall be rotated gently by hand so that uniform seating may be obtained. The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

Manuscript received April 27, 2017

Pawan Kumar, M.Tech.(CTM- Civil Engineering) scholar – Roll No.17152409, HCTM Technical Campus, Kaithal 136027(Haryana),

Dr. D.P.Gupta, Professor – Professor, Department of Civil Engineering, Haryana College of Technology & Management, HCTM Technical Campus, Kaithal (Haryana) INDIA

Dr. Arvind Dewangan – Professor & H.O.D., Department of Civil Engineering, Haryana College of Technology & Management, HCTM Technical Campus, Kaithal (Haryana) INDIA

Er. Rahul Sikka – Asstt. Professor Department of Civil Engineering, Haryana College of Technology & Management, HCTM Technical Campus, Kaithal (Haryana) INDIA

Fig :cube testing machine

Compressive strength results

This chapter includes the results obtained in the research, compressive strength comparison between silica fume concrete and rice husk ash concrete. Also, optimum level of cement replacement by silica fume and rice husk ash is also being determined.

Cubical moulds of size 15 cm x 15cm x 15 cm are commonly used. This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen.

These specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

PROCEDURE

1. Remove the specimen from water after specified curing time and wipe out excess water from the surface.
2. Take the dimension of the specimen to the nearest 0.2m
3. Clean the bearing surface of the testing machine
4. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
5. Align the specimen centrally on the base plate of the machine.
6. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
7. Apply the load gradually without shock and continuously at the rate of 140kg/cm2/minute till the specimen fails
8. Record the maximum load and note any unusual features in the type of failure.

The compressive strength is determined for each batch. For each batch 3 cubes were casted, which are to be tested after 7 days, 14 days and 28 days. The average value of three cubes were taken, which represents the compressive strength of cube.

The table (2.1) below shows the compressive strength value and also workability in terms of compaction factor for silica fume concrete.

Table 2.1 compressive strength of SF concrete

Identification mark	0% SF	2.5% SF	5% SF	7.5% SF	10% SF	12.5% SF
Compressive strength(Mpa) 7 Days	46.4	50.12	53.5	55.4	59.14	57.3
Compressive strength(Mpa) 14 Days	52.8	54.2	57.32	58.6	67.12	64.3
Compressive strength(Mpa) 28 Days	61.85	65.31	68.37	70.78	80.2	77.6
Compaction factor	0 .96	0.93	0.92	0.91	0.89	0.83

The table (2.2) below shows the compressive strength value and also workability in terms of compaction factor for rice husk ash concrete.

Table 2.2 compressive strength of RHA concrete

Identification mark	0% RHA	5% RHA	10% RHA	15% RHA	20% RHA	25% RHA	30% RHA

Compressive strength(Mpa) 7 Days	46.4	48.2	47.1	45.2	43.9	41.0	39.6
Compressive strength(Mpa) 14 Days	52.8	53.9	53.4	51.7	48.7	46.6	44.1
Compressive strength(Mpa) 28 Days	61.85	63.4	62.6	58.7	57.6	55.1	53.2
Compaction factor	0.94	0.91	0.88	0.84	0.81	0.78	0.75


Fig2.10: cubes at the time of casting


Fig2.11 : cubes for testing


Fig2.12 : cubes after testing showing fracture


Fig 2.13 : Cube in Compression Testing Machine

Discussions

The 7 day, 14 days and 28 days cube strength of concrete without any mineral admixture and concrete with silica fume and rice husk ash were evaluated. Compressive strength of the concrete mix with silica fume shows the higher strength. At 7 days, the strength of standard concrete cube is 46.4MPa, which leads to a considerable increase after 10% replacement of cement by silica fume, 59.14Mpa. However, the highest strength reached at 10 % replacement is 80.2Mpa at 28 days increasing the strength by 29 %. The partial replacement of cement with silica fume in concrete mixes would lead to considerable increase in the strength of the concrete, this is due to the improvement in the microstructure due to pozzolanic action and filler effects of silica fume.

It can also be clearly seen that the strength after replacement more than 10%, that is at 12.5 % is reduced, by approximately 3%. This may be due to excessive presence of micro silica which after filling the smaller voids, would try to remove the cement particles from there position.

On the other hand, concrete mix with rice husk ash shows opposite results from silica fume. After 5% replacement, the strength increases by approximately 2.5 %. But as the rice husk ash quantity increases the strength goes down on a decreasing scale. At 30% replacement, the strength of concrete gets reduced by approximately 15%. Therefore, high amount of rice husk ash would result in decreased strength. Up to 10% RHA content, strengths of RHA concrete is not much different than the control. Further increase of RHA content decrease the compressive strength due to high water content required to maintain similar workability.

Concrete requires approximate increase in water cement ratio due to increase in percentage of RHA. Because RHA is highly porous material. The workability of rice husk ash concrete and silica fume concrete has been found to decrease with increase in rice husk ash and silica fume replacement respectively.

The consistency behavior of cementitious materials is also discussed. As the silica fume and rice husk percentage increases, the consistency of the mix also increases which obviously leads to the slight reduction in workability. (fig 2.4 & 2.5)

The comparison of silica fume concrete and rice husk ash concrete is shown below (fig2.13,2.14)

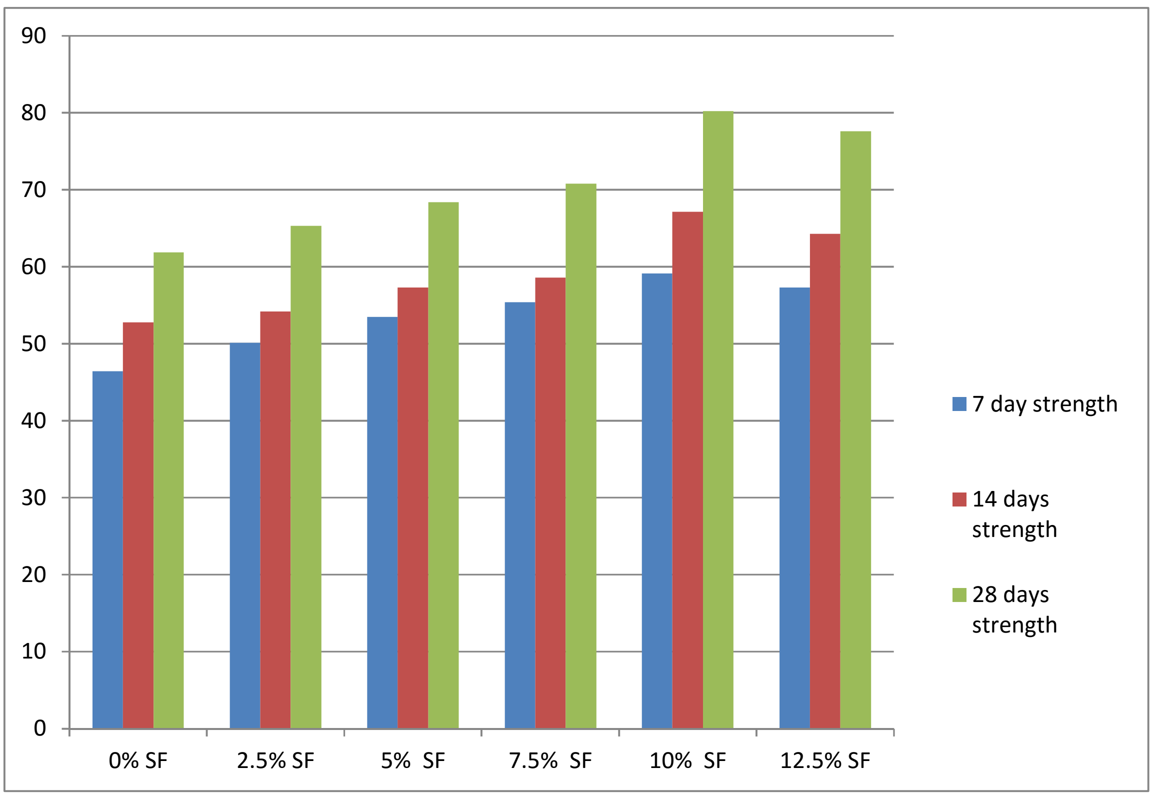

Fig2.15 : comparison of compressive strength of silica fume concrete

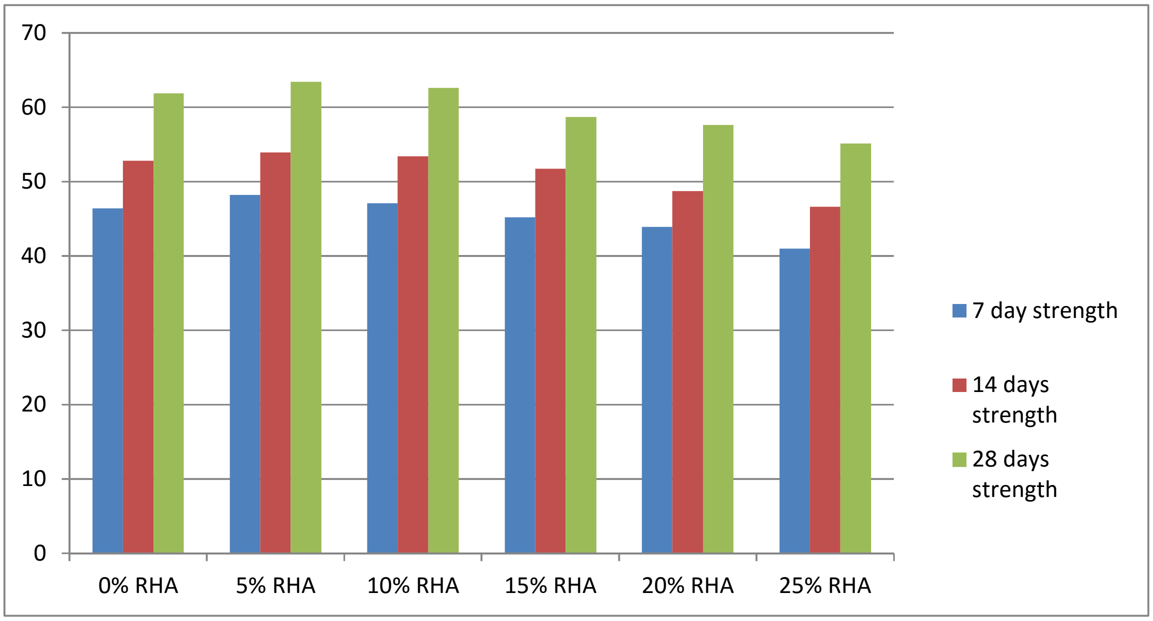

Fig2.16 : comparison of compressive strength of rice husk ash concrete

CONCLUSIONS

Based on the results of investigation reported in this research, the following conclusions are made

1. Compressive strength of concrete increases with the increase in the percentage of silica fume and rice husk ash up to a certain level.
2. Cement replacement level of 10 percent with SF in M70 grade of High strength concrete mix is found to be the optimum level to obtain higher values of compressive strength. At10% replacement of cement by silica fume, 80.2Mpa strength is achieved after 28 days.
3. However, strength started decreasing beyond further replacement after 10%, this may be due to excessive presence of micro silica which after filling the smaller voids, would try to remove the cement particles from there position.
4. Up to 10% RHA content, strengths of RHA concrete is not much different than the control. Further increase of RHA content decrease the compressive strength due to high water content required to maintain similar workability.
5. However, at 5% replacement of cement by rice husk ash, strength increases by approximately 2.5%
6. The workability of rice husk ash concrete and silica fume concrete has been found to decrease with increase in rice husk ash and silica fume replacement respectively.
7. As the silica fume and rice husk percentage increases, the consistency of the mix also increases which obviously leads to the slight reduction in workability.
8. The results of the strength related tests have demonstrated superior strength characteristics of high strength concrete mix containing SF. This is due to the improvement in the microstructure due to pozzolanic action and filler effects of SF, resulting in fine structure.
9. The compression failure pattern of concrete is due to the crushing of coarse aggregate and not due to bond failure.
10. As far the comparison is concerned between the two mineral admixtures, silica fume has shown better results in comparison with rice husk ash.

REFERENCES

1. Berntsson, L., Chandra, S. and Kutti, T., "Principles andFactors Influencing High-StrengthConcreteProduction,"Concrete International, December, (1990).
2. Mehta,P.K.andAïtcin,P.C.,"PrinciplesUnderlyingProductionofHigh-Performance (1990).
3. K. Perumal and R. Sundararajan, " Effect of partial replacement of cement with silica fume on the strength characterstics of high strength concrete" CI-Premier (2004).
4. Rafat Siddique, "Utilization of silica fume in concrete : review of hardened properties"Volume 55, Issue 11, September 2011, Pages 923-932 .
5. V.T. Giner, S. Ivorra, F.J. Baeza, E. Zornoza, B. Ferrer, "Silica fume admixture effect on properties of concrete" Construction and Building Materials, Volume 25, Issue 8, August 2011, Pages 3272-3277
6. Neville A.M., Uproperties of concrete", 4th and final edition, Pearson Education Asia Pte. Ltd.,England, First Indian reprint, 2000.
7. Metha P and Monterio J.M., "Concrete; microstructure, properties and materials", Indianedition, Indian Concrete Institute, Chennai, 1999.
8. Joshi N.G., "Evolution of HPC mixes containing silica fume," Indian Concrete Journal, Oct. 2001, Vol. 75, NO.10, pp 627-633.
9. IS 12269 – 1987 . "Specification for 53 grade ordinary Portland cement" Bureau of Indian Standards, New Delhi.
10. IS 383 – 1970 (Reaffirmed 2002) "Specification for coarse and fine aggregates" Bureau of Indian Standards, New Delhi.
11. IS 10262 – 2009, "Concrete mix proportioning guidelines (First revision)" Bureau of Indian Standards, New Delhi.

12. IS 2720 Part-3, “Dtermination of specific gravity of cement” Bureau of Indian Standards, New Delhi.
13. IS 2386, 1963 PART-3 “Specfic gravity tests for aggregates” Bureau of Indian Standards, New Delhi.
14. IS 4031 PART-4, “Methods of physical test for hydraulic cement” (1988) Bureau of Indian Standards, New Delhi.
15. IS 1199 (1959) “Method of sampling and analysis of concrete” Bureau of Indian Standards, New Delhi.
16. IS 516 – 1959 (reaffirmed 2004) “Methods of test for strength of concrete” Bureau of Indian Standards, New Delhi.
17. Guidance for the specification of microsilica – Elkem Ltd, C1-05 General information manual.
18. “Specification of Master Glenium Sky 8777, super plastizer” PDS Ref. No. : MasterGlnxxSKY8777/01/0313.
19. IS 456 (2000), Plain and Reinforced Concrete- Code of Practice, Bureau of Indian Standards, New Delhi.
20. V. Bhikshma∗a, K. Nitturkarb and Y. Venkateshamc , “Investigations on properties ofhigh strength silica fume concrete”, ASIAN JOURNAL OF CIVIL ENGINEERING (BUILDING AND HOUSING) VOL. 10, NO. 3 (2009) PAGES 335-346 .
21. Verma Ajay , Chandak Rajeev and Yadav R.K., “ effect of microsilica on the strength of concrete with OPC”, Research Journal of Engineering Sciences ISSN 2278 – 9472 Vol. 1(3), 1-4, Sept. (2012).
22. Shetty M. S. "Concrete Technology" S. Chand & Co.Ltd, 1997.
23. Alireza Naji Givi , Suraya Abdul Rashid , Farah Nora A. Aziz , Mohamad Amran Mohd Salleh developed “Contribution of Rice Husk Ash to the Properties of Mortar and Concrete:A Review”.
24. Dao Van Dong- Doctor, Pham Duy Huu- Professor, Nguyen Ngoc Lan- Engineer developed “Effect of rice husk ash on properties of high strength concrete”.