

Research Article

Evaluation of Mechanical Properties of Rice Husk Ash Concrete for M25 Grade

Patil S. S.[†] and Patil B. P.^{†*}

[†]Civil Engineering Department, Solapur University, Solapur, Maharashtra, India

Accepted 05 July 2015, Available online 11 July 2015, Vol.5, No.4 (Aug 2015)

Abstract

This research was experimentally carried out to investigate the effect of introducing rice husk ash as a partial replacement of ordinary Portland cement on the structural properties of concrete. RHA is an agro waste product & it indicate high amount of silica which is a very good value for workability. Then various experiments were carried out to determined properties of concrete incorporating optimum RHA. Tests include compressive strength, splitting tensile strength, flexural strength, Compaction factor and Workability. Results shows that concrete incorporating RHA had higher compressive strength, splitting tensile strength, flexural strength at various ages compared with that of the control concrete. In addition results shows that RHA as an artificial pozzolonic material has reduced the chloride diffusion.

Keywords: Rice Husk Ash, Compressive strength, Compaction factor, Split tensile strength, Flexural strength, Workability.

1. Introduction

Rice Husk Ash (RHA) is a byproduct of the agricultural industry which contains high amount of silicon dioxide (SiO₂). Sustainable development of the cement & concrete industry requires the utilization of industrial and agricultural waste components. RHA is a superpozzolan & its use in civil construction, besides reducing environmental pollutants factors will bring several improvements to concrete characteristics. The ideal temperature for producing RHA is between 600° to 700°. Concrete is well known as heterogeneous mix of cement, water and aggregate. The admixtures may be added in concrete in order to enhance some of the properties desired specially. Various materials are added such as admixture with rice husk ash to obtain concrete of desired property. The key to achieving a strong, durable concrete rests in the careful proportioning, mixing & compacting of the ingredients. The detail experimental investigation doing to study the effect of partial replacement of cement by RHA in concrete. In this project I started proportion from 0% to 20% in concrete by replacement of cement with gradual increasing of RHA by 4%. Various tests are performed on wet concrete such as workability tests, compaction factor test. The test includes compressive strength on concrete cube for size (150x150x150)mm, flexural strength on concrete beam (150x150x700)mm, split tensile strength on concrete cylinder (150mmΦ x300mm) as per IS:516-1959.

2. Material Specification

2.1 Cement

The cement used in this experimental work is 53 grades Ordinary Portland Cement. All properties of cement are tested by referring IS 12269 - 1987 Specification for 53 Grade Ordinary Portland cement. The specific gravity of the cement is 3.15. The initial and final setting times were found as 111 minutes and 221 minutes respectively. Standard consistency of cement was 30.50%.

2.2 Water

Potable water used for the experimentation.

2.3 Fine aggregate

Locally available sand passed through 4.75mm IS sieve is used. The specific gravity of 2.82 and fineness modulus of 3.895 are used as fine aggregate. The loose and compacted bulk density values of sand are 2.773 and 2.893 kg/ltr respectively. The water absorption is of 1.270%.

2.4 Fine aggregate

20MSA:-Crushed aggregate available from local sources has been used. The coarse aggregates with a

*Corresponding author: Patil B. P

maximum size of 20mm having the specific gravity value of 2.90 and fineness modulus of 7.136 are used as coarse aggregate. The water absorption is of 0.85%. The loose and compacted bulk density values of coarse aggregates (20mm) are 2.100 and 2.340 kg/ltr respectively.

3. Experimental Procedure

3.1 Mix Design

The proportions for normal mix of M25 Normal Mix are 1:1.932:3.057 with water cement ratio of 0.47. In the present study, method for mix design is the Indian Standard Method. The mix design involves the calculation of the amount of cement, fine aggregate and coarse aggregate in addition to other related parameters dependent on the properties of constituent material. The modifications are made and quantities of constituent materials used to cast concrete.

3.2 Batching, Mixing and Casting

Batching, mixing and casting operations were carefully done. The Concrete mixture was prepared by hand mixing on a watertight platform. The coarse Aggregates and fine aggregates were weighed first with an accuracy of 0.5 grams. On the watertight platform, the coarse, fine aggregates, Rice Husk Ash were mixed thoroughly. In manual mixing method RHA is added by sprinkling. Then water was added carefully so that no water was lost during mixing. The moulds were filled with various mix category of different percentage of RHA in concrete. Vibration was given to the cube moulds using table vibrator. The top surface of the specimen was leveled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank wherein they were allowed to cure for 7, 28, 45 & 90 days. The entire specimen was tested in the Structural Engineering laboratory of Walchand Institute of Technology, Solapur.

3.3 Workability Test

Workability is carried out by conducting the slump test and compaction factor test as per I.S. 1199-1959 on ordinary concrete and rice husk ash concrete.

3.4 Compressive strength test

The compressive strength of concrete is one of the most important properties of concrete in most structural applications. For compressive strength test, cube specimens of dimensions 150 x 150 x 150 mm & cylinder specimens of dimension 150 mm diameter and 300 mm length were cast for M25 grade of concrete. After curing, these cubes & cylinders were tested on Compression Testing machine as per I.S. 516-1959. The failure load was noted. In each category three cubes & cylinders were tested and their average value is reported. The compressive strength was

calculated as follows, Compressive strength (MPa) = Failure load / cross sectional area.

3.5 Flexural strength test

For flexural strength test, beam specimens of dimension 150x150x700 mm were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank where in they were allowed to cure for 28 days. These flexural strength specimens were tested under two point loading as per I.S. 516-1959, over an effective span of 600 mm divided into three equal parts and rest on Flexural testing machine. The load is normally increased & failure load is noted at cracking of beam specimen. In each category, three beams were tested and their average value is reported. The flexural strength was calculated as follows. Flexural strength (MPa) = $(P \times L) / (b \times d^2)$, Where, P = Failure load, L = Centre to centre distance between the support = 600 mm, b = width of Specimen=150 mm, d = depth of specimen= 150 mm.

3.6 Split Tensile strength test

For split tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm length were cast. The specimens were demoulded after 24 hours of casting and were transferred to curing tank wherein they were allowed to cure for 28 days. These specimens were tested under compression testing machine. In each category, three cylinders were tested and their average value is reported. Split Tensile strength (MPa) = $2P / \pi DL$, Where, P = failure load, D = diameter of cylinder, L = length of cylinder.

4. Experimental Results

4.1 Fresh Concrete

All category samples are tested & analyzed for properties of Fresh concrete i.e. Slump, Compaction Factor & Density. These samples are also tested for properties of Hardened concrete i.e. Compressive Strength, Split tensile strength, Flexural Strength & Deflection values.

Table 1 Properties of Fresh RHA Concrete

| Series F (RHA) | Slump Value (mm) | Compaction Factor | Density of concrete (kg/m ³) |
|----------------|------------------|-------------------|------------------------------------------|
| F0 | 120 | 0.94 | 2654.81 |
| F1 | 100 | 0.93 | 2648.88 |
| F2 | 95 | 0.89 | 2640.88 |
| F3 | 90 | 0.88 | 2637.04 |
| F4 | 75 | 0.87 | 2634.07 |
| F5 | 61 | 0.82 | 2604.44 |

The samples are designated as sample F (RHA) where F0 (0%), F1 (4%), F2 (8%), F3 (12%), F4 (16%), F5 (20%)...etc. denotes for first category M25 grade, RHA denotes % of Rice Husk Ash in the sample. The schedule and technical details during casting of standard sample category are detailed as above.

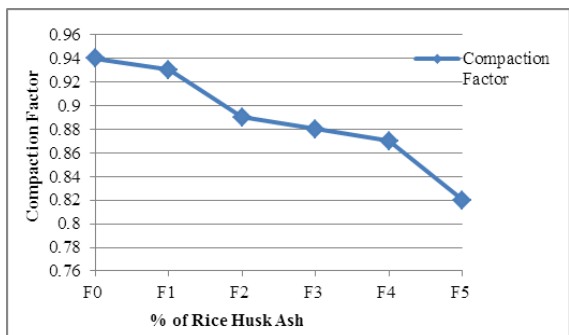


Fig.1 Relationships between Compaction Factor & % of RHA

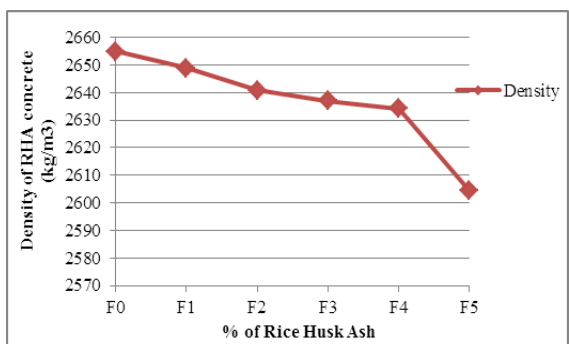


Fig.2 Relationships between Density & % of RHA

4.2 Hardened Concrete

The hardened concrete specimen properties are checked by compressive strength, Flexural strength & split tensile strength.

A-Compressive Strength of cube

The compressive strength of cube specimen is checked after 7, 28, 45 & 90 days in compressive testing machine. The result of compressive strength is shown in Table 2 and Fig. 3

Table 2 Result of Compressive Strength at 7th, 28th, 45th, 90th Days

| Series F (RHA) | Comp. Strength 7th (N/mm ²) | Comp. Strength 28th (N/mm ²) | Comp. Strength 45th (N/mm ²) | Comp. Strength 90th ((N/m ²) |
|----------------|-----------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|
| F0 | 22.23 | 33.14 | 35.79 | 37.9 |

| | | | | |
|----|-------|-------|-------|-------|
| F1 | 22.68 | 33.16 | 35.48 | 38.8 |
| F2 | 22.25 | 32.91 | 35.54 | 38.54 |
| F3 | 21.69 | 32.89 | 34.86 | 37.86 |
| F4 | 22.09 | 32.06 | 34.94 | 36.94 |
| F5 | 17.78 | 26.67 | 28 | 30.5 |

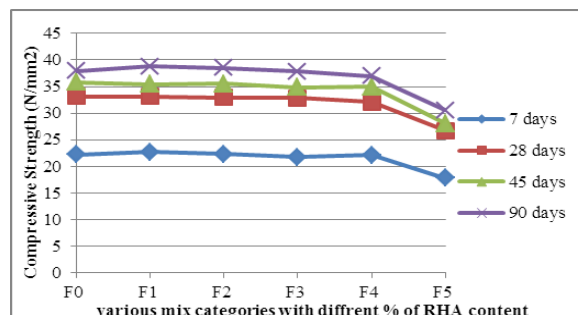


Fig.3 Compressive Strength at Different Age of RHA Concrete



Fig.4 Testing of cube specimen



Fig.5 Failure of cube specimen

B-Compressive Strength of cylinder

The compressive strength of cylinder specimen is checked after 7, 28, 45 & 90 days in compressive testing machine. The result of compressive strength is shown in Table 3 and Fig. 6

Table 3 Result of Compressive Strength at 7th, 28th, 45th, 90th Days

| Series F (RHA) | Comp. Strength 7th (N/mm ²) | Comp. Strength 28th (N/mm ²) | Comp. Strength 45th (N/mm ²) | Comp. Strength 90th (N/mm ²) |
|----------------|-----------------------------------------|------------------------------------------|------------------------------------------|------------------------------------------|
| F0 | 17.78 | 26.51 | 27.57 | 29.75 |
| F1 | 18.14 | 26.52 | 27.58 | 30.18 |
| F2 | 17.8 | 26.33 | 27.38 | 30.11 |
| F3 | 17.35 | 26.31 | 27.62 | 30.05 |
| F4 | 17.67 | 25.64 | 26.92 | 28.92 |
| F5 | 14.22 | 21.33 | 22.39 | 23.9 |

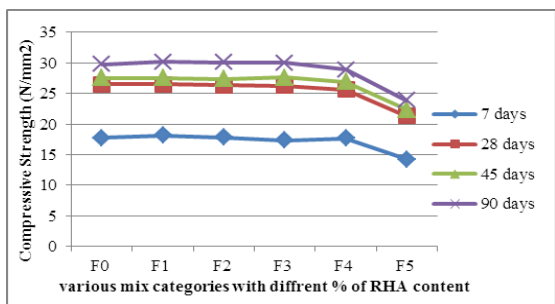


Fig.6 Compressive Strength at Different Age of RHA Concrete



Fig.7 Comp. Test on cylinder



Fig.8 Failure of cylinder specimen

C- Flexural Strength

The Flexural test of beam specimen is checked after 28days. The result of flexural strength is shown in the Table 4 and Fig. 9.

Table 4 Result of Flexural Strength at 28th Days

| Series F (RHA) | Flexural Strength (N/mm ²) |
|----------------|----------------------------------------|
| F0 | 3.72 |
| F1 | 3.67 |
| F2 | 3.55 |
| F3 | 3.49 |
| F4 | 3.45 |
| F5 | 2.96 |

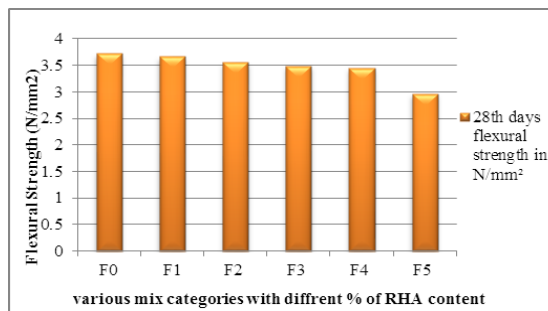


Fig.9 Flexural Strength at 28th Day for M25 Grade of RHA Concrete with Different % of Rice Husk Ash Content



Fig.10 Testing of beam specimen

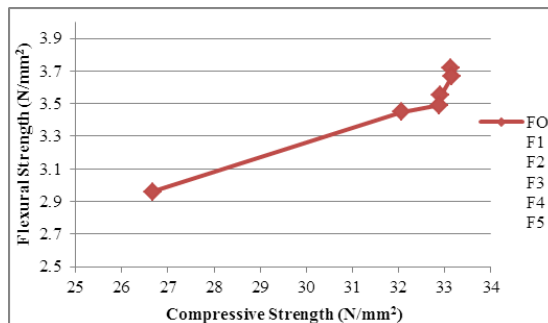


Fig.11 Relationships between Compressive Strength & Flexural Strength at 28th Day

D-Split Tensile Strength

The Split Tensile Strength test of Cylinder specimen is checked after 28days. The result of Split Tensile Strength is shown in Table 5 and Fig. 12

Table 5 Result of Split Tensile Strength at 28th Day

| Series F (RHA) | Split tensile Strength (N/mm ²) |
|----------------|---------------------------------------------|
| F0 | 2.80 |
| F1 | 2.81 |
| F2 | 2.60 |
| F3 | 2.13 |
| F4 | 1.95 |
| F5 | 1.91 |

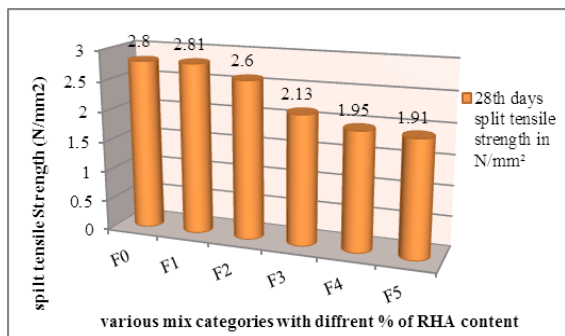


Fig.12 Split Tensile Strength at 28th Day for M25 Grade of Concrete with Different % of Rice Husk Ash

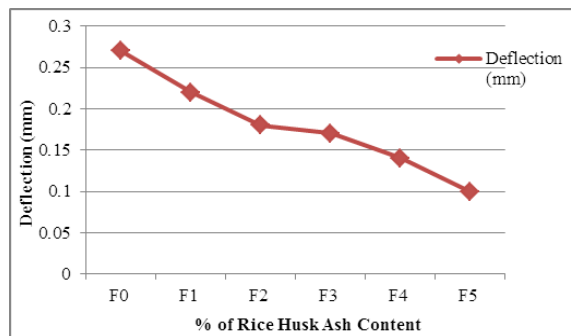


Fig.17 Relationships between Deflection & Different % of RHA Content at 28th Day



Fig.13 Testing of cylinder specimen



Fig.14 Testing of Cylinder



Fig.15 Failure of Specimen

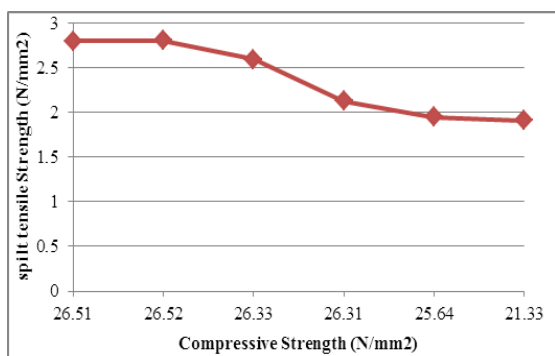


Fig.16 Split Tensile Strength at 28th Day for M25 Grade of Concrete with Different % of Rice Husk Ash

Conclusions

The study on the effect of Rice Husk Ash with different proportion can still be a promising work as there is always a need to overcome the problem of workability, brittleness of concrete. The following conclusions could be drawn from the present investigation.

- 1) RHA when added in the concrete reduces the weight of concrete up to 5% to 10% after 45 days of curing.
- 2) More amount of water is required for getting desired workability.
- 3) The use of more Rice Husk ash in concrete affects the homogeneity of mix which directly affects workability.
- 4) Till 20% of replacement of cement content with Rice Husk Ash gives safe and economic results.
- 5) Compressive strength increases with the increase in the percentage of Rice Husk Ash up to 20% replacement of cement in concrete for different mix proportion.
- 6) The maximum 28 days compressive strength, split tensile strength, flexural strength was obtained with 4% to 12% rice husk ash mix.
- 7) Rice Husk Ash contains more silica and hence we prefer rice husk ash use in concrete than silica fume to increase the strength.
- 8) Rice husk ash can is used with plasticizers for increasing the strength of concrete with partial replacement of cement.
- 9) 45 & 90 days compressive strength, split tensile strength and flexural strength of concrete increases up to 5% as compare to 28 days strength means increasing age of concrete strength also get increases.

References

Alireza Naji Givi & Suraya Abdul Rashid (2010), Contribution of Rice Husk Ash to the Properties of Mortar and Concrete, Journal of American science; 6(3):157-165. (ISSN: 1545-1003).

Godwin A. Akeke & Maurice E. Ephraim (2013), Structural Properties of Rice Husk Ash Concrete, International Journal of Engineering and Applied Sciences; Vol. 3, No. 3 ISSN2305-8269.

- James S. Fabiyi *et al* (2013), Suitability of Portland cement and Rice Husk Ash Pozzolan Systems for Cement Bonded Composites Production, *J. Mater. Environ. Sci.* 4 (6) 848-854 ISSN: 2028-2508.
- Ramezaniapour *et al* (June 2009), The Effect of Rice Husk Ash on Mechanical Properties and Durability of Sustainable Concretes *International Journal of Civil Engineering*. Vol. 7, No. 2.
- Satish D. Kene, Pravin V. Domke (2010), Assessment Of Concrete Strength Using Fly Ash And Rice Husk Ash, *International Journal Of Engineering Research And Applications (IJERA)* ISSN: 2248-9622 Vol.1, ISSUE 3, PP.524-534
- I.S. 456-2000, Indian standard code of practice for Plain and Reinforced Concrete (fourth revision), Bureau of Indian standards, New Delhi.
- I.S. 1199-1959 Method of Sampling and Analysis of Concrete.
- IS 383:1970, Specification for coarse and fine aggregates from natural sources for concrete (second revision), Bureau of Indian standards, New Delhi, India.
- I.S. 516-1959 Method of Test for Strength of Concrete.
- I.S. 10262-2009 Concrete Mix proportioning-Guideline (First Revision).
- I.S. 4031 (part III & V) Method of Physical Test for Cement.
- I.S. 10086-1982 Mould for Use in Test of Cement and Concrete.
- I.S. 5816-1999 Method of Test for Splitting Tensile Strength of Concrete.