

Analytical Study of the Rice Husk Ash and Steel Fiber as Partial Replacement of Cement and Its Effect on Strength of Concrete

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Abstract— The strength of concrete depends upon the ingredients and researchers are trying for some alternative materials of cement which will not only partially replace the cement content but also improves its strength. In this research work the Rice Husk Ash (RHA) and steel fiber (SF) are used as partial replacement. The main benefit of combining the accompanying cementing material not only improves the strength but also help in preventing the pollution. The analysis has been carried out from various ratios of RHA on concrete Indicators had been added in percentage increments with proportions of 0%, 5%, 10%, 15%, 20% and 25% RHA by weight of cement in addition to that combined effect of adding various percentage of SF of 0.5%, 1% and 1.5% to obtain optimum result. The analytical study concluded that mix 10% RHA and 1.5% SF is the best combination among all mixes.

Keywords: Rice Husk Ash (RHA), Ordinary Portland cement (OPC), Partial Replacement

I. INTRODUCTION

The construction industry is increasing at an exponential proportion and this has an influence on the prerequisite for construction materials which plays vital role in any industry. Currently, sustainable progress is one of the most wellbeing in India and around the world. Natural material like aggregates used in construction is bit by bit being depleted. Therefore, the development of sustainable construction materials is necessary. There is a direct correlation between the construction industry, available resources, energy intake and emissions of carbon dioxide (CO₂). Negative environmental

Impacts associated with widespread use of cement has led researchers to take giant steps concerning the advancement of tools and materials with the aim of decreasing the over-reliance of cement in the production of concrete and masonry building materials

On the other hand, a large quantity of agricultural leftover was disposed in most of countries particularly in Asia region like India, Thailand, Philippine and Malaysia. If the agriculture waste is not disposed appropriately, it will lead to social and environmental concerns. Recycling or reusing of the disposed material is one of the appropriate ways of treating the agricultural leftover and waste. The use of RHA material in the development of a composite material that can be used for construction can be helpful in many prospects. RHA is hazardous to environment if not dispose appropriately.

It is well known fact that, during manufacturing of 1 tone of Portland cement, cements industry required equal amount of earth resources and equal amount of CO₂ are released into the nature. Past researches have been focusing towards the utilization of waste materials in concretes. Even research has been intensified in the use of some locally available materials which can serve as partial replacement for cement in construction works due to the need to decrease to

high cost involved in using Ordinary Portland cement in concrete. In this paper, the research works carried out to analyses the effect of RHA on the compressive strength of concrete after 7, 14 and 28 days at different percentages and to evaluate the combine effect of RHA and steel fiber added to concrete as a partial replacement.

A. Need of Study

The need of carrying out the research can be summarized in following points

- 1) Increase in strength after adding appropriate quantity of RHA concrete proves it to be a better material than various other supplemental materials.
- 2) By using RHA in concrete as a partial replacement safeguard the environment by decreasing the emission of greenhouse.
- 3) The technical and economic advantage of incorporating RHA in concrete is very important for the rice growing nations like India.
- 4) This study is relevant in the scenario towards attaining sustainable development.

B. Objective of Study

- 1) To investigate optimum percentage of RHA as a partial replacement of cement.
- 2) To study the combined effect of different percentage of RHA and SF to obtain optimum strength of concrete.

II. LITERATURE REVIEW

An extensive literature review has been carried out to explore the background information on current knowledge related to the research topic.

| Year of Publish | Title of Research Paper | RHA (%) | Properties | Effect |
|-----------------|--|---------|----------------------|-----------|
| 2017 | Rice husk ash as a partial replacement of cement in high strength concrete containing micro silica | 20 | Compressive Strength | + 6.9 % |
| | | | Tensile Strength | +6.8 % |
| | | | water Permeability | -26% |
| | | | chloride Permeation | -78% |
| 2012 | Effect of RHA as Partial Replacement of Cement on Concrete Properties | 20 | Workability | Dec. |
| | | | Compressive Strength | Inc. |
| | | | Shrinkage | No effect |
| | | | Setting Times | Inc. |
| 2013 | Performance Evaluation of Steel Fibers in Rice Husk Ash | 10 | Compressive Strength | Inc. |
| | | | Tensile Strength | Inc. |

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|------|--|-------|----------------------|----------|
| | Substituted Concretes | | | |
| 2014 | Effect of Rice Husk Ash on Properties of Concrete | 20 | Compressive Strength | Inc. |
| | | | Tensile, Flexure | Inc. |
| 2014 | Use Of Rice Husk Ash As Partial Replacement For Cement In Concrete | 0 -20 | Compacting Factor | Dec. |
| | | | Compressive Strength | Inc. |
| 2015 | Effect of Partial Replacement of Cement by Rice Husk Ash in Concrete | 10 | Cost | -(7-10)% |
| | | | Compressive Strength | Inc. |
| 2017 | Experimental Study on Rice Husk Ash in Concrete by Partial Replacement | 12.5 | Tensile Strength | Inc. |
| | | | Flexural Strength | Inc. |
| | | | Compressive Strength | Inc. |
| 2017 | An Experimental Study on Rice Husk Ash as Partial Replacement for Cement in Concrete | 20 | Flexural Strength | Inc. |
| | | | Compressive Strength | Inc. |
| | | | Cost | Dec. |
| 2018 | Characteristics of Fiber-Reinforced Rice Husk Ash Concrete on Strength | 15 | Flexural Strength | Inc. |
| | | | Compressive Strength | Inc. |
| | | | Cost | Dec. |

Table 1: Research Paper on RHA

| Year of Publi sh | Tittle of Research Paper | SF (%) | Properties | Effect |
|------------------|--|--------|----------------------------|----------|
| 2016 | Effect of Partial Replacement of Cement by Fly Ash, Rice Husk Ash with Using Steel Fiber in Concrete | 0.75 | Compressive Strength | Inc. |
| | | | Flexural Strength | Inc. |
| 2018 | Characteristic s of Fiber-Reinforced Rice Husk Ash Concrete on Strength | 1.5 | Compressive Strength | +29.79 % |
| | | | Splitting Tensile Strength | +15.44 % |
| | | | Flexural Strength | +47.61 % |

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|------|--|------|----------------------------|------|
| 2019 | Optimization of Mechanical Properties of Glass Fiber Reinforced Concrete with the Combination of Rice Husk Ash | 1 | Compressive Strength | Inc. |
| | | | Flexural Strength | Inc. |
| 2019 | Experimental Study on Strength of Concrete by Using Artificial Fibers with Rice Husk Ash | 0.75 | Splitting Tensile Strength | Inc. |
| | | | Flexural Strength | Inc. |
| 2020 | Experimental study on steel fiber reinforced concrete with a partial replacement of cement by rice husk ash | 1.5 | Compressive Strength | Inc. |
| | | | Splitting Tensile Strength | Inc. |
| | | | Flexural Strength | Inc. |

Table 2: Research Paper on SF

III. MATERIALS

Although all materials that go into concrete mix are essential. The properties of material used for making concrete mix are resolute in laboratory as per relevant code of practice. Different materials used in present study were cement, coarse aggregates, fine aggregates, Rice husk Ash and steel fibers.

A. Cement

Aditya Birla Cement Company, Ordinary Portland Cement (OPC) of 43 Grade of an Ultra tech brand from a single lot was used throughout the course of the investigation. It was fresh and without any lumps. The physical properties of the cement as determined from third party certification to the lot were conforming to Indian Standards IS: 8112:1989.

B. Fine Aggregate

The sand used for the work was locally procured and conformed to Indian Standard Specifications IS: 383-1970. In this experimental program, fine aggregate (stone dust) were collected from Shree Siddhivinayak Stone Crusher, Waghalwadi and conforming to Grade Zone I. It was coarse sand light brown in colour.

C. Course Aggregate

Locally available coarse aggregate having the maximum size of 20 mm was used in this work. The aggregates were tested as per IS: 383-1970. The aggregates were washed to remove dirt, dust and then dried to surface dry condition.

D. Rice Husk Ash

Rice husk ash used in investigation has been obtained from ASHVINI TRADERS. It is Parboiled rice unit located in Chandrashekhar Ward, Gondia. The Specific gravity of rice husk ash sample is 2.28.

E. Steel Fiber

Mild steel fibers used in this investigation are purchased from Mega Fiber from Bhosari Gaonthan area, Pune having 30 mm length and 0.6 mm thickness i.e. aspect ratio (L/d) 50 which are corrugated and obtained through respective cutting of steel wires to have a good workability in used.

F. Water

The potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly potable water was used from laboratory tap for making concrete. The water was clean, free from any visible impurities and any detrimental contaminants and was good to be used quality.

IV. RESULT AND DISCUSSION

The test has been performed in standard size 150 X 150 X 150 mm to check the compressive strength with mix for various percentage of steel fiber and replacement of Rice husk Ash has been illustrated in tabular form as follows.

| Srl No. | Composition of concrete | 7 days | 14 days | 28 days |
|---------|-------------------------|--------|---------|---------|
| 1 | RHA 0% / SF 0% | 27.0 | 37.6 | 48.3 |
| 2 | RHA 5% / SF 0% | 26.6 | 36.7 | 46.7 |
| 3 | RHA 10% / SF 0% | 26.4 | 36.4 | 46.3 |
| 4 | RHA 15% / SF 0% | 25.1 | 33.2 | 41.3 |
| 5 | RHA 20% / SF 0% | 23.4 | 30.1 | 36.7 |
| 6 | RHA 25% / SF 0% | 21.6 | 28.8 | 35.9 |
| 7 | RHA 5% / SF 0.5% | 26.7 | 37.4 | 48.1 |
| 8 | RHA 10% / SF 0.5% | 26.8 | 37.5 | 48.3 |
| 9 | RHA 15% / SF 0.5% | 23.7 | 33.6 | 43.6 |
| 10 | RHA 20% / SF 0.5% | 22.0 | 29.8 | 37.7 |
| 11 | RHA 25% / SF 0.5% | 20.5 | 27.9 | 35.2 |
| 12 | RHA 5% / SF 1% | 27.0 | 38.1 | 49.1 |
| 13 | RHA 10% / SF 1% | 27.6 | 38.5 | 49.5 |
| 14 | RHA 15% / SF 1% | 25.4 | 34.6 | 43.8 |
| 15 | RHA 20% / SF 1% | 22.6 | 30.7 | 38.7 |
| 16 | RHA 25% / SF 1% | 20.9 | 29.3 | 37.6 |
| 17 | RHA 5% / SF 1.5% | 27.6 | 38.4 | 49.2 |
| 18 | RHA 10% / SF 1.5% | 28.3 | 39.6 | 50.9 |
| 19 | RHA 15% / SF 1.5% | 25.1 | 35.0 | 45.0 |
| 20 | RHA 20% / SF 1.5% | 22.2 | 31.0 | 39.8 |
| 21 | RHA 25% / SF 1.5% | 21.8 | 29.5 | 37.2 |

Table 3: Compressive Strength of Cube Specimen at Various Intervals

Above table clearly showing the variation of compressive strength, it is also observed that with the increase in percentage of steel fiber the strength increases. This happens because when steel fibers are added to concrete, the propagation of cracks was restrained due to the bonding of fibers into the concrete (ductile failure). Also it is observed that one of the most desirable benefits of adding fibers to concrete is to increase its energy absorbing capability or saying more precisely ductility. Referring to the graphs of

above section, it is observed that for addition of 1.5% steel fiber and replacement of cement with 10% Rice husk Ash, the compressive strength increases the most when compared to nominal mix.

The test has been performed in standard size 150 X 150 X 700 mm to check the flexure strength with mix for various percentage of steel fiber and replacement of Rice husk Ash in flexure test machine has been illustrated in tabular as follows.

| Srl No. | Composition of concrete | 7 days | 14 days | 28 days |
|---------|-------------------------|--------|---------|---------|
| 1 | RHA 0% / SF 0% | 4.26 | 4.81 | 5.35 |
| 2 | RHA 5% / SF 0% | 4.10 | 4.66 | 5.21 |
| 3 | RHA 10% / SF 0% | 3.83 | 4.35 | 4.86 |
| 4 | RHA 15% / SF 0% | 2.80 | 3.56 | 4.32 |
| 5 | RHA 20% / SF 0% | 2.52 | 3.16 | 3.80 |
| 6 | RHA 25% / SF 0% | 2.20 | 2.87 | 3.54 |
| 7 | RHA 5% / SF 0.5% | 4.03 | 4.58 | 5.12 |
| 8 | RHA 10% / SF 0.5% | 3.80 | 4.44 | 5.08 |
| 9 | RHA 15% / SF 0.5% | 2.94 | 3.68 | 4.41 |
| 10 | RHA 20% / SF 0.5% | 2.65 | 3.32 | 3.99 |
| 11 | RHA 25% / SF 0.5% | 2.34 | 2.95 | 3.55 |
| 12 | RHA 5% / SF 1% | 4.20 | 4.75 | 5.30 |
| 13 | RHA 10% / SF 1% | 4.10 | 4.70 | 5.29 |
| 14 | RHA 15% / SF 1% | 3.09 | 3.81 | 4.52 |
| 15 | RHA 20% / SF 1% | 2.78 | 3.49 | 4.19 |
| 16 | RHA 25% / SF 1% | 2.53 | 3.26 | 3.98 |
| 17 | RHA 5% / SF 1.5% | 4.35 | 4.86 | 5.37 |
| 18 | RHA 10% / SF 1.5% | 4.43 | 5.04 | 5.64 |
| 19 | RHA 15% / SF 1.5% | 3.93 | 4.68 | 5.43 |
| 20 | RHA 20% / SF 1.5% | 2.97 | 3.84 | 4.7 |
| 21 | RHA 25% / SF 1.5% | 2.65 | 3.47 | 4.29 |

Table 4: Flexure Strength of Cube Specimen at Various Intervals

Above section clearly showing the variation of flexure strength, it is also observed that with the increase in percentage of steel fiber the strength increases. This happens because when steel fibers are added to concrete, the propagation of cracks was restrained due to the bonding of fibers into the concrete (ductile failure). Also it is observed that one of the most desirable benefits of adding fibers to concrete is to increase its energy absorbing capability or saying more precisely ductility. Referring to the graphs of above section, it is observed that for addition of 1.5% steel fiber and replacement of cement with 10% Rice husk Ash, the flexure strength increases the most when compared to nominal mix.

V. CONCLUSION

- Concrete mix with 10 percent Rice husk Ash as replacement of cement and 1.5% addition of steel fiber is the optimum level and it has been observed to show a significant increase in compressive strength at 7days, 21 days and 28 days when compared with nominal mix.
- The flexure strength also tends to increase with the increase percentage of steel fiber, a trend similar to increase in compressive strength.

- On increasing the percentage replacement of cement with Rice husk Ash beyond 10%, there is significantly decrease in compressive and flexure strength value.

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