# Mechanical Behavior of Self Compacting Concrete using Rice Husk Ash as Partial Replacement of Cement a Comparative Study

M.Venkatnaveen Kumar[1], K.Venkataramanayada[2], K. Srinivas Yadav[3],
M. Pavan Yadav[4], M. Srikanth Reddy[5]
*B.TECH.Student[1234], B.SC Student[5]*
*[12]Department of Mechanical Engineering, [34]Department of Civil Engineering, [5]Department of B.SC M.P.C.*
*Guru Nanak Institute of Technology[12], Ibrahimpatnam, Mahatma Gandhi Institute of Technology[34],Gandipet,*
*Nizam college[5], Basheer Bagh, Telangana,India [12345]*

***Abstract: Self-Compacting Concrete is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its own weight, achieving full compaction, even in the presence of congested reinforcement. The disadvantage of self-compacting concrete is its cost and durability, associated with the use of high volumes of Portland cement and use of chemical admixtures. One alternative to reduce the cost of self-compacting concrete is the use of mineral ad mixtures such as Rice Husk Ash which is finely divided material added to concrete during mixture procedure. When RHA replaces a part of the Portland cement, the cost of self-compacting concrete will be reduced especially if the mineral ad mixtures are waste or industrial by-product. Moreover, the use of mineral ad mixtures in the production of self-compacting concrete not only provides economical benefits but also reduces heat of hydration making it durable. The incorporation of mineral ad mixtures also eliminates the need for viscosity- enhancing chemical ad mixtures. The lower water content of the concrete leads to higher durability, in addition to better mechanical integrity of the structure. This thesis work presents an experimental investigation on strength aspects like compressive, flexural and split tensile strength of self-compacting concrete containing Rice Husk Ash as partial replacement of cement. The methodology adopted is that Rice Husk Ash has been partially replaced with cement with a varying percentage of 0%, 5%, 10%, 15%, 20%, 25% and 30% and the influence of Rice Husk Ash on the mechanical property of self-compacting concrete was investigated. The following inferences were made; optimum dosage of super plasticizer enhanced the flow property of the concrete. As a result, over all improvements in the flow and filling ability of the self-compacting concrete were observed. From this view point, a cost effective self-compacting concrete design can be obtained by incorporating reasonable amounts of rice husk ash.***

***Keywords: Rice Husk Ash (RHA), Self-Compacting Concrete (SCC), Compressive strength, Split tensile strength, Flexural strength.***

## I. INTRODUCTION

Self-compacting concrete (SCC) is a fluid mixture, which is suitable for placing in difficult conditions and also in congested reinforcement, without vibration. Development of self-compacting concrete (SCC) is a desirable achievement in the construction industry in order to overcome problems associated with cast-in-place concrete. A self-compacting must have1) A fluidity that allows self-compaction without external energy.2) Remain homogeneous in a form during and after the placing process.3) Flow easily through reinforcement.

Self-compacting concrete is not affected by the skills of workers, the shape and amount of reinforcing bars or the arrangement of a structure and, due to its high-fluidity and resistance to segregation it can be pumped longer distances. However due to higher content of cement in SCC, the heat of hydration generated is more and more prone to plastic shrink age and thermal cracks and there for e not durable. With the addition of RHA the durability problem of SCC has been resolved to a maximum level. Addition of RHA not only makes the concrete durable but also makes it economical The criteria required for the RHA to be used as partial replacement of cement are 1) it should be burnt under a control temperature between 550°C and 700°C for 10 to 12hr. 2) it should be further ground even finer then cement.

## II. LITERATURE SURVEY

***M.A.Ahmadietal., [1]*** It is concluded that RHA provides a positive effect on the Mechanical properties at age after 60 days. Also specimens with 20% replacement of cement by RHA have the best performance.

***SyedMehdiAbbasetal., [2]*** Strength of concrete containing 25% of RHA is not affected appreciably but the cost is reduced considerably. It is also found that the resistance to chemical attack of RHA concrete is much better than ordinary Portland cement concrete.

***Shriram,H.Mahureetal.,[3]*** RHA being pozzolanic materials shown much better performance after 90 days curing as compared with the same at 28 days. It was observed that the water absorption within acceptable limit. Hence the concrete will be impermeable.

***ChatveeraB,LertwattanarukP.,[4]*** investigated that RHA provides a positive effect on the outage no us shrink age and weight loss of concretes exposed to hydrochloric and sulphuric acid attacks.

***S.KanakambaraRaoetal., [5]*** result show that with addition of RHA the inter facial transition zone (ITZ) between the cement paste and the aggregate in self-compacting concrete partially replaced with RHA gets improved.

***Obilade,I.Oetal.,[6].***result revealed that when RHA is used as partial replacement for Ordinary Portland Cement(OPC) in concrete by weight at 0%, 5%, 10%, 15%, 20% and 25% replacement. The results revealed that the Compacting factor decreased as the percentage replacement of OPC with RHA increased.

***HaThanh, Sang Thanh Nguye., [7]*** workability of SCC containing RHA decreases at the higher replacement levels compared to that of the control mixture due to the pore structure of RHA. In replacement range of 5-20% RHA, there exists an optimum RHA content resulting in the highest compressive strength of concrete.

***SilvioDelvasto., [8]*** revealed that the particular rice-husk-ash (RHA) consists of 99% of silica, highly amorphous, white in colour and of greater pozzolanic activity than the silica fume and another rice-husk-ash prepared with only by a thermal treatment.

## III. PROPOSED METHODOLOGY AND DISCUSSION

The present study consists of experimental study of SCC using RHA as partial replacement of cement and to check the durability. The experimental method refers to the casting of cubes (150mmx150mmx150mm), cylinders (150mm diameter and 300mm long), prisms (500cmx100mmx100mm) for M30 grade of concrete as per Indian standard method to determine the compressive strength, split tensile strength, flexural strength of concrete for different proportion of RHA varying from (0%,5%,10%,15%,20%,25%, and 30%) Mix design procedure as per modified ***nansu mix design method [9]*** for M30 grade of concrete.

**Material properties:**

**Cement:** Ordinary Portland Cement (OPC) of 53-grade Coro mandal King Brand, obtained from INDIA Cements Pvt. Ltd (Jamshedpur) was used conforming to ***IS12269–2013[10]*** for the chemical composition of OPC-53

**Table-I Typical Properties of OPC-53 Grade Cement**

| S.No | Properties | Results obtained | IS:12269-2013 Specifications |
|---|---|---|---|
| 1 | Fineness retained on ISsieve90μ | 1.7% | - |
| 2 | Soundness (mm) | 3.45 | 10(max) |
| 3 | Normal Consistency | 35% | - |
| 4 | Initial Setting Time(min) | 67 | 30(min) |
| 5 | Final Setting Time(min) | 365 | 600(max) |
| 6 | 3days compressive strength (MPa) | 26.6 | 27 |
| 7 | 7days compressive strength (MPa) | 36.2 | 37 |
| 8 | 28days compressive strength (MPa) | 54.3 | 53 |
| 9 | Specific Gravity | 3.05 | 3.15 |

**Aggregate:** The test for aggregate is done as per Indian standard procedure confirming to ***IS383-1970[11].***The materials were collected from the local market of Jamshedpur of size 20 mm down and 10mm down the 20mm down aggregate was taken 65% and 10mm down aggregate was taken 35% to get maximum density.

**Table-II Typical Property of Aggregate**

| **S.No** | **Property** | **Fine Aggregate** | **Coarse Aggregate** |
|---|---|---|---|
| 1 | Specific gravity | 2.48 | 2.8 |
| 2 | Fineness modulus | 2.65 | 6.68 |
| 3 | Water absorption(%) | 1.626 | 0.50 |
| 4 | Free moisture content(%) | 1.87 | 0.9 |
| 5 | Silt Content | 4.17% | - |

| | | | |
|---|---|---|---|
| 6 | Bulk density(kg/m$^3$) | 1440 | 1550 |
| 7 | Aggregate Impact value | - | 13.74 |
| 8 | Aggregate Crushing value | - | 12.10 |

**Table III Chemical Composition of RHA**

| S.NO. | Particulars | Proportion |
|---|---|---|
| 1 | Silicon Dioxide | 86.94% |
| 2 | Aluminium Oxide | 0.2% |
| 3 | Iron Oxide | 0.1% |
| 4 | Calcium Oxide | 0.3–2.25% |
| 5 | Magnesium Oxide | 0.2–0.6% |
| 6 | Sodium Oxide | 0.1-0.8% |
| 7 | Silicon Dioxide | 86.94% |
| 8 | Aluminium Oxide | 0.2% |
| 9 | Iron Oxide | 0.1% |
| 10 | LOI | 5.83% |

## IV. EXPERIMENTAL TEST AND RESULT

**Slump Flow Test:** The slump flow test is done to assess the horizontal flow of concrete in the absence of obstruction. It is most commonly used test and gives good assessment of filling ability. It can be used at sites. The test also indicates the resistance to segregation. According to EFNARC the slump flow should lie between (650to800) mm.

**V-Funnel test:** This test is basically used to determine filling ability of concrete. Time taken for the concrete to flow down is recorded. If the concrete shows segregation then the flow time will increase significantly. According to EFNARC the V-Funnel value should lie between (8to12) sec.

**Cube Compressive Strength:**

After finalization of mix proportion of M30 with W/C=0.35 and super plasticizer dose of 1.2%, the cubes were casted for different proportion of RHA as partial replacement of cement by weight and tested for compressive strength. Concrete cube specimen sofsize150mmx150mmx150mm were cast, cured and tested at 7, 28, 60 and 90 days of maturity as per ***IS:516-1959[12]***

**Table-V Compressive Strength test result for all ages:**

| %RHA | 7-daysstrength (N/mm2) | 28-days strength(N/mm2) | 60-days strength (N/mm2) | 90-days strength (N/mm2) |
|---|---|---|---|---|
| 0% | 31 | 49 | 50 | 51 |
| 5% | 29.03 | 46.48 | 47 | 48 |
| 10% | 25 | 37 | 41 | 44 |
| 15% | 22 | 33 | 37 | 39 |
| 20% | 18 | 26.93 | 31 | 35.48 |
| 25% | 11 | 18 | 21 | 23 |
| 30% | 9 | 14 | 17 | 19 |

**Table-V** shows that the compressive strength of concrete decreases with increase in % replacement of RHA. However the result shows that with increase in age of concrete, the compressive strength for a particular mix increases showing that pozzolanic activities increases with age. Upto 20% replacement of RHA the target strength was achieved.

**Split Tensile Strength of Concrete:**

The split tensile strength of concrete was determined after 28, 60, and 90 days of curing of the cylindrical specimens. The cylindrical mould shall be of 150mm diameter and 300mm height using 2000kN compression testing machine as per the procedure given in ***BIS (IS: 5816-1999)[13***]

**Table-VI Split tensile strength test results for all ages:**

| Mix of RHA | 28-days strength (N/mm$^2$) | 60-days strength (N/mm$^2$) | 90-days strength (N/mm$^2$) |
|---|---|---|---|
| 0% | 4.20 | 4.49 | 4.53 |
| 5% | 4.13 | 4.46 | 4.47 |
| 10% | 3.97 | 4.18 | 4.23 |
| 15% | 3.49 | 3.71 | 3.77 |
| 20% | 3.22 | 3.39 | 3.46 |
| 25% | 2.15 | 2.30 | 2.33 |
| 30% | 1.42 | 1.48 | 1.50 |

**Flexural Strength of Concrete:** This test was per formed in accordance with ***BIS (IS:516-1959)***on prisms of size100 x100x500mm after 28, 60 and 90 days of water curing for finding flexural strength. The specimen was supported on two roller support spaced at 400mmc/c. The load was then applied at a rate of 0.7N/mm$^2$/min through two similar rollers mounted at third point of the span (133.3mm c/c) till the failure occurred.

**Table-VII Flexural strength test results for all Ages:**

| Mix of RHA in percentage | 28-daysstrength (N/mm$^2$) | 60-daysstrength (N/mm$^2$) | 90-daysstrength (N/mm$^2$) |
|---|---|---|---|
| 0% | 7.26 | 7.93 | 8.13 |
| 5% | 7.13 | 7.86 | 8.00 |
| 10% | 6.93 | 7.60 | 7.86 |
| 15% | 6.73 | 7.33 | 7.46 |
| 20% | 5.06 | 5.26 | 5.40 |
| 25% | 3.13 | 3.26 | 3.40 |
| 30% | 2.20 | 2.40 | 2.46 |

**Figure-6: Experimental Setup for Flexural Strength**

Sulphate attack causes concrete deterioration by chemical or physical reactions. In this phenomenon, the sulphateions penetrating from soil or ground water react with the aluminate phase of the cement causing deterioration of concrete. The sulphate attack testing procedure was conducted by immersing concrete specimens of the size150mmx150mmx150mm in a water tank containing 5% Sodium sulphate solution for 28 and 90 days. The degree of sulphate attack was evaluated by measuring loss in compressive strength of the specimen sat 28 days and 90 days.

**Sulphate Attack test:**

**Table-VIII Average reduction in comp strength due to curing in sulphate solution:**

| % RHA | Normal Curing 28 days comp strength | Sulphate Curing 28 days Comp strength after | Comp Strength After 90 days | Sulphate Curing 90 days Comp strength after | % loss of comp. Strength in 28 days | % loss of comp. Strength in 90 days |
|---|---|---|---|---|---|---|
| 0% | 49 | 42.91 | 51 | 44.83 | 12.42 | 12.09 |
| 5% | 46.48 | 42.56 | 48 | 43.50 | 9.37 | 5.77 |
| 10% | 37 | 34.45 | 44 | 41.50 | 6.89 | 5.68 |
| 15% | 33 | 30.84 | 39 | 37 | 6.54 | 5.12 |
| 20% | 26.93 | 25.24 | 35.48 | 34 | 6.27 | 4.17 |
| 25% | 18 | 16.69 | 23 | 20.94 | 7.27 | 8.95 |
| 30% | 14 | 12.89 | 19 | 17.23 | 7.92 | 9.31 |

**Table-VIII** shows that % loss of compressive strength decreases with increase in partial replacement of RHA upto 20% replacement. Above 20% replacement the compressive strength decreases as weak concrete will not be a durable concrete. Also with increase in age the % loss of compressive strength decreases as pozzolanic action has taken place consuming $Ca(OH)_2$ which affects the durability.

**Acid Resistance test:**

Acid resistance was tested on 150mm size cube specimen sat the age of 28 and 90 days of curing. The cube specimens were weighed and immersed in water diluted with one percent by weight of sulphuric acid for 28 and 90 days. Then, the specimens were taken out from the acid water and the surfaces of the cubes were cleaned. Then, the compressive strength of the specimens was found out and the average percentage of loss of compressive strength was calculated.

**Table-IX Average reduction in comp strength due to curing in $H_2SO_4$ solution:**

| % RHA | Normal curing28 days comp strength | $H_2SO_4$ curing28days Comp strength after | Comp strength after90 days | $H_2SO_4$ curing90days Comp strength After | %lossof comp. strength in28days | %lossof comp. strength in90days |
|---|---|---|---|---|---|---|
| 0% | 49 | 44.21 | 51 | 45.23 | 13.24 | 11.31 |
| 5% | 46.48 | 41.32 | 48 | 43.13 | 11.1 | 10.14 |
| 10% | 37 | 33.27 | 44 | 39.90 | 10.08 | 9.31 |
| 15% | 33 | 30.12 | 39 | 36.43 | 8.72 | 6.58 |
| 20% | 26.93 | 24.84 | 35.48 | 33.77 | 7.76 | 4.81 |
| 25% | 18 | 16.39 | 23 | 19.94 | 8.94 | 13.3 |
| 30% | 14 | 11.89 | 19 | 16.13 | 15.07 | 15.1 |

**Table-IX** shows that % loss of compressive strength decreases with increase in partial replacement of RHA up to 20% replacement. Above 20% replacement the compressive strength decreases as weak concrete will not be a durable concrete. Also with increase in age the % loss of compressive strength decreases as pozzolanic action has taken place consuming Ca $(OH)_2$ which affects the durability.

## V. CONCLUSION

On the basis of the experimental investigations and analysis, the following conclusions can be drawn:

1. RHA being a waste material obtained from the steel plant causing pollution. Partial replacement of RHA with cement reduces environmental problem which is a big concern for the whole world.

2. Incorporating RHA as a partial replacement of cement we can make an economical self-compacting concrete.

3. As per the EFNARC specification, the slump flow value, V-funnel, L-box & J-Ring Test showed acceptable value up to replacement of 20% cement by RHA.

4. The target strength for Compressive Split tensile and Flexural Strength for M30 grade concrete was achieved upto a replacement of 20% of cement by RHA.

5. Partial replacement of cement by RHA resists the thermal cracks generated due to hydration of cement and makes the concrete durable.

6. Calcium hydroxide released during hydration of cement is mainly responsible for many chemical attacks like acid attack and sulphate attack. The partial replacement of cement by RHA upto 20% replacement resist these phenomenon as RHA chemically react with calcium hydroxide in the presence of moisture to convert it into C-S-H gel and improves the transition zone which h the weakest link of the concrete.

7. Use of RHA increases the packing density of concrete which result in impervious concrete.

## REFERENCES

[1] Ahmadi, M.A., Alidoust, O., Sadrinejad, I., Nayeri, M. Development of Mechanical Properties of Self Compacting Concrete Contain Rice Husk Ash, World Academy of Science, Engineering and Technology 342007,Volno.1pp100-103,2007

[2] Syedmehdiabbas,Use of rice-husk-ash in concrete as partial cement replacement material, International Journal of Scientific & Engineering Research (ISSN2229-5518),Volno.6pp276-278.

[3] Prof. Shriram H. Mahure, Dr. V. M. Mohitkar, Effect of Rice-Husk-Ash on Fresh and Hardened Properties of Self Compacting Concrete. International Journal of Scientific & Engineering Research (ISSN2229-5518), Vol. no. 5issue7pp833-839, December 2015.

[4] Chatveera B, Lertwattanaruk P, Durability of conventional concrete containing black rice-husk-ash. J. Environ. Manage, Vol. no.92, issue1, pp59-66, (sept2010),

[5] S. Kanakambara Rao "A Review on Experimental Behavior of Self Compaction Concrete Incorporated with Rice-Husk-Ash" International Journal of Science and Advanced Technology (ISSN2221-8386).Vol.no.2, pp75-80, march2012

[6] Bilade, I.O., use of rice-husk-ash as partial replacement for cement in concrete, (ISSN2305-8269). Vol. no. 5.No.04, pp11-16, Sept.2014

[7] HaThanh, Sang Thanh Nguyena, study on high performance fine grained concrete containing rice-husk-ash, International Journal of Concrete Structures and Materials.Vol.no.8, issue4, pp301-307,March2014.

[8] Silvio Delvasto, ASalas, R. Mejia Developing high performance concrete incorporating highly reactive rice-husk-ash, in genieirae investigacion.Vol.no.33, issue2, pp49-55,2013.

[9] Nansu, Kung-chung Hsu, is-wenchai, As implemix design method for self-compacting concrete, Cement and Concrete Research, Cement and Concrete Research 31volume 3, issue 2, pp.1799-1807. December 2001.IS: 12269-2013, Specifications of Ordinary Portland cement 53Grade, Bureau of Indian Standards, New Delhi.