Rice Husk Ash as a Partial Replacement of Cement in M-20 & M-40 Grade Concrete: Evaluating Durability & Mechanical Properties

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Abstract: Construction activities are increasing rapidly hence resulted in shortage of conventional construction materials. Mainly Coarse Aggregate, Crushed Sand and cement are used in the preparation of concrete. While the use of agricultural by-product i.e. rice husk ash can be used as a partial replacement with Cement. Due to the pozzolanic reactivity, rice husk ash (RHA) is employed as supplementary cementing material in concrete. The rice husk ash (RHA) contain near about 90 % of Silicon Dioxide (Sio2). By using rice husk ash in concrete, various properties of concrete can be improved. The addition of these admixtures also results in significant savings in energy and cost. The detailed experimental investigation is to study the effect of partial replacement of cement by Rice husk ash. Specimen with M-20 & M-40 grade concrete is casted and tested. Properties like Slump Cone, Compressive strength, Tensile Strength, Flexural Strength and Durability Test for various amount of replacement of cement i.e. 10%, 15% and 20% with Rice Husk Ash for both the grades of concrete is compared with that of conventional concrete which without Rice Husk Ash. The optimum level of replacement of Rice Husk Ash will be found out for both the grades of concrete which is 15% for both the grade of concrete. Cost analysis based on the result obtained is determined and the reduction in cost of construction is calculated.

Keywords — Rice Hush Ash, Compressive Strength, Flexural Strength, Durability

I. INTRODUCTION

Construction Industries is one of the largest industries worldwide which plays vital role in the economic as well social growth of the country. In India, creating quality concrete in the present climate does not depend solely on achieving a high strength property. It also depends on improving the durability of the concrete to sustain a longer life span and producing a greener concrete. By using industrial by-products such as rice husk ash as a mineral admixture and partially replacing Ordinary Portland Cement (OPC) in the concrete, the amount of greenhouse gas produced in making the concrete and the energy required to produce the concrete are reduced.

Rice husk are the hard protective coverings of rice grains which are separated from the grains during milling process. Rice husk is an abundantly available waste material in all rice producing countries, and it contains about 30%–50% of organic carbon. In the course of a typical milling process, the husk are removed from the raw grain to reveal whole brown rice which upon further milling to remove the bran layer will yield white rice. Current rice production in the world is estimated to be 700 million tons. Rice husk constitutes about 20% of the weight of rice and its composition is as follows: cellulose (50%), lignin (25%–30%), silica (15%–20%), and moisture (10%–15%). Bulk density of rice husk is low and lies in the range 90–150 kg/m3. Sources of rice husk ash (RHA) will be in the rice growing regions of the world, as for example China, India, and the far-East countries.

RHA is the product of incineration of rice husk. Most of the evaporable components of rice husk are slowly lost during burning and the Primary residues are the silicates. The characteristics of the ash are dependent on (1) composition of the rice husks, (2) burning temperature, and (3) burning time. Every 100 kg of husks burnt in a boiler for example will yield about 25 kg of RHA. In certain areas, rice husk is

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used as a fuel for parboiling paddy in rice mills, whereas in some places it is field-burnt as a local fuel. However, the combustion of rice husks in such cases is far from complete and the partial burning also contributes to air pollution

II. OBJECTIVE

1. To study the effect of different volume of rice husk ash on strength parameters of Concrete mixes.
2. To compare the mechanical properties of concrete in the varying percentage of Rice husk ash, with conventional concrete.
3. To check durability Parameters of Concrete with partial replacement of Cement with Rice Husk Ash.
4. To perform a cost analysis based on the result obtained and to determine the reduction of cost.

III. CONCRETE MIX FOR M-20 & M-40

Concrete Mix Design is as per IS 10262-2019. Cement used is OPC -53 Grade cement. Maximum water cement ratio for M-20 grade concrete is 0.55 & for M-40 grade concrete is 0.40. M-20 grade concrete is design for slump of 100mm±20 mm & M-40 grade concrete is design for slump of 50mm±20.

Table 01: Conventional M-20 Grade Mix Design

Ingredients	Conventional Concrete
Cement	337.99
Rice Hush Ash	0.00
10mm Agg.	471.48
20mm Agg.	713.97
Crushed sand	761.58
Water	165.61
Admixture	3.38
Total	**2454.01**

Table 02: Concrete Mix for M-20 Grade

Ingredients	10% RHA	15% RHA	20% RHA
Cement	304.19	287.29	270.39
Rice Hush Ash	33.80	50.70	67.60
10mm Agg.	471.48	471.48	471.48
20mm Agg.	713.97	713.97	713.97
Crushed sand	761.58	761.58	761.58
Water	165.61	165.61	165.61
Admixture	3.38	3.38	3.38
Total	**2454.01**	**2454.01**	**2454.01**

Table 03: Concrete Mix for M-40 Grade Conventional

Ingredients	Conventional Concrete
Cement	414.51
Rice Hush Ash	0.00
10mm Agg.	489.96
20mm Agg.	742.99
Crushed sand	703.63
Water	145.08
Admixture	4.14
Total	**2500.31**

Table 04: Concrete Mix for M-40 Grade

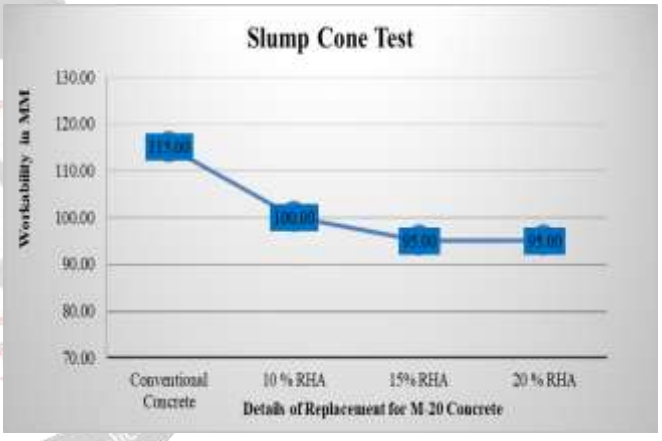
Ingredients	10% RHA	15% RHA	20% RHA
Cement	373.06	352.33	331.61
Rice Hush Ash	41.45	62.18	82.90
10mm Agg.	489.96	489.96	489.96
20mm Agg.	742.99	742.99	742.99
Crushed sand	703.63	703.63	703.63
Water	145.08	145.08	145.08
Admixture	4.14	4.14	4.14
Total	**2500.31**	**2500.31**	**2500.31**

IV. ANALYSIS OF RESULTS

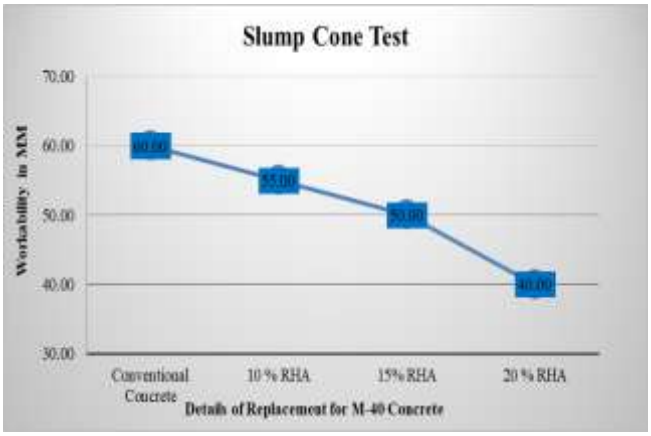
A. Workability

Table 05: Workability Test Result M-20 & M-40 Grade

Details of Replacement	M-20 Grade Concrete Slump(mm)	M-40 Grade Concrete Slump(mm)
Conventional Concrete	115 mm	60 mm
RHA 10 %	100 mm	55 mm
RHA 15 %	95 mm	50 mm
RHA 20 %	95 mm	40 mm



Graph 01: Workability Test Result M-20 Grade



Graph 02: Workability Test Result M-40 Grade

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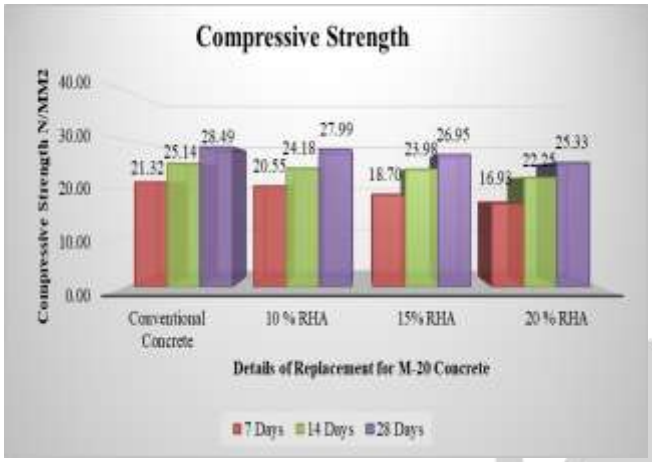
B. Compressive Strength

Table 07: Compressive Strength Results M-20 Grade

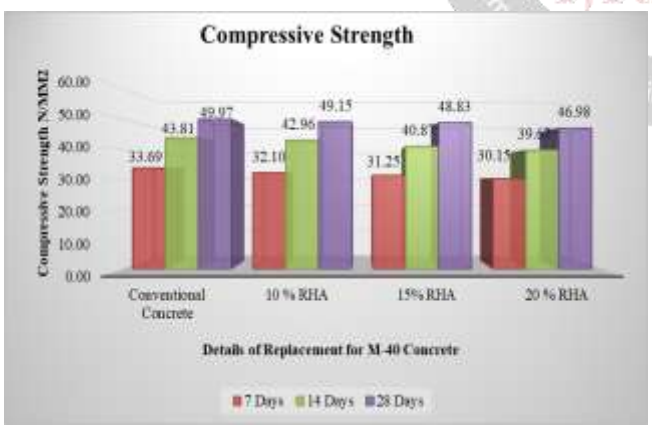
Details of Replacement	7 Days (Mpa)	14 Days (Mpa)	28 Days (Mpa)
Conventional Concrete	21.32	25.14	28.49
RHA 10 %	20.55	24.18	27.99
RHA 15 %	18.70	23.98	26.95
RHA 20 %	16.93	22.25	25.33



Graph 03: Compressive Test Result M-20 Grade

Table 08: Compressive Strength Results M-40 Grade

Details of Replacement	7 Days (Mpa)	14 Days (Mpa)	28 Days (Mpa)
Conventional Concrete	33.69	43.81	49.97
RHA 10 %	32.10	42.96	49.15
RHA 15 %	31.25	40.87	48.83
RHA 20 %	30.15	39.67	46.98

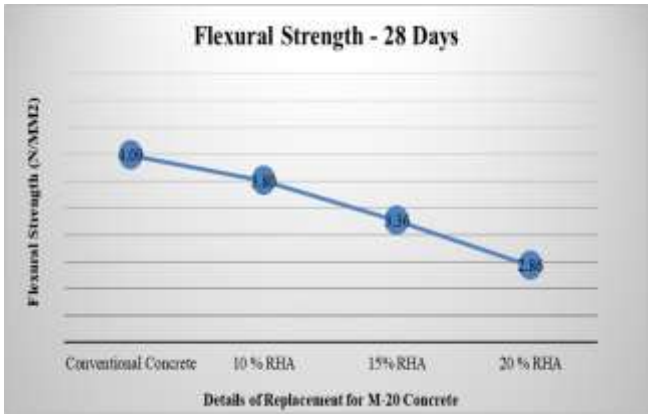


Graph 04: Compressive Test Result M-20 Grade

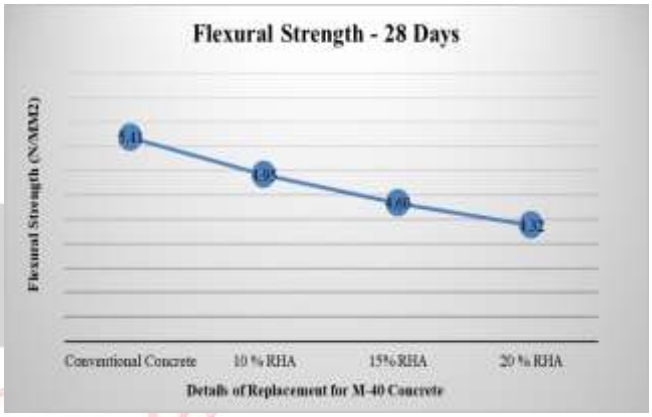
C. Flexural Strength

Table 09: Flexural Strength Results M-20 & M-40 Grade

Details of Replacement	28 Days (Mpa)	28 Days (Mpa))
Conventional Concrete	4.09	5.41
RHA 10 %	3.80	4.95
RHA 15 %	3.36	4.60
RHA 20 %	2.86	4.32



Graph 05: Flexural Test Result M-20 Grade



Graph 06: Flexural Test Result M-40 Grade

D. Split Tensile Strength

Table 11: Split Tensile Strength Results M-20 Grade

Details of Replacement	28 Days (Mpa)	28 Days (Mpa))
Conventional Concrete	4.01	5.22
RHA 10 %	3.71	4.94
RHA 15 %	3.27	4.56
RHA 20 %	2.80	4.29

Graph 07: Split Tensile Test Result M-20 Grade

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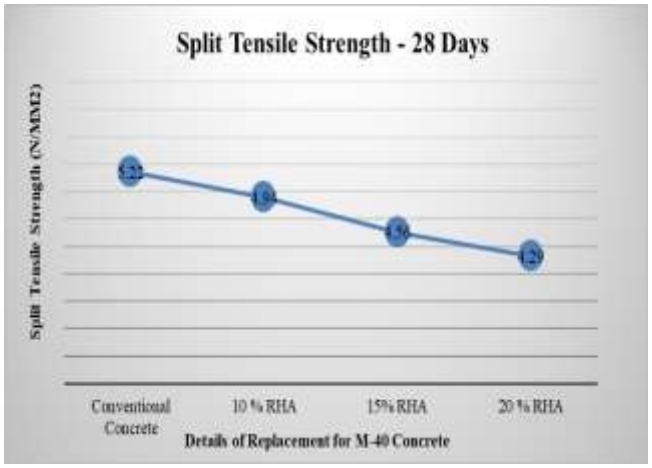
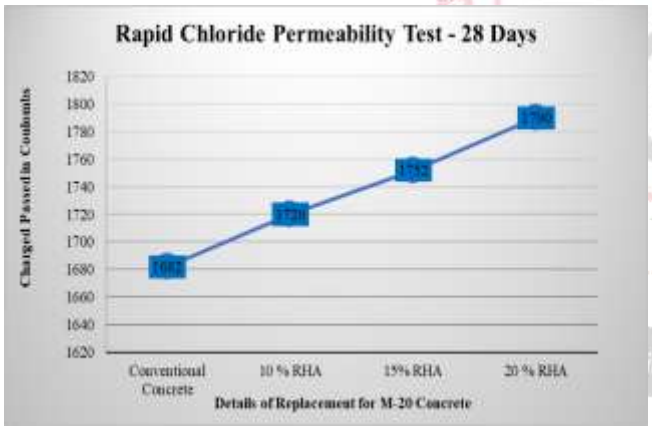


Graph 08: Split Tensile Test Result M-40 Grade

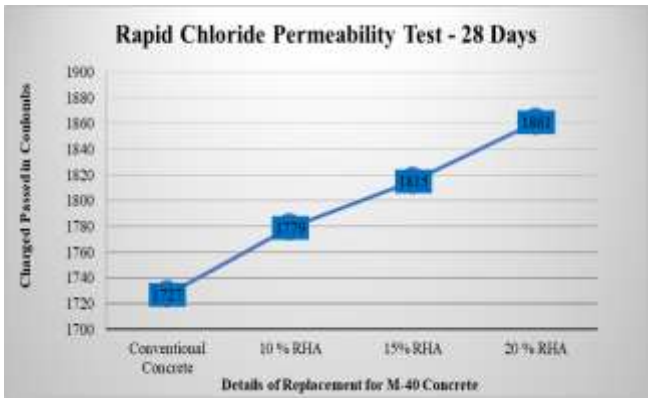
E. Durability-Rapid Chloride Penetration Test

Table 13: Rapid Chloride Penetration Test Result M-20 Grade

Details of Replacement	28 Days (Charged Passed in Coulombs)	28 Days (Charged Passed in Coulombs)
Conventional Concrete	1682	1727
RHA 10 %	1720	1779
RHA 15 %	1752	1815
RHA 20 %	1790	1861



Graph 08: RCPT Result M-20 Grade



Graph 09: RCPT Result M-40 Grade

V. COST ANALYSIS

Table 15: Cost for M-20 Conventional Concrete/m3

Element	Quantity	Price/Kg	Total Price
Cement	337.99	Rs. 4.90	Rs. 1,656.15
10mm	471.48	Rs. 0.745	Rs. 351.25
20mm	713.97	Rs. 0.745	Rs. 531.91
Crushed sand	761.58	Rs. 0.860	Rs. 654.96
Water	165.61	Rs. 1.00	Rs. 165.61
Admixture	3.38	Rs. 41.00	Rs. 138.58
Total cost			**Rs. 3498.40**

Table 16: Cost/m3 for M-20-(15 % RHA Replacement)

Element	Quantity	Price/Kg	Total Price
Cement	287.29	Rs. 4.90	Rs. 1407.72
Rice Husk Ash	50.70	Rs. 1.60	Rs. 81.12
10mm	471.48	Rs. 0.745	Rs. 351.25
20mm	713.97	Rs. 0.745	Rs. 531.91
Crushed sand	761.58	Rs. 0.860	Rs. 654.96
Water	165.61	Rs. 1.00	Rs. 165.61
Admixture	3.38	Rs. 41.00	Rs. 138.58
Total cost			**Rs. 3,331.15**

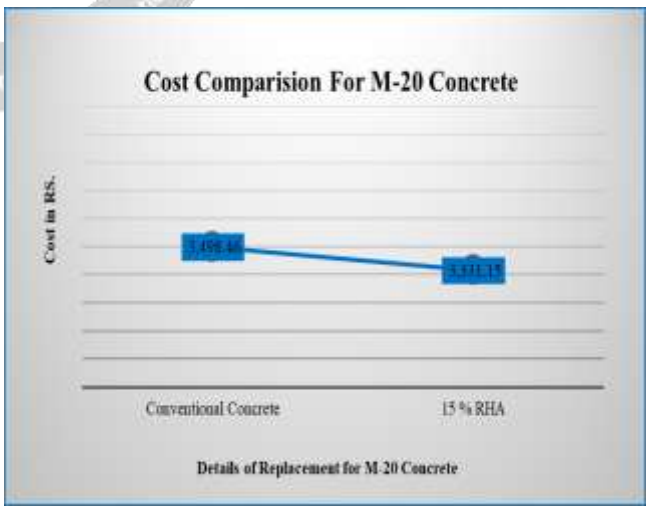


Table 17: Cost for M-40 Conventional Concrete/m3

Element	Quantity	Price/Kg	Total Price
Cement	352.33	Rs. 4.90	Rs. 1726.42
Rice Husk Ash	62.18	Rs. 1.60	Rs. 99.49

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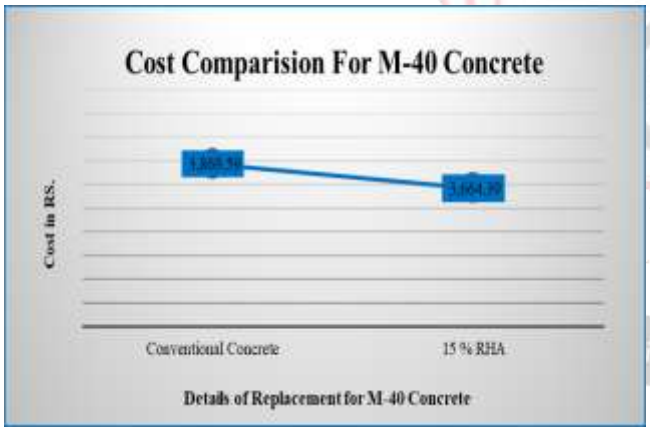
10mm	489.96	Rs. 0.745	Rs. 365.02
20mm	742.99	Rs. 0.745	Rs. 553.53
Crushed sand	703.63	Rs. 0.860	Rs. 605.12
Water	145.08	Rs. 1.00	Rs. 145.08
Admixture	4.14	Rs. 41.00	Rs. 169.74
Total cost			**Rs. 3,664.39**

Table 18: Cost/m3 for M-40-(15 % RHA Replacement)

Element	Quantity	Price/Kg	Total Price
Cement	414.51	Rs. 4.90	Rs. 2031.10
10mm	489.96	Rs. 0.745	Rs. 365.02
20mm	742.99	Rs. 0.745	Rs. 553.53
Crushed sand	703.63	Rs. 0.860	Rs. 605.12
Water	145.08	Rs. 1.00	Rs. 145.08
Admixture	4.14	Rs. 41.00	Rs. 169.74
Total cost			**Rs. 3,869.59**



VI. Conclusion

The present experimental study was designed to determine the influence of varying percentages of rice husk ash (RHA) as partial replacement of cement in making concrete mixes. For this, 10%, 15%, 20%, RHA was introduced in concrete mixes of theses mixes were compared with corresponding conventional concrete. Properties of concrete mixes such as workability, Compressive strength after 7, 14, 28days, Split Tensile and Flexural Strength for 28days the results of this experimental investigation have been analyzed and the major finding of this study is presented as follows:

- The use of RHA as replacement of cement reduced workability of the mix. This reduction in workability increased with increasing RHA percentages for M-20 grade and M-40 concrete reduction was 17.39% and 16.67% for 15% RHA replacement.
- 15% RHA replacement satisfied the criteria of target strength which is 26.6 N/mm2 48.25 N/mm2 for M-20 & M-40 grade concrete. It was 1.3% and 1.18% more than target strength which is 26.95 N/mm2 and 48.83 N/mm2.
- Split tensile strength and flexural strength was also satisfied the result with 15% RHA replacement with Cement.
- Rapid Chloride Penetration Test result satisfied for both the grade of concrete, chloride ion penetrability is in range of low, but with increase of RHA Charge passed (coulombs) also increase which is not good, so replacement of RHA should be stop at certain percentage.
- The cost analysis is prepared between conventional concrete and concrete prepared by using 15% RHA.
- The total cost for 1 Cum conventional concrete is estimated to Rs.3498.46/- for M-20 Grade Concrete and Rs.3869.59/- for M-40 Grade Concrete and cost for 1 Cum concrete prepared by using 15% RHA is estimated to Rs.3331.15/- for M-20 Grade Concrete and Rs.3664.39/- for M-40 Grade Concrete
- When the estimated cost of conventional concrete is compared with concrete prepared by using 15% RHA, the difference between in the cost is approximately equal to Rs.167.31 per Cum for M-20 Grade Concrete and Rs.205.19 per Cum for M-40 Grade Concrete.
- Therefore, on the basis of results the use upto15% RHA in concrete mixes can be recommended for practical application in various construction sectors.

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