# BEHAVIOR OF CEMENT-RICE HUSK ASH CONCRETE FOR PAVEMENT

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## ABSTRACT

Behavior of concrete for pavement by replacing different percentage of rise hush ash by weight of cement for a control mix of M40 grade concrete. To study the effect of rice husk ash (RHA) on the performance of various parameters of concrete so as to produce an economical concrete for rigid pavements. An attempt has been made to utilize the achieved flexural strength of concrete in the rigid pavement design which is greater than the required flexural strength as per IRC:58-2002.

Design results are verified with Finite Element Code ANSYS. A comparison is made between the cost of concrete pavement with use of RHA and normal concrete for a given soil and traffic condition.

**Key words:** Rice husk ash, Mineral Admixture, Rigid pavement, Pavement Analysis, Cost Effective Pavement

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## INTRODUCTION

Concrete is the most widely used construction material. Cement, sand, coarse aggregate and water are the main ingredients in concrete. The cost of concrete is reduced by replacing cement with pozzolanas [fly ash, silica fume, rice husk ash, metakaoline, and ground granulated blast furnace slag].

The present investigation is carried out to study the effect of rice husk ash (RHA) on the performance of various parameters of concrete so as to produce an economical concrete for rigid pavements. Partial replacement of cement with RHA gives equivalent flexural strength of concrete which is more important for concrete pavement.

The mechanical properties of concrete including impact and porosity are studied by partially replace different percentage of rise hush ash by weight of cement for a control mix of M40 grade concrete.

An attempt has been made to utilize the achieved flexural strength of concrete in the rigid pavement design which is greater than the required flexural strength as per IRC:58-2002. Design results are verified with Finite Element Code ANSYS. A comparison is made between the cost of concrete pavement with use of RHA and normal concrete for a given soil and traffic condition.

## RICE HUSK ASH

Rice husk ash (RHA) is produced by incinerating the husks of rice paddy. Controlled incineration of rice husks between 5000C and 8000C produces non-crystalline amorphous RHA. They have 90% to 95% amorphous silica. Due to high silica content, RHA possesses excellent pozzolanic activity. It has been found that RHA provides improvements in hardened properties   and durability of concrete. Moreover,    the expense of some concrete admixture such as silica fume and high reactivity metakaoline increases the overall material cost of concrete. Therefore, the use of less-expensive RHA is more desirable to decrease the overall production cost of concrete. The RHA particles are mostly in the size range of 4 to 75μm. The specific surface area RHA can be in the range of 50 to 100m$^2$/g.

## EXPERIMENTAL INVESTIGATION

Table 1: Mix Proportion

| Mix | Cement | sand | Coarse aggregate | Water |
|---|---|---|---|---|
| Ratio | 1 | 1.632 | 2.353 | 0.40 |
| Quantity | 442 Kg/m$^3$ | 734.9 Kg/m$^3$ | 1048.53Kg/m$^3$ | 176.5 Kg/m$^3$ |

## PERCENTAGE OF REPLACEMENT

Concrete for the pavement by replacing of rice hush ask with 0%,5%,10%,15%, 20% and 25%   by weight of cement for control mix of M40 Grade concrete.

## RESULTS AND DISCUSSIONS

## SLUMP TEST

The values of slump obtained by experimentally were tabulated below and it is found that the value of slump goes on decreases with incremental percentage of rice husk ash (RHA). As per IS: 456-2000 slump for pavement is low slump (Less than 25 mm). Slump test results are shown in Table 2.

Table 2: Slump test results

| MIX | Sl.NO | RHA Replacement | SLUMP VALUE (mm) |
|---|---|---|---|
| M40 | 1 | 0% | 71 |
|  | 2 | 5% | 33 |
|  | 3 | 10% | 18 |
|  | 4 | 15% | 5 |
|  | 5 | 20% | - |
|  | 6 | 25% | - |

## COMPACTION FACTOR TEST

The experiment test conducted on various percentage of rice husk ash (RHA) for concrete mix M40 to find compaction factor is tabulated below.   As per IS:456-2000 compacting factor for pavement is in range of 0.75 to 0.80. Compaction factor test results are shown in Table 3.

Table 3. Compaction factor test

| MIX | S.NO | RHA Replacement | COMPACTION FACTOR (%) |
|-----|------|-----------------|-----------------------|
| M40 | 1 | 0% | 0.874 |
|     | 2 | 5% | 0.853 |
|     | 3 | 10% | 0.762 |
|     | 4 | 15% | 0.743 |
|     | 5 | 20% | 0.708 |
|     | 6 | 25% | 0.709 |

## VEE-BEE  TEST

The values of Vee-Bee value obtained by experimentally were tabulated below and it is found that the value of Vee-Bee value goes on increases with incremental percentage of rice husk ash (RHA).  Vee bee test results are shown in Table 4

Table 4 : Vee bee test results

| MIX | S.NO | RHA Replacement | Vee-Bee Value (sec) |
|-----|------|-----------------|---------------------|
| M40 | 1 | 0% | 9 |
|     | 2 | 5% | 11 |
|     | 3 | 10% | 21 |
|     | 4 | 15% | 25 |
|     | 5 | 20% | Above 30 |
|     | 6 | 25% | Above 30 |

## COMPRESSIVE STRENGTH TEST

The compressive strength of concrete is one of the most important and useful properties of concrete. In most structural applications concrete is used primarily to resist compressive stress. The compressive strength of concrete cubes with 0%, 5%, 10%, 15%,

20% and 25% of replacement were determined and give table. Below table show the compressive strength for 7th day. Compressive strength test results are shown in Figure 1
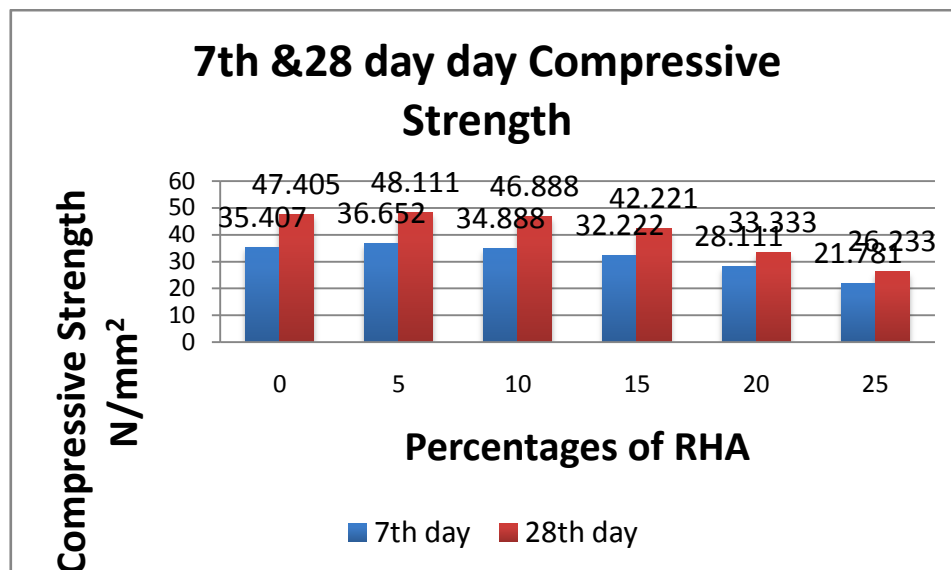


Fig 1: compressive strength test

## FLEXURAL STRENGTH OF CONCRETE

In this test, a plain concrete beam is subjected to flexure using symmetrical two point loading until failure occurs. Because the load point is placed at 1/3rd of the span, the test is also called as third point loading test. The theoretical maximum tensile stress reached in the bottom fiber of the test beam is called modulus of rupture. Flexural strength test are shown in Figure 2
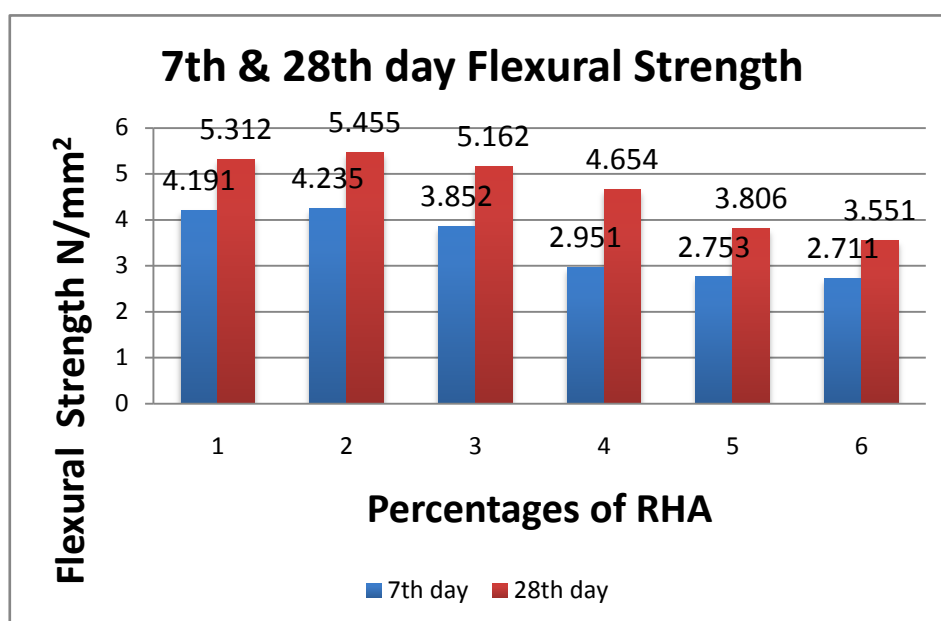


Fig 2: Flexural strength test

## SPLIT TENSILE STRENGTH

Results of 28th day Split tensile strength for different percentage of RHA.Split tensile strength decreases with the increases in RHA. Split tensile strength test are shown in Fig 3.
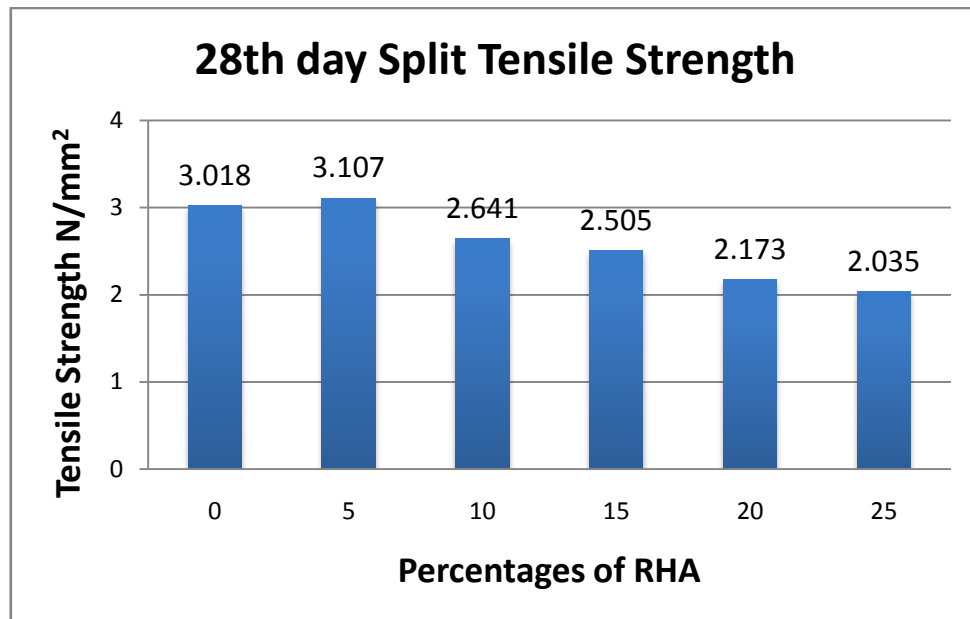
**28th day Split Tensile Strength**

| Percentages of RHA | Tensile Strength N/mm² |
|---|---|
| 0 | 3.018 |
| 5 | 3.107 |
| 10 | 2.641 |
| 15 | 2.505 |
| 20 | 2.173 |
| 25 | 2.035 |

Fig 3: Split tensile strength test

## MODULUS OF ELASTICITY

The value of strain corresponding to different stress for various percentages of RHA. Modulus of elasticity of concrete is shown in Table 5.

Table 5. Modulus of elasticity

| S.NO | RHA Replacement | Modulus of elasticity (N/mm$^2$) x 10$^4$ |
|---|---|---|
| 1 | 0% | 4.527 |
| 2 | 5% | 4.237 |
| 3 | 10% | 3.182 |
| 4 | 15% | 2.744 |
| 5 | 20% | 1.968 |
| 6 | 25% | 1.667 |

## POISSON'S RATIO

Poisson's ratio increases with the increases in RHA. Poisson's ratio test results are shown in Table 6.

Table 6. Poisson's ratio

| SL.NO | RHA Replacement | Poisson's ratio |
|-------|-----------------|-----------------|
| 1 | 0% | 0.160 |
| 2 | 5% | 0.177 |
| 3 | 10% | 0.186 |
| 4 | 15% | 0.201 |
| 5 | 20% | 0.244 |
| 6 | 25% | 0.256 |

## POROSITY TEST

The porosity test shown the void ratio is reduced up to 10% replacement, and voids increases in future increment of RHA. Percentage of RHA Vs 28th day Porosity test results is shown in figure 4.
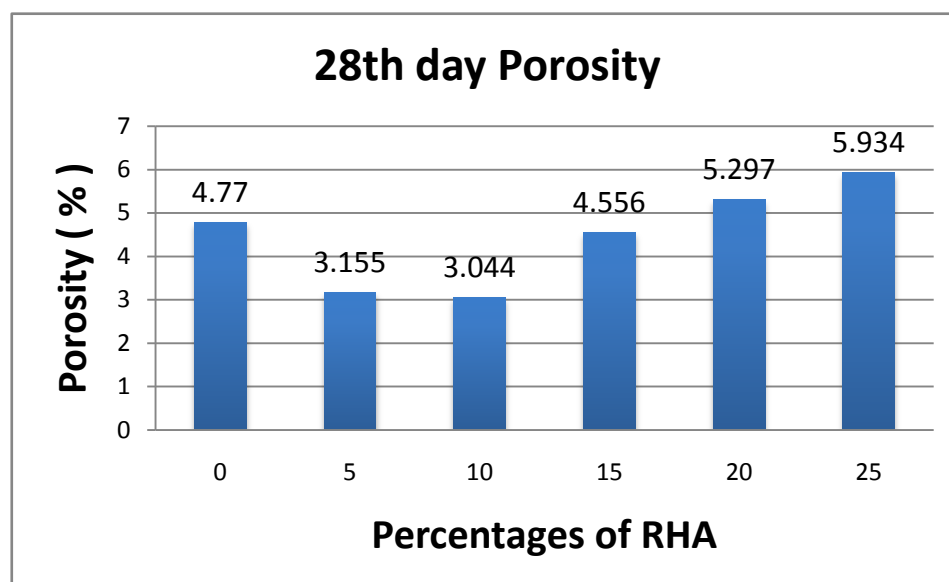


Fig 4: Percentage of RHA Vs 28th day Porosity

## IMPACT STRENGTH

Impact strength decreases with the increases in RHA. Percentage of RHA Vs 28th day impact strength test results are shown in figure.5
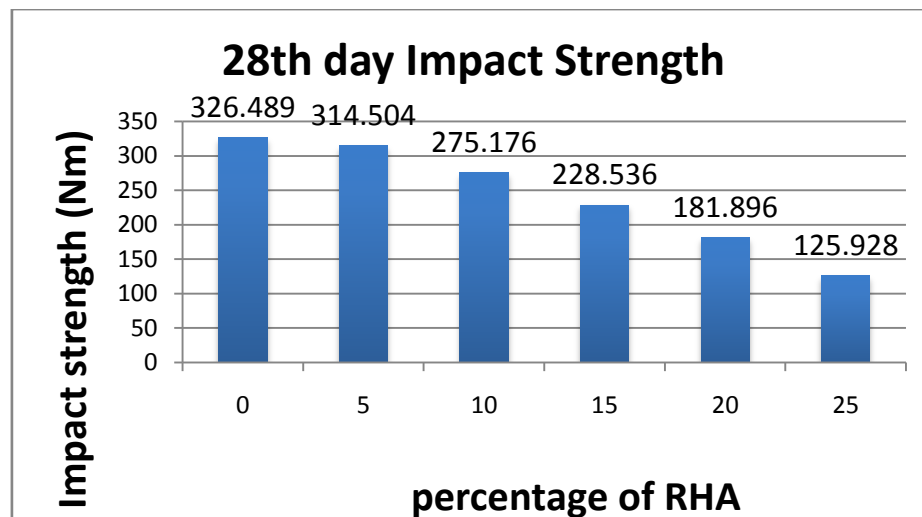
Fig 5: Percentage of RHA Vs 28th day impact strength

## PAVEMENT DESIGN AS PER IRC: 58-2002

Results from experiments (0% RHA)
Flexural strength     = 53.12 kg/cm2
Elastic modulus       = 4.527 x 105 kg/cm2  .
Poisson's ratio        = 0.16
Trial thickness          = 32 cm
Modulus of sub grade = 8 kg/cm3
Load safety factor        = 1.2
Design of pavement slab results are shown in Table 6.The design is safe since cumulative fatigue life consumed should be less than 1.0

Table 7. Design of pavement slab

| Axle load(AL), tonnes | AL x 1.2 | Stress kg/cm$^2$ from chart | Stress ratio | Expected repetition | Fatigue life, N | Fatigue life consumed |
|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7=5/6 |
| Single axle | | | | | | |
| 20<br>18 | 24.0<br>21.6 | 25.19<br>22.98 | 0.47<br>0.43 | 71127<br>177820 | 5.202 x 10$^6$<br>Infinite | 0.01<br>0.00 |
| Tandem axle | | | | | | |
| 36 | 43.2 | 20.07 | 0.37 | 35564 | Infinite | 0.00 |

## CHECK FOR TEMPERATURE STRESSES

Total of temperature warping stress and the highest axle load stress    = 45.3 kg/cm$^2$ Which is less than 53.12kg/cm$^{2,\text{ the}}$ flexural strength. So the pavement thickness of 32cm is safe under the combined action of wheel load and temperature.

## CHECK FOR CORNER STRESSES

Corner stress = 17.149 kg/cm2
    The corner stress is less than the flexural strength of the concrete, i.e., 53.12kg/cm2 and the pavement thickness of 32cm assumed is safe.
    For 5% RHA Replacement pavement thickness of 32cm is safe.
    For 10% RHA Replacement pavement thickness of 32cm is safe.

## ANALYTICAL INVESTIGATION ON CONCRETE PAVEMENT USING ANSYS 10.0 CODE.

From the two figures, the vertical displacement is maximum at the load position. The top surface of the concrete pavement has been subjected to a maximum displacement value of 65 mm. Displacement of concrete pavement slab are shown in  Fig 7.
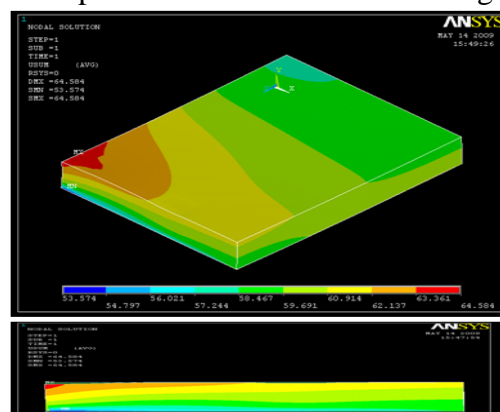


Fig 6: Displacement of concrete pavement.

From the two figures, the contour plot of strain distribution has been demonstrated for a single axle load of concrete pavements. It is inferred that the maximum strain occurs at the bottom surface of sub base materials.  Hence to design any sub base for laying concrete pavements needs to be properly designed with good quality material. Strain of concrete pavement are shown in Fig 8.
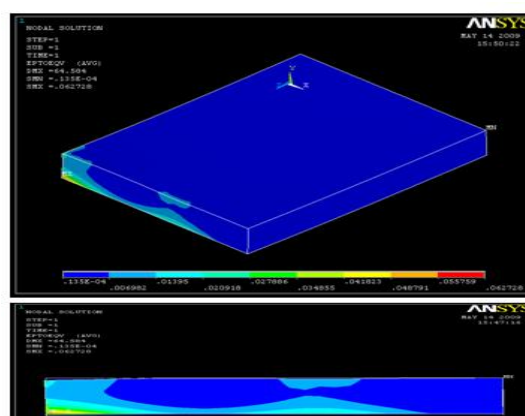


Fig 7: Strain of concrete pavement.

From the two figures shows the contour plot of stress distribution for concrete pavement. From figures, stress distribution along the bottom surface of the sub base material is maximum. Stress of concrete pavement are shown in Fig 9.
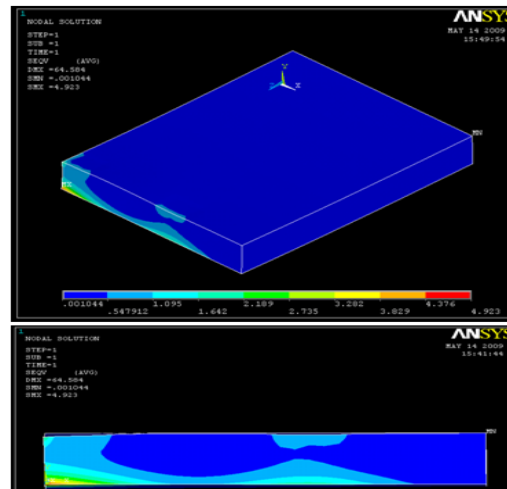


Fig 8: Stress of concrete pavement.

## COST ANALYSIS

Cost of materials for one square meter of pavement of even thickness 32cm.cost comparison is shown in Table 8.

Table 8. Cost Reduction of materials

| RHA Replacement | CEMENT (kg) | RHA (kg) | FINE AGGREGATE (kg) | COARSE AGGREGATE (kg) | WATER (lit) |
|---|---|---|---|---|---|
| 0% | 141.44 | - | 235.2 | 335.5 | 56.57 |
| 5% | 134.36 | 7.07 | 235.2 | 335.5 | 56.57 |
| 10% | 127.3 | 14.14 | 235.2 | 335.5 | 56.57 |

## CONCLUSIONS

1. The compressive strength decreases with the increases in percentage of rice husk ash (RHA).For 10% replacement, the reduction is very less when compare to 20%, and 30% replacement.
2. The flexural strength of the cement-RHA concrete very less reduction in 5% & 10% of replacement.
3. The porosity test shown the void ratio is reduced up to 10% replacement, and voids increases in future increment of RHA.
4. The split tensile strength, impact strength also decreases with the increases in percentage of rice husk ash (RHA).

5.  The Modulus of elasticity decreases with the increases in percentage of rice husk ash.
6.  The Poisson's ratio increases with the increases in percentage of rice husk ash.
7.  The pavement design due to achieved flexural strength of cement-RHA concrete. And cost reductions for 10%RHA are 7.55% respectively are calculated.
8.  Analysis the stress distribution for concrete pavement using Finite Element Code ANSYS.

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