*International Journal on Emerging Technologies* **6**(1): 144-150(2015)

**ISSN No. (Print) : 0975-8364**
**ISSN No. (Online) : 2249-3255**

# Effect of Rice Husk on Compressive Strength of Concrete

***Naveen*, Sumit Bansal** and Yogender Antil******
**M. Tech. Scholar, Department of Civil Engineering. GIET, Sonipat, (HR), INDIA*
***Assistant Professor Department of Civil Engineering. GIET, Sonipat, (HR), INDIA*
****Assistant Professor Department of Civil Engineering. GIET, Sonipat, (HR), INDIA*

*(Corresponding author: Naveen)*
*(Received 04 May, 2015 Accepted 04 June, 2015)*
*(Published by Research Trend, Website: www.researchtrend.net)*

**ABSTRACT: During last few decades requirement of high performance and highly durable concrete has been on rise. Concrete is no longer made of aggregates, Portland cement and water only. Often, if not always it has to incorporate at least one of the additional ingredients such as admixtures, supplementary cementious material or fibers to enhance its strength and durability. The use of mineral admixture in combination with chemical admixture has allowed the concrete technologists to tailor the concrete for many specific requirements. Amongst the mineral admixture, silica fume, because of its finely divided state and very high percentage of amorphous silica, proved to be most useful, if not essential for the development of very high strength concretes and concrete of very high durability i.e. high performance concrete. Therefore it is being used on a worldwide scale in concrete, for the making of high performance concrete. In spite of its numerous advantages silica fume suffers from one major disadvantage that it is imported therefore, very costly. In this work an attempt has made to find a suitable alternate of rice husk ash. The objective of research paper to analysis the M-30 and M-60 grade concrete and find what effect on compressive strength of concrete at 7 days and 28 days. Replacement of cement by rice husk ash showed in M30 grade concrete compressive strength improvement up to the replacement of 10% in all ages. Both concrete mixes at 10% rice husk ash level showed 3 to 10% increase in compressive strength. Rice husk ash levels of 15 to 20% showed reduction in compressive strength in all ages.**

**Keywords:** Rice Husk, Strength of Concrete, Portland cement,

## I. INTRODUCTION

Concrete has continuously posed challenges to architects, engineers, researchers and constructors all these years. While trying to improve certain properties of concrete, the other properties have suffered, hence maintaining a perfect balance between the various requirements of concrete happens to be the key to successfully use this wonderful material in emerging India. India is fastest growing economy among all developing nation. So replacement of ordinary Portland cement by pozzolana Portland cement is more efficient in terms of economy in mass construction. Replacement of pozzolana Portland cement by mineral admixtures (slag, silica fume) shows more efficiency in terms of both economy & strength. Industrialization in developing countries has resulted in an increase in agricultural output and consequent accumulation of unmanageable agro wastes. Pollution arising from wastes is a cause of concern for many developing nations such as India, Nigeria. Recycling of such waste into new building materials could be a viable solution not only to the pollution problem, but also to the problem of the high cost of building materials currently facing these nations. Using sawdust ash (SDA) instead of sawdust in its natural form may lead to a cheaper concrete. Rice husk constitute about $1/5^{th}$ of the 300 million metric tons of rice produced annually in the world. Rice husk ash is obtained from agricultural waste rice husk. Controlled burning of rice husk between 500 and 600°C for short duration of about 2hrs yields ash with low un-burnt carbon and anamorphous silica. When rice husk is burnt in an uncontrolled manner, the ash, which is essentially silica, is converted to crystalline forms and is less reactive. Both the crystalline and amorphous rice husk ash is used to manufacture a lime- rice husk ash mix or a Portland rice husk ash cement or the rice husk ash can be used as a Portland cement replacement in concrete. Research in India and the United States has found that if the hulls or straw are burned at a controlled low temperature, the ash collected can be ground to produce a pozzolan very similar to (and in some ways superior to) silica fume and heat produced during burning can beneficially used in power production, by doing so not only crop waste can effectively disposed, but also can generate electricity for the area, and provide high quality cement.

There are two well -known methods for producing rice husk ash, fluidized bed technology which is practiced in U.S and second method is torbed reactor which was developed recently developed in Egypt, it is found that the rice husk ash produced by the torbed technology is superior than fluidized bed technology. The characteristics of the typical rice husk produce in India has organic amorphous silica (made of rice husk ash) with silica content of above 85%, in very small particle size of less than 25 microns, which is used for making green concrete, high performance concrete, refectories, insulators, flame retardants etc. Mauro observed that, when rice husk ash is added to concrete there was 38.7% decrease in water absorption and 25% of increment in compressive strength was obtained when 5% of rice husk ash was added to ordinary Portland cement. Dass and other several investigators have examined the characteristics and properties of rice husk ash as; the Blaine air fineness is around 400 to 600 $m^2$/kg and its specific gravity is around 2.3. The presence of silica in RHA was known since 1938 and an extensive literature search highlighted many uses of RHA as silica replacement. Two main industrial uses were identified: as an insulator in the steel industry and as a pozzolan in the cement industry. RHA is used by the steel industry in the production of high-quality flat steel. Moreover, RHA is an excellent insulator, having low thermal conductivity, high melting point, low bulk density, and high porosity. It is this insulating property that makes it an excellent "tundish powder" that prevents rapid cooling of the steel and ensures uniform solidification in the continuous casting process. In addition, substantial research was carried out on its use in the manufacture of concrete. In particular, there are two areas for which RHA is used: in the manufacture of low cost building blocks and in the production of high quality cement. The addition of RHA to cement enhances the cement properties. Addition of RHA to Portland cement not only improves the early strength of concrete, but also leads to the formation of a calcium silicate hydrate gel around the cement particles, which becomes highly dense and less porous. This may increase the strength of concrete against cracking. In general, concrete made with Portland cement containing RHA has a higher compressive strength.

Burning of rice husk at different temperatures produces different kinds of ashes. Once the rice husk is burned without releasing $CO_2$ in the atmosphere the end product is rice husk ash. It has many industrial uses. The company uses a patented technology to purify the silica content of the ash up to 99%. The impurities are metallic salts which can be processed as fertilizers in rice production. The purified $SiO_2$ can be processed further to produce Silicon crystals for the production of microchips and solar cells or photovoltaic panels.

## II. MATERIAL AND METHODS

The various material used in the experimental work were cement, fine aggregate, coarse aggregate, mineral admixtures, (namely rice husk ash) superplasticizer and water.

The cement used in this research work was ordinary Portland cement of 53 grade. Cement was tested for its suitability according to IS 12269:1999. The various properties of the cement are shown in Table 1. Sand used, as a fine aggregate in this experimental study was land quarried and locally known as Koilwar, generally used in and around Patna. The sieve analysis of fine aggregate is shown in Table 2. The sand used in this experiment falls in Grading zone 2, as per IS: 83:1970.

## III. OBSERVATION

**Table 1: Properties of cement.**

| Test Parameter | Value | Permissible Range As per IS:12269:1999 |
|---|---|---|
| Specific Gravity | 3.15 | 3.10-3.15 |
| Blaine Fineness ($m^2$/Kg) | 307 | 225 |
| Normal Consistency (%) | 32 | 30-35 |
| Initial setting time (min) | 62 | 30 |
| Final setting time (min) | 260 | 600 |
| Soundness of cement (Le Chatelier expansion value in mm) | 2 | 10 |
| Compressive Strength (MPa) | | |
| 7 days | 37 | |
| 28 days | 58 | 53 |

**Table 2: Sieve analysis of fine aggregate and Zones as per IS:383-1970.**

| Sieve Size (mm) | Passing (%) | (%) Passing Zones as per IS:383-1970 | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| 10 | 100 | 100 | 100 | 100 |
| 4.75 | 98.5 | 90-100 | 90-100 | 90-100 |
| 2.36 | 95.5 | 60-95 | 75-100 | 85-100 |
| 1.18 | 87.5 | 30-70 | 55-90 | 75-100 |
| 0.600 | 54 | 15-34 | 35-59 | 60-79 |
| 0.300 | 8 | 5-20 | 8-30 | 12-40 |
| 0.150 | 3.75 | 0-10 | 0-10 | 0-10 |

**Table 3: Properties of fine aggregate.**

| Properties | Values |
|---|---|
| Fineness Modulus | 2.5 |
| Specific Gravity | 2.66 |
| Bulk Density (kg/m$^3$) | 1614 |

Graded crushed stone aggregate with maximum nominal size of 20mm and down was used a coarse aggregate. Type of coarse aggregate was used to have better gradation and higher density of the mix. The sieve analysis data for coarse aggregate is shown. The various properties of coarse aggregates are given in Table.

**Table 4: Sieve analysis of coarse aggregate.**

| Sieve Size (mm) | Percent Passing (20mm and down) |
|---|---|
| 20 | 100 |
| 12.5 | 95 |
| 10 | 86 |
| 4.75 | 18 |
| 2.36 | 4.5 |

Rice husk ash is obtained from agricultural waste of rice husk. Rice husk used in the experimental study is obtained from a M/S Prakash Rice mill Danapur, Bihar and its specific gravity is 2.06. Bulk density of rice husk ash used was 718 kg/m$^3$. The particles of rice husk ash used were finer than 45 m.Various properties of Rice husk ash are given in Table 6. Potable water was used in the experiment, whose Ph value is greater than 6.

**Table 5: Properties of coarse aggregate.**

| Properties | Values |
|---|---|
| Fineness Modulus | 6.7 |
| Specific Gravity | 2.68 |
| Water Absorption (%) | 0.4 |
| Bulk Density (kg/m$^3$) | 1810 |

**Table 6: Properties of Rice husk ash.**

| Parameters | Values |
|---|---|
| Silicon dioxide ($SiO_2$) | 87.20% |
| Aluminium oxide ($Al_2O_3$) | 0.15% |
| Ferric oxide ($Fe_2O_3$) | 0.16% |
| Calcium oxide (CaO) | 0.55% |
| Magnesium oxide (MgO) | 0.35% |
| Sulphur trioxide ($SO_3$) | 0.24% |
| Carbon (C) | 5.91% |
| Loss on Ignition | 5.44% |
| Fineness passing 45 micron | 96% |
| Mineralogy | Non crystalline |
| Shape | Irregular |

The proportions of various mixes are given. Water/cementious material ratio is kept around 0.43 and 0.35. M30 M60 grades concrete are used throughout the experimental study. A total of 10 concrete mixes were used for this study. Concrete mixes were made with 5%, 10%, 15% and 20% replacement of cement with rice husk ash. The details of the mix proportions are given in Table 7.

**Table 7: Mix Proportions for M30 grade concrete Mixtures.**

| Mix Designations | BC | BR1 | BR2 | BR3 | BR4 |
|---|---|---|---|---|---|
| Rice Husk Ash Present (%) | 0 | 5 | 10 | 15 | 20 |
| w/c ratio | 0.43 | 0.43 | 0.43 | 0.43 | 0.43 |
| Cement (Kg/m$^3$) | 420 | 399 | 378 | 357 | 336 |
| Rice Husk Ash (Kg/m$^3$) | 0 | 21 | 42 | 63 | 84 |
| Sand (Kg/m$^3$) | 621.60 | 582.18 | 542.88 | 503.59 | 464.29 |
| Coarse Aggregate (Kg/m$^3$) | 1108.80 | 1108.80 | 1108.80 | 1108.80 | 1108.80 |
| Water (lit/m$^3$) | 180.60 | 180.60 | 180.60 | 180.60 | 180.60 |

**Table 8: Mix Proportions for M60 grade concrete Mixtures.**

| **Mix Designations** | **CC** | **CR1** | **CR2** | **CR3** | **CR4** |
|---|---|---|---|---|---|
| Rice Husk Ash Present (%) | 0 | 5 | 10 | 15 | 20 |
| w/c ratio | 0.35 | 0.35 | 0.35 | 0.35 | 0.35 |
| Cement (Kg/$m^3$) | 474 | 450.3 | 426.6 | 402.9 | 379.2 |
| Rice Husk Ash (Kg/$m^3$) | 0 | 23.7 | 47.4 | 71.1 | 94.8 |
| Sand (Kg/$m^3$) | 636 | 585.10 | 535.61 | 483.21 | 433.72 |
| Coarse Aggregate (Kg/$m^3$) | 1113 | 1113 | 1113 | 1113 | 1113 |
| Water (lit/$m^3$) | 166 | 166 | 166 | 166 | 166 |

Concrete specimens are prepared by proper mixing of ingredients in proportions as mentioned in Table 10 and Table 11. First of all small amount of water is poured into tilting drum mixer then coarse aggregate, fine aggregate, cement and mineral admixture are fed, thereafter the ingredients are mixed dry in the mixer for about 30 seconds, then water was added and mixing was continued till the concrete attained the uniform colour and consistency, then mixer was stopped for about two minutes. Slump was measured. Then compaction factor test was conducted. Specimens were compacted by placing them on the vibrating table. Density and temperature were measured subsequently. Total numbers and types of specimen cast for each mix are given in Table 12. The Compression Test had been carried out at different ages of 7 and 28 days. Splitting Tensile Test had been carried out at ages of 7 and 28 days. Flexural strength Test is conducted at age of 28 days.

**Table 9: Number of Specimens.**

| Specimen Type | Number |
|---|---|
| Cubes 150X150X150mm | 60 |
| Cylinders 150X300mm | 30 |
| Beams 150X150X500mm | 20 |

After 24 hours of casting, specimens were de-moulded and marked and immediately submerged in the curing tank of fresh water. They were cured continuously in water tank till testing. Compressive strength test is most important one, as concrete is primarily meant to withstand compressive stresses. Three cubes of 150mm size are cast for testing at each selected age i.e. 7day, and 28days.

Direct compressive load is applied without shock and increased continuously at rate of 140 kg/$cm^2$/min (31.5t/min) until the resistance of specimen to the increasing load breaks down and no greater load was sustained, as shown in Fig. 6. The Failure load for each of the specimen was noted. Average of three specimens at each age of testing was taken as the representative compressive strength of the concrete.

**Fig. 6. Compressive strength test.**

## RESULTS AND DISCUSSIONS

This results of various test conducted on both fresh as well as hardened concrete. Relationship developed between percentage of rice husk ash added, compressive strength of different mixes. The tests for compressive strength of concrete were conducted for different concrete mixes i.e. M30 and M60 grade with different rice hush ash content i.e. 0%, 5%, 10%, 15% and 20% at the selected age i.e. 7 days and 28days. The results are complied in the Table 10 and Table 11 given below.

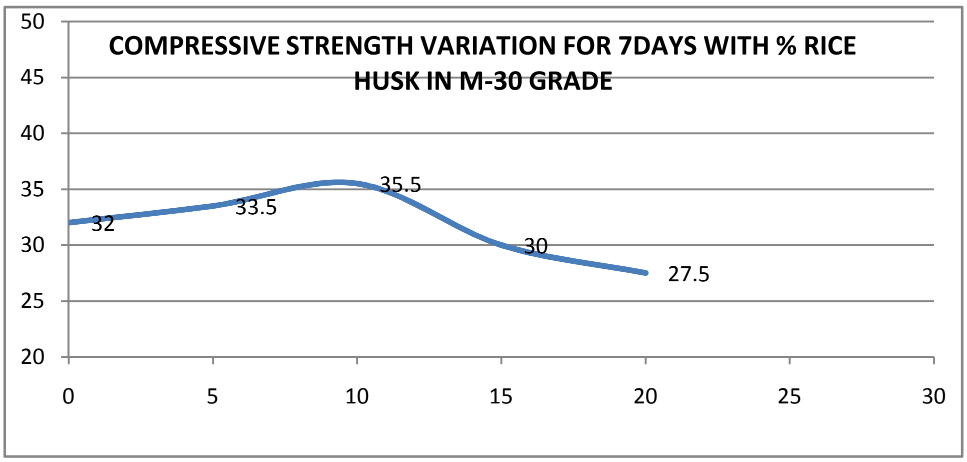
**Table 10: Compressive Strength of M30 Grade RHA Concrete.**

| **S.No.** | **Mix designation** | **RHA content (%)** | **Compressive Strength in MPa for** | |
|---|---|---|---|---|
| | | | **7 days** | **28 days** |
| 1. | BC | 0% | 32 | 44.5 |
| 2. | BR1 | 5% | 33.5 | 46 |
| 3. | BR2 | 10% | 35.5 | 47.5 |
| 4. | BR3 | 15% | 30 | 38.5 |
| 5. | BR4 | 20% | 27.5 | 36.5 |

**Table 11: Compressive Strength of M60 Grade RHA Concrete.**

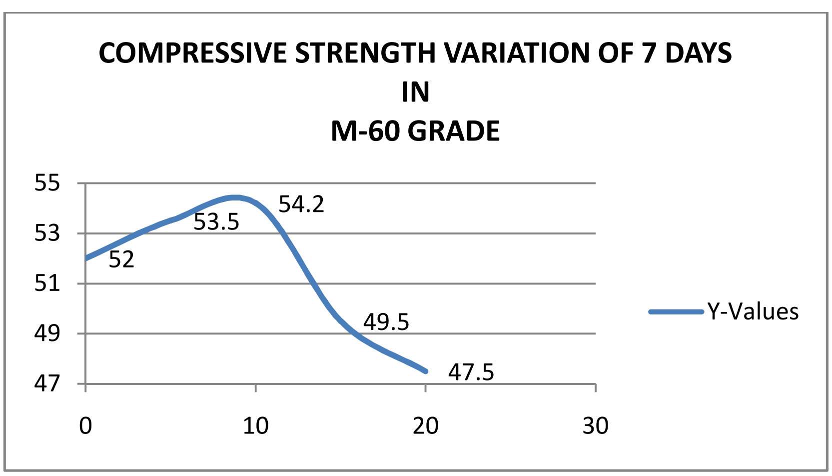
| S.No. | Mix designation | RHA content (%) | Compressive Strength in MPa for | |
|---|---|---|---|---|
| | | | 7 days | 28 days |
| 1. | CC | 0% | 52 | 61.5 |
| 2. | CR1 | 5% | 53.5 | 64.5 |
| 3. | CR2 | 10% | 54.2 | 65.5 |
| 4. | CR3 | 15% | 49.5 | 62 |
| 5. | CR4 | 20% | 47.5 | 58 |

Graphical representation gives a clear picture of the increase or decrease in Compressive strength and Flexural strength with different percentages of rice husk ash. Graphs were plotted between percentage of rice husk ash added (i.e. 0%, 5%, 10%, 15% and 20%) and Compressive Strength for ages of 7 days and 28 days. Similarly, Graphs were plotted between percentage of rice husk ash added and Flexural Strength.



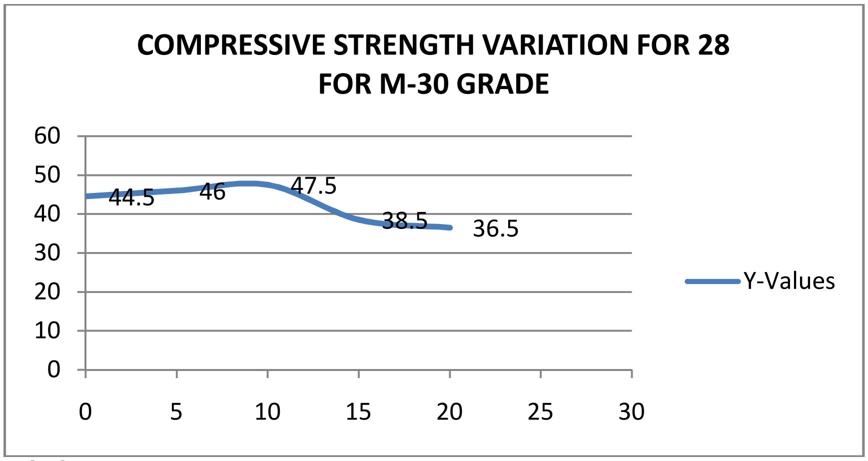

X-axis represent- % Rice husk
Y axis represent- compressive strength variation for 7 days in MPA for M-30

**Graph 1: Compressive Strength Variation for 7days for M-30 Grade.**



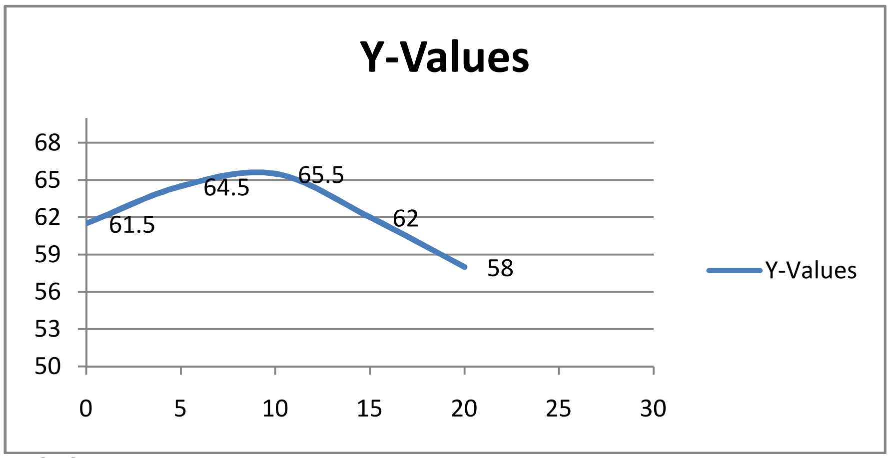

X-axis represent- % Rice husk, Y axis represent- compressive strength variation for 7 days in MPA for M-60

**Graph 2: Compressive Strength Variation of 7 Days for M-60 Grade.**




X-axis represent- % Rice husk
Y axis represent- compressive strength variation for 28 days in MPA for M-30

**Graph 3: Compressive Strength Variation for 28 for M-30 Grade.**




X-axis represent- % Rice husk
Y axis represent- compressive strength variation for 28 days in MPA for M-60

**Graph 4: Compressive Strength Variation for 28 Days for M60 Grade.**

**Table 12: Change in Compressive strength of M30 Grade of Concrete compared with Control Concrete in respective ages.**

| S.No. | Mix designation | RHA content(%) | Change in Compressive Strength | |
|---|---|---|---|---|
| | | | **7 days** | **28 days** |
| 1. | BC | 0% | - | - |
| 2. | BR1 | 5% | 33.5 (Increased by 4.68 times) | 46 (Increased by 3.37 times) |
| 3. | BR2 | 10% | 35.5 (Increased by 10.93 times) | 47.5 (Increased by 6.74 times) |
| 4. | BR3 | 15% | 30 (Decreased by 6.25 times) | 38.5 (Decreased by 13.48 times) |
| 5. | BR4 | 20% | 27.5 (Decreased by 14.06 times) | 36.5 (Decreased by 17.97 times) |

**Table 13: Change in Compressive strength of M60 Grade of Concrete compared with Control Concrete in respective ages.**

| S.No. | Mix designation | RHA content (%) | Change in Compressive Strength | |
|---|---|---|---|---|
| | | | 7 days | 28 days |
| 1. | CC | 0% | - | - |
| 2. | CR1 | 5% | 53.5 (Increased by 2.88 times) | 64.5 (Increased by 4.87 times) |
| 3. | CR2 | 10% | 54.2 (Increased by 4.23 times) | 65.5 (Increased by 6.50 times) |
| 4. | CR3 | 15% | 49.5 (Decreased by 4.80 times) | 62 (Increased by 0.8 times) |
| 5. | CR4 | 20% | 47.5 (Decreased by 8.65 times) | 58 (Decreased by 5.69 times) |

## CONCLUSIONS

**Effect of Rice Husk Ash on Compressive Strength.** Replacement of cement by rice husk ash showed in M30 grade concrete compressive strength improvement up to the replacement of 10% in all ages. Both concrete mixes at 10% rice husk ash level showed 3 to 10% increase in compressive strength. Rice husk ash levels of 15 to 20% showed reduction in compressive strength in all ages.

The numerous tests performed to check the performance of rice husk ash as a cement replacement material can be concluded by the following points:

(i) There was a significant improvement in Compressive strength of the Concrete with rice husk ash content of 10% for different grades namely M30 and M60 and at different ages i.e. 7 days and 28 days.

(ii) The increase in Compressive strength was of the order of 4.23% to 10.93% for different grades and at different ages.

## FUTURE SCOPE

Further research is needed to establish the long-term durability of concrete containing mineral admixtures. The microstructure properties of concrete are needed to be further researched. Other innovative low cost locally available materials that can be used, as mineral admixtures are required to be developed. Other levels of replacement of cement can be researched. Some tests relating to durability aspect such as water permeability, resistance to the penetration of Chloride ions, corrosion of steel reinforcement, resistance to Sulphate attack, durability in marine environment etc. needs investigation.

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