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# Conservation of Environment by using Fly Ash and Rice Husk Ash as a Partial Cement Replacement in Concrete

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**Abstract—***Concrete is the most widely used man-made construction material in the world. Its importance is increasing every day. Cement is the primary ingredient in concrete, which in turn forms the foundations and structures of the buildings we live and work in, and the roads and bridges we drive on. Concrete is the second most consumed substance on Earth after water. On average, each year, three tons of concrete are consumed by every person on the planet (Madeleine Rubenstein, 2012). Cement production is a significant source of global carbon dioxide ($CO_2$) emissions, making up approximately 2.4 percent of global $CO_2$ emissions from industrial and energy sources (Marland et al., 1989) which contributes to global warming. In order to reduce the effect of global warming, the emission of $CO_2$ into the environment has to be reduced. Alternatively, if we manage to reduce the amount of cement production, then the impact of global warming can be minimized. In this paper, we have attempted to reduce the amount of cement by replacing it with fly ash and rice husk ash as a construction material.*

**Keywords:** *Concrete, Cement, Fly ash, Rice Husk Ash, Global Warming*

## 1. INTRODUCTION

Concrete is the most widely used man made construction material in the world, and is second only to water as the most utilized substance on the planet. The importance of concrete is increasing every day. It is obtained by mixing cement, water, fine aggregates (sand) and coarse aggregates (stones) in required proportions. The mixture when placed in forms and allowed to cure, hardens and forms a rock like mass known as concrete. Cement is the primary ingredient in concrete, which in turn forms the foundations and structures of the buildings we live and work in, and the roads and bridges we drive on. In the cement plant, the various raw materials of cement like limestone, clay, shells etc. are fed into the rotary kiln where these raw materials are burnt to a very high temperature of 1450°C. On burning, these raw materials forms very complex compounds which we called clinker. These clinkers are then cooled and ground to the required fineness to form a powdery substance known as cement. During the manufacture of cement in the cement plant large amount of carbon dioxide ($CO_2$) are released into the environment. This carbon dioxide ($CO_2$) is basically a byproduct of a chemical conversion process used in the production of clinker in which limestone ($CaCO_3$) is converted to lime (CaO).

$$CaCO_3 \rightarrow CaO + CO_2$$

According to Marland et al., 1989, during cement production about 2.4% of global $CO_2$ is released into the environment which is causing a serious problem leading to global warming and greenhouse effect.In order to reduce the effect of global warming, the emission of $CO_2$ into the environment has to be reduced. Alternatively, if we manage to reduce the amount of cement production, then the impact of global warming can be minimized.

Fly Ash and Rice Husk Ash (RHA) can be used as a partial replacement of cement in concrete. Electricity is the key for development of any country. Coal is a major source of fuel for production of electricity in many countries in the world. In the process of electricity generation large quantity of fly ash gets produced and becomes available as a byproduct of coal-based power stations. It is a fine powder resulting from the combustion of powdered coal - transported by the flue gases of the boiler and collected in the Electrostatic Precipitators (ESP). Rice husk ash (RHA) is obtained by burning rice husk in a controlled manner without causing environmental pollution. It is a by-product of agricultural industry. Fly Ash and Rice Husk Ash are *pozzolanic* materials. A pozzolanic material is essentially a silicious(containing $SiO_2$) and aluminous (containing $Al_2O_3$) material which possesses no cementitious properties. This pozzolanic material in finely divided form and in the presence of water react with calcium hydroxide, liberated in the hydration process to form compounds possessing cementitious properties. If we use Fly Ash and Rice Husk Ash (RHA) as a partial replacement of cement in concrete as a construction material, the release of carbon dioxide into the environment from cement production can be reduced. Moreover, the cost of concrete construction can also be reduced to a great extent.

## 2. METHODOLOGY

The methodology involves the collection of Fly Ash and Rice Husk Ash (RHA) from Coke Industry situated near IIT Guwahati and Rice Mill situated near LokhraChariali respectively.

Fly Ash and Rice Husk Ash (RHA) are collected and a concrete mix is prepared with 5%, 10%, 15% and 20% cement replacement. The desired quantity of materials for M20 grade are taken and they are mixed in the proportion of 1:1.5:3 (cement:sand:aggregate).The materials used for making the concrete mix are given in Table 1 and Table 2.

**Table 1: Mix Proportion of Concrete for Fly Ash**

| Mix Proportions of Concrete | | | | | |
|---|---|---|---|---|---|
| | Fly Ash | Cement | Aggregate | | Water |
| | | | Fine | Coarse | |
| Normal Concrete | 0 | 1.875Kg | 2.812Kg | 5.625Kg | 0.937L |
| 5 % Fly Ash | 0.094Kg | 1.781Kg | 2.812Kg | 5.625Kg | 0.937L |
| 10 % Fly Ash | 0.187Kg | 1.688Kg | 2.812Kg | 5.625Kg | 0.937L |
| 15 % Fly Ash | 0.281Kg | 1.594Kg | 2.812Kg | 5.625Kg | 0.937L |
| 20 % Fly Ash | 0.375Kg | 1.500Kg | 2.812Kg | 5.625Kg | 0.937L |

**Table 2: Mix Proportion of Concrete for Rice Husk Ash**

| Mix Proportions of Concrete | | | | | |
|---|---|---|---|---|---|
| | RHA | Cement | Aggregate | | Water |
| | | | Fine | Coarse | |
| Normal Concrete | 0 | 1.875Kg | 2.812Kg | 5.625Kg | 0.937L |
| 5 % RHA | 0.094Kg | 1.781Kg | 2.812Kg | 5.625Kg | 0.937L |
| 10 % RHA | 0.187Kg | 1.688Kg | 2.812Kg | 5.625Kg | 0.937L |
| 15 % RHA | 0.281Kg | 1.594Kg | 2.812Kg | 5.625Kg | 0.937L |
| 20 % RHA | 0.375Kg | 1.500Kg | 2.812Kg | 5.625Kg | 0.937L |

After mixing in the required proportions, the mixture is then poured into a cubical metal mould of 150mm x150mm x 150mm. After 24 hours, the concrete cube is removed from the metal mould and kept in the water tank for curing. The concrete cube is then transferred to the Compressive Testing Machine (CTM) for determining the strength. Following the above procedure 10 moulds are casted and they are tested for 7 days, 14 days and 28 days.

## 3. RESULTS AND DISCUSSIONS

The average test results for the various concrete cubes for 7 days, 14 days and 28 days are given in Table 3 and Table 4.

**Table 3: Compressive Strength of Concrete with Fly Ash**

| Compressive Strength of Concrete with Fly Ash ($N/mm^2$) | | | | | |
|---|---|---|---|---|---|
| | Normal Concrete | 5% Fly Ash | 10% Fly Ash | 15% Fly Ash | 20% Fly Ash |
| 7 days | 16.08 | 17.38 | 18.84 | 19.86 | 22.78 |
| 14 days | 20.63 | 22.75 | 23.88 | 25.09 | 29.24 |
| 28 days | 24.25 | 25.56 | 26.87 | 28.56 | 33.23 |

**Table 4: Compressive Strength of Concrete with Rice Husk Ash (RHA)**

| Compressive Strength of Concrete with Rice Husk Ash (RHA) ($N/mm^2$) | | | | | |
|---|---|---|---|---|---|
| | Normal Concrete | 5% RHA | 10% RHA | 15% RHA | 20% RHA |
| 7 days | 16.08 | 17.27 | 17.56 | 18.72 | 20.33 |
| 14 days | 20.63 | 21.22 | 22.17 | 23.28 | 25.43 |
| 28 days | 24.25 | 24.77 | 25.88 | 27.25 | 29.48 |

A comparison is made between the strength of normal concrete and the strength of Fly Ash and Rice Husk Ash (RHA). It is found that on increasing the percentage of Fly Ash and Rice Husk Ash (RHA), the strength of the concrete goes on increasing. This is evident from the graphsgiven below.

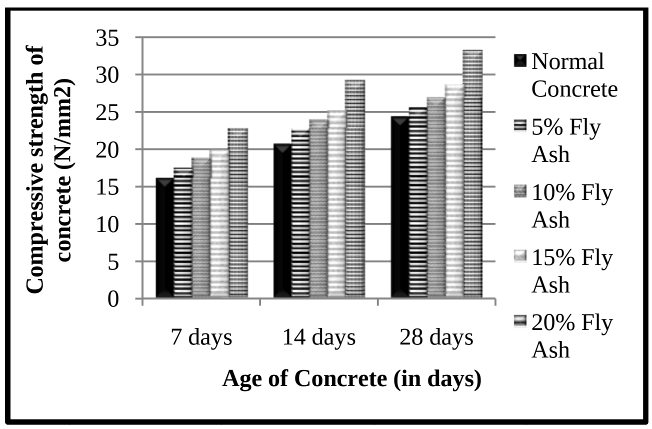


**Fig. 1: Comparison between Normal Concrete and Fly Ash**

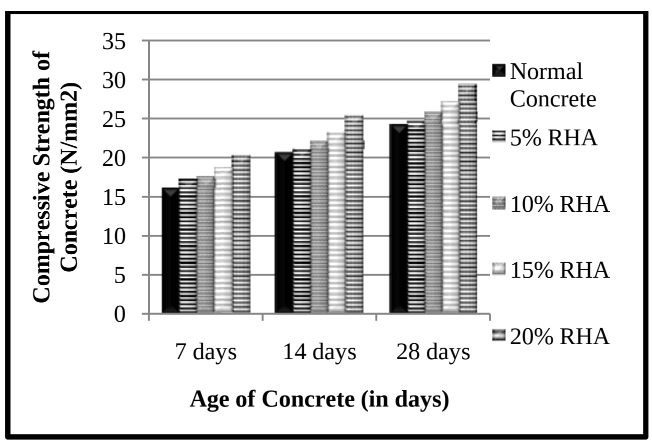


**Fig. 2: Comparison between Normal Concrete and Rice Husk Ash (RHA)**

It has been observed that by increasing the percentage of Fly Ash and Rice Husk Ash (RHA) with cement the strength of the concrete increases considerably. According to Patilet. al (2012) the Fly Ash contains around 90% of $SiO_2$ and according to Oyetola and Abdullahi(2006) the Rice Husk Ash (RHA) contains around 70% of $SiO_2$. It is due to the presence of high silica content in Fly ash and Rice Husk Ash, these materials are called Pozzolanic. These Pozzolanic materials reacts with calcium hydroxide ($Ca(OH)_2$) liberated in the hydration process to form Calcium Silicate Hydrate (C-S-H) gel. This C-S-H gel helps in binding the materials as stated by M.S.Shetty (1982); B.L.Gupta and Amit Gupta (1989)

The chemical reaction between Portland Cement and Water is given as under:

Portland Cement + Water $\longrightarrow$ C-S-H gel + $Ca(OH)_2$

The Pozzolanic reaction is given as under:

Portland Cement+Pozzolana (RHA/FA)+Water C-S-H gel $\longrightarrow$

The reaction between Portland Cement and Water releases calcium hydroxide as a byproduct which makes the concrete porous, weak and undurable. $Ca(OH)_2$ also reacts with sulphates present in water or soil to form calcium sulphate which causes deterioration of concrete. The effect of $Ca(OH)_2$ can be reduced by using pozzolanic material like Fly Ash and Rice Husk Ash. Moreover, these pozzolanic materials are filler materials thereby filling up the spaces between the fine aggregates and make it a closer spacing and results in increase in strength. Also, on comparing the strength of Fly Ash and Rice Husk Ash, it is found that Fly Ash gives more strength than Rice Husk Ash. This is justified from the fact that Fly Ash contains considerably high amount of $SiO_2$ which results in greater amount of C-S-H gel and hence greater is the strength.

Finally, we can conclude that:

1. The strength of the concrete increases considerably by increasing the amount of Fly Ash or Rice Husk Ash (RHA).
2. With the use of Fly Ash and Rice Husk Ash (RHA) as a partial replacement of cement in concrete, the cost of construction reduces.
3. With the increase in the use of Fly Ash and Rice Husk Ash (RHA) as a partial replacement of cement in concrete the amount of cement production can be reduced, thereby, reducing the emission of $CO_2$ into the environment.
4. Fly Ash gives more strength than Rice Husk Ash due to higher amount of $SiO_2$.
5. Fly Ash and Rice Husk Ash being eco-friendly (Dr. Rout &Venkatesh. M respectively, 2013) reduces the impact of global warming.

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