# An Experimental Study on Strength Development of Concrete Containing Composite Ash (Flay Ash-F & Rice Husk Ash)

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***Abstract* - In this Study, the detailed mechanical property was done to study the effect of partial replacement of cement by Fly Ash-Class F(FA) and Rice Husk Ash (RHA) in combine proportion started from 5% FA and 5% RHA mix together in concrete by replacement of cement with the gradual increase of RHA & FA. Last proportion was taken 20% FA and 20% RHA. The tests on hardened concrete were destructive in nature which includes compressive test and flexural strength at 7, 28 and 56 of curing as per IS: 516 1959, and split tensile strength on cylinder at 28 days of curing as per IS: 5816 1999. The work presented inthis paper reports the effects on the behavior of concrete produced from cement with combination of FA and RHA at different proportionson the mechanical properties of concrete.This study showed that strength increases with increasing amount of combined fly ash and rice husk ash up to an optimum value, beyond which strength starts todecrease with further addition of combined fly ash and rice husk ash. The optimum value of combined Fly ash(15%) and rice husk ash(15%) for the four test groups is about 30% of cement. FA&RHA/cement ratio is an important factor determining the efficiency of puzzolana.**



## I. INTRODUCTION

Portland cement is widely used in construction in the last few decades. The production of cement involves very high temperature of $1400^0$ to $1500^0$C, the destruction of natural quarries to extract raw materials, the emission of the pollutant gases of CO2 and NO. The climate change due to global warming, one of the greatest environmental issues has become a major concern during the last decade. The global warming is caused by the emission of greenhouse gases, such as CO2, to the atmosphere by human activities. In the Indian scenario, among thegreenhouse gases CO2 contributes about 70% of global warming. The production of cement is increasing annually by 3% with present daytechnology, the production of 1 tonne of cement results in a CO2 emission of an average 0.8-0.9 tonnes.Fly ash is the byproduct of the combustion of pulverized coal and is collected by mechanical and electrostatic separators from the fuel gases of power plants where coal is used as a fuel. It is estimated that approximately 600 million tonnes of fly ash is available worldwide, but at present the current worldwide utilization rate of fly ash in concrete is about 10 per cent indicating that there is a potential for the use of much larger amounts of fly ash in concrete.The utilization of fly ash instead of dumping it as a waste material can be partly used on economic grounds as pozzolana for partial replacement of cement. And partly because of its beneficial effects such as lower water demand for similar workability, reduced bleeding, and lower evolution of heat. It has been used particularly in mass concrete applications and large volume placement to control expansion due to heat of hydration and also helps in reducing cracking at early ages.The utilization of rice husk ash (RHA) as cement replacement is a new trend in concrete technology. Besides, as far as the sustainability is concerned, it will also help to solve problems otherwise encountered in disposing of the wastes [Chandra, 1997]. Disposal of the husks is a big problem and open heap burning is not acceptable on environmental grounds, and so the majority ofhuskis currently going into landfill. The disposal of rice husks create environmental problem that leads to the idea of substituting RHA for silica in cement manufactured. The content of silica in the ash is about 92-97%.Research had shown that small amounts of inert filler have always been acceptable as cement replacement. RHA is very reach in silicon dioxide which makes it very reactive with lime due to its non-crystalline silica content and its specific surface. In addition of high strength and performance embedding high contents of rice husk ash resulted in high electrical resistivity.RHA with cellular microstructure and highly pozzolanic activity is formed. It contains high silica content in the form of non-crystalline or amorphous silica up to 95%. The utilization of fly ash instead of dumping it as a waste material can be partly used on economic grounds as pozzolana for partial replacement of cement and partly because of its beneficial effects such as lower water demand for similar workability, reduced bleeding, and lower evolution of heat. It has been used particularly in mass concrete applications and large volume placement to control expansion due to heat of hydration and also helps in reducing cracking at early ages.

## II. MATERIALS AND PROPERTIES

### A. *Cement*

In this project ordinary Portland cement of grade 53 is used.

### B. Fly Ash

Fly ash produced from the burning of younger lignite or sub bituminous coal, in addition to having pozzolanic properties, also has some self-cementing properties. In the presence of water, Class F fly ash will hardenand gain strength over time. Class F fly ash generally contains less than 20% lime (CaO). Unlike Class C, Fly ash for the purpose of this investigation was obtained from Mettur ThermalPower Plant (MTSP) in Tamilnadu.

### C. Rice Husk Ash

India produces about 218.2 million tonnes (18.90 million tones in Tamil nadu) of paddy every year. During milling of paddy about 78 % of weight is received as rice. Rest 22 % of the weight of paddy is received as husk. This husk is used as fuel in the rice mills to generate steam for the parboiling process. This husk contains about 75 % organic volatile matter and the balance 25 % of the weight of this husk is converted into ash during the firing process, is known as rice husk ash (RHA). This RHA in turn contains around 85 % - 90 % amorphous silica.

### D. Fine Aggregate

Local clean river sand conforming to grading zone was used. The sand is sieved using 4.75 mm sieve to remove all the pebbles. Fine aggregate having a specific gravity of 2.56 and fineness modulus of 2.75 and bulk density 1693 Kg/m$^3$ was used.

### E. Coarse Aggregate

Locally available well graded aggregates of normal size greater than 4.75 mm and less than 20 mm.Coarse aggregates having a specific gravity of 2.73, fineness modulus of 6.64 and bulk density 1527 Kg/m$^3$ were used.

### F. Superplasticizer

Sulphonatednapthaline formaldehyde (SNF) Manufactured by normal resinification of melamine – formaldehyde.

### G. Physical Properties of Materials

Table 1 - Physical Properties

| Property | Fly ash | RHA | Cement | Fine aggregate | Coarse aggregate |
|---|---|---|---|---|---|
| Specifc gravity | 1.77 | 1.96 | 3.10 | 2.56 | 2.70 |
| Finenes moduls | - | - | - | 2.75 | 6.64 |
| Bulk density | 1190 kg/m$^3$ | 496 kg/m$^3$ | - | 1693 Kg/m$^3$ | 1527 Kg/m$^3$ |

### H. Chemical Characteristics

Table 2 -Chemical Characteristics

| | $SiO_2$ | $Fe_2O_3$ | $Al_2O_3$ | Cao | Mgo | $SO_3$ |
|---|---|---|---|---|---|---|
| Cement | 20.25 | 3.16 | 5.04 | 63.61 | 4.56 | 0.56 |
| Fly ash | 56.65 | 4.29 | 27.35 | 2.19 | 0.57 | 0.45 |
| RHA | 67.23 | 1.36 | 2.37 | 1.92 | 0.99 | 0.28 |

## III. METHODS OF TESTING

### A. Compressive strength

Compressive strength test is conducted on cubes of size 150mmX150mmX150mm. All specimens were tested in saturated surface dry condition, after wiping out the moisture. For each percentages and for normal three identical specimens were tested and is tested under a uniform rate of loading of 140 kg/cm$^2$/min.

### B. Split Tensile Strength

Split tensile strength test was conducted on fly ash and RHA blended concrete cylinders as per IS 5816-1999 after 28 days curing. For that cylinder of size 150mm dia and 300mm height were made and tested.

### *C. Flexural Strength Of Concrete*

Compressive strength test is conducted on beam of size 500mmX10mmX10mm. All specimens were tested in saturated surface dry condition, after wiping out the moisture. For each percentages and for normal three identical specimens were tested and is tested under a uniform rate of loading of 140 kg/cm$^2$/min.

### *D. Standard Consistency*

Consistency of standard cement paste is defined as that Consistency which will permit the vicat plunger 50mm long and having 10mm dia to Penetrate to a point 5mm to 7mm from bottom of the vicatmould.

*Result*

Table 3 -Standard consistency results

| S.NO | % Replacement | | Standard consistency (%) |
|---|---|---|---|
| | FA | RHA | |
| 1 | - | - | 31 |
| 2 | 5 | 5 | 32 |
| 3 | 10 | 10 | 34 |
| 4 | 15 | 15 | 36 |
| 5 | 20 | 20 | 36 |

### *E. Initial & Final Setting Time*

The change of cement paste from fluid to a rigid state may be referred to as setting. The gaining of strength of a set cement paste is known as hardening.

*Result*

Table 4 -Initial & Final setting time

| S.No. | % Replacement | | Setting Time(min) | |
|---|---|---|---|---|
| | FA | RHA | Initial | Final |
| 1 | - | - | 70 | 285 |
| 2 | 5 | 5 | 67 | 245 |
| 3 | 10 | 10 | 65 | 220 |
| 4 | 15 | 15 | 56 | 185 |
| 5 | 20 | 20 | 49 | 265 |

### F. pH test

pH is defined as the negative logarithmic value of the Hydrogen ion ($H^+$) concentration

pH = -log [$H^+$]
when the pH is above 7 the solution is basic (alkaline)

when the pH is below 7 the solution is acidic

*Result*

Table 5 -pH Value

| S.NO | % Replacement | | pH Value |
|---|---|---|---|
| | FA | RHA | |
| 1 | Water | | 7.2 |
| 2 | Pure cement Slurry | | 12 |
| 3 | 5 | 5 | 11.98 |
| 4 | 10 | 10 | 11.97 |
| 5 | 15 | 15 | 11.95 |
| 6 | 20 | 20 | 11.94 |



### *G. Compressive strength of composite ash cement motor*

Compressive strength of cement indicates the compressive strength of cement mortar cubes (7.07cmx7.07cmx7.07cm) of 1:3 proportion, using standard sand as specified by IS :650 (1966) as fine aggregate , tested under compression Many other properties of mortar / concrete are related to compressive strength of cement, because cement is used in structure in the form of mortar or concrete.

*Result*

Table 6-*Compressive strength of composite ash cement motor*

| S.NO | % Replacement | | Load Kg | Strength N/mm$^2$ |
|---|---|---|---|---|
| | FA | RHA | | |
| 1 | Control | | 16000 | 31.90 |
| 2 | 5 | 5 | 12000 | 28.45 |
| 3 | 10 | 10 | 13000 | 27.03 |
| 4 | 15 | 15 | 12500 | 26.44 |
| 5 | 20 | 20 | 11000 | 26.14 |

### H. Soundness Of Cement

Soundness is nothing but volumetric change of the cement .Presents of chemicals such as CaO, MgO will react with the water present in the cement paste and it will increase the volume of cement paste while hardening.It may vary to each type of cement even for each batch. Soundness should not exceed 10mm for OP

*Result*

Table 7 - Soundness Of Cement

| S.NO | % Replacement | | Initial Reading (cm) | Final Reading (cm) | Soundness value(mm) |
|---|---|---|---|---|---|
| | FA | RHA | | | |
| 1 | Control | | 1 | 1.1 | 2 |
| 2 | 5 | 5 | 1.1 | 1.3 | 2 |
| 3 | 10 | 10 | 1.1 | 1.4 | 3 |
| 4 | 15 | 15 | 1.2 | 1.6 | 4 |
| 5 | 20 | 20 | 1.6 | 2.0 | 5 |

## IV. MIX PROPROTION

(M20 GRADE CONCRETE)

| Water | Cement | Fine aggregate | Coarse aggregate |
|---|---|---|---|
| 191.6 | 383 | 536.16 | 1229.61 |
| 0.5 | 1 | 1.45 | 3.30 |

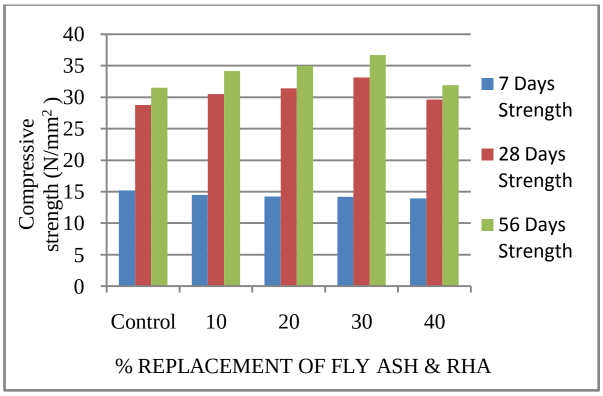
## V. RESULTS AND DISCUSSIONS

### *A. Compressive Strength Of Composite Ash Concrete*

Table 7 -*Compressive Strength Of Composite Ash Concrete*

| S.NO | % Replacement | | Compressive Strength ($N/mm^2$ ) | | |
|---|---|---|---|---|---|
| | FA | RHA | 7 Days | 28 Days | 56 Days |
| 1 | Control | | 15.20 | 28.77 | 31.52 |
| 2 | 5 | 5 | 14.50 | 30.52 | 34.17 |
| 3 | 10 | 10 | 14.25 | 31.40 | 34.95 |
| 4 | 15 | 15 | 14.20 | 33.13 | 36.71 |
| 5 | 20 | 20 | 13.92 | 29.64 | 31.90 |

Table shows the result of compressive strength of the blendedconcrete containing fly ash and RHA(composite ash). The strength is increasing up to 30% and there is a slight decrease in 40% replacement but it is also higher than the normal concrete strength. The incorporation of fly ash and RHA increases the strength of the concrete.




Grape 1-*Compressive Strength Of Composite Ash Concrete*

### *B. Split Tensile Strength Test*

*Result*

Table 8–*Split Tensile Strength Test*

| S.NO | % Replacement | | Split tensile strength ($KN/mm^2$) | | |
|---|---|---|---|---|---|
| | FA | RHA | 7 Days | 28 Days | 56 Days |
| 1 | Control | | 2.90 | 3.30 | 3.80 |
| 2 | 5 | 5 | 3.15 | 3.44 | 4.05 |
| 3 | 10 | 10 | 3.20 | 3.70 | 4.15 |
| 4 | 15 | 15 | 3.25 | 3.83 | 4.38 |
| 5 | 20 | 20 | 2.95 | 3.75 | 4.00 |



The split tensile strength of the blended concrete containing fly ash and RHA concrete after 7,28&56 days of curing are shown in table. It can be clearly seen that the splitting tensile strength value increases with fly ash and RHA content up to 30 % and the 40% is the optimal limit.

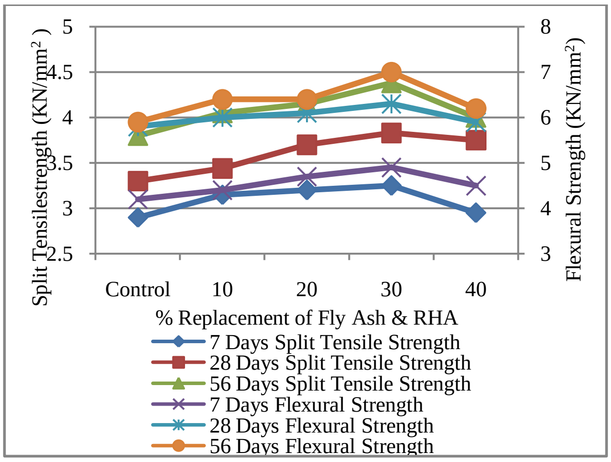
### *C. Flexural Strength Test Result*

*Result*

Table 9–*Flexural Strength Test Result*

| S.NO | % Replacement | | Flexural strength ($KN/mm^2$) | | |
|---|---|---|---|---|---|
| | FA | RHA | 7 Days | 28 Days | 56 Days |
| 1 | Control | | 4.2 | 5.8 | 5.9 |
| 2 | 5 | 5 | 4.4 | 6.0 | 6.4 |
| 3 | 10 | 10 | 4.7 | 6.1 | 6.4 |
| 4 | 15 | 15 | 4.9 | 6.3 | 7.0 |
| 5 | 20 | 20 | 4.5 | 5.9 | 6.2 |

The flexural strength of the blended concrete containing fly ash and RHA concrete after 7, 28&56 days of curing are shown in table. It can be clearly seen that the splitting tensile strength value increases with fly ash and RHA content up to 30 % and the 30% is the optimal limit.




Graph 2 - *Split Tensile Strength &Flexural Strength Test*

## VI. CONCLUSION

Fly ash and Rice husk ash is found to be superior supplementary materials. Fly ash – F and Rice husk ash used inthis study is efficient as a pozzolanic material; Due to low specific gravity of ash whichleads to reduction in mass per unit volume, thus adding it reduces the dead load on the structure. Used of Fly ash and Ricehusk ash helps in reducing the environment pollution during the disposal of excess Fly ash and Rice husk ash. Cement iscostly material, so the partial replacements of these materials by Rice husk ash and Fly ash reduces the cost of concrete.Based on the results presented above, the following conclusions can be drawn:-

1. Compressive strength increases with the increase in the percentage of Fly ash and Rice Husk Ash up to replacement (15%FA and 15% RHA) of Cement in Concrete for different mix proportions.

2. The maximum 7, 28&56 days split tensile strength and flexural strength was obtained with combination ash of 30%( FA 15% and RHA 15%)

3. In the long run, our study has revealed the fact that composite ash (15%FA 15% RHA )may be treated as an finest creation in view of enhanced value of compressive strength, flexural and split tensile strength, superior corrosion inhabiting and desirable functionality.

4. The percentage of water cement ratio is reliant on quantity of ash used in concrete. Because ash is a highly porous material

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