# Fly Ash Class F: Opportunities for Development of Low Cost Mortar

**Rushabh A. Shah, Jayeshkumar Pitroda**

***Abstract-Fly ash (Class F) investigated for its use as a partial replacement for cement in cement mortar (1:3). The utilization of Fly Ashas cement replacement material in mortar or as additive in cement introduces many benefits from economical, technical and environmental points of view. This paper presents the results of the cement mortar of mix proportion 1:3 in which cement is partially replaced with Fly Ash(Class F)as 0%, 10%, 30%and 50% by weight of cement. Two set of mixture proportions were made. First were control mix (without Fly Ash(Class F)with regional fine aggregate (sand)) and the other mixing contained Fly Ash(Class F)obtained from Thermal industrythe compressive strength has been obtained with partial replacement of Fly Ash(Class F)withcement.Test results indicate the decreases in the strength properties of mortar with Fly Ash(Class F)for strength at 7 & 28 days as partial replacement with the cement in the cement mortar 1:3. So it can be used in non-structural elements with the low range compressive strength where strength is not required and low cost temporary structure is prepared.***

***Keywords:Fly ash(Class F),Partial replacement, Compressive strength, Cement, Fine aggregate, Cost***

## I. INTRODUCTION

Mortar is a worldwide accepted building construction material in all types of civil engineering structures. Stone and Brick masonry construction is very much preferred one for load bearing structures and high rise buildings. It has been used for the construction of a number of historical and traditional buildings. Though these masonry is not much understood in the aspect of strength and other parameters, because of its non-homogeneity. Most of the walls of buildings and residential houses are masonry walls, made of stones, bricks or concrete blocks, with rendering on both sides. Even though mortar makes up as little as 7% of the total volume of a masonry wall, it plays a crucial role in the performance of the structure. Due to the environment concern and the need to conserve energy, various research efforts have been directed toward the utilization of waste materials.

The cost of cement is also steadily increasing. With ever-increasing environmental problems because of industrial waste products comes a great need to use these products in an appropriate manner to reduce health and environmental problems. For this purpose, experimental investigation is carried out to develop the data on the compressive strength development of mortar with time and with different percent replacement of Fly Ash(Class F).

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The objectives of the present study are:

- To select the Fly Ash (Class F)mix proportion for cement mortar.
- To investigate change in compressive strength of cement mortar with Fly Ash(Class F)replacement.
- To perform the experiments on the time-dependent compressive strength of cement mortar with Fly Ash (Class F). The strengths were measured at the age of 7 & 28 days.

## II. DESIGN MIX MATERIALS

### A. Cement

The cement used is SANGHI OPC 53 grade cement. The Ordinary Portland Cement of 53 grade conforming to IS: 8112-1989is be use. Tests were conducted on cement like Specific gravity, consistency tests, setting tests, soundness,Compressive strength N/mm$^2$ at 28 days.


**Fig 1: SANGHI OPC 53 Grade Cement**

**TABLE - 1**
**PROPERTIES OF CEMENT**

| Sr. No. | Physical properties of SANGHI OPC 53cement | Result | Requirements as per IS:8112-1989 |
|---|---|---|---|
| 1 | Specific gravity | 3.15 | 3.10-3.15 |
| 2 | Standard consistency (%) | 31.5 % | 30-35 |
| 3 | Initial setting time (hours, min) | 91 min | 30 minimum |
| 4 | Final setting time (hours, min) | 211 min | 600 maximum |
| 5 | Soundness | 2.8 mm | 10mm maximum |
| 6 | Compressive strength N/mm$^2$ at 28 days | 58 N/mm$^2$ | 53 N/mm$^2$ minimum |

**B. Fine aggregate**

Those fractions from 4.75 mm to 150 micron are termed as fine aggregate. The river sand is used as fine aggregate conforming to the requirements of IS: 383. The river sand is wash and screen, to eliminate deleterious materials and over size particles.

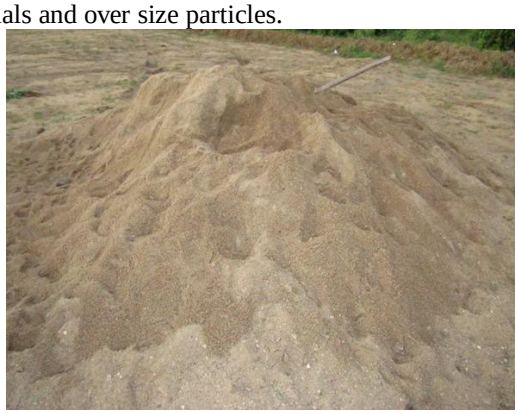

**Fig 2: Fine aggregate (River sand)**

**Table- 2**
**Properties Of Fine Aggregate**

| Property | Fine Aggregate (River sand) |
|---|---|
| Fineness modulus | 3.10 |
| Specific Gravity | 2.76 |
| Water absorption (%) | 1.20 |
| Bulk Density (gm/cc) | 1.78 |

**C. Water**

Water is an important ingredient of Mortar as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

**D. Fly Ash (Class F)**

The fly ash (Class F)is procured from Maize Products (A division of Sayaji Industries Ltd) Power plant. This plant is located near kathwada in Ahmedabad District in Gujarat State. The plant is an establishment of 1941. Presently it is partially being used by nearby farmers for soil nourishment, and brick manufacturers as an additive to clay.

**Table- 3**
**Chemical Properties Of Fly Ash (Class F) Test Method As Per Is 1727-1967**

| Sr. No. | Chemical Properties | Fly Ash (Class F) |
|---|---|---|
| 1 | $SiO_2$ | 62.22 |
| 2 | MgO | 6.09 |
| 3 | $SO_3$ | 3.00 |
| 4 | CaO | 5.30 |
| 5 | LOI | 9.98 |
| 6 | $AL_2O_3$ | 7.63 |
| 7 | $Fe_2O_3$ | 0.13 |

## III. DESIGN MIX METHODOLOGY

***Mortar compositions***

A cement mortar mix 1:3 was designed as per IS: 269 methods and the same were used to prepare the test samples. The design mix proportion is done in Table 4 and 5.

**Table - 4**
**Mix Design Proportions**

| | Water | Cement | Fine Aggregate |
|---|---|---|---|
| **By weight, [gms]** | 86 | 200 | 600 |
| **By volume, [$m^3$]** | 0.43 | 1 | 3 |

**Table -5**
**Cement Replacement By Fly Ash (Class F)**

| Sr. No. | Types of Mortar | Description of Mortar |
|---|---|---|
| 1 | A1 | River sand Mortar (1:3) |
| 2 | E1 | 10% Cement Replacement by Fly Ash (Class F) |
| 3 | E2 | 30% Cement Replacement by Fly Ash (Class F) |
| 4 | E3 | 50% Cement Replacement by Fly Ash (Class F) |

**Table - 6**
**Design Mix Proportions For Mortar (1:3)**

| Types of Mortar | W/C ratio | % Replacement in cement | Design Mix Proportions For Mortar (1:3) | | |
|---|---|---|---|---|---|
| | | | C | F.A.R. | Fly Ash (Class F) |
| A1 | 0.45 | 0 | 1 | 3 | - |
| E1 | 0.45 | 10% | 0.9 | 3 | 0.1 |
| E2 | 0.45 | 30% | 0.7 | 3 | 0.3 |
| E3 | 0.45 | 50% | 0.5 | 3 | 0.5 |

W= Water, C= Cement, F. A.R. = Fine AggregateRegional

## IV. EXPERIMENTAL METHODOLOGY

**A. Testing methodology**

The evaluation of Fly Ash(Class F) for use as a supplementary cementitious material (SCM), i.e., as a pozzalona, begins with the mortar testing. Mortar is similar to concrete in that it contains cement, water and aggregate, except that in mortar graded fine aggregate is the only aggregate present. With the control mortar, i.e.10%,30% and 50% of the ordinary Portland cement (OPC) confirming IS 269IV is replaced with Fly Ash(Class F), the data from the Fly Ash (Class F) mortar is compared with data from a "control" mortar without Fly Ash(Class F). Three cube samples were cast on the mould of size 70.7 x 70.7 x 70.7 mm for each 1:3 cement mortars with partial replacement of cement with Fly Ash(Class F) with w/c ratio as 0.43 were also cast. After about 48 h the specimens were de-moulded and water curing was continued till the respective specimens were tested after 7& 28 days for compressive strength.

**Fig 3: Set up of Crucible for Mixing Cement and Fine Aggregate (Sand)**

### B. Compressive strength

Compressive strength tests were performed on compression testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this paper. The loading rate on the cube is 35 N/mm$^2$ per min. The comparative studies were made on their characteristics for cement mortar ratio of 1:3with partial replacement of cement with Fly Ash(Class F) as 0%, 10%, 30%and 50%.

**Fig 4: Set up of Compressive Testing Machine**

## V. RESULT

Table -7
Compressive Strength Of Cement Mortar (N/Mm$^2$) At 7days

| **Types of Mortar** | **Average Early Compressive Strength of cement mortar (N/mm$^2$) at 7 days** | **% change in compressive strength of cement mortar (N/mm$^2$) at 7 days** |
|---|---|---|
| A1 | 33.81 | 0 |
| E1 | 32.01 | -5.32 |
| E2 | 24.01 | -28.98 |
| E3 | 15.34 | -54.62 |

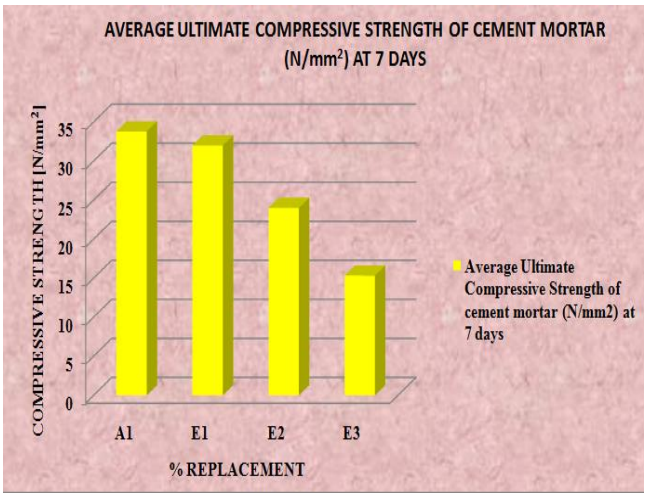


**Fig 5: % Replacement of Fly Ash versus Compressive Strength of Cement Mortar(1:3) N/mm$^2$at 7 days**

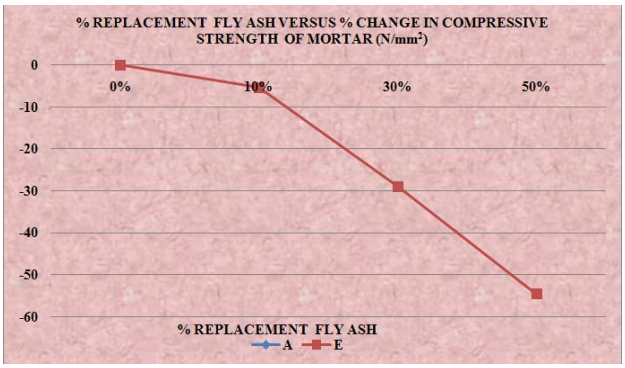


**Fig 6: % Replacement of Fly Ash(Class F)v/s % Change in Compressive Strength of Cement Mortar(1:3) at 7 days**

**Table -8**
**Compressive Strength Of Cement Mortar (N/Mm$^2$) At 28 Days**

| Types of Mortar | Average Ultimate Compressive Strength of cement mortar (N/mm$^2$) at 28 days | % change in compressive strength of cement mortar (N/mm$^2$) at 28 days |
|---|---|---|
| A1 | 50.42 | 0 |
| E1 | 38.81 | -23.03 |
| E2 | 33.01 | -34.53 |
| E3 | 18.34 | -63.63 |

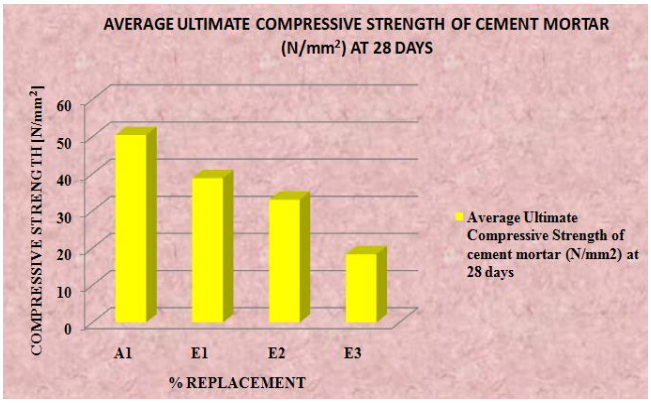


Fig 7: % Replacement of Fly Ash(Class F)versusCompressive Strength of Cement Mortar (1:3) N/mm$^2$at 28 days

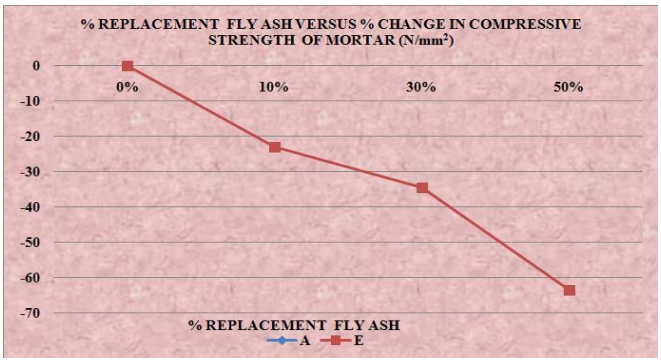


Fig 8: % Replacement of Fly Ash(Class F)% Change in Compressive Strength of Cement Mortar (1:3) at 28 days

## VI. ECONOMIC FEASABILITY

TABLE- 9 COSTS OF MATERIALS

| Sr. No. | Materials | Rate (Rs/Kg) |
|---|---|---|
| 1 | Cement (SANGHI OPC 53 grade) | 6.00 |
| 2 | Fine aggregate (Regional ) | 0.61 |
| 3 | Fly Ash (Class F) | 0.50 |

TABLE - 10
MATERIALS FOR DESIGNE MIX MORTAR (1:3)

| Types of Mortar | % Replacement in cement | Materials | | | Total Cost [$m^3$] | % Change in Cost |
|---|---|---|---|---|---|---|
| | | C [$kg/m^3$] | F.A.R. [$kg/m^3$] | Fly Ash (Class F) [$kg/m^3$] | | |
| A1 | 0 | 566.57 | 1699.72 | 0 | 4504.24 | 0 |
| E1 | 10% | 509.91 | 1699.72 | 56.65 | 4192.62 | (-) 6.91 |
| E2 | 30% | 396.59 | 1699.72 | 169.97 | 3569.40 | (-) 20.75 |
| E3 | 50% | 283.28 | 1699.72 | 283.28 | 2946.17 | (-) 34.59 |

C= Cement, F. A.R. = Fine AggregateRegional

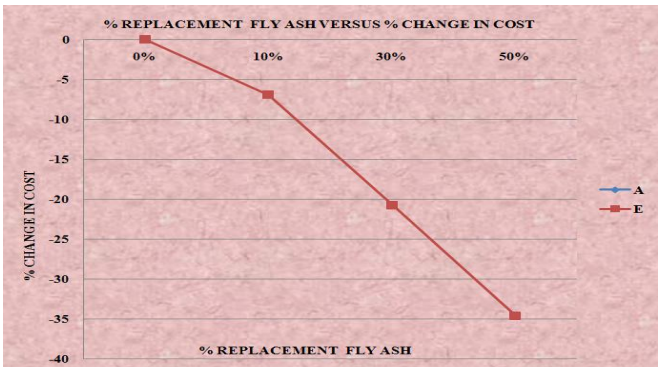


Fig 9: % Replacement Fly Ash(Class F)versus % Change in Cost

## VII. CONCLUSION

From this study the following conclusion can be drawn:

- The results presented in this paper, indicate that the incorporation of a Fly Ash (class F)in mixed cement is not feasible for making masonry mortars for high strength.
- Adequate strength developments were not found in mortars made of the mixed cement and Fly Ash(class F) as cement replacement for 1:3 mortars at 28 days.
- Fly Ash(class F) may be used in masonry mortar to improve the long-term bond strength. Partial replacement of the Portland cement with Fly Ash (class F) does not improve the masonry bond strength at early age of 7 days.
- So it can be used in non-structural elements with the low range compressive strength where strength is not required.
- Fly Ash (class F) can be used to prepared low cost temporary structure.
- The results indicate that the % change in cost reduce up to 34.59 for 50% replacement of Fly Ash (class F).

## VIII. ACKNOWLEDGEMENT

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