

# 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 Ash as 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).

**Manuscript published on 30 March 2013.**

\*Correspondence Author(s)

**Rushabh A. Shah**, Student of final year M.E. C E & M,B.V.M. Engineering College, Vallabh Vidyanagar Anand-Gujara, India.

**Prof. Jayeshkumar Pitroda**, Assistant Professor & Research Scholar, Civil Engg Department, B.V.M. Engineering College, Vallabh Vidyanagar-Anand-Gujarat, India.

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an [open access](http://creativecommons.org/licenses/by-nc-nd/4.0/) article under the CC-BY-NC-ND license <http://creativecommons.org/licenses/by-nc-nd/4.0/>.

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<sup>2</sup> 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 <sup>2</sup> at 28 days	58 N/mm <sup>2</sup>	53 N/mm <sup>2</sup> 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 form 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 <sub>2</sub>	62.22
2	MgO	6.09
3	SO <sub>3</sub>	3.00
4	CaO	5.30
5	LOI	9.98
6	AL <sub>2</sub> O <sub>3</sub>	7.63
7	Fe <sub>2</sub> O <sub>3</sub>	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 <sup>3</sup> ]	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	% Replace ment 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) conforming 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<sup>2</sup> per min. The comparative studies were made on their characteristics for cement mortar ratio of 1:3 with 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<sup>2</sup>) AT 7DAYS

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

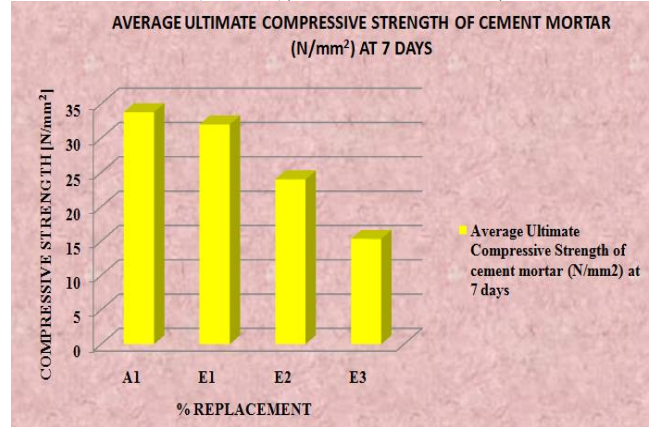


Fig 5: % Replacement of Fly Ash versus Compressive Strength of Cement Mortar(1:3) N/mm<sup>2</sup> at 7 days

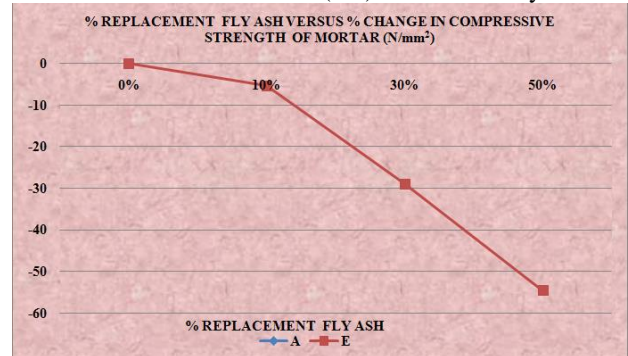


Fig 6: % Replacement of Fly Ash(Class F)v/s % Change in Compressive Strength of Cement Mortar(1:3) at 7 days

TABLE -8  
COMPRESSIVE STRENGTH OF CEMENT MORTAR (N/mm<sup>2</sup>) AT 28 DAYS

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

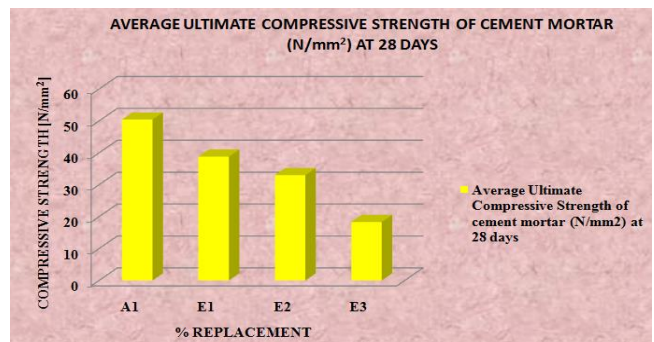


Fig 7: % Replacement of Fly Ash(Class F) versus Compressive Strength of Cement Mortar (1:3) N/mm<sup>2</sup> at 28 days

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

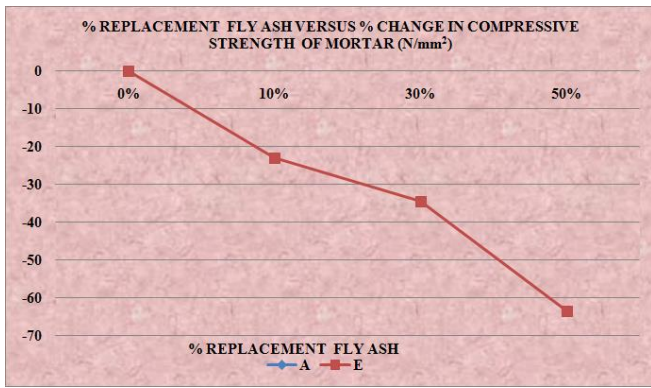


Fig 8: % Replacement of Fly Ash(Class F)% Change in Compressive Strength of Cement Mortar (1:3) at 28 days

## VI. ECONOMIC FEASIBILITY

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 <sup>3</sup> ]	% Change in Cost
		C [kg/m <sup>3</sup> ]	F.A.R. [kg/m <sup>3</sup> ]	Fly Ash (Class F) [kg/m <sup>3</sup> ]		
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

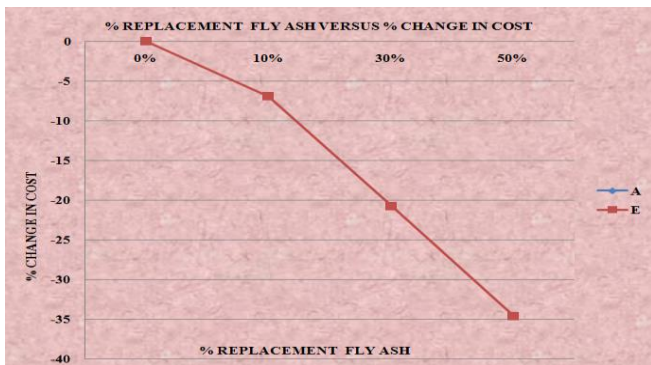


Fig 9: % Replacement Fly Ash(Class F)versus % Change in Cost

## 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

The Authors thankfully acknowledge to Dr.C.L.Patel, Chairman, Charutar Vidya Mandal, Er.V.M.Patel, Hon.Jt. Secretary, Charutar Vidya Mandal, Mr. Yatinbhai Desai, Jay Maharaj construction, Vallabh Vidyanagar, Gujarat, India for their motivational and infrastructural support to carry out this research.

## REFERENCES

- C Freeda Christy, D Tensing, (2010), "Effect of Class-F Fly Ash as Partial replacement with Cement and Fine Aggregate in Mortar", International Journal of Engineering & Materials Sciences, Volume 17, April 2010, pp:140-144.
- IS 1344 - 1968: Code of practice on pozzalona for mortars. Indian standards Institution, New Delhi
- IS 269 -1970 Code of Practice far Portland cement. Indian standards Institution, New Delhi
- IS 3812 (part- I) 1966 and part - II Indian standard code of practice on mortars. Indian standards Institution, New Delhi
- Rushabh A. Shah,Prof. Jayeshkumar Pitroda (2013), "Effect of Pozzocrete as Partial Replacement with Cement in Mortar" International Journal Global Research Analysis, (GRA), Volume: 2, Issue: 1, Jan 2013, ISSN No 2277 – 8160, pp-44-46.
- Rushabh A. Shah, Prof. Jayeshkumar Pitroda (2013), "Pozzocrete: Modern Material Partially Replaced with Cement in Mortar" International Journal of Innovative Technology and Exploring Engineering (IJITEE), ISSN: 2278-3075, Volume-2, Issue-3, February 2013, pp-105-108.

**Rushabh Ajay kumar Shah** was born in 1990 in Vyara Town. He received his Bachelor of Engineering degree in Civil Engineering from the Birla Vishvakarma Mahavidyalaya Engineering Collage, Sardar Patel University, Vallabh Vidya Nagar in 2011. At present he is Final year student of Master's Degree in Construction Engineering and Management from Birla Vishvakarma Mahavidyalaya, Gujarat Technological University. He has papers published in International Journals.

**Prof. Jayeshkumar R. Pitroda** was born in 1977 in Vadodara City. He received his Bachelor of Engineering degree in Civil Engineering from the Birla Vishvakarma Mahavidyalaya, Sardar Patel University in 2000. In 2009 he received his Master's Degree in Construction Engineering and Management from Birla Vishvakarma Mahavidyalaya, Sardar Patel University. He joined Birla Vishvakarma Mahavidyalaya Engineering College as a faculty where he is Assistant Professor of Civil Engineering Department with a total experience of 12 years in field of Research, Designing and education. He is guiding M.E. (Construction Engineering & Management) Thesis work in field of Civil/ Construction Engineering. He has papers published in National Conferences and International Journals.

