Experimental Investigation of Fly Ash Based Solid Block Masonry Prism by Using M-Sand as Partial Replacement of Fine Aggregate

Surya.I[1], Surya.M[1] ,Deepan Chakravarthi.A.V[2]

[1](UG student, Department of Civil Engineering, Velammal College of Engineering and Technology, India)
[2](Assistant professor, Department of Civil Engineering, Velammal College of Engineering and Technology, India)

Abstract

This paper presents an experimental investigation on fly ash based solid block masonry prism by using m-sand as partial replacement of fine aggregate. Masonry prisms were constructed with various mortar grades 1:4, 1:5 and 1:6 and the respective compressive strength of cement mortar were tested for 7days, 28days and 90days.River sand M-sand is one be the suitable replacement for river sand.In this experimental work solid block is produced by a constant replacement of cement by 10%of fly ash and fine aggregate by M-sand of proportion 0%, 20%, 40%, 60%, 80% and 100%. Masonry prisms are tested for various mortar proportions to determine the compressive strength. The mechanical properties of solid block prism are compared with code provision such as IS:1905-1987 and ASTM C1314. The result clearly states that the compression strength of the masonry prism is affected by the mortar grade.

Keywords -*Fly ash, Masonry prism, M-sand, Compressive strength*

I. INTRODUCTION

A solid block prism is an arrangement of masonry unit with mortar, which is built as a test specimen for finding its properties. According to ASTM-447 standard test methods prisms are tested to determine the compressive strength. To ensure the flexural bond strength prisms are also constructed. A stepwise increase in industrial revolution and urbanization in a state, a plenty of infrastructure development are made. Due to over utilization of natural source either river sand or any construction material from a natural source creates shortage. To overcome these problems new materials should be employed as a new construction material. Our attempt is taking fly ash as a partial replacement for cement and replacing fine aggregate by manufactured sand. Flue ash is another word for fly ash. It is normally created in combustion and it gives the fine particles with flue gases.

Over 80million tons of fly ash is generated each year from thermal power plants in India. The amount we utilize is less than 10% only. It is used in concrete blocks as a partial replacement for cement in order to minimize the amount of cement used in concrete blocks. Using fly ash as a building material is purely depends on its mineral structure and pozzolanic property. Natural sand is generally regarded as a fine aggregate and also a stone which moves through the 600micron also called as fine aggregate. Ninety percentage of fine aggregate passes through 4.75mm IS sieve and in rare case some passes through 150micron. Fine aggregate are used for constructing a thin wall and reinforced concrete elements. It also used in runway (airport) and highway due to its fineness. Their properties are given below. Cement is one of the most widely used building materials which act as a binding agent. Its work is to adhere between building units like bricks, stone, tiles etc…

The cement is a word which came from roman called caementicium it explains the masonry. Later pulverized brick and volcanic ash supplement are mixed to the burnt lime to get hydraulic binder. Then day by day it is often called as cementum and cement. Normally cements are classified into two type namely hydraulic and non-hydraulic cement. Hydraulic one is hardened by the addition of water. Carbonation hardens the non-hydraulic cement. Ordinary portland cement of grade 53 is the cement which we used in this project. In our project m-sand is used in the range 20%, 40%, 60% and 100%. It is an eco-friendly one, gives less damage to the environment and also having zero silt content. Moisture content is available when it is washed by water. Manufactured sand normally gives higher strength than river sand.

Kushal, Amitkumarbiswal, et al.[2017] investigated the use of fly ash in concrete by replacing cement by fly ash in a range 0%, 25%, 50%, 75% and 100%. From the results they stated 25% replacement of cement by fly ash achieve maximum strength.

M.S.Krishnahygrive, I.Siva Kishore et al. [2017]investigated the compressive strength of fly ash concrete by replacing cement by fly ash in the range 20%, 30%, 40%, 50% and finally they achieve the maximum strength in 20% replacement of cement by fly ash.

Amitmittal, Kaisare, made an experimental study on use of fly ash in concrete by replacing cement by fly ash in the range 20%, 30%, 40% and 50%. Result clearly shows that 20% replacement gives considerable strength.

Abdulhalimkarasinand Murat dogruyol [2014] take an experimental study on strength and durability for utilization of fly ash in concrete mix. Result shows that 20% replacement gives a bit difference in strength properties.

S.Muralikrishnan, T.Felixkala, P.Asha et al.[2018] studied about the properties of concrete using m-sand as fine aggregate by replacing fine aggregate by m-sand. Their result shows that 50% replacement of m-sand has high flexural strength when compared to normal concretemix.

Y.Boopathi, J.Doraikannan [2016] studied about the m-sand as a partial replacement of fine aggregate in concrete. Here they use m-sand as replacement for fine aggregate in the range 0%, 20%, 40%, 60% and 80%. Their test result shows that 60% replacement gives maximum strength.

AMZ Zimar, GKPN Samarawickrama, WSD Karunarathna [2018] aimed to determine the effect of manufactured sand as a replacement for fine aggregate in concrete. Here they use m-sand as a fine aggregate in the range 0%, 30%, 50%, 70% and 100%. They stated increase in m-sand which decreases the strength of concrete.

Yajurvedreddy, Swetha, Dhani [2015] studied about the properties of concrete with manufactured sand as replacement to natural sand. This paper investigate the strength and durability of concrete by using m-sand as replacement to natural sand in the range 0%, 20%, 40%, 60% and 100%. Result shows that 60% replacement gives considerable strength in concrete.

Sachinkumar, Roshan s kotian [2018] investigated the m-sand an alternative to the river sand in construction technology. Here they compare the strength of river sand and m-sand. Finally they concluded that manufactured sand gives same or greater value than river sand in compressive, flexural, split tensile strength tests.

In our current experimental work, the result displays that more consumption of m-sand ie. When increasing the proportion of replacing m-sand which gradually decreases the strength of concrete.

II. EXPERIMENTAL PROGRAM

A. Casting of solid block

Nowadays, bricks are replaced by concrete blocks in masonry construction. Three types of blocks are generally available namely solid, hollow and cellular. In our project we are using a solid concrete block of size 300mm x 150mm x 200mmcasted in a block manufacturing plant in Madurai near azhagar temple. There are two types of manufacturing process for concrete blocks viz. manmade and machine made. Our blocks are machine made one. Blocks are made in the mix ratio 1:1.5:3 with 10% fly ash as a partial replacement for cement and m-sand in the range 20%, 40%, 60%, 80% and 100% for fine aggregate. After casting the block, cured it for 14days and then allowed to dry for 3-4 weeks. By placing a solid block one by one in vertical order, prisms are made with various mortar mix (1:4 1:5 1:6). Then it is subjected to continuous curing. Finally, the specimen is tested in universal testing machine (UTM) to find out the compressive strength. Apply the load slowly and watch the testing specimen carefully. When it’s starts to crack stop applying the load and note the reading.

Fig.1 Casting of a solid block

B. Compressive strength test for cement mortar

It is the capability of a structure or any material to carry loads on its surface without any crack or deflection. Compressive strength test for mortar is determined by using the measurement of a mortar cube calculate the cross sectional area. Size of cube (70.6 x 70.6 x 70.6)mm. Place the mortar cube in the center of loading area. Make the surface of cube in contact with the compressive testing machine and then gradually apply the load. Observe the specimen, when it starts to break stop applying the load and note the reading (ultimate load). By using the load divide it by the cross sectional area it gives the compressive strength.

Table 1 Mix Proportion for 1:4 mix ratio

Mix	Cement(Kg)	Fine aggregate (Kg)
CM	450	2000

Table 2 Mix Proportion for 1:5 mix ratio

Mix	Cement(Kg)	Fine aggregate(Kg)
CM	370	2050

Table 3 Mix Proportion for 1:6 mix ratio

Mix	Cement(Kg)	Fine aggregate(Kg)
CM	320	2200

Table 4 Water-Cement Ratio for mortar

Mix Ratio	Water-cement ratio(w/c)
1:4	0.6
1:5	0.6
1:6	0.7

Table 5 Mix Proportion of solid concrete blocks

Mix designation	Cement (kg/m^3)	Fly ash (kg/m^3)	Coarse aggregate (kg/m^3)	Fine aggregate (kg/m^3)	M-sand (kg/m^3)	Water (kg/m^3)
CM	410	-	1140	860	-	246
SF10	369	41	1140	860	-	246
SF10M20	369	41	1140	688	172	246
SF10M40	369	41	1140	516	344	246
SF10M60	369	41	1140	344	516	246
SF10M80	369	41	1140	172	688	246
SF10M100	369	41	1140	-	860	246

C. Compressive strength test for masonry prism

Compressive strength test for prism is done by using the measurement of a solid block prism calculate the cross sectional area. Place the prism in the center of loading area. Fit the piston and make contact with the surface of the specimen. Apply the load slowly and observe the specimen. After seeing the crack stop applying the load and note the reading (ultimate load). By using the load divide it by the cross sectional area it gives the compressive strength.
The mix proportion of the solid block is tabulated in Table 5.

III. RESULTS AND CONCLUSION

The test results for mortar cube and masonry prism are arranged in tabular form with chart. Table 5 indicates the compressive strength of mortar cube and table 6, 7 and 8 indicates the compressive strength of masonry prism.

Table 6 Compression Strength of mortar Cube

Mix ID	Mix ratio	7days(N/mm^2)	28days(N/mm^2)
SCM	1:4	9.62	12.14
SCM	1:5	8.43	11.35
SCM	1:6	6.17	9.25

Mortar cube of Mix Ratio 1:4 have high compressive strength. The Table 6, Table 7 and Table 8 gives us the compressive Strength and actual compressive strength of prism with mortar mix ratio of 1:4 , 1:5 and 1:6 respectively.

Table 6 Actual compressive Strength of prism with mortar mix ratio - 1:4

Mix	Mortar thickness (mm)	h/t	Compressive strength of prisms (Mpa)				Maximum Compressive strength of prisms (f_p)(Mpa) as per Code provision			
			Initial crack	Final crack	Initial crack	Final crack	IS:1905-1987		ASTM C1314	
			7days		28days		CF	f_p	CF	f_p
SCM	10	4.1	6.23	7.32	8.33	10.55	1.15	12.13	1.56	16.45
SF10	10	4.1	6.31	7.38	8.41	10.61	1.15	12.21	1.56	16.55
SF10M20	10	4.1	6.41	7.47	8.52	10.71	1.15	12.31	1.56	16.71
SF10M40	10	4.1	6.52	7.63	8.62	10.89	1.15	12.52	1.56	16.98
SF10M60	10	4.1	6.89	7.82	8.85	11.23	1.15	12.91	1.56	17.51
SF10M80	10	4.1	6.48	7.58	8.57	10.98	1.15	12.62	1.56	17.12
SF10M100	10	4.1	6.37	7.43	8.48	10.84	1.15	12.46	1.56	16.91

Table 7 Actual compressive Strength of prism with mortar mix ratio - 1:5

Mix	Mortar thickness (mm)	h/t	Compressive strength of prisms (Mpa)				Maximum Compressive strength of prisms (f_p)(Mpa) as per Code provision			
			Initial crack	Final crack	Initial crack	Final crack	IS:1905-1987		ASTM C1314	
			7days		28days		CF	f_p	CF	f_p
SCM	10	4.1	6.22	7.29	8.31	10.52	1.15	12.09	1.56	16.41
SF10	10	4.1	6.27	7.32	8.38	10.64	1.15	12.23	1.56	16.59
SF10M20	10	4.1	6.38	7.45	8.49	10.79	1.15	12.41	1.56	16.83
SF10M40	10	4.1	6.49	7.59	8.58	10.91	1.15	12.54	1.56	17.01
SF10M60	10	4.1	6.82	7.78	8.81	11.38	1.15	13.08	1.56	17.75
SF10M80	10	4.1	6.64	7.61	8.64	10.97	1.15	12.61	1.56	17.12
SF10M100	10	4.1	6.52	7.53	8.51	10.81	1.15	12.43	1.56	16.86

Table8 Actual compressive Strength of prism with mortar mix ratio - 1:6

Mix	Mortar thickness (mm)	h/t	Compressive strength of prisms (Mpa)				Maximum Compressive strength of prisms (f_p)(Mpa) as per Code provision			
			Initial crack	Final crack	Initial crack	Final crack	IS:1905-1987		ASTM C1314	
			7days		28days		CF	f_p	CF	f_p
SCM	10	4.1	6.18	7.28	8.28	10.48	1.15	12.05	1.56	16.34
SF10	10	4.1	6.21	7.35	8.34	10.56	1.15	12.14	1.56	16.47
SF10M20	10	4.1	6.34	7.41	8.45	10.75	1.15	12.36	1.56	16.77
SF10M40	10	4.1	6.44	7.54	8.56	10.92	1.15	12.55	1.56	17.03
SF10M60	10	4.1	6.78	7.73	8.78	11.34	1.15	13.04	1.56	17.69
SF10M80	10	4.1	6.61	7.64	8.62	10.92	1.15	12.55	1.56	17.04
SF10M100	10	4.1	6.54	7.52	8.51	10.79	1.15	12.41	1.56	16.83

The Fig. 2 shows a graph of the compressive strength of masonry prism for 7 and 28days using 1:4 cement. From table 6 and fig. 2, the compressive strength of masonry prism by 1:4 cement mortar with 10% replacement of cement by fly ash and 60% replacement by m-sand gets increased by 6.8% and 6.4% in 7 days and 28 days strength when compared to control mix. SF10MS60 gives maximum strength.

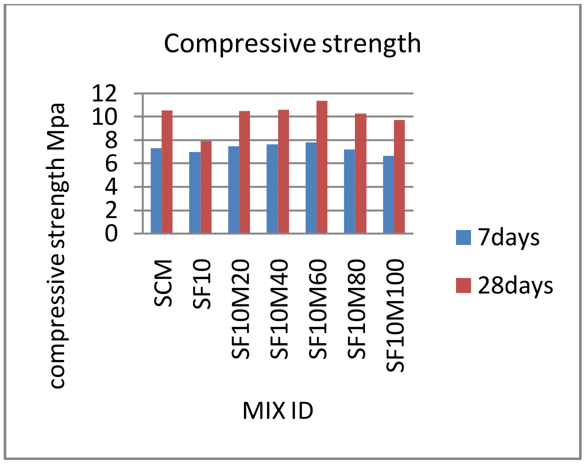

Fig. 2 Graph shows the compressive strength of masonry prism for 7 and 28days of mix ratio 1:4

The Fig. 3 shows a graph of the compressive strength of masonry prism for 7 and 28days using 1:5 cement.

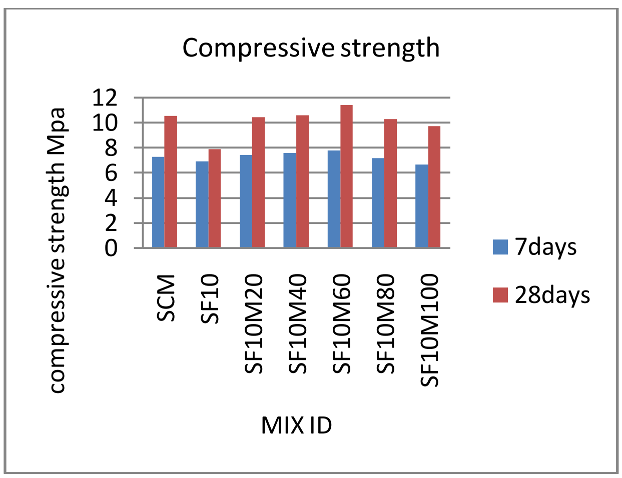

Fig. 4 Graph shows the compressive strength of masonry prism for 7 and 28days of mix ratio 1:6

From table 7 and fig. 3, the compressive strength of masonry prism by 1:5 cement mortar with 10% replacement of cement by fly ash and 60% replacement by m-sand gets increased by 6.7% and 8.17% in 7 days and 28 days strength when compared to control mix. SF10MS60 gives maximum strength.

The Fig. 4 shows a graph of the compressive strength of masonry prism for 7 and 28days using mix ratio1:6.

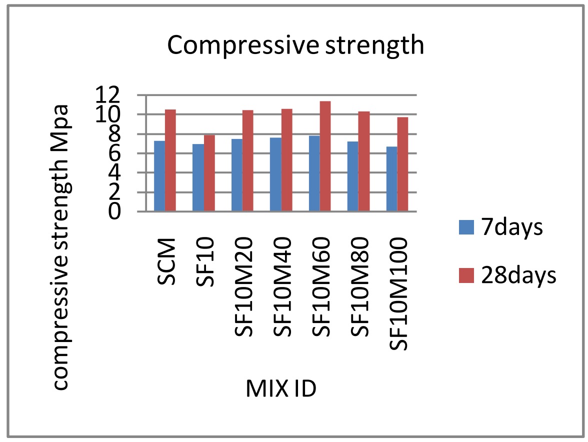

Fig. 3 Graph shows the compressive strength of masonry prism for 7 and 28days of Mix Ratio 1:5

From table 8 and fig. 4, the compressive strength of masonry prism by 1:6 cement mortar with 10% replacement of cement by fly ash and 60% replacement by m-sand gets increased by 6.18% and 8.2% in 7 days and 28 days strength when compared to control mix. SF10MS60 gives maximum strength.

VI. CONCLUSION

From the experimental study of the effect of using m-sand as a fine aggregate and cement partially replaced by fly ash, the following results are obtained.

- For the compression test on solid block using prism, we used three types of mortar mix viz. 1:4, 1:5 and 1:6. The compressive strength of masonry prism gets increased with the compressive strength of blocks and mortar.
- The strength of prism is increasing by changing the proportion, 10%fly ash, 10%fly ash & 20% m-sand, 10%fly ash & 40% m-sand, 10%fly ash & 60% m-sand, 10%fly ash & 80% m-sand and 10%fly ash & 100% m-sand.
- Among these 60% replacement of fine aggregate by m-sand with 10% fly ash in cement gives higher strength.
- And also the cement mortar mix 1:4 gives better performance and this is due to its high ultimate load carrying capacity.
- Cement mortar ratio is also depends on the environment, type of wall, internal or external wall plastering. If the wall does not carry much load, 1:6 mortar mix is more than enough because the wall is not carryingany structural load and it is constructed as a partition wall.
- Thecompressive strength of the masonry prism is compared with the code provision IS 1905-1987 and ASTM C1314 to get the actual compressive strength by using correction

factor (CF). Correction factor can be determined by using height to thickness ratio of the prism.

- As perIS 1905-1987 and ASTM C1314 the compressive strength of the prism gets increased by 14.92% and 55.96% after applying the respective correction factor.
- In our experimental work, replacing10%fly ash in cement and 60% m-sand in fine aggregate gives better result and it is considered as more suitable one.

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