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Evaluation of Workability and Strength of Fly Ash Based Solid Block Using M-Sand as Replacement of Fine Aggregate

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Abstract:

This paper aims to investigate the study of strength of fly ash based solid block using M-sand (MS) as replacement of fine aggregate. The cement is replaced by Fly ash (FA) at a constant proportion (10%). River sand (RS) is the commonly used fine aggregate in construction. Due to the high demand and less availability of RS, the cost of RS is increasing. So there is a need to find an alternative for RS. MS is an economical alternative for RS. Therefore, the fine aggregate is replaced by MS in proportions of 0%, 20%, 40%, 60%, 80% and 100%. The workability of concrete is determined by a slump cone test and compaction factor test. The mechanical properties of the concrete such as a compressive test for cube and solid block, split tensile strength, flexural strength and durability test. The concrete is placed in moulds, and they are cured and tested at 7, 28 and 90 days. The machine compressed concrete blocks are cured and tested. The results clearly state that the increasing amount of M-sand affects the strength of the block. From the results, it is found that the solid block mix designSF10MS60 has achieved the maximum compressive strength.

Keywords: *Fly ash, Compressive Strength, M-sand, Solid block, durability*

I. INTRODUCTION

Concrete block is one of the construction material since the 18th century. It is durable, cheap and commonly available one. Due to rapid industrialization and urbanization in the country, lots of infrastructure developments are taking place. So researchers introduced concrete blocks as a new building material. The usage of the concrete block has increased these days. RS is one of the most essential fine aggregate used in concrete blocks. Due to environmental restriction concrete block manufactures look an alternative for River sand. One such alternative is 'manufactured sand' it is the crushed granite stone. So the consumption of m-sand is increased in concrete industries. So, there is a need to find workability strength and durability of concrete blocks made by using MS.

The non-availability of sufficient quality of river sand for making cement concrete is affecting the growth of the construction industry in many parts of the country. Recently, the Tamilnadu government has imposed restriction on removal of sand from the river beds due to unsafe impacts threatening many parts of the state. Ordinary Portland cement is the most commonly used building material in the construction field, and it will retain its status shortly because of its demand and expansion of the construction industry. FA with shows pozzolanic properties are being used as a partial replacement in concrete is fineness less than cement to make a good bond between cement and FA.

The following observation was made in previous studies, Fly ash replacement of 0%, 25%, 50%, 75% and 100% concrete mix proportion is prepared in this experimental work. Workability, setting time, compressive strength and water contents fly ash effect are studied. From the result of this study, that the cement replacement by fly ash is useful in lower grades of cement such as M20. It can be stated that at 25% of replacement of cement by fly ash, there are considerable increases in strength properties [1],[2]. The M20 and M30 mix grade are taken. Slump cone, compaction factor and vee-bee time tests were conducted to determine workability [3], [4]. In this project, cement blocks are prepared from waste (dust) materials which comprise in roadways with the replacement of (0%, 25%, 50%, 75%, 100%). The density, water absorption, compression strength decreases with the increase in replacement of road dust [5]. The concrete mix is prepared by varying the proportions of fly ash for 30%, 40% and 50% of cubes and prisms cured in normal water for 28days and the respective test for concrete were done. Workability of concrete will be improved. The compressive strength of concrete will decrease with the increase of fly ash. [6]

In this study, the block cast is made up of replacement of fly ash 10% is instead of cement and m-sand and 0%, 20%, 40%, 60%, 80% and 100%. The concrete is prepared in correct proportion, and workability test are conducted. The moulds are oiled, and concrete is placed and cured for 28days. After curing blocks are tested at 7days, 28days and 90days.

II. MATERIAL USED

A. Cement

Cement is being used since the advent of human civilization; the development of cement is from the 18th century. The cement is a binder that sets, hardens and adheres to other material. Ordinary Portland cement (OPC) of grade 53 is used. Ultra Tech cement is used throughout the project. The properties of the cement used in this study are tabulated in Table 1.

Table 1 Properties of Cement

Properties	Result
Initial setting time	55min
Final setting time	210min
Fineness	7%

B. Fly Ash

FA or flue ash is a by-product of power generating plants from burning coal. Depending on the chemical and physical properties, both fly ash and cement exhibits cementations properties. Locally available FA is taken, and laboratory tests are conducted. The properties of the Fly Ash used in this study are tabulated in Table 2.

Table 2 Properties of Fly ash

Properties	Test Value
Particle retained on 45micron IS sieve in %	34
Water req. In % control	105
Soundness by Autoclave test	1.8

C. Fine Aggregate

Fine aggregate is usually natural sand. It is a natural source of granular substances. Its quality depends on the nature of rock present at that local. The fine aggregate quality influence the strength of the concrete, the size of aggregate less than 4.5mm is fine aggregate. The properties of the River Sand used in this study are tabulated in Table 3.

Tables 3 Properties of River Sand

Properties	Test Value
Specific Gravity	2.6
Density	1669 Kg/m^3
Water absorption	1.49%

D. M-Sand

M-sand or ‘manufacture sand’ is an alternative for river sand. In the development of the construction industry, the tremendous demand for river sand is increasing due to depletion of river sand next alternative for river sand is m-sand. The m-sand is a dust-free and size free of the m-sand is easily controlled. MS of size 4.7mm to 75μ is used. The properties of the M sand used in this study are tabulated in Table 4.

Table 4 Properties of M-Sand

Properties	Test Value
Specific gravity	2.48
Density	1.73 Kg/m^3
Water absorption	2.36%

E. Coarse Aggregate

Aggregate is mostly mined material in the world. The particle size greater than 4.75mm are commonly known as aggregate, and the maximum size of the aggregate is 40mm. The Locally available 6mm size aggregate is used. The properties of the coarse aggregate used in this study are tabulated in Table5.

Table 5 Properties of coarse aggregate

Properties	Test value
Specific gravity	2.60
Density	1672 Kg/m^3
Water absorption	0.82%
Crushing value	20.43%
Impact value	13.2%

III. MIX PROPORTION

The mix proportion of the solid blocks used is shown in Table 6. The Solid blocks and all other test specimens are cast as per the mix proportion in Table 6, as per IS10262:2009 “Code of concrete mix proportioning guidelines” mix design is designed.

Table 6 Mix Proportion of Solid Block

Mix design	Cement (Kg/m^3)	Fly ash (Kg/m^3)	M-sand (Kg/m^3)	Coarse aggregate (Kg/m^3)	Fine aggregate (Kg/m^3)	Water (Kg/m^3)
CM	400	-	1130	850	-	240
FA10	360	40	1130	850	-	240
FA10MS20	360	40	1130	380	170	240
FA10MS40	360	40	1130	510	340	240
FA10MS60	360	40	1130	340	510	240
FA10MS80	360	40	1130	170	680	240
FA10MS100	360	40	1130	-	850	240

IV. EXPERIMENTAL INVESTIGATION

A. Water Absorption test

Three full-size blocks are wholly immersed in clean water at room temperature for 24hours. The block allows for draining for one minute by placing them on a 10mm or a coarse wire mesh, visible surface water being removed with a damp cloth, saturated and surface dry blocks immediately weighted. After weighing all the blocks are dried in a ventilated oven at 100ºC to 1150ºC for not less than 24 hours and until two successive weighings at intervals of 2hours increment of loss not greater than 0.2 per cent of the lost previously determine the mass of the specimen.

B. Compressive Test

Compressive strength or compression strength is the capacity of material or structure to withstand load tend to elongate. In other words, compressive strength resists compression (being pushed together), whereas the tensile strength, shear strength can be analyzed independently.

Compressive strength is the key value for design structure. Compressive strength is often measured in Universal Testing Machine (UTM). 53MN tabletop systems are used.

C. Split Tensile Test

The split tensile strength is the most important test to find the size of cracking in the structures cast. Concrete is weak in tension, so it gives accurate crack failure. Split tensile strength on the cylinder to determine the tensile of concrete. It is an indirect test conducted on concrete to find the tensile strength.

D. Flexural Strength

Flexural strength is to measure the bending failure of concrete in an un-reinforced concrete beam or Slab. It is used to find the quality of the concrete. It is found in two methods three-point and four-point method.

E. Acid Test

To study the Effect of exposure to acidic environment, specimens are immersed in 3% solution of sulphuric acid. The solution is replaced at regular interval to maintain the concentration of solution throughout the test period. After removing the specimen from the solution, the surfaces were cleaned under the running tap water to remove the weak product and loose material from the surface. Later the specimens are allowed to dry, and measurements are taken. From the initial measurements and measurements at particular intervals, the loss or gain of the weight are studied.

F. Slump cone Test

To determine the workability (or), consistency of concrete slump cone test is conducted. It is conducted to know the mix proportion, material quality and various properties.

G. Compaction Factor test

Compaction factor test is to find the workability of the concrete. It is a laboratory test. Concrete with low workability does not suit slump cone, so the compaction factor test is used.

V. RESULT AND DISCUSSION

The concrete cubes cast with cement replacement of fly ash 10% and partial replacement m-sand for fine aggregate are tested for compressive strength. Split tensile, flexural strength is also tested. The following observations made are tabulated in Table 7, Table 8 and Table 9 shows the compressive strength of Cube and Solid Blocks.

Table 7 states that the maximum result obtained in the fly ash 10%(FA10) than other mix proportions. From this FA10 is taken for future nix proportions.

Table 7 Compressive strength of cube by partial replacement of cement with FA

Mix Design	7 days (N/mm^2)	28 days (N/mm^2)	90 days (N/mm^2)
CM	12.73	18.02	18.47
FA5	12.81	18.12	18.52
FA10	13.16	18.53	18.78
FA15	13.02	18.39	18.71
FA20	12.94	18.21	18.57

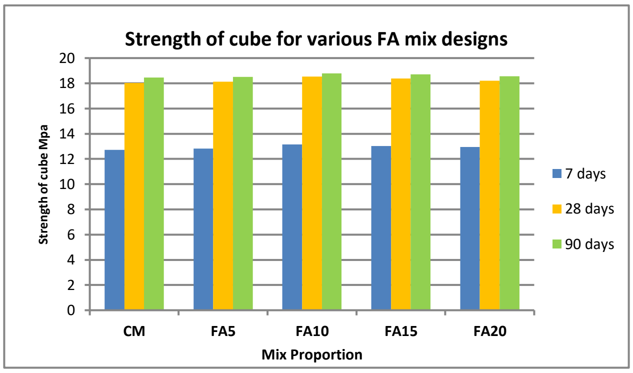

Fig.1 Compressive strength of cube partial replacement FA

Table 8 Compressive strength of cube for 10% FA and various proportion of MS replacement

Mix Design	7 days (N/mm^2)	28 days (N/mm^2)	90 days (N/mm^2)
CM	12.97	18.34	18.39
FA10	12.99	18.42	18.45
FA10MS20	13.03	18.69	18.72
FA10MS40	13.59	19.16	19.18
FA10MS60	14.37	19.87	19.95
FA10MS80	13.92	19.59	19.76
FA10MS100	13.85	18.85	19.27

From table 8, it is assured that the MS 60% replacement (FA10MS60) shows maximum result than other mix proportions.

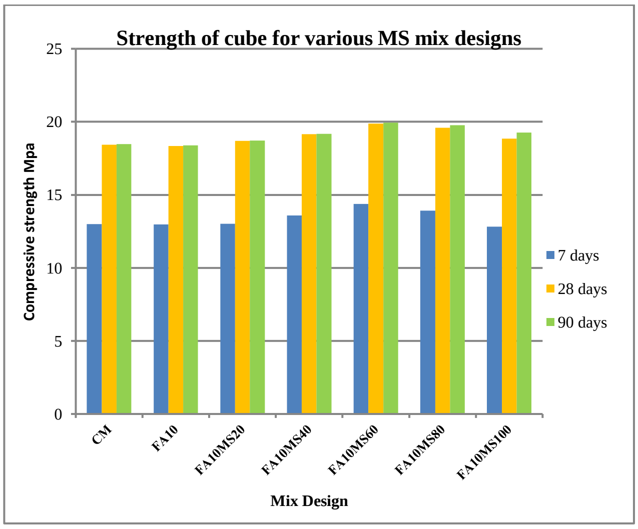

Fig. 2 Graph showing compressive strength of cube for a various proportion of MS

The fig.1 and fig. 2 states the Compressive strength of cube partial- replacement of FA and compressive strength of cube for various mix proportions.

Table 9 Compressive strength of Solid block

Mix Design	7 days (N/mm^2)	28 days (N/mm^2)	90 days (N/mm^2)
CM	5.75	10.57	10.66
FA10	5.78	10.61	10.61
FA10MS20	6.52	10.63	10.84
FA10MS40	7.16	11.09	11.53
FA10MS60	7.86	12.22	12.41
FA10MS80	6.72	11.29	11.67
FA10MS100	6.18	11.01	11.24

The strength attained in the solid block is more at MS 60% replacement gives good results when compared to another per cent of MS replacement mix proportions.

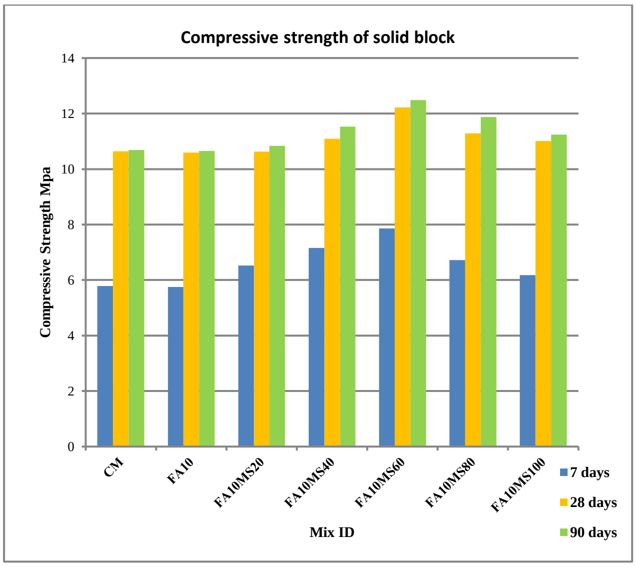

Fig. 3 Graph showing Compressive Strength of Solid block for different Curing Stages

The table 10 and table 11 shows the observations made on split tensile strength and flexural strength of different mix design made,

Table 10 Split tensile strength of concrete

Mix Design	7 days (N/mm^2)	28 days (N/mm^2)	90 days (N/mm^2)
CM	1.71	2.94	3.89
FA10	1.74	2.97	3.93
FA10MS20	1.79	3.11	3.95
FA10MS40	1.82	3.64	4.02
FA10MS60	2.29	4.02	4.85
FA10MS80	2.02	3.97	4.67
FA10MS100	1.78	3.64	4.43

From above-tabulated observations, when compared to other MS per cent replacement, MS 60% shows good result.

Table 11 Flexural strength of concrete

Mix design	7 days (N/mm^2)	28 days (N/mm^2)	90 days (N/mm^2)
CM	3.6	3.8	5.6
FA10	3.7	4.0	5.8
FA10MS20	4.2	4.5	6.7
FA10MS40	4.9	5.0	6.9
FA10MS60	5.4	5.8	7.4
FA10MS80	5.1	5.4	7.1
FA10MS100	3.8	4.3	6.5

The following observation made is tabulated in Table 12 explain the workability of concrete,

Table 12 Slump and Compaction factor value

Mix design	Slump (mm)	Compaction factor
CM	41	0.84
FA10	44	0.87
FA10MS20	53	0.82
FA10MS40	57	0.95
FA10MS60	68	0.97
FA10MS80	64	0.91
FA10MS100	45	0.93

The following observations made in table 13, table 14, table 15, table 16, table 17, and table 18 shows the durability of concrete,

Table 13 Weight loss of concrete in HCL

Mix design	% weight loss		
	7 days	28 days	90 days
CM	2.49	2.55	3.27
FA10	2.47	2.52	3.23
FA10MS20	2.41	2.48	3.20
FA10MS40	2.37	2.39	3.15
FA10MS60	2.15	2.23	3.02
FA10MS80	2.22	2.28	3.10
FA10MS100	2.25	2.31	3.18

Table 14 Strength loss of concrete in HCL

Mix Design	Strength loss %		
	7 days	28 days	90 days
CM	3.27	7.93	11.29
FA10	3.23	7.89	11.25
FA10MS20	3.20	7.74	11.03
FA10MS40	3.16	7.69	11.00
FA10MS60	3.09	7.55	10.95
FA10MS80	3.13	7.64	11.08
FA10MS100	3.38	7.95	11.32

The weight loss of concrete in HCL solution and strength loss per cent of concrete in HCL solution are tabulated in table 13 and table 14 explain that the low exposure of concrete is obtained in MS replacement of 60 %. (FA10MS60).

Table 15 Weight loss of concrete in H_2SO_4

Mix design	% weight loss		
	7 days	28 days	90 days
CM	1.89	2.46	3.16
FA10	1.82	2.45	3.12
FA10MS20	1.76	2.35	3.09
FA10MS40	1.66	2.27	2.97
FA10MS60	1.42	2.39	2.86
FA10MS80	1.75	2.41	2.95
FA10MS100	1.92	2.48	2.98

Table 16 Strength loss of concrete in H_2SO_4

Mix design	% strength loss		
	7 days	28 days	90 days
CM	2.54	6.28	7.95
FA10	2.48	6.23	7.92
FA10MS20	2.45	6.18	7.88
FA10MS40	2.42	6.16	7.84
FA10MS60	2.25	6.12	7.79
FA10MS80	2.45	6.23	7.85
FA10MS100	2.56	6.31	7.98

The weight loss per cent and strength loss per cent of concrete in H_2SO_4 solution results are tabulated in above table 15 and table 16 it states that the minimum value is achieved in MS 60% replacement.

Table 17 Weight loss of concrete in NaOH

Mix design	Weight loss %		
	7 days	28 days	90days
CM	1.77	2.24	2.78
FA10	1.74	2.22	2.74
FA10MS20	1.65	2.20	2.54
FA10MS40	1.54	2.14	2.46
FA10MS60	1.39	2.05	2.37
FA10MS80	1.64	2.15	2.42
FA10MS100	1.81	2.29	2.81

Table 18 Strength loss of concrete in NaOH

Mix design	% strength loss		
	7 days	28 days	90 days
CM	2.28	3.14	3.96
FA10	2.22	3.11	3.94
FA10MS20	2.13	2.98	3.88
FA10MS40	2.08	2.93	3.81
FA10MS60	1.98	2.84	3.76
FA10MS80	2.11	2.94	3.82
FA10MS100	2.31	3.16	3.98

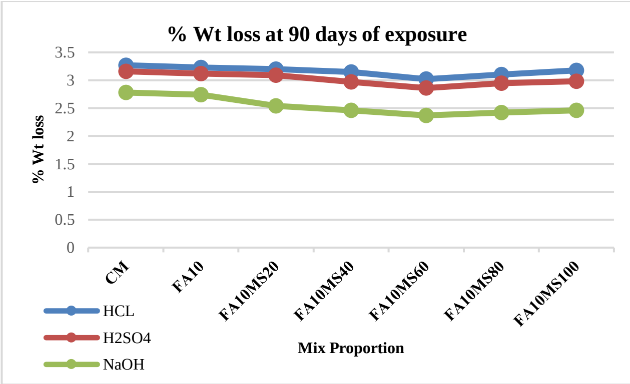

Fig. 4 Weight loss percent at 90 days

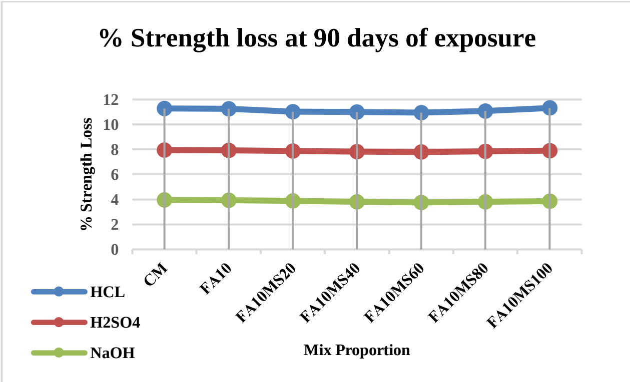

Fig. 5 Strength loss per cent at 90days of exposure

Figure 4 and Figure 5 represent the 90 days exposure result of concrete in HCL, H_2SO_4 and NaOH solutions.

The following observation in Table 19 shows the water absorption percentage of the mix design

Table 19 Water absorption of concrete cube

Mix Design	Average water absorption %	
	7 days	28 days
CM	5.63	6.71
FA10	5.59	6.68
FA10MS20	5.32	6.61
FA10MS40	5.25	6.53
FA10MS60	4.92	5.87
FA10MS80	5.07	5.93
FA10MS100	5.66	6.74

The observation in Table 20 shows the density of the blocks,

Table 20 Density of concrete blocks

Mix design	Density (Kg/m^3)
CM	1671
FA10	1614
FA10MS20	1783
FA10MS40	1961
FA10MS60	2004
FA10MS80	2087
FA10MS100	2109

The maximum strength obtained in the tests conducted above clearly states that the fly ash replacement 10% of cement and m-sand 60% replacement gives the maximum the strength than other mix designs.

VI. CONCLUSION

The primary conclusion from the tests conducted on fly ash replacement in cement and partial replacement of m-sand in fine aggregate in concrete is,

1. The replacement of cement by FA at mix proportion from 5%, 10%, 15% and 20% by cement weight. FA 10% replacement gives good strength than other mixes.
2. The MS is the best alternative for RS; it gives better result in tests conducted but, not more than 60% replacement MS in RS.
3. The increase in fly ash content in concrete decreases the strength of the concrete, the fly ash at 10% gives a better result in the strength of concrete.
4. Therefore, Fly ash replacement of cement 10% and partial replacement of m-sand by river sand at 60% shows the better result(FA10MS60).
5. The compressive test, split tensile strength and flexural strength 90 days test results for FA10MS60 are 19.95Mpa, 4.85Mpa and 7.4Mpa, which are the maximum result than other mix proportions.
6. The Durability test also shows promising result in FA10MS60.
7. Usage of FA in concrete does not affect the strength of concrete, and it reduces the waste dumping of FA in the soil.
8. The MS is the best alternative for river sand in increasing demand for sand in the construction industry.

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