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An Experimental Study on Behaviour of Alkali Activated High Volume Flyash Concrete

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ABSTRACT
In today's world the need for replacement of conventional building material in construction industry is highly emphasized. As far as considering first half year of 2020 – 2021, only about 57.93 percent of total fly ash produced in India was utilized. The remaining was disposed by means of landfills which pollute environment. In order to increase the amount of fly ash utilized in construction, various new concepts were discussed throughout the world. Out of which the promising fields are high volume fly ash concrete and geopolymer. Here in this report the works carried out by various researchers throughout the world in the above mentioned fields are discussed. Their work resulted in using of high volume of fly ash in concrete with low shrinkage, low heat evolution during hydration, increased workability, and low density of concrete. The works in geopolymer concrete obtained the results as increased use of fly ash, high strength and acid resistant, similar behavior to RC elements. Further more the methodology will be proposed for the project.
Keywords: *Analysis , concrete , geopolymer , building , cement*

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I. INTRODUCTION

1.1 GENERAL

In this paper, the works carried out by various researchers regarding high volume fly ash concrete and geo polymer are discussed. Based on the literature study, the methodology and future work process of the project will be discussed

1.2 INTRODUCTION

Construction industry which is rather growing at rapid phase due to the rapid advancing economy and rising standards of living and to meet the requirements of people. This rapid increase leads to increase in use of natural resources which are depleting alarmingly without the source to replenish it. Due to that reason we are forced to exploit other resources that are left behind during development of a society as waste. The concept of Reduce Recycle Reuse has now garnered tremendous attention by the people of present decade. In construction industry, the concept of reuse has lead to development of various alternatives to replace traditional practices from concreting to painting. The novel among them are use of fly ash as partial replacement for cement , mountain sand in place of river sand and use of blended cements. These alternatives have gained more approval over the decade.

Researches are carried out by many across the world to replace the ingredients of conventional concrete with alternate materials without exploiting natural resources. The ideas are complete replacement of cement by fly ash, coarse aggregate by recycled aggregates and other such ideas are being exploited.

II. MATERIAL PROPERTIES

CEMENT

Conventional Portland concrete (OPC) affirming to IS 8112 (53 Grade) was utilized for the test work. The tests were conducted on cement to determine specific gravity, fineness, standard consistency, initial setting time and final setting time. The properties of cement are present in table 1.

Table 1.Properties of Cement

Particulars	Values
Grade	OPC 53 Grade
Specific gravity	3.15

Fineness	4%
Standard consistency	35%
Initial setting time	45 minutes

FINE AGGREGATE
Good quality river sand was used and it is tested to determine the different physical properties as per 1S 383 (Part III)-1970. River sand having fineness modulus 3.2 and specific gravity 2.67.
COARSE AGGREGATE
Natural aggregates were used to manufacture specimens for the control mix to be compared with that of the proposed mixes. Coarse aggregate having fineness modulus 7.2 and specific gravity 2.81.
Fly Ash
Class F fly ash produced from Mettur thermal power plant, Tamil Nadu is used. The specific gravity of fly ash is 2.38..

Table 2 Chemical Composition of fly ash

Compound	Mass (wt. %)
SiO2	40.80
Al2O3	15.70
Fe2O3	18.48
TiO2	1.02
CaO	16.10
MgO	3.30
SO3	1.50
K2O	1.79
MnO	0.16
BaO	0.27
SrO	0.11

Alkaline Activator Solution
The alkaline activator solution (AAS) plays an important role in Geopolymer concrete. The AAS is the combination of sodium hydroxide and sodium silicate solutions. The on centration of NaOH solution can vary in the range between 8M to 16M; in this study, 8M, 10M, 12M is considered. Preparation of NaOH for 12M is 12 x 40 (Molecular weight) = 480gms should dissolve in 1 litter of water. After mixing the NaOH flakes in water its molecular weight reduces to 361gms for 12 Molarity. For 12M NaOH solution, for 1 litter of water we require 36.1% of NaOH flakes and 63.9% of water. The solution must be prepared at least 24 hours before to use.

Concrete
Based on the aggregated properties obtained according to the aforementioned IS standards, the concrete mix proportions were designed to achieve the strength of 30 N/mm2 (M30) as mentioned in annexure 1. The mix proportion of the concrete is to be designed. A constant water to cement ratio (W/C) was observed for all mixtures, and the value was about 0.40. A test is performed to determine the 28 days compressive strength of concrete using 150mmx150mmx150mm cubes.

III. EXPERIMENTAL INVESTIGATION

WORKABILITY TEST
Workability of conventional and high volume fly ash concrete was determined at different NaOH concentration level. The result of workability in terms of slump is given in table 3. The same results are shown in graphical form in figure for visual observation.

Table 3: Slump

Mix	w/c	Slump (mm)
M0		88
M1		83
M2	0.4	78
M3		80
M4		85

From Fig 1, it is evident that there is increase in workability is increased in high volume fly ash concrete in both with and without alkali solution compared to conventional concrete. However increased workability is shown by mix M1

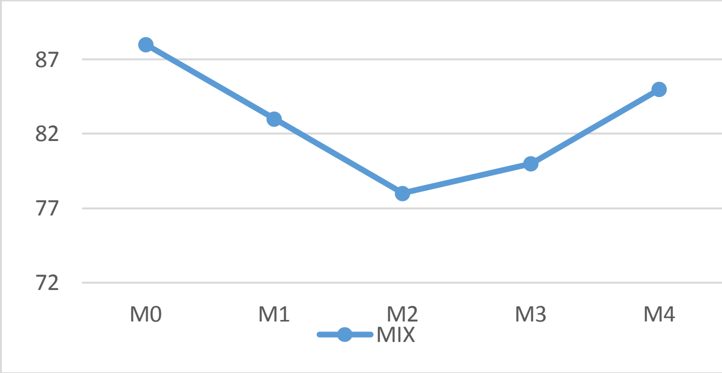

FIG 1 Variation in slump for design mix proportion

COMPRESSIVE STRENGTH

To obtain optimum compressive strength in concrete, a design mix proportion has been designed. Compressive strength of different batch of concrete was tested for 7 days & 28 days, through compressive testing machine. The cubes were cured in water at 27ºC ±3ºC.

FIG : 2 Compressive strength test

Table 4. Compressive Strength Test (7 & 28 Days)

Mix	Compressive strength (MPa)	
	7 days	28 days
M0	18.5	35.12
M1	16	31.56
M2	17	34.25
M3	17.83	40.72
M4	18.05	33.25

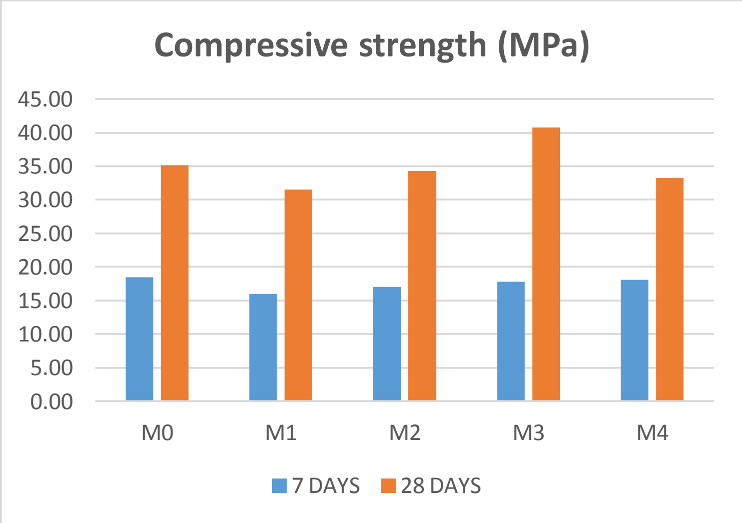

Fig 3: Variation in compressive strength for design mix

On observation it is found that mix M1 shows 10% decrease in strength, M2 shows 2.5% in decrease, M3 shows 16% increase in strength and M4 shows 5% decrease in strength in comparison to the conventional concrete M0.

Therefore from fig 3, it can be observed that compressive strength of M1 is 10 % lesser than that of M0 which is conventional concrete. How ever there is increase in strength upon addition of alkali activator solution. The mix with high strength compared to all mix is M3, shows increase in strength up to 16 %, which has 10 M NaOH solution is 40.12 Nmm-2. But when the concentration is further increased to 12M, the compressive strength of M4 decreases about 5% than that of conventional concrete. Therefore it is ascertained that mix M3 with 10M NaOH solution is optimal.

FLEXURAL STRENGTH

The flexural strength results of the beam mould were determined by curing for 7 and 28 days and the results are given in table. The beam moulds of 29 size 100mm x 100 mm x 500 mm were used with three trials for each combination.

Fig :4 Flexural strength Test

Table 5. flexural strength Test (7 & 28 Days)

Mix	Flexural strength (MPa)	
	7 days	28 days
M0	4.5	7.55
M1	4.12	7.08
M2	4.65	7.48
M3	5.05	7.95
M4	4.55	7.4

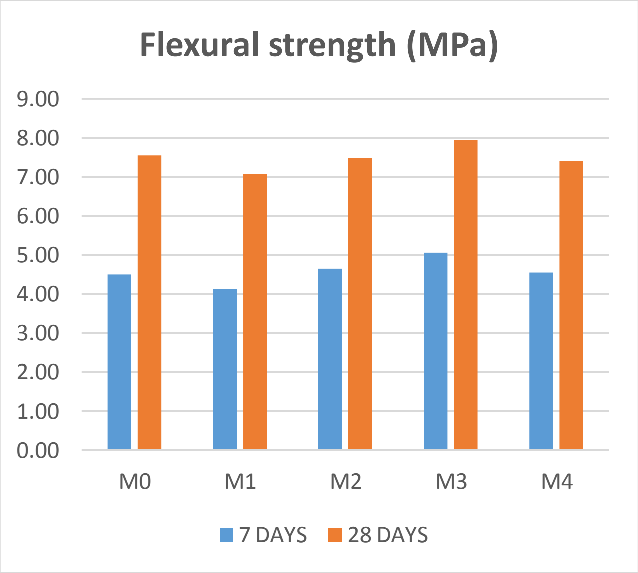

Fig:5 Variation in flexural strength for design mix

The percentage change in the flexural strength of the mixes helps in better understanding. On comparison with conventional concrete M0, mix M1 showed 1% decrease in flexural strength, mix M2 showed 1% decrease in strength while M3 showed 5% increase in strength and mix m4 showed 2% decrease I the strength.
From fig 5, it is evident that there are no significant changes in flexural strength of concrete upon addition of high volume of fly ash with or without alkali solution. However the optimal mix will be M3 as it shows 5% increase in flexural strength however small it may be.

sSPLITTING TENSILE STRENGTH
The tensile strength results of the cylinder mould were determined by curing for 7 and 28 days and the results are given in table. The cylinder moulds of diameter 100mm and height 300mm were used with three trials for each combination

Table 6 Tensile strength of specimens (7&28 Days)

Mix	Splitting Tensile strength (MPa)	
	7 days	28 days
M0	1.5	5
M1	1.25	4.95
M2	1.3	5.05
M3	1.42	5.2
M4	1.33	5.1

The comparison of the HVFA mix (M1, M2, M3, and M4) with alkali activator solution with the conventional mix M0 provided us with the required results. The mix M1 showed 1% decrease in splitting tensile strength, mix M2 showed 1% increase in strength while mix M3 showed 4% increase in strength and mix M4 showed 2increase in strength in comparison to conventional mix M0. From fig 6.4, it is evident that there are no significant changes in tensile strength of concrete upon addition of high volume of fly ash with or without alkali solution. Though the increase in strength is minimal, mix M3 is considered to be optimal mix as it showed higher increase in strength compared to other mixes.

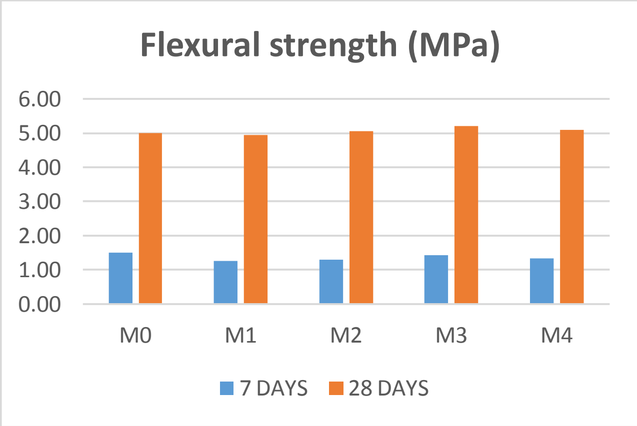

Fig 6: Variation in splitting tensile strength for design mix

FLEXURAL BEHAVIOUR OF RC BEAM

The beam which is casted as per design calculation in annexure 2 loaded into the loading frame for testing after 28 days curing. The two point loading is done to determine the deflection of the beam. The loading carried out until the beam fails. The load and the corresponding deflection are noted using load cell
and dial gauge respectively. The table shows the deflection of the RC beam element cast using mix M0 and M3 for the load
From figure 7, it can be ascertained that there is no significant change in regards to deflection of the beam element. So the RC elements of both the mixes M0 and M3 behave similarly.

IV. CONCLUSION

- Workability of the concrete increases with addition of high volume of fly ash.
- There is increase in compressive strength of high volume fly ash concrete upon addition of alkali activator solution.
- However increase in molarity of sodium hydroxide solution results in decrease in strength of concrete
- Mix with 10 M NaOH solution has strength higher than that of conventional concrete
- In spite of increase in compressive strength, there is an only slight change in flexural strength of concrete.
- There is no significant change in tensile strength of high volume fly ash concrete with or without alkali activator.
- Behaviour of high volume fly ash concrete RC element with alkali activator solution acts similar to that conventional concrete RC element.

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