Effect of Quality of Fly Ash on Concrete

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Abstract— **At present, large quantity of fly ash is being dumped in slurry form in large areas close to the power plants without being put to gainful use in India. Only a very small percentage (<35%) of fly ash generated in India is being used for gainful applications whereas the corresponding figures of other countries may vary from 60 to 100%[2].**

Although fly ash offers environmental advantages, it also improves the performance and quality of concrete. Fly ash affects the plastic properties of concrete by improving workability, reducing water demand, reducing segregation and bleeding, and lowering heat of hydration. Fly ash increases strength, reduces permeability, reduces corrosion of reinforcing steel, increases sulphate resistance, and reduces alkali-aggregate reaction. Fly ash reaches its maximum strength more slowly than concrete made with only portland cement. The techniques for working with this type of concrete are standard for the industry and will not impact the budget of a job. So as a Civil Engineer we should effectively try to use fly ash in construction, as it helps in saving environment with reduced construction cost along with many other advantages, but now question rises to what extent or percentage fly ash could be used in concrete for construction works, and to answer this present study have been made. The scope of present study aims at providing the M40 concrete with an optimum quantity of fly ash content that could be used in structural work/ road construction with acceptable strength values such that the cost of construction may be reduced to a great extent. Moreover, it also helps in reducing the harmful impact of fly ash on environment.

Key Words : Partial Replacement, Marble Powders, Flexural Strength, Compressive Strength

Sub Area : Construction Technology & Management

Broad Area :Civil Engineering

INTRODUCTION

Concrete, typically composed of gravel, sand, water, and portland cement, is an extremely versatile building material that is used extensively worldwide. Reinforced concrete is very strong and can be cast in nearly any desired shape. Unfortunately, significant environmental problems result from the manufacture of Portland cement. Worldwide, the manufacture of Portland cement accounts for 6-7% of the total carbon dioxide (CO_2) produced by humans, adding the greenhouse gas equivalent of 330 million cars driving 12,500 miles per year[1].

Fortunately, a waste product Fly Ash can be substituted for large portions of Portland cement, significantly improving concrete's environmental characteristics. Fly Ash, consisting mostly of silica, alumina, and iron, forms a compound similar to Portland cement when mixed with lime and water. Fly ash is a non- combusted by-product of coal-fired power plants and generally ends up in a landfill. However, when high volumes are used in concrete (displacing more than 25% of the cement), it creates a stronger, more durable product and reduces concrete's environmental impact considerably. Due to its strength and lower water content, cracking is reduced.

In the HVFAC mechanism, physical and chemical factors combines at all ages to densify and bind the paste. In the early age of concrete, the important factors of strength development are

Physical effect - fine particles of fly ash act as micro aggregates and densify the mass

Chemical contribution of the formation of ettringite or related sulpho-aluminate production.

In the later age hydration reaction dominate in the strength development process as additional binders are generated by reaction involving fly ash. Any concrete that uses more fly ash than 25% (weight of cement) would be considered high volume fly ash concrete. With high volume fly ash concrete, you will see less early age strength, but the long term strength is about the same as with normal concrete.

Objectives

The main objective of the present study is to compare the strength characteristics of M40 concrete by using sample of different percentages of fly ash by mass of cementetious material, and also comparison is made between there cost. To achieve this objective following steps are to be followed:

1. Design of M40 concrete mix to obtain the ratio of different components of concrete.
2. By using the above calculated ratio samples for compressive and flexural strength test for 28%, 50%, 70% replacement of cement by fly ash is to be made.
3. Compressive strength of 3,7 and 28 days is to be calculated by casting cubes for M40 mix at 28%, 50% and 70% fly ash replacement by cement.
4. Flexural strength of 28 and 56 days is to be calculated by casting beam shaped samples of M40 mix at 28%, 50% and 70% fly ash replacement by cement.
5. Comparison of the compressive and the flexural strength obtained at different percentages of fly ash is to be made.
6. Cost comparison of 28%, 50% and 70% fly ash concrete is to be made.

Manuscript received April 27, 2017

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EFFECT OF QUALITY OF FLY ASH ON CONCRETE

The characteristics of fly ash depends upon the characteristics of coal burnt in the furnace of boiler, degree of pulverization of coal, rate and temperature of combustion, fuel air ratio etc. The important characteristics, which affect the performance of fly ash in concrete, are:

1. Loss on Ignition (LOI)
2. Fineness
3. Calcium (CaO) content

1) Loss on Ignition

When fly ash is burnt at about 1000^0C, it suffers a loss of weight through the presence of carbonates, combined water in residual clay mineral and combustion of free carbon. The combined effect is termed the LOI. The carbon contained in fly ash has high porosity and a very large specific area and is able to absorb significant quantity of water as well as admixture. Thus increase water and admixture requirement and affect properties of concrete. It may be stated that lower the LOI, the better will be the fly ash.

2) Fineness

Fineness of fly ash, which is also represented in terms of specific surface area, is determined by Blaine method. This method is based on the resistance offered by material to airflow. More the surface area greater will be fineness. Fineness is also determined by wet sieve analysis and represented in terms of amount retained when wet-sieved on 45 micron (No. 325) sieve. Finer fly ash will have more reactive surface area available to react with lime and thus more will be the pozzolanic activity of fly ash. In short, it can be concluded that finer the fly ash and lower the carbon content, the greater will be the pozzolanic activity and greater the contribution to the strength in concrete of the same workability.

3) Calcium (CaO) content

Fly ash consist of large amount of noncrystalline particles or glass and small amount of one or more of the four major crystalline phases; quartz, mullite, magnetite and hematite. The reactivity of fly ash is related to the noncrystalline phases or glass. Pozzolanic reactivity of fly ash is more in high calcium fly ash than low calcium fly ash. The reason for high reactivity in high calcium fly ash partially may be because of different chemical composition of glass than the glass of low calcium fly ash.

Compressive Strength Test:

The test was conducted according to IS 516-1959[41]. Specimens were taken out from curing tank at the age of 3,7 and 28 days and tested by air drying the samples. The position of cube while testing was at right angles to that of casting position. The load was gradually applied without any shock and increased at constant rate of 14 N/mm2/minute until failure of specimen takes place. It was tested on compression testing machine.

Flexural Strength:

The beams were taken out from the tank at the age of 28 and 56 days of curing and tested after the specimens are air dried. The test was performed by two point loading method (IS.516-1959[41]) on flexural testing machine.

In this chapter the results of compressive and the flexural test on the concrete mixes with 28%, 50% and 70% fly ash by the mass of cement are presented and discussed. Comparison of the results are made, in order to present the ideas of the present study. First the compressive strength test results are discussed followed by the results of flexural strength test.

COMPRESSIVE STRENGTH

The compressive strength results with different percentage replacement (28%, 50% and 70%) of cement by fly ash in concrete at 3, 7 and 28 days of curing are shown in Table 6.1 (a, b, c) and Table 6.2. These results are expressed graphically in Fig 6.1.

FLEXURAL STRENGTH

The flexural strength results with different percentage replacement (28%, 50% and 70%) of cement by fly ash in concrete at 28 and 56 days of curing are shown in Table 6.3 (a, b, c) and Table 6.4. These results are expressed graphically in Fig 6.2.

DISCUSSION

The following points are needed to be discussed from Fig 6.1 and 6.2:

The compressive strength of 28 days of 50% fly ash concrete is only 12% less than the 28% fly ash concrete.

The compressive strength of 28 days of 70% fly ash concrete is much low (43%) than the 28% fly ash concrete.

The flexural strength at 28 and 56 days for 50% fly ash concrete is 18% and 10% respectively less than the 28% fly ash concrete. This shows fly ash gives less early age strength but increases the latter age strength.

The flexural strength of 28 and 56 days of 70% fly ash concrete is 66% and 50% respectively less than the 28% fly ash concrete. This is a huge difference and is not accepted.

Results obtained of 28% and 50% fly ash concrete are good and acceptable.

The results obtained of 70% fly ash concrete are comparable to M25 concrete.

The cost comparison of these will be done in next chapter.

Table 6.1 (a): Compressive strength of M40 concrete for 28% fly ash content.

Sr.No	% Fly Ash Concrete	Curing Period (days)	Compressive Strength (N/mm²)	Average Compressive Strength(N/mm²)
1.	28%	3	25 22 26	24.33
2.	28%	7	34 28 35	32.33
3.	28%	28	46 45 47.05	46.60

Table 6.1 (b): Compressive strength of M40 concrete for 50% fly ash content.

Sr.No	% Fly Ash Concrete	Curing Period (days)	Compressive Strength (N/mm^2)	Average Compressive Strength(
1.	50%	3	19.5 20.20 20.50	20.03
2.	50%	7	27.40 25.80 25.10	26.10
3.	50%	28	42.00 41.00 40.00	41.00

Table 6.1 (c): Compressive strength of M40 concrete for 70% fly ash content.

Sr.No	% Fly Ash Concrete	Curing Period (days)	Compressive Strength	Average Compressive
1.	70%	3	8.57 11.02 11.47	10.34
2.	70%	7	15.3 15.00 14.40	15.00
3.	70%	28	29.00 27.00 25.00	27

Table 6.2: Combined Table of Compressive strength of M40 concrete for 28%, 50% and 70% fly ash content.

Percent Fly Ash Concrete	3 Days Curing (Mean Mpa)	7 Days Curing (Mean Mpa)	28 Days Curing (Mean Mpa)
28%	24.33	32.33	46.6
50%	20	26.1	41
70%	10.3	15	27

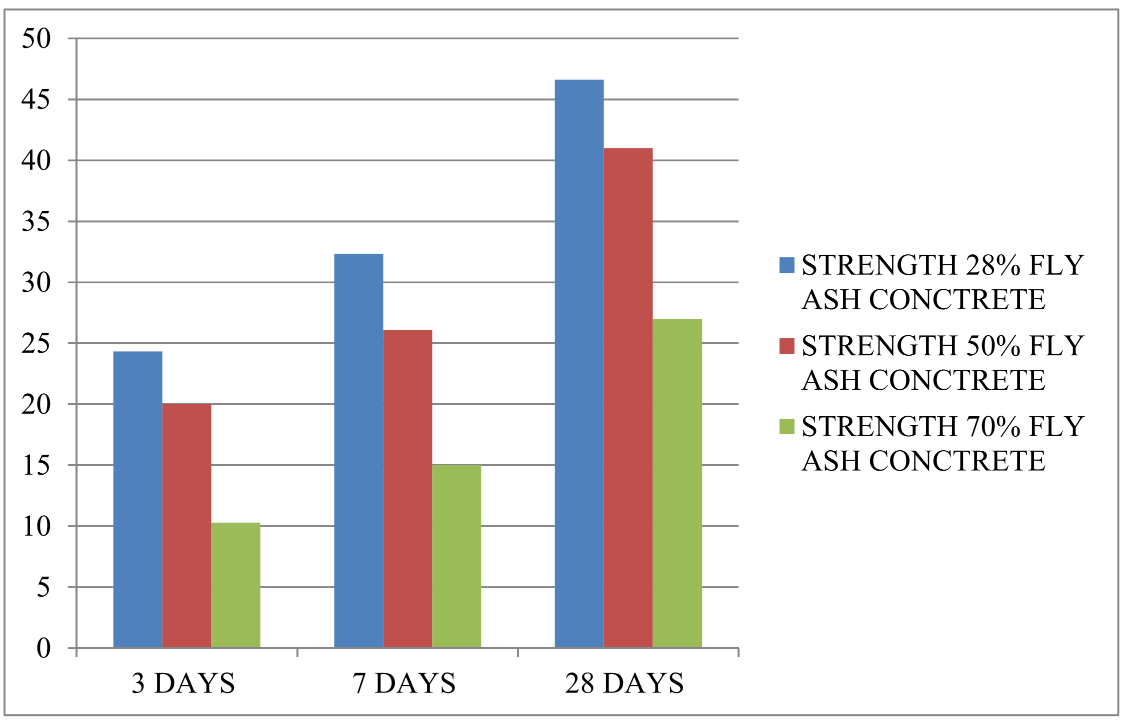

Figure 6.1: Compressive strength comparison of M40 concrete for 28%, 50% and 70% fly ash content.

Sr.No	% Fly Ash Concrete	Curing Period (days)	Flexural Strength (N/mm^2)	Average Flexural Strength(N/mm^2)
1.	28%	28	6.50 5.00 5.50	6.00
2.	28%	56	8.00 7.00 8.52	7.84

Table 6.3 (b): Flexural strength of M40 concrete for 50% fly ash content.

Sr.No	% Fly Ash Concrete	Curing Period (days)	Flexural Strength (N/mm^2)	Average Flexural Strength(N/mm^2)
1.	50%	28	5.00 4.00 5.7	4.90
2.	50%	56	7.00 8.00 6.00	7.00

Table 6.3 (c): Flexural strength of M40 concrete for 70% fly ash content.

Sr.No	% Fly Ash Concrete	Curing Period (days)	Flexural Strength (N/mm^2)	Average Flexural Strength(N/mm^2)
1.	70%	28	1.50 2.50 2.00	2
2.	70%	56	4.00 3.00 4.7	3.9

CONCLUSION

In conclusion, the high -volume concrete offers a holistic solution to the problem of meeting the increasing demands for concrete in the future in a sustainable manner and at a reduced or no additional cost, and at the same time reducing the environmental impact of two industries that are vital to economic development namely the cement industry and the coal-fired power industry. The technology of high-volume fly ash concrete is especially significant for countries like China and India, where, given the limited amount of financial and natural resources, the huge demand for concrete needed for infrastructure, road construction and housing can be easily met in a cost-effective and ecological manner. In this chapter concluding remarks are discussed obtained from the present study and scope of future work is also given.

CONCLUDING REMARKS

Base on the present study following conclusions can be drawn:

The compressive and flexural strength of M40 concrete at 50% fly ash replacement by the mass of cement are acceptable, and therefore can be used in construction practice. If we compare M25 concrete with the compressive and flexural strength of M40 concrete at 70% fly ash replacement by the mass of cement the result are acceptable and at a cost lower than M25 concrete.

The present study works on following three R's:

Reuse

Reduce

Recycle

As in this present study I have Reused the waste product i.e. fly ash, by Reducing the quantity of cement in concrete, in this way the waste product i.e fly ash, is Recycled into a much useful and cost effective concrete.

If more serious work is done in this field surely concrete and construction industry would be in gainful side and concrete upto some extent would be eco-friendly.

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