HIGH VOLUME FLY ASH CONCRETE IN CONSTRUCTION

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ABSTRACT

High Volume Fly ash Concrete (HVFC) consists more than 50% of Fly ash by weight in the Cement. This is an approach to maximize the Fly ash input in the concrete .The fall of strength belated rheology on account of Fly ash are counteracted through efficient control of water-cement ratio and effective role of super plasticizers. The HVFC so developed has all the attributes of high performance concrete .Viz, excellent mechanical properties, Low permeability and superior durability because of high input of Fly ash, the autogenous temperature is very much under control.

In the present work an attempt has been made to study the behaviour of high volume Fly ash concrete in compression and flexure. In the investigations, M20 and M30 Grade concrete mixes are designed at different percentages of Fly ash (0%, 20%, 40%, 60%, 80%) and tests are conducted for Compressive and Flexural Strengths at 7 and 28 days. Then the results are compared with normal concrete.

The study reveals that use of HVFC has a beneficial effect on the workability, the cost economy of concrete and Durability of the structure. Large quantities of energy replacement of cement results in energy savings since Fly ash does not need additional energy input before use. Larger the quantity of Fly ash replacement, the energy saved is proportionately more.

1. INTRODUCTION :

The Indian Fly ash can be divided into two classes depending on the combustion parameters of the boilers and the behavioral effect of the resultant Fly ash on the end product.

1.Low temperature Fly ash produced at combustion temperature of 800^0C-850^0C. These ashes are more reactive at early ages and hence are preferred for precasting building materials such as brick and block works.

2.High temperature Fly ash produced at combustion temperature of 1000^0 c-1400^0 c. The pozzolanic reaction is slow in these ashes and they kept accelerated with age. These types of ashes are more suitable for cement and concrete industries

ADVANTAGES OF HVFC:

- Low permeability and high durability.
- Prevents thermal cracking.
- Reduction in shrinkage cracking.
- High long term compressive and Flexural Strength.
- High Resistance to Sulphate Attack.
- High resistance to Alkali Aggregate reaction

2.SCOPE OF THE WORK

In this work, extensive experimental investigations are carried out on Fly ash concretes of different mixes (M20, M30) with different cement replacement percentages of Fly ash by weight (0%, 20%, 40%, 60%, 80%) and at different ages (7days, 28days). The tests are conducted for flexural strengths and The response of Fly ash concretes of various grades to Flexural loading. In addition to this, the compressive strengths for 7 days and 28 days with different percentages of Fly ash (0%, 20%, 40%, 60%, and 80%) for both M20 and M30 mixes are studied. Results are compared with normal concrete and for different percentages of Fly ash concretes

3.Features of Fly ash

- Spherical shape: Fly ash particles are almost totally spherical in shape, allowing them to flow and blend freely in mixtures.
- Ball bearing effect: The "ball-bearing" effect of Fly ash particles creates a lubricating action when concrete is in its plastic state.
- Higher Strength: Fly ash continues to combine with free lime, increasing structural strength over time.
- Decreased Permeability: Increased density and long-term pozzolanic action of Fly ash, which ties up free lime, results in fewer bleed channels and decreases permeability.
- Increased Durability: Dense Fly ash concrete helps keep aggressive compounds on the surface, where destructive action is lessened. Fly ash concrete is also more resistant to attack by sulphate, mild acid, soft (lime-hungry) water, and seawater.
- Reduced Sulphate Attack: Fly ash ties up free lime that can combine with sulphate to create destructive expansion.
- Reduced Efflorescence: Fly ash chemically binds free lime and salts that can create efflorescence and dense concrete holds efflorescence producing compounds on the inside.
- Reduced Shrinkage: The largest contributor to drying shrinkage is water content. The lubricating action of Fly ash reduces water content and drying shrinkage.
- Reduced Heat of Hydration: The pozzolanic reaction between Fly ash and lime generates less heat, resulting in reduced thermal cracking when Fly ash is used to replace Portland cement.
- Reduced Alkali Silica Reactivity: Fly ash combines with alkalis from cement that might otherwise combine with silica from aggregates, causing destructive expansion.
- Workability: Concrete is easier to place with less effort, responding better to vibration to fill forms more completely. Ease of Pumping. Pumping requires less energy and longer pumping distances are possible.
- Improved Finishing: Sharp, clear architectural definition is easier to achieve, with less worry about in-place integrity.
- Reduced Bleeding: Fewer bleed channels decreases porosity and chemical attack. Bleed streaking is reduced for architectural finishes. Improved paste to aggregate contact results in enhanced bond strengths.
- Reduced Segregation: Improved cohesiveness of Fly ash concrete reduces segregation that can lead to rock pockets and blemishes.
- Reduced Slump Loss: More dependable concrete allows for greater working time, especially in hot weather.

4.Chemistry Of Fly ash

Fly ash may be represented by silica and the principal constituent of Fly ash is non-crystalline silica glass. When Fly ash is added to Portland cement, silica combines with the calcium hydroxide released on the hydration of

Portland cement. Calcium hydroxide in hydrated Portland cement does not do anything for strength and so it must be used up reactive silica. Slowly and gradually it forms additional Calcium Silicate hydrate which is a binder, and which fills up the space, and gives concrete impermeability and more and more strength.

The above discussion is expressed as below: -

C_3S + H ⟶ C- S- H + C – H + Fly ash S C- S – H

Portland Cement

Pozzolanic activity is mostly related to the reaction between the reactive silica of the Pozzolana and calcium hydroxide, Producing calcium silicate hydrate. High- Calcium Fly ash, which is mainly composed of Glass phase and some crystalline phases (including C_2S, C_3A, $CaSO_4$, MgO, free CaO and C_4A_3S), has self-hardening properties. Ettringite, monosulphoaluminate hydrate, and C-S-H cause hardening of the Fly ash when mixed with water. Ghosh and Pratt reported that the hydration behavior of C_3A and C_2S in Fly ash is the same as that in cement, but the rate of formation of C-S-H from the glass phase is comparatively Low-calcium Fly ash, which has very little or no self -cementing properties, hydrates when alkalis and Ca $(OH)_2$ are added .The hydration products such as C-S-H, C_2ASH_8 and C_4AH_{13} are formed, and hydrogamet is produced at a later stage. As more Ca $(OH)_2$ is supplied, more of it is fixed by silica and alumina in Fly ash. The degree of hydration of Fly ash is increased in the presence of gypsum because the surface is activated by the destruction of the structure of the glass and crystalline phases and crystalline phases caused by the disassociation of Al_2O_3 reacting with SO_4^{2-} .

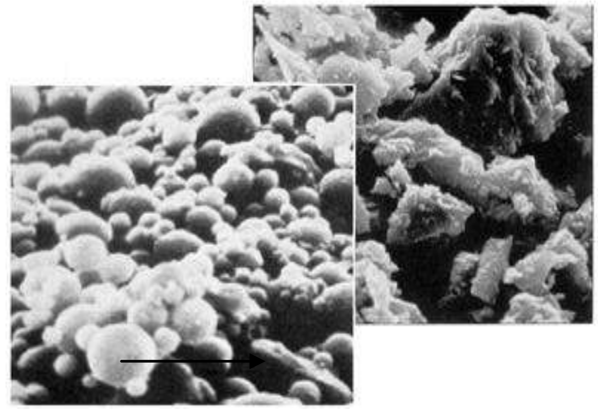


FIG 1 Typical Micro structures of Fly ash and Cement

4.1 Factors Affecting Pozzolanic Reactivity Of Fly ashes

The reactivity of Fly ash and other pozzolanes with lime or cement is affected by inherent characteristics of the Fly ash such as chemical and mineralogical composition, morphology, fineness and the amount of glass phase. External factors, such as thermal treatments and the addition of admixtures also affect pozzolanic reactivity.

The sum of Silica+alumina+iron of Fly ash has been stipulated by ASTM and other standard associations as a major requirement .The silica +Alumina content of Fly ashes shows a good co-relation with long term pozzolanic activity, although silica and alumina in an amorphous from only contribute to the pozzolanic activity, whereas Mullite and Quartz, which from by partial crystallization of the glassy phases in the Fly ash, are non-reactive. Also in most Fly ashes, most of the iron oxide (Fe_2O_3) is present as Non-reactive hematite and magnetite. A small amount of iron, which is presenting glass, is reported to have a deleterious effect on the pozzolanic activity of Fly ashes. Hence, it has to be separated from silica and alumina when chemical requirements and pozzolanic activity of Fly ashes are considered. It was reported that the carbon content did not significantly influence pozzolanic activity index in terms of compressive strengths ratio.

Typically, owners and designers look at compressive strength as an indicator of a material's ability to perform in an environment or a repeated impact load. This can be very misleading. A material with high compressive strength can be very little and may be easily failed due to impact, whereas a more resilient material with much less compressive strength would perform better.

A number of variables in concrete can cause changes in the impact resistance in concrete .The more notable ones are aggregate type and shape, admixture and fiber reinforcements. By using of harder but more brittle aggregate, the compressive strengths can generally be increased, but impact resistance logically goes down. This can also be the case when high range water reducers are used. If for example, a warehouse floor spalls and cracks due to impact of equipment and heavy parts dropping on it, a designer might well specify a higher compressive strength concrete for repair material. But the concrete material was not falling from compression, it was falling from impact. Thus impact is used as a design parameter. The test method presented here appears to be a good indicator, not only of impact. But also other important properties like fatigue, toughness and strain capacity indirectly.

5.Results

The Cube specimens are tested for compressive strength at 7 days and 28 days for two mixes M20 and M30 and the results obtained are tabulated below.

Grade	F/C RATIO	Compressive Cube Strength (N/mm^2) at Ages (days)	
		7 days	28 days
M20	0.00	16.90	28.80
	0.20	14.70	29.30
	0.40	13.10	29.80
	0.60	11.30	27.30
	0.80	9.80	22.90
M30	0.00	22.90	41.23
	0.20	22.70	41.50
	0.40	21.50	39.20
	0.60	20.40	35.80
	0.80	18.10	33.35

***Table 1* Values of compressive strength of concrete with different percentages of Fly ash at different ages**.

The flexural strength of normal Concrete and Fly ash concrete specimens of two mixes M20 and M30 and at different ages are found and tabulated below.

Grade	F/C Ratio	Flexural Strength (N/mm^2) at Ages (days)	
		7 days	28 days
M20	0.00	4.10	5.73
	0.20	3.20	5.80
	0.40	3.06	5.70
	0.60	2.70	5.63
	0.80	2.40	5.36
M30	0.00	4.70	6.43
	0.20	4.30	6.50
	0.40	3.50	6.36
	0.60	3.10	6.33
	0.80	2.80	6.10

Table 2 **Values of Flexural strength of concrete with different percentages of Fly ash at different ages.**

5.2 Discussions

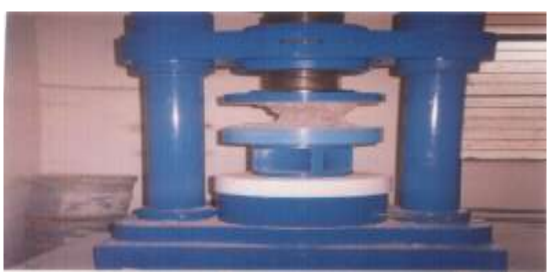


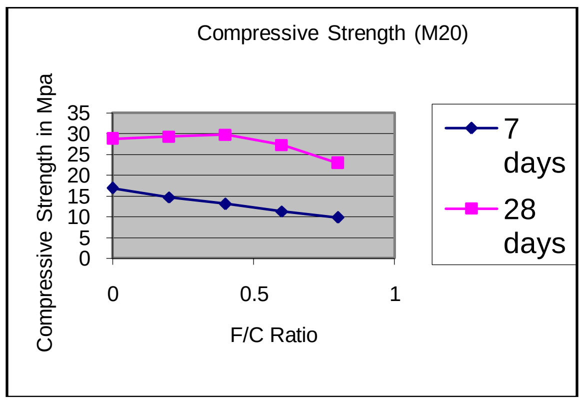
FIg: 2 **TYPICAL FRACTURE PATTERN OF CUBE SPECIMENS DUE TO COMPRESSION LOAD**

The failure of concrete cube is shown in figure. The failure of Fly ash concrete is as that of normal concrete. The value of compressive strength may be much higher for an aggregate of superior quality.

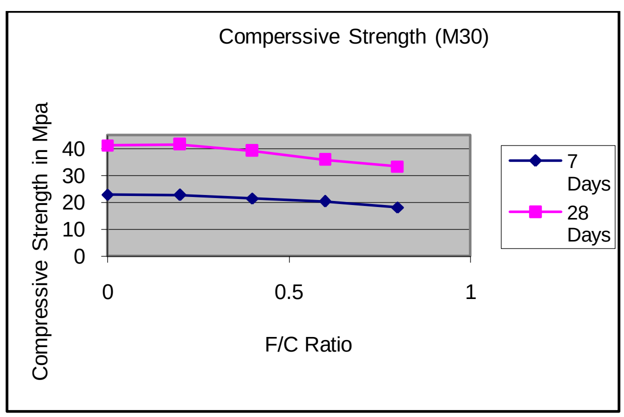
The graphs 1 & 2 are plotted for compressive strength Vs Age for two grades M20 and M30 and for all percentages of normal and Fly ash concretes.

The graphs 3 & 4 are plotted for Flexural strength Vs Age for two grades M20 and M30 and for all percentages of normal and Fly ash concretes.

Graph 1 Indicates the Compressive strength of M20 at 7 days and 28 days with different percentage of Fly ash (0%, 20%, 40%, 60%, 80%). Graph 2 indicates the Compressive strength of M30 at 7 days and 28 days with different percentage of Fly ash (0%, 20%, 40%, 60%, 80%). The compressive strengths of cube specimens of the two grades showed relatively lower value at early ages (7 Days) for Fly ash concretes (20%, 40%, 60%, 80%) than for normal concretes of all mixes.



Graph 1, **Compressive strength for M20 concrete**

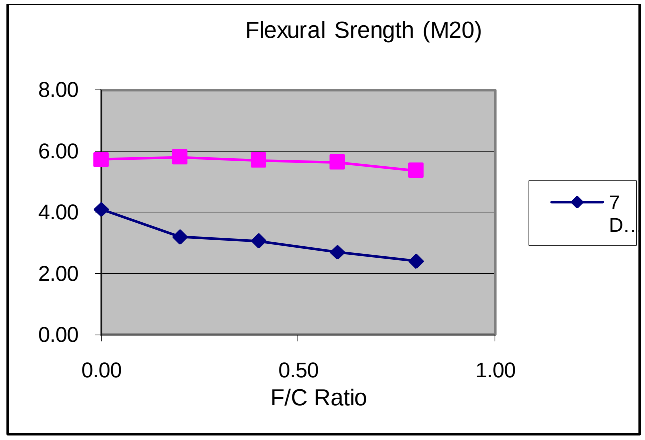


Graph 2, **Compressive strength for M30 concrete**

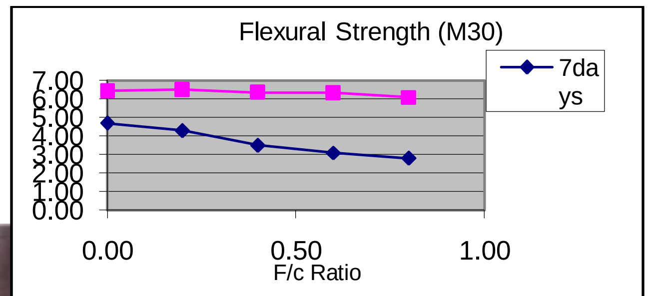
Fig: 9 **TYPICAL FRACTURE PATTERN OF BEAM SPECIMENS DUE TO FLEXURAL LOAD (M20, 0% Fly ash)**

Fig:10 TYPICAL FRACTURE PATTERN OF BEAM SPECIMENS DUE TO FLEXURAL LOAD**(M30, 0% Fly ash**

Graph 3 indicates the flexural strength of M20 at 7 days and 28 days with different percentage of Fly ash (0%, 20%, 40%, 60%, 80%). *Graph 4* indicates the Flexural strength of M30 at 7 days and 28 days with different percentage of Fly ash (0%, 20%, 40%, 60%, 80%). The 7 and 28 days flexural strength of normal concrete is better than the Fly ash Concrete.



Graph 3**, flexural strength for M20 concrete**



Graph 4**, Flexural strength for M30 concrete**

6. CONCLUSIONS

Based on the study conducted on M20 and M30 grade concrete with different percentages of Fly ash at different ages the following conclusions are drawn:

- **General Conclusions**

  1. At early ages, Fly ash concrete gave lower strength as compared to normal concretes.
  2. Using Fly ash is Eco-friendly and Economical in Construction of Structures.
  3. Strength increases with the increase in age of Fly ash concrete.

- **Specific Conclusions**

  1. The compressive strengths of cube specimens of the two grades showed relatively lower value at early ages (7

Days) for Fly ash concretes (20%, 40%, 60%, 80%) than for normal concretes for all mixes.

2. The 28 Days compressive strength of Fly ash concretes (20%, 40%) are nearly equal to normal concretes. But the Fly ash concretes of (60%, 80%) gives lower value than normal concretes. According to the present investigations, the Mix Design may not give good results for High Volume Fly ash Concretes.
3. The flexural strength of the beam specimen of the two grades showed relatively lower value at early ages (7 days), for Fly ash concrete (20%, 40%, 60%, 80%) than normal concretes for all mixes.
4. The 28 Days flexural strength of Fly ash concretes are nearly equal to that of normal concretes

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