STRENGTH STUDY ON ACTIVATED FLY ASH CONCRETE WITH GLASS FIBER USING BEAM

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Abstract: ***Concrete has become an indispensable construction material and it is now used in greater quantities than any other material. In the current era, the concept of durability and the sustainable development are the key issues for the development. The replacement of cement with fly ash benefits cost saving, energy saving environmental protection and conservation of resources. The replacement of cement with fly ash decreases the early strength and increases setting time. But chemical activation is simple and economical. The chemical activators destroy the crystalline structure and produces calcium silicate hydrate which enhances the strength and durability of concrete. In this study fly ash is activated using chemicals like calcium oxide (CaO) and sodium silicate (Na_2SiO_3) in the ratio of 1:8 for the effective inclusion of fly ash as replacement to cement. The percentages of replacement of activated fly ash (AFC) are 30%. The hardened concrete properties are studied and compared with control mix with PPC and fly ash concrete without activation .In general the concrete is weak in tension to increase the tension nature in the concrete addition of fiber is taken place. So we are using glass polymer fiber to gain such tensile strength. The proportion of the fiber we are used 0.5% and 1% from the weight of cement.***

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Keywords : Fly Ash, Activated Fly Ash, Glass fiber, workability, strength

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I. INTRODUCTION

Fly ash is being increasingly used in concrete to lower the costs and improve the properties of concrete. However the replacement of Portland cement with fly ash especially in high volume decreases the earlier strength of the concrete.

Fly ash contributes the strength of concrete in three ways,

- By reduction of water requirement for a given slump.
- By increasing the volume of paste there by improvement of workability.
- By pozzolanic reaction between fly ash and CaO.

The first two aspects are beneficial to the earlier strength. Thus, the decrease of earlier strength of concrete containing fly ash is attributed to the slow pozzolanic reaction between fly ash and CaO.

Little work has been done on the chemical activation of the reactivity of fly ash. Earlier studies have indicated that the addition of chemical activators can effectively accelerate or improve the pozzolanic reaction of natural pozzolans. In a primary study, it was found that the reactivity of fly ash could significantly increased by addition of **CaO** and **Na_2 SiO_3**. This study examines the effect of chemical activators **CaO** and **Na_2SiO_3** on early microstructure development of lime fly ash pastes and the strength of concrete compared to ordinary Portland cement and inactivated fly ash. The M_{20} grade of concrete was used with mix proportion of 1:1.28:2.78 kg/m^3 at 0.50 water binder ratio. The mechanical properties such as cube compressive strength, split tensile strength & flexural strength were studied at 7 and 14days.

II. MATERIALS AND METHODS

FLY ASH: Fly ash is one of the residues generated in the combustion of coal. Fly ash is generally captured from the chimneys of power generation facilities, whereas bottom ash is, as the name suggests, removed from the bottom of the furnace. In the past, fly ash was generally released into the atmosphere via the smoke stack, but pollution control equipment mandated in recent decades now require that it be captured prior to release. It is generally stored on site at most US electric power generation facilities. Depending upon the source and makeup of the coal being burned, the components of the fly ash produced vary considerably, but all fly ash includes substantial amounts of silica (silicon dioxide, SiO_2) (both amorphous and crystalline) and lime (calcium oxide, CaO). Fly ash is commonly used to supplement Portland cement in concrete production, where it can bring both technological and economic benefits, and is increasingly finding use in synthesis of geopolymers and zeolites.

Fly ash is a residue left after burning of coal in thermal power plants and need suitable disposal systems so that it does not become hazardous and injurious to human life, ecology and environment. Beside the use of fly ash as partial cement replacement materials, its use as aggregate in concrete can pave the way for large-scale use of fly ash.

Fly ash is a powdery pozzolana capable of utilizing both heat and calcium hydroxide generated during cement hydration of Portland cement. Hence, it has become a partial replacement material, as already explicitly in IS 456-2000. Annual production of fly ash in India is expected to reach 120 million tonne by 2020. Only about 15% of fly ash produced is utilized at present India. Attempts to use fly ash in production of Portland pozzolana and also as cement replacement material on site, as construction activities have been able to utilize only small fraction of the available fly ash in the country.

Due to lower thermal conductivity of fly ash, there will be enhanced comfort in the building and also energy saving when the buildings are air-conditioned to house important commercial utility and production facilities. Fly ash varies in colour from light to dark grey. This grey colour of fly ash is due to its carbon content. Generally Indian fly ash consists of relatively high silica content, high alumina content, high unburnt carbon and low CaO content.

ACTIVATED FLY ASH: The utilization of fly ash as construction material largely depends on its mineral structure and pozzolanic property. These two properties of fly ash can be enhanced by different methods of activation. The chemical activators destroy the crystalline structure and produce calcium silicate hydrate, which enhances the strength and tolerance capacity of the concrete against corrosive atmosphere

Fig 1. Powdered form of Activated Flyash

Fig 2: Glass fibres

This project highlights the chemical activation of fly ash by using CaO and Na_2SiO_3 in the ratio 1:8 and inclusion of activated fly ash as replacement material in PPC at various levels 10%, 20% and 30%.

Physical, thermal and chemical activation methods have been effected and their performance characteristics tested by aggressive macro cell corrosion technique. Earlier studies show that the physical and thermal activation of fly ash proves to be difficult which needs special methods and costly machinery whereas the chemical activation is simple and cheap.

GLASS FIBER: Glass fiber also called fiber glass it is made from extremely fine fiber of glass of fiber glass is a lightweight extremely strong and robust material. It is bulk strength and weight properties are also very favourable when compare to metals and it can be easily formed using moulding process.

Laboratory work and Test Procedure

i. Fly ash in dry powder form obtained from Thermal power plant. It was used for the entire study
ii. Activation of fly ash was carried out using Calcium Oxide and Sodium Silicate in the ratio 1:8
iii. The required quantity of sodium silicate in gel form and calcium oxide in paste form are mixed in a vessel and heated at a temperature of 103°C to ensure proper mixing
iv. Then finally paste like apparance occurs ,then it gets cooled and grinded in to fine powder form
v. This powder form activated fly ash is replaced as 30% in ordinary cement.
vi. In general the concrete is weak in tension to increase the tension nature in the concrete addition of fiber is taken place. So we are using glass polymer fiber to gain such tensile strength.
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xiii. The proportion of the fiber we are used 0.5% and 1% from the weight of cement.

Sl.no	Physical properties	Values in %
1	Fineness(passing through 45µm)	78.7
2	Specific gravity	2.3

Table: 1 PHYSICAL PROPERTIES OF FLY ASH

Sl.no	Chemical properties	Values in %
1	Silica	59.62
2	Alumina	26.43
3	Iron oxide	6.61
4	Calcium oxide	1.2
5	Magnesium oxide	0.76
6	Sulphur trioxide	0.58
7	Tinoxide	1.56
8	Loss on ignition	1.76

Table: 2 CHEMICAL PROPERTIES OF FLY ASH

Water	Cement	Fine Aggregate	Course Aggregate
191.6	383	546	1187
0.50	1	1.28	2.87

Table : 3 MIX PROPORTION

III. RESULTS AND OBSERVATIONS

COMPRESSIVE STRENGTH(CUBE) :compressive strength of concrete was determined at 7 ,14 and 28 days of curing. Tests were carried out on 150mm x 150mm x 150mm size cubes. A 2000 KN capacity standard compression testing machine was used to conduct the test.

The results of AFC concrete are compared with that of conventional concrete.

Mix	Replacement	7 Days (Mpa)	14 Days (Mpa)	28 Days (Mpa)
Control (PPC)	-	17.33	18.55	**25.33**
0.5 % FIBRE	30%	16.90	19.55	**26.66**
1.0 % FIBRE	30%	18.22	20.88	**28.44**

Table 4: COMPRESSIVE STRENGTH VALUES

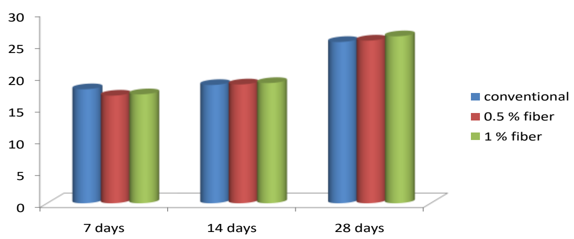

CHART 1: COMPRESSIVE STRENTH

- The compressive result for 0.5% fiber added to the 7days test when compare to conventional are decreases up to 1.22% and increases 8% when 1% fiber get added.
- The compressive strength result for 0.5% &1.0% fiber added to the 14days test when compare to conventional concrete increases up to 2.65% and 10.22%.
- The compressive value for 0.5%&1% fiber added to the 28days test strength increases up to 2.66% and 10.22% respectively.

SPLIT TENSILE STRENGTH: Split tensile strength was determined for 28 days. The test was carried out on cylindrical specimens of 150mm diameter and length 300 mm using 2000kN capacity compression testing machine.

Mix	Replacement	7 Days (Mpa)	14 Days (Mpa)	28 Days (Mpa)
Control (PPC)	-	1.2	1.97	**3.11**
0.5 % FIBRE	30%	1.45	2.12	**3.39**
1.0 % FIBRE	30%	1.74	2.44	**3.96**

TABLE: 5 SPLIT TENSILE STRENGTH VALUES

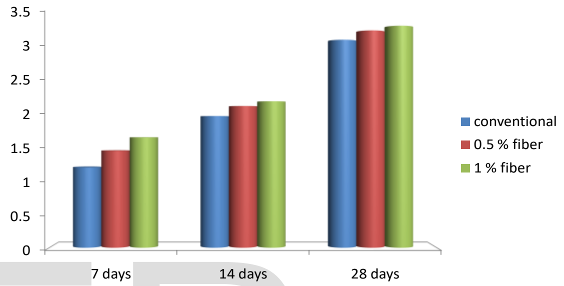

CHART 2: SPLIT TENSILE STRENGTH

• The split tensile strength result for 0.5% &1.0% fiber added to the 7days test when compare to conventional concrete increases up to 0.77% and 1.91%.
•The split tensile strength result for 0.5% &1.0% fiber added to the 14days test when compare to conventional concrete increases up to 0.67% and 1.94%.
•The split tensile strength value for 0.5%&1% fiber added to the 28days test strength increases up to 0.70% and 2.22% respectively.

FLEXURAL STRENGTH TEST – PRISM:

Mix	Replacement	7 Days (Mpa)	14 Days (Mpa)	28 Days (Mpa)
Control (PPC)	-	2.37	3.22	5.51
0.5 % FIBRE	30%	2.58	3.72	5.97
1.0 % FIBRE	30%	2.72	4.02	6.37

TABLE 6: FLEXURAL STRENGTH TEST VALUES

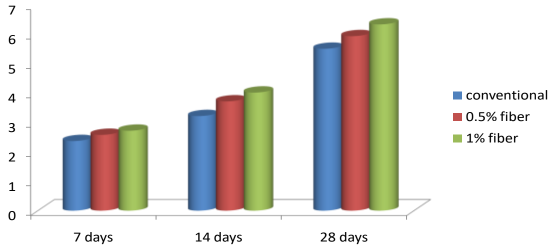

CHART 3: FLEXURAL STRENGTH

• The flexural strength result for 0.5% &1.0% fiber added to the 7days test when compare to conventional concrete increases up to 0.85% and 3.14%.
•The flexural strength result for 0.5% &1.0% fiber added to the 14days test when compare to conventional concrete increases up to 1.14% and 1.60%.
•The flexural strength value for 0.5%&1% fiber added to the 28days test strength increases up to 1.3% and 3.65% respectively.

DISCUSSION:

7th DAY STRENGTH :

From the result of 7th day compressive strength, PPC is more than AFFC with 1.22 %.
For the result of 7th day split tensile strength, conventional concrete is less than AFFC 1.92 %.
For the flexural strength of 7th day is conventional is less than compare to AFFC 3.14%.

14th DAY STRENGTH:

From the result of 14th day compressive strength, AFFC with 10.60% is more than PPC and that of AFFC.
From the result of 14th day tensile strength, AFFC with 1.22% is more than PPC and that of AFFC.
From the result of 14th day flexural strength, AFFC with 1.60% is more than PPC.

28th DAY STRENGTH

For 28th day compressive strength it is found that with the replacement of 30% AFFA the value is 26.66 N/mm^2 for 0.5 % and 28.44N/mm^2 for 1.0 % fiber**,** whereas compressive strength attained in 28th day FA concrete is less than the designed strength. By chemical activation, the crystalline structure of the fly ash is modified and also enhances the pozzolonic reaction to the strength at early stage when compared to the inactivated fly ash concrete.

EXPERIMENTAL SETUP FOR BEAM

The test setup for reinforced beam is shown in the figure for static loading. The testing of the beams specimens was conducted in the loading frame of 100 ton capacity. The test setup consists of the rollers for providing the simply supported condition. The load was applied to the specimen using to measure the applied load .A dial gauge is placed at the midpoint in the bottom side of the beam to measure the midpoint and deflection.

LOAD VS DEFLECTION ON BEHAVIOUR

The load deflection history for all beams was recorded from the load deflection shown in figure 5.4 .It was noted that the flexural behaviour as all the beams were good as compared to the reference concrete beam (RCB).

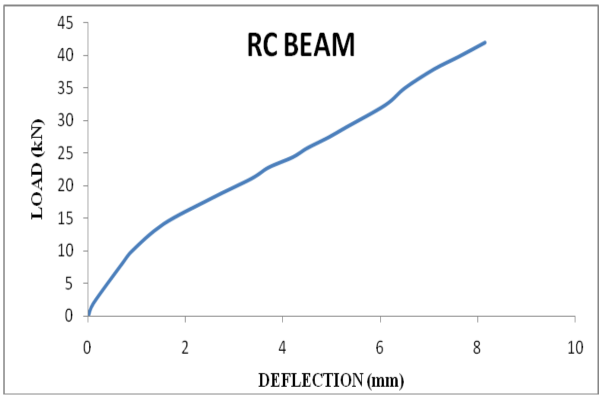

Fig 3: load vs deflection behaviour for RCB

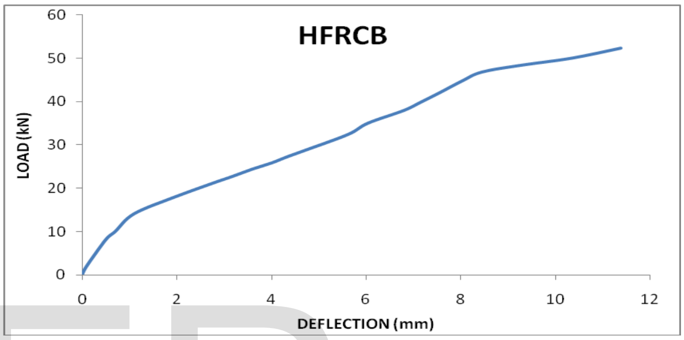

Fig 4: Load vs deflection behaviour for Activated flyash fibre reinforced concrete

The partial replacement of activated flyash with glass fiber combination performed better than all other slab. It was observed that addition of 10% improves the performance of the beam as compared to the conventional RC beam.

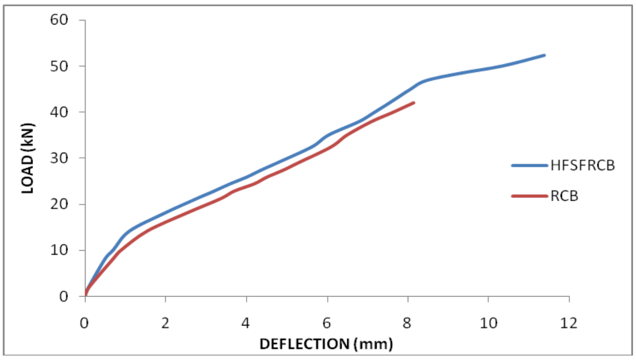

Fig 5: Combined- load vs deflection on behaviour

FIRST CRACK LOAD AND DEFLECTION

The static load was applied to all the beam specimens. The mid –point load deflection was noted using the dial gauge. The figure 6 shows the variation of first crack load and the ultimate load the first crack load for RCB, HFRC were 2.51kN and 3.2kN respectively. The HFRC shows 27.5% increase in first crack load this is due to the effect of steel fiber, glass fiber and silica fume which increase the first crack load and also resist their propagation.

The ultimate load carrying capacity of the beams RCB, HFRC is 8.15kN and 11.38kN respectively. There is an increase of ultimate load 39.6% as compared to the convention RCB. The importance of using glass fiber and activated fly ash to have a ductile failure rather than brittle failure of the specimen and all the specimens were observed to fail in ductile manner. All the beams were fail in flexural mode, there is any shear failure in the beam.

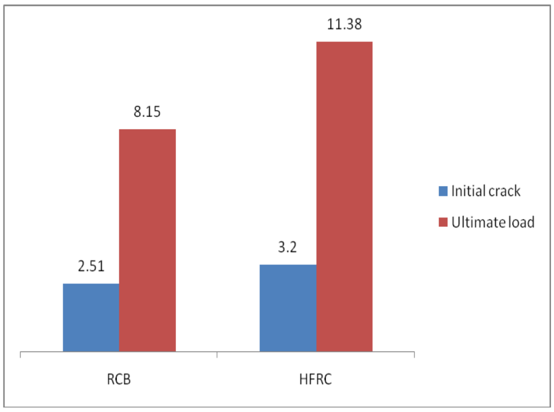

Fig6: Comparison for initial crack and ultimate load

STIFFNESS

Stiffness may be defined as the amount of load required to cause a unit deflection. The stiffness for the beam specimens was calculated by drawing a tangent gives to initial crack load, and the slope of that tangent gives the values of stiffness. The addition of the glass fiber and activated fly ash improves the stiffness as compared to that of RCB. The increase in percentage of stiffness for RCB, HFRC was 16.9%.

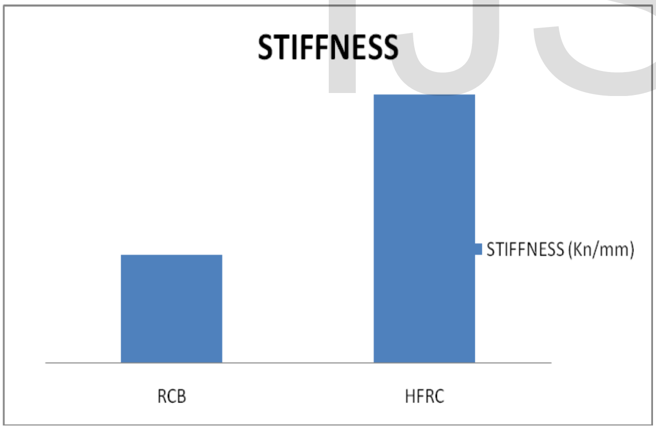

Fig7: comparison for stiffness

DUCTILITY FACTOR

Ductility factor is defined as the ratio between deflections of ultimate load to the deflection at yield. The ductility factors of beam were increased consider as compared to the conventional RCB. The increase in 37.5% as compared with the RCB and it also shows that the additions of glass fiber and activated flyash increased the ductility of the conventional concrete to a large extent and make the material more ductile rather than a brittle failure of concrete.

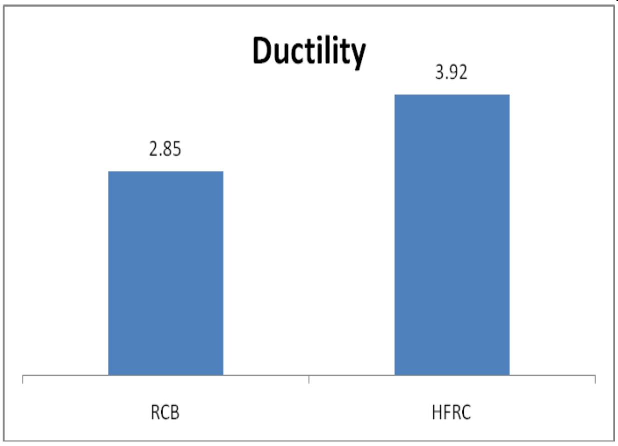

Fig 8: Comparison for ductility

SI.no	Load (KN)	Deflection (mm)	Specimen observation	SI.no	Load (KN)	Deflection (mm)	Specimen observation
1	0	0		10	25.8	4.5	
2	1.9	0.1		11	27.3	4.9	
3	8.1	0.7		12	29	5.3	
4	10	0.9		13	32.4	6.1	
5	14.1	1.54		14	35	6.5	
6	18	2.51	Initial crack	15	37.9	7.1	
7	21.1	3.35		16	39.8	7.6	
8	22.8	3.7		17	42	8.15	Ultimate load
9	24.4	4.2		18	44.8	7.5	

ENERGY ABSORPTION CAPACITY

Energy absorption capacity is an important parameter as it as indication of has much the energy being absorbed by the beam before it fails .The energy absorption capacity is obtained by calculations the area under the load deflection curve. It is observed that the glass fiber and activated flyash shows higher energy absorption with reference to the RCB. The increase in percentage of energy absorption of RCB, HFRC was 110 %.

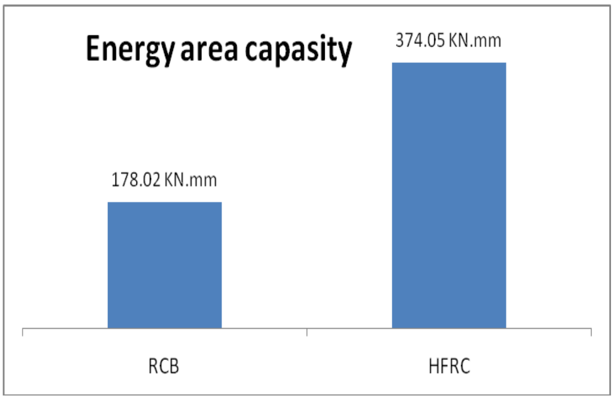

Fig 9: Comparison for E.A.C

Table7: Load- Deflection test for conventional concrete

SI.no	Load (KN)	Deflection (mm)	Specimen observation	SI.no	Load (KN)	Deflection (mm)	Specimen observation
1	0	0		12	29	4.78	
2	1.9	0.09		13	32.4	5.62	
3	8.1	0.5		14	35	6.04	
4	10	0.7		15	37.9	6.79	
5	14.1	1.1		16	39.8	7.15	
6	18	1.97		17	42	7.55	
7	21.1	2.75		18	44.8	8.04	
8	22.8	3.2	Initial crack	19	46.8	8.45	
9	24.4	3.6		20	48.4	9.3	
10	25.8	4		21	50	10.35	
11	27.3	4.35		22	52.3	11.38	Ultimate load

Table 8: Load- Deflection test for AFFRC

IV. CONCLUSIONS

- Since fly ash is very tiny particle it reduces corrosion in reinforcement.
- It reduces heat of hydration when compare to concrete.
- It does not emit any carbon-di-oxide and protect global warming.
- The replacement of activated (calcium oxide and sodium silicate) fly ash 30% in the volume of cement the required strength get obtained in 28 days.
- To increase the tensile nature in the concrete the fiber are used, that fiber will also attain proper strength in 14 days itself.
- Further replacement of 50% activated fly ash with cement has been carried out by different chemicals.
- And also the replacement of fiber up to 2-3% may get increased tensile strength of concrete.
- The AFRC shows 27.5% increase in first crack load this is due to the effect of glass fiber and activated flyash which increase the first crack load and also resist their propagation.
- The ultimate load carrying capacity of the beams RCB, AFRC is 8.15kN and 11.38kN respectively. There is an increase of ultimate load 39.6% as compared to the convention RCB.
- The addition of the glass fiber and activated flyash improves the stiffness as compared to that of RCB. The increase in percentage of stiffness for RCB, AFRC was 16.9%.

REFERENCES

[1] **P.Arjunan,M.R.Silpsee,D.M.Roy** , "Chemical activation of low calcium fly ash Part I&II effect of mineralogical composition on alkali action"

[2] V.Saraswathy,S.Muralidharan,K.Thangavel and S.Srinivasan, "Activated fly ash cements:Tolerable limit of replacement for durable steel reinforced concrete".

[3] Ferna'ndez-jime'nez,A.Palomo,M.Criado, "Microstructure development of alkali-activated fly ash cementra descriptive model"

[4]Ana M.Ferna'ndez-Jime'nez,Angel Palomo,and Cecilio Lo'pez-Hombrados, "experimental research on certain engineering properties of a new(Portland cement-free) concrete made with alkali-activated fly ash".

.

[5] .**Malhotra V.M. ,** "Making concrete greener with fly ash"

[6] Prabir C.Bassu and Subhajit Saraswati, "High volume fly ash concrete with Indian ingredients"

[7] V.M.Malhotra., "Global warming role of supplementary cementing Materials and Super Plasticizers in reducing Green house gas emissions from the manufacturing of Portland cement",

[8] B.S.Krishnamurthy,Rose Sherin Jose, K.B.Prakash, An Experimental Investigation on The Properties of Concrete Containing Ternary Blends,Fly Ash

[9] K.Ganesan,K.Rajagopal,K.Thangavel,R.Selavaraj and V.Saraswathy, "Rice husk ash- A versatile supplementary Cementitious material"

[10] A.K Prashar,D Venkateswaran , proving efficiency of ashes from power plants-technoligical options".

[11] Quan Jueshi,shi Caiijun and Wang Zhi, "Activation of blended cements incorporating fly ash"

[12] Shi.C and Day.R.L, "Pozzolanic reactions in the presence of chemical activation,part I,reaction kinetics",

[13] J.K.Dattatreya,M.Neelamegam & N.P.Rajamane, "A comparison of effects of ultra fine fly ash and silica fume in concrete".