Properties of Concrete by Partial Replacement of Cement with Flyash – A Comparative Study

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Abstract

The main source of fly ash is thermal power plants where the coal burns for the production of electricity. For experimental analysis, fly ash from three different sources (Source-1 from NTPC Korba; Source-2, Balco Korba and Source-3 Lanco Amarkantak) were collected and their physical and chemical properties were compared as per Indian standard code. After their comparison, it was found that this fly ash can be used for construction. Now from each source, three mixes of M-30 Grade were made by replacing cement with fly ash in 20%, 30% and 40%. Analysis and comparison of all the mixes of each source were then done with the normal concrete of M-30 grade (Using OPC 53-grade cement). Mix design calculation as per the empirical formula of IS Code 10262 and IS Code 456: 2000.

Keywords: Flyash, Thermal Power Plants, super plasticizer.

1. Introduction

In developing countries like India power generation is the most important requirement for economic and social development. At the time of independence in 1947, the installed capacity was 1,361 MW, which increased to 2,07,732 MW on 31 March 2015. Out of it, 1,40,232 MW is thermal (Coal/Lignite) based and is responsible for co-generate nearly 225 million tons of fly ash per year. In the 12th Five-Year Plan, the Planning Commission has set up a target to enhance power capacity by 89,000 MW, out of which 53,400 MW will come from Coal/Lignite based thermal power plants. By the end of the 12th Plan (2017), the fly ash generation is expected to reach 300 million tons per year and is likely to continue to grow at the same pace at least for the next two to three decades.

The first thermal power plant was set up in India in 1910, with a capacity of only 15 MW. After the establishment of N.T.P.C (National Thermal Power Co-operation Grid) in 1976, the demand for power increased in India, as well the production of fly ash also increase. According to N.T.P.C Journal the first plant in Singrauli in 1976 of capacity 35 MW. By the end of 1994, the demand for the production was 15000 MW, and by the end of 2001, the production was 20000 MW. Thus the production of fly ash also increases from time to time, year to year. At the end of 90's the production of fly ash was 74 Million Metric tons, it increased to 125 Million Metric tons at the end of 2010, and as per N.T.P.C annual calculation for 2014- 2015 is almost 235 Million Metric tons

In other views of global warming, efforts are on to reduce the emission of COz to the environment. The cement industry is a major contributor to the emission of COz as well as using up high levels of energy resources in the production of cement. By replacing cement with a material of pozzolanic characteristics, such as fly ash the cement and concrete industry together can meet the growing demand in the construction industry as well as help in reducing the environmental pollution.

1.1 Collection of Fly Ash

Fly ash is collected from three different places

Bottom part of the boiler.

Hoppers of Electrostatic Preceptor.

Washed out with water and collected in the pond (also named Lagoon Ash)

The classifications of fly ash depend on the burning of coal. The Fly ash produced by the burning of old anthracite or bituminous coal type class- F having less than 20 % lime, Class - C type having more than 20 % lime, and produce by burning of lignite or Sub-Bituminous coal. These two types of fly ash used in the cement and construction industries depend on their physical and chemical parameters.

Table 1 Chemical Requirement for Cement Industries (IS Code 3812 Part –I)

S.NO.	Composition	Requirement
1	$Sio_2 + Al_2O_3 + Fe_2O_3$ by mass Minimum	70.0
2	Silica , Sio_2 % by mass Minimum	35.0
3	MgO % by mass Maximum	5.0
4	Sulfate , SO_3 % by mass Maximum	2.8
5	Total alkalies , $K_2O + Na_2O$% by mass Maximum	1.5
6	Loss on ignition	12.0

Table 2 : Physical Requirement for Cement Industries (IS Code 3812 Part –I)

S.NO.	Characteristic	Requirement	
		TYPE-I	TYPE-II
1.	Fineness specific surface in m^2 / kg by Blades permeability method Minimum	320	250
2.	Lime reactivity average compressive strength in N/mm^2	4	3
3.	Compressive strength at 28 days in N/mm^2	Not less than 80% 0of compressive strength of plane cement mortar	
4.	Dry Shrinkage Maximum	.015	0.1
5.	Soundness % Maximum	0.8	0.8

Table 2a : Chemical Requirement using fly ash in concrete or cement mortar as an admixture (IS Code 3812 Part –I)

S.NO.	Composition	Requirement	
		Siliceous Pulverized Fuel Ash (Type –I)	**Calcareous Pulverized Fuel Ash (Type –II)**
1	Sio_2 + Al_2O_3 + Fe_2O_3 by mass Minimum	70.0	50.0
2	Silica, Sio_2 % by mass Minimum	35.0	25.0
3	MgO % by mass Maximum	5.0	5.0
4	Sulfate, SO_3 % by mass Maximum	5.0	5.0
5	Total alkalies, K_2O + Na_2O% by mass Maximum	1.5	1.5
6	Total Chloride in 5 by mass Maximum	0.05	0.05
7	Loss on ignition	5.0	5.0

Table 3 : Physical using fly ash in concrete or cement mortar as an admixture (IS Code 3812 Part –II)

S.NO.	Characteristic	Requirement
1	Fineness specific surface in m^2 / kg by Blades permeability method Minimum	200
2	Particle retained on 45 micron IS sieve (Wet Sieving) in %, Maximum	50
3	Soundness by autoclave test, Maximum	0.8

The flying ash which is not meeting the physical and chemical parameter (shown in Table 1.2 to 1.5) are used for the filling of pits, agriculture, road embanking, road filling works, duke raising etc. Utilization of fly ash in different area, percentage wise.

Table 4. Utilization of fly ash: Table 1.6: As per NTPC Journal APR-2015

S.No.	Description	Percentage of Usage
1.	Cement	40%
2.	Concrete	10%
3.	Filling	17%
4.	Road Embanking	16%
5.	Duke Raising	4%
6.	Brick Making	5%
7.	Agriculture	4%
8.	Miscellaneous	4%

As shown in Table 1.1, the utilization percentage is near 60 % as compared to production of fly ash. Thus the innovative ideas are required for the more utilization of fly ash and saving the natural resources for the future use.

2. Problem Identification

From literature review of research papers related to Fly ash base concrete following points are summarized:

- With high content of carbon particles in the fly ash i.e. more than 4 %, the consumption of air entraining agent increases.
- With the high percentage of fly ash in concrete, tensile strength reduces.
- For the high workability more quantity of super plasticizer is required.
- The tendency of crack and shrinkage increase with w/c ratio exceeds the value of 0.4.
- De-icing salt has shown lower performance.
- Initial setting time increases more than 2 hrs.

The aim is to find out the most optimum percentage of fly ash for making concrete using, from three different sources. Comparing their compressive strength, splitting tensile strength, workability and modulus of elasticity. Analysing all the data in laboratory.

3. Materials And Methods

3.1. Materials

The constituent materials for fly ash base concrete are the same as those used in traditional normal vibrated concrete conforming to IS 456:2000. But mixture proportion of Fly ash base concrete is differing from the traditional vibrated concrete, in the addition of mineral admixture, as suggested in IS: Code 10262-2009.

3.2 Cement

Portland cement is a hydraulic binder and a finely ground inorganic material. When mixed with water, it forms a paste which sets and hardens by means of hydraulic reactions. All cements which conform to IS 456:2000. The correct choice of cement type is normally dictated by the specific requirements of each application and confirm from IS 12269: 1987.

3.3 Fly ash

Fly ash has the most popular mineral admixture which shown the effective properties on concrete. Fly ash increases the cohesiveness of concrete and reduced the sensitivity to changes in water content. However, high levels of fly ash may produce a paste fraction which is so cohesive that it can be resistant to flow. Before using of fly ash directly in concrete, it's physical and chemical properties should be confirm from IS: 3812, Part -I & Part - II.

3.4 Source and Properties of fly ash

Fly ash used in the mix is from three different sources.

- Source-I: NTPC, Korba
- Source-2: BALCO, Korba
- Source-3: LANCO, Amarkantak

Table 5: Physical properties of all the 3 different sources of fly ash

S.No	Characteristics	Requirement as per IS: Code 3812-Part- II	Source – 1 NTPC	Source -2 BALCO	Source - 3 LANCO
1.	Fineness specific surface in m^2 /kg by Blane's Permeability method Minimum	200	250	280	340
2.	Particle retained on 45 micron IS sieve (Wet Sieving) in % Maximum	50	34.51	47.8	55.2
3.	Soundness by autoclave test, Maximum	0.8	0.8	0.74	0.76

3.5 Chemical Properties

Chemical properties of all the three sources of fly ash and comparison with IS: Code3812 Part- II

Table 5a: Chemical properties of all the 3 different sources of fly ash

S.No	Characteristics	Requirement as per IS: Code 3812-Part- II	Source–1 NTPC	Source-2 BALCO	Source-3 LANCO
1.	$SiO_2 + Al_2O_3 + Fe_2O_3$ by mass Min	70.0	74	76	87
2.	Silica , SiO_2 % by mass Minimum	35.0	57.4	61.2	65.4
3.	MgO % by mass Maximum	5.0	4.1	3.8	3.2
4.	Sulfate , SO_3 % by mass Maximum	2.8	1.8	1.5	1.9
5.	Total alkalies, $K_2O + Na_2O$% by mass Maximum	1.5	1.2	0.8	1.1
6.	Loss on ignition	12.0	5	8	6

3.6 Admixtures

Superplasticisers or high range water reducing admixtures conforming to European federation 934-2 Tables 3.1 and 3.2 are an essential component of pump able concrete. Viscosity modifying admixtures (VMA) may also be used to help reduce segregation and the sensitivity of the mix due to variations in other constituents, especially to moisture content. Other admixtures including air entraining, accelerating and retarding may be used in the same way as in traditional vibrated concrete but advice should be sought from the admixture manufacturer on use and the optimum time for addition and they should conform to EN 934-2.

Choice of admixture for optimum performance may be influenced by the physical and chemical properties of the binder/addition. Factors such as fineness, carbon content, alkalis and CA may have an effect. It is therefore recommended that compatibility is carefully checked if a change in supply of any of these constituents is to be made.

Admixtures will normally be very consistent from batch to batch but moving to another source or to another type from the same manufacturer is likely to have a significant effect on concrete performance and should be fully checked before any change is made.

3.7 Super plasticizer / High range water reducing admixtures

Most admixture manufacturers will have a range of super plasticizer admixtures tailored to specific user requirements and the effects of other mix constituents. The admixture should bring about the required water reduction and fluidity but should also maintain its dispersing effect during the time required for transport and application. The required consistence retention will depend on the application. Precast concrete is likely to require a shorter retention time than for concrete that has to be transported to and placed on site. The super plasticizer used should confirm from IS 9103:1999.

Product name: Conplast SP430 (FOSROC, Material)

3.6.1 Physical Properties:

i. Specific Gravity : 1.22
ii. Chloride Content: Nil to IS:456
iii. Air entrainment : Approx 1 % additional air is entrained
iv. Water reduces : 25 % reducing the water.

3.7 Methodology adopted

- Literature Review.
- Collection of fly ash from different sources and their test reports.
- Collection of aggregate from different sources and testing them in laboratory.
- Selection of super plasticizer.
- Planning of the Experiment.

i. To decide the grade of concrete to prepared.
ii. Mix design without using fly ash.
iii. Mix design with suing fly ash at various proportion and different source
iv. Testing the properties on fresh concrete.
    a. Workability.
v. Testing the properties on hard concrete.
    a. Earlier Strength
    1. Compressive strength for 7 days.
    2. Splitting tensile strength for 7 days.
    b. Final Strength
    1. Compressive strength for 28 days.
    2. Splitting tensile strength for 28 days.
    3. Modulus of Elasticity for 28 days.
vi. Comparison among the all mix and testing value .

3.8 Methods adopted

Composition of Concrete mix is satisfying all criteria of occurring for the workability or workable concrete. To satisfy all performance criteria for the concrete in both the fresh and hardened states, selection of mix composition is important.

3.9 Basic Principle for mix design of concrete

For designing concrete mix, it is important to achieve required fresh properties of concrete are:

The fluidity and viscosity of the paste is balance and adjusted by careful selection and portioning of the cement and Fly ash. By limiting the water-cement ratio and then incorporates high range water reducers (HRWR, super plasticizers) in required amounts and frequently. For achieving good filling ability, passing ability and resistance to segregation and bleeding of concrete is very important.

Fluidity of paste in concrete mix is very important, because volume of past give the flow ability to aggregate, hence the paste must be greater than the void volume in the aggregate so that all individual aggregate particles are fully coated and lubricated by a layer of paste.

The course to fine aggregate ratio in the mix is reduced so that individual coarse aggregate particles are fully surrounded by a layer of mortar. This reduces aggregate interlock and bridging when the concrete passes through narrow openings or gaps between reinforcement and increases the passing ability of the concrete.

These mix design principles result in vibrated concrete, normally contains:

- Lower the water cement ratio.
- Filling of void of coarse aggregate with cement paste and fine aggregate.
- Workability in terms of cement paste should be flow able.
- Extra addition of super plasticizer if required for workability.

3.9 Principle for concrete mix designing

The procedure of the mix design as per India standard is based on the empirical formula given in IS Code 10262: 2009. The guideline for the cement content, admixtures, coarse and fine aggregate to be use for the mix is given in IS Code 456: 2000.

3.9.1 Indian Standard Code Guide line

This method was first introducing in Indian Standard Code on 1982 and after many researches and experiment the latest edition is2009. Guide line related this method is as follows:

3.9.1 a. Cement

The Selection criteria for the cement selection depend up on the grade cement, as shown in IS Code 12269. Minimum cement content as per grade of concrete is given in IS 456: 2000

3.9.1 b. Coarse and Fine Aggregates

The Selection of aggregate by size, water absorption is given in 2386, Part -I and Part - II. For the sieve analysis and gradation curve, shown in IS: 383.

3.9.1 c. Mineral Admixture / Fly ash

The selection criteria for the fly ash to be use for concrete are classified in IS: 3812 Part-I, Part - II.

3.9.1 d. Super Plasticizer

The selection criteria for the use of super plasticizer in concrete mix is classified in IS: 9103.

3.9.1 e. Water Cement Ratio

The selection criterion for the water cement ratio is shown in Table 5, IS 456: 2000.

3.9.1 f. Cement and Fly Ash Content

The calculations of the cementitious depend up on the percentage of fly ash used in the mix, normally 10% increase in the cementitious value is recommended.

4. Calculation For Mix Proportion

Calculation the volume of cement, fly ash, water and admixture in CuM and Subtracting it with one CuM, will give the volume of other aggregates and multiply with the specific gravity and ratio with give the mix proportion.

4.1 Analyzing Concrete Properties

Concrete properties can be analyzed by testing the properties of fresh and hard concrete.

4.1.1 Test on Fresh Concrete

Slump test is commonly use for this purpose. Concrete is filled in the slump cone in three layers and each layer is tapped with tapping rod of diameter 16 mm as per IS 516

4.1.2 Testing of Hard concrete

Testing of hard concrete is very important, to know about the strength and durability of mix.

1.Compressive Strength: The cubes are made as per IS: 516 and the strength of cube was tested for 7 days and 28 days.

2.Splitting Tensile Strength (Cube Specimen): This method is used for determining the tensile strength of the mix, as per IS: 5618.The Cube of size 150 x 150 × 150 was made as per IS: 516 and placed in Compression testing Machine, With a arrangement of square at center of size 5 × 5 mm. Load is applied at one end.

3. Modulus of Elasticity: This test is use for determining the elasticity of the concrete, by casting cylinder after 28 days. The dial gauge at the centre of specimen give the reading for the change in length of the cylinder specimen at particular load applied. Thus the relationships between stress and strain are plotted in the graph sheet to calculate the design modulus of elasticity and ultimate elasticity of concrete.

5. Experimental Work

5.1 Mix design and Calculation for M-30 grade concrete

Experimental work is carried on M 30 grade concrete in laboratory. The Calculation for the mix is as follows:

Mix Design for M-30, Trail-1:

Table 6 : Stipulation Proportion of M-30 for Trail -1

1.	Grade Designation	M-30
2.	Type of Cement	OPC -53 Grade
3.	Maximum Size of Coarse Agg	20nm
4.	Minimum Cement content	320 kg/Cum

5.	Maximum Water Cement Ratio	0.45
6.	Workability	75 – 100 nm
7.	Exposure condition	Severe
8.	Method of concrete Placing	Pumping
9.	Degree of supervision	Good
10.	Type of aggregate	Crushed angular
11.	Maximum Cement content	450 kg /Cum
12.	Chemical Admixture Type	Super Plasticizer

Stipulation Proportion for 20% Fly Ash (Source-1)

1.	Grade Designation	M-30
2.	Type of Cement	OPC -53 Grade
3.	Type of Mineral Admixture	Fly Ash,Confirming IS3812 (Part – I)
4.	Maximum Size of Coarse Agg	20nm
5.	Minimum Cement content	320 kg/Cum
6.	Maximum Water Cement Ratio	0.45
7.	Workability	75 – 100 nm
8.	Exposure condition	Severe
9.	Method of concrete Placing	Pumping
10.	Degree of supervision	Good
11.	Type of aggregate	Crushed angular
12.	Maximum Cement content	450 kg /Cum
13.	Chemical Admixture Type	Super Plasticizer

Table 7 : Stipulation Proportion for 30% Fly Ash (Source-1)

1.	Grade Designation	M-30
2.	Type of Cement	OPC -53 Grade
3.	Type of Mineral Admixture	Fly Ash,Confirming IS3812 (Part – I)
4.	Maximum Size of Coarse Agg	20nm
5.	Minimum Cement content	320 kg/Cum
6.	Maximum Water Cement Ratio	0.45
7.	Workability	75 – 100 nm
8.	Exposure condition	Severe
9.	Method of concrete Placing	Pumping

10.	Degree of supervision	Good
11.	Type of aggregate	Crushed angular
12.	Maximum Cement content	450 kg /Cum
13.	Chemical Admixture Type	Super Plasticizer

Table 8: Material Specification for 40% Fly Ash (Source – 1)

1.	Cement Used	OPC -53 Grade
2.	Sp gravity of cement	3.15
3.	Chemical Admixture	Super Plasticizer
4.	Sp gravity of Coarse Agg	2.64
5.	Sp gravity of Fine Agg	2.74
6.	Water absorption of C.A	0.50%
7.	Sp gravity of Fly Ash	2.2
8.	Source of Fly Ash	NTPC, KORBA Power Plant
9.	Water absorption of F.A	1.00%
10.	Free Moisture C.A	Nil
11.	Free Moisture F.A	Nil
12.	Sieve analysis of F.A	Zone-II fromIS-383
13.	Sieve analysis of C.A	60%,40%Fraction from IS: 383

Table 9: Stipulation Proportion for 20% Fly Ash (Source-2)

1.	Grade Designation	M-30
2.	Type of Cement	OPC -53 Grade
3.	Type of Mineral Admixture	Fly Ash,Confirming IS3812 (Part – I)
4.	Maximum Size of Coarse Agg	20nm
5.	Minimum Cement content	320 kg/Cum
6.	Maximum Water Cement Ratio	0.45
7.	Workability	75 – 100 nm
8.	Exposure condition	Severe
9.	Method of concrete Placing	Pumping
10.	Degree of supervision	Good
11.	Type of aggregate	Crushed angular
12.	Maximum Cement content	450 kg /Cum
13.	Chemical Admixture Type	Super Plasticizer

Stipulation Proportion for 30% Fly Ash (Source-1I)

1.	Grade Designation	M-30
2.	Type of Cement	OPC -53 Grade
3.	Type of Mineral Admixture	Fly Ash,Confirming IS3812 (Part – I)
4.	Maximum Size of Coarse Agg	20nm
5.	Minimum Cement content	320 kg/Cum
6.	Maximum Water Cement Ratio	0.45
7.	Workability	75 – 100 nm
8.	Exposure condition	Severe
9.	Method of concrete Placing	Pumping
10.	Degree of supervision	Good
11.	Type of aggregate	Crushed angular
12.	Maximum Cement content	450 kg /Cum
13.	Chemical Admixture Type	Super Plasticizer

Table 10: Stipulation Proportion for 40% Fly Ash (Source-2)

1.	Grade Designation	M-30
2.	Type of Cement	OPC -53 Grade
3.	Type of Mineral Admixture	Fly Ash,Confirming IS3812 (Part – I)
4.	Maximum Size of Coarse Agg	20nm
5.	Minimum Cement content	320 kg/Cum
6.	Maximum Water Cement Ratio	0.45
7.	Workability	75 – 100 nm
8.	Exposure condition	Severe
9.	Method of concrete Placing	Pumping
10.	Degree of supervision	Good
11.	Type of aggregate	Crushed angular
12.	Maximum Cement content	450 kg /Cum
13.	Chemical Admixture Type	Super Plasticizer

Stipulation Proportion for 20% Fly Ash (Source-3)

1.	Grade Designation	M-30
2.	Type of Cement	OPC -53 Grade
3.	Type of Mineral Admixture	Fly Ash,Confirming IS3812 (Part – I)
4.	Maximum Size of Coarse Agg	20nm
5.	Minimum Cement content	320 kg/Cum
6.	Maximum Water Cement Ratio	0.45
7.	Workability	75 – 100 nm

8.	Exposure condition	Severe
9.	Method of concrete Placing	Pumping
10.	Degree of supervision	Good
11.	Type of aggregate	Crushed angular
12.	Maximum Cement content	450 kg /Cum
13.	Chemical Admixture Type	Super Plasticizer

Stipulation Proportion for 30% Fly Ash (Source-3)

1.	Grade Designation	M-30
2.	Type of Cement	OPC -53 Grade
3.	Type of Mineral Admixture	Fly Ash,Confirming IS3812 (Part – I)
4.	Maximum Size of Coarse Agg	20nm
5.	Minimum Cement content	320 kg/Cum
6.	Maximum Water Cement Ratio	0.45
7.	Workability	75 – 100 nm
8.	Exposure condition	Severe
9.	Method of concrete Placing	Pumping
10.	Degree of supervision	Good
11.	Type of aggregate	Crushed angular
12.	Maximum Cement content	450 kg /Cum
13.	Chemical Admixture Type	Super Plasticizer

Stipulation Proportion for 40% Fly Ash (Source-3)

1.	Grade Designation	M-30
2.	Type of Cement	OPC -53 Grade
3.	Type of Mineral Admixture	Fly Ash,Confirming IS3812 (Part – I)
4.	Maximum Size of Coarse Agg	20nm
5.	Minimum Cement content	320 kg/Cum
6.	Maximum Water Cement Ratio	0.45
7.	Workability	75 – 100 nm
8.	Exposure condition	Severe
9.	Method of concrete Placing	Pumping
10.	Degree of supervision	Good
11.	Type of aggregate	Crushed angular
12.	Maximum Cement content	450 kg /Cum
13.	Chemical Admixture Type	Super Plasticizer

Table 11: Proportions of Gradient in various mixes

S.NO	Mix ID	Source of Fly Ash	Percentage of Fly Ash	Value in Kg/CuM					
				Cement	Fly Ash	Sand	Coarse Aggregate	Water	Super Plasticizer
1.	NM1	NA	0	330	0	885	1093	148	6.6
2.	S1M1	NTPC	20	295	74	885	1093	148	9.25
3.	S1M2	NTPC	30	258	111	841	1061	148	10.57
4.	S1M3	NTPC	40	221	148	818	1032	148	12.91
5.	S2M1	BALCO	20	295	74	853	1076	148	9.25
6.	S2M2	BALCO	30	258	111	847	1069	148	10.57
7.	S2M3	BALCO	40	221	148	798	1006	148	12.91
8.	S3M1	LANCO	20	295	74	845	1066	148	9.25
9.	S3M2	LANCO	30	258	111	806	1016	148	10.57
10.	S3M3	LANCO	40	221	148	781	1001	148	12.91

6. Results And Discussions

Effect of different source of Fly ash in different percentage on fresh and hardened state of concrete is as reported.

6.1 Properties of Fresh Concrete

Workability / Slump Value: Design slump value for all the mixes are in the range of 15-100 mm, keeping the water cement ratio 0.44.

6.2 Properties of Hardened Concrete

- Density
- Compressive Strength
- Splitting Tensile Strength
- Modulus of Elasticity

6.2.1 Density

Density for all the ten mixes us reported as follows

Table 12 : Density for all the ten mixes

S.NO.	MIX- ID	SOURCE	% of Fly Ash	Avg. Wt .of cube in Kg		Vol.of Cube in m^2	Avg. Density in Kg	
				7 days	28 days		7 days	28 days
1.	NM1	NA	0	8.76	8.77	0.0034	2596.296	2597.531
2.	S1M1	1	20	8.63	8.43	0.0034	2555.556	2498.765
3.	S1M2	1	30	8.38	8.33	0.0034	2481.481	2498.765
4.	S1M3	1	40	8.37	8.25	0.0034	2480	2444.444
5.	S2M1	2	20	8.58	8.40	0.0034	2540.741	2488.889

S.NO.	MIX- ID	SOURCE	% of Fly Ash	Avg. Wt .of cube in Kg		Vol.of Cube in m^2	Avg. Density in Kg	
				7 days	28 days		7 days	28 days
6.	S2M2	2	30	8.35	8.27	0.0034	2474.074	2449.383
7.	S2M3	2	40	8.25	8.07	0.0034	2444.444	2390.123
8.	S3M1	3	20	8.20	8.43	0.0034	2429.63	2498.765
9.	S3M2	3	30	8.08	8.17	0.0034	2392.593	2419.753
10.	S3M3	3	40	8.03	8.05	0.0034	2377.778	2385.185

6.2.2 Compressive Strength

Compressive strength of 7 days and 28 days is reported as follows:

S.No.	MIX- ID	SOURCE	% of Fly Ash	Compressive Strength in N/mm^2	
				7 days	28 days
1.	NM1	NA	0	27.11	40
2.	S1M1	1	20	24.67	33.33
3.	S1M2	1	30	22.67	31.7
4.	S1M3	1	40	20	28.59
5.	S2M1	2	20	22.67	31.7
6.	S2M2	2	30	20.22	30.96
7.	S2M3	2	40	18.44	22.22
8.	S3M1	3	20	23.11	35.56
9.	S3M2	3	30	15.56	22.22
10.	S3M3	3	40	14.67	19.11

6.2.3 Split Tensile Strength in N/mm^2

S.No.	MIX- ID	SOURCE	% of Fly Ash	Split Tensile Strength in N/mm^2	
				7 days	28 days
1.	NM1	NA	0	2.26	3.96
2.	S1M1	1	20	2.26	3.26
3.	S1M2	1	30	2.12	3.11
4.	S1M3	1	40	1.98	2.97
5.	S2M1	2	20	2.26	3.11
6.	S2M2	2	30	1.98	2.26

S.No.	MIX- ID	SOURCE	% of Fly Ash	Split Tensile Strength in N/mm^2	
				7 days	28 days
7.	S2M3	2	40	1.42	2.26
8.	S3M1	3	20	2.26	3.26
9.	S3M2	3	30	1.84	2.55
10.	S3M3	3	40	1.56	1.98

6.2.4 Modulus of Elasticity

Modulus of Elasticity for different proportions of fly ash (0, 20, 30% & 40%) in each from three different sources has been analyzed. Longitudinal compression is measured by using dial gauge in cylinder specimen. Eo i.e., secant modulus at 33% of fractural strength and E, i.e., rupture modulus has been determined and trend is discussed.

Table 13 : Secant Modulus and Rupture Modulus of Elasticity for all Mixes

S.No.	MIX- ID	SOURCE	% of Fly Ash	Modulus of Elasticity for Design E_0 in MPa	Modulus of Elasticity for Rupture Ea in Mpa
11.	NM1	NA	0	8.45	5.95
12.	S1M1	1	20	12.41	13.44
13.	S1M2	1	30	8.75	7.36
14.	S1M3	1	40	9.05	8.41
15.	S2M1	2	20	8.12	5.92
16.	S2M2	2	30	7.92	6.19
17.	S2M3	2	40	7.36	5.92
18.	S3M1	3	20	7.64	6.19
19.	S3M2	3	30	5.25	3.96
20.	S3M3	3	40	7.84	5.66

7. Conclusions

i. Fly ash is the waste by-products of power plant, the availably of source of ash depend up on the nearby (With 150 km) power plant which can able to give a regular feed. When required. M-30 grade concrete mix are commonly used for the high-rise buildings, for the road construction having heavy traffic condition, heavy Bridges and stop dams. IS Code 10262: 2009 have been used for design the concrete of M-30 Grade.

ii. This topic is an experimental study by replacing cement with My ash in different proportion (20%, 30% & 40%) from three different source, to produce the best concrete mix in terms of resulting properties such a requirement of super plasticizer for desired slump, density of 7 and 28 days. compressive strength of 7 and 28 days, Split tensile. strength of 7 and 28 days and Modulus of elasticity from 28 days.

iii. Taking the target slump in between 75-100 mm and keeping the water cement ratio as 0.43, finalized the design mix for all the ten mixes.

iv. Fresh concrete proportion of all the ten mixes having with slump value between 75-100 mm, with different dosing of super plasticizer. Super plasticizer compass SP-430 is a Forsoc product, having ability for reducing the water demand by 25 % and increasing the compressive strength by 20%. As recommended in browser / Manual.

v. Density of the normal concrete remains almost same for 7 days and 28 days. But it is observed that the density of all the three mix (20%,30% & 40% replaced cement with fly ash) of each source (i.e. source-1 & source-2) decrease from 7 days to 28 days. Only the source-3 mixes showing the increase in the density from 7 days to 28 days.

vi. Compressive Strength of the mix decrease with increase in the percentage of ash. Compressive strength of normal of normal concrete remains high in gaining the earlier strength and final strength as well.

vii. For achieving the earlier strength of 7 days all the mixes from source-I shows the better rest than source-2 and sourece-3. Source-3 mixes are all having lower earlier strength.

viii. Ultimate strength of 28 days source-3 20% mix shows the higher result value among all other source of same percentage. Mix of 30% & 40 % replaced fly ash of source-1 shows higher result value other sources.

ix. Split tensile strength value (cube specimen) of 20% fly ash of all the three sources and normal mix for 7 days are equal. For 28 days value source-1 and source-3 are equal, 15% lower than normal mix and 12% higher than source-2.

x. Split tensile strength value (cube specimen) of 30% and 40% fly ash of all the three sources, normal mix for 7 days is at higher side. Source-3 having the lower value for 7 days and gradually increases for 28 days, as compared with source-2.

xi. Source-1 has higher value at 7 days than that of source-2 and source-3. Source-1 also shows the higher value for 28 days strength, making it suitable for using in road construction work.

xii. Secant modulus of elasticity of source-1 20% fly ash is found to be at higher side than all other mixes. Rupture modulus of elasticity value of source-1 20% fly ash is also found to higher side all other mix. Hence this mix is suitable for the structural construction work.

xiii. All the mixes of source-1 having the higher value for secant modulus, rupture modulus, Split tensile strength and compressive strength compared with other mixes from other different sources. Hence the mix made from source- I can be used for the construction activity.

xiv. According to particle size distribution of fly ash the particle size up to 45 micro take part in the reaction. In fly ash from source-3, particle retaining on 45 Micro sieves is 55.5%.Thus the large size particle of fly ash does not take participate in the reaction and a major cause for lower strength.

xv. In case of source-2 retaining percentage in 45 micro sieves is 47.5. Thus show the slower development in the strength of concrete.

xvi. In case of source-1 37.5% retain on 45 micro sieves, thus shows the better bonding and good strength.

References

[1] Binod Kumar & G.K Tike 2007. "Evaluation of properties of high volume fly ash concrete for pavement'. ASCE, p. 27-34, July 2007.

[2] Weerachat & Tangechriapat. "Use of ultra fine fly ash to improve properties of recycle aggregate". Use of recycle aggregate Journal, America Vol-25, 2010.

[3] Amit Mittal and M.B. Kaisara. "Experimental study on use of fly ash in concrete. Indian Concrete Journal'. P. 34-46, March 2009.

[4] Dr. S.P. Mishra and M. Reddy "Decision optimization doses of admixture in concrete."
International Journal of Engineering research and Industrial application. Vol 4/1, p395-409, 2011.

[5] Mark Reiner & Kevin Ren. "High volume fly ash concrete analysis and application". ASCE, p. 31-36, March 2010.

[6] Sushant Upadhaya and Kran Mishra. "Evolution of in place strength of high volume fly ash concrete". World Coal Research Journal, Vol. 14. May -2009.

[7] Cengiz Duran. "High volume fly ash abrasion resistant concrete". ASCE Journal, p. 45-52, 2002.

[8] M.N. Balakrishna and M.C. Nataraja. "Proportioning of fly ash concrete mix a compressive approach". Internal Journal of Engineering Science and Engineering. Vol. 12, June 2003.

[9] Carolyne Nammagg and Rebecca. "Optimization of fly ash in concrete, High lime fly ash as a replacement for cement and filter material'. World Coal Research Journal. Vol - 15, May -2010FS.

[10] Bilodeau and N.M. Malhotra. "Use of High Volume Fly Ash concrete at Lie Centre. Indian Concrete Journal'. AEML, p. 23-27, January 2008.

[11] P. Kumar & K.D. Metha. "High Performance, High Volume fly ash concrete for sustainable and development". University of California 2005.

[12] Cengiz Duran. "High volume fly ash concrete with high strength and low shrinkage". ASCE, p. 12-17, July-2013.