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Investigational Study on Mechanical Properties of High Performance Concrte

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Abstract **- The concrete is obtained by mixing cement, aggregates and water in required proportions, with or without a suitable admixture. We added the ingredient of mineral admixture fly ash by partial replacement of cement. This paper indicates the results of an investigational study on mechanical properties of high strength concrete. This high strength concrete is made by replacement of cement by fly ash with 50%, 60%, and 70%. The mix proportion of concrete M40.super plasticizer quantity of 1.5% by weight of cement is added to achieve required degree of workability, compressive strength, split tensile strength and flexural strength is found by testing the specimen for 28days, 56days and 90 days.**

1. INTRODUCTION

Concrete is a composite building material made from the combination of aggregate and a binder such as cement. The most common form of concrete is Portland cement concrete, which consists of mineral aggregate (generally gravel and sand), Portland cement and water. In concrete mix, cement and water form a "paste" or "matrix" which fills the voids of the fine aggregate and binds them together. The matrix is usually 22 – 34% of the total volume. After mixing, the cement hydrates and eventually hardens into a stone-like material. When used in the generic sense, this is the material referred to by the term "concrete"

1.1 HIGH PERFORMANCE CONCRETE

- Long term performance of the structure has become vital to the economy of all nations.
- HPC containing 50 – 60 % flyash (HVFA) is best suited for hot climate condition.
- HPC is defined as the concrete meeting the special contribution of Performance and uniformity requirements that cannot be achieved in normal mixing practice of normal strength concrete (ordinary concrete) HPC is defined in terms of strength & durability. The governing factors are strength, long term durability, serviceability and long terms environmental effects.

1.2 ADMIXTURES

- Admixtures are substance introduced into a batch of concrete during or immediately before its mixing in order to alter or improve the properties of the fresh and hardened concrete.

2. MATERIALSND METHODS

2.1 METHODOLOGY FOR EXPERIMENTAL PROGRAM

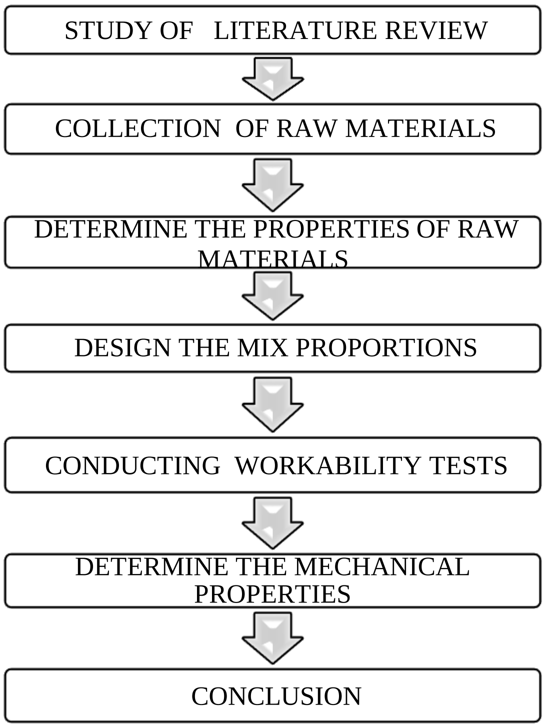

Fig1.1 Methodology

2.1 CONCRETE INGREDIENTS

The concrete mixture consists of the following ingredients,

- Cement
- Coarse aggregate
- Fine aggregate
- Water
- Mineral admixtures (Fly Ash)
- Super plasticizer (Glenium B233)

2.1.1 CEMENT

Cement can be defined as material having adhesive and cohesive properties which make it capable of bonding material fragments into a compact mass.

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Table 2.1.1 Properties of Cement

S.No	Name of the test	Value
1	Consistency	28 %
2	Initial Setting Time	1 hr 15 minutes
3	Fineness modulus	3 %
4	Specific gravity	3.15

2.1.2 FINE AGGREGATE

The sand used for experimental program was locally procured and conforming to zone II.

Table 2.1.2 Properties of Fine aggregate

S.No	Name of the test	Value
1	Specific Gravity	2.62
2	Fineness modulus	2.70
3	Water absorption	2.5 %
4	Bulk Density	1487.6 kg/m^3

2.1.3 COARSE AGGREGATE

Aggregates typically constitute 70–80 wt-% of concrete, hence aggregate types and sizes play an essential role in modifying the concrete properties.The maximum size of aggregate is generally limited to 20mm

Table 2.1.3 Properties of Coarse aggregates

S.No	Name of the test	Value
1	Specific Gravity	2.8
2	Water absorption	0.65%
3	Bulk density	1652.89 kg/m^3
4.	Crushing strength	22.12%
5.	Impact strength	19.18%
6	Flakiness index	99.85%
7.	Elongation index	99.65%

2.1.4 WATER

- It is the most important and least expensive ingredient of concrete. A part of the mixing water is utilized in the hydration of cement to form the binding matrix in which the inert aggregates are held in suspension until the matrix has hardened. The remaining water serves as a lubricant between the fine and coarse aggregates and makes the concrete workable.
- The presence of sodium carbonate and bicarbonates in water has an adverse effect on the setting time of cement. The presence of calcium chloride in water accelerates setting and hardening of cement. The quantity of calcium chloride is restricted to 1.5% by weight of cement

2.1.5 FLY ASH

- Fly ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electrostatic precipitator. Fly ash is the most widely used pozzolanic material all over the world. The use of fly ash as concrete admixture not only extends technical advantages to the properties of concrete but also contributes to the environmental
- pollution control.
- In India alone, we produce about 75 million tons of fly ash per year, the disposal of which has become a serious environmental problem. The effective utilization of fly ash in concrete making is therefore, attracting serious considerations of concrete technologist and government departments. The quality of fly ash is governed by IS 3812-Part I-2013.

ASTM broadly classifies fly ash into two classes. They are

- Class F Fly ash
- Class C Fly ash

Class **F:** Fly ash normally produced by burning anthracite or bituminous coal, usually has less than 20% Cao. Class F fly ash has pozzolanic properties only.

Class C**:** Fly ash normally produced by burning lignite or sub-bituminous coal. Some class C fly ash may have Cao content in excess of 20%.In addition to pozzolanic properties; class C fly ash also possesses cementitious properties.

Table 2.1.5: Physical Properties of Fly Ash

S. No	Characteristics	Properties
1	Colour	Whitish grey to grey with slight black
2	Specific gravity	2.2
3	fineness, cm^2/gm	3200

Table 2.1.6: Chemical Properties of Fly Ash

S. No.	Constituents	Percentage by weight
1.	Silica (SiO_2)	59.62
2.	Iron Oxide ($Fe_2 O_3$)	6.61
3.	Alumina ($Al_2 O_3$)	26.43
4.	Calcium Oxide (CaO)	1.2
5.	Magnesium Oxide (MgO)	0.76
6.	Total Sulphur (SO_3)	0.07
7.	Sodium Oxide (Na_2O)	0.58
8.	Potassium Oxide (K_2O)	1.26

2.1.6 SUPERPLASTICIZER

- The new generation of superplasticizers which are based on poly – carboxylatether,chemical composition of Glenium B233 with the generic name of multicarboxylatether (MCE) is found more suitable for production of High Performance Concrete.

PROPERTIES OF POLYCARBOXYLATEHER

- Excellent flow ability at low w/c ratio
- High reduction of water
- Lower slump loss with time
- Very high early strength
- It works at low dosages

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3. MIX DESIGN

Mix design is the process of selecting suitable ingredients of concrete, determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.

- There are number of methods of concrete mix design.
- In this project work, the concrete mix design recommended by IS 10262 : 2009.

Table 3.1 Mix proportion

Material required	Cement	Fine aggregate	Coarse Aggregate	water
Weight in	500	802	966	185
Percentage	1.00	1.60	1.93	0.37

4. MEASUREMENT OF WORKABILITY SLUMP TEST

- The apparatus for conducting slump test consists of a metallic mould in the form of a frustum of a cone (bottom diameter-20 cm; top diameter- 10 cm; height-30 cm).
- For tamping the concrete, a steel tamping rod of 16 mm diameter, 0.6 m long with bullet end is used.
- The mould is placed on a smooth, horizontal, rigid and non-absorbent surface. The mould is then filled in four layers. Each layer is tamped 25 times by the tamping rod by giving strokes evenly over the cross section.
- The mould is removed from the concrete immediately by raising it slowly and carefully in vertical direction. This allows concrete to subside and this subsidence is referred as SLUMP of concrete.

Table 4.1 Slump test value of concrete

S.No	**Percentage of fly ash added**	**Slump value (mm)**
1	0	71
2	50	73
3	60	77
4	70	75

5. TESTING OF SPECIMEN

Testing of concrete plays an important role in controlling and confirming the quality of concrete. Cube, beam and cylinder are tested for its strength characteristics.

5.1 CUBE COMPRESSION TEST

150 mm X 150mm X 150mm concrete cubes were casting using M40 grade concrete. Specimens with ordinary Portland cement (OPC). During casting the cubes were mechanically vibrated by using a table vibrator. After 24 hours, the specimens were removed from the mould and subjected to water curing for 7, 14 and 28 days. After curing, the specimens were tested for compressive strength using a calibrated compression testing machine of 2000kN capacity.

Cube specimen as per BS: 1881-198 (Part 108). Filling in layers with 50mm for each layer strokes 35 times for 150mm. Curing has been done at 20+5°C and 90% relative humidity.

Compressive Strength = Failure Load / Area of the Cube

5.2 SPLIT TENSILE STRENGTH OF CYLINDER

The cylindrical specimens of size 150mm x 300 mm are used to determine the split tensile strength as per IS: 516 – 1959. Test were carried out at the end of 28 days using Compressive Testing Machine (CTM) of 2000 KN capacity.

Tensile strength = 2P / 3.14 DL

Where, P - Failure load
D - Diameter of the specimen
L - Length of the specimen

5.3 FLEXURAL STRENGTH OF BEAM

The beam specimens of size 100 x 100 x 500 mm are used to determine the flexural strength as per IS: 516 – 1959. Test was carried out at the end of 28 days using Universal Testing Machine (UTM) of 400 KN capacities and flexural strength of beam The flexural strength of specimen expressed as,

Modulus of rupture, $f_b = \frac{3Pa}{bd^2}$ (If crack falls outside the load point)

Where,
a = distance between the line of fracture and the nearer support.
P = applied load.
b = width of the specimen.
d = depth of the specimen.

Modulus of rupture, $f_b = \frac{PL}{bd^2}$ (If crack falls within the load point)

Where, L = clear span of the specimen.
a = distance between the line of Fracture and the nearer support.
P = applied load.
b = width of the specimen.
d = depth of the specimen.

6. RESULTS AND DISCUSSION

From the test results, the compressive is maximum when fly ash 50% is replaced by cement, so adding 50% of fly ash is optimum and it gives maximum result comparing 60% & 70% adding of fly ash.

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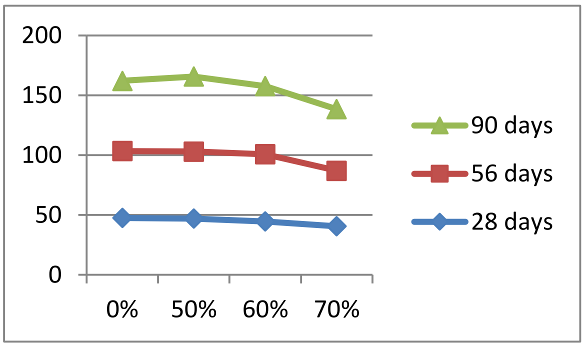
6.1 COMPRESSIVE STRENGTH RESULT

Specimen	Fly ash used in concrete (%)	Compressive strength at 28 days (Mpa)	Compressive strength at 56 days (Mpa)	Compressive strength at 90 days (Mpa)
1	0.0	48.86	54.54	58.48
2		46.80	56.55	59.15
3		47.15	56.40	58.40
1	50.0	47.20	58.10	64.10
2		47.80	58.55	65.55
3		46.15	51.40	58.06
1	60.0	44.20	57.10	59.10
2		45.80	56.55	54.55
3		44.15	54.40	57.40
1	70.0	40.20	45.10	48.10
2		38.80	46.55	52.55
3		43.15	47.40	53.40

Compressive strength and % change of strength at 28,56 and 90 days for M40

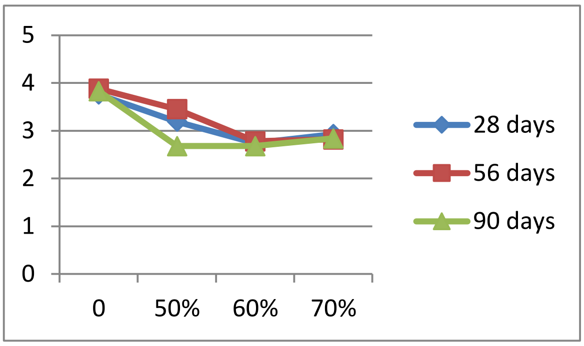


comparsion of Compressive strength

6.2 SPLIT TENSILE STRENGTH RESULTS

Specimen	Flyash used in concrete (%)	Split tensile strength at 28 days (Mpa)	Split tensile strength at 56 days (Mpa)	Split tensile strength at 90 days (Mpa)
1	0	3.96	3.91	3.89
2		3.45	3.75	3.93
3		3.89	3.99	3.67
1	50.0	3.15	3.58	3.58
2		3.24	3.45	3.54
3		3.19	3.33	3.39
1	60.0	2.76	2.60	2.69
2		2.69	2.85	2.65
3		2.77	2.90	2.70
1	70.0	3.04	2.85	2.91
2		2.80	2.55	2.85
3		2.95	3.06	2.77

split tensile strength and % change of strength at 28,56 and 90 days for M40

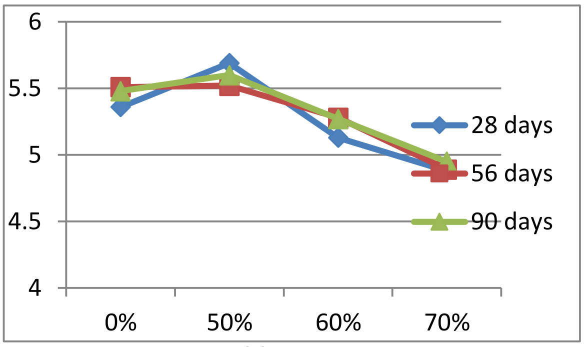


comparison of split tensile strength

6.3 FLEXURAL STRENGTH RESULTS

Flexural strength and % change of strength at 28, 56 and 90 days for M40

Specimen	Flyash used in concrete (%)	Flexural strength at 28 days (Mpa)	Flexural strength at 56 days (Mpa)	Flexural strength at 90 days (Mpa)
1	0	5.52	5.58	5.85
2		5.43	5.55	5.55
3		5.15	5.40	5.40
1	50	5.85	5.55	5.76
2		5.90	5.80	5.67
3		5.33	5.23	5.39
1	60	5.20	5.50	5.56
2		5.16	5.24	5.09
3		5.05	5.10	5.16
1	70	5.01	5.12	5.08
2		4.96	4.56	4.87
3		4.67	4.99	4.91



Comparison of flexural strength

CONCLUSION

The utilization of fly ash in concrete is a productive way of disposal of industrial waste.

Use of fly ash in concrete can save the coal and thermal industry disposal costs and produce a 'greener' concrete for construction.

The compressive strength is maximum during 90 days of curing (62.57Mpa) when the fly ash is replaced by 50% of cement comparing 60% and 70%.

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The flexural strength of the concrete also gives maximum strength of 5.60 Mpa when the fly ash is replaced by 50% of the cement. So fly ash can be added to the concrete, thereby utilizing the waste materials in construction industry.

The Cement content of 50% was replaced by Fly ash so that the target mean strength obtained at later days and 50% addition of fly ash is optimum.

The cost analysis indicates that percentage cement reduction decreases cost of concrete but at the same time strength also decrease when the percentage of fly ash increases in replacement of cement.

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