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Use of Steel Fiber Reinforcement in Self Compacting Concrete with Partial Replacement Of Fly Ash

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Abstract: The term Concrete Mix Design is the methodology of selecting suitable materials of concrete and finding out their relative amounts with an objective of generating a concrete of the required characteristics such as strength, durability, and workability in an economical manner. The required concrete proportioning of ingredient is directed by the performance of concrete in 2 stages i,e the plastic and hardened stage. The plastic concrete cannot be properly placed and compacted if it is not workable. Therefore workability as a property of concrete has a vital importance. In hardened concrete, the compressive strength is generally considered to be an basis of its other properties, depends upon many factors, e.g. quality and quantity of cement , water and aggregates; batching and mixing; placing ,compaction and curing. The aim of this study is to evaluate the mechanical performance of M 40 grade concrete containing fly ash and 1 % of steel fibers. The test on mechanical properties of concrete i,e compressive , tensile and flexural strength being carried out, on concrete is conducted for 7,14 and 28 days of cured specimen for both the fiber reinforced and the conventional concrete. The study gives clear picture regarding the effect caused by the addition of steel fibers and fly ash compared with that of the conventional concrete.

Keywords: Fly ash, Compressive strength, Split tensile strength, flexural strength.

I. INTRODUCTION

Cement-based products are the nearly all plentiful of all man-made products and so are very essential design products, in fact it is more than likely that they'll go on to own similar value in the future. Nevertheless, these design and also anatomist products need to meet new and also larger demands. As soon as struggling with troubles of production, overall economy, top quality and also setting, weather resistant take on some other design products for instance plastic material, material and also timber. Just one direction within this advancement is usually to Self-Compacting Concrete (SCC), some sort of improved product that will, devoid of additional compaction vitality, passes and also consolidates intoxicated by its bodyweight. The employment of SCC provides a additional industrialized creation. Besides does it reduce the harmful responsibilities intended for workers, it can also reduce the specialized prices of in situ solid concrete constructions, on account of improved upon sending your line routine, top quality, sturdiness, area conclude and also trustworthiness of concrete set ups and also eliminating many of the possibility of human being malfunction. Nevertheless, SCC is a sensitive mix, powerfully determined by the composition as well as the attributes of their constituents. It's got to acquire the incompatible houses of substantial circulation ability as well as substantial segregation level of resistance. That harmony is manufactured doable through the dispersing consequence of high-range water-reducing admixture (superplasticizer) combined with cohesiveness manufactured by a higher focus of fine allergens in additional filler product. The principle things controlling this specific fine harmony tend to be relevant to area physics and also chemistry hence, SCC is usually powerfully determined by the game on the admixtures, together with about the large surface area earned through the substantial written content of fees. Fresh new SCC, similar to all cementitious products, is a centred particle suspension together with an array of particle sizing's (from 10- to be able to 25 mm intended for concrete). This allergens are influenced by some sort of sophisticated harmony of inter-particle forces (i. electronic. interlocking, frictional, colloidal, and also electrostatic forces), producing a period of time dependancy and also visco-plastic non-Newtonian behavior.

II. MATERIALS

Following materials are used in present study

- Cement
- Sand
- Aggregate

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- Water
- Fly Ash (Steel Plant)
- Steel Fiber
- Superplasticizer

Cement

A hydraulic cement made by finely pulverizing the clinker produced by calcining to incipient fusion a mixture of argillaceous and calcareous materials Portland cement is the fine gray powder that is the active ingredient in concrete. For present study 43 grade OPC was used.

Sand

River sand is a widely used construction material all over the world, especially in the production of concrete, cement-sand mortar and concrete blocks. Sand is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO2), usually in the form of quartz. Locally available river sand was used in present study.

Aggregate

In addition to cement, water and aggregates are the other primary constituents of concrete mixtures. Aggregate is a rocklike material of various sizes and shapes, used in the manufacture of Portland cement concrete, bituminous (asphalt) concrete plaster, grout, filter beds, and so on. The ASTM standards (C125 and D8) define aggregate as a granular material such as sand, gravel, crushed stone, or iron- blast furnace slag used with a cementing medium to form mortar or concrete, or alone as in base course or railroad ballast.

Water

Potable water was used in this study. Water is a crucial component of concrete as it is viably included in chemical responses with cement, particularly hydration. In the present examination consumable water is used according to IS 456: 2000 was used for preparation of cement, the water concrete proportion chooses the quality of cement.

Table 2.1 Chemical Composition of Fly Ash

Item	ASTM	European Specifications			IS 3812
	C-618	En-450	En-197-I	En-3892-I	2003- I
Sio_2 minimum					35
Reactive/soluble Sio_2, min.		25	25		20
Sio_2+Al2O3+Fi_2O_3 minimum	70				70
MgO, Maximum					70
LOI(1hour)max.	6	5-7	5-7	7	5
Total alkalis, max.	1.5				1.5
SO_3, maximum	5	3		2	3.0
Free CaO, maximum		1	1		
Total/reactive CaO, maximum		10	10	10	
Fineness, 45 micron, maximum	34	40		12	34
Blaines fineness m^2/kg min.					320
Cement activity 28 days	75	75		80	80
Lime reactivity, N/mm^2					4.5
Soundness, Le-Chatelier, mm		10	10	10	10
Autoclave, Percent	0.8				0.8

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Fly Ash

Fly ash is a residual material of energy production using coal, which has been found to have numerous advantage for use in concrete. Some of the advantage include improved workability, reduced permeability, increased ultimate strength, reduced bleeding, better surface and reduced heat of hydration. Several types of fly ash are produced depending on the coal and coal combustion process. It is a pozzolanic material and has been classified into two classes Fly ash is one of the residues generated in combustion , and comprises the fine particles that rise with the flue gases . Ash which does not rise is termed bottom ash . In an industrial context, fly ash usually refers to ash produced during combustion of coal . Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment before the flue gases reach the chimneys of coal fired power plants , and together with bottom ash removed from the bottom of the furnace is in this case jointly known as coal ash . Depending upon the source and makeup of the coal being burned in the past, fly ash was generally released into the atmosphere , but pollution control equipment mandated in recent decades now require that it be captured prior to release.

Steel Fiber Reinforcement

Steel Fibers (crimped) of length 50mm and thickness 1mm with an aspect ratio of 50,is been used in the current project. A constant percentage of fibers i,e 1% is added and is used for the experimental study. They are uniformly dispersed in the concrete while mixing and casting.

Table 2.2 Properties of Steel Fibers Used in Present Study

Sr. No.	Property	Description
1	Color	Dark Brown / Black
2	Specific Gravity	1.20 at 25 C
3	All Entrainment	1% maximum depending upon grading of sand and water content
4	Chloride Content	Nil
5	Nitrate Content	Nil
6	Freezing Point	0 C
7	Flash Point	None
8	Diameter	33 – 35 micron
9	Cut Length	6 mm, 12 mm, 24 mm, 50 mm
10	Tensile Sterngth	6000 Kg /Cm

Superplasticizer

Superplasticizers constitute of a relatively new category and improved version of plasticizer, the use of which was developed in Japan and Germany during 1960 and 1970, respectively. They are chemically different from normal plasticizers. The use of plasticizers permits reduction of water to an extent up to 30% without reducing the workability in contrast to the possible reduction up to 15% in case of plasticizers. There are a number of superplasticizers available in the market, out of which three superplasticizers will be used in this research to study their effect on workability and mechanical properties of concrete mixture in both fresh and hardened state. Superplasticizers produce a homogeneous, cohesive concrete generally without any tendency for segregation and bleeding.

III.METHODOLOGY

In this experimental investigation an attempt has been made to find out the strength of concrete produced by replacing the cement with fly ash in various percentages ranging from 10% to 50% in increments of 10% [0%, 10%, 20%, 30%, 40%, and 50%] and constant steel fibers 1 %. Ordinary Portland cement (OPC) 53 grade, locally available sand and coarse aggregates were used in this experiments. The sand used was a Zone II had the specific gravity 2.62 the specific gravity of the coarse aggregate was 2.86. The coarse aggregate used were of 20 mm and down size. The fly ash was obtained from steel plant. The 150 micron passing fraction was used for the experimentation. Mix design carried out for M 40 as per IS 10262:2009 yielded a mix proportion of 1: 1.83: 2.65 with water cement ratio of 0.41. Specimens were prepared according to the mix proportion and by replacing cement with fly ash in different proportion and use of sand.

3.1 COMPRESSIVE STRENGTH TEST

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. For cube test two types of specimens either cubes of 15 cm X 15 cm X 15 cm or 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15 cm x 15cm x 15 cm are commonly used. This concrete is

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poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth...These specimens are tested by compression testing machine after 7, 14 and 28 days curing. The compressive strength of concrete is the most common performance measure used in designing buildings and other structures. The compressive strength is generally measured by breaking cubical concrete specimens in a compression-testing machine. The compressive strength is calculated from the failure load divided by the cross-sectional area resisting the load Compressive strength test results are primarily used to determine that the concrete mixture as delivered meets the requirements of the specified strength, fck in the jobs specification. The test was conducted on the cube specimen of size 150×150×150mm.

Compressive Strength = Failure Load / Cross Sectional Area of Cube

Table 3.1 Compressive Strength Result

Sr. No.	**Fly Ash %**	**Avg. Strength After 7 Days (N/mm^2)**	**Avg. Strength After 14 Days (N/mm^2)**	**Avg. Strength After 28 Days (N/mm^2)**
1	**0%**	20.79	23.84	41.68
2	**10%**	23.55	27.00	47.20
2	**20%**	25.23	29.65	51.83
4	**30%**	29.36	33.67	58.86
5	**40%**	25.98	29.79	52.07
6	**50%**	20.64	23.67	41.37

3.2 SPLIT TENSILE STRENGTH

This test method consists of applying a diametral compressive force along the length of a cylindrical concrete specimen at a rate that is within a prescribed range until failure occurs. This loading induces tensile stresses on the plane containing the applied load and relatively high compressive stresses in the area immediately around the applied load. Tensile failure occurs rather than compressive failure because the areas of load application are in a state of triaxial compression, thereby allowing them to withstand much higher compressive stresses than would be indicated by a uniaxial com- pressive strength test result.

Procedure
Marking
Draw diametral lines on each end of the specimen using a suitable device that will ensure that they are in the same axial plane

Measurements
Determine the diameter of the test specimen to the nearest 0.01 in. [0.25 mm] by averaging three diameters measured near the ends and the middle of the specimen and lying in the plane containing the lines marked on the two ends. Determine the length of the specimen to the nearest 0.1 in. [2 mm] by averaging at least two length measurements taken in the plane containing the lines marked
on the two ends.

Positioning Using Marked Diametral Lines
Center one of the plywood strips along the center of the lower bearing block. Place the specimen on the plywood strip and align so that the lines marked on the ends of the specimen are vertical and centered over the plywood strip. Place a second plywood strip lengthwise on the cylinder, centered on the lines marked on the ends of the cylinder.

Rate of Loading
Apply the load continuously and without shock, at a constant rate within the range 100 to 200 psi/min [0.7 to 1.4 MPa/min] splitting tensile stress until failure of the specimen

Calculation
Calculate the splitting tensile strength of the specimen as follows:

$$T = 2.P / \Pi.l.d$$

where:
T= splitting tensile strength, psi [MPa]
P= maximum applied load indicated by the testing machine, lbf [N],
l= length, in. [mm], and
d= diameter, in. [mm]

Table 3.2 Split Tensile Strength Result

Sr. No.	Fly Ash %	Avg. Strength After 7 Days (N/mm^2)	Avg. Strength After 14 Days (N/mm^2)	Avg. Strength After 28 Days (N/mm^2)
1	**0%**	3.52	4.71	8.84
2	**10%**	3.99	5.33	10.01
2	**20%**	4.27	5.86	10.99
4	**30%**	4.97	6.65	12.48
5	**40%**	5.06	7.26	12.92
6	**50%**	3.50	4.67	8.77

3.3 FLEXURAL STRENGTH

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 6 x 6-inch (150 x 150-mm) concrete beams with a span length at least three times the depth. The flexural strength is expressed as Modulus of Rupture (MR) in psi (MPa) and is determined by standard test methods ASTM C 78 (third-point load- ing) or ASTM C 293 (center-point loading). Flexural MR is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. However, the best correlation for specific materials is obtained by laboratory tests for given materials and mix design. The MR deter- mined by third-point loading is lower than the MR de- termined by center-point loading, sometimes by as much as 15%.

The test specimen shall have approximate dimensions of 6 in. x 6 in. x 20 in. (152 mm x 152 mm x 508 mm). The test specimen shall be kept wet until the time of the test.

1. Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar as specified above. Tamping should be distributed uniformly over the entire cross section of the beam mould and throughout the depth of each layer.
2. Clean the bearing surfaces of the supporting and loading rollers , and remove any loose sand or other material from the surfaces of the specimen where they are to make contact with the rollers.
3. Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be **3d** and the distance between the inner rollers shall be **d**. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.
4. The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly centered with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normal to the direction of loading.
5. The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

The Flexural Strength or modulus of rupture (f_b) is given by

$$f_b = pl/bd^2$$ (when **a**> 20.0cm for 15.0cm specimen or > 13.0cm for 10cm specimen)

or

$$f_b = 3pa/bd^2$$ (when **a**< 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.)

Where,
a = the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen
b = width of specimen (cm)
d = failure point depth (cm)
l = supported length (cm)
p = max. Load (kg)

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Table 3.3 Flexural Strength Result

Sr. No.	Fly Ash %	Avg. Strength After 28 Days (N/mm^2)
1	**0%**	3.44
2	**10%**	3.90
2	**20%**	4.28
4	**30%**	4.86
5	**40%**	4.30
6	**50%**	3.42

IV. CONCLUSION

Test result on the specimen shows there is improvement in compressive strength because of continuous increase of fly ash. The strength increases with addition of fly at 10%, 20% 30% and after that declines at 40% and 50% gradually

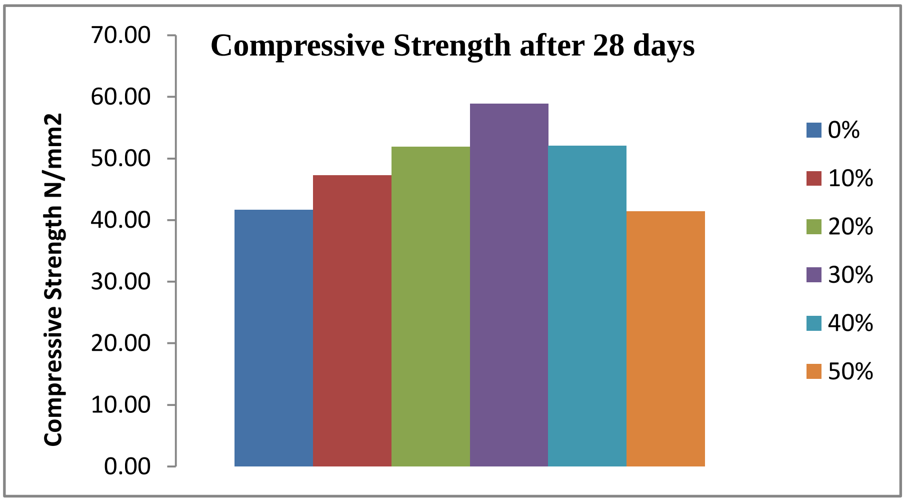

Fig. 4.1 Compressive Strength after 28 days

The aftereffects of split tensile strength of concrete mixes by partial substitution of cement by fly ash and utilizing 1 % of steel fiber reinforcement was tested at 7, 14 and 28 days. Thus result tensile of concrete increases with expansion in rate of fly ash which can be supplanted up to 40% as indicated in graphical representation.

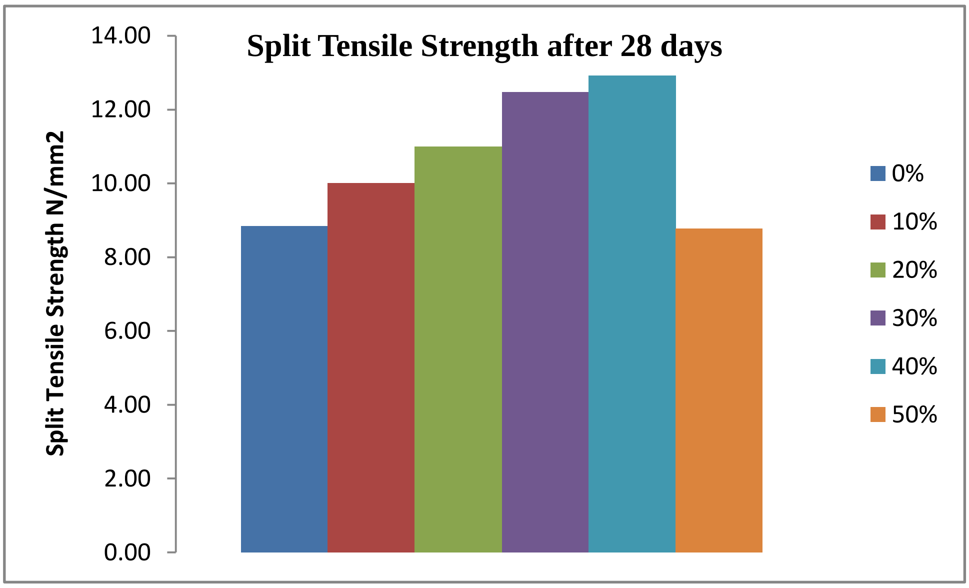

Fig. 4.2 Split Tensile Strength after 28 days

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The consequences of flexural strength of concrete mix M 40 by fractional supplanting of cement with fly ash were tested at 28 and 56 days, the concrete with addition of 10%, 20% 30% and 40% of waste fly ash demonstrated most extreme strength when contrasted to conventional concrete.

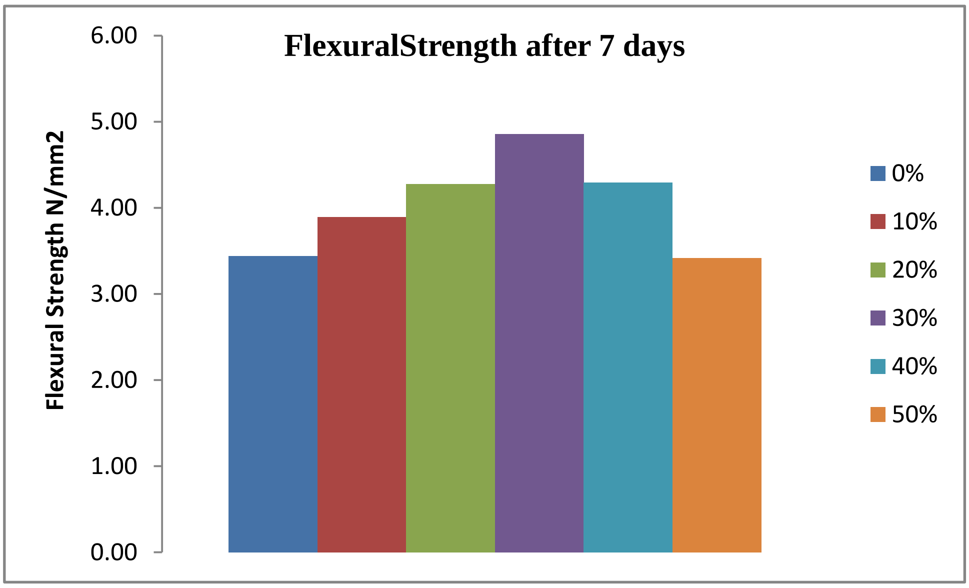

Fig. 4.3 Flexural Strength after 7 days

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