Strength Characteristic Study of Polyester Fiber Reinforced Concrete

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***Abstract*— Normally the concrete structures have high compressive strength but have low tensile strength. The use of polyester fiber increasing the properties of concrete such as compressive strength, tensile strength, impact strength and abrasion resistance. Fibers provide support to concrete in all direction by equally distributed throughout the matrix. It also prevents the problem of corrosion.**

The production of cement will produce large amount of carbon dioxide. Fly ash is one of the byproduct produced from coal industry. The replacement of fly ash reduces the carbon dioxide emission. So, it is used as a sustainable material in concrete industry.

Keywords —Conventional concrete, Fly ash, Polyester Fiber

I. INTRODUCTION

Plane concrete has very low tensile strength and cause formation of cracks in stressed and unstressed states. It has low strain, brittle and has less ductility in nature.

To modify these problems by using polyester fiber reinforced concrete. These fibers are randomly distributed fibers that need in Portland cement concrete reinforcement. Polyester in normal concrete improves the compressive and flexural strength of a concrete. It also improves the abrasion to resistance and resistance to alkaline condition. This paper includes final mix composition, compressive and flexural strength test results at different stages.

Fly ash is the best known and commonly uses pozzolan. It is a waste product of coal. It is based on electricity generating thermal power. Fly ash is spherical in shape and allow them to flow and blend freely in mixtures. These materials greatly improve the durability of concrete. Fly ash can be observed as safely and economically used. As a sustainable development it made to reduce the use of cement in concrete by replacing it. It also reduces carbon-dioxide emission in environment by all possible ways.

II. EXPERIMENTAL DETAILS

A. MATERIAL

In this study M30 concrete mix is prepared for 53 grade OPC. Cement, crushed natural stone as fine aggregate and coarse aggregate, Fly ash superplasticizer, polyester fiber is used. Following tables shows the properties of materials.

TABLE 1: PROPERTIES OF CEMENT

Test	Result
Specific Gravity	2.67
Bulk Density(g/cm³)	1.89
Porosity	0.12
Void Ratio	0.134
Fineness Modulus	3.95

TABLE 2:PROPERTIES OF COARSE AGGREGATE

Tests	Result
Fineness	7%
Consistency	33%
Specific Gravity	3.13
Initial setting time(min)	40
Final setting time(min)	360
3rd day compressive strength (N/mm²)	30
7th day compressive strength (N/mm²)	39

TABLE 3:PROPERTIES OF FINE AGGREGATE

Test	Result
Specific Gravity	2.8
Bulk Density(g/cm³)	1.605
Porosity	0.437
Void Ratio	0.7

TABLE 4: PROPERTIES OF FLY ASH

Chemical Composition	Percentage (mass)
SiO_2	60.28
Al_2O_3	31.76
Na_2O	2.1
P_2O	5 1.46
SO_3	0.97
Fe_2O_3	0.89
CaO	0.72
K_2O	0.69
TiO_2	0.64
MgO	0.52

TABLE 5:PROPERTIES OF POLYESTER FIBER

Fibre Length	12mm
Diameter	36 micron
Young's Modulus	4 Gpa
Specific Gravity	1.36
Tensile Strength	500 Mpa
Melting Point	>250ºC
Aspect Ratio	334

FIG. 1:MATERIALS

B. *Mix Proportioning*

Details of mix

IS 10262-2009 is used for mix design. Concrete mix 1:2:3.428 proportions are used for M_{30} grade. For the experimental study 6 different mixes are prepared. One conventional mix, 10% cement is replaced by fly ash for next 5 composition. One normal mix, mix with 0.025% polyester fiber, mix with 0.05% polyester fiber, mix with 0.075% polyester fiber and mix with 0.1% polyester fiber. For 1m³ concrete the following are the proportion of materials.

TABLE 6:DETAILS OF THE MIX

Cement	315 kg/m³
Fly ash	35 kg/m³
Coarse Aggregate	1200 kg/m³
Fine Aggregate	703.39 kg/m³
Water	140 kg/m³
Super Plasticizer	3.5 kg/m³
W/C ratio	0.4

TABLE 7:MIX DESIGNATION

Volume fraction (Fly ash, Polyester fiber)	Specification
(0%, 0%)	N
(10%, 0%)	P0
(10%, 0.025%)	P1
(10%, 0.05%)	P2
(10%, 0.075%)	P3
(10%, 0.1%)	P4

C. *Prepration and curing*

At first the mould is cleaned and then oiled it. Materials are collected at correct proportion. Then fibers are spread over the mix. Then the mix is placed over the mould at three layers and also 25 tamps are applied for each layer. The top most surface is leveled by using trowel. The remolding is done after 24 hours and place on the curing tank.

After the curing period take out from the curing tank and allow to dry. Then the specimen is introduced to various tests.

For various test, cube specimen of 150mm X 150mm, beam specimen of 500mm X 100mm X 100mm, Cylindrical specimen 150mm diameter 300mm height and specimen of 50mm thick 150mm diameter disc were cast. 114 total specimens were cast.

FIG.2:SPECIMEN PREPARATION

FIG. 3:SPECIMEN CURING

D. *Workability of fresh concrete*

Slump test:

Slump test is mainly used for finding the workability of freshly prepared concrete. The frustum of cone having height 30cm and bottom and top diameter are of 20cm and 10cm. Initially fill the mould with concrete of about 4 layers and tamp for 25 strokes. Clean the excess concrete and level the surface. Rise the mould from the concrete immediately and slowly in vertical. Measure the difference between height of mould and that of height of point of specimen being tested.

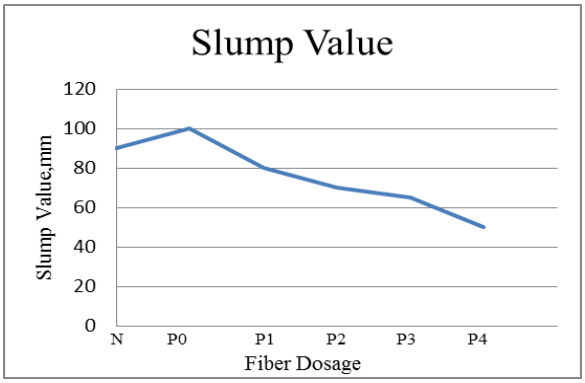


CHART 1:SLUMP VALUE

Compaction factor test:

In laboratory, compaction factor test is done for finding the workability of fresh concrete. Initially place the concrete sample on the upper hopper using trowel and level it. Open the trap door at the bottom of the upper hopper and followed by reaching of concrete to the lower hopper. Then open the trap door of lower hopper, concrete falls on the cylinder and then weigh it. Then refill the cylinder with concrete and compact it.

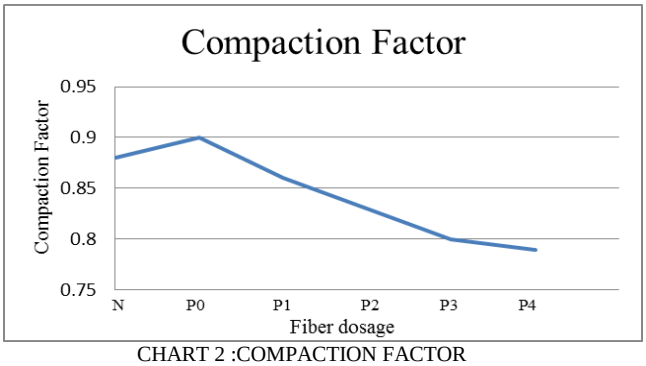


CHART 2 :COMPACTION FACTOR

FIG 4:TEST ON FRESH CONCRETE

E. *Strength study on hardened concrete*

Compression test on concrete:

Compressive strength gives the overall picture on strength of concrete cubes. The dimension of specimen is 150mm X 150mm X 150mm. The test specimen is placed on the specimen. The load is applied at a rate of 140kg/cm²/min. The maximum load is noted.

FIG. 5:COMPRESSION TEST ON CUBE

TABLE 8: COMPRESSIVE STRENGTH OF DIFFERENT MIXES

Mix	Compressive strength (N/mm²)		
	7th day	*14th day*	*28th day*
N	23.11	29.33	35.11
P0	22	28	34
P1	24.89	30	38.22
P2	26.67	32	41.33
P3	24.89	28.89	39.11
P4	23.11	26	35.11

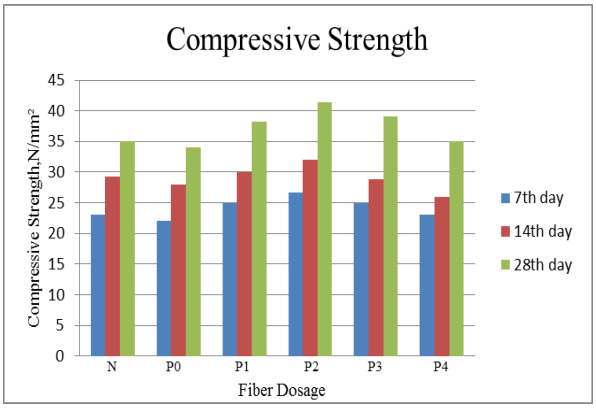


CHART 3: COMPRESSIVE STRENGTH

Split tensile strength test:

Tensile strength test is used to measure the tension forces. The concrete develops cracks due to tension forces. The size of specimen 150 X 300mm height is used. Load is applied at on the specimen. The load is applied up to the specimen fails.

FIG. 6 :SPLIT TENSILE STRENGTH TEST ON CYLINDER

TABLE 9 :SPLIT TENSILE STRENGTH OF DIFFERENT MIXES

Mix	Split Tensile Strength(N/mm²)
	28th day
P0	3.25
P1	4.24
P2	5.38
P3	4.8
P4	3.96

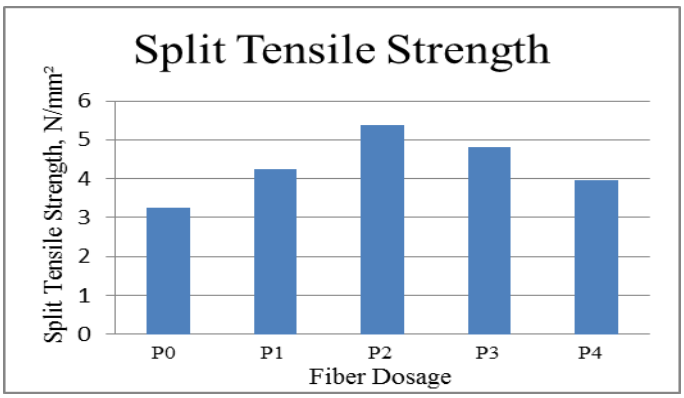


CHART 4:SPLIT TENSILE STRENGTH

Impact resistance test:

Impact resistance test is used to determining the resistance of material under high speed. In this test hammer strikes the beam at the rate of 4.5 kg load and height of 460 mm. The measurement is taken by using gauges. The experiment is continued after until the crack appears.

Table 10:Impact resistance of different mixes

Mix	Impact resistance		
	No. of blows for 1st crack	*No. of blows for ultimate crack*	*Impact ductility index*
P0	12	15	1.25
P1	13	20	1.538
P2	15	50	3.33
P3	16	40	2.5
P4	13	30	2.3

FIG.7:IMPACT RESISTANCE TEST ON DISC

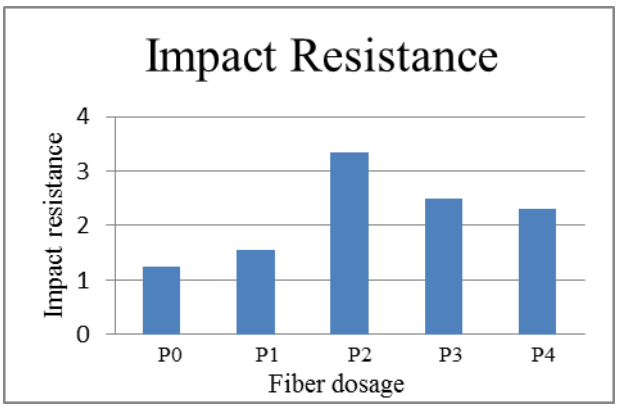


CHART 5: IMPACT RESISTANCE

Modulus of elasticity:

The modulus of elasticity cylinder can be find out by uni-axial compression test. Here we use a cylinder of size 150mm X 300mm. The use of compressometer and dial gauge is needed for finding the modulus of elasticity. The deformation of cylinder is measured by using dial gauge meter attached to the compressometer. Load is increased and corresponding stress strain graph are plotted.

FIG. 8:MODULUS OF ELASTICITY TEST OF CYLINDER

FIG.9: FLEXURAL TEST ON BEAM

TABLE 11:MODULUS OF ELASTICITY OF DIFFERENT MIXES

Mix	Flexural strength(N/mm²) *28thday*
P0	6.3
P1	8
P2	10.5
P3	9.5
P4	7

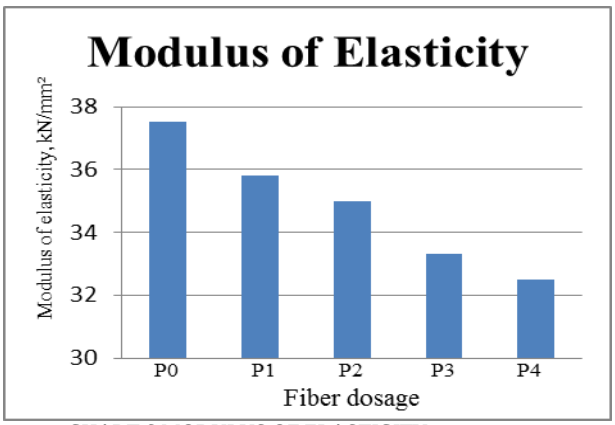
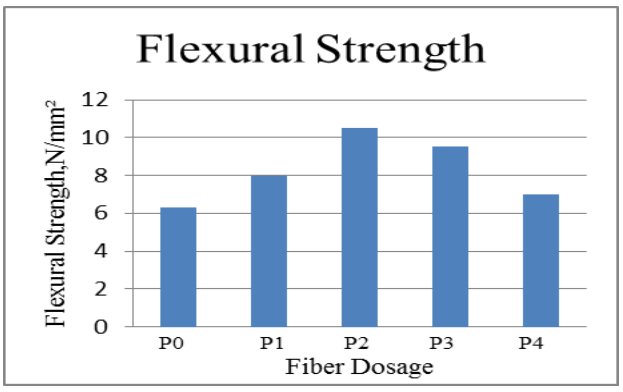


CHART 6:MODULUS OF ELASTICITY

TABLE 12: FLEXURAL STRENGTH OF DIFFERENT MIXES

Mix	Modulus of elasticity(kN/mm²) *28th day*
P0	37.5
P1	35.8
P2	35
P3	33.33
P4	32.5

CHART 7:FLEXURAL STRENGTH



Flexural test on concrete:

Flexural strength is used to measure tensile strength of concrete. It resists failures of bending. The test is carried out in beams and span length is at least three times the depth. Then load is applied at a particular point crack is developed and point is noted.

III. CONCLUSIONS

1) Workability of polyester fibre reinforced concrete decreases with increase of fiber. In all mixes slump value and compression factor is less than conventional mix.
2) Compressive strength, Flexural strength and split tensile strength get increased due to the addition of polyester fiber.
3) Compressive strength is 21.5%increased due to the addition of fiber.
4) Split tensile strength is 65.5% increased due to the addition of fiber.

5) Flexural strength is 66.66% increased due to the addition of fiber.
6) Impact ductility index is increased with increasing fiber content. It is due to the high bonding of fiber.
7) Modulus of elasticity is decreases 7.14% due to the addition of fiber.
8) The optimum fiber concrete will give the strength of M40 mix.
9) The replacement of fly ash creates an economical mix.
10) The replacement of fly ash provide a workable mix.

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