Strength Characteristic Study of Glass Fiber Reinforced Concrete

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***Abstract*— Any concrete structure develops cracks due to shrinkage at various climatic conditions. The addition of glass fiber reduces cracks and it's also acts as an additional reinforcement. The concrete without fibers develops plastic shrinkage, drying shrinkage and it also reduces bleeding of water.**

The abundant production of fly ash from coal based thermal power plants as water production becomes a problem for the disposal and it also hazardous to the environment. The addition of fly ash in glass fiber reinforced reduces environmental pollution.

***Keywords*— Conventional concrete, Fly ash, Glass Fiber**

I. INTRODUCTION

Concrete is one of the most versatile and durable building material for construction. It has a very low coefficient of thermal expansion. Concrete has high compressive strength but lower strength. Concrete without adding fiber then it may cause cracks in concrete.

By adding Glass fiber in concrete it eliminates cracks and shrinkage. Glass fibers are thus high strength and have many applications. It increases structural integrity. Fiber reinforced concrete mainly used in ground floors and pavements. Glass fiber reinforced concrete made of cement, coarse aggregate, Fine aggregate, water, glass fiber, and plasticizer. Glass fibers can be incorporated in continuous or discontinuous manner. Glass fiber is usually round and straight with diameter 0.05mm to 0.15mm. Glass can be easily formed using moulding process. It is an oldest and most familiar performance fiber.

Production of ordinary Portland cement will produce large amount of carbon dioxide (CO_2).This will leads to many environmental problems. But cement is the major ingredient of concrete. So fully replacement of cement is not applicable. But partial replacement is possible.

Fly ash is the main by product from thermal industries. It will create many environmental problems. So, proper disposal is required for fly ash.

For solve both of this problems cement can be partially replaced by fly ash. For this study 10% of cement is replaced by fly ash. Usage of high amount of fly ash will take more time to attain high strength characteristics. And also it requires large curing time period.

II. EXPERIMENTAL DETAILS

A. *MATERIAL*

IS 10262-2009 is used to determine the proportions of materials. For this experimental study use 53 grade ordinary Portland cement, fly ash, fine aggregate, coarse aggregate, portable water, glass fiber and plasticizer. The properties of these materials are given below.

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 GLASS FIBER

Fibre Length	12 mm
Diameter	0.05 mm
Water absorption	85
Specific Gravity	2.68
Tensile Strength	1700 MPa
Density, kg/m³	2550
Aspect Ratio	240

FIG.1:MATERIALS

B. *Mix Proportioning*

Details of mix

Mix design is carried out in the basis of IS 10262-2009. For M_{30} grade concrete mix 1:2:3.428 proportions are used. For the study 6 different mixes are prepared. One normal mix without fly ash , 10% cement is replaced by fly ash in next 5 mix. One normal mix , mix with 0.025% glass fiber, mix with 0.05% glass fiber, mix with 0.075% glass fiber and mix with 0.1% glass fiber. For 1m³ concrete the following are the amount of ingredients.

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 , Glass fiber)	Specification
(0%, 0%)	N
(10%, 0%)	G0
(10%, 0.025%)	G1
(10%, 0.05%)	G2
(10%, 0.075%)	G3
(10%, 0.1%)	G4

C. *Specimen preparation and curing*

For specimen preparation tight the moulds then oil the mould. Then mix dry ingredients and water is mixed .Mix all the ingredients thoroughly. Then slump test and compaction factor test are conducted. Then mix is filled in mould as 3 layers, for each layer 25 tamps are provided.Finish the surface with trowel. After 24 hour remould the specimen and placed in a curing water tank.

After the curing period specimen is taken out and allow drying. Then various tests are conducted for strength determination.

Cube specimen of 150 mm X 150mm, cylindrical specimen of 150mm diameter 300mm height, Beam specimen of 500mm X 100mm X 100mm and disc specimen of 150mm diameter 50mm thick are specimens were cast. Total 114 number of specimens were cast in this experimental study.

FIG.2: SPECIMEN PREPARATION

FIG 3. SPECIMEN CURING

D. *Workability of fresh concrete*

Slump test and compaction factor test is conducted in fresh concrete. Both of these tests are conducted for measuring the workability of concrete.

Slump test:

Slump test is used to determine the consistency of concrete before it sets. The mould for the test specimen is in the form of frustum of a cone having internal dimension of 20cm bottom and 10cm top and 30cm height. The mould is placed on the base plate and fresh concrete is applied. The test is continued until specimen collapse or shear.

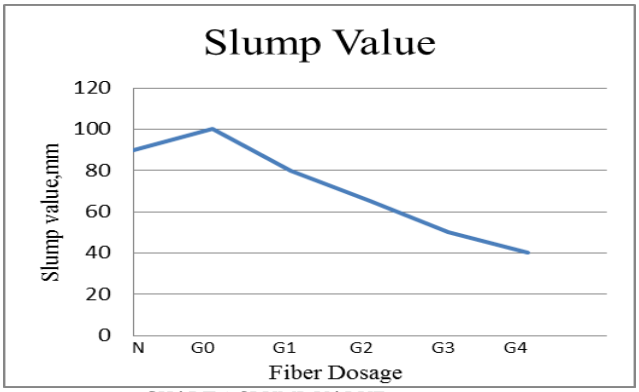


CHART 1:SLUMP VALUE

Mix	Compressive strength (N/mm²)		
	7th day	*14th day*	*28th day*
N	23.11	29.33	35.11
G0	22	28	34
G1	24	30	36
G2	27.11	34.22	38.22
G3	30.22	35.11	41.33
G4	25.77	32	36

Compacting factor test:

Compacting factor test is used to measure the workability of concrete. The test is based on IS 1199-1959. The concrete is filled in upper hopper. Then open the hopper and concrete shall be allowing fill in cylinder.

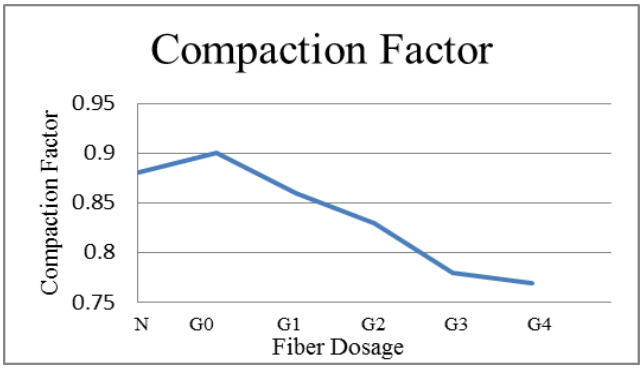


CHART 2:COMPACTION FACTOR

FIG. 4:FRESH CONCRETE TESTING

E. Strength study on harened concrete

Compressive strength test:

Compressive strength is the most important property in concrete. It is used to measure the ability to resist static load. The specimen is prepared having dimensions of 150mm X 150mm X 150mm. The specimen is taken out in the curing water and cleaned the specimen. Then the test is conducted for various fiber dosages.

FIG.5: COMPRESSION TEST ON CUBE

TABLE 8:COMPRESSIVE STRENGTH OF DIFFERENT MIXES

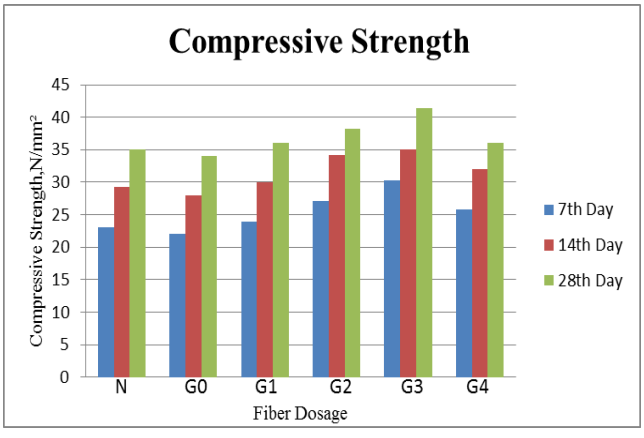


CHART 3:COMPACTION STRENGTH

Split tensile strength:

Tensile strength test on concrete is basic test for measuring the resistance of pull out forces. Specimen is a

cylinder of size 150mm X 300 mm (height).Load is applied on specimen. The load is applied upto fails.

TABLE 9 :SPLIT TENSILE STRENGTH OF DIFFERENT MIXES

Mix	Split Tensile Strength(N/mm²)
	28th day
G0	3.25
G1	3.53
G2	4.04
G3	4.6
G4	3.68

FIG 6:SPLIT TENSILE STRENGTH TEST ON CYLINDER

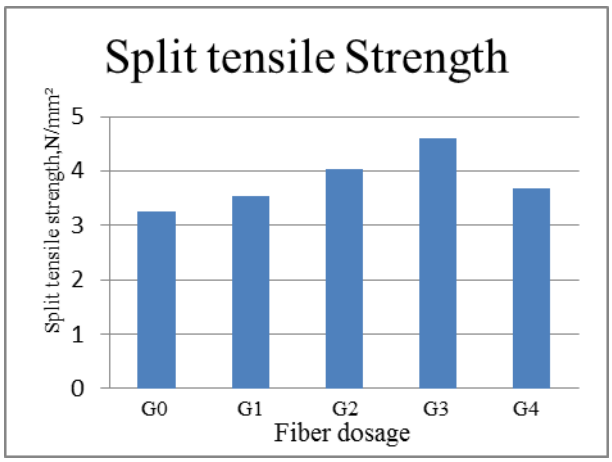


CHART 4:SPLIT TENSILE STRENGTH

Impact resistance:

Impact resistance is used to determining the impact resistance of concrete after 28 days curing. This test is carried out by dropping a hammer of weight 4.5 kg and height of 460 mm rapidly on a 64mm diameter. This test is continued until cracks will appear.

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*
G0	12	15	1.25
G1	8	15	1.875
G2	10	20	2
G3	10	40	4
G4	12	35	2.9

FIG.7:IMPACT RESISTANCE TEST ON DISC

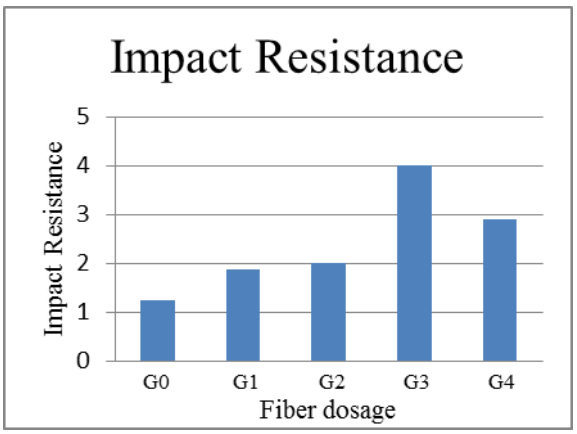


CHART 5:IMPACT RESISTANCE

Flexural test:

Flexural strength is stress in a material just before it yields in a flexural test. A proving ring of capacity 500kN was used to measure the applied load. The specimen is placed on UTM. The load at which the crack occurred was noted. And the appearance of fracture faces is noted.

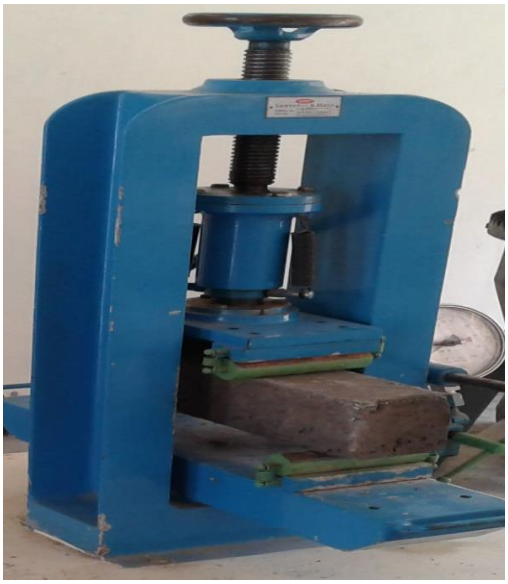


FIG.8:FLEXURAL TEST ON BEAM

TABLE 11:FLEXURAL STRENGTH OF DIFFERENT MIXES

Mix	Modulus of elasticity(kN/mm²)
	28th day
G0	37.5
G1	36
G2	35.7
G3	34
G4	32.75

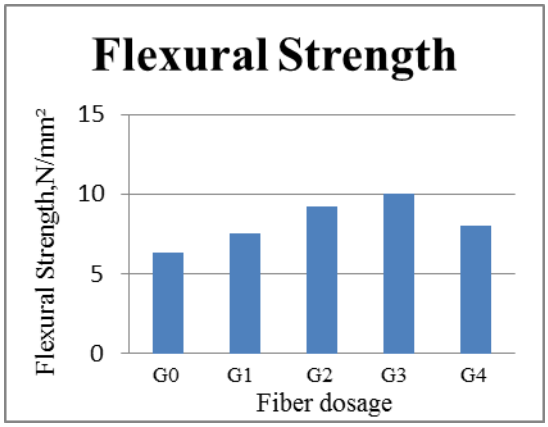


CHART 6 :FLEXURAL STRENGTH

Modulus of elasticity:

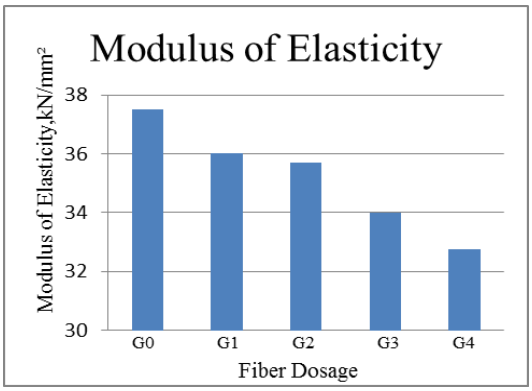
Modulus of elasticity was determined subjected to cylinder specimen having 150mm and 300mm height. The tested specimens is placed on compression testing machine and center it. Apply load continuously at the rate of 140 kg/cm²/minute until a stress of (e+5) kg/cm² is reached average compressive strength of specimen.

FIG.9: MODULUS OF ELASTICITY TEST ON BEAM

TABLE 12: MODULUS OF ELASTICITY OF DIFFERENT MIXES

Mix	Flexural strength(N/mm²)
	28th day
G0	6.3
G1	7.5
G2	9.25
G3	10
G4	8

CHART 7 :MODULUS OF ELASTICITY



III. CONCLUSIONS

1) Workability of glass 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 glass fiber.

3) Compressive strength is 21.5%increased due to the addition of fiber.

4) Split tensile strength is 41.5% increased due to the addition of fiber.

5) Flexural strength is 58.7% 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 10.3% 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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