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Compressive Strength Behavior of Glass Fibre Reinforced Concrete

Mr.Yogesh S.Lanjewar[1], Mr.S.V.Rayadu[2]
[1] *Assistant Professor, CED KITS Ramtek, yogeshlanjewar@gmail.com,Mob:-9975722733*
[2] *Assistant Professor, CED KITS Ramtek,rayadushrinivas@gmail.com Mob:-9096915511*

Abstract: Concrete is basically the most important material concerning with the construction and infrastructural procedures, for which it should be of good strength and durability. Many researches are being conducted to make concrete more sustainable and of more strength and durability. Therefore keeping this in mind we have chosen to do the comparative study regarding the strength of normal concrete with the glass fibre added concrete using mix design procedure as per IS 10262-2009 for M25 grade concrete. Also to understand the various clauses concerned with mix design of concrete and to study strength, efficiency and economy by casting normal concrete blocks and blocks with addition of fibres.On addition of glass fibres in the concrete it has been observed that the concrete achieved considerably more strength than that of the ordinary concrete. Comparing with ordinary concrete strength, the obtained test results resembles that for 7 days, on addition of 1% glass fibre, the concrete strength increased by 27.08% while on addition of 2% glass fibre 6.34% strength increment is observed.For 28 days, on addition of 1% glass fibre, the concrete strength increased by 14.47% while on addition of 2% glass fibre 7.64% strength increment is observed.

Keywords – concrete, ,glass fibre concrete,strength.

1. INTRODUCTION

Concrete is a material often used in the world of construction because of its good mechanical properties, but its high cost of conventional construction materials is a dominating factor affecting housing system around the world. This has necessitated research work into alternative material in the construction field. The aim of the study is to investigate the experimentation on the strength of concrete using glass fibre.

The compressive strength of concrete is one of the most important and useful properties of concrete. In most structural applications, concrete is employed primarily to resist compressive stresses. So we need to calculate the compressive strength of concrete. The compressive strength of concrete is generally determined by testing cubes or cylinders in laboratory.

Glass fibre is most durable kind of fibre. These are the best alkali resistant fibre even when kept in high alkali environment. Deshmukh, S.H., Bhusari J. P (2012) said that glass fibre used in concrete suppressed the localization of the micro cracks into macro cracks, hence tensile strength increases. It improves durability of concrete by increasing the strength of concrete. Chandramouli, K., Rao Srinivasa P (2010) states that reduction in bleeding can be observed by addition of glass fibres in the glass fibre concrete mixes, due to reduction in bleeding it improves the surface integrity of concrete, improves its homogeneity and reduces the probability of cracks.

2. MATERIALS AND VARIOUS TESTS

For any kind of experimental work materials are very important and testing of that material is very crucial. Testing of materials gives the information regarding the strength and quality of material used which ultimately effects the result of the experiment. Materials chosen are cement, fine aggregate and coarse aggregate.

i.Cement:-
A cement is a binder , a substance that sets and hardens and can bind other materials together. For all testing purpose Portland pozzolana cement (PPC) is used.

- Test on cement:
    1. Standard consistency test.
    2. Soundness of cement.

The apparatus used for testing is "vicat's apparatus" for finding out the percentage of water required to produce a cement paste of standard consistency or normal consistency.
Normal consistency = **33.75%.**

Soundness is measured with help of the Le-Chatelier's apparatus. It is very important that the

cement after setting shall not undergo any appreciable change of volume.

Table 1: Observation for soundness of cement

Sr no.	D1(cm)	D2(cm)	Difference in cm(D2-D1)
1.	1.55	1.65	0.1
2.	1	1.10	0.1
3.	1	1.05	0.05

- Test on aggregates:
    1. Bulk density, void ratio and % of void test.
    2. Specific gravity and water absorption test.
    3. Sieve analysis test.
    4. Slump test

Table 2: Observation for bulk density, void ratio and percentage of voids.

Sr.no.	Contents	Fine aggregate	Coarse aggregate
1.	total voids(w3-w2)	210	510
2.	Total volume(w4-w1)	510	980
3.	Volume of solids(w4-w1)-(w3-w2)	300	470
4.	Bulk density(w2-w1/w4-w1)	1.49	1.39
5.	Void ratio(w3-w2)/(w4-w1)-(w3-w2)	0.7	1.09
6.	Percentage of voids	41.18%	52.04%

(a) For fine aggregate –
1. Bulk density = 1.49 kg/ltr
2. Void ratio = 0.70
3. % of voids = 41.18%

(b) For coarse aggregate –
1. Bulk density = 1.39 kg/ltr
2. Void ratio = 1.09
3. % of voids = 52.04%

ii.specific gravity and water absorption of aggregates.

For Fine Aggregate
(a) Apparent Specific gravity = 1.256
(b) Water absorption = 23.91

For Coarse Aggregate
(a) Apparent Specific gravity = 2.72
(b) Water absorption = 3.06

iii.Seive analysis test on fine aggregate for zone determination

Sieve analysis: This is the name given to the operation of diving a sample of aggregate into various fractions each consisting of particles of same size. The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, which is called gradation.

Table 3: Observation for Sieve analysis

Sr.no.	Sieve size	Passing percentage (%) of sieve
1	10mm	100
2	4.75mm	96.5
3	2.36mm	92.2
4	1.18mm	81.3
5	600 microns	53.7
6	300 microns	10.8
7	150 microns	0.04

From the above observation it is observed that the fine aggregate belongs to ZONE-2.

iv.Slump Cone test

Slump test is the most commonly used method of measuring the consistency of concrete which can be employed either in laboratory or at site of work. It is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. Additional information on workability and quality of concrete can be obtained by observing the manner in which concrete slumps. Quality of concrete can also be further assessed by giving a few tapping or blows by tamping rod to the base plate. The deformation shows the characteristics of concrete with respect to tendency for segregation.

Table 4: Observations for Slump Test

Sr.no.	W/C ratio	Slump(mm)
1	0.45	0
2	0.5	105
3	0.60	160

Slump obtained for the W/C ratio **0.50** is **105 mm**.

3. Mix design for M25 grade of concrete

Mix design is the process of selecting suitable ingredients of concrete and determining their relative amounts with the objective of producing a concrete of the required strength, durability and workability as economically as possible.

The proportioning of ingredients of concrete is governed by the required performance of concrete in two states namely plastic and hardened states if the plastic concrete is not workable it cannot be properly placed and compacted. The property of workability becomes vital importance.

4.Mix Design Data

i.Cement – PPC53 grade
ii.Specific gravity –
a) Fine aggregate =1.256
b) Coarse aggregate = 2.72
iii.Water absorption –
a) Fine aggregate = 23.90 %
b) Coarse aggregate = 3.06 %
iv.Free surface moisture –
a) Fine aggregate = Nil
b) Coarse aggregate = Nil
v. Zone – 2
Target mean strength: The target mean strength is the concrete strength for which a concrete mix is designed and which is expected to be the average of all test results.As per IS 10262-2009 it is given as,

$$f'ck = fck + 1.65S$$

where,
fck = characterstic strength for M25 grade of concrete
S = standard deviation

$$f'ck = fck + 1.65S$$
$$f'ck = 25 + 1.65\times4.0$$
$$f'ck = 31.6\ N/mm^2$$

Mix design calculation is made as per IS10262-2009.So after refering IS code for mix design and IS 456-2000,the following values are obtained for M25 grade of concrete.
Cement = 383.16 kg/m^3
Fly ash present in cement (for P.P.C.) = 383.16 × (0.6/100) = 2.55 kg/m^3
Total volume of cement = 385.458 kg/m^3
Fine aggregate = 677.71 kg/m^3
Coarse aggregate =1153.94 kg/m^3
Cement: fine aggregate: coarse aggregate
1: 1.75: 2.99
So for 1 kg of cement, we need 1.75 kg of sand and 2.99 kg of coarse aggregate.

For production of quality concrete it requires utmost care that is to be exercised at every stage starting from proportioning, mixing and finally casting. It is interesting to note that the ingredients of good concrete and bad concrete are the same, if care is not taken, and good rules are not observed, the resultant concrete is going to be of bad quality. With the same material, if intense care is taken to exercise control at every stage, it will result in good concrete. Therefore it is necessary to know, what are the good rules to be followed in each stage for producing good quality concrete. The various stages are followed as given below:

- Mixing of ingredients
  i. Dry mixing
  ii. Wet mixing
- Casting of concrete blocks
  i. Normal concrete blocks
  ii. Fibre concrete blocks
- Compaction by vibration

5.Proportion of materials for one cube

The proportioning of materials is done for 1 block of concrete as follows:
Size of cube = (15*15*15)cm
Volume of cube = L^3
= $3375cm^3$
= $3375*10^{-6}\ m^3$
Cement = cement content*volume of cube
= $385.458\ /m^3 * 3375 * 10^{-6}\ m^3$
= 1.3kg
Fine aggregate = fine aggregate content*volume of cube
= $677.71kg/m^3 * 3375 * 10^{-6}\ m^3$
= 2.287kg
Coarse aggregat = coarse aggregate content * volume of cube
= $1153.94kg/m^3 * 3375 * 10^{-6}\ m^3$
= 3.894kg
Water/cement = 0.5
= 0.5 * 1.3
= 0.65kg

Proportion for Glass Fibre:
Cem Fil Anti Crack Glass Fibre is used.

- 1% Glass Fibre for one block
  1/100 * Wt of cement =0.01 x 1.3
  =0.013 Kg
  =13.00 gm
- 2% glass fibre for one block

2/100*wt of cement = 0.02 x 1.300
= 0.0260kg
= 26.0 gm

Fig.1: Glass fibre

6.Mixing of ingredients

Thorough mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in colour and consistency. There are two methods of mixing the ingredients:

i. Dry mixing
ii. Wet mixing

i. Dry mixing:

iii. Dry mixing is the process of mixing in which, the ingredients i.e cement, fine aggregate, coarse aggregate are mixed thoroughly without the interference of water in it.

ii.Wet mixing:

Wet mixing is the process of mixing the ingredients i.e cement, fine aggregates and coarse aggregate with the interference of water after dry mixing.

There are two methods of Wet mixing which are as follows:-

i. Hand mixing
ii. Machine mixing

7.Casting of concrete blocks

Ordinary concrete blocks:

After the mixing operation, the next step is conducted i.e. casting of normal concrete blocks. In this operation firstly the casting moulds were tighten properly to avoid the leakage of slurry and bleeding. Then the moulds were oiled to avoid the sticking of concrete to the moulds and easy removal after setting. The moulds are now filled with concrete mix in three layers and each layer is compacted by applying the 25 blows of tamping rod for proper compaction. Accordingly 6 blocks were prepared in which 3 blocks were for 7days curing and remaining 3 blocks for 28days curing.

Fibre concrete blocks:

In casting of concrete blocks using fibres, after the pouring of concrete mix in the pan it is uniformly spread in the pan and the fibres were spread over the mix uniformly. After spreading of the fibres the concrete mix is again mixed with shovel simultaneously with the small interference of water for proper mixing and consistency. Accordingly total 12 blocks were prepared out of which 6 blocks with 1% glass fibre and remaining 6 blocks with 2% glass fibre were prepared. out of the above total 12 blocks 6 blocks for 7 days curing and other 12 blocks for 28 days curing for each fibre.

Compaction by vibration:

Compaction of the concrete is the process adopted for expelling the entrapped air from the concrete which is entrapped during the process of mixing. For the compaction process of concrete blocks table vibrator is used on which each block is vibrated for 2-3 minutes respectively.

Fig.2 Vibrator

Testing on blocks:

Compressive test is carried out for every block by applying compressive load on the every block.

Then for calculation of compressive strength, the load (N) is divided by the area of the block i.e. (150mm x 150mm) then we got the result in terms of N/mm^2.

Fig.3: Compression testing machine

Table 5: Compressive strength result for 7 days.

Sr. No.	Material	Load Applied (kN)			Average Load (kN)	Compressive strength (N/mm^2)
		P1	P2	P3		

1	Ordinary Concrete	390	404	410	401.33	17.83
2	Concrete with 1% of Glass fibre	510	505	515	510	22.66
3	Concrete with 2% of Glass fibre	440	410	430	426.66	18.96

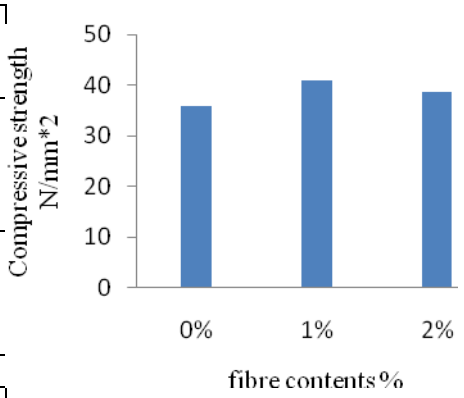

Fig.5 compressive strength for 28 days

Table 6: Compressive strength result for 28 days.

Sr. No	Material	Load Applied (kN)			Average Load (kN)	Comp. Strength (N/mm^2)
		P1	P2	P3		
1	Ordinary Concrete	835	780	805	806.67	35.85
2	Concrete with 1% of Glass fibre	925	895	950	923.23	41.04
3	Concrete with 2% of Glass fibre	890	850	865	868.33	38.59

8.Bar Charts

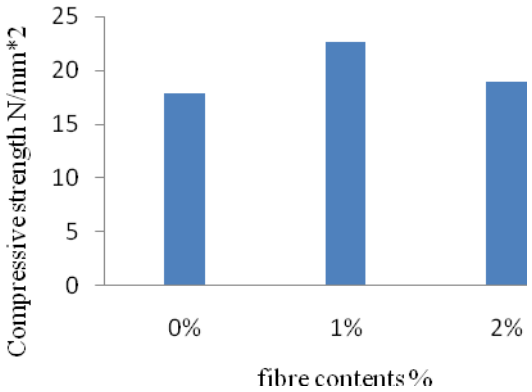

Fig.4 compressive strength for 7 days

After getting the results from testing on ordinary concrete block and Glass fibre Concrete blocks, bar charts are plotted between Compressive strength with respect to fibre contents in concrete,which shows the variation of compressive strength.

9. Conclusion

i. Use of Glass fibre and Coir in Normal Concrete gives more strength than Normal Concrete.
ii. On addition of 1% glass fibre, the concrete strength increased by 27.08% while on addition of 2% glass fibre 6.34% strength increment is observed for 7 days, strength as compared to that of ordinary concrete strength.
iii. For 28 days, on addition of 1% glass fibre, the concrete strength increased by 14.47% while on addition of 2% glass fibre 7.64% strength increment is observed.
iv. 1% of fibre gives more strength as compared to 2% of fibre.

10. Future work

i. In similar way, we can cast a block for 1.5 % of Glass fibre in ordinary Concrete and check what results we can get from it and compare with 1% and 2% of glass fibre result.
ii. Compression test may be carried out by casting cylinders by using 1% and 2% of glass fibre and compare results with normal concrete.
iii. Flexural strength can also be carried out and compare results with normal concrete.
iv. A study can be carried out on Failure pattern of block with glass fibre.

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