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EXPERIMENTAL STUDY & STRENGTH OF CONCRETE BY USING STEEL & GLASS FIBERS

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Abstract - Concrete is the most widely utilized "man-made" material globally for construction in many developing countries in all types of civil engineering works. Also, concrete is an environmental - friendly material and in areas of growing environment – related awareness that is of prime importance. Many of investigations were attempted by the researchers to improve the quality, strength and durability against adverse exposures, since decades. Portland cement concrete is considered to be a relatively brittle material. When subjected to tensile stresses, unreinforced concrete will crack and fail. Since the mid 1800's steel reinforcing has been used to overcome this problem. As a composite system, the reinforcing steel is assumed to carry all tensile loads. When fibers are added to the concrete mix, it too can add to the tensile loading capacity of the composite system. In fact, research has shown that the ultimate strength of concrete can be increased by adding fiber reinforcing. In this research paper, an attempt is made to use mixed steel and glass fibers with varying percentages of fibers from 0.5, 0.75, 1.0 percentages of total fiber content for M 25 grade structural concrete with locally available aggregates (i.e. fine & coarse aggregates) and Portland pozzolanic Cement (i.e. PPC). The details of investigation along with the analysis and discussion of the test results are reported here in.

Key Words: Mixed steel; glass fibers; Portland pozzolanic Cement.

1.INTRODUCTION

Concrete is the most widely utilized "man-made" material globally for construction in many developing countries in all types of civil engineering works. Also, concrete is an environmental - friendly material and in areas of growing environment - related awareness that is of prime importance. It is construction material due to its many advantages such as high compressive strength, availability of ingredients at reasonable cost, mould-ability to any shape giving aesthetic appearance and resistance to fire and weathering.

1.1. History of Fiber Reinforced Concrete

Fibers have been used since ancient times to reinforced brittle material. Horse hair was used to reinforce plaster, straws and asbestos fibers were used to reinforce bricks and Portland cement in early yearly in 1910, Porter first put forward the idea that concrete can be strengthened by inclusion of fibers. Little progress was made in the development of this material till 1963, when Ramouldi J.P and Batson G.B published their classical paper on the subject. In the early 1970s Steel Fiber Reinforced Concrete (SFRC) has been used in pavement construction.

Fig -1: Coir Natural Fiber

1.2. Need for Fiber Reinforced Concrete

Plain concrete is weak in tension and has limited ductility and little resistance to cracking. Micro cracks are present in concrete and because of its poor tensile strength; the cracks propagate with the application of load, leading to brittle fracture of concrete.Micro cracks in concrete are formed during its hardening stage. A discontinuous system exists even before the application of any external load. When the load is applied, micro cracks start developing along the planes, which may experience relatively low tensile strains, at about 25 to 35% of the ultimate strength in compression. Further application of the load leads to uncontrolled growth of the micro cracks. The low resistance to tensile crack propagation in turn results in a low fracture toughness and limited resistance to impact and explosive loading. Fiber in the cement based matrix acts as crack arrester, which restricts the growth of flaws in the matrix, preventing these from enlarging under load into cracks, which eventually cause failure. Prevention of propagation of cracks originating from internal flaws can result in improvement in static and dynamic properties of the matrix.

2. LITERATURE REVIEW

A PORTER [1] has investigated as early as 1970, the concept of concrete as a truly homogeneous materials strengthened by the inclusion of short pieces of steel.

GRAHAM [2] in 1911 suggested that the use of steel fibers in addition to conventional reinforcement to increase the strength and stability of reinforced concrete. Suggestions were also made as early as the 1920's to produce a mouldable and mechinable material made of cement plates and reinforced with 40% - 50% volumeof small steel fibers, 0.3 mm dia and 2mm long.

MEISCHKE – SEMITH [3] indentified the need to improve improve fiber shape and the significance of bond.

R. SIDDIWUE AND C.B.KUKREJA [4] in this investigation carried out on properties of san fiber reinforced high fly ash concrete. In this investigation to study the effects of replacement of cement (by mass) with three percentage of high fly ash content, and the effect of addition of san fibers on the slump, vipe time, compressive strength, split tensile strength and compressive stress strain behavior of high fly ash concrete are studied. Cement has been replaced by mass with 40%, 45% and 50% of fly ash content three percentages of san fibers (0.25%, 0.5% and 0.75%) of 25mm in length have been used in this investigation. The test results indicated that replacement of cement with fly ash increased the workability (slump and vee Bee) and decreases compressive strength, split tensile strength and static modulus of plain concrete.

KHALEEL AZAD & SWAMY [5] have conducted tests on glass fiber reinforced concrete the strength properties such as compressive strength, split tensile strength and flexural strength using aspect ratio of 857:1 with varying percentage of fibers from 0.0 to 0.3 percentages have been studied by casting and testing total number of 128 specimens. These consist of 48 Nos. of cubes of size 100 x 100 x 100 mm, 48 No's of cylinders of size 150mm dia x 300 mm height and 32 flexural beams of size 500 x 100x 100mm. From the test results and attempt has been made to understand the strength characteristics to the extent possible.

3. PREPARE YOURMIX DESIGN FOR M25 GRADE OF CONCRETE BY I.S.METHOD

3.1. Mix Design for M_{25} Grade

Design specification: -

Charateristic compressive strength M25 grade at 28 days (fck) = 25 N/mm2
Maximum size of aggregate (Angular) = 20mm
Degree of workability in terms of slump = 50 to 75 mm (Compaction Factor)
Degree of quality control (assumed) = Good
Assumed type of exposer = Moderate

(b). Test data of materials: -
53 grade Cement used (RASI GOLD)= PPC
Specific gravity of cement = 3.15
Specific gravity of C.A = 2.68
Specific gravity of F.A (Zone-II)= 2.55

(c). Target mean strength of concret: -
Standard deviation for M25 grade and good degree of control(S) = 5.3
Target average compressive strength at 28 days
Fck= fck + t X S=25 + 1.65 X 5.3=33.745 N/mm2

(d). Selection of water cement ratio: -
From the graph given is IS:10262:1982 corresponding to target strength (fck) and curve we have
(i) water cement ratio = 0.50
(ii) Estimation of air content: -
For 20 mm size coarse aggregate per centage of entrapped air = 2.0%

(e). Selection of water content and fine to total aggregate ratio :--(Table-4 of IS:10262-1982)
For 20 mm size of aggregate water content per m3 of concrete = 186 Kg.
Percentage of sand= 35%

(f). Adjustment of values in water content and sand percentage of other conditions:
For sand confinming to zone II percentage of reduction of sand = 0
Sand percentage = 35%
Increase in water content for increase in value of compaction factor by 0.1
Required water content
= 186 +186X(1.5/100)= 188.79 Kg. (Or) 189 Kg.

(g). Calculation of cement content
Water cement ratio = 0.50
Water = 189 Kg.
Cement content = 189/0.5 = 378 Kg. > 300 Kg.

(h). Adopting the equation from I.S : 10262-1982 for Calculation of aggregates

$$V = [w + \frac{C}{S_c} + \frac{1}{P} X \frac{F_S}{S_{Fa}}] X \frac{1}{1000}$$

Where,

V = Absolute volume of fresh concrete, which is equal to gross volume minus the volume of entrapped air= 0.98
W = Mass of water (Kg) per cubic meter of concrete= 189Kgs.
Mass of cement(Kg) per cubic meter of concrete =378Kgs.
P = Ratio of F.A (Kg) per cubic meter of concrete= 0.335
Sc = Specific gravity of cement = 3.15
Sfa = Specific gravity of fine agregate = 2.55
Sca = Specific gravity of course agregate = 2.68
Fs = Total mass of F.A(Kg) per cubic meter of concrete
Ca = Total mass of C.A(Kg) per cubic meter of concrete

Weight of fine aggregate $= V = [w + \frac{C}{S_c} + \frac{1}{P} X \frac{F_S}{S_{Fa}}] X \frac{1}{1000}$

Fa = 573.04 Kg (Or) 573 Kg
Weight of course aggregate = V = 1196 Kg.

3.2. Abbrevations and Acronyms Quantities of fibers for 1.00% Total fibers content(Steel fibers & Glass fibers) for concrete cylinder

Total quantities of materials for for 1 cum of concrete : 378 + 573 + 1196: 2147 Kg.

Fibers quantity for 1.00% total fiber content: 2147 X 1.00/100 : 21.470 kg.

Total no. of cylinders to be casted: 6 Nos.

Concrete quantity for 6 cylinders: (22/7) X 0.15^2 /4 X 0.30 X 6 : 0.032 cum.

Quantity of fibers for 6 concrete cylinders: 0.032 X 21.470 : 0.515 Kg.

Table -1: CYLINDER TEST SPECIMEN

S.No	Glass Fiber	Weight (kgs)	Steel Fiber	Weight (kgs)
1	0%	0	100%	0.687
2	25%	0.172	75%	0.515
3	50%	0.3435	50%	0.3435
4	75%	0.515	25%	0.172
5	100%	0.687	0%	0

3.3. Water Cement Ratio

Water cement ratio has been fixed depending on the compacting factor test the workability tests are carried out by tallying different water cement ratios to find-out the compacting factor as moderate, w/c ratio is maintained as 0.5 in this investigation.

4. MANUFACTURING PROCESSES

For the past few decades, aerospace industry was the major use of advanced composite materials in concrete. Recently civil engineers and the construction industry began to realize the potential of these materials in providing remedies for problems associated with cracking and deterioration of structures. In light of this, comprehensive experimental investigations were conducted by using various types of fibers in concrete.

The structural elements of concrete show distress by cracking. This may be caused by short term effects, such as over loading and/or impact loading or long term effects such as creep and drying shrinkage. In reinforced concrete elements, very thin cracks are considered to be of little significance and will be neglected without affecting the serviceability of the structure, which may in turn result in corrosion of reinforcement and thereby aggregates the situation resulting in large deflections and weakening of the structure.

4.1. Testing Programme

In the present investigation, it is intended to study the behavior of concrete and various strength parameters that are compressive, tensile and flexural strength with laboratory samples are evaluated. The mixed glass and steel short fibers with varying percentages of 0%, 25%, 50% 100% from 0.5, 0.75, 1.0 percentages of total fiber content are used for structural concrete. For each replacement of glass with steel fibers by 0%, 25%, 50% 100% from each 0.5, 0.75, 1.0 percentages of total fiber content, 6 cubes & 6 cylinders were cast. Totally 18 cubes & 18 cylinders were cast with locally available good materials and are taken for testing in this investigation. These 18 cubes & 18 cylinders for 28 days were used for finding compressive strength, split tensile strength and flexural strength test respectively.

4.2. Preparation of Specimens

The specimens are prepared (i.e cubes, cylinders and beams) and the various steps involved starting from the materials required to the handling of samples (i.e cubes, cylinders and beams). The various physical properties of materials are found out and recorded. From these properties mix proportions for M25 Grade concrete are worked out using the mix design principles of IS : 10262:1982.Mix proportions are worked out keeping in view the durability requirements. The water cement ratio used is 0.5, Since the maximum water-cement ratio is 0.5 for moderate environment .The materials required for cubic meter of concrete worked out . The details of formwork, casting procedure and curing of samples (i.e cubes, cylinders and beams).

4.3. Testing of Test Specimens

Compressive Strength: At the end of the curing period, the cube specimens were tested under the compression testing machine of 3000KN capacity. Testing machine has different loading ranges (in each range) of 600KN, 1500KN and 3000KN. The least count for the said loading ranges is 10KN. The test specimen was placed in the correct position and then the load was applied. The rate of loading was maintained at 10MPa per minute. The cubes were tested for compressive strength using compression testing machine. In the machine, the cube is placed with cast faces at right angles to that of compressive faces .according to I.S specification, the load on the cube is applied at constant rate of 140kg /sq.cm/minute up to failure and the ultimate load is noted.

$$\text{Compressive Strength } (f_{cu}) = \frac{P_u}{A}$$

Split Tensile Strength: For the split tensile strength, cylindrical specimens were tested in compression testing machine. This test was developed in Brazil in 1943. Therefore this is sometimes referred to as "Brazilian Test " . The cylindrical specimens are placed horizontally the loading surfaces of a comprehension testing machine and the load was applied until the failure of the cylinder, along the vertical diameter.

The split tensile strength of cylinder is obtained from the formula.

$$\text{Split Tensile Strength} = \frac{2P}{\Pi DL}$$

4. TEST RESULTS

The concrete specimens using steel and glass fibers are prepared in the laboratory have been tested as per the standard specifications. The results of the Compressive Strength, Split Tensile Strength and Flexural Strength for 0.5, 0.75 & 1.0 percentage total fiber content at 28 days are reported. Further the Cracking characteristics and ductility characteristics were studied. The graphs are plotted based on the test results.

The test results are tabulated for easy and better evaluation.

5.1. COMPRESSIVE STRENGTH TEST RESULTS FOR REPLACEMENT OF STEEL AND GLASS FIBER BY 0, 25, 50, 100 PERCENTAGES FROM TOTAL CONTENT OF 0.50 BY WEIGHT:

Concrete Specimens Details: -

Mix : M25
Specimens designation : C1-1 to C1-6

Table -2: CONCRETE SPECIMEN TEST

Concrete specimen No.	Glass Fiber%	Steel Fiber%	Ultimate Compressive Load in KN	Compressive Strength in N/mm2	Increase in Strength %
C_{1-1}	0	100	1180	52.44	27.12
C_{1-2}	25	75	1160	51.56	25.87
C_{1-3}	50	50	1060	47.11	18.87
C_{1-4}	75	25	980	43.56	12.25
C_{1-5}	100	0	930	41.33	7.53
C_{1-6}	Conventional Concrete		860	38.22	00.00

Concrete Specimens Details: -

Mix : M25
Specimens designation : S1-1 to S1-6

Table -3: SPLIT TENSILE STRENGTH TEST

Concrete specimen No.	Glass Fiber%	Steel Fiber%	Ultimate Compressive Load in KN	Compressive Strength in N/mm2	Increase in Strength %
1	2	3	4	5	6
S_{1-1}	0	100	320	4.53	21.85
S_{1-2}	25	75	305	4.31	17.87
S_{1-3}	50	50	295	4.17	15.11
S_{1-4}	75	25	275	3.89	9.00
S_{1-6}	Conventional Concrete		250	3.54	00.00

5.2. COMPRESSION STRENGTH TEST RESULTS FOR REPLACEMENT OF STEEL AND GLASS FIBER BY 0,25,50,100 PERCENTAGES FROM TOTAL CONTENT OF 0.75 BY WEIGHT.

Table -4: CONCRETE TEST-II

Concrete specimen No.	Glass Fiber%	Steel Fiber%	Ultimate Compressive Load in KN	Compressive Strength in N/mm2	Increase in Strength %
1	2	3	4	5	6
C_{2-1}	0	100	1210	53.78	28.93
C_{2-2}	25	75	1190	52.89	27.74

$C_{2\text{-}4}$	75	25	1000	44.44	14.00
$C_{2\text{-}5}$	100	0	970	43.11	11.34
$C_{2\text{-}6}$	Conventional Concrete		860	38.22	00.00

Concrete Specimens Details: -

Mix : M25
Specimens designation : S2-1 to S2-6

Table -5: SPLIT TENSILE STRENGTH TEST-II

Concrete specimen No.	Glass Fiber%	Steel Fiber%	Ultimate Compressive Load in KN	Compressive Strength in N/mm2	Increase in Strength %
1	2	3	4	5	6
$S_{2\text{-}1}$	0	100	340	4.81	26.40
$S_{2\text{-}2}$	25	75	320	4.53	21.85
$S_{2\text{-}3}$	50	50	310	4.38	19.18
$S_{2\text{-}4}$	75	25	295	4.17	15.11
$S_{2\text{-}5}$	100	0	275	3.89	9.00
$S_{2\text{-}6}$	Conventional Concrete		250	3.54	00.00

5.3. COMPRESSIVE STRENGTH TEST RESULTS FOR REPLACEMENT OF STEEL AND GLASS FIBER BY 0, 25, 50, 100 PERCENTAGES FROM TOTAL CONTENT OF 1.00 BY WEIGHT

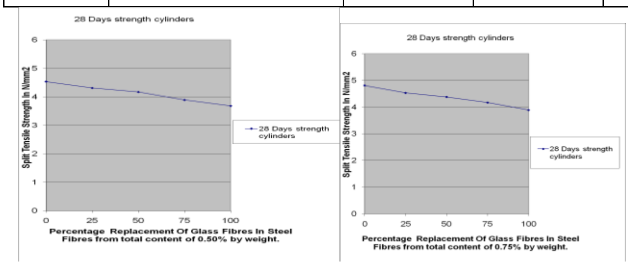
Table -6: CONCRETE TEST-III

Concrete specimen No.	Glass Fiber%	Steel Fiber%	Ultimate Compressive Load in KN	Compressive Strength in N/mm2	Increase in Strength %
1	2	3	4	5	6
$C_{3\text{-}1}$	0	100	1270	56.44	32.28
$C_{3\text{-}2}$	25	75	1230	54.67	30.09
$C_{3\text{-}3}$	50	50	1150	51.11	25.22
$C_{3\text{-}4}$	75	25	1060	47.11	18.87
$C_{3\text{-}5}$	100	0	1010	44.89	14.86
$C_{3\text{-}6}$	Conventional Concrete		860	38.22	00.00

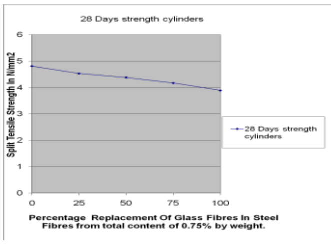
Concrete Specimens Details: -
Mix : M25
Specimens designation : S3-1 to S3-6

Table -7: SPLIT TENSILE STRENGTH TEST-III

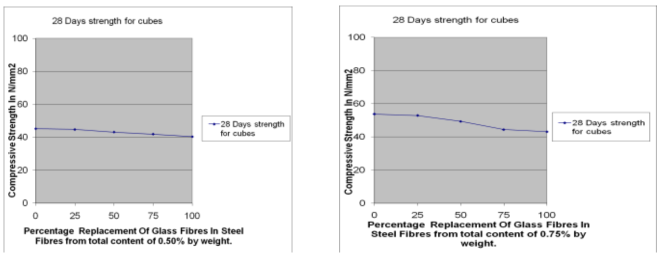
Concrete specimen No.	Glass Fiber%	Steel Fiber%	Ultimate Compressive Load in KN	Compressive Strength in N/mm2	Increase in Strength %
1	2	3	4	5	6
$S_{3\text{-}1}$	0	100	360	5.09	30.45
$S_{3\text{-}2}$	25	75	345	4.88	27.46
$S_{3\text{-}3}$	50	50	330	4.67	24.20
$S_{3\text{-}4}$	75	25	305	4.31	17.87
$S_{3\text{-}5}$	100	0	280	3.96	10.61
$S_{3\text{-}6}$	Conventional Concrete		250	3.54	00.00



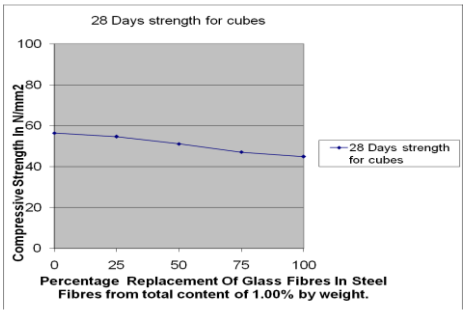
Graph -1: 0.5% & 0.7% of Replacemnt of Glass Fibers in Steel by weight for cylinder.



Graph -2: 1.00% & of Replacement of Glass Fibers in Steel by weight for cylinder.



Graph -3: 0.5% & 0.7% of Replacemnt of Glass Fibers in Steel by weight for cube.



Graph -4: 1.00% of Replacemnt of Glass Fibers in Steel by weight for cube.

6. CONCLUSION

On the basis of experimental studies carried out and the analysis of test results, the following conclusions are drawn. The structural integrity of the tested concrete specimens is found to be good under loading.With the above test results, the concrete mixed with dual fibers can be recommended for earthquake resistance structures.In addition to the fibrous contents, some of the admixtures/plasticizer can be mixed to enhance some of the strength properties of concrete satisfactorily. It can be concluded that the concrete mixed with dual fiber would also have much more life in comparison with the conventional concrete.The fibrous concrete is found to have maximum ultimate load carrying capacity as conventional concrete .The fibrous concrete is stiffer than the conventional concrete in appreciable way.For the nominal M25 mix with a water cement ratio of 0.5 used in the present investigation, the workability of concrete is only marginally affected even with a total fiber content of 1.0 percent by volume. The compressive strength of dual fiber concrete is found to be maximum at 1.0% total fiber content of steel at 28 days compared to plain concrete. Also, with a total of 1.0 % glass fiber by volume the increase of compressive strength at 28 days compared to plain concrete.

There is substantial increase in the compressive strength for mixed fiber combination. As the percentage of steel fiber is reduced and glass fiber is increased, the compressive strength is getting reduced compared to that of 100% steel fiber in the matrix. Steel fiber of 1 mm diameter and length of 50 mm having an aspect ratio of 50 can be satisfactorily mixed along with glass fiber having an aspect ratio of nearly 800 to increase the strength and other characteristics. The split tensile strength of dual fiber concrete is found to be maximum at 1.0 % total steel fiber content at 28 days compared to plain cement concrete. Also, with a total of 1.0 % glass fiber by volume the increase of split tensile strength in 28 Days compared to plain cement concrete.

As the percentage of steel fiber is reduced and glass fiber is increase, the split tensile strength is getting reduced compared to that of 100 % steel fiber in the matrix. The ductility characteristics were found to improve by adding steel fibers. The flexural strength of dual fiber concrete is found to be maximum at 1.0 % total steel fiber content at 28 days compared to plain concrete. Also, with a total of 1.0 % glass fiber by volume the increase of flexural strength in 28 days compared to plain cement concrete. The ductility characteristics have improved with the addition of glass fibers. The failure is gradual compared to that of brittle failure of plain concrete. Cracks can be controlled by introducing glass fibers.

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