STUDY OF AXIAL STRENGTH OF FRP-CONCRETE ELEMENT OF DIFFERENT CROSS-SECTIONAL ASPECT RATIO

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ABSTRACT

Strength of concrete is a prime property which represents structure's ability. To improve concrets strength and cracking resistance there are many ways but use of fiber is one which got popularity in industry. The fibres are used in concrete to control crack. So here in this project our aim is to perform axial strength tests on fiber reinforced concrete element for different aspect ratio. In the present work we fabricated, tested and compare distinct fiber reinforced polymer composite concrete element of different aspect ratios. The properties of this FRP concrete elements is compared with plain concrete elements having different aspect ratio. The fibres used are hooked end steel fiber. The grade of concrete is M25. In this experiment three aspect ratios-1.3,1.6,1.9 are selected and percentage of steel in each case is 1.5% by weight of cement. Compressive strength test and Split tensile strength test were conducted on several cylinders to measure the effect of steel fibres on strength of concrete. For each aspect ratio of element three cylinders were tested for compressive and tensile strength test at curing period of 7 days and 28 days respectively. This will be beneficial to society where innovative structural designs are to be implemented by use of concrete.

Keyword: - *Concrete, Hooked end steel Fibres, Axial strength, Aspect ratio of FRP concrete element, Fibre reinforced concrete.*

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1. INTRODUCTION:

In all around the world efforts are made to make a structure more durable and to increase life of structure without sacrificing of beauty of structure. To maintain the beauty and esthetic view of structure it is essential to resist cracks in concrete. And also to make structure economical, concrete or construction materials should improve the strength of concrete and of structure ultimately. As concrete is a brittle material and it has low tensile strength. It has not enough resistance for cracking. It has low ductility. This limitation can be improved by using short and uniformly distributed fibres in concrete. These fibres are added in concrete by some percentage of cement/concrete. Normally the fiber content varies 0.5% to 4% by volume of concrete. As the value of fiber content and types of fibre varies, the strength of concrete may increases or decrease. To improve it is essential that the elasticity of fibres should be greater than the other concrete materials, which is satisfied by steel fibres. Steel fibres can be easily obtainable and pollution free material. There is lots of experimental works are available for finding out optimum doses of fibres. In this experiment the work is performed to study effect of various aspect ratio of element on SFRC. Slender sections, like slender columns fail by buckling. Buckling of concrete columns starts by cracking which is due to low tensile strength of concrete. Therefore introducing steel fibres buckling can be restricted at some percentage. As the tension applied on concrete matrix will transfer to steel fibres which are ductile, so failure by cracking can be prevented at some level, which gives more durability to structure. So here in this project our aim is to perform axial strength tests on fiber reinforced concrete element of different aspect ratio. In the present work we fabricated, tested and compare fiber reinforced polymer composite concrete element of different aspect ratios. The properties of these FRP concrete elements are compared with plain concrete elements for different aspect ratio. The fibres used are hooked end steel fiber. The grade of concrete is M25. In this experiment three aspect ratios-1.3, 1.6 and 1.9 are selected and percentage of steel in each case is 1.5% by weight of cement. Compressive strength test and Split tensile strength test were conducted on several cylinders to measure the effect of steel fibres on strength of concrete. For each aspect ratio of element three cylinders were tested for compressive and tensile strength test at curing period of 7 days and 28 days respectively.

Concrete is a brittle material and it has low tensile strength. It has not enough resistance for cracking. One of the basic concerns in SFRC is to achieve the desired improvements in mechanical behaviour of concrete.

SFRC is a concrete that has a homogenous distribution of randomly oriented discontinuous and discrete steel fibres. Steel fibres are introduced in the concrete matrix during the mixing of its constituent ingredients. Upon hardening, these fibres improve the properties of concrete such as ductility, fracture toughness, energy dissipation, impact resistance, fatigue resistance and limiting of crack propagation. Under tension, as cracks start propagating inside concrete, steel fibres present in the matrix bridge the cracks and transfer the tension across them during this process. Thus, steel fibres actually contribute in improving the load carrying capacity of a structural system on account of increased toughness and rotation capacity.

2. MATERIALS, CONCRETE MIX PROPORTIONS, SPECIMEN PREPARATION, TESTING:

Selection of materials is very important task to get desired strength of concrete. Even 70% cost is consumed in materials of total cost of project. Selected materials are listed below:

1.1 CEMENT:

In this work OPC cement 53 grade is used.

Table -1: Physical properties of cement

Physical properties of cement		
S. No	**Property**	**Test results**
1	Normal consistency	29%
2	Specific gravity	3.15
3	Initial setting time	30 minutes(min)
4	Final setting time	600 minutes(max)

1.2 FINE AGGREGATE: The size of fine aggregate is less than 4.75 mm.

Table- 2: Physical properties of fine Aggregate

Physical properties of fine Aggregate		
SR. No	**Property**	**Value**
1	Specific gravity	2.75
2	Fineness modulus	2.46
3	Bulk density (Loose) Bulk density (Compacted)	$14kN/m^3$ $15kN/m^3$
4	Grading	Zone-3

1.3COARSE AGGREGATE: coarse aggregate gives 75% strength of total comprehensive strength to concrete.

The size of coarse aggregate is generally greater than 4.75 mm.

Table -3: Physical properties of coarse aggregates

Physical properties of coarse aggregates		
Sr. No	**Property**	**Value**
1	Specific gravity	2.75
2	Fineness modulus	7.21
3	Bulk density (Loose) Bulk density (Compacted)	$14\ kN/m^3$ $16\ kN/m^3$
4	Maximum size	20 mm

1.4 FIBRES: In frp-concrete, fibres are used to improve mechanical properties of ordinary concrete. Using fibres high strength can be obtain with keeping same material proportion. For example, the strength of M30 and higher grade of concrete can be obtained using steel fibres in M25 grade of concrete. Therefore, selection of fibres and its content in concrete is very important.

The fibres used are Shaktiman steel fibres of dia 0.5mm and 30mm length with hooked end of 1.5% by weight of cement. Here steel fibres are used because it has good ductility and its modulus of elasticity is high which would increase tensile and compressive strength of concrete and also resist the cracking in concrete from normal shacking or crushing etc. Even increase in steel fibre content is increases more strength but it will decrease mixability and workability of concrete. Even more content of fibres create honeycomb in concrete. Therefore, in this work 1.5% of fibre by weight of cement is selected.

Fig -1: Hooked end steel fibres

1.5 WATER

Normal portable water conforming to IS: 456-2000 - "water for concreting and curing" is used.

The ratio of water added to the cement was w/c=0.45.

2 MIX PROPORTIONS FOR 1 m^3 CONCRETE:

Cement = 438.2 kg, Water= 197.16 liters, Fine aggregate= 640 kg, Coarse aggregate= 1187 kg

Table -4: Mix proportions

Water	**Cement**	**F.A.**	**C.A.**
197.16	438.2	640	1187
0.445	1	1.46	2.71

3. CASTING OF CUBES AND CYLINDERS

Six cubes were casted for establishment test for M25 grade of concrete. After testing of cubes for 7 & 28 day test, cylinders of different aspect ratios of 1.3, 1.6 and 1.9 were casted. The cylindrical moulds of 100mm diameter and 130mm, 160mm, 190mm height were used. Six cylinders were prepared for each aspect ratio of element of both plain and FRP concrete, out of which three cylinders for compressive strength and another three for split tensile strength test. After 24 hours from casting curing process was made for 22℃ to 32℃.After 7 days and 28 days of curing specimens were taken out from tank to make them dry and the compressive and split tensile strength test were conducted respectively. Normally in construction work like public building, curing is provided for only for 7day therefore to study its effect we tested cylinders after curing of 7days.

Fig -2: SFRP Concrete

Fig- 3: Testing machine details

Fig- 4: Testing Machine

4. RESULT AND DISCUSSION:

Table -5: Test result for FRP concrete (Compressive strength)

Height of mould	**Load (KN)**	**Load (KN)**	**Load (KN)**	**Average Load (KN)**	**Area of mould (mm^2)**	**Compressive strength At 7days ($\frac{N}{mm^2}$)**
1.3	220	215	200	212	7853.98	27
1.6	250	190	190	210	7853.98	26.73
1.9	250	210	230	230	7853.98	29.28

Table- 6: Test result for plain concrete (Compressive strength)

Height (mould)	**Load (KN)**	**Load (KN)**	**Load (KN)**	**Average Load (KN)**	**Area of mould (mm^2)**	**Compressive strength At 7days ($\frac{N}{mm^2}$)**
1.3	220	170	165	185	7853.98	23.55
1.6	160	210	170	180	7853.98	23
1.9	250	145	150	182	7853.98	23.2

Table -7: Test result for FRP concrete (Spilt tensile strength)

Height (mould)	**Load (KN)**	**Load (KN)**	**Load (KN)**	**Average Load (KN)**	**Spilt tensile strength At 28 days ($\frac{N}{mm^2}$)**
1.3	180	200	200	193.33	9.46
1.6	220	240	240	233.33	9.28
1.9	265	260	255	260	8.71

FOR CALCULATION OF SPLIT TENSILE STRENGTH

$T = 2P/\pi DL$ Where P = applied load

D = diameter of the specimen = 100mm

L = length of the specimen =130mm, 160mm, 190mm

Table- 8: Test result for plain concrete (Spilt tensile strength)

Height (mould)	**Load (KN)**	**Load (KN)**	**Load (KN)**	**Average Load (KN)**	**Spilt Tensile strength 28 days ($\frac{N}{mm^2}$)**
1.3	150	140	145	145	3.55
1.6	205	200	190	198.33	3.95
1.9	200	205	200	201.67	6.76

(a) Plain concrete cylinder

(b) FRP concrete cylinder

Fig-6: Cylinders after split tensile strength test

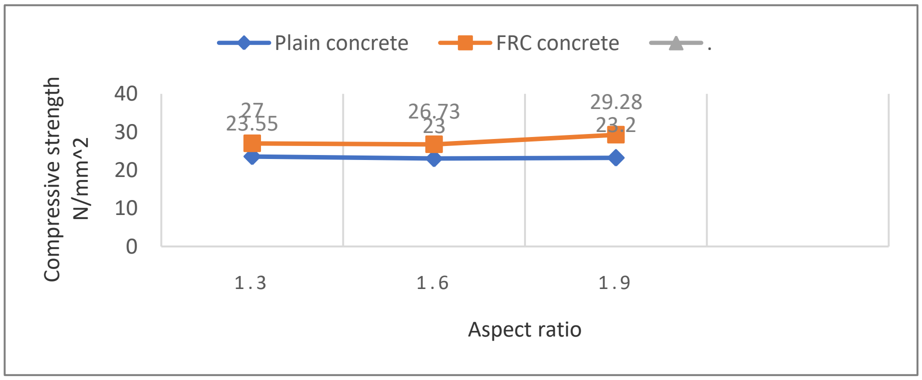

Chart -1 Comparative result graph of compressive strength for FRPC & plain concrete

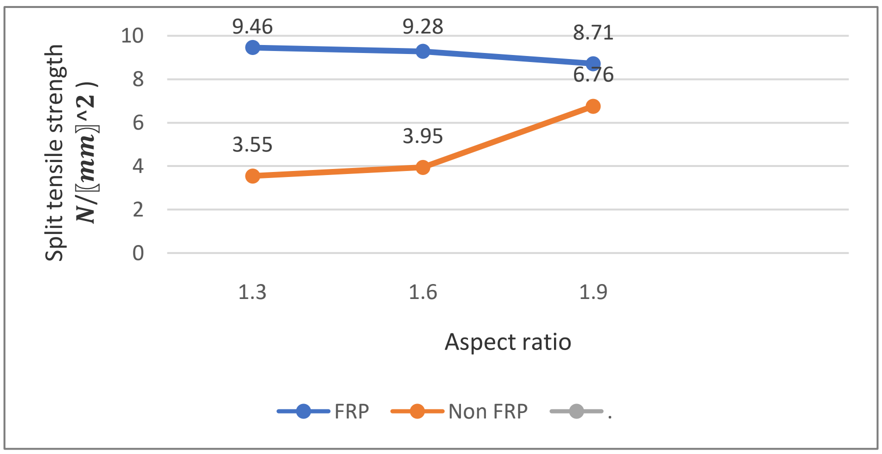

Chart 2 Comparative result graph of split tensile strength for FRPC & plain concrete

3.1 COMPARISON OF STRENGTH OF FRPC AND NFRPC

Sr. no.	Aspect ratio	Compressive Strength			Tensile strength		
		FRPC $(\frac{N}{mm^2})$	NFRPC $(\frac{N}{mm^2})$	% Improved	FRPC $(\frac{N}{mm^2})$	NFRPC $(\frac{N}{mm^2})$	% Improved
1	1.3	27	23.55	14.65	9.46	3.55	166.48
2	1.6	26.73	23	16.22	9.28	3.95	134.94
3	1.9	29.28	23.2	26.21	8.71	6.76	28.85

Table 9 Comparison of strength of FRPC and NFRPC

- For aspect ratio 1.3 and 1.6 of element the improvements in compressive strength and tensile strength of SFRP concrete is more.
- For aspect ratio 1.9 of element the improvements in compressive strength is more but tensile strength of SFRP concrete is less as compared to aspect ratio of 1.3 and 1.6 of element.

- By using of steel fibres, we can get strength of M30 grade concrete using same quantity of materials as of M25 grade concrete.

4. CONCLUSIONS

The FRP- concrete cylinder gives more compressive strength than the ordinary concrete cylinder. It also provides good cracking resistance as compare to ordinary one. It improves around 14%, 16% and 26% of comprehensive strength for aspect ratio of 1.3, 1.6 and 1.9 of cylinder respectively. Therefore, it is advisable to use steel fibred concrete where higher compressive and good cracking resistance required.

The FRP- concrete cylinder gives more split tensile strength than the ordinary concrete cylinder. It improves around 166.48%, 134.94% and 28.85% of split tensile strength for aspect ratio of 1.3, 1.6 and 1.9 of cylinder respectively.

In split tensile test, it is observed that the concrete cylinders without fibres can be easily splilitted in two separate parts (see the fig. 6(a)) while; concrete cylinders with steel fibres were not being separated during entire test due to bond between fibres and concrete (see the fig. 6(b)).

Therefore, it is suggestible to use steel fibres to improve effectiveness of stress transfer between concrete matrix and fiber.

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