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Experimental Investigation of Shear Behavior for Steel and PFRC Beams

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ABSTRACT: This thesis presents a series of tests for investigation of shear behavior of PFRC beams subjected to shear loading. The experimental program involves two types of fibers, steel fiber and a polypropylene fiber. As a reference, plain concrete and conventionally reinforced concrete specimen have also been casted and tested in the laboratory as per ASTM standards. The ultimate shear carrying capacities of the beams are calculated. The study confirms that the shear crack resistance of the Material is greatly enhanced by the fibers. Fibers reduced the crack width to approximately a fifth of that in beams with stirrups. The use of steel fibers raises the ductility and fracture energy of concrete. Addition of steel fibers to concrete improves its post cracking behavior in tension. The shear resistance increased with increasing as per ratio of fibers and volume fraction of fibers.

I. INTRODUCTION

Both steel and polymeric fibers have been used to reinforce concrete and consequently increase its toughness and crack resistance. Fiber reinforced concrete can be used in some structural applications with a reduced amount or even without any conventional reinforcement.

The shear strength of concrete beams mainly depends on the following variables: Depth of members or size effect, Shear span to effective depth a/d or moment to shear ratio, Longitudinal Reinforcement or dowel action, Axial Force, The tensile strength of concrete, Crushing strength of beam web, Yielding of stirrups, The aggregates sizes leading to aggregate interlocking, Failure of Tension chord, Failure of Stirrups anchorage, Serviceability failure due to excessive crack width at service load. In this research, the shear effect of transverse steel & fibers instead of transverse steel has been studied. Four beams have been tested in this research. The test results and beam failure mechanism for both of beams has also been observed. The test results and beam failure mechanism for all four beams has also been observed.

ADVANTAGES OF FIBERS

- 1 Improved long-term serviceability of the structure or product
- 2 High ductility
- 3 Prevents the occurrence of large crack widths
- 4 Increases matrix tensile strength at high volume percentages of fibers
- 5 Results in saving of expensive mortar, cement and sand

APPLICATIONS OF FIBERS

1. Rock slope stabilization and support of excavated foundations in conjunction with rock and soil anchor systems
2. Industrial floorings, road pavements, warehouses, channel linings
3. Protect bridge abutments
4. Rehabilitation of deteriorated marine structures such as light stations, bulk heads, piers, sea walls and dry docks

SHEAR RESISTANT MECHANISMS OF FRC BEAMS

The shear design of beams, the European and American Codes consider that the ultimate shear capacity, V_u , is the sum of the contributions of the concrete and the stirrups, V_{cd} and V_{wd} , respectively:

$$V_u = V_{cd} + V_{wd}$$



OBJECTIVES

1. To investigate the effect of shear span to effective depth “a/d” ratio and contribution of stirrups on the shear capacity of concrete slender beams.
2. To investigate the failure mechanism of reinforced concrete beam and Fiber reinforced concrete beams (Steel and Polypropylene).
3. To study the shear strength of reinforced concrete beam and Fiber reinforced concrete beams (Steel and Polypropylene).
4. To compare the shear strength of reinforced concrete beam and Fiber reinforced concrete beams (Steel and Polypropylene).

II. EXPERIMENTAL PROGRAMMES

In the present work the experimental program consisted of testing two normal reinforced concrete and two fiber reinforced concrete beams of identical cross section (100×150mm). The span length of the beam was 2000 mm. The mix was designed to resist the cylinder compressive strength of 25 MPa. The major variables were the shear span to effective depth ratio.

WATER

Water is an important ingredient of concrete as it actively participates in the chemical reactions with cement to form the hydration product, calcium-silicate-hydrate (C-S-H) gel. As per Neville (2000), the quantity of water added should be the minimum requirement for chemical reaction of unhydrated cement, as the excess water would end up only in the formation of undesirable voids in the hardened cement paste of concrete.

FIBER

- Metallic fibers
- Polymeric fibers
- Mineral fibers
- Naturally occurring fibers

MATERIALS

A concrete with 25 Mpa compressive strength was considered for the mixes. Two types of fibers were considered, Dramix 80/60 BN hook-ended steel fibers, and polypropylene fibers. In all cases fiber volume was fixed at 0.4%. Table 1 summarizes the cast specimens

III. TEST RESULTS AND DISCUSSIONS

The structural-scale beams were tested under shear loading through the two-point load configuration, with a shear span to depth ratio equal to 2.67. The smaller anchorage length provided for the longitudinal reinforcement did not allow the development of arch effect, which caused failure by debonding of the flexural reinforcement in the case of beams without conventional shear reinforcement.

Load and Displacement values for Reinforced Concrete Beam.

Sl.no.	Load in KN.	Displacement in mm(atpoint1)	Displacement in mm(atcenter)	Displacement in mm(atpoint 2)
1.	8.26	0.28	0.28	0.26
2.	16.46	0.65	0.66	0.61
3.	24.69	0.98	0.98	0.92
4.	32.96	1.42	1.47	1.33
5.	41.00	2.24	2.41	2.13
6.	49.32	3.2	3.24	2.86
7.	57.42	3.68	4.02	3.56
8.	65.15	4.72	5.10	4.56
9.	72.74	6.99	8.20	6.86
10.	80.30	7.50	8.62	7.20
11.	78.50	7.92	9.20	7.62

*Shear crack on Reinforced Concrete Beam with minimum stirrups***Load and Displacement values for SFRC beam.**

Sl.no.	Load in KN	Displacement in mm(atpoint 1)	Displacement in mm(atcenter)	Displacement in mm(atpoint 2)
1.	8.26	0.36	0.38	0.38
2.	16.46	0.82	0.85	0.78
3.	24.67	1.08	1.12	1.04
4.	32.94	1.76	1.90	1.70
5.	41.00	2.29	2.52	2.24
6.	49.30	2.96	3.20	2.85
7.	57.43	3.81	4.26	3.69
8.	65.16	4.56	5.07	4.39
9.	72.74	5.55	6.22	5.42
10.	70.00	6.29	7.10	6.25
11.	68.52	8.00	10.26	8.25

Load and Displacement values for PFRC beam

Sl.no.	Load inKN	Displacement inmm(atpoint 1)	Displacement in mm(atcenter)	Displacement inmm (atpoint2)
1.	8.24	0.45	0.54	0.39
2.	16.45	0.86	0.82	0.72
3.	24.67	1.09	1.09	1.04
4.	32.94	1.89	2.0	1.76
5.	41.00	2.23	2.43	2.11
6.	49.30	2.60	2.90	2.51
7.	57.40	3.60	4.04	3.51
8.	65.15	4.32	4.87	4.24
9.	63.00	5.20	6.70	5.60
10.	61.50	8.60	9.80	8.80

IV.CONCLUSIONS

The following conclusions were drawn with in the limitations of experimental investigation

- It has been observed that the incorporation of fibers to the mix increases the material toughness both in tension and compression, as represented by the toughness indexes of the ASTM and JSCE standards. The toughness increases results in higher shear strength of the concrete and better deformability, i.e. the deflection at maximum load is significantly higher for FRC beam than plain concrete specimens.
- The compressive strength increase only marginally due to fiber incorporation in concrete.
- First crack occurs earlier in PFRC when compared to SFRC.
- In SFRC beams, the maximum load increased by approximately 20% of the plain concrete.
- The length and width of the crack is reduced due to the incorporation of fibers in the concrete

SCOPE FOR FUTURE WORK

1. Fiber dosage can be varied and studied for shear test
2. Hybrid fiber can be used for the study.
3. Dimensions of the beam can be varied and studied.
4. Orientation of fibers can be studied

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