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Experimental Investigation on Strength Characteristics of Binary Blended Concrete

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Abstract

An experimental investigation has been carried out to assess the behavior of concrete beams blended with steel crimped fiber and flyash subjected to combined torsion-bending-shear with longitudinal reinforcement. The concrete is binary blended with 15% of fly ash by weight of cement as partial replacement of cement and addition of 0%, 0.5%, 0.75%, 1% of crimped steel fibers with aspect ratio of 80 are used for the study purpose. Compressive strength of concrete is measured by testing standard cubes (150mm x 150mm x 150mm) at the age of 28 days, the combined torsion-bending-shear strength is measured by testing beams of size 100x100mm and length 1200mm with a bracket attached at center of size 100x100x300mm.This bracket is adequately reinforced to avoid any failure at joint. The tests were conducted on 12 beams for varying percentages of steel fibers and studied for their behavior under combined torsion-bending-shear. The study involved the influence of fiber addition on the ultimate torsion-bending-shear strength of beams.Test results indicated that fibrous concrete beams exhibited improved overall performance with respect to corresponding non-fibrous beams. Flyash with steel fiber has shown considerable improvement in the compressive and torsion-bending-shear strength of concrete. From the test results it is observed that the concrete mix with 15% fly ash replacement of cement of M30 grade concrete mixture has shown maximum compressive strength of 47 MPa at 28 days. Concrete mixture with 15% fly ash replacement of cement along with 0.75% of crimped steel fibers has shown significant improvement in various properties at the age 0f 28 days indicated by 38% increase in compressive strength and 58% increase in the combined torsion-bending-shear strength of concrete. Hence binary blended crimped steel fiber reinforced concrete with 15% fly ash with 0.75 % steel fibers is a novel material having superior performance characteristics compared with conventional concrete.

Keywords: Steel fiber reinforced concrete (SFRC), combined torsion-bending-shearstrength, binary blended, ultimate torsion-bending-shear strength , longitudinal reinforcement

Introduction

The well-known inherent deficiencies of concrete are its tensile strength and its brittleness. These weaknesses of concrete lead to immediate collapse of plain concrete beams after formation of the first crack and its propagation, at very low values of tensile stress developed in the cross section due to direct (axial) and / or indirect (flexural, shear or torsional) nature of loading. These deficiencies are overcome by reinforced concrete and pre-stressed concrete systems. These systems are not improving the weaknesses of the concrete matrix but are aiding the concrete with tensile reinforcement for sharing almost totally the tensile load on the elements. And many other investigators have well established that the inclusion of high strength, high elasticity modulus steel fibers of short length and small diameter enhances the tensile strength, ductility and other properties of concrete significantly and also acts as crack arrestors. Concrete with steel fibers is known as steel fiber reinforced concrete (SFRC) closely spaced steel fibers effectively arrest the cracks but due to practical difficulties short, randomly oriented steel fibers are preferredIt has been established by many researchers that the inclusion of steel fibers in concrete improves the torsional strength of the elements in pure torsion as well in combined loading. Some of them proposed analytical models and empirical formulae to estimate the ultimate torsional strength of the steel fiber reinforced rectangular concrete beams. Some of the formulae are independent of the properties of steel fibers and depend only on the cube strength of fiber reinforced concrete and few of the researchers have proposed a combined effect of steel fiber properties and cube strength of fiber reinforce concrete in a single combined term of the expression. The members of a reinforced concrete structures are subjected to shear forces, axial forces, bending moments and torsional moments. Many

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researchers carried out tests on reinforced concrete beams under bending-torsion and shear-torsion. And proposed modes of failure .The investigations made in the field of the analysis of behavior of SFRC rectangular beams in combined loading, are fewer as compared with that in the field of torsion.In the present investigation twelve reinforced concrete beams with steel crimped fibers were tested under combined torsion-bending-shear.

Literature review

Gunneswara raoet al (2010) has concluded the behavior of over reinforced sfrc members subjected totorsional loading. torsion tests on the 15 reinforced steel fiber reinforced concrete beams revealed that, fiber has noticeable effect on the cracking torque and very little effect on the ultimate torsional strength of the member. however fiber inclusion could improve the torsional toughness of the member. Fiber addition has very little improvement on the ultimate torsional strength of the member irrespective of the way in which the beam is over reinforced with respect to torsional loads. Even at 1.2% fiber volume fraction, the increase in the ultimate torsional strength is noticed as 5%. Addition of fibers increased the twist at cracking torque more compared to the same at the ultimate torque.S. P Avinash (2009) has concluded an experimental investigation to assess the torsional behavior of steel fiber reinforced concrete (SFRC) rectangular beams subjected to combined torsion-bending-shear with longitudinal and web reinforcement. For the tested prototype beams, all the parameters were maintained identical except the three chosen parameters viz. torsion to moment ratio (T/M), torsion to shear ratio (T/V) and percentage of web reinforcement. The values of aspect ratio and volume fraction are kept uniform to 60 and 0.6% respectively for all the beams. The study involved the influence of web reinforcement on the ultimate torsional strength of SFRC beams under variable values of T/M and T/V ratios.

Experimental investigation

Preparation of Test Specimens

Mixing

Mixing of ingredients is done in a rotating drum. Thorough mixing by hand, using trowels is adopted. The cementitious materials are thoroughly blended with hand and then the aggregate is added and mixed followed by gradual addition of water and mixing in case of fiber reinforced concrete fiber was sprinkled evenly during mixing of the matrix. Wet mixing is done until a mixture of uniform colour and consistency are achieved which is then ready for casting. Before casting the specimens, workability of the mixes was found by slump test.

Casting of Specimens

The cast iron moulds are cleaned of dustparticles and applied with mineral oil on all sides before concrete is poured in the moulds. The moulds are of size 150mm x 150mm for cubes and themouldsareofsize(1200x100x100mm) longand(300x100x100mm) arms extend at center for the beam specimens. The moulds are placed on a level platform. The well mixed concrete is filled in to the moulds by vibration with needle vibrator. Excess concrete was removed with trowel and top surface is finished level and smooth.

Curing of Specimens

The specimens are left in the moulds undisturbed at room temperature for about 24 hours After casting. The specimens are then removed from the moulds and immediately Transferred to the curing pond containing clean and fresh water.

Testing of Specimens

A time schedule for testing of specimens is maintained to ensure their proper testing on the due date and time. The cast specimens are tested as per standard procedures, immediately after they are removed from curing pond and wiped off the surface water. The test results are tabulated carefully.

Description of Compression Testing Machine

The compression testing machine used for testing the cube specimens is of standard make. The capacity of the testing machine is 200 Tonnes or 2000 KN. The machine has a facility to control the rate of loading with a control valve. The machine has an ideal gauge on which the load applied can be read directly. The oil level is checked, the MS plates are cleaned and the machine is kept ready for testing specimens.

Testing Arrangement

The specimens are removed from the curing pond just before testing on the specified due date and time and cleaned to wipe off the surface water. The cube specimen is placed on the lower platen such that the load is applied centrally on the faces other than top and bottom faces of casting. The top plate is brought in contact with the specimen by rotating the handle the oil pressure valve is closed and the machine is switched on a uniform rate of loading is maintained. The maximum load at failure at which the specimen breaks and pointer starts moving back is noted. The test is repeated for the three specimens and the average

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value is taken as mean strength. The compressive strength is taken as load applied on the specimen divided by the area of the load bearing surface of specimen (P/A).

Tests Conducted

Compressive Strength of Concrete Specimens

Compressive strength test was conducted for plane concrete cube specimens of M30 grade of concrete and fiber reinforced concrete cube specimens of same batch at various intervals of time 28 days and test results for compressive strength of both were compared. The compression test was conducted on universal testing machine.The compressive strength of ordinary concrete, Binary blended concrete containing 15% Fly ash with various percentages of crimped steel fibers concrete specimens having W/C 0.40, were tested

Fig.3.3.Beam specimen testing machine

Test setup

The experimental setup of beam with the bracket extended at the centre. as shown in Fig3.3& 3.4.The total length of the specimens was 1200mm and the bracket extended at the centre 300mm. the cross-section of the beam is 100x100mm. Beams were supported on two fixed supports at each end of the specimen. These supports ensured that the beam was restricted from rotation at ends. The load was applied through a point load on the end of the central bracket at an eccentricity of 300mm to produce combined torsion, bending and shear as shown in Fig. The end parts of the specimens were also heavily reinforced with high volume of stirrups in-order to bear without cracking the imposed torsional loading at the ends of the 300 mm long concrete arms. This way, the examined test region was the central part of the specimens. During the test procedure, torsional helical diagonal cracking and, finally, failure were localized within this test region. The heavily reinforced end parts and the over-reinforced concrete arms of the beams remained quite intact. The load was imposed consistently in low rate and measured by a load cell with accuracy equal to 0.05 KN. The beams were tested in gradually increasing point load until the ultimate Torsion, bending-shear strength is achieved and subsequently until the total failureofthespecimen.

Fig.3.3.Beam specimen testing machine

Discussion of test results

Workability

Addition of flyash and steel fiber into the concrete reduced the workability. The concrete mix was found to become strongly cohesive and stable compared to that of ordinary plain concrete. No bleeding was observed. This may be due to the void filling action of the superfine nature of fly ash particles, which gives a high cohesion to the mix. Mix with fly ash, crimped steel fiber tends to become harsh, sticky and stiff. However addition of super plasticizer to the concrete

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increased the workability at the same water cement ratio. By varying the dosage of super plasticizer workability ismaintainedi.e.,maintainingthe compaction 0.8 to 0.9. After application of vibration mixes were found to become mobile.

Compressive Strength

Cube specimens were tested for compression and ultimate compressive strength was determined from failure load measured using compression testing machine. The average value of compressive strength of 3 specimens for each category at the age of 28 days are tabulated in the Table 4.1. The Table shows the percentage increase in the compressive strength of binary blended steel fiber reinforced concrete .The relative compressive strength at 28 days age is shown in Figure 4.1.

Table 4.1 Compressive Strength of Concrete cubes with 15% of flyash and different percentages of crimped steel fiber at 28 days age.

S.no	Description of specimen	% of fiber	Compressive strength (N/mm2)	Avg. compressive strength(N/mm2)
1	C1	0%	33.33	33.67
2	C2	0%	34.00	
3	C3	0.50%	36.00	36.83
4	C4	0.50%	36.71	
5	C5	0.50%	37.78	
6	C6	0.75%	46.67	46.53
7	C7	0.75%	44.89	
8	C8	0.75%	48.04	
9	C9	1%	42.67	42.81
10	C10	1%	41.78	
11	C11	1%	44.0	

Fig. 4.1. Compressive strength of concrete cubes

The compressive strength of concrete cubes with crimped steel fiber and 15% fly ash was found to increase with increase in fiber content. The 28 days strengths were found to increase over the control mix. The maximum strength is achieved with 0.75% addition of fiber. The increase was observed as 38% over the control mix at the age of 28 days.

Torsion-bending-Shear Strength

Beam specimens were tested for combined torsion-bending-shear. All beam specimens are tested using machine specially setup to produce combined torsion, bending and shear at the same instant when a point load is applied at the end of the bracket as shown in fig 3.4.Each specimen was test under gradually increasing load until the ultimate torsion, bending and shear strength is achieved and subsequently until the total failure of specimen. Load values for all beams are tabulated in table 4.2.Using these values average minor principal stresses are calculated and tabulated in

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the same table. Using these values a graph was plot between percentages of crimped steel fibers and average minor principal stresses which is a curve with a polynomial equation which shows the increases in average principal stresses with increase in percentage of crimped steel fiber upto a certain percentage and then fall down with further increase in percentage of crimped steel fibers. The polynomial equation is used as a proposed formula for calculating theoretical values of minor principal stress by substituting different percentages of crimped steel fibers and those values are also tabulate. The ratio of theoretical minor principal stress to avg. principal was calculated and tabulated.

Concrete under combined torsion, bending and shear minor principal stresses

S.No	Specimen	% of fiber	Load (W) N	Torsion (T=W*e)/2 Nmm	B.Moment (M=WL/8) Nmm	Shear Force (V=W/2) N	Elemental Stresses				Minor Prinicipal Stresses= σn2 (N/mm2)	Average Minor Principal Stress σn2 (N/mm)	Theoritical Values for Proposed Formula	Theoritical/Actual Value
							Bending Stress =M/Z (N/mm2)	Shear Stress= V/bd (N/mm2)	Torsional Stress= T*R1/J (N/mm2)	Total Shear Stresses (Column =S+T) (N/mm2)				
1	T1R0F0	0.00%	6160	924000.00	924000.00	3080.00	5.5329	0.308	3.84	4.15	7.60			
2	T2R1F0	0.00%	6540	981000.00	981000.00	3270.00	5.8743	0.327	4.08	4.41	8.07	7.8824	7.759	0.99
3	T3R1F0	0.00%	6460	969000.00	969000.00	3230.00	5.8024	0.323	4.03	4.35	7.97			
4	T4R0F0.5	0.50%	8560	1284000.00	1284000.00	4280.00	7.6886	0.428	5.34	5.77	10.56			
5	T5R1F0.5	0.50%	9075	1361250.00	1361250.00	4537.50	8.1512	0.454	5.66	6.12	11.20	11.0070	10.985	0.9980
6	T6R1F0.5	0.50%	9120	1368000.00	1368000.00	4560.00	8.1916	0.456	5.69	6.15	11.26			
7	T7R0F0.75	0.75%	10250	1537500.00	1537500.00	5125.00	9.2066	0.512	6.39	6.90	11.93			
8	T8R1F0.75	0.75%	10160	1524000.00	1524000.00	5080.00	9.1257	0.508	6.34	6.85	12.54	12.3872	12.412	1.0020
9	T9R1F0.75	0.75%	10280	1542000.00	1542000.00	5140.00	9.2335	0.514	6.41	6.93	12.69			
10	T10R0F1.0	1.00%	9450	1417500.00	1417500.00	4725.00	8.4880	0.473	5.90	6.37	11.66			
11	T11R1F1.0	1.00%	9950	1492500.00	1492500.00	4975.00	8.9371	0.498	6.21	6.71	12.28	12.1445	12.080	0.9900
12	T12R1F1.0	1.00%	10120	1518000.00	1518000.00	5060.00	9.0898	0.506	6.31	6.82	12.49			

Table 4.2 Concrete under Combined Torsion, Bending and Shear

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Inference of results

From the above tables and graphs it was noticed that there is a substantial improvement in the combined torsion-bending-shear strength of concrete measured in terms of minor principal stress with 15% of fly ash found to be increased with the increase of fiber content. As expected plain concrete specimens showed no ductility resulting in brittle failure when the first crack forms. After the initial cracking in the fiber reinforced concrete the specimen exhibited a sudden drop in load carrying capacity but had some post peak resistance due to presence of fiber that were bridging the cracks. This indicated that the addition of fibers to the concrete improves its ductility and energy absorption capacity. The maximum average minor principal stress for a mix with 15% fly ash and 0.75% addition of steel fiber is 12.4 N/mm^2 i.e., 57% increase over control mix

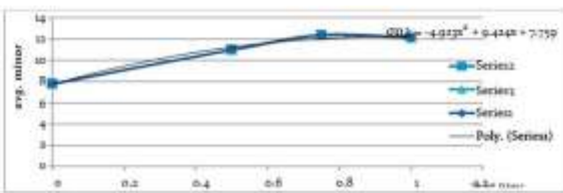

Figure 4.5 Equation for curve plotted for percentage of fiber vs avg. minor principal stress

Conclusions

Combined torsion-bending-shear strength in terms of minor principal stress was increased by 58% for binary blended steel reinforced concrete with 15% fly ash and 0.75% crimped steel fibers. Test results indicate that fibrous concrete beams exhibit improved overall combined torsion, bending and shear performance with respect to the corresponding non-fibrous beams .Addition of steel fibers consistently decreased crack spacing and sizes, increased deformation capacity and changed a brittle mode to a ductile one.Steel fibers enhance the torsional toughness of the members to a greater extent, which imparts better resistance to the structure in resisting dynamic forces.

References

1. Zdenek et al (1988):" Size effect tests of torsional failure of plain and reinforced concrete beams", ACI Structural Journal, Vol.99, No. 4, pp108-116.
2. L. Vandewalle (1999): "Cracking behaviour of concrete beams reinforced with a combination of ordinary reinforcement and steel fibers", Materials and Structures/Matdriauxet Constructions, Vol. 33, pp 164-17.
3. S. Panchacharam and A. Belarbi (2002):"Torsional Behavior of Reinforced Concrete Beams Strengthened with FRP Composites," First FIB Congress, Osaka, Japan, Vol.1,pp 01-110.
4. T.D. Gunneswara (2003): **"**torsion of steel fiber reinforced concrete member" (Cement and Concrete Research ,7 May 2003).
5. Nguyen Van CHANH (2005):"Steel Fiber Reinforced Concrete", ACI Structural Journal, Vol.99, No. 4, pp108-116.
6. T.D. GunneswaraRao, D. Rama Seshu (2005): "Torsional response of fibrous reinforced concrete members Effect of single type of reinforcement", Construction and Building Materials, Vol. 20, pp 187-192.
7. S. P. Avinash and R.S. Parekar (2009): **"**Steel fiber reinforced concrete beams Concrete Beams with an Opening", JKAU: Engineering. Science, Vol. 2, pp. 95- under combined torsion-bending-shear", Journal of Civil Engineering (IEB), 38 (1), page 31-38