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Strength And Behavior Of Polypropylene Fibre In Impact Characteristics Of Concrete

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ABSTRACT:*Concrete structures are often subjected to short duration (static or dynamic) due to relatively low tensile strength and fracture energy, the impact resistance of concrete is poor. There are several situations in which concrete structural elements are subjected to impact loading. The behavior of concrete under impact loads is far from adequate and there is significant variability in the published literature. In this work, an attempt is made to study the impact resistance of fibrous concrete using ACI drop weight Impact tester.Three grades of concrete's namely M1, M2, and M3 are considered in this investigation with 0.1%, 0.2%, 0.3% dosage of Polypropylene fiber. The experimental test results of fiber concrete's are compared with plain concrete and conclusions are arrived.*

KEYWORDS: *ACI drop weight Impact testing,Fibrous Concrete, Impact Strength, Polypropylene Fiber, Ultimate load*

I. INTRODUCTION

Research work carried out so far towards the development of concrete that exhibits improved impact resistance than conventional concrete. There are several situations in which concrete structural elements are subjected to impact loading. The behaviour of concrete under impact loads is far from adequate and there is significant variability in the published literature. The primary reason for this is the lack of a standardized technique of testing concrete under impact.The primary reason for this is the lack of a standardized technique of testing concrete under impact.

II. REVIEW OF LITERATURE

Benter .etal (1989) has investigated the effects of low volumes of fibrillated fiber reinforcement on the proprieties of concrete, in particular on impact resistance. Low content of polypropylene fiber reinforcement 0.1 to 0.5%) had only a small positive influence on the impact resistance of both normal and high strength concretes. Chauvel el at (1989) have investigated impact resistance of slab are increased by fiber addition together, with the ultimate deformation energy for impact load subjecting the specimen to flexure shear and torsion. Chu el at (1989) has investigated Polypropylene fibers in impact test on small concrete beams. The impact resistance is increased by 29% for the beam in presence of Polypropylene fibers. Sivaraj.etal (1989) have presented the results of an investigation carried out to determine the flexural, endurance limit and impact strength of steel fiber reinforced refractory concrete at 0.5%, 1.0% and 1.5% by volume of fiber. These properties are compared to the same refractory concrete mix without steel fiber. The fatigue strength of increased 61%, 159% and 199% to 0.5%, 1.0% and 1.5% by volume of steel fiber respectively. The endurance limit expressed as a percentage of plain concrete modulus of rupture, increased 60%, 160% and 200%. When reinforced with 0.50%, 1.0% and 1.5% of steel fiber by volume, respectively. The addition of steel fiber also substantially increased the strength of refractory concrete. Bischoff.etal (1990) has studied polystyrene aggregate to minimize potential impact damage to structure–low crushing strength and a high degree of deformability energy absorbing material properties demonstrate through experiments on impact testing.Soroushian el at (1992) has studied the effects of Collated Fibrillated Polypropylene fiber on the impact resistance, chloride permeability and abrasion resistance materials, and incorporating different types of pozzolanic materials. Plain pozzolan concrete has 40%less ultimate impact resistance than conventional concrete, and percentage increase in ultimate resistance of conventional and pozzolan concrete with addition of polypropylene fibers were 50% and 100% respectively.Souatchof .etal (1993) has found that energy absorption capability of GRC plates can be realistically estimated by the energy loss of the hammer during impact. It was found that the absorbed energy was linearly related to the plate's thickness. No significant changes in the energy absorption of GRC plates were found due to change to change boundary conditions. Gorst el at (1992) has studied special types of specimens to create failure due to flexure, shear and torsion. Steel and Polypropylene fiber reinforced concrete is studied

Lifshitz .etal (1995) have investigated low velocity impact of carbon fiber reinforced epoxy and it was conducted in 48 and 40 layered beams of different combination of 0˚, 90˚, 45˚ and -45˚ stacking sequences. The test setup included an instrumented drop weight and data acquisition system. Beams of two lengths were tested. Long (199mm) and "short" (55mm), under impact and quasi-static loading conditions. They acceleration pulse was analyzed in the frequency domain to determine the source of high frequency vibrations and a simple two degree of freedom model was used to distinguish between the force on the Sticker and the force applied to the beam. It is shown that the elastic response of the beams is the same under the two loading regimes. Zhou el at (1995) have investigated thick glass, polyester woven roving laminated plates subjected to low velocity impact using a guided drop weight testing and found that the impact resistance is increased by 36% for thin plates and by 22% for the thick plates. Wang el at (1996) has used polypropylene and steel fiber in impact tests on small on small concrete beams. Polypropylene fiber less than 0.5% gave a modest increase in fracture energy. Steel fibers could bring about much greater increase in fracture energy. Fiber breaking was the primary failure mechanism for steel fibers less than 0.5%. Fiber pull out was the primary mechanism for failure with fibers more than 0.75%.

III. EXPERIMENT

All the samples were prepared using designed mix. Mix design for the M1grade concrete was done based on I.S. code method. M2 and M3 grade concrete was done based on ACI method and Trial method respectively. The optimum mix obtained for M1, M2, and M3 grade concrete is shown in Table -1. Table 2 & 3 shows the test result of controlled concrete & details of the specimen. Table – 4 describes the impact strength test results.

ACI Drop weight impact test

The experimental set up is as shown in Figure – 1 .The test specimens is to move horizontally, 2.8mm off the center between the four positioning lugs. The steel ball is free to move vertically with the sleeve 45 N drop hammers through a height of 457 mm to cause the first visible crack and ultimate failure.

Testing Procedure

Thickness of the specimens is recorded to the nearest millimeter at its center and at the end of a diameter prior to the test. The specimens were placed on the base plate with finished face up and positioned within four lugs of the impact testing equipment. The bracket with the cylindrical sleeve ball is placed on the top of the specimens within bracket. The drop hammer was then placed with base upon the steel ball and held vertically. The hammer was dropped repeatedly, and the number of blows required for the first visible crack to form at the top surface of the specimen and for ultimate failure was recorded.

The first crack was based on visual observation. White washing the surface of the test, specimens facilitated the identification of this crack. Ultimate failure is defined in terms of the numbers of required to open the crack in the specimens sufficiently to enable the fractured Pieces to touch three of the four positioning lugs plate. The stage of ultimate failure is clearly recognized by the fractured specimens butting against lugs on the base plate. With fiber reinforced concrete specimens the pieces were not often broken clearly, whereas in plain concrete specimens were clearly broken.Figure - 2 and 3 shows the failure pattern of Plain Concrete and Fibre Concrete. Figure – 4 shows the overview of the tested specimens.

IV. FIGURES AND TABLES

Figure 1: Experimental setup

Figure 2: Plain Concrete Specimen

Figure 3: Polypropylene fibre Concrete Specimen

Figure 4: Overview of tested specimen

Table 1: Mix Proportions

Sl. No.	Concrete ITEM	M1 Quantity (kg/m³)	M2 Quantity (kg/m³)	M3 Quantity (kg/m³)
1.	Cement (OPC)	479	683	950
2.	Fine aggregate	530	784	552
3.	Coarse aggregate	1140	768	761
4.	Water	191	205	205
5.	Mix proportion adopted	1:1.10:2.4 w/c: 0.40	1:1.14:1.12 w/c 0.38	1:0.58 :0.80 w/c 0.36
6	Super plasticizer 1% by the weight of cement	----	6.8 liters	9.5 liters

Table 2: Test results of control specimens

Sl. No	Grade of concrete	Mix proportion	Average compressive Strength in 7 days N/mm^2
1.	M1	1:1.10:2.40/0.38	21.37
2.	M2	1:1.14:1.12/0.36	32.50
3.	M3	1:0.58:0.80/0.36	48.30

Table 3: Details of specimens

Sl. No	Grade of concrete	Dosage of Polypropylene fibres in Plain Concrete , %	No. of Specimens
1.	M1	0.0, 0.1, 0.2, 0.3	4 X 5 = 20
2.	M2	0.0, 0.1, 0.2, 0.3	4 X 5 = 20
3.	M3	0.0, 0.1, 0.2, 0.3	4 X 5 = 20

Total No. of Specimens = 60

Table 4: Impact strength test results

Grade of concrete	Dosage of fiber In concrete %	No. of blows for first crack (Average of 5 Specimens)	No. of blows for ultimate strength (Average of 5 Specimens)
M 1	0.0	348	368
	0.1	400	425
	0.2	437	482
	0.3	493	537
M 2	0.0	448	510
	0.1	493	552
	0.2	558	622
	0.3	490	551
M 3	0.0	624	691
	0.1	705	796
	0.2	945	1015
	0.3	1059	1204

Table 5 Characteristic Impact strength of concrete

(a) For First Crack

Grade of Concrete	N_{CK} Value for first crack in no. of blows			
	0.0%	0.1%	0.2%	0.3%
M1	338	390	427	493
M2	437	482	547	479
M3	613	621	863	1208

(b) For Ultimate Strength

Grade of Concrete	Improvement in no. of blows of Polypropylene fibre concrete over plain concrete for first crack		
	0.1%	0.2%	0.3%
M1	15.38	26.33	45.85
M2	10.29	25.17	9.61
M3	1.30	40.78	97.06

Table 6: Improvement in no. of blows of Polypropylene fibre concrete over Plain concrete

(a) For First Crack

Grade of Concrete	N_{CK} Value for first crack in no. of blows			
	0.0%	0.1%	0.2%	0.3%
M1	361	415	472	527
M2	499	541	611	540
M3	686	17	934	1398

(b) For Ultimate Strength

Grade of Concrete	Improvement in no. of blows of Polypropylene fibre concrete over plain concrete for first crack		
	0.1%	0.2%	0.3%
M1	14.95	30.74	45.98
M2	8.41	22.44	8.21
M3	4.51	36.15	103.79

Table 7: Comparison of % Improvement in no. of blows of Polypropylene fibre concrete over Plain concrete

(a) For First Crack

Grade of Concrete	0.1 % ~ 0.2 %	0.1 % ~ 0.3 %
M1	71.19%	198.11%
M2	144.60%	-6.60%
M3	3036.92%	7366.15%

(b) For Ultimate Strength

Grade of Concrete	0.1 % ~ 0.2 %	0.1 % ~ 0.3 %
M1	105.61%	207.55%
M2	166.82%	-2.37%
M3	701.55%	2201.33%

* -ve sign represents, the % of improvement in no. of blows decreases

Table 8: Comparison of test results of M1 grade concrete with M2 &M3 grade concrete

(a) For First crack

Grade of Concrete	N_{CK} Value for first crack in no. of blows			
	0.0%	0.1%	0.2%	0.3%
M1 ~ M2	29.28	23.58	28.10	-2.83
M1 ~ M3	81.36	59.23	102.10	145.03

(b) For Ultimate Strength

Grade of Concrete	N_{CK} Value for ultimate strength in no. of blows			
	0.0%	0.1%	0.2%	0.3%
M1 ~ M2	38.22	30.36	29.44	2.46
M1 ~ M3	90.02	72.77	97.88	65.27

* -ve sign represents, the % of improvement in no. of blows decreases

Table 9: Cost comparisons of different fibres

Sl .No	Name of the fiber	Dosage in kg/m^3	Cost Per m^3 in Rs.
1.	Steel (0.5%)	40.0	2000.00
2.	Polypropylene (0.1%)	0.910	745.00
3.	Reengineered Plastic Shreds (0.5%)	4.0	600.00

V. RESULTS DISCUSSION

The results of impact strength measured as no. of blows for first cracking and failure show a wide variation. Using means of measures of deviation, the characteristic value number of blows for first and ultimate cracking are obtained as,

NCK =N-1.64 x S

Where,

NCK=Characteristics no of blows
N = Average no of blows
S =Sample deviation

From Table - 5 & 6 shows the performance improvement in no. of blows for first and ultimate strength. From the Table - 5 addition of 0.1%, 0.2%, 0.3% of fibres in plain concrete shows the improvement in no. of blows for first crack to an extent of 15.38%,26.33%,45.85% for M1, 10.29%, 25.17%, 9.16% for M2 and 1.30%, 40.78%, 97.06% respectively.
From the Table - 6 addition of 0.1%, 0.2%, 0.3% of fibres in plain concrete shows the improvement in no. of blows for Ultimate strength to an extent of 14.92%,30.74%,45.98% for M1, 8.41%, 22.49%, 45.98% for M2 and 4.51%, 36.15%, 103.79% respectively.

From Table – 7 shows comparison of percentage of improvement in no. of blows between different dosages of fiber content in plain concrete. Addition of 0.2% & 0.3% of Polypropylene fibre in plain concrete shows improvement in no. of blows over 0.1% incorporation of fibre in plain concrete are 71.19%, 198.11% and 105.61%, 207.55% for M1 grade of concrete, 144.60% -6.60% and 166.82%, -2.37% for M2 grade of concrete and 3036.92%, 7366.15% and 705.55%, 2201.33% for M3 grade of concrete for first crack and ultimate strength respectively.

From Table – 8 shows comparison of test results of M1 grade concrete with M2 & M3 grade concrete. The percentage of Improvement in no. of blows increases to an extent of 29.28% - 81.36%, 23.58 – 59.23%, 28.10 – 102.10%, 145.03 – 2.83% for first crack, 38.22% - 90.92%, 30.36% - 72.77%, 29.44 – 97.88%, 2.46 – 165.27% for ultimate strength of M2 and M3 over M1 grade of concrete with 0.0%, 0.1%, 0.2% and 0.3% incorporation of fibres in Plain concrete respectively.

Table – 9 Shows the cost comparison of Polypropylene fibres with other available artificial fibres.

VI. CONCLUSIONS

The following conclusions are presented based on experimental results from investigations,

For M1 Grade of Concrete

Addition of 0.0%, 0.1%, 0.2% and 0.3% dosage of Polypropylene fibres in plain concrete improves the characteristic no. of blows to a maximum extent of 15.38% - 45.85% for first crack and 14.95% - 45.98% for ultimate strength.Addition of 0.2% and 0.3% dosage of Polypropylene fibres in plain concrete shows improvement in no. of blows by 71.19% , 198.11% and 105.61% , 207.55% for first crack & ultimate strength of M2 and M3 grade of concrete compared to M1 grade of concrete.

For M2 Grade of Concrete

Addition of 0.0%, 0.1%, 0.2% and 0.3% dosage of Polypropylene fibres in plain concrete improves the characteristic no. of blows to a maximum extent of 9.61% - 25.17% for first crack and 8.21% - 22.44% for ultimate strength.Addition of 0.2% and 0.3% dosage of Polypropylene fibres in plain concrete shows improvement in no. of blows by 144.60% and 166.82% for first crack & ultimate strength of M2 and M3 grade of concrete compared to M1 grade of concrete.

For M3 Grade of Concrete

Addition of 0.0%, 0.1%, 0.2% and 0.3% dosage of Polypropylene fibres in plain concrete improves the characteristic no. of blows to a maximum extent of 1.30% - 97.06% for first crack and 4.51% - 103.79% for ultimate strength.Addition of 0.2% and 0.3% dosage of Polypropylene fibres in plain concrete shows improvement in no. of blows by 3036.92% - 7366.15% for first crack & ultimate strength of M2 and M3 grade of concrete compared to M1 grade of concrete.

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