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An Experimental Evaluation of Impact Strength of Fiber Reinfoced Concrete by using Drop Weight Test Method

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Abstract: Using the Drop weight test method on slab panels with various types of fibre and their various proportions, this research examines the impact resistance of reinforced concrete's fibre resistance. The results of the IS drop weight test method, which measured the impact qualities of objects travelling at low and high speeds as well as the spilling and scabbing areas, are discussed in the current review study. The most frequently employed test. The results will be increases with the fibers added in percentages.
Keywords: Glass fiber, Polypropylene fiber, Plastic Fiber, Impact test on concrete, drop weight test. Etc.

I. INTRODUCTION

The most often employed test surfaces for determining the deformability, toughness, and energy absorption of FRC are concrete slab panels. Structures made of concrete are frequently subjected to dynamic, short-duration loads. These loads are caused by things like the impact of bullets and missiles, wind gusts, earthquakes, machine vibrations, and moving vehicles. Concrete has poor impact resistance since its tensile strength is relatively low and its fractures have high energy. Therefore, a lot of research has gone into creating concrete that is more impact resistant than regular concrete. The initial and final crackings are being determined utilising the drop weight test method.

II. OBJECTIVES

1) To look into the characteristics of fibre-reinforced concrete and observe how it responds to an impact load test.
2) To examine the relationship between the impact load, the quantity of strikes, and the hammer's weight on the slab.
3) The primary goal of this study is to give engineers and architects direction in situations where protection against impact loads is required, protecting people, structures, and expensive interior equipment.
4) The goal of this project is to develop impact-resistant buildings and to be a leader in putting the appropriate laws into action to reduce both structural and human loss from impacts and other human-sourced dangers.
5) Create structures that are more durable, secure, and affordable for the next generation.
6) To analyse and design the structures to withstand anomalous loading situations such blast loads, severe winds, etc., which calls for a thorough grasp of the phenomenon of blasts.
7) To examine how different structural components, such as columns, beams, slabs, and connections, respond dynamically in steel and RCC structures.

III. LITERATURE REVIEW

1) Ganeshram & Gopalan (2015) "An Experimental Study on Impact Strength of Self Compacting Concrete". The impact strength of self-compacting concrete was assessed in this work by laboratory research. 20% of the fly ash is replaced with cement. Ordinary Portland cement of grade 53, fine aggregate, coarse aggregate, super plasticizer, class-F fly ash from thermal power plants, and a viscosity modifying agent are the ingredients used in SCC. By using a trial-and-error methodology, the mix design is carried out for about M30 grade of concrete. Both self-compacting concrete and traditional concrete were used to prepare the slab. The drop Weight method was used to evaluate the specimens for impact research. The impact test results of self-compacting concrete are compared with those of conventional M30 grade concrete as the slabs are tested at 7 and 28.

2) Atef Badra, Ashraf F. Ashourb, Andrew K. Plattenaa, Department of Built Environment "Statistical variations in impact resistance of polypropylene fiber reinforced concrete". The repeated drop-weight impact test recommended by ACI Committee 544 was used to investigate the impact resistance of polypropylene fibre reinforced concrete (FRC). The results were analysed using a statistical approach. This study has highlighted the need to modify this test in order to improve its accuracy and decrease the large variation in results.
3) Xue-Chao Zhu, Han Zhu, and Hao-Ran Li, (2015). "Drop-Weight Impact Test on U-Shape Concrete Specimens with Statistical and Regression Analyses" In this experiment, self-designed U-shape specimens and a newly developed drop-weight impact test apparatus were used to Determine the impact resistance of concrete. Four distinct drop hammer masses (0.875, 0.8, 0.675, and 0.5 kg) were used in a series of drop-weight impact tests. The test findings demonstrate that the results for impact resistance do not adhere to a normal distribution. As anticipated, U-shaped specimens are particularly good at predicting where the cracks will appear. The first-crack and final failure impact resistance had a good linear connection, with the largest coefficient of variation in this investigation being 31.2%.
4) Petr Máca, Radoslav Sovják, Petr Konvalinka, (2014). "Impact Testing of Concrete" In this investigation testing of ultra-high performance fiber reinforced concrete under impact loading. In addition a design method of a revolutionary impact measurement device is provided in work. This work however proposes an impact machine that is based on a pendulum basis. Such a test design provides a number of benefits, including the removal of double hits, simple sample access, and high device modulability.

IV. MATERIALS USED

1) *Cement:* The cement used in the tests was Ordinary Portland Cement (Grade 53) locally available.
2) *Crushed Sand:* Locally available clean and good graded crushed aggregate was used after passing through I.S sieve 2.36 mm.
3) *Water:* Ordinary drinking water was used for mixing and curing of concrete. The water was clean and free from acids, alkalis and organic impurities.
4) *Fibres:*

Three types of Fibers were used:

a) *Glass Fiber*

Random glass fiber were selected because of their availability in the local market.

Fibre properties	Quantity
Fibre length	12 mm
Aspect ratio	857
Specific gravity	2.68 g/cm^3
Modulus of elasticity	72 GPa
Tensile strength	1700 MPa
Chemical resistance	Very high
Electrical conductivity	Very low
Softening point	860 °C
Material	Alkali Resistant Glass
Shape	Straight

b) *Polypropylene Fiber*

In general, PP fibre offers good abrasion resistance, great chemical resistance to acids and alkalis, and resilience to insects and pests. In addition, PP fibre is less expensive and simpler to produce than other synthetic fibres.

Composition	100% Virgin polypropylene fiber
Fiber length	18mm
Specific gravity	0.91
Melting point	160°C
Tensile strength	(137-689) MPa
Young's modulus	(5500-7000) MPa
Fiber thickness	18-30 microns
Elongation	25-40 %
Alkali content	Nil
Sulfate content	Nil
Chloride content	Nil

c) Plastic Fiber

In addition to having a high strength to weight ratio, plastic fiber composites exhibit excellent qualities such great durability, stiffness, damping property, flexural strength, and resistance to corrosion, wear, impact, and fire.

S.NO	Composite material properties (E-glass/polyester)		
	Property	**Direction**	**Value**
1	Longitudinal modulus (GPa)	$\mathbf{E_{11}} = E_f V_f + E_m V_m$	50.21
2	Transverse modulus (GPa)	$\mathbf{E_{22}} = (E_f E_m / (E_m V_f + E_f V_m))$	20.8913
3	Shear modulus (GPa)	$\mathbf{G_{12}} = G_f G_m / (G_m V_f + G_f V_m)$	7.7518
4	Poisson's ratio	$\mathbf{v_{12}} = V_m \nu_f + V_f \nu_m$	0.263
5	Density (kg/m^3)	$\boldsymbol{\rho_C} = \rho_f \nu_f + \rho_m \nu_m$	2167

V. METHODOLOGY

A. Procedure Adopted For Compression Test on Cubes

1) Before starting the test, all materials must be warmed to room temperature, preferably 27 degree C.
2) For each batch of concrete, aggregate samples must be of the desired grading and be in an air-dried state. To guarantee the greatest blending and consistency in the material, the cement samples must be well mixed dry upon arrival at the laboratory, either by hand or in an appropriate mixer. Foreign materials are being kept out with great care.
3) The proportions of the ingredients, including water, in concrete mixes used to assess the suitability of the materials on hand must be identical to those to be used in the job in all other aspects.
4) Cubes measuring 15 cm X 15 cm X 15 cm were utilised for the cube test.
5) This concrete is properly tempered after being poured into the mould to prevent voids. Moulds are removed after 24 hours, and test specimens are then submerged in water to cure. These specimens' top surfaces ought to be level and smooth. To accomplish this, apply cement paste evenly throughout the whole surface of the specimen.
6) After seven or 28 days of curing, these specimens are evaluated using a compression testing equipment. Until the specimens fail, a load should be applied gradually at a rate of 140 kg/cm2 per minute. Compressive strength is calculated by dividing the load at failure by the specimen's area.

Cube Testing on CTM

B. Procedure Adopted For Impact Load Test

1) Prior to the test, the thickness of the specimens was measured to the nearest millimetre at each end and the centre of the diameter.
2) The specimens were set on the base plate, finished face up, and within four lugs of the impact testing apparatus. The specimens were then coated with a thin layer of grease on the bottom. It was secured in place to hold the bracket with the cylindrical sleeve.
3) The specimen was positioned inside the bracket with the hardened steel ball on top. The placement of the lugs limits the specimen's movement during testing to the first discernible cracks.
4) The drop hammer was then held vertically while its base was positioned on the steel ball. The hammer was repeatedly dropped on plate of size 50cm X 50cm X 5cm.

Based on ocular observation, the first crack was made. The test specimen's surface was painted, which made it easier to spot this fissure. The number of blows necessary to crack the specimen enough for the fractured pieces to touch three of the four positioning lugs on the base plate is the definition of ultimate failure.

The fracture specimen butting against the lugs on the base plate makes it easy to identify the last stage of failure. In contrast to conventional concrete samples, where specimens were broken into distinct pieces, fibre reinforced concrete specimens did not always have well defined portions. The amount of strikes needed to compare the plain concrete specimens. Through testing, the compressive strength of the various ages was determined.

a) Experimental Setup

Following are the dimensions of equipment used-

1) Size of Cube : 15 X 15 X 15 cm
2) Size of Plate : 50 X 50 X 5 cm
3) Total Height of Model: 2.760 m
4) Weight of Hammer: 6.35 kg

b) Sample Calculations:

Following Formula adopted for calculation of Impact Energy Produced on Concrete Plate-

EI = Nmgh

Where,

EI is the Impact Energy in Joule

N is the Number of Blows

m is the Mass or Weight of Hammer in kg

g is the acceleration due to gravity (9.81 m/s^2)

h is the height of fall of the hammer in m

- Plastic 1%

  EI = Nmgh

  = 3 x 6.35 x 9.81 x 2.760

  = 515.79 Nm or Joule

  ......(1Nm = 1Joule)

Impact Testing by Drop Weight Hammer

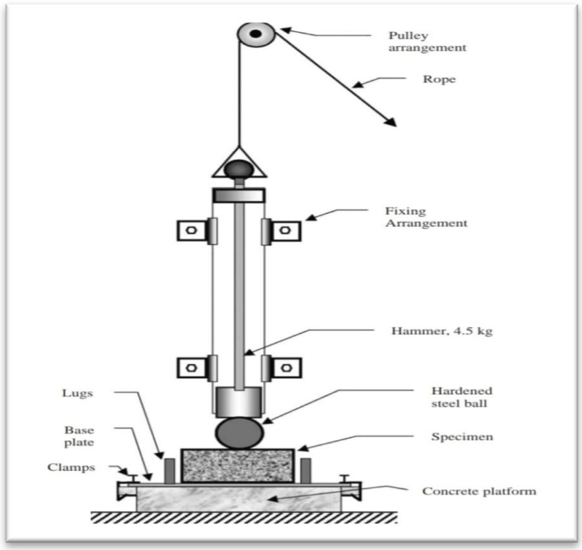

Diagram: Drop Weight Impact Test Model

Patterns of Cracks Observed on Plates

Sr.no	Material	Crack Pattern	
		Front Face	Back Side
1	Normal Concrete	3 long hair cracks	2 short hair cracks
2	Glass Fiber 1 %	4 long hair cracks	3 short hair cracks
	2%	3 long hair cracks	2 short hair cracks
Sr.no	Material	Crack Pattern	
		Front Face	Back Side
3	Plastic Fiber 1%	4 long hair cracks	2 short hair cracks
	2%	3 long hair cracks	1 short hair crack
4	Polypropylene fiber 1%	4 long hair cracks	3 short hair cracks
	2%	3 long hair cracks	2 short hair cracks

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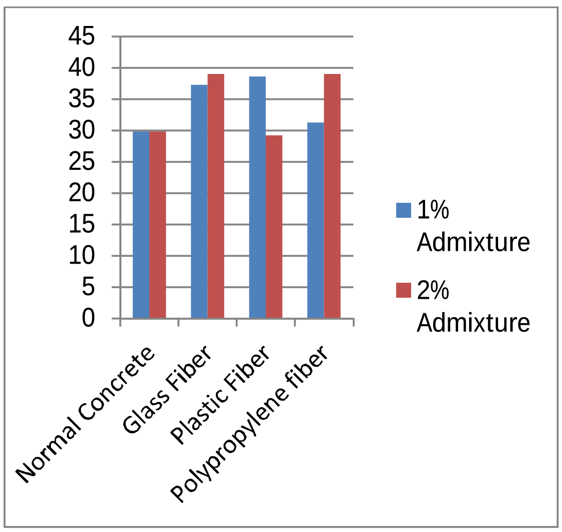
Photographs of Cracking Pattern Seen on Impact Testing of Plates

VI. EXPERIMENTAL TEST RESULTS

Following results are obtained from this experiment.

A. Results of Compression Test

Sr. No	Materials	No. Of cube	Avg.Compressive Strength	
			1%	2%
1	Normal concrete	02	29.8	28.9
2	Glass fiber	02	37.26	38.98
3	Plastic fiber	02	38.64	29.22
4	Polypropylene fiber	02	31.29	38.98



Graph 1) Fiber Vs Compressive Strength

B. Results of Impact Test

Sr. no	Materials	No of plate	Avg. Impact Strength
1	Normal concrete	02	171.93
2	Glass fiber	02	601.755
3	Plastic fiber	02	601.755
4	Polypropylene fiber	02	429.825

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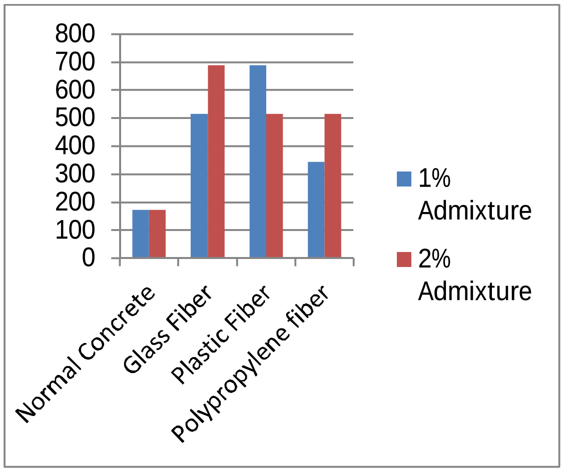

Graph: % Added Fibers Vs Impact Strength

VII. CONCLUSION

Based upon the experimental test results and discussion of the concrete slab panels the following conclusions can be stated-

1) Addition of fibers, even in a small quantity, considerably improves the impact resistance of concrete.
2) Even a tiny addition of fibres can significantly increase the compressive strength of concrete.
3) Normal concrete's impact strength and glass fibre concrete panel's impact strength are both increased by 1% and 2%, respectively, from 2 to 3 times.
4) The impact strength of normal concrete and polypropylene fibers concrete panel with 1% and 2% improves impact strength from 1 to 2 times.
5) Additionally, a higher amount of fibre might increase the concrete's compressive and impact resistant strength.

VIII. FUTURE SCOPE

1) The same job can be completed using various blends of all fibres.
2) Comparable work can be done by substituting nylon or crimped steel fibre for glass fibre.
3) Only the impact and compressive strengths of the panels are determined in this work. The same panels' flexural strength can also be a research topic.
4) A separate research could be done and the size and thickness of the slab panels might be changed.
5) Sometimes we can adjust the hammer's free fall height to increase the maximum number of strikes, while still using the least amount of hammer weight.
6) Future versions of this experiment can be conducted by varying the proportions of the fibres used, the apparatus dimensions, and the testing specimen.

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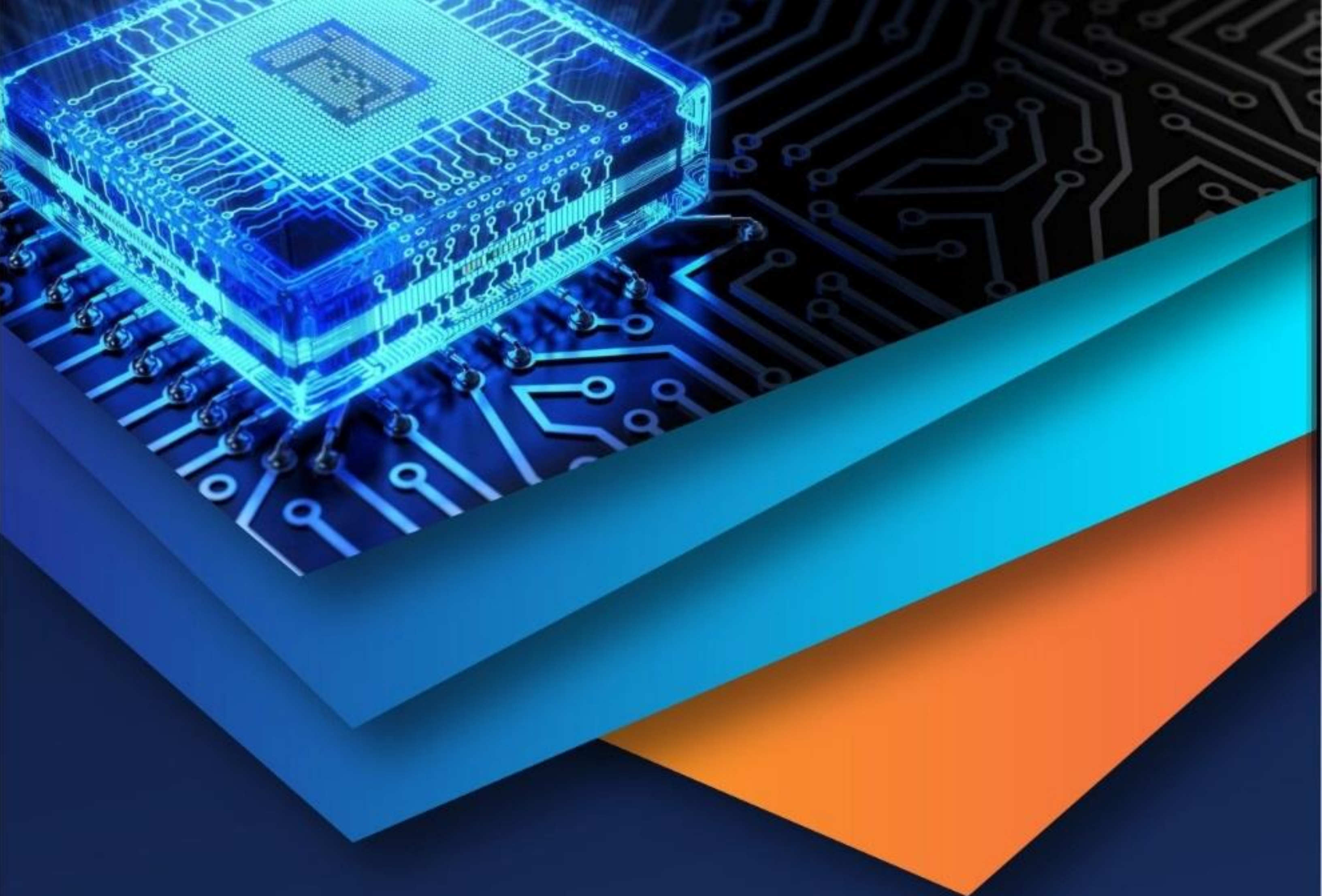

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