iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** III **Month of publication:** March 2019

DOI: http://doi.org/10.22214/ijraset.2019.3486

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue III, Mar 2019- Available at www.ijraset.com

Experimental Investigation on Concrete Considering Different Types of Steel Fibers

Dhaval C. Hadiyal[1], Krunal J. Dhandha[2]
[1]*PG Student, Civil Engineering Department, Darshan Insitute of Engineering and Technology-Rajkot, Gujarat, India*
[2]*Assistant Professor, Civil Engineering Department, Darshan Insitute of Engineering and Technology-Rajkot, Gujarat, India*

***Abstract:** This research is based on investigation the effect of different types of steel fiber, different fiber content with different aspect ratio on strength parameters for M-20 grade of concrete. Three types of steel fibers, i.e., straight, crimped and hooked fiber, four fiber content (by weight of concrete) of 1%, 2%, 3% and 4% with different aspect ratios 50 to 85. The hardened properties like compression strength test at 7, 28 days, split tensile strength test, flexural strength test at 28 days of curing for M-20 grade concrete. Test result clearly show that increase of strength like Compressive strength, Flexural strength and Split Tensile strength up to 3% of addition of steel fiber for M20 Grade of Concrete.*
***Keywords:** Steel fiber: Straight, Crimped and Hooked fiber, Compressive strength, Split Tensile strength, Flexural strength*

I. INTRODUCTION

Concrete is one of the world most widely used construction material. It has been known that concrete is weak in tension. Weak tensile strength combined with brittle behaviour result in sudden tensile failure without warning. Thus, concrete requires some form of tensile reinforcement to compensate its brittle behaviour and improve its tensile strength and strain capacity to be used in structural applications. Historically, steel fiber has been used as the material of choice for tensile reinforcement in concrete.

Steel fiber concrete is one of the special concrete that normal concrete mix with discontinuous discrete steel fiber. There are abundant of small-scale fibers are distribute randomly during the concrete mix. The evolution of using steel fibers in the field is to replace and reduce the traditional reinforcement bar in the concrete members. Thus steel fiber tend to increase the tensile strength of the concrete by deflecting micro cracks which develop in the concrete under exterior force and load effects. The lengths of the steel fibers are usually small and short, this is because it wants to avoid inadequate workability of the concrete mixture.

II. MATERIAL

A. Cement

Ordinary Portland Cement 53 Grade conforming to IS 12269-2013 is be used. In the most general sense of the word, a cement is a binder, a substance that sets and hardens independently, and can bind other materials together.

B. Coarse Aggregate

The fraction content range from 20 mm to 4.75 mm are used as coarse aggregate. The coarse aggregates from crushed basalt rock, conforming to IS: 383-2016 is being use.

C. Fine Aggregate

Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is used in combination as fine aggregate conforming to the requirements of IS: 383-2016. The river sand is washed and screens to eliminate deleterious materials and oversize particles.

D. Straight Steel Fiber

These steel fiber are used in three-dimensional reinforcement of concrete and replaces steel mesh.

E. Crimped Steel Fiber

Crimped Steel Fiber is used as a piece of either dry or wet process shotcreting to enhance Flexibility, quality and impact resistance.

F. Hooked Steel Fiber

Hooked Steel Fiber can be used with any concrete mix and high concrete density is less mandatory then for undulated or for flat-end fibers. Load transfer in the crack is very good with this fiber shape.

G. Water

Normal portable water of college is used.

H. Super Plasticizer

To impart additional workability a super plasticizer (Redwoop) 0.6% to 0.8% by weight of cement was used. It is based on sulphonated naphthalene polymers.

Physical Properties of experimental properties are shown in Table 1.

TABLE 1
PHYSICAL PROPERTIES

Sr. No	Test	Coarse Aggregate	Fine Aggregate
1	Specific Gravity	2.74	2.70
2	Water Absorption	0.26%	0.41%

Physical and Chemical Properties of steel fiber are shown in Table 2 & 3.

TABLE 2
PHYSICAL PROPERTIES

Sr.No	Physical Properties	
1	Diameter (D)	0.8 - 1.0 mm
2	Length (L)	25mm to 80 mm
3	Tensile strength	1403 Mpa
4	Tolerance for Length and Diameter	(+/-) %10

TABLE 3
CHEMICAL PROPERTIES

Sr.No	Chemical Properties	
	Chemical Composition	Percentage (%)
1	Carbon (C)	0.036
2	Magnesium (M)	0.290
3	Silicon (Si)	0.027
4	Phosphors (P)	0.013
5	Sulphate (S)	0.006

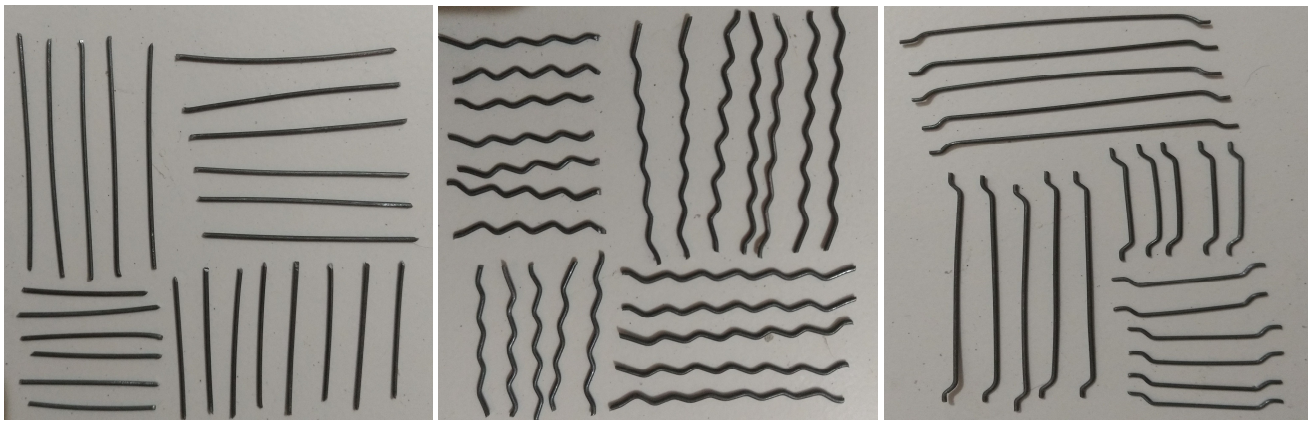

Fig. 1 Image of the different types of steel fiber

III. OBJECTIVE AND SCOPE OF WORK

The objective of the present work is to improve the properties of the concrete mainly in tension portion, to achieve this different types of steel fiber is used with different aspect ratio. To determine the best types of steel fiber and aspect ratio can be used in concrete to achieve the best result according to tensile requirement.

Three types of steel fibers, i.e., straight, crimped and hooked fiber, four fiber content of 1%, 2%, 3% and 4% with 50 and 80 aspect ratios selected.

To investigate the strength property of normal concrete by performing various tests

Compressive strength at 7, 28 days

Split tensile strength at 28 days

Flexural strength at 28 days

IV. EXPERIMENTAL METHODOLOGY

A. Concrete Mix Design

In this experiment study different mixes with different fiber combination are designed for M20 grade of concrete as per IS: 10262-2009.

B. Preparation and Testing of Specimen

The present work is made to investigate experimentally and the following test are carried out, namely Cubes (150mm*150mm*150m) for Compressive strength, Cylinder (300mm*150mm) for Split Tensile strength and Prism (500mm*100mm*100mm) for Flexural strength. Casting of the concrete specimens ware done according to IS 516-1959.The details of mixing and specimen designations are as shown in Table 4.

Table 4
Detail of mixing

Sr.No	Identification mark	Types of steel fiber	Fiber content (%)
1	CM	Control Mix	0
2	M 1	Hooked Small (HS)	1
3	M 2	Hooked Small (HS)	2
4	M 3	Hooked Small (HS)	3
5	M 4	Hooked Small (HS)	4
6	M 5	Hooked Long (HL)	1
7	M 6	Hooked Long (HL)	2
8	M 7	Hooked Long (HL)	3
9	M 8	Hooked Long (HL)	4
10	M 9	Crimped Small (CS)	1
11	M 10	Crimped Small (CS)	2
12	M 11	Crimped Small ((CS)	3
13	M 12	Crimped Small	4
Sr.No	Identification mark	Types of steel fiber	Fiber content (%)
14	M 13	Crimped Long (CL)	1
15	M 14	Crimped Long (CL)	2
16	M 15	Crimped Long (CL)	3
17	M 16	Crimped Long (CL)	4
18	M 17	Straight Small (SS)	1
19	M 18	Straight Small (SS)	2
20	M 19	Straight Small (SS)	3
21	M 20	Straight Small (SS)	4
22	M 21	Straight Long (SL)	1
23	M 22	Straight Long (SL)	2
24	M 23	Straight Long (SL)	3
25	M 24	Straight Long (SL)	4

V. EXPERIMENTAL METHODOLOGY

A. Fresh concrete properties

Fresh properties of M20 grade of concrete are as shown in Table 5.

1) Slump Test: From the observation of the addition of steel fiber in concrete the slump was decreases. The percentage of steel fiber was increase form 1% to 4%, the slump was decreases from 1% to 28.57%.

Table 5
Fresh Concrete Properties

Sr.No	Concrete Mix	Types of steel fiber	Fiber content (%)	Slump (mm)
1	CM	Control Mix	0	70
2	M 1	Hooked Small (HS)	1	69
3	M 2	Hooked Small (HS)	2	66
4	M 3	Hooked Small (HS)	3	60
5	M 4	Hooked Small (HS)	4	56
6	M 5	Hooked Long (HL)	1	67
7	M 6	Hooked Long (HL)	2	64
8	M 7	Hooked Long (HL)	3	58
9	M 8	Hooked Long (HL)	4	53
10	M 9	Crimped Small (CS)	1	68
11	M 10	Crimped Small (CS)	2	64
12	M 11	Crimped Small (CS)	3	58
13	M 12	Crimped Small (CS)	4	55
14	M 13	Crimped Long (CL)	1	65
15	M 14	Crimped Long (CL)	2	62
16	M 15	Crimped Long (CL)	3	54
17	M 16	Crimped Long (CL)	4	50
18	M 17	Straight Small (SS)	1	70
19	M 18	Straight Small (SS)	2	68
20	M 19	Straight Small (SS)	3	63
21	M 20	Straight Small (SS)	4	59
22	M 21	Straight Long (SL)	1	68
23	M 22	Straight Long (SL)	2	63
24	M 23	Straight Long (SL)	3	58
25	M 24	Straight Long (SL)	4	55

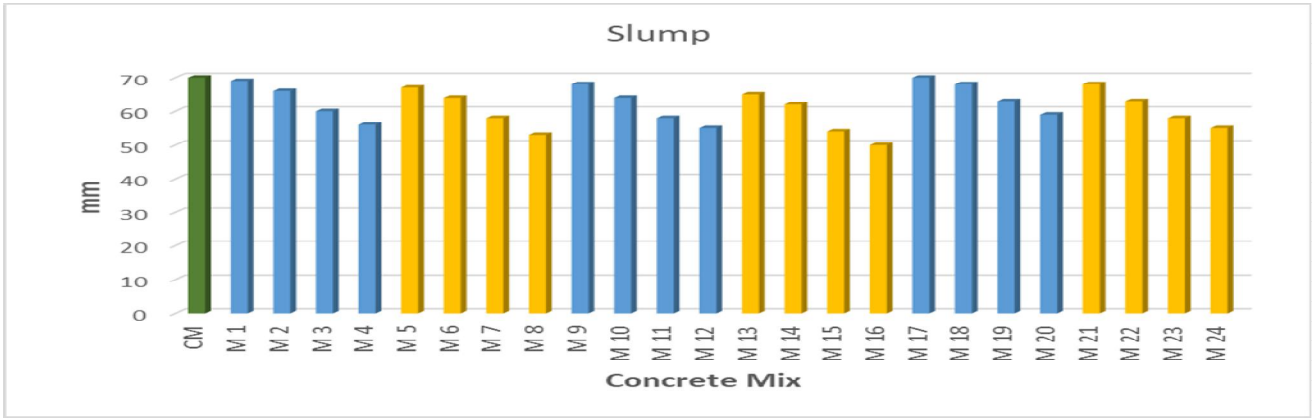

Fig. 2 Slump Test Results of Concrete Mix

B. Hardened concrete properties

Hardened properties of M20 grade of concrete are as shown in Table 6.

Table 6
Hardened Concrete Properties

Concrete Mix	Types of steel fiber	Fiber content (%)	Compressive Strength(N/mm^2)		Split Tensile Strength (N/mm^2)	Flexural Strength (N/mm^2)
			7 Days	28 Days	28 Days	28 Days
CM	Control Mix	0	18.81	28.65	2.70	3.71
M 1	Hooked Small (HS)	1	19.94	29.99	2.91	4.75
M 2	Hooked Small (HS)	2	22.46	35.69	3.11	5.17
M 3	Hooked Small (HS)	3	24.25	38.64	3.43	5.56
M 4	Hooked Small (HS)	4	23.82	39.19	3.23	5.45
M 5	Hooked Long (HL)	1	21.73	32.74	3.18	5.12
M 6	Hooked Long (HL)	2	26.50	40.22	3.61	5.97
M 7	Hooked Long (HL)	3	30.33	43.79	3.91	6.47
M 8	Hooked Long (HL)	4	29.88	43.54	3.79	6.32
M 9	Crimped Small (CS)	1	19.59	29.42	2.79	4.49
M 10	Crimped Small (CS)	2	21.70	33.60	3.00	4.88
M 11	Crimped Small (CS)	3	23.29	37.02	3.31	5.33
M 12	Crimped Small (CS)	4	23.01	37.41	3.18	5.17
M 13	Crimped Long (CL)	1	20.74	30.83	3.02	4.85
M 14	Crimped Long (CL)	2	25.75	38.74	3.33	5.37
M 15	Crimped Long (CL)	3	28.96	41.14	3.56	5.47
M 16	Crimped Long (CL)	4	28.96	40.71	3.44	5.23
M 17	Straight Small (SS)	1	19.02	28.88	2.74	4.06
M 18	Straight Small (SS)	2	21.24	32.88	2.92	4.70
M 19	Straight Small (SS)	3	22.74	35.83	3.10	5.16
M 20	Straight Small (SS)	4	22.40	36.28	3.04	5.08
M 21	Straight Long (SL)	1	19.82	29.24	2.92	4.58
M 22	Straight Long (SL)	2	24.28	37.42	3.09	4.96
M 23	Straight Long (SL)	3	26.66	39.03	3.24	5.25
M 24	Straight Long (SL)	4	26.35	38.51	3.15	5.12

1) *Compressive Strength Test:* It has been seen that compressive strength of the concrete increase 52.84% compare to conventional concrete for 3% of Hooked steel fiber, compressive strength of the concrete increase 43.59% compare to conventional concrete for 3% of long Crimped steel fiber and compressive strength of the concrete increase 36.23% compare to conventional concrete for 3% of long Straight steel fiber.

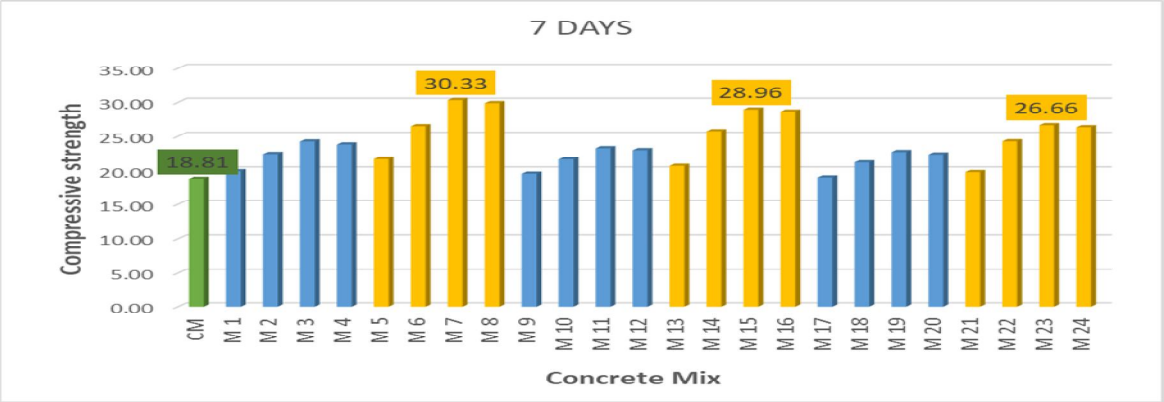

Fig. 3 Compressive Strength Test Results of Concrete Mix at 7 Days

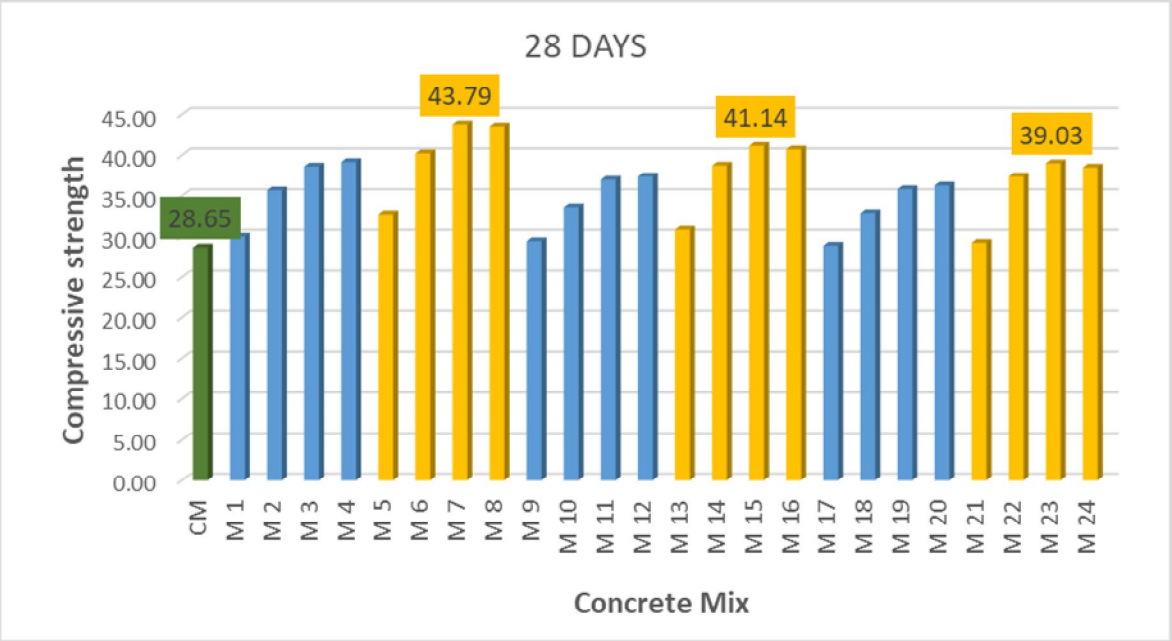

Fig. 4 Compressive Strength Test Results of Concrete Mix at 28 Days

2) *Split Tensile Strength Test:* It has been seen that split tensile strength of the concrete increase 44.81% compare to conventional concrete for 3% of Hooked steel fiber, split tensile strength of the concrete increase 31.85% compare to conventional concrete for 3% of long Crimped steel fiber and split tensile strength of the concrete increase 20.00% compare to conventional concrete for 3% of long Straight steel fiber.

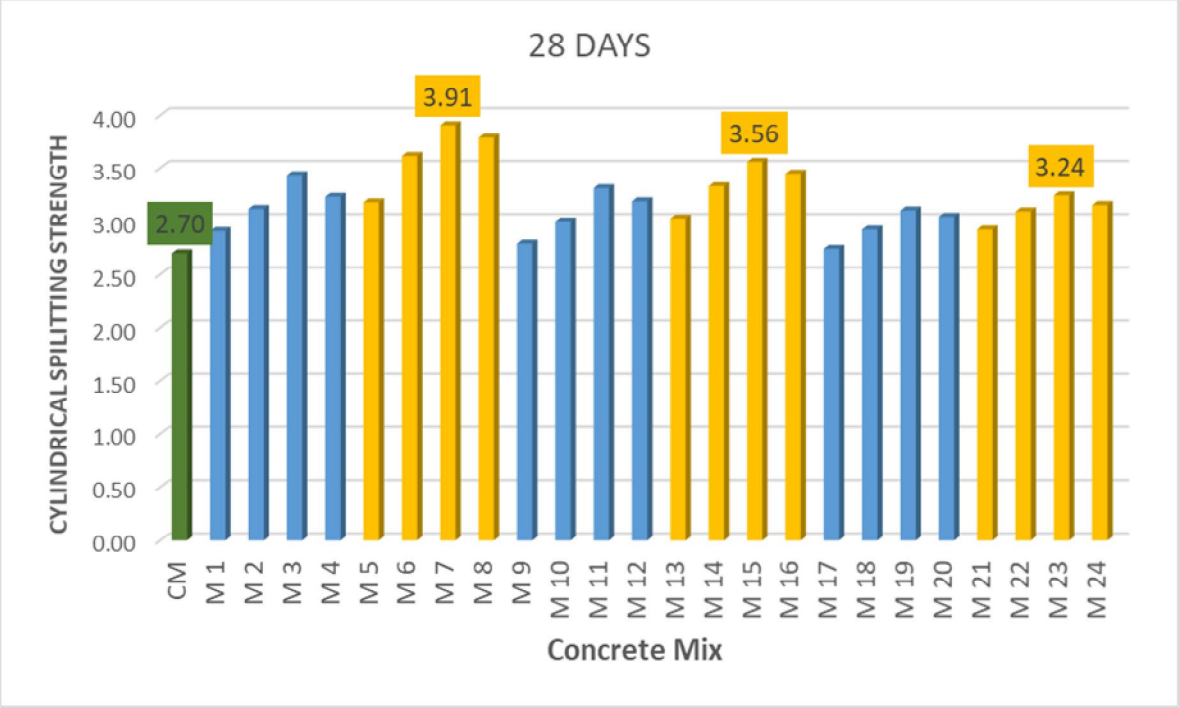

Fig. 5 Split Tensile Strength Test Results of Concrete Mix at 28 Days

3) *Flexural Strength Test:* It has been seen that flexural strength of the concrete increase 74.46% compare to conventional concrete for 3% of Hooked steel fiber, flexural strength of the concrete increase 47.48% compare to conventional concrete for 3% of long Crimped steel fiber and flexural strength of the concrete increase 38.00% compare to conventional concrete for 3% of long Straight steel fiber.

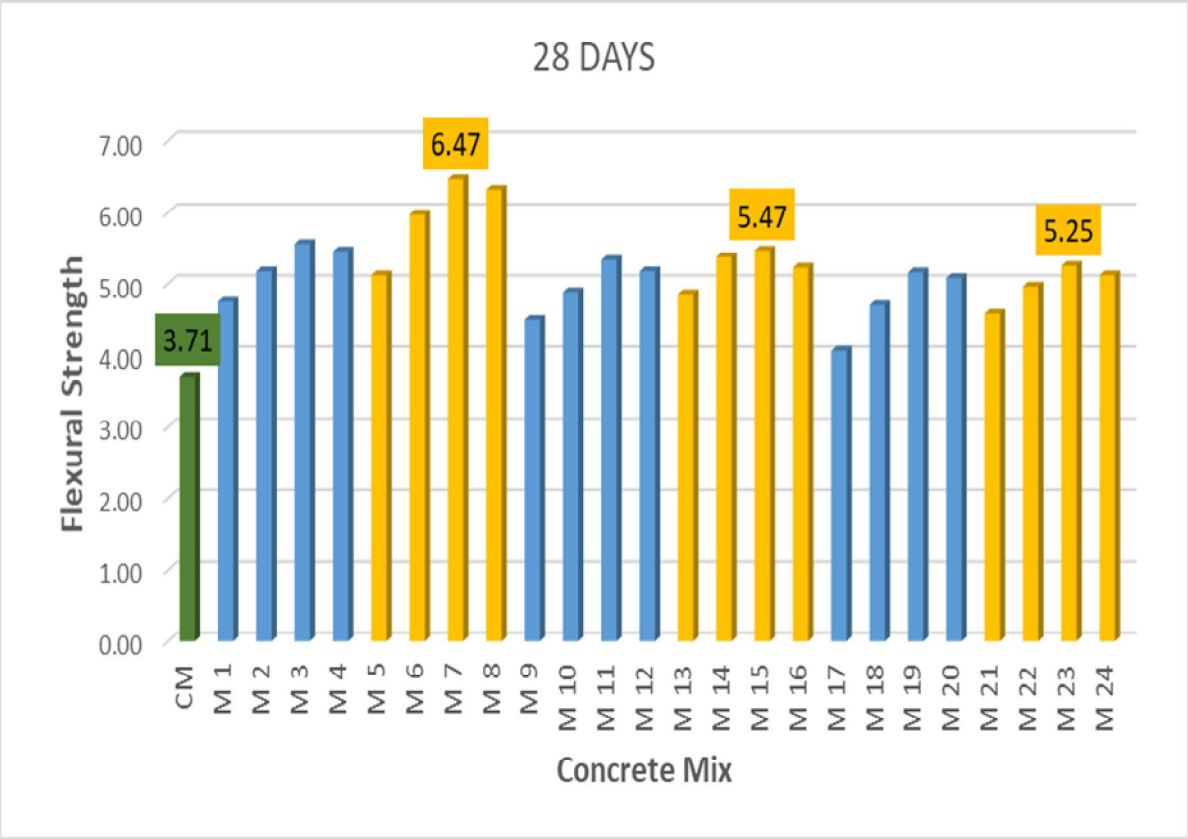

Fig. 6 Flexural Tensile Strength Test Results of Concrete Mix at 28 Days

VI. CONCLUSIONS

Based on the results obtained from study, the following conclusions can be drawn:

A. From results, it can be concluded that compressive strength of the concrete increase 52.84% compare to conventional concrete, split tensile strength increase 44.81%compare to conventional concrete and flexural strength of concrete increase 74.46% compare to conventional concrete for 3% of long hooked steel fiber.

B. From results, it can be concluded that compressive strength of the concrete increase 43.59% compare to conventional concrete, split tensile strength increase 31.85% compare to conventional concrete and flexural strength of concrete increase 47.48% compare to conventional concrete for 3% of long crimped steel fiber.

C. From results, it can be concluded that compressive strength of the concrete increase 36.23% compare to conventional concrete, split tensile strength increase 20.00%compare to conventional concrete and flexural strength of concrete increase 38.00% compare to conventional concrete for 3% of long straight steel fiber.

D. It has been seen that best results of long hooked steel fiber in mix of concrete,it improve the properties of concrete mainly in tension area,in which concrete is weak.

E. Workability decrease with increase in fiber content.

VII. ACKNOWLEDGMENT

This project consumed huge amount of work, research and direction,still implementation would not have possible if I did not have support of many people.Therefor I would like to extent my sincere gratitude to all of them. I would like to extent my sincere gratitude to my thesis guide prof. krunal j. dhandha,civil engineering department,DIET-Rajkot,for his guidence,inspiration,and moral support through the course of this research. I consider myself as very foutunate to get this opportunity to work under this guidence.

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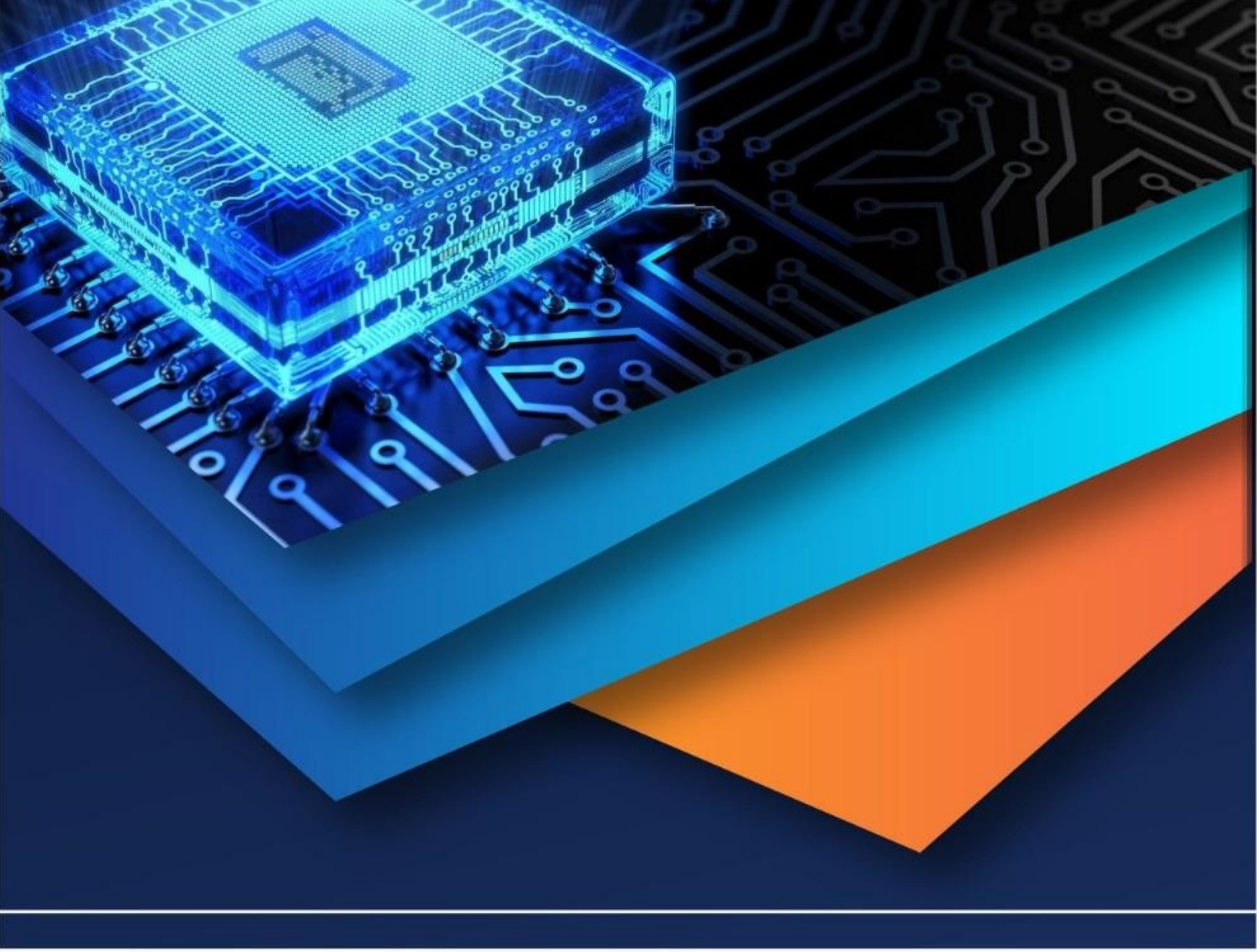

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