iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 **Issue:** II **Month of publication:** February 2023

DOI: https://doi.org/10.22214/ijraset.2023.48984

Strength Characteristics of Hybrid Fiber Reinforced Concrete Produced with Different Aspect Ratios

Dr. Rudraswamy M. P[1], Dr. B. R Patagundi[2]
[1]*Assistant Professor, SJB Institute of Technology Bengaluru, Karnataka*
[2]*Principal, S.G. Balekundri Institute of Technology, Belagavi, Karnataka*

Abstract: Nowadays, fibre reinforced concrete is more popular due to its improved ductility properties. It can be transformed into a useful construction material in areas where earthquake pressures are likely to cause harm. The ability of the materials to absorb energy in these situations is crucial.
The addition of various fibres, such as carbon, steel, polypropylene, or any other type of fibre, will increase the concrete's ability to absorb energy.
There isn't enough research on the effects of using hybrid fibres with various aspect ratios to concrete. This experimental study sheds some information on how hybrid fibre reinforced concrete behaves when fibres of different aspect ratio are used.
Strength characteristics like compressive strength, tensile strength, flexural strength, shear strength, and impact strength are determined for concrete produced by using fibers of different aspect ratios.
Keywords: hybrid fiber reinforced concrete, aspect ratio, compressive strength, tensile strength, flexural strength, shear strength, impact strength.

I. INTRODUCTION

To enhance the tensile strength of concrete, fibres may be introduced into the concrete either in orderly form or in random. This type of concrete is called fiber reinforced concrete.
Different fibres such as steel, carbon, polypropylene, basalt, HDPE, etc., have been successfully used in the production of fibre reinforced concrete and even have seen many applications in civil engineering field.
To overcome, the limitations of fibre reinforced concrete, concept of hybrid fibre reinforced concrete is becoming more and more popular. In hybrid fibre reinforced concrete, two different fibres(example steel and polypropylene fibres) are combined. Among the two fibres, usually one fibre will have higher modulus of elasticity and the other have low modulus of elasticity. These high modulus and low modulus fibres when combined can act synergistically and arrests the cracks more efficiently as compared to mono fibre reinforced concrete. Similarly, hybrid fibre reinforced concrete can also be produced by using fibres of different aspect ratios. In this case also, the fibres with different aspect ratio can act synergistically and resist the cracks more tactfully.
Hybrid fibre reinforced concrete has also seen many applications in the field of civil engineering. Therefore, hybrid fibre reinforced concrete is attracting more and more researchers for further enhanced applications in the field of civil engineering.

II. OBJECTIVE

The primary goal of this research work is to study the behaviour of hybrid fibre reinforced concrete made with fibres of various aspect ratios. Steel, GI, HDPE, waste plastic, and polypropylene fibres with various aspect ratios are used in this study. The study is mainly focused on compressive strength, tensile strength, flexural strength, shear strength and impact strength.

III. MATERIALS USED

A. Cement

Bharathi cement, a regular Portland cement (43 grade) that complies with a IS: 8112 - 1989 criteria, is used in the experimentation.
In table 1, the properties of Ordinary Portland Cement (OPC) 43 grade are listed.

Table 1: Properties of cement used

Material property	Results
Specific gravity	3.15
Fineness	4%
Normal consistency	30%
Initial setting time	30 minutes
Final setting time	5 hours 45 minutes

B. Fine Aggregates

Local sand conforming to IS 383-1970, with Zone-II has been used here. Table 2 displays the fine aggregates' physical characteristics.

Table 2 Physical properties of fine aggregate (as per IS: 383-1970)

Material property	Results
Specific gravity	2.58
Water absorption	1%
Density	1752 kg/m^3
Zone	II

C. Coarse Aggregates

Locally available crushed coarse aggregate are used. Coarse aggregates conform to IS: 383-1970 and 2386-1963 (I, II, and III) requirements. The physical properties are listed in Table 3.

Table 3 Physical properties of coarse aggregate

Material property	Results
Specific gravity	2.61
Water absorption	0.6 %
Density	1782 kg/m3

D. Steel Fibres (SF)

The steel fibres used are 40 mm length, 1mm in thickness, with an aspect ratio of 40. Another steel fiber of length 100 mm, 1mm thick, with 100 aspect ratio are also employed. Steel fibres are added 1% by volume fraction. Steel fibre has a maximum tensile strength of 395 N/mm^2 and a density 7850 kg/m$^{3.}$

E. Galvanized Iron Fibers (GIF)
Galvanized iron wires are collected from nearby shop and cut into pieces with lengths of 40 and 100 mm. The diameter of GI fibre is found to be 1mm. The aspect ratio of GI fibres is 40 and 100. GI fibre has an ultimate strength of 395 N/mm^2 and a density of 7850 kg/m^3.

F. High Density Polyethylene Fibers (HDPEF)
High density polyethylene fibres are obtained by cutting oil cans found at petrol pumps. These cans are cut into fibre form measuring 40 mm and 100 mm in length and 1 mm in width. The thickness is found as 1 mm as a result, the aspect ratio is 40 and 100. HDPE fibres have a density of 900 kg/m^3.

G. Waste Plastic Fiber (WPF)
Waste plastic fibres, are obtained by cutting the used plastic buckets. Plastic fibres had lengths 40 and 100 mm. Thickness of fibres is found as 1 mm. Thus, aspect ratio of fibres was 40 and 100.

H. Poly Propylene Fiber (PPF)
They are commercially available fibres. 6 mm and 12 mm length, PPF fibres are used in the experiment. PPF fibres have a bulk density of 930 kg/m^3.

IV. MIX DESIGN FOR M 30 GRADE OF CONCRETE
The mix design for M30 concrete has yielded the following quantities.

Cement = 413.33 kg/m^3
Water = 186.00 kg/m^3
Fine aggregate = 652.00 kg/m^3
Coarse aggregate = 1123.0 kg/m^3
W/C = 0.45

Therefore, actual quantities of different constituents required as per the mix proportion per bag of cement are as follows:

Table 4: Mix proportion for M 30 grade concrete

Grade of concrete	Cement	Fine aggregate	Coarse aggregate	W/C
M 30	1.00	1.58	2.71	0.45

V. PROCEDURE
The concrete mix used was 1:1.58:2.71, with a water-cement ratio of 0.45 which corresponding to M30 grade concrete. For compressive strength, specimens of size 150 mm×150mm×150 mm were cast, and all specimens were validated in accordance with IS 516:1959.

The cylindrical specimens used for tensile strength were 300 mm in length and 150 m diameter. Split tensile strength test was conducted on prepared specimens using Indian Standard 5816:1999. Similarly, beam specimens of size 100mm x 100mm x 500mm were employed for flexural strength testing. Impact strength test specimens were 150mm in diameter and 60mm in height, while shear strength test specimens were of L-shaped.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue II Feb 2023- Available at www.ijraset.com

VI. TEST RESULTS

A. Compressive Strength Test Results

Table 5 gives the compressive strength test results of concrete for different fibres and hybrid fibres. The variation of compressive strength is represented in fig.1.

Table 5: Results of compressive strength

Concrete produced with different fibres	Specimen identification	Aspect ratio	Average compressive strength (MPa)
SF	A	40	41.19
	B	100	38.22
	C	40+100	39.56
GI	D	40	40.15
	E	100	37.93
	F	40+100	38.67
HDPE	G	40	36.89
	H	100	35.56
	I	40+100	36
WPF	J	40	34.96
	K	100	33.63
	L	40+100	34.07
PPF	M	300	33.04
	N	600	31.85
	O	300+600	32.3

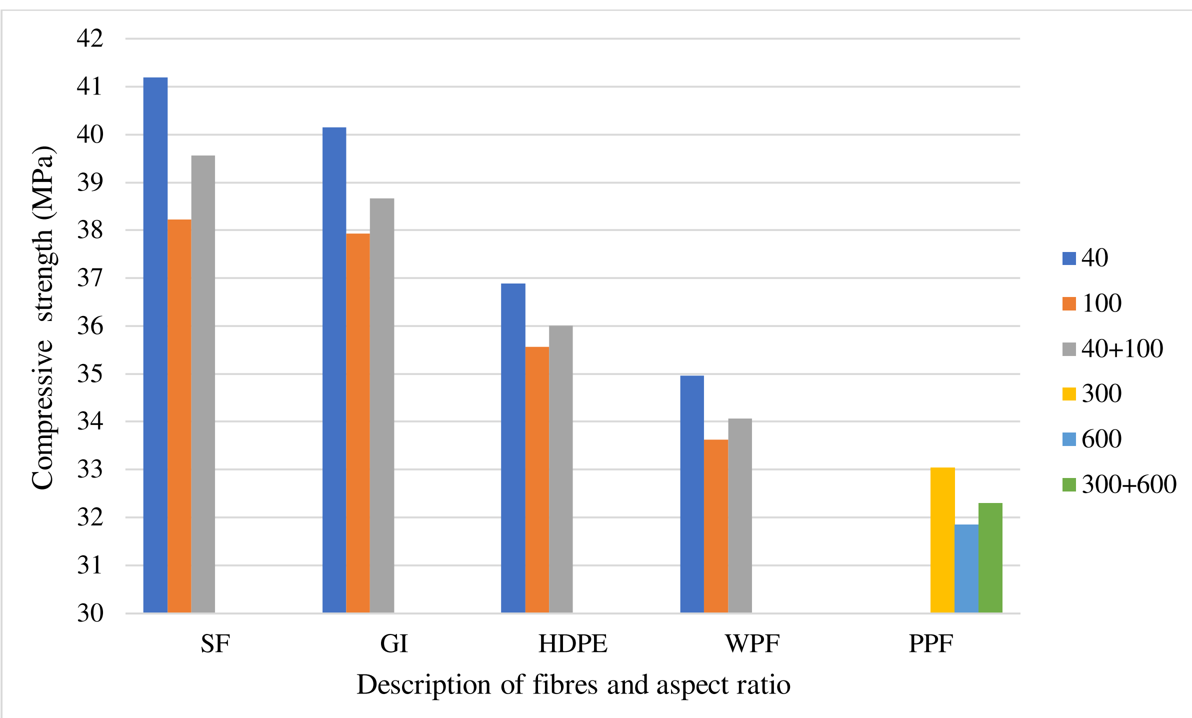


Figure 1: Variation of compressive strength

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue II Feb 2023- Available at www.ijraset.com

B. Tensile Strength Test Results

Table 6 gives the tensile strength test results of concrete for different fibres and hybrid fibres. The variation of tensile strength is represented in fig.2.

Table 6: Results of tensile strength

Concrete produced with different fibres	Specimen identification	Aspect ratio	Tensile strength (MPa)
SF	A	40	4.29
	B	100	4.1
	C	40+100	4.2
GI	D	40	4.01
	E	100	3.87
	F	40+100	3.96
HDPE	G	40	3.82
	H	100	3.63
	I	40+100	3.77
WPF	J	40	3.58
	K	100	3.49
	L	40+100	3.54
PPF	M	300	3.3
	N	600	3.16
	O	300+600	3.25

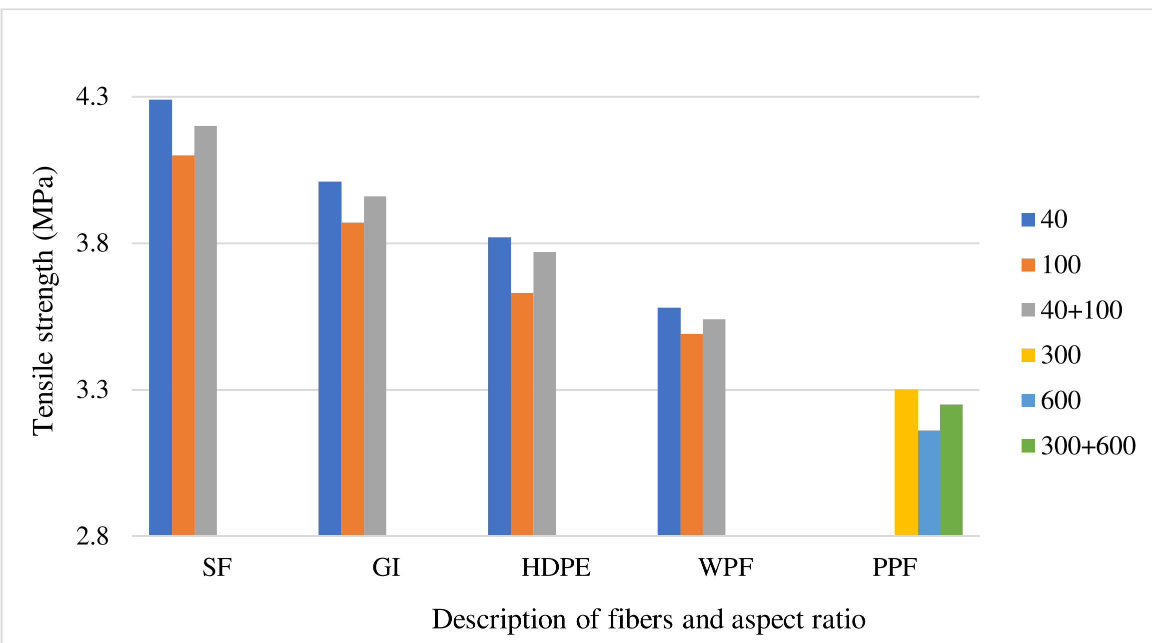


Figure 2 Variation of tensile strength

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue II Feb 2023- Available at www.ijraset.com

C. Flexural Strength Test Results

Table 7 gives the flexural strength test results of concrete for different fibres and hybrid fibres. The variation of flexural strength is represented in fig.3.

Table 7: Results of flexural strength

Concrete produced with different fibres	Specimen identification	Aspect ratio	Flexural strength (MPa)
SF	A	40	11.27
	B	100	10.58
	C	40+100	10.79
GI	D	40	10.65
	E	100	10.16
	F	40+100	10.23
HDPE	G	40	9.2
	H	100	8.78
	I	40+100	8.99
WPF	J	40	8.5
	K	100	8.02
	L	40+100	8.3
PPF	M	300	8.16
	N	600	7.67
	O	300+600	8.02

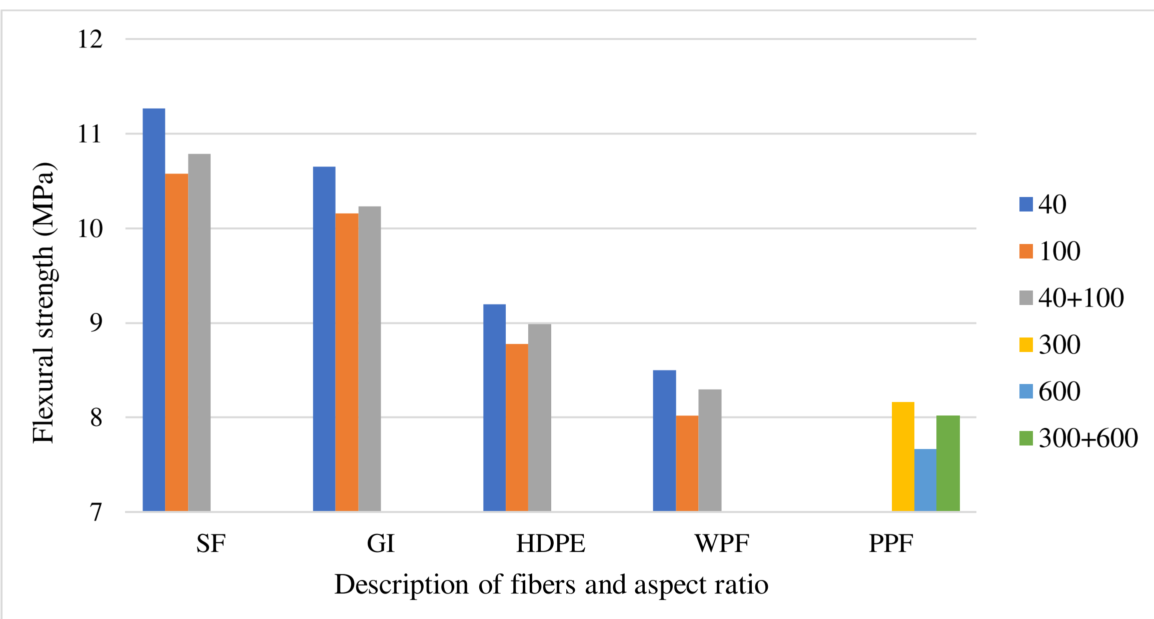


Figure 3: Variation of flexural strength

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue II Feb 2023- Available at www.ijraset.com

D. Shear Strength Test Results

Table 8 gives the shear strength test results of concrete for different fibres and hybrid fibres. The variation of shear strength is represented in fig.4.

Table 8: Results of shear strength

Concrete produced with different fibres	Specimen identification	Aspect ratio	Shear strength (MPa)
SF	A	40	7.96
	B	100	7.22
	C	40+100	7.59
GI	D	40	7.78
	E	100	7.04
	F	40+100	7.41
HDPE	G	40	6.85
	H	100	5.93
	I	40+100	6.3
WPF	J	40	5.93
	K	100	5.56
	L	40+100	5.74
PPF	M	300	5.19
	N	600	4.81
	O	300+600	5

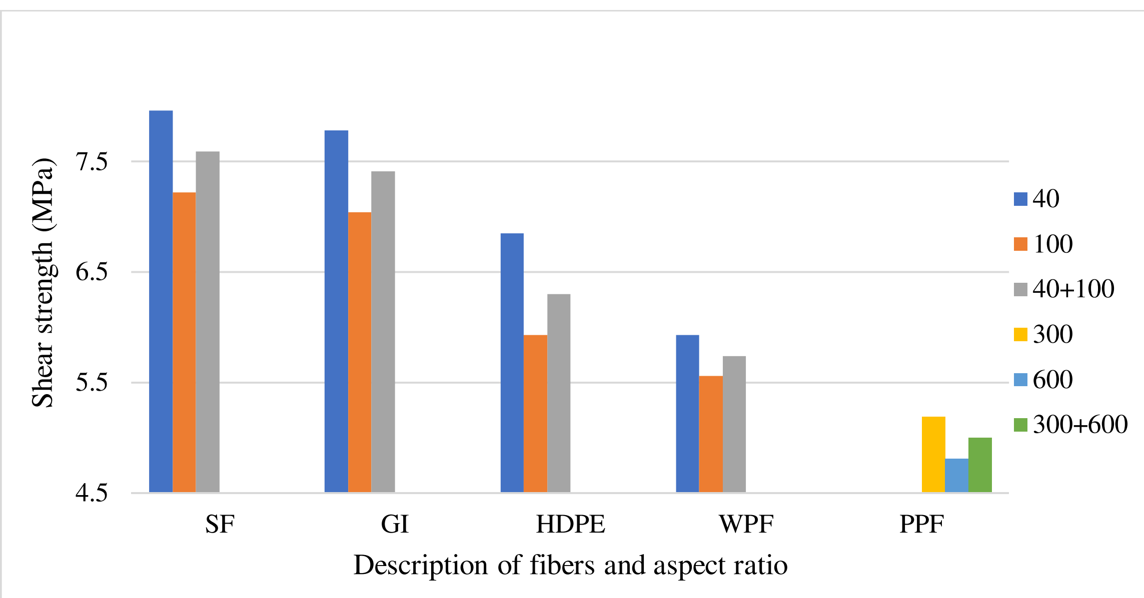


Fig 4: Variation of shear strength

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue II Feb 2023- Available at www.ijraset.com

E. Impact Strength Test Results

Table 9 gives the impact strength test results of concrete for different fibres and hybrid fibres. The variation of impact strength is represented in fig.5.

Table 9: Results of impact strength

Concrete produced with different fibres	Specimen identification	Aspect ratio	Impact strength (N-m)
SF	A	40	6992.1
	B	100	5401.74
	C	40+100	6183.21
GI	D	40	5634.81
	E	100	4915.04
	F	40+100	5127.54
HDPE	G	40	4160.99
	H	100	3571.46
	I	40+100	4085.58
WPF	J	40	3790.82
	K	100	3358.95
	L	40+100	3509.76
PPF	M	300	3091.61
	N	600	2378.685
	O	300+600	2851.68

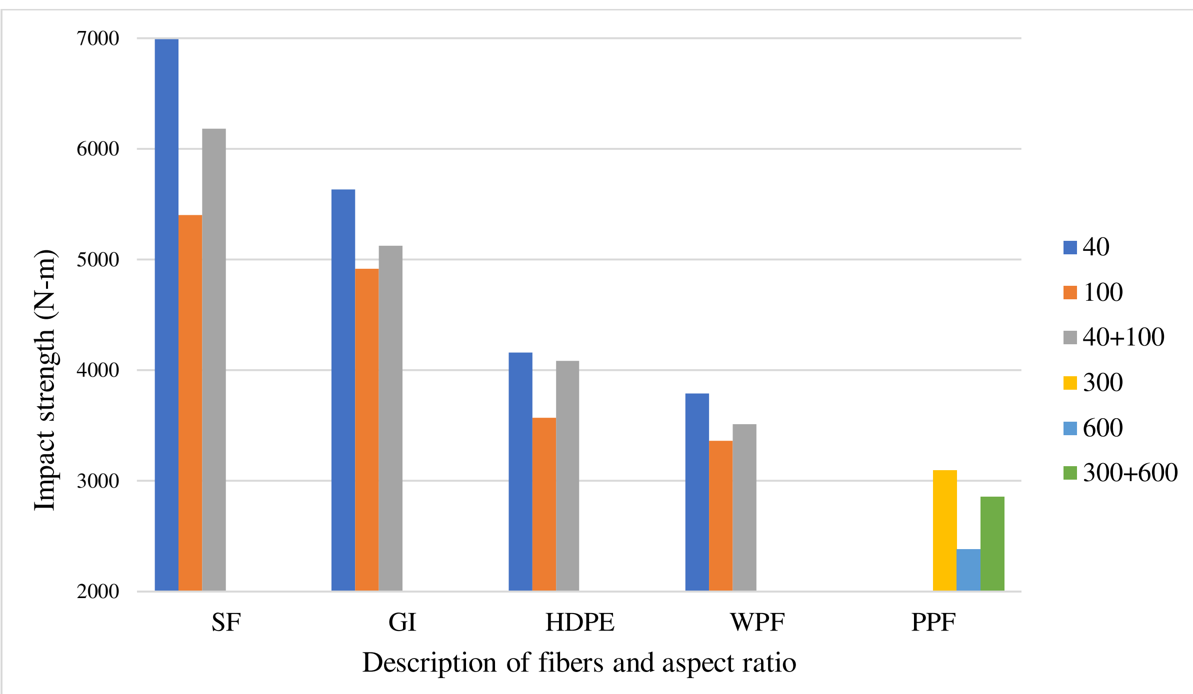


Figure 5 Variation of impact strength

VII. OBSERVATION AND DISCUSSIONS

Following observations are made based on the experimental results.

1) The compressive strength of fibre reinforced concrete containing steel fibres is found to be 41.19 MPa and 38.22MPa for an aspect ratio of 40 and 100 respectively. Thus, it is observed that compressive strength decreases as aspect ratio increases. A similar trend is observed for concrete produced with other fibres such as GI, HDPE, WPF, PPF. This is due to the fact that, higher aspect ratio fibres always exhibit slender character and unable to transmit the load to concrete matrix. For, every fibre there is an optimum aspect ratio which have to be found by experimentation. This optimum aspect ratio is capable of transmitting the loads effectively.
2) Also, it is observed that the compressive strength of hybrid fibre reinforced concrete containing steel fibres with different aspect ratio (40+100) is more (39.56 MPa) as compared to the compressive strength of fibre reinforced concrete containing steel fibres with an aspect ratio of 100 (38.22 MPa). A similar trend is observed for hybrid fibre reinforced concrete with GI, HDPE, WPF and PPF. This is due to the fact that hybrid fibres with different aspect ratio, when added in concrete, show synergistic effect, in which different aspect ratio fibres bridge the cracks at different load levels.
3) It is also observed that the steel fibre reinforced concrete and steel hybrid fibre reinforced concrete exhibit higher compressive strength as compared to that of fibres, GI, HDPE, WPF and PPF. The least value is observed for concrete with PPF fibres. The descending order of fibres w.r.t compressive strength may be written as SF, GI, HDPE, WPF and PPF.
4) The tensile strength of fibre reinforced concrete containing steel fibres is found to be 4.29 MPa and 4.10 MPa for an aspect ratio of 40 and 100 respectively. Thus, it is observed that tensile strength decreases as aspect ratio increases. A similar trend is observed for concrete produced with other fibres such as GI, HDPE, WPF, PPF. This is due to the fact that, higher aspect ratio fibres always exhibit slender character and unable to transmit the load to concrete matrix. For, every fibre there is an optimum aspect ratio which have to be found by experimentation. This optimum aspect ratio is capable of transmitting the loads effectively.
5) Also, it is observed that the tensile strength of hybrid fibre reinforced concrete containing steel fibres with different aspect ratio (40+100) is more (4.20 MPa) as compared to the tensile strength of fibre reinforced concrete containing steel fibres with an aspect ratio of 100 (4.10 MPa). A similar trend is observed for hybrid fibre reinforced concrete with GI, HDPE, WPF and PPF. This is due to the fact that hybrid fibres with different aspect ratio, when added in concrete, show synergistic effect, in which different aspect ratio fibres bridge the cracks at different load levels.
6) It is also observed that the steel fibre reinforced concrete and steel hybrid fibre reinforced concrete exhibit higher tensile strength as compared to that of fibres, GI, HDPE, WPF and PPF. The least value is observed for concrete with PPF fibres. The descending order of fibres w.r.t tensile strength may be written as SF, GI, HDPE, WPF and PPF.
7) The flexural strength of fibre reinforced concrete containing steel fibres is found to be 11.27 MPa and 10.58 MPa for an aspect ratio of 40 and 100 respectively. Thus, it is observed that flexural strength decreases as aspect ratio increases. A similar trend is observed for concrete produced with other fibres such as GI, HDPE, WPF, PPF. This is due to the fact that, higher aspect ratio fibres always exhibit slender character and unable to transmit the load to concrete matrix. For, every fibre there is an optimum aspect ratio which have to be found by experimentation. This optimum aspect ratio is capable of transmitting the loads effectively.
8) Also, it is observed that the flexural strength of hybrid fibre reinforced concrete containing steel fibres with different aspect ratio (40+100) is more (10.79 MPa) as compared to the flexural strength of fibre reinforced concrete containing steel fibres with an aspect ratio of 100 (10.58 MPa). A similar trend is observed for hybrid fibre reinforced concrete with GI, HDPE, WPF and PPF. This is due to the fact that hybrid fibres with different aspect ratio, when added in concrete, show synergistic effect, in which different aspect ratio fibres bridge the cracks at different load levels.
9) It is also observed that the steel fibre reinforced concrete and steel hybrid fibre reinforced concrete exhibit higher flexural strength as compared to that of fibres, GI, HDPE, WPF and PPF. The least value is observed for concrete with PPF fibres. The descending order of fibres w.r.t flexural strength may be written as SF, GI, HDPE, WPF and PPF.
10) The shear strength of fibre reinforced concrete containing steel fibres is found to be 7.96 MPa and 7.22 MPa for an aspect ratio of 40 and 100 respectively. Thus, it is observed that shear strength decreases as aspect ratio increases. A similar trend is observed for concrete produced with other fibres such as GI, HDPE, WPF, PPF. This is due to the fact that, higher aspect ratio fibres always exhibit slender character and unable to transmit the load to concrete matrix. For, every fibre there is an optimum aspect ratio which have to be found by experimentation. This optimum aspect ratio is capable of transmitting the loads effectively.

11) Also, it is observed that the shear strength of hybrid fibre reinforced concrete containing steel fibres with different aspect ratio (40+100) is more (7.59 MPa) as compared to the shear strength of fibre reinforced concrete containing steel fibres with an aspect ratio of 100 (7.22 MPa). A similar trend is observed for hybrid fibre reinforced concrete with GI, HDPE, WPF and PPF. This is due to the fact that hybrid fibres with different aspect ratio, when added in concrete, show synergistic effect, in which different aspect ratio fibres bridge the cracks at different load levels.
12) It is also observed that the steel fibre reinforced concrete and steel hybrid fibre reinforced concrete exhibit higher shear strength as compared to that of fibres, GI, HDPE, WPF and PPF. The least value is observed for concrete with PPF fibres. The descending order of fibres w.r.t shear strength may be written as SF, GI, HDPE, WPF and PPF.
13) The impact strength of fibre reinforced concrete containing steel fibres is found to be 6992.1 N-m and 5401.2 N-m for an aspect ratio of 40 and 100 respectively. Thus, it is observed that impact strength decreases as aspect ratio increases. A similar trend is observed for concrete produced with other fibres such as GI, HDPE, WPF, PPF. This is due to the fact that, higher aspect ratio fibres always exhibit slender character and unable to transmit the load to concrete matrix. For, every fibre there is an optimum aspect ratio which have to be found by experimentation. This optimum aspect ratio is capable of transmitting the loads effectively.
14) Also, it is observed that the impact strength of hybrid fibre reinforced concrete containing steel fibres with different aspect ratio (40+100) is more (6183.21 N-m) as compared to the impact strength of fibre reinforced concrete containing steel fibres with an aspect ratio of 100 (5401.2 N-m). A similar trend is observed for hybrid fibre reinforced concrete with GI, HDPE, WPF and PPF. This is due to the fact that hybrid fibres with different aspect ratio, when added in concrete, show synergistic effect, in which different aspect ratio fibres bridge the cracks at different load levels.
15) It is also observed that the steel fibre reinforced concrete and steel hybrid fibre reinforced concrete exhibit higher impact strength as compared to that of fibres, GI, HDPE, WPF and PPF. The least value is observed for concrete with PPF fibres. The descending order of fibres w.r.t impact strength may be written as SF, GI, HDPE, WPF and PPF.

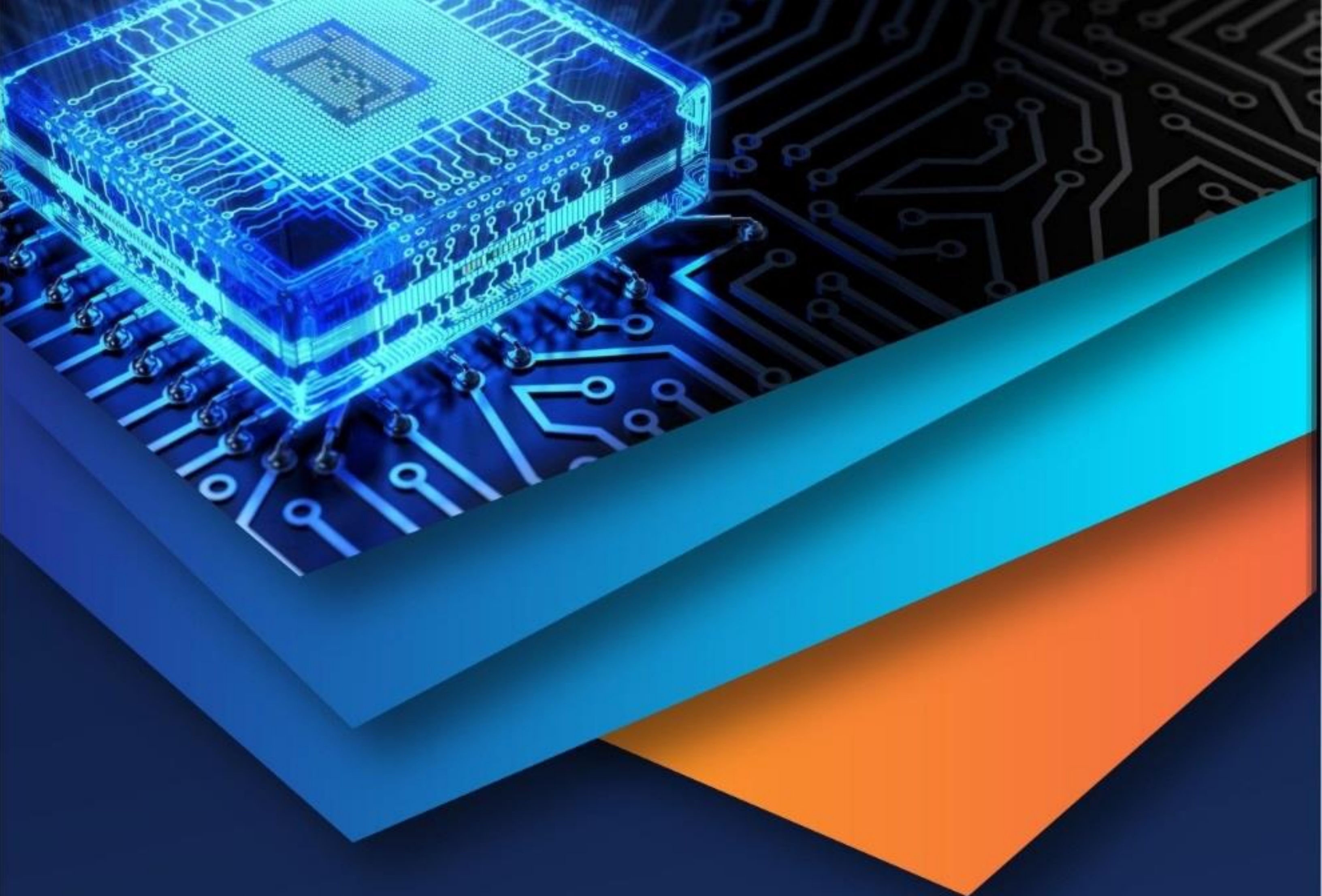
VIII. CONCLUSIONS

Following conclusions may be drawn based on the study.

1) The strength characteristics of fibre reinforced concrete such as compressive strength, tensile strength, flexural strength, shear strength and impact strength decrease as the aspect ratio of fibre increase. For any fibre there exists an optimum aspect ratio which have to be found from the experimentation.
2) The strength characteristics of hybrid fibre reinforced concrete such as compressive strength, tensile strength, flexural strength, shear strength and impact strength containing fibres with different aspect ratio (40+100) are higher as compared to that of fibre reinforced concrete with an aspect ratio 100, which proves the synergistic effect of hybrid fibres.
3) The strength characteristics of steel fibre reinforced concrete and steel hybrid fibre reinforced concrete are higher as compared to that of fibres GI, HDPE, WPF and PPF. The least value is observed for concrete with PPF fibres. The descending order of fibres w.r.t strength characteristics may be written as SF, GI, HDPE, WPF and PPF.

REFERENCES

[1] Shikha Shrivastava, Vijay Kumar Shrivastava “Behavior of concrete using the hybrid fiber with and without fly ash” (2018). IJIRST –International Journal for Innovative Research in Science & Technology, Volume 4, Issue 9, February 2018, ISSN: 2349-6010, PP: 4-6.
[2] Kannan Rajkumar P.R, Krishnaraj L, Shyam Sundar C “Characteristic studies on high performance hybrid fibre reinforced concrete” International Journal of Pure and Applied Mathematics Volume 118 No. 20 2018, ISSN: 1311-8080 PP: 2147-2153 (2018).
[3] Rajaram M, Ravichandran A and Muthadhi A “Studies on hybrid fiber concrete with GGBS” (2018). International Journal of Pure and Applied Mathematics, Volume 119, ISSN: 1314-3395 PP-581-595.
[4] Kulkarni S K, Kekade G.A, Halkude S A “Experimental study on hybrid fiber reinforced concrete deep beams” (2017). SSRG International Journal of Civil Engineering (SSRG-IJCE) – volume 4 Issue 2 – February 2017, ISSN: 2348 – 8352, PP-34-40.
[5] Shahzaeb Azam Chowdhary and Kshipra Kapoor “A review on durability and mechanical properties of steel, poly propylene and hybrid fibre reinforced concrete” (2017). International Research Journal of Engineering and Technology (IRJET) ISSN: 2395-0056 Volume: 04 Issue: 10 | Oct -2017 PP-87-90.
[6] Mounika K and Suchith Reddy A “Performance of supplementary cementitious material-based hybrid fibre reinforced concrete” (2017). International Journal of Innovative Research in Science, Engineering and Technology, Vol. 6, Issue 6, June 2017, ISSN(Online): 2319-8753, pp-10517-10525.
[7] Pravin R. Dalvi and Rathi V R ” Workability of hybrid fiber reinforced self-compacting concrete” (2017). International Journal of Innovations in Engineering Sciences and Technology: Civil , volume. 3, issue. 2 ISSN: 2455-2933, PP 1-9.



doi crossref
10.22214/IJRASET

INDEX COPERNICUS
45.98

ISRA JIF
IMPACT FACTOR:
7.129

SJIFactor
TOGETHER WE REACH THE GOAL
IMPACT FACTOR:
7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY