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Analysis of Flexural Strength for Steel, Glass and Polypropylene Fiber Reinforced Concrete

Chapala. Venkata Ramana
P.G. Student, Structural Engineering
University college of Engineering, JNTU, Kakinada
Email ID : venkataramana.chapala@gmail.com

CH.Naga Sindhura
P.G. Student, Structural Engineering
University college of Engineering, JNTU, Kakinada
Email ID : nagasindhura.ch@gmail.com

Abstract **-This analysis study is done by using different types of fibres such as steel, glass and polypropylene with aspect ratio varying from 20 to 120 for steel, 600 to 860 for glass and 30 to 100 for polypropylene fibres.The total fibre percentages of 0 to 2% for steel, 0 to 2% for glass and 0 to 2.5% for polypropylene with variation of 0.25%.The design mix varying from M20 to M60 with water cement ratio 0.3 to 0.55 for steel, 0.16 to 0.55 for glass and 0.46 for polypropylene.After being cured under the standard conditions for age of 28 days the specimens of each mixture were tested to determine the corresponding flexural strength. The parameters such as grade of concrete, aspect ratio, volume fraction and tensile strength of fibre for steel, glass and polypropylene fibres respectively, while the flexural strength of the concrete were chosen as output variable. The results obtained from the model and the experiments were compared by using regression analysis, and it was check in artificial neural networks. Finally form an empirical relation between flexural strength tograde of concrete, aspect ratio, volume fraction and tensile strength of fibre for steel, glass and polypropylene fibres.**

Keywords **- Steel fiber glass fiber, polypropylene fibe, fiber strength, flexural strength.**

I. INTRODUCTION

Experimental studies have shown that a fibre improves the mechanical properties of concrete such as flexural strength, splitting tensile strength, compressive strength. Moreover, the addition of fibres makes the concrete more homogenous, isotropic and ductile material.The concrete-reinforcing fibres include metallic and non-metallic fibres like steel, glass and polypropylene and various other types. With time and stress the cracks are developed exposing internal microstructure to moisture and to various other harmful effects leading to deteriorating of concrete and corrosion of reinforcement. Fibers should be significantly stiffer than matrix, i.e. have higher modulus of elasticity than matrix. Concrete is quite brittle; it has very good compressive strength but comparatively little tensile strength, which makes it likely to crack under many conditions. Cracking leads to further damage. Fibrereinforced concrete is less likely is less likely to crack than standard concrete. Fibre reinforced concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinues, discrete, uniformly dispersed suitable fibers.

Experimental Investigation From Collected Data

The details of materials used in the present analysis is as follows

A.Cement

OPC of 53 grade having different specific gravities.

B. Coarse aggregate

In this analysis the data have been collected regarding to mechanical crushed well graded aggregate of nominal size varying from 12.5mm to 20mm from local source are used specifies from IS codes.

C. Fine aggregate

River sand locally available is used and specific gravity is depending on mix proportion.

D. Glass fibre

The glass fiber provides higher resistance tobroad cast and occurrence of early cracks supporting higher stresses. Addition of this fiber increases compressive strength up to 1% by volume at higher fiber percentages and strength decreases if the fiber content increases. This material is very good in making shapes on the front of any building and it is fewer dens steel.

The collected data regarding glass fibre is as fallows.

Fiber	Density (t/m^3)	E (GPa)	Tensile strength (MPa)	Density (µ)	L (mm)	No.of fibers (million/kg)
AR-Glass	2.6	73	1700	14	12	212
HD	2.6	72	1100	14	12	212
E-Glass	2.6	80	2500	14	12	212

Where E=Elastic modulus (MPa)
L=Length of fiber (mm)

E. Steel fibre

Steel fiber is the most popular type of fiber used in reinforced concrete. These fibers in a concrete matrix improve all mechanical properties of concrete, especially tensile strength, impact strength andtoughness. Steel fiber reinforced concrete (SFRC). Is also known as steel fiber added concrete (SFAC) has extensive applications such as tunnel linings, large slabs and floors with great live load, rock slope anddam constructions.

The collected data regarding steel fibre is as fallows.

Fibre	Tensile strength(MPa)	Length (mm)	Diameter (mm)
hooked end steel fibres	1100	60	0.75
crimped	1100	50	0.75
Monofilament	910	55	1
Steel fibre	1100	35	0.55

F. Polypropylene fiber

Polypropylene fiber is multifilament homopolymer from high quantitypolypropylene fibers which is used for micro reinforcement on driveways, sidewalks, airport runways, walls, box culverts, composite decks, bridges, dams, tunnels, concrete and cement pipes, wastewater treatment, marine structures, industrial flooring, corrugated concrete sheets, decorative concrete etc.

The collected data regarding polypropylene fibre is as fallows.

Fibre	Tensile strength(MPa)	Length (mm)	Diameter (mm)
Polypropylene	400	12	0.016
Triangularshaped	1700	12	0.014
polypropylene	225	25	0.1

G. Water

Locally available portable water is used.

II. Analysis of Experimental Results for Steel

Regarding to collected data from previous conducting tests, by using fallowing data apply regression analysis for empirical equation.The data useful for the regression analysis for formation of empirical equation for steel fibre reinforced concrete is as follows

Grade	AR	VF	fiber strength	W/C	Fs
30	40	0.5	345	0.48	4.1
30	40	1	345	0.48	4.3
30	40	1.5	345	0.48	4.6
30	40	2	345	0.48	4.4
35	64	0	1100	0.46	4.2
35	64	1	1100	0.46	5.6
25	60	0.5	1100	0.45	5.75
25	60	1	1100	0.45	6.25
25	60	1.5	1100	0.45	6.85
25	60	2	1100	0.45	7.1
50	80	0	910	0.4	5.61
50	80	0.5	910	0.4	6.68
50	80	1	910	0.4	7.17
50	80	1.5	910	0.4	7.46
20	55	0	1150	0.5	5.76
20	55	0.75	1150	0.5	7.96
30	66.67	0	1100	0.56	18
30	66.67	0.5	1100	0.56	18.3
30	66.67	1	1100	0.56	19.9
30	66.67	1.5	1100	0.56	16.9
30	66.67	2	1100	0.56	16.7
50	66.67	1	1100	0.4	22
50	66.67	1.5	1100	0.4	17.9
50	66.67	2	1100	0.4	17.5
55	40	1	1100	0.35	7.45
55	40	1.5	1100	0.35	8.44
55	40	2	1100	0.35	8.92
30	64.64	0	615	0.35	4.1
30	64.64	0.5	615	0.35	4.1
30	64.64	1	615	0.35	4.9
75	64	0.25	1150	0.4	7.82
75	64	0.5	1150	0.4	7.38
75	64	1	1150	0.4	7.37
75	64	1.5	1150	0.4	8.24
20	50	0	1150	0.55	8.4
20	50	0.25	1150	0.55	8.8
20	50	0.5	1150	0.55	9.16
20	50	0.75	1150	0.55	9.44
20	50	1	1150	0.55	10
30	50	0	1150	0.44	9.2
30	50	0.25	1150	0.44	7.2
30	50	0.5	1150	0.44	7.28
30	50	0.75	1150	0.44	7.4
30	50	1	1150	0.44	7.6
40	0	0	1100	0.35	7.6
40	50	1	1100	0.35	8.8
40	50	2	1100	0.35	9.47
40	50	3	1100	0.35	10.4
40	0	0	1100	0.35	7.2
40	60	1	1100	0.35	8.4
40	60	2	1100	0.35	9.2
40	60	3	1100	0.35	10
40	0	0	1100	0.35	7.6
40	75	1	1100	0.35	8.27
40	75	2	1100	0.35	9
40	75	3	1100	0.35	9.73
20	0	0	1150	0.5	4.83
20	30	0.5	1150	0.5	5.28
20	30	1	1150	0.5	5.74
20	30	1.5	1150	0.5	6.18
30	0	0	1150	0.45	4.32
30	30	0.5	1150	0.45	4.6
30	30	1	1150	0.45	4.9
30	30	1.5	1150	0.45	5.2
40	0	0	1150	0.4	4.68
40	30	0.5	1150	0.4	5.05
40	30	1	1150	0.4	5.37
40	30	1.5	1150	0.4	5.68
25	0	0	1100	0.5	4.63
25	55	0.5	1100	0.5	6.47
25	55	0.75	1100	0.5	6.9
25	55	1	1100	0.5	7.43
25	55	1.5	1100	0.5	7.97
20	0	0	1150	0.62	3.67
20	21.8	0.4	1150	0.62	5.32
20	21.8	0.8	1150	0.62	5.81
20	21.8	1.2	1150	0.62	7.43
20	100	0	1150	0.48	3.95
20	100	0.5	1150	0.48	8.03

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20	100	0.75	1150	0.48	8.59
20	100	1	1150	0.48	9.48
20	100	1.25	1150	0.48	8.93
60	54	0	1150	0.47	9.12
60	54	0.25	1150	0.47	9.88
60	54	0.5	1150	0.47	11.24
60	54	0.75	1150	0.47	12.68
60	54	1	1150	0.47	14.43
60	54	1.25	1150	0.47	14.85
60	54	1.5	1150	0.47	15.33
60	54	1.75	1150	0.47	18.42
60	54	2	1150	0.47	17.36
50	72	0	615	0.36	4.92
50	72	0.5	615	0.36	4.73
50	72	1	615	0.36	4.18
65	64	0	441	0.35	7.82
65	64	0.5	441	0.35	7.37
65	64	1	441	0.35	8.24
65	64	1.5	441	0.35	10.14
30	100	0	1150	0.4	5.29
30	100	0.5	1150	0.4	5.55
30	100	1	1150	0.4	5.86
30	100	1.25	1150	0.4	5.94
30	100	1.5	1150	0.4	6.13
30	100	1.75	1150	0.4	6.32
30	100	2	1150	0.4	6.44
30	100	2.25	1150	0.4	6.48
30	100	2.5	1150	0.4	6.68
30	100	2.75	1150	0.4	6.97
30	100	3	1150	0.4	7.14

The developed equation (eqn.i) for steel fibre reinforced concrete by usingregression analysis for the data as shown in the above table is

Y=Grade*0.08+Ar*0.006+VF*0.73+
Fiber strength*0.001+w/c*5.54……. (i)

These results are applied in artificial neural networks the developed graph between flexural strength to grade, aspect ratio, volume fraction and fiber strength(as shown in fig1) i.e.

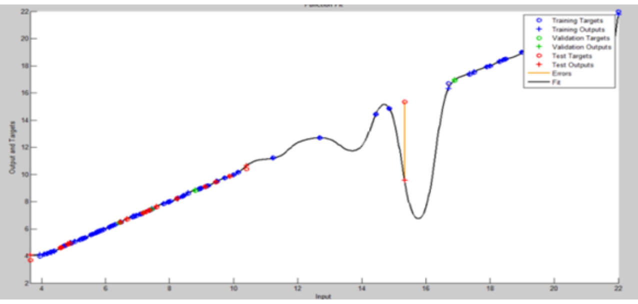

Fig.1

III. Analysis of Experimental Results Glass

Regarding to collected data from previous conducting tests, by using fallowing data apply regression analysis for empirical equation. The data useful for the regression analysis for formation of empirical equation for glass fibre reinforced concrete is as follows:

Grade	Ar	Vf	w/c	Fiber strength	Fs
20	857	0	0.5	1700	5.75
20	857	0.2	0.5	1700	6.3
20	857	0.25	0.5	1700	6.8
20	857	0.3	0.5	1700	7.1
20	857	0.5	0.5	1700	7.36
20	857	1	0.5	1700	7.62
20	857	1.5	0.5	1700	8.37
20	857	0	0.44	3550	3.84
40	857	0	0.44	3550	4.94
50	428.47	0	0.5	1700	5.84
50	428.47	0.01	0.5	1700	5.78
50	428.47	0.02	0.5	1700	5.12
50	428.47	0.03	0.5	1700	6.8
25	0	0	0.5	1700	4.63
25	857	0.5	0.5	1700	5.56
25	857	0.75	0.5	1700	5.67
25	857	1	0.5	1700	5.9
25	857	1.5	0.5	1700	6.3
20	857.1	0	0.35	2500	3.344
20	857.1	0.03	0.35	2500	3.587
20	857.1	0.06	0.35	2500	3.654
20	857.1	0.1	0.35	2500	3.99
20	857.1	0	0.55	1700	3.52
20	857.1	0.03	0.55	1700	4.08
30	857.1	0	0.5	1700	4.12
30	857.1	0.03	0.5	1700	4.78
40	857.1	0	0.4	1700	4.72
40	857.1	0.03	0.4	1700	5.52
50	857.1	0	0.36	1700	5.42
50	857.1	0.03	0.36	1700	6.23
35	857.1	0	0.51	2500	4.65
35	857.1	0.1	0.51	2500	4.5
35	857.1	0.2	0.51	2500	5
35	857.1	0.3	0.51	2500	5.2
60	857	1.5	0.16	1100	5.46
60	857	1.5	0.16	1100	5.37
60	857	1.5	0.16	1100	5.62
60	857	2	0.16	1100	5.49
60	857	2	0.16	1100	6.4
60	857	2	0.16	1100	6.56
20	857.1	0	0.5	2500	3.95
20	857.1	0.5	0.5	2500	7.82
20	857.1	0.75	0.5	2500	8.16
20	857.1	1	0.5	2500	8.95
20	857.1	1.25	0.5	2500	8.93
35	857.1	0	0.38	2500	7.15
35	857.1	0.5	0.38	2500	8.45
35	857.1	1	0.38	2500	9.75
35	857.1	1.5	0.38	2500	8.75
35	857.1	2	0.38	2500	7.35
20	857	0	0.5	2500	3.27
20	857	1	0.5	2500	3.84
40	857	0	0.5	2500	4.32
40	857	1	0.5	2500	4.94

The developed equation (eqn.ii) for glass fibre reinforced concrete by using regression analysis for the data as shown in the above table is

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Y=Grade*0.022+Ar*0.0003+VF*1.78+ W/c*7.31+Fibre strength*0.0002…… (ii)

These results are applied in artificial neural networks the developed result between flexural strength to grade,aspect ratio, volume fraction and fiber strength graph (as shown in fig2)i.e.

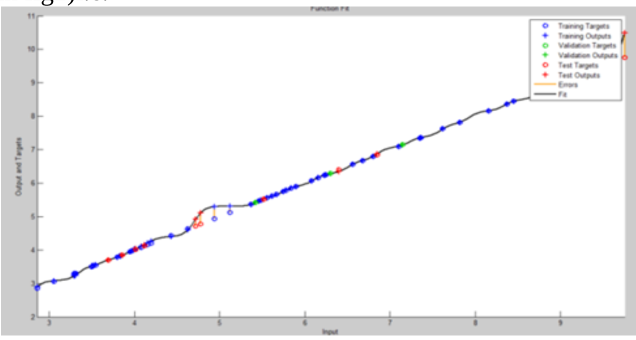


Fig.2

IV. Analysis of Experimental Results for Polypropylene

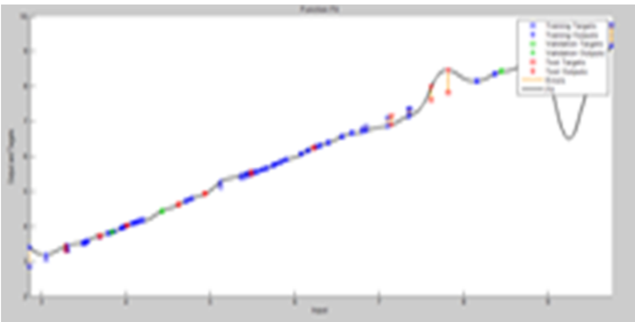
Regarding to collected data from previous conducting tests, by using fallowing data apply regression analysis for empirical equation. The data useful for the regression analysis for formation of empirical equation for polypropylene fibre reinforced concrete is as follows

Grade	AR	VF	W/C	fiber strength	Fs
20	857	0	0.5	1700	5.75
20	857	0.2	0.5	1700	6.3
20	857	0.25	0.5	1700	6.8
20	857	0.3	0.5	1700	7.1
20	857	0.5	0.5	1700	7.36
20	857	1	0.5	1700	7.62
20	857	1.5	0.5	1700	8.37
50	857	0	0.44	1700	6.08
50	857	0.01	0.44	1700	6.16
50	857	0.02	0.44	1700	6.68
50	857	0.03	0.44	1700	6.8
20	857	0	0.44	3550	3.84
40	857	0	0.44	3550	4.94
50	600	0	0.55	1700	5.84
50	600	0.01	0.55	1700	5.78
50	600	0.02	0.55	1700	5.12
50	600	0.03	0.55	1700	6.8
25	0	0	0.5	1700	4.63
25	857	0.5	0.5	1700	5.56
25	857	0.75	0.5	1700	5.67
25	857	1	0.5	1700	5.9
25	857	1.5	0.5	1700	6.3
35	857.1	0	0.51	2500	3.7
35	857.1	0	0.51	2500	3.5
35	857.1	0.1	0.51	2500	3.8
35	857.1	0.2	0.51	2500	3.95
35	857.1	0.3	0.51	2500	4.15
20	857.1	0	0.55	2500	3.312
20	857.1	0	0.55	2500	2.86
20	857.1	0	0.55	2500	3.86
20	857.1	0.03	0.55	2500	3.06
20	857.1	0.03	0.55	2500	3.696
20	857.1	0.03	0.55	2500	4.006
20	857.1	0.06	0.55	2500	3.296
20	857.1	0.06	0.55	2500	3.7
20	857.1	0.06	0.55	2500	3.968
20	857.1	0.1	0.55	2500	3.548
20	857.1	0.1	0.55	2500	4.018
20	857.1	0.1	0.55	2500	4.43
20	857.1	0	0.55	1700	3.52
20	857.1	0.03	0.55	1700	4.08
30	857.1	0	0.5	1700	4.12
30	857.1	0.03	0.5	1700	4.78
40	857.1	0	0.4	1700	4.72
40	857.1	0.03	0.4	1700	5.52
50	857.1	0	0.36	1700	5.42
50	857.1	0.03	0.36	1700	6.23
60	857	1.5	0.16	1100	5.46
60	857	1.5	0.16	1100	5.37
60	857	1.5	0.16	1100	5.62
60	857	2	0.16	1100	5.49
60	857	2	0.16	1100	6.4
60	857	2	0.16	1100	6.56
20	857.1	0	0.5	2500	3.95
20	857.1	0.5	0.5	2500	7.82
20	857.1	0.75	0.5	2500	8.16
20	857.1	1	0.5	2500	8.95
20	857.1	1.25	0.5	2500	8.93
35	857.1	0	0.38	1700	7.15
35	857.1	0.5	0.38	1700	8.45
35	857.1	1	0.38	1700	9.75
35	857.1	1.5	0.38	1700	8.75
35	857.1	2	0.38	1700	7.35
35	857.1	0	0.46	1700	4.2
35	857.1	1	0.46	1700	3.3
25	42	0.5	550	0.45	5.75
25	42	1	550	0.45	6.25
25	42	1.5	550	0.45	6.85
25	42	2	550	0.45	7.1

WhereFs=Flexural strength (MPa)
Ar=Aspect ratio
Vf=Volume fraction
W/c=water cement ratio

The developed equation (iii) for glass fibre reinforced concrete by using regression analysis for the data as shown in the above table is
Y=Grade*0.02+Ar*0.003+Vf*1.27+w/c*0.007+Fibre strength*0.0003…………… (iii)

These results are applied in artificial neural networks the result is developedbetween flexural strength to grade, aspect ratio and Volume fraction and fiber strength graph(as shown in fig3) i.e.



V. CONCLUSIONS

From this analysis of test results, the conclusions are

1. For steel fibers, the flexural strength is increases up to 3% volume fraction, after that the strength remains constant.
2. For polypropylene fibers, the flexural strength is increases up to 2% after that the strength remains constant.
3. Cracks can be controlled by introducing glass fibers. Cracks have occurred and propagated gradually till the final failure. Glass fiber also helps in controlling the shrinkage cracks.
4. From this analysis the developed empirical equation for flexural strength, is used for finding flexural strength for any grade, at any Ar, having Vf, at particular w/c and having particular fiber tensile strength either it's glass, steel and polypropylene fiber.

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AUTHOR'S PROFILE

Chapala. Venkata Ramana
P.G. Student, Structural Engineering
University college of Engineering, JNTU, Kakinada
Email ID : venkataramana.chapala@gmail.com

CH.Naga Sindhura
P.G. Student, Structural Engineering
University college of Engineering, JNTU, Kakinada
Email ID : nagasindhura.ch@gmail.com