Optimization of Percentages of Crimped Steel and AR-Glass Fiber Reinforced Concrete

Dineshkumar K. Chaudhari
Department of Structural Engineering
Merchant institute of technology, mehasana, gujarat, India

Abstract- *Concrete is week in tension and has brittle character. concrete has some deficiency as low tensile strength low ductility limited fatigue life/brittleness and low post cracking capacity not capable to large deformation .The concept of using fiber to improve the tensile strength and ductility and additional to concrete arrest crack formation and thus improve the strength and ductility , substantially. However, the incorporation of fibers into a plain concrete disrupts the granular skeleton and quickly causes problems of mixing as a result of the loss of mixture workability that will be translated into a difficult concrete casting in site. This study was concerned on the one hand with optimizing the fibers reinforced concrete mixes in the fresh concrete. In this paper optimization of fibers by using different percentages in crimped type steel and alkali resistance type glass fiber reinforced concrete of Standard grade M50 have been studied. It optimizes 0.90% content by volume of cement for steel Fiber content and 0.20% for glass fiber content by the volume of cement is used in concrete.*

Keywords: fibers, fragile materials, cracking, substantially

I. INTRODUCTION

Fiber reinforced concrete (FRC) is Portland cement concrete reinforced with more or less randomly distributed fibers. In FRC, thousands of small fibers are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties in all directions. FRC is cement-based composite material that has been developed in recent years. It has been successfully used in construction with its excellent flexural-tensile strength, resistance to spitting, impact resistance and excellent permeability and frost resistance. It is an effective way to increase toughness, shock resistance and resistance to plastic shrinkage cracking of the mortar. Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular, triangular or flat in cross-section. The fire is often described by a convenient parameter called ―aspect ratio‖. The aspect ratio of the fiber is the ratio of its length to its diameter. The principle reason for incorporating fibers into a cement matrix is to increase the toughness and tensile strength and improve the cracking deformation characteristics of the resultant composite. For FRC to be a viable construction material, it must be able to compete economically with existing reinforcing system. FRC composite properties, such as crack resistance, reinforcement and increase in toughness are dependent on the mechanical properties of the fiber, bonding properties of the fiber and matrix, as well as the quantity and distribution within the matrix of the fibers

II. TYPES OF FIBERS

2.1 Steel Fiber Reinforced Concrete

Steel fibre reinforce concrete is a composite material which is made up from cement concrete mix and steel fibres as a reinforcing. The steel fibres, which are uniformly distributed in the cementations mix .This mix, have various volume fractions, geometries, orientations and material properties. It has been shown in the research that fibres with low volume fractions (<1%), in fibre reinforced concrete, have an insignificant effect on both the compressive and tensile strength.

- Increases impact and abrasion resistance of concrete
- Reduces segregation, plastic settlement, and shrinkage cracking of Concrete
- Provides three-dimensional reinforcement against macro-cracking.
- Increases overall durability and flexural strength.
- Reduction of in-place cost versus wire mesh for temperature / shrinkage crack control
- Easily added to concrete mixture at any time prior to placement

2.2 Glass Fiber Reinforced Concrete

Glass fibre–reinforced concrete is (GFRC) basically a concrete composition which is composed of material like cement, sand, water, and admixtures, in which short length

- Main role of fibre is to bridge the cracks that develop in concrete and increase the ductility of concrete elements, Improves toughness of concrete.
- Flexural strength is improved by up to 30% by decreasing the propagation of cracks.

- Improves tensile strength, More economical than steel reinforcement.
- Less prone to corrosion, Lowers the permeability of concrete matrix and thus reduce the bleeding of water.

Fig-1. Steel fiber and glass fiber

Discrete glass fibers are dispersed. Inclusion of these fibres in these composite results in improved tensile strength and impact strength of the material.GFRC has been used for a period of 30 years in several construction elements but at that time it was not so popular, mainly in non-structural ones, like facing panels (about 80% of the GRC production), used in piping for sanitation network systems, decorative non-recoverable formwork, and other products. At the beginning age of the GFRC development, one of the most considerable problems was the durability of the glass fiber, which becomes more brittle with time, due to the alkalinity of the cement mortar. After some research, significant improvement have been made, and presently, the problem is practically solved with the new types of alkali- resistant (AR resistance) glass fibers and with mortar additives that prevent the processes that lead to the embrittlement of GFRC.

III. MIX RATIO

Mix design using 10 mm size graded aggregates:

Characteristic strength = 50 MPa.
Target mean strength = 50 + 1.65 x 5 = 58.25Mpa.
Maximum size of graded aggregate = 10 mm
Bulk density of loose coarse aggregate = 1494kg/m^3
Bulk density of loose fine aggregate = 1460 kg/m^3
Volume of fine/coarse aggregate ratio = 52/48
Volume ratio of fine aggregates to total aggregates(s/a) = 52/100

Determination of Coarse aggregate: Assume P.F = 1.12

Amount of coarse aggregate, W g = P.F x W gL (1-s/a) = 1252.53kg/m^3

Determination of fine aggregate:
Amount of fine aggregates, W s = P.F x W sL (s/a)
= 613.095 kg/m3
Determination of cement:
C = f' c /20
Given 0.14Mpa = 20 psi
Hence C = 80/0.14 =525.76 kg/m^3

Determination of water:
Water/cement ratio for 26.6 Mpa = 0.25
Hence quantity of water required = 525.52 x 0.25= 157.85 kg/m^3

Estimation of Cement Content

Maximum Water cement ratio	0.3
Water cement ratio desired	0.3
Cement Content (kg)	525.76
Minimum Cement content (kg)	300
Final cement content (kg)	525.76
Final water content (kg)	157.728

Mix Proportion Of trial 1 for 1m^3 Concrete

Volume of Concrete (cu.m.) - 1
Cement Content (kg) - 394.32
Water Content (kg) - 197.16
Fine aggregate (kg) - 687.55
Kapachi (kg) - 755.59
Grit (kg) - 425.022
Admixture (kg) - 0
Weight (kg) - 2459.65

Determination of S.P dosage (W sp);
S.P dosage =1.8% of (571.42+35.46) =10.92kg/m^3
Water content in S.P = (1-0.4) x 10.92= 6.55 kg/m^3
Total water content = 142.85+8.86 – 6.55 = 145.16 kg/m^3
Water binder ratio (W/B) = 145.16/ (571.42+35.46) 0.239.

Table 1: mix proportions

	Cement	Fine aggregae	Coarse aggregate	Water w/b
Quantity (kg/m^3)	394.32	687.55	1180.25	197.16
Proportions	1	1.7436	2.9923	0.350

IV. OPTIMIZATION

From a material and structural point of view, there is a delicate balance in optimizing the bond between the fiber and the matrix. *ƒ* If the fibers have a weak bond with the matrix, they can slip out at low loads and do not contribute very much to bridge the cracks. In this situation, the fibers do not increase the toughness of the system. ƒ If the bond with the matrix is too strong, many of the fibers may break before they dissipate energy by sliding out. In this case, the fibers behave as non-active inclusions leading to only marginal improvement in the mechanical properties.

4.1 Steel Fiber Optimization

Different percentages of steel fibers are used in concrete of grade M50 like 0.3% ,0.6%, 0.9%, 1.2%.

4.2 Glass fiber optimization

Different percentages of glass fibers are used in concrete of grade M50 like 0.05% ,0.1%, 0.15%, 0.20%, 0.25%.

V. RESULTS & DISCUSSIONS

In the above graph comparison of compressive strength of different percentage of steel fibers added to optimize the grade M50 concrete . The compressive strength of 0.3 % of at 7 days is 28.7 N/mm^2, and 28 days is 58.68 N/mm^2 and The compressive strength of 0.6 % of at 7days

TABLE -2 compressive strength

Compressive Strength (Mpa)			
	7 days	14 days	28 days
Normal	28.26	36.90	52.24
0.3 % SF	28.72	38.32	58.68
0.6 % SF	30.82	41.78	64.92
0.9 % SF	31.24	45.48	69.90
1.2 % SF	27.98	36.84	53.34
0.05% GF	29.03	37.45	52.61
0.1% GF	32.51	41.94	58.92
0.15% GF	35.37	45.64	64.10
0.2% GF	31.34	47.64	69.02
0.25%GF	27.78	43.22	50.34

TABLE-3Tensile strength

Split Tensile Strength (Mpa)			
	7 days	14 days	28 days
Normal	3.13	4.65	5.54
0.3 % SF	3.88	5.90	6.86
0.6 % SF	4.14	6.31	7.58
0.9 % SF	4.54	6.66	8.19
1.2 % SF	3.32	5.54	6.81
0.05% GF	3.71	5.02	6.13
0.1% GF	4.42	5.62	6.87
0.15% GF	4.81	6.12	7.47
0.2% GF	5.18	6.59	8.04
0.25%GF	2.96	4.84	5.90

TABLE - 4 Flexural strength

Flexural Strength (Mpa)			
	7 days	14 days	28 days
Normal	2.91	4.12	5.18
0.3 % SF	3.48	4.86	6.08
0.6 % SF	3.75	4.99	6.85
0.9 % SF	3.96	5.54	7.33
1.2 % SF	3.56	4.45	5.82
0.05% GF	3.67	4.69	5.93
0.1% GF	4.11	5.25	6.64
0.15% GF	4.47	5.72	7.23
0.2% GF	4.82	6.15	7.78
0.25%GF	4.19	4.97	5.44

30.82 N/mm^2 of at 28 days is 64.92N/mm^2, 0.9% steel fiber 7day 31.24N/mm^2 and 28day 69.90 N/mm^2.than 1.2% The compressive strength of for 7day 27.98 % of at 28 days is 53.34 N/mm^2. In the above graph comparison of compressive strength of different percentage of glassl fibers added to optimize the grade M50 concrete. The compressive strength of 0.05 % of at 7 days is 29.03 N/mm2, and 28 days is 52.68 N/mm^2 and The compressive strength of 0.1 % of at 7days

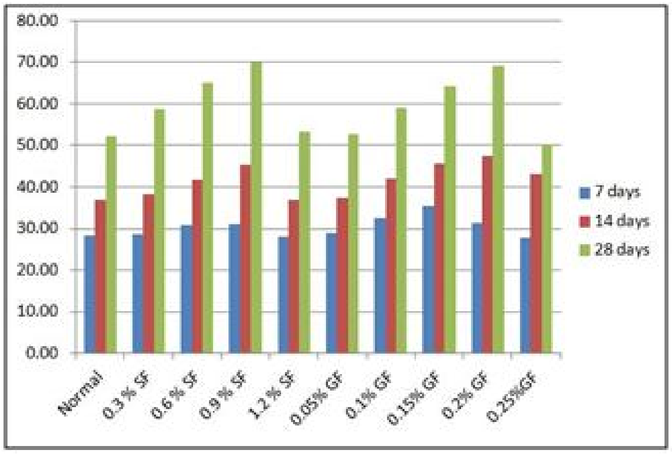

Fig-2 compressive strength

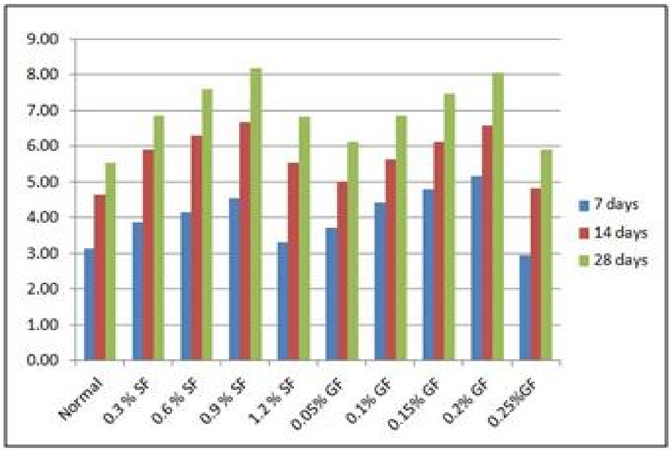

Fig-3 Tensile strength

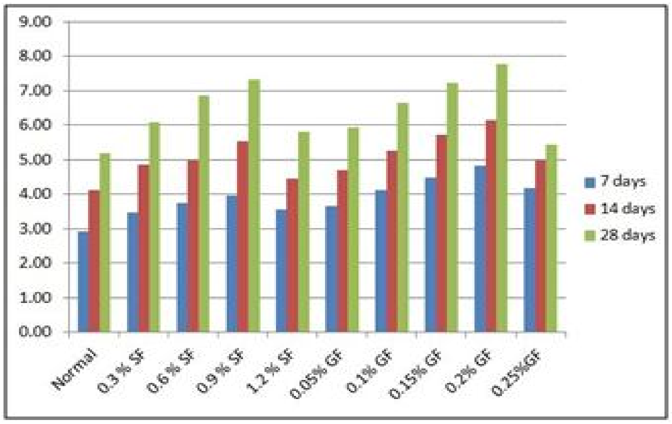

Fig-4 Flexural strength

compressive strength 32.51 N/mm^2 than 28day 58.920 N/mm than 0.15 % of at 7 days is 35.37 N/mm^2, 28 days is 64.10 N/mm^2 and 0.20% compressive strength 7 days is 31.34 N/mm^2 and 28day 69.02 N/mm^2, The compressive strength of 0.25% of at 7days is 27.78 N/mm^2, 28 days is 50.34 N/mm^2.Fig num-2 is compressive strength fig-3 Tensile strength and fig-3 is Flexural strength.

Show the all result in table tensile strength and flexural strength of steel and glass fiber use different percentage and to obtained 7day to 28day result in table and graph. After the research work conclude that for Standard Grade M50 optimum percentage of steel fiber is 0.90% and optimum percentage of glass fiber is 0.20%.

REFERENCES

[1] Cement & Concrete Association of New Zealand. 2009. Information Bulletin: IB 39, Fibre Reinforced Concrete

[2] J. H. Morton. Developing Fiber Application in Structural Concrete. Buckeye Technology, 1001 Tillman St., Memphis, TN 38108, USA.

[3] R. B. Abdul-Ahad and O. Q. Aziz. 1999. Flexural Strength of Reinforced Concrete T-Beans with Steel Fibers. Cement and Concrete Compositions. Volume 21 Issue 4. pp 263-268.

[4] M. Yakhlaf, M. Safiuddin, and K. A. Soudki. 2013. Properties of Freshly Mixed Carbon Fibre Reinforced Self-Consolidating Concrete. Construction and Building Materials, Vol. 46, pp. 224-231.

[5] D. D. L. Chung. 2000. Cement Reinforced with Short Carbon Fibers: A Multifunctional Material. Composites: 31 (B) 511-526.

[6] P. W. Chen and D. D. L. Chung. 1992. Concrete Reinforced with up to 2% of Short Carbon Fibers. State University of New York at Buffalo, USA.

[7] T. Ochi, S. Okubo, K. Fukui .2007. Developed of Recycle PET Fiber and Its Application as Concrete Reinforcing Fiber. Cement and Concrete Compositions. Cement and Concrete Composites, 29. pp 448-455.

[8] D.A. Silva, A. M. Betioli, P. J. P. Gleize, H. R. Roman, L. A. Gomez, J. L. D. Ribeiro. 2005. Degradation of Recycled PET Fibers in Portland Cement-Based Materials. Cement and Concrete Research, Volume 35, Issue 9. pp 1741-1746

[9] D. Foti. 2011. Preliminary Analyses of Concrete Reinforced with Waste Bottles PET Fibers. Construction and Building Materials, Volume 25, Issue 4. pp 1906-1915.

[10] S. H. Kosmatka, B. Kerkhoff, R. D. Hooton, and R. J. McGrath, Design and Control of Concrete Mixtures, EB101, 8th edition, Cement Association of Canada, Ottawa, Ontario, Canada 2010.

[11] CSA A23.2-5C. 2012. Slump and Slump Flow of Concrete. Canadian Standard Association, Toronto, Canada .

[12] CSA A23.2-3C. 1990. Making and Curing Concrete Compression and Flexural Test Specimens. Canadian Standard Association, Toronto, Canada.

[13] CSA A23.2-9C. 2012. Compressive Strength of Cylindrical Concrete Specimens. Canadian Standard Association, Toronto, Canada.

[14] CSA A23.2-13C. 1990. Splitting Tensile Strength of Cylindrical Concrete Specimens. Canadian Standard Association, Toronto, Canada.

[15] CSA A23.2-8A. 1990. Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading). Canadian Standard Association, Toronto, Canada.

[16] Wafa, F. F. Properties and Applications of Fiber Reinforced Concrete. JKAU: Eng. Sci., Vol. 2. pp 49-63.