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Improvement of Performance of Concrete using Straight and 3D Steel Fibres

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Abstract – *Concrete is the most widely used construction material in the world. Concrete possess high compressive strength, but it is weak in tension. Weak tensile strength combined with brittle behavior result in sudden tensile failure without warning. To enhance the mechanical properties of the concrete, steel fibres can be introduced into it. Fibre reinforced concrete is defined as a composite material essentially consisting of conventional concrete or mortar reinforced by the random dispersal of short, discontinuous and discrete fine fibres of specific geometry. In practical life, different types of steel fibres such as straight steel fibre, hooked end fibre etc. are already used in concrete structures. These fibres provide reinforcement only in 2D when inside concrete. Instead of straight steel fibres, 3D fibres can also be used. 3D fibres are called so, as it provides reinforcement in x, y and z plane which cannot be guaranteed by straight steel fibres. Experimental studies were carried out to understand the effect of 3D steel fibres in concrete. It was found that the mechanical properties of concrete reinforced with 3D steel fibre is much better than that of concrete with 2D steel fibres. In this study the effect of different 3D shapes and straight steel fibre in concrete is studied and maximum steel fibre content and the best shape to get better results is found.*

***Key Words*: Straight steel fibres, single closed loop, double closed loop, 3D steel fibres, compressive strength, split tensile strength, flexural strength**

1. INTRODUCTION

Concrete is one of the most frequently used building materials. Concrete has high compressive strength. It has some disadvantages too like low tensile strength, low ductility and low toughness. Concrete has a very low coefficient of thermal expansion and shrinks as it matures. All concrete structures crack to some extent, due to shrinkage and tension. Concrete that is subjected to long-duration forces is prone to creep. The elasticity of concrete is relatively constant at low stress levels but starts decreasing at higher stress levels as matrix cracking develop. Since the tensile strength is low for concrete, it is usually reinforced with materials that are strong in tension. Steel bars of diameter varying between 6-32 mm, is used in reinforced concrete. Unlike conventional reinforcing bars, which are specifically designed and placed in the tensile zone of the concrete member, fibres that are thin and short are distributed randomly throughout the concrete member. Steel fibres can also be used for enhancing the mechanical property of concrete because of its advantages on the toughness and ductility. Fibres are generally randomly distributed in the whole element. In addition, it can be used in part of the elements. The main role of dispersed fibres is to control the opening and developing of cracks by bridging the faces of crack. The success of bridging effect generally depends on pull-out mechanisms. Pull-out strength depends on not only bond quality between fibre and matrix but also fibre properties such as strength. Energy absorption capacity, load carrying capacity, ductility, toughness, fracture energy, tensile and shear strengths and impact resistance are marginally increased. Steel fibre reinforced concrete (SFRC) is widely used in civil engineering structures; industrial floors, airports and highway pavements, tunnels, bridges, hydraulic structures, earthquake and impact resistant structures etc. The increment in the mechanical properties of the SFRC will depend primarily on the type of the fibres, their geometrical properties and the amount of fibres added. In this study, effect of different shaped steel fibres on mechanical properties of concrete will be investigated by an experimental study.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials

The cement used in the study was Portland Pozzolana cement of grade 53 confirming to IS 1489 (Part 1) 1991. The coarse aggregate passing through 20 mm sieve and retaining on 4.75 mm sieve was used and M-sand was used as fine aggregate belonging to zone II. Mild steel fibres having diameter 1.21 mm were used. Three shapes were adopted for steel fibre i.e straight, single closed loop and double closed loop. Straight fibres were of length 50 mm and 3D fibres of 230 mm. The single closed loop shape was obtained by making a loop with straight fibre and twisting at ends then bending the loop at an angle. The double closed loop shape was obtained by combining two single closed loops. The single and double closed loop shapes are referred to as 3D shape in the sense that they provide reinforcement in x, y and z plane when inside the concrete.

Table -1: Properties of steel fibres

Properties	Straight steel fibre	Single closed loop	Double closed loop
Aspect ratio	41.152	189.300	378.600
Density	7.8 g/cm^3	7.8 g/cm^3	7.8 g/cm^3
Tensile strength	669 MPa	669 MPa	669 MPa

Fig -1 Straight steel fibre

Fig -2 Single and double closed loop

2.2 Concrete mix details

The M30 grade concrete was chosen for study. The mix design for M30 was done according to the recommendations mentioned in IS 456:2000 and IS 10262:2009. The materials were tested for various properties required for the mix design. After various trials, the mix proportion was arrived at 1:1.853:3.108. Master glenium sky 8233 was added as admixture to increase the workability of concrete and to minimize the amount of water-cement ratio, for obtaining a desired slump range of 75 mm – 100 mm as per IS 456:2000. The mix proportion is given in the table 2.

Table -2: Mix proportion

Mix proportion	1 : 1.853 : 3.108
Water-cement ratio	0.4
Cement (kg/m^3)	394
Coarse aggregate (kg/m^3)	730.14
Fine aggregate (kg/m^3)	1224.64
Admixture (kg/m^3)	1.576

2.2 Preparation of Test Specimen

The study consisted of an experimental investigation on the compressive, split tensile and flexural strength of plain cement concrete reinforced with steel fibres. Control specimens of cubes, cylinders and beams were casted by placing concrete in layers inside the moulds and hand compaction was done. For steel fibre reinforced specimens, steel fibres were sprinkled randomly over each layer. The steel fibre reinforced specimens were cast of straight steel fibres, single closed loop and double closed loop at four different fibre percentages of 0.5%, 1.0%, 1.5% and 2% by weight of cement. Then the specimens were cured for 28 days. At the end of curing, the cube and cylinder specimen were tested in compression testing machine (2000 kN) and beam specimen in flexural testing machine (1000 kN).

Fig -3 Placing steel fibres over concrete layer

3. RESULTS AND DISCUSSIONS

3.1 Compressive strength

The compressive strength test was conducted on cube specimens of size 150 x 150 x 150 mm in a compression testing machine of capacity 2000 kN.

Fig -3 Cube testing using compression testing machine

Table -3: Compressive strength test result of specimens

Steel percentage	Straight steel fibre	Single closed loop	Double closed loop
0	31.88	31.88	31.88
0.5	32.55	34.40	40.00
1	36.88	39.66	42.66
1.5	34.60	35.80	39.55
2.0	30.40	33.11	36.44

The compressive strength of the concrete has been increased with the use of steel fibres. The 28 days compressive strength of the concrete increased linearly with the increase in amount of steel added to it, but to a maximum of 1% steel fibre inclusion. After that the compressive strength decreases. Use of higher percentage of fibre is likely to cause segregation and hardness of concrete and mortar. The variation in the compressive strength is shown in chart 1.

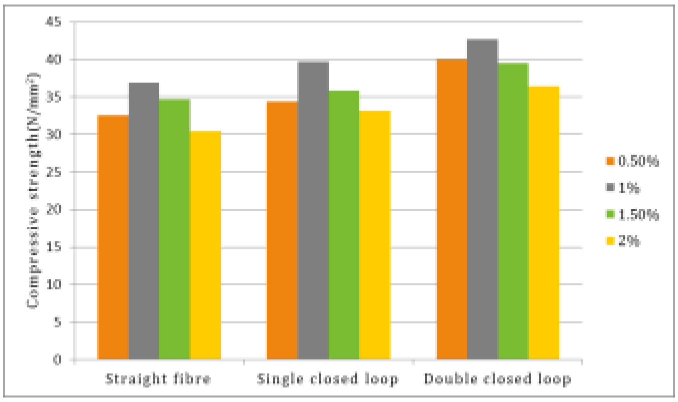

Chart -1: Compressive strength of specimens of different steel types

3.2 Split tensile strength

The split tensile strength test was conducted on cylinder specimens of 150 mm diameter and 300 mm height in a compression testing machine of capacity 2000 kN.

Fig -4 Cylinder testing using compression testing machine

Table -4: Split tensile strength test results of specimens

Steel percentage	Straight steel fibre	Single closed loop	Double closed loop
0	2.61	2.61	2.61
0.5	2.76	3.11	3.25
1	2.83	3.25	3.39
1.5	2.97	3.53	3.82
2.0	3.18	3.68	4.24

The split tensile strength of the concrete was observed to be increasing as the percentage of steel fibres was increased. Addition of steel fibres added to the split tensile strength of the concrete. The maximum percentage increase was found to be 62.4%. The double closed loop showed better result than other two shapes. This may be because the steel fibres will effectively hold the micro cracks in concrete mass. The optimum percentage of steel is 2% for maximum split tensile strength. The variations in split tensile strength for different shapes are shown in chart 2.

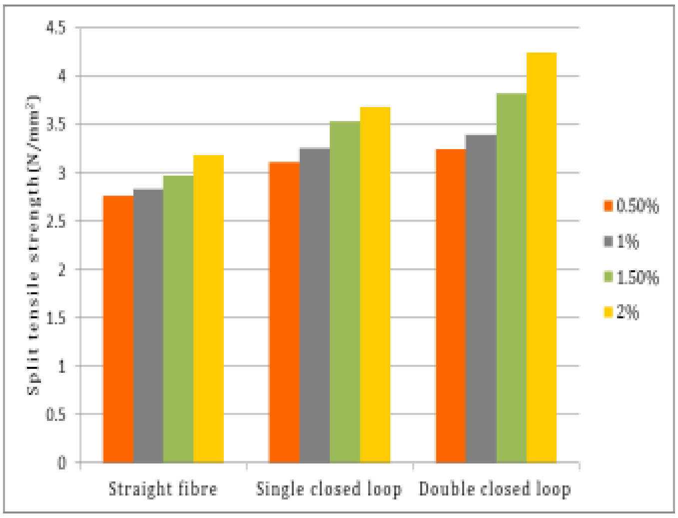

Chart -2: Split tensile strength of different steel types

3.3 Flexural strength

The flexural strength test was conducted on beam specimens of size 500 x 100 x 100 mm in a flexural testing machine of capacity 1000 kN.

Fig -5 Flexural testing machine

Table -5: Flexural strength test results of specimens

Steel percentage	Straight steel fibre	Single closed loop	Double closed loop
0	5.72	5.72	5.72
0.5	6.50	7.00	8.00
1	8.00	9.50	10.25
1.5	10.50	12.75	12.50
2.0	9.25	10.50	14.75

The flexural strength of the concrete increased with increase in percentage of addition of steel fibre but decreased beyond 1.5% addition for straight and single closed loop fibres whereas in case of double closed loop, the flexural strength keeps on increasing with percentage increase in steel fibre addition. The flexural behavior of fibrous beams was superior to that of beams without fibre because of the crack bridging action of fibres. Due to high tensile strength of steel fibre, the concrete become stiffer under flexural strength test, which enhance the capability of concrete to withstand higher load magnitude at first crack. The optimum percentage was found to be 1.5 % for straight and single closed loop whereas for double closed loop it is 2 %.

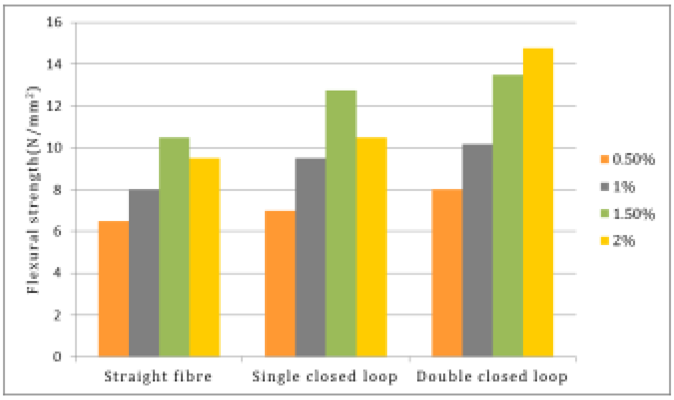

Chart -3: Flexural strength of different steel percentages

4. CONCLUSIONS

The study on of effect of straight and 3D steel fibres on concrete strength is proved to be very promising, as it prolongs sustainability of concrete structures. Following are the results obtained for the tests conducted:

- The compressive strength, split tensile strength and flexural strength was experimentally evaluated and it was found that compressive strength increases to a certain value then decreases as the percentage of steel fibre increases. Split tensile strength increases with the increase in the percentage of steel fibres. Flexural strength changes as similar as compressive strength both in the case of straight steel fibre and single closed loop but in the case of double closed loop it continuously increases with the increase in the percentage of the steel fibre.

- The percentage of steel fiber that gives maximum compressive strength, split tensile and flexural strength are 1%, 2% and 2% respectively.

- The better steel fibre type is found to be double closed loop. When concrete is reinforced with double closed loop, the compressive strength increased by 33.81%, split tensile strength increased by 62.45% and flexural strength increased by 157.86 %.

The addition of steel fibre in concrete increases the tensile properties of concrete and also improves resistance to cracking, splitting tensile strength increase significantly with increase in fibre volume fraction. The applications of steel fibre reinforced concrete includes

- Blast protection

The fibres used in concrete reduce fragmentation by providing high levels of toughness. It can be used for protection against secondary injuries resulting from energized fragments during blast.

- Earthquake resistant structure

Fibre reinforced concrete could be used for concrete elements such as beams and columns for buildings in earthquake prone locations due to its high energy absorption properties.

- It can be used

-For industrial floors and machine foundations.

-In construction of bridges, tunnels and hydraulic structures.

-In airport and highway pavements.

REFERENCES

[1] A.G. Dahake, K.S. Charkah, “Effect of steel fibres on strength of concrete”, Journal of engineering, science and management education,Vol-9 (I), 45-51, 2016

[2] Alan Richardsom, Marcus Heather, “Improving the performance of concrete using 3D fibres”, Procedia engineering 51, 2013,101-109

[3] A.M. Shende, A.M. Pande, M. Gulfam Pathan, “Experimental study on steel fibre reinforced concrete for M-40 grade”, International Refereed journal of Engineering and science, September 2012, 43-48

[4] Ann Mary Baby, Reshmi P R, “Improving the flexural performance of concrete beams using 2D steel fibres”, International Research journal of Engineering and Technology, April 2017,3274-3277

[5] Hassan Ghanem, Yehia Obeid, “The effect of steel fibers on the rhyological and mechanical properties of steel compacting concrete”, European scientific journal, July 2005, 85-98

[6] Kishore S Sable, Madhuri K Rathi, “Effect of different type of steel fibre and aspect ratio on mechanical properties of self-compacted concrete”, International journal of Engineering and Innovative technology, June 2013,184-188

[7] Tarun Gehlot, Divanshu Seervi, Dr. Peeyush Chowdhary, “Study of the compressive strength behavior of steel fibre reinforced concrete using various percentage of steel fibre”, International journal of engineering science invention, August 2017, 41-47

[8] Y Gunduz, E Taskan, Y Sahin, “Using hooked and end fibers on high performance steel fibre reinforced concrete”, High performance and optimum design of structures and materials, 2016

[9] Yifei Hao,Hong Hao, “Mechanical properties and behavior of concrete reinforced with spiral shaped steel fibres under dynamic splitting tension”, Magazine of concrete research, 2016, 1110-1121

[10] Dr. Zainab A.AL-Kaissi, Dr.Ahmed Saheb Daib, Rusul RAED Abdull-Hussain, “Experimental and numerical analysis of steel fiber reinforced concrete”, Journal of Engineering and Sustainable Development, November 2016, 135-155