International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2017): 7.296

Effect of Replacement of Coarse Aggregate with Steel Fibers in Concrete

Harleen Kaur

B.Tech Student, Shaheed Bhagat Singh State Technical Campus, Ferozepur, Punjab, India

Abstract: ***Strength and ductility are the two important factors to be considered in the design of structures subjected to seismic and other dynamic forces. Hence many attempts have been made in the recent past to develop new materials which exhibit higher1 strength and ductility than conventional concrete, so that they could be used in the case of structures subjected to seismic loading, impact or blast loading, cyclic loading etc. It has been understood from the literature that many of the engineering properties such as tensile strength, compressive strength, flexural strength, fracture toughness, energy absorption capacity, strain at peak load etc. of the conventional concrete could be improved by the addition of steel fibers. This study aimed at analyzing the variation in strength of Steel Fiber (used in place of coarse aggregate) reinforced concrete at varying fiber contents and to compare it with that of conventional concrete. The various strength aspects analyzed are the flexural, compressive and tensile strength of the steel fiber reinforced concrete at varying percentages (5%, 10% by the weight of cement) of fiber.***

Keywords: Steel Fibers, Compressive Strenght, Srfc, Concrete, Aggregates, Flexural Strenght, Cement, Durability, Shear Resistance

1. Introduction

Concrete is most widely used building material in the world, as well as the largest user of natural resources with annual consumption of 12.6 billion tons. Basically it consists of aggregates which are bonded together by cement and water. The major part of concrete besides the cement is the aggregate. Aggregate include sand and crushed stone / Gravel. Use of these conventional materials in concrete is likely to deplete the resources unless there is a suitable substitute. Concrete has relatively high compressive strength, but significantly lower tensile strength.

The Ingredients of concrete are easily available in most of the places & unlike natural stones, Concrete is free from defects and flaws. Concrete can be manufactured to desired strength with an economy. The durability of concrete is very high. It can be cast to any desired shape. The casting of concrete can be done in the working site which makes it economical. Maintenance cost of concrete is almost negligible. The deterioration of concrete is not appreciable with age. Concrete makes a building fire-safe due to its noncombustible nature. Concrete can withstand high temperatures. Concrete is resistant to wind and water. Therefore, it is a very useful in storm shelters. Many types of concrete are available, distinguished by the proportions of the main ingredients below. In this way or by substitution for the cementitious and aggregate phases, the finished product can be tailored to its application. Strength, density, as well chemical and thermal resistance varies. Reinforcement is often included in concrete. Concrete can be formulated with high compressive strength, but always has lower tensile strength. For this reason, it is usually reinforced with materials that are strong in tension

As Compared to other binding materials, the tensile strength of concrete is relatively low & concrete is less ductile. Moreover, the weight of concrete is high compared to its strength. The Shrinkage causes crack development and strength loss. So as to overcome these disadvantages of concrete, reinforcement is provided to concrete so that to increase its strength to withstand the forces & provide strength to the structure. Steel fibres do the work. It provides the strength needed to the concrete.

Reinforced concrete (RC) is a composite material in which concrete's relatively low tensile strength and ductility are counteracted by the inclusion of reinforcement having higher tensile strength or ductility. The reinforcement is usually, though not necessarily, steel reinforcing bars and is usually embedded passively in the concrete before the concrete sets. Reinforcing schemes are generally designed to resist tensile stresses in particular regions of the concrete that might cause unacceptable cracking and/or structural failure.

Steel fibers strengthen concrete by resisting tensile cracking. Fiber reinforced concrete has a higher flexural strength than that of unreinforced concrete and concrete reinforced with welded wire fabric. But unlike conventional reinforcement – which strengthens in one or possibly two directions – Steel fibers reinforce iso tropically, greatly improving the concrete's resistance to cracking, fragmentation, spalling and fatigue. When an unreinforced concrete beam is stressed by bending, its deflection increases in proportion with the load to a point at which failure occurs and the beam breaks apart.

Steel Fiber reinforced concrete (SFRC) is defined as concrete made with hydraulic cement containing Fine and coarse aggregate and discontinuous discrete fiber. In SFRC, thousands of small fibers are dispersed and distributed randomly in the concrete during mixing, and thus improve concrete properties. SFRC is being increasingly used to improve static and dynamic tensile strength, energy absorbing capacity and better fatigue strength. The addition of steel fiber increases the ultimate strength and ductility. It has been found that different type of fibers added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the structure. The plain structure cracks into two pieces when the structure is subjected to the peak tensile load and cannot withstand further load or deformation. Steel fibers are generally used to enhance the tensile strength and ductility of concrete. It increases the initial first crack strength. Using large numbers of fibers helps in intercepting the micro-cracks and preventing propagation by controlling tensile strength. Fiber volume fraction used in producing steel fiber reinforced concrete should be also being produced steel fibers with low tensile strength (7141kg/cm2) are also produced from low carbon flat rolled steel coils. Generally, the steel fibers used in concrete as reinforcement of diameter lying inbetween5-500mm specific gravity 7.8, modulus of elasticity 200 GPA, Failure3-4% and Tensile strength 1 to 3 GPA.

2. Properties of SRFC

2.1 Toughness

The main reason for incorporating steel fibers in concrete and concrete is to impart ductility to an otherwise brittle material. Steel fiber reinforcement improves the energy absorption, impact resistance and crack resistance of concrete. Steel fiber reinforcement enables the concrete to continuously carry load after cracking called post crackbehavior variety of tests have been developed to measure and quantify the improvements achievable in steel fiber reinforced concrete.

2.2 Durability

The corrosion resistance of Steel Fiber Reinforced concrete (SFRC) is governed by the same factors that influence the corrosion resistance of conventionally reinforced concrete. As long as the matrix retains inherent alkalinity and remains uncracked, deterioration of SFRC is not likely to occur. It has been found that good quality SFRC when exposed to atmospheric pollution, chemicals or a marine environment, will only carbonate to a depth of a couple of millimeters over a period of many years. Steel fiber immediate layer of corrode to the depth of surface carbonation, causing some rust colored surface staining. In a trafficked or abrasive exposure environment such corroded surface fibers rapidly wear away and disappear. The interior fibers beneath the immediate carbonated surface layer, however, remain totally protected, provide the SFRC remain sun cracked.

2.3 Shear Resistance

Large earthquakes result in high shear forces within the beam-column joint. To withstand such forces, hoop spacing is decreased within the joint region. This can sometimes result in congestion problems that can result in construction difficulty. SFRC can be used with increased hoop spacing to provide higher shear resistance.

2.4 Fiber Volume Content

One of the key variables influencing the behavior of SFRC is the fiber volume fraction. Many tension-critical tests, such as the uniaxial direct tension test, flexural test and direct shear test, have shown that increases in fiber volume fraction will lead to improved toughness, ductility and strength. As the fiber content increases, more fibers are likely to intersect cracks, improving the matrix's ability to bridge cracks and enhance post-cracked behavior. Doubling the fiber content from 0.5% to 1.0% increased the concrete uniaxial tensile toughness from 1.8 times to 2.7 times that of the plain concrete, but the concrete uniaxial tensile strength was only increased from 1.1 times to 1.3 times that of plain concrete. These improved behavior were more pronounced in flexural tests.

Despite the advantages associated with increases in the fiber content, limits should be placed on the maximum fiber volume fraction due to workability issues and fiber saturation. An increase in fiber content will reduce workability because the fibers reduce the paste volume fraction available for the free movement of coarse aggregates and fibers. As a result, producing SFRC with high fiber contents often requires special mixing and placing methods. Although the maximum fiber content for sufficient workability depends on many variables including placement conditions, conventional reinforcement ratios, composition of the concrete mix and fiber properties, ACI Committee 544 (1993) recommends a maximum fiber volume fraction of 2.0% for conventional SFRC. If small steel micro fibers were used, the fiber content can be between 5.0 - 9.0% and the product becomes what is commonly known as ultrahigh performance fiber reinforced concrete.

2.5 Fiber Geometry

The fiber length, may also be an influential factor in the structural behavior of SFRC. Various studies have shown improvements in overall response when shorter fibers were used with the same fiber aspect ratio, shorter fibers will result in a significantly larger number of fibers required to achieve the same fiber volume fraction; this larger number of fibers would lead to improved crack bridging and better stress transfer across the cracks. The shape of the fiber is another important variable. Steel fibers may be straight, end-hooked, crimpled, flattened-end, etc. Many studies have shown that at the onset of failure, steel fibers tend to be pulled out from the matrix instead of rupturing as a result, the mechanical anchorage from deformed fibers are critical in the overall response of SFRC. Recent experimental investigations and constitutive model developments have been based upon straight fibers with end-hooks are not indented. Only the initial, introductory paragraph has a drop cap.

3. Objective & Scope

In this project, aim of study is the effectiveness of Steel as substitute for coarse aggregate to improve the properties of concrete. Aggregate properties viz., specific gravity, water absorption, toughness etc. are to be conducted to ascertain the properties. Concrete specimens are to be casted and tested for concrete mix with various percentage of replacement accordingly (0%, 5% & 10%) with coarse aggregates. The required cubes are made of each percentage & the strength of each cube is determined after the period of 7 days, 21 days, 28 days. The compressive strength is calculated & compared with the strength of plane concrete. The results are plotted graphically.

4. Methodology

This study aims at utilizing steel fibers as a constituent in concrete mixes and its products as a partial replacement of natural and artificial coarse aggregates components.

M20 concrete will be used for the comparison between traditional concrete and Steel Fiber reinforced concrete. After the tests are performed, the comparison would be done in the results of concrete made in the traditional method & the concrete made by adding the Steel Fibers of various percentages i.e. 5% & 10%. The moulds which will be made during test procedures, will be tested after 7, 21 & 28 days curing.

5. Materials Used

The basic ingredients which were used in this research work are:
1) PPC-43 grade Ultra Tech Cement.
2) Natural Coarse aggregate (10 to 20mm size).
3) Natural Fine aggregate (2.36 sieve size).
4) Water
5) Steel Fiber

6. Result and Discussion

The compressive strength of standard Concrete, concrete with 5% replacement of coarse aggregates & concrete with 10% replacement of coarse aggregates is calculated & the results are as shown in tables below:

The weight (in kg) of cement cube is 8.6 kg Cross Sectional Area (in mm²) is 225 mm².

6.1. Compressive Strength Test of Standard Concrete (M25) Cubes with 0% replacement of coarse aggregates

Age of Cube	Compressive Strength (N/mm^2)	Compressive Load (KN)	Average Strength (N/mm^2)
7 Days	20.81	468.3	20.64 N/mm^2
	20.99	472.4	
	20.11	475.5	
21 Days	27.05	609.7	26.60 N/mm^2
	26.52	596.7	
	26.24	590.4	
28 Days	29.40	661.5	29.39 N/mm^2
	29.20	657.2	
	29.58	665.7	

6.2 Compressive Strength Test of Standard Concrete (M25) Cubes with 10% replacement of coarse aggregates.

Age of Cube	Compressive Strength (N/mm^2)	Compressive Load (KN)	Average Strength (N/mm^2)
7 Days	23.52	529.2	23.73 N/mm^2
	23.76	584.6	
	23.92	538.4	
21 Days	27.12	610.3	28.18 N/mm^2
	28.95	651.0	
	28.48	640.8	
28 Days	29.44	662.4	29.44 N/mm^2
	29.36	660.8	
	29.52	664.2	

6.3 Compressive Strength Test of Standard Concrete (M25) Cubes with 10% replacement of coarse aggregates.

Age of Cube	Compressive Strength (N/mm^2)	Compressive Load (KN)	Average Strength (N/mm^2)
7 Days	17.48	393.3	17.46 N/mm^2
	17.64	397.0	
	17.26	388.4	
21 Days	19.56	440.1	19.27 N/mm^2
	19.23	432.7	
	19.03	428.2	
28 Days	20.81	468.3	20.79 N/mm^2
	21.02	473.6	
	20.56	462.8	

7. Conclusion

The compressive strength of concrete is increased when 5% steel fiber was added replacing the coarse aggregates. The strength achieved was more than plain concrete. But on the addition of 10% of steel fiber, the strength reduced gradually. So, addition of steel fiber upto certain % is allowed as more addition will lead to less strength of the concrete. So proper calculations are needed for how much steel fiber need to be used in construction purposes. Limited amount of steel fbre should be used to achieve concrete with strength higher than that of plain concrete.

References

[1] R.V. Balendran, A. Nadeem, GF.P. Zhou (November 2001) Influence of Steel Fiber on Strength of Concrete.
[2] Milind V. Mohod. (December 2012) Performance of Steel Fiber Reinforced Concrete.
[3] E Arunakanthi, J.D. Chaitanya Kumar (September 2016) Experimental studies of Fiber Reinforced Concrete
[4] Er. Mello, C.Ribellato,E.Mohamedel Hassan (2014) Improving Concrete Properties with Fiber Addition
[5] Ali N. Alzead (October 2014) Effects of Iron fillings on Concrete Strength
[6] Tanvir Qureshi & Mustaq Ahmed (February 2015) Waste Metal for Concrete Performance
[7] Nur Yazdani, Tanvir Manzur & Md. Abul Basher (March 2016) Improving Performance of Concrete using Low Cost Steel Fiber
[8] V.Kesavaraj & Dr. K Srinivisa Rao (November 2016) Performance of Steel Fiber on Standard Concrete
[9] Y. Bontia, S. Djebali, D. Atlaoui & M.S. Kachi (October 2014) Strengthening of Concrete with Metallic Chips
[10] Pramod Kawde & Abhijit Warudkar (January 2017) Steel fiber Reinforced Concrete
[11] Er. Gulzar Ahmed & Er. Kshipra Kapoor (June 2016) Study on Use of Steel Fibers as Reinforced Material in Concrete
[12] R.Vengadesan , S. Divya , S. Vijipriya, R. Anbarasi (June 2016) Study the behavious of Concrete in Addition of Steel Fiber
[13] R.Rajalakshmi , .V.Thilagavathi & U.Ramya, R.gopinath (March 2014) Experimental Study on Concrete using Steel Fiber
[14] R. M. Saravana Kumar, E. Ramya, B. KarthickHari, S. Nalini (November (2014) behavior of Steel Fiber Reinforced Concrete
[15] S. Krishna Rao & B. Panduranga Rao (October 2013) Study on Properties of Steel Fiber Reinforced Concrete
[16] S.A. Mahadik, S.K. Kamane, A.C. Lande (2014) Effect of Steel Fiber on Srength of Concrete