

# **Use of Discrete Fiber in Construction**

T.Sirisha <sup>1</sup>, A.V.S Sai kumar <sup>2</sup>, B.Madhanna <sup>3</sup>

P.G. Student, Department of Civil Engineering, Dhruva Institute Engg &Tech, Chotuppal, Nalgonda, India<sup>1</sup>

Assistant Professor, Department of Civil Engineering, Princeton College Of Engg & Tech, Hyderabad, India<sup>2</sup>

Assistant Professor, Department of Civil Engineering, ACE Engineering College, Ankushapur, India<sup>3</sup>

**ABSTRACT:** Shrinkage cracking of concrete is a major problem in plain cement concrete pavements especially in tropical regions. To overcome shrinkage cracking of plain concrete, sometimes the addition of synthetic fiber to the concrete mix is suggested. This paper briefly discusses the effects of addition of polypropylene discrete and fibrillated fibre on the properties of a paving grade concrete mix of 48 MPa compressive strength at 28-day. Six concrete mixes with fiber dosages 0.05%, 0.10% and 0.15% by volume fraction besides the control concrete mix were manufactured. Discrete and fibrillated polypropylene fiber was used in this study. The properties such as settlement, compressive strength, drying shrinkage, and abrasion resistance of the concrete were evaluated. The study suggested a significant reduction in settlement and drying shrinkage without significant change in compressive strength for the concrete mixes reinforced with fiber. Further, an improved abrasion resistance for the concrete mixes reinforced with fibre was also observed

**KEYWORDS:** Concrete, Shrinkage, Descrete, Steel fiber, Compressive strength & synthetic fiber.

## **I. INTRODUCTION**

The weak matrix in concrete, when reinforced with steel fibers, uniformly distributed across its entire mass, gets strengthened enormously, thereby rendering the matrix to behave as a composite material with properties significantly different from conventional concrete. Because of the vast improvements achieved by the addition of fibers to concrete, there are several applications where Fibers Reinforced Concrete (FRC) can be intelligently and beneficially used. These fibers have already been used in many large projects involving the construction of industrial floors, pavements, highway-overlays, etc. in India. The principal fibers in common commercial use for Civil Engineering applications include steel (SFRC/SFRS), glass, carbon and aramid. These fibers are also used in the production of continuous fibers and are used as a placement to reinforcing steel. High percentages of steel fibers are used extensively in pavements and in tunneling. This invention uses Slurry Infiltrated Fiber Concrete (SIFCON). Fibers in the form of mat are also being used in the development of high-performance structural composite. Continuous fiber-mat high performance fiber reinforced concrete (HPFRCs) called Slurry Infiltrated Mat Concrete (SIMCON) issued in the production of High performance concrete. Use of basalt fibers are picking up in western countries. Steel fibers are also used in the production new generation concretes such as Reactive Powder Concrete (RPC), Ductile and Compact Reinforcing Concrete (CRC). Properties and applications of SFRC and some of these new generation fiber concrete materials are discussed.

## **II. LITERATURE REVIEW**

**K. Vamshi krishna1, J. Venkateswara Rao** “Experimental study on behaviour of fiber reinforced concrete for rigid pavements” This paper deals with experimental investigation on mechanical properties of M20 grade concrete by incorporating polyester fibers in the mix. Polyester fibers of 0.1%,0.2%,0.3%,0.4% by weight of cement are added to the mix. A comparative analysis has been carried out for conventional concrete to that of the fiber reinforced in relation to compressive, split tensile, flexural strengths. As the fiber content increases compressive, split tensile and flexural strengths are proportionally increasing. It is observed that 0.3% fibers by weight of cement is the optimum dosage. It is found that with 0.3% fiber content results in 20% reduction of pavement thickness.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

**S.A Kanalli, Ramu Palankar, Bharath Kumar, Praveen Kumar, Prakash S.K** “Comparative study of polymer fibre reinforced Concrete with conventional concrete pavement” Road transportation is undoubtedly the lifeline of the nation and its development is a crucial concern. The traditional bituminous pavements and their needs for continuous maintenance and rehabilitation operations points towards the scope for cement concrete pavements. There are several advantages of cement concrete pavements over bituminous pavements. This paper emphasizes on POLYMER FIBRE REINFORCED CONCRETE PAVEMENTS, which is a recent advancement in the field of reinforced concrete pavement design. A comparative study of these pavements with the conventional concrete pavements has been made using Polypropylene fiber waste as fiber reinforcement.

**Chintan Patel, Kishan Patel, Prof. Manjurali, I. Balya , Prof. Vikrant A. Patel** “Performance Evaluation of Polymer Fiber “RECRON-3S” in Pavement Quality Concrete” Road transportation is undoubtedly the lifeline of the nation and its development is a crucial concern. The traditional bituminous pavements and their needs for continuous maintenance and rehabilitation operations points towards the scope for cement concrete pavements. There are several advantages of cement concrete pavements over bituminous pavements. But, there are also some problems outcomes with concrete pavement like micro-shrinkage, cracking, and low water permeability. To overcome this kind of problems, the secondary construction material “Recron-3S” is preferable to add in concrete for making stronger and batter road pavement. Present paper focuses how the compressive and flexural strength of the Pavement Quality Concrete (PQC) increases using Recron-3S fiber with compression test of the concrete. The testing results of the prepared sample cube with Recron-3S has compared with other samples which is without the mixture of the Recron-3S

**Nitin Kumar, Sangeeta** “A Review study on use of Steel Fiber as Reinforcement Material with Concrete” Reinforcement is defined as the process of mixing various materials whether chemical, natural or Artificial for improving the strength and durability of parent substance. Now a days there exists many Reinforcement techniques for improving the strength of t Hose materials which lacks load carrying and less Durable capacity. Use of steel fiber to enhance the strength and reduce maintenance is an effective technology Established in recent times. Fiber reinforced polymer (FRP) application is very effective way to Repair and Strengthen structures that have become structurally weak over their life span. FRP repair system provides an Economically viable alternative to traditional repair system and material

**N. Sagaresan** Fracture in quasi-brittle materials such as concrete is accompanied by excessive cracking. Numerical analysis of concrete fracture is either based on smeared crack method or discrete crack method. Smeared crack methods are computationally less challenging than the discrete crack method. However, this simplicity brings loss of accuracy. We propose a novel simplified and highly efficient meshless method for discrete cracks and study fracture of concrete. The method exploits the advantages of smeared crack method and maintains the accuracy of discrete crack method. The discrete crack is modeled by set of discrete crack segments placed through the entire domain of influence of a node. We use Neo-Hooke material in the bulk material and cohesive zone model once discrete cracks occur. We demonstrate the accuracy of the proposed mesh-less discrete crack method for complex problems involving mode-I and mixed mode failure.

### III. MATERIALS AND IT’S APPLICATIONS

#### (a)High-performance composite infrastructural systems utilizing advanced cementitious composites

This system is a partially cast-in-place high-performance composite frame system (HPCFS) developed by selectively using high-performance materials, including Continuous fiber-mat high performance fiber reinforced concrete (HPFRCs) called slurry infiltrated mat concrete (SIMCON), Discontinuous fiber HPFRCs called slurry infiltrated fiber concrete (SIFCON), and high-strength, lightweight aggregate fiber reinforced concrete (HS-LWA FRC).

A controlled quantity of high-range water-reducing admixture (super plasticizer) may be used for improving the flowing characteristics of SIFCON. All types of steel fibers, namely, straight, hooked, or crimped can be used. Proportions of cement and sand generally used for making SIFCON are 1: 1, 1:1.5, or 1:2. Cement slurry alone can also be used for some applications. Generally, fly ash or silica-fume equal to 10 to 15% by weight of cement is used in the mix. The water-cement ratio varies between 0.3 and 0.4, while the percentage of the super plasticizer varies from 2 to 5%

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

by weight of cement. The percentage of fibres by volume can be anywhere from 4 to 20%, even though the current practical range ranges only from 4 to 12%.

SIMCON can also be considered a pre-placed fiber concrete, similar to SIFCON. However, in the making of SIMCON, the fibres are placed in a “mat form” rather than as discrete fibres. The advantage of using steel fiber mats over a large volume of discrete fibers is that the mat configuration provides inherent strength and utilizes the fibers contained in it with very much higher aspect ratios. The fiber volume enhance, be substantially less than that required for making of SIFCON, still achieving identical flexural strength and energy absorbing toughness. SIMCON is made using a non-woven “steel fiber mats” that are infiltrated with a concrete slurry. Steel fibres produced directly from molten metal using a chilled wheel concept are interwoven into a 0.5 to 2 inches thick mat. This mat is then rolled and coiled into weight sand sizes convenient to a customer’s application (normally up to 120 cm wide and weighing around 200 kg).

As in conventional SFRC, factors such as aspect ratio and fiber volume have a direct influence on the performance of SIMCON. Higher aspect ratios are desirable to obtain increased flexural strength. Generally, because of the use of mats, SIMCON the aspect ratios of fibres contained in it could well exceed 500. Since the mat is already in are formed shape, handling problems are significantly minimized resulting in savings in labor cost. Besides this, “balling” of fibres does not become a factor at all in the production of SIMCON.

### (b) Carbon fiber based linear reinforcing elements

Due to their light weight (about one fifth that of steel), high tensile strength (higher than steel) and good overall environmental durability, carbon fiber based tendons and cables are increasingly being used for reinforcement of concrete structures in Japan. The reduction in weight facilitates better handling and easier field installation compared to steel. These elements also cause significantly less sag under their own weight, which increases load capacity while enabling the construction of longer bridge spans.

Leadline reinforcing elements are circular rods that are pultruded using uni-directional carbon fibers at 65% fiber volume fraction with an epoxy resin. The rods have a specific gravity of 1.6, a relaxation ratio of 2-4% at 20°C, and a coefficient of thermal expansion of  $0.68 \times 10^{-6} / ^\circ\text{C}$  in the longitudinal direction. The rods have a tensile modulus of 147 GPa and 1.5 to 1.7% elongations at break. Rods are available in a number of diameters with four major surface types.

Characteristics on leading rods											
	Round rods							Indented rod			
Designation	R1	R3	R5	R8	R10	R12	R17	D5	D8	D10	D12
Dia(mm)	1	3	5	8	10	12	17	5	8	10	12
Tension(kN)	1.8	16	44	111	170	255	512	40	104	162	245
c/s area(mm <sup>2</sup> )	0.8	7.1	19.6	49.0	75.4	113.1	227	17.8	46.1	71.8	108.6
Weight(g/m)	1.2	11	32	78	119	178	360	30	77	118	177

### (c) Steel Fiber Reinforced Concrete (SFRC)

Concrete is the most widely used structural material in the world with an annual production of over seven billion tons. For a variety of reasons, much of this concrete is cracked. The reason for concrete to suffer cracking may be attributed to structural, environmental or economic factors, but most of the cracks are formed due to the inherent weakness of the material to resist tensile forces. Again, concrete shrinks and will again crack, when it is restrained. It is now well established that steel fiber reinforcement offers solution to the problem of cracking by making concrete tougher and more ductile. It has also been proved by extensive research and field trials carried out over the past three decades, that addition of steel fibers to conventional plain or reinforced and prestressed concrete members at the time of mixing/production imparts improvements to several properties of concrete, particularly those related to strength, performance and durability.

The weak matrix in concrete, when reinforced with steel fibers, uniformly distributed across its entire mass, gets strengthened enormously, thereby rendering the matrix to behave as a composite material with properties significantly different from conventional concrete.

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

The randomly-oriented steel fibers assist in controlling the propagation of micro-cracks present in the matrix, first by improving the overall cracking resistance of matrix itself, and later by bridging across even smaller cracks formed after the application of load on the member, thereby preventing their widening into major cracks

The idea that concrete can be strengthened by fiber inclusion was first put forward by Porter in 1910, but little progress was made in its development till 1963, when Roumaldian Batson carried out extensive laboratory investigations and published their classical paper on the subject. Since then, there has been a great wave of interest in and applications of SFRC in many parts of the world. While steel fibers improve the compressive strength of concrete only marginally by about 10 to 30%, significant improvement is achieved in several

## (d) Mix Design for SFRC

Just as different types of fibers have different characteristics, concrete made with steel fibers will also have different properties. When developing an SFRC mix design, the fiber type and the application of the concrete must be considered. There must be sufficient quantity of mortar fraction in the concrete to adhere to the fibers and allow them to flow without tangling together, a phenomenon called 'balling of fibers'. Cement content is, therefore, usually higher for SFRC than conventional mixes. Aggregate shape and content is critical. Coarse aggregates of sizes ranging from 10 mm to 20 mm are commonly used with SFRC. Larger aggregate sizes usually require less volume of fibers per cubic meter. SFRC with 10 mm maximum size aggregates typically uses 50 to 75 kg of fibers per cubic meter, while the one with 20 mm size uses 40 to 60 kg. It has been demonstrated that the coarse aggregate shape has a significant effect on workability and material properties.

Crushed coarse aggregates result in higher strength and tensile strain capacity. Fine aggregates in SFRC mixes typically constitute about 45 to 55 percent of the total aggregate content.

Typical mix proportions for SFRC will be: cement 325 to 560 kg; water-cement ratio 0.4- 0.6; ratio of fine aggregate to total aggregate 0.5-1.0; maximum aggregate size 10mm; air content 6-9%; fiber content 0.5-2.5% by volume of concrete. An appropriate pozzolan may be used as a replacement for a portion of the Portland cement to improve workability further, and reduce heat of hydration and production cost.

The use of steel fibers in concrete generally reduces the slump by about 50 mm. To overcome this and to improve workability, it is highly recommended that a super plasticizer be included in the mix. This is especially true for SFRC used for high performance applications. Generally, the ACI Committee Report No. ACI 554 'Guide for Specifying, Mixing, Placing and Finishing Steel Fiber Reinforced Concrete' is followed for the design of SFRC mixes appropriate to specific applications.

## IV. CONCLUSION

(i) The performance of the thinner SFRC slabs on the ground is found comparable to thicker plain concrete slabs. Accordingly, a 25 percent thickness reduction is possible by incorporating 30 kg/m<sup>3</sup> of hooked end steel fibres.

(ii) The extended design approach resulted in SFRC slabs that are equivalent to the plain concrete slab under in-service traffic loading. This approach can serve as an interim design approach for SFRC roads while our understanding of the behavior of SFRC roads evolves and more advanced methods are developed.

Following conclusions are drawn based on the previous & present experimental study on SFRC and new generation high performance fiber reinforced concrete:

1. The growth of the amount of research and applications of steel fiber reinforced concrete (SFRC) and high performance concrete has been phenomenal in the past seven or eight years. High performance concrete has become widely accepted practically on all continents.
2. A generalized definition of high performance concrete seems to have been accepted by the engineering community. Such a definition is based on achievement of certain performance requirements or characteristics of concrete for a given application that otherwise cannot be obtained from normal concrete as a commodity product. In many applications use of fiber is mandatory

# International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 8, August 2016

3. Much of the application of HP-SFRC remains in the areas of long-span bridges and high-rise buildings. It is used more for bridges than buildings in Europe and Japan, while more buildings than bridges used HPC in the U. S. However, the situation is changing. Use of HPC in buildings is increasing these days.
4. Increasing emphasis is being placed on concrete durability than its strength. In many applications, high strength concrete is used only because of its high durability quality rather than the need for its strength.
5. Much research continues to be focused on the mechanical properties of high and very-high-strength concretes with and without fibers and their structural applications. The results of this research are being incorporated into various national codes of practice. However, more information is needed on the behavior of the concrete at its early age and its relationship to the long-term performance.
6. The Slurry Infiltrated Mat Concrete (SIMCON) and the delivery system for non-metallic fibers developed are two significant recent developments in the area of high performance fiber reinforced concrete.
7. There has been significant interest and development in the use of continuous fiber reinforcement for improving the behavior of concrete. Fiber Reinforced Polymers (FRP) or sometime also referred to as Fiber Reinforced Plastic are increasingly being accepted as an alternative for uncoated and epoxy-coated steel reinforcement for prestressed and non-prestressed concrete applications.
8. Compact Reinforced Concrete and Reactive Powder Concrete (Ductal) have gained popularity in western countries.
9. Finally the use of this high performance new generation fiber concretes in India is only in laboratories and in research centers. It will take many years to see in practice.

## REFERENCES

- [1] P. N. Balaguru and S. P. Shah. 1992. **Fiber Reinforced Cement Composites**. McGraw-Hill, New York, 1992.
- [2] ACI Committee 544. 1982. State-of-the-Art Report on Fiber Reinforced Concrete (ACI 544.1R-82). **Concrete International**, May, Vol. 4, No. 5, pp. 9-30.
- [3] Nataraja, M. C., Dhang, N and Gupta, A. P (1999), 'Statistical Variations in Impact Resistance of Steel Fiber Reinforced Concrete Subjected to Drop Weight Test', **Cement and Concrete Research**, Pergoman press, USA, Vol. 29, No. 7, 1999, pp.989-995.
- [4] A.V.S.Sai. Kumar and B.Krishna rao (2014) A Study on Strength of Concrete With Partial Replacement Of Cement With Quarry Dust And Metakaolin. ISSN: 2319-8753, PP 10467-10403
- [5] . Nataraja, M. C., Dhang, N and Gupta, A. P (1999). 'Stress-strain Curves for Steel fiber Reinforced Concrete in Compression', **Cement and Concrete Composites UK**, Vol. 21, No. 5/6, 1999, pp. 383-390.
- [6] Nataraja, M. C., Dhang, N and Gupta, A. P (2000), 'Toughness Characterization of Steel Fiber Reinforced Concrete by JSCE Approach', **Cement and Concrete Research**, Pergoman press, USA, Vol. 30, No. 4, 2000, pp. 593-597.
- [7] Nataraja, M. C., Dhang, N and Gupta, A. P (2001). 'Splitting Tensile Strength of Steel fiber Reinforced Concrete', **Indian Concrete Journal**, Vol. 75, No. 4, April 2001, pp. 287-290.
- [8] **K. Vamshi krishna1, J. Venkateswara Rao**"Experimental study on behavior of fiber reinforced concrete for rigid pavements
- [9] Nitin Kumar, Sangeeta "A Review study on use of Steel Fiber as Reinforcement Material with Concrete"
- [10] ACI Committee 544. 1990. State-of-the-Art Report on Fiber Reinforced Concrete. **ACI Manual of Concrete Practice, Part 5**, American Concrete Institute, Detroit, MI, 22 pp.
- [11] Chintan Patel, Kishan Patel, Prof. Manjurali, I. Balya , Prof. Vikrant A. Patel "Performance Evaluation of Polymer Fiber "RECRON-3S" in Pavement Quality Concrete"
- [12] ACI Committee 440. 1996. State-of-the-Art Report on Fiber Reinforced Plastic (FRP) for Concrete Structures (ACI 440R). **ACI Manual of Concrete Practice, Part 5**, American Concrete Institute, Detroit, MI, 68 pp.
- [13] Nataraja, M. C., Dhang, N and Gupta, A. P (2000), 'A Study on the Behavior of Steel Fiber Reinforced Subjected to Splitting Test', **Asian Journal of Civil Engineering**, Teheran, Iran, Vol. 1, No. 1, Jan. 2000, pp. 1-11