

# Study on Behaviour of Steel Fiber Reinforced Crumb Rubber Concrete

R. Saravana Kumar<sup>1</sup>, T.C. Aswin<sup>2</sup>, S. Sam Marshall<sup>3</sup>

Professor, Department of Civil Engineering, St. Joseph's College of Engineering, Chennai, India<sup>1</sup>

U.G. Student, Department of Civil Engineering, St. Joseph's College of Engineering, Chennai, India<sup>2,3</sup>

**ABSTRACT:** This study focuses on the improvement of the strength of crumb rubber concrete sleepers. Crumb rubber concrete has been proved that it has superior vibration properties compared to conventional concrete and is qualified as a potential sleeper. But crumb rubber decreases the compressive strength of the concrete. To increase the compressive strength of crumb rubber concrete, steel fiber was added with silica fume in various proportions. The best proportions and nominal size of silica fume and crumb rubber was chosen (75micron). Mix design for M30 grade of concrete have been carried out. Steel fiber later was added to the concrete mix in proportions 0.5%, 1%, 1.5%,2% to the total volume of the cube and beam. The casting of samples was done and the testing of all the samples have been carried out. The compressive strength, split tensile strength and flexural strength of the samples have been found out by testing. Finally the best proportions have been suggested to improve the strength property of the crumb rubber sleepers.

**KEYWORDS:** crumb rubber, steel fiber, concrete sleepers, silica fume

## I. INTRODUCTION

Concrete is a widely used construction material all over the globe due to its high compressive strength. Further, reinforcements were provided to enhance the tensile strength of the concrete. It is called as reinforced concrete. Various grades of concrete having higher strengths and different types of steel having various strength characteristics were developed to account for our needs. To reduce the cost of concrete and also to enhance certain properties, certain substitutes such as fly ash, blast furnace slag, different fibers, etc. are added in various proportions are added according to our need. Adding substitutes and experimenting with concrete will never stop and it will result in different types of concrete in the future also. In this paper, crumb rubber, steel fiber and silica fume are the materials added to concrete in various proportions. The strength, durability and other characteristic of concrete depends on the properties of its ingredients, proportion of mix, method of compaction and other controls during placing and curing.

## II. MATERIALS

### A. Cement

Cement is a binder material which is used in construction for adhering purposes. It is seldom used on its own. It is mixed with sand to become mortar in a proportion and used for laying masonry, etc. It is one of the important constituents of concrete. In this project, OPC grade 53 is used.

### B. Fine aggregate

Fine aggregate generally means sand like river sand and M-sand which are finely grained. It is used for construction purposes. It is used in cement mortar and concrete. Sand which passed through 2.36 mm sieve is used in this project.

### **C. Coarse aggregate**

Coarse aggregate is coarse to medium grained crushed stones, gravel, recycled concrete, etc. that are used in concrete for construction. In this project, crushed granite angular aggregates of size - 60% of 20mm passing and 12.5mm retaining and 40% of 12.5mm passing and 10mm retaining conforming to grading zone -I has been used.

### **D. Concrete**

Generally, concrete is a mixture of cement paste, fine aggregate like sand and coarse aggregate like gravel. The aggregates are sieved according to the need and a particular grade of cement is used for the strength needed. The proportions of constituents of concrete are determined by mix design.

### **E. Crumb rubber**

Crumb rubber is recycled rubber produced from automotive and truck scrap tires. Continued processing with a granulator or cracker mill, possibly with the aid of cryogenics or by mechanical means, reduces the size of the particles further [13]. In this project, 5% of sand is replaced by crumb rubber which pass through 75  $\mu$  sieve.

### **F. Silica fume**

Silica fume is added to Portland cement concrete to improve its properties, in particular its compressive strength, bond strength, and abrasion resistance. Addition of silica fume also reduces the permeability of concrete to chloride ions, which protects the reinforcing steel of concrete from corrosion. Silica fume reduces bleeding significantly [13]. In this project, 95% pure silica fume is used and 10% of cement will be replaced by silica fume.

### **G. Fiber**

Fiber-reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. fibers include steel fibers, glass fibers, synthetic fibers and natural fiber. In addition, the character of fiber-reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation, and densities [13]. In this project, crimped steel fiber having aspect ratio 70 is used and certain percentage of mass of concrete is replaced by this fiber.

### **E. Super Plasticizer**

They are used to reduce the water content in concrete to increase the strength and increase the workability at the same time. In this project, super plasticizer having density of 1.2 kg/l is used. 2% of cement is replaced by super plasticizer.

## **III. TESTS CONDUCTED**

### **A. Specific gravity test**

Specific gravity is the ratio of the density of a substance to the density of a reference substance. The experiment is done with the help of the pycnometer. The fine aggregates like river sand and crumb rubber, coarse aggregates and cement used for investigation are tested to determine the specific gravity. Water is used in pycnometer for testing the fine aggregates and coarse aggregates, but in case of cement water is replaced with kerosene.

### **B. Fineness modulus test**

The Fineness modulus (FM) is an empirical figure obtained by adding the total percentage of the sample of an aggregate retained on each of a specified series of sieves and dividing the sum by 100. For fine aggregate and crumb rubber, about 2 kg of each of them is passed into various sieve size arranged in the order of 4.75mm, 2.36mm,

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

An ISO 3297: 2007 Certified Organization

Volume 7, Special Issue 5, April 2018

1<sup>st</sup> International Conference on Recent Innovation in Civil Engineering and Management (ICRICEM '18)

22<sup>nd</sup> March 2018

Organized by

Department of Civil Engineering & MBA, Loyola Institute of Technology, Chennai, Tamilnadu, India

1.18mm, 0.6mm, 0.3mm, 0.15mm and lesser than 0.15mm (top to bottom) with pan at the bottom. For coarse aggregate, about 2kg is passed into various sieve size arranged in the order of 20mm, 19mm, 13.2mm, 11.2mm, 9.5mm, 6.7mm, 5.6mm, 4.75mm and 2.36mm (top to bottom) with pan at the bottom.

**C. Slump cone test**

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. A frustum having height 30 cm with top and bottom diameter of 10 cm and 20 cm respectively is used.

**D. Compressive strength test**

The maximum compressive strength is that under gradually applied load given solid material will sustain without fracture. Compressive strength is calculated by dividing the maximum load by the original cross-sectional area of a specimen in a compression test. The mould used is of dimensions 150mm × 150mm × 150mm..

**E. Split tensile strength test**

A test for tensile strength in which a cylindrical specimen is loaded to failure in diametral compression applied along the entire length. The resistance of a material to longitudinal stress, measured by the minimum amount of longitudinal stress required to rupture the material. The concrete cylinder used for split tensile strength test is 150mm in diameter and 300mm long.

**F. Flexural strength test**

Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test. The flexural strength represents the highest stress experienced within the material at its moment of yield. Beam mould of size 150 x 150 x 700 mm is used.

**IV. MIX DESIGN**

Grade designation - M30

Type of cement - OPC 53 confirming IS12269-1987

Nominal size of aggregate (60%) - 20mm (passing) – 12.5mm (retaining)

Nominal size of aggregate (40%) - 12.5mm (passing) – 10mm (retaining)

Minimum cement content - 320 kg/m<sup>3</sup> (as per IS456 table 8), Maximum cement content - 450 kg/m<sup>3</sup> Max  
water content ratio - 0.4 (As per IS456 table 5)

Workability - 100 mm (slump)

Type of aggregate - Crushed angular aggregate Mix  
proportion obtained – 1 : 1.71 : 2.6

The following designations were followed in the below tests M1 -  
control mix., M2 - Crumb rubber concrete,

M3, M4, M5, M6 – steel fiber reinforced crumb rubber concrete with 0.5%, 1%, 1.5%, 2% steel fiber respectively.

**V. MASS CALCULATION**

**Table 1 Mass calculation for each mould**

Contents	Cube mould (kg)	Beam mould (kg)	Cylinder mould (kg)
Cement	1.59	7.42	2.5
Fine aggregate	2.72	12.69	4.27
Coarse aggregate	4.1	19.29	6.49

**VI. RESULTS**

*A. Specific gravity test*

**Table 2 Specific gravity**

Contents	Specific gravity
Cement	3.14
Fine aggregate	2.45
Coarse aggregate	3.04
Crumb rubber	1.26
Silica fume	2.2

*B. Fineness modulus test*

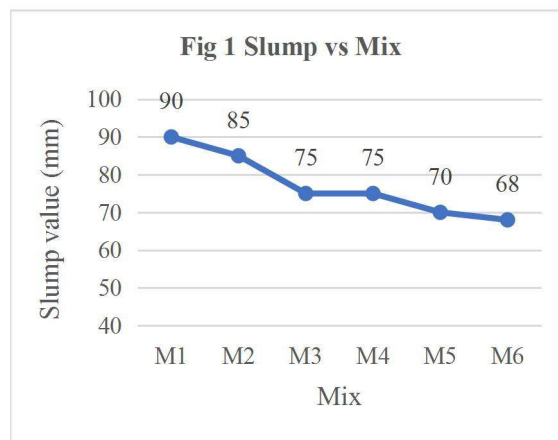
**Table 3 Fineness modulus**

Contents	Fineness modulus
Fine aggregate	3.769
Coarse aggregate	3.105
Crumb rubber	6.15

C. Slump cone test

**Table 4 Slump cone test**

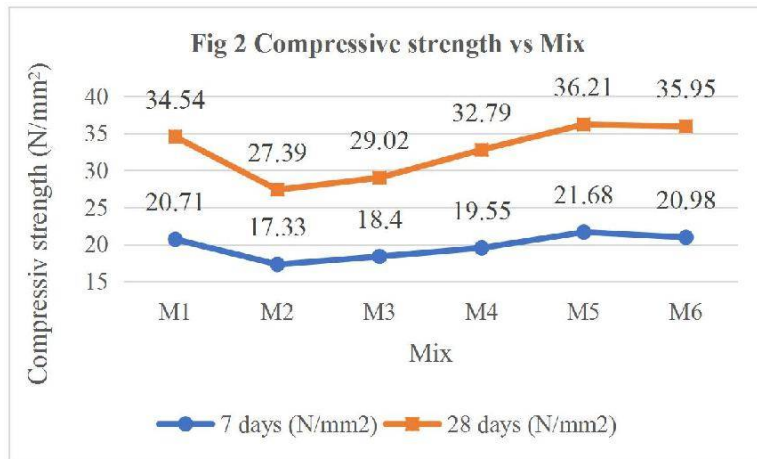
Mix	Crumb rubber (%)	Silica fume (%)	Steel fiber (%)	Slump value (mm)
M1	0	0	0	90
M2	5	10	0	85
M3	5	10	0.5	75
M4	5	10	1	75
M5	5	10	1.5	70
M6	5	10	2	68



D. Compressive strength test

**Table 5 Compressive strength**

Mix	Crumb rubber (%)	Silica fume (%)	Steel fiber (%)	7 days (N/mm <sup>2</sup> )	28 days (N/mm <sup>2</sup> )
M1	0	0	0	20.71	34.54
M2	5	10	0	17.33	27.39
M3	5	10	0.5	18.4	29.02
M4	5	10	1	19.55	32.79
M5	5	10	1.5	21.68	36.21
M6	5	10	2	20.98	35.95

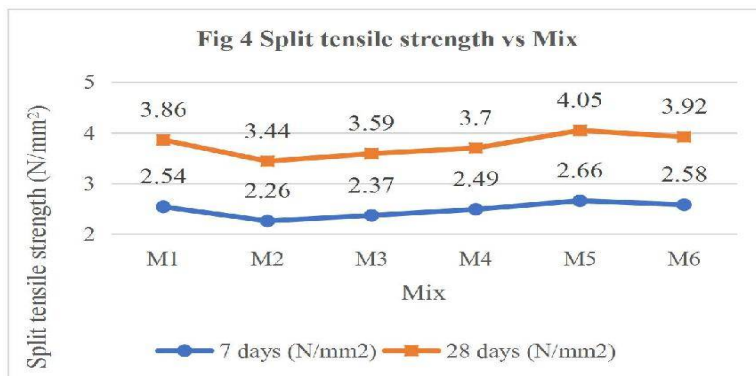


**Fig 3 Compressive strength test**

E. Split tensile strength test

**Table 6 Split tensile strength**

Mix	Crumb rubber (%)	Silica fume (%)	Steel fiber (%)	7 days (N/mm <sup>2</sup> )	28 days (N/mm <sup>2</sup> )
M1	0	0	0	2.54	3.86
M2	5	10	0	2.26	3.44
M3	5	10	0.5	2.37	3.59
M4	5	10	1	2.49	3.7
M5	5	10	1.5	2.66	4.05
M6	5	10	2	2.58	3.92



**Fig 5 Split tensile strength test**

E. Flexural strength test

Table 7 Flexure strength

Mix	Crumb rubber (%)	Silica fume (%)	Steel fiber (%)	28 days (N/mm <sup>2</sup> )
M1	0	0	0	5.33
M2	5	10	0	4.81
M3	5	10	0.5	4.95
M4	5	10	1	5.27
M5	5	10	1.5	5.67
M6	5	10	2	5.66

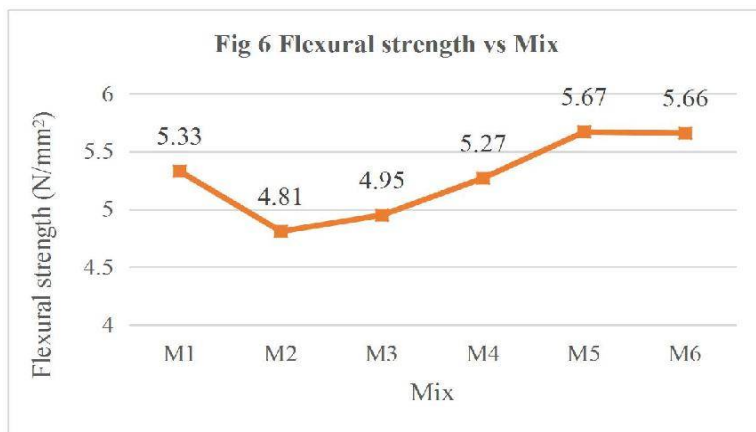


Fig 7 Flexural strength test

**VII. CONCLUSION**

Various strength tests are conducted on concrete having seven different types of mix proportions for 7 days and 28 days. The graphs obtained from the results clearly indicate that the addition of 1.5% of steel fiber in crumb rubber concrete significantly increases the overall strength than the concrete with other mix proportions. It is concluded that the addition of 1.5% steel fiber addition to the crumb rubber concrete is an optimum choice compared to the other percentages considered.

**VIII. ACKNOWLEDGEMENT**

The authors are thankful to St. Joseph's College of Engineering, Chennai – 600 119 for their support, guidance and encouragement throughout the entire project.

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

*An ISO 3297: 2007 Certified Organization*

*Volume 7, Special Issue 5, April 2018*

**1<sup>st</sup> International Conference on Recent Innovation in Civil Engineering and Management (ICRICEM '18)**

**22<sup>nd</sup> March 2018**

**Organized by**

**Department of Civil Engineering & MBA, Loyola Institute of Technology, Chennai, Tamilnadu, India**

**REFERENCES**

- [1] Poon. C.S, (2011), "Effects of metakaolin and silica fume on properties of concrete", Concrete International Nov.1994, pp. 37-44.
- [2] Sakdirat Kaewunruen. K (2017), "Vibration characteristics of micro engineering crumb rubber concrete for railway sleeper applications", Cement Concrete. Res. 25 1501 – 1511.
- [3] Ananth Ramaswamy. S (2015), "Composition of fiber reinforced concrete", Cement Concrete. Compos. 21 1 – 9.
- [4] Reda. M.M, Shrive. M.P, Gillott. J.E (1999), "Microstructural investigation of innovative UHPC", Cement Concrete. Res. 29 323 – 329.
- [5] Bonneau. O, Vernet. C, Moranville. M, Aitcin. P.C (2000), "Characterization of the granular packing and percolation threshold of reactive powder concrete", Cement Concrete. Res. 30 1861 – 1867.
- [6] Feylessoufi. A, Tenoudji. F.C, Morin. V, Richard. P (2001), "Shrinkage mechanisms of ultra-high-performance cement-based materials", Cement Concrete. Res. 31 1573 – 1579.
- [7] Matte. V, Moranville. M (1999), "Durability of reactive powder composites: influence of silica fume on the leaching properties of very low water/ binder pastes", Cement Concrete. Res. 60 18671 – 1887.
- [8] IS 383-1970 "Specification for Coarse and Fine aggregate from natural sources for concrete" Bureau of Indian Standards, New Delhi, India.
- [9] IS 456-2000 "Code practice for Plain and cement concrete" Bureau of Indian Standards, New Delhi, India.
- [10] IS 516-1959 "Methods of test for strength of concrete" Bureau of Indian Standards, New Delhi, India.
- [11] IS 2386-1963(part-III) "Determination of Specific gravity, voids, Absorption" Bureau of Indian Standards New Delhi India.
- [12] IS 10262-2009 "Guidelines for Concrete Mix Design" Bureau of Indian Standards, New Delhi.
- [13] <https://www.wikipedia.org/>