Utilization of Recycled Steel Fibre Extracted from Scrap Tyres in Concrete

R. Lakshmi Kusama[1] Y. Priyanka[2] V. Bhargavi[3]
[1]PG Student [2]Assistant Professor [3]Associate Professor
[1,2,3]Visakha Technical Campus, Visakhapatnam, Andhra Pradesh, India

Abstract— The use of recycled fibers from crumb rubber waste for concrete is a very attractive approach, with such benefits as performance enhancement, low-cost raw materials, and reduced needs for landfilling. This project undergoes the study of general advantages of fiber reinforcement and study of Mechanical properties by use of crumb rubber waste fibers for concrete in structures. Expected outcome on the study of recycled crumb rubber waste fibers for fiber-reinforced concrete can show a significant toughness increase. In these studies, were carried in accordance with utilization of wide range of fiber dosage rates, from 0.2 to 1.0 vol.%. The results were further analyzed by comparison of mechanical properties and found that 1% addition of RSRC can be utilized in proportion.

Keywords: Rubber waste Fibers, Recycling, Mechanical Properties

I. INTRODUCTION

The weak matrix in concrete, when reinforced with steel fibres, 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 fibres to concrete, there are several applications where Fibres Reinforced Concrete (FRC) can be intelligently and beneficially used. These fibres have already been used in many large projects involving the construction of industrial floors, pavements, highway-overlays, etc. in India. The principal fibres in common commercial use for Civil Engineering applications include steel (SFRC/SFRS), glass, carbon and aramid. These fibres are also used in the production of continuous fibres and are used as a replacement to reinforcing steel. High percentages of steel fibres are used extensively in tunneling.

Cement concrete is characterized by brittle failure, it can be overcome by the inclusion of a small amount of short randomly distributed fibers (natural and manmade) and can be practiced among others that weaknesses of concrete, such as low growth resistance, high shrinkage cracking, low durability, etc.

The presence of micro cracks at the mortar-aggregate interface is responsible for the inherent weakness of plain concrete. This weakness can be removed by inclusion of fibers in the mix to increase its toughness or ability to resist crack growth. Fibers help to improve the post peak ductility performance, pre-crack tensile strength, fatigue strength, impact strength and eliminate temperature and shrinkage cracks. The fibers help to transfer loads at the internal micro cracks. Such a concrete is called fiber-reinforced concrete.

Fiber reinforced concrete beams satisfy two of the much-demanded requirements of the construction material in India economy and reduced pollution. It also has several other advantages like longer life, low maintenance cost, good quality, increased load carrying capacity and impermeability to water over short term failures.

The pyrolysis method for recycling used tires is a technique which heats whole or shredded tires in a reactor vessel containing an oxygen-free atmosphere. In the reactor the rubber is softened after which the rubber polymers break down into smaller molecules. These smaller molecules eventually vaporize and exit from the reactor. These vapors can be burned directly to produce power or condensed into an oily type liquid, generally used as a fuel. Some molecules are too small to condense. They remain as a gas which can be burned as fuel. The minerals that were part of the tire, about 40% by weight, are removed as solid ashes. When performed properly, the tire pyrolysis process is a clean operation and produces little emissions or waste, however, concerns about air pollution due to incomplete combustion as is the case with tire fires have been documented.[20]

The properties of the gas, liquid, and solid output are determined by the type of feed-stock used and the process conditions. For instance whole tires contain fibers and steel. Shredded tires have most of the steel and sometimes most of the fiber removed. Processes can be either batch or continuous. The energy required to drive the decomposition of the rubber include using directly fired fuel (like a gas oven), electrical induction (like an electrically heated oven) or by microwaves (like a microwave oven). Sometimes a catalyst is used to accelerate the decomposition. The choice of feed-stock and process can affect the value of the finished products.

The historical issue of tire pyrolysis has been the solid mineral stream, which accounts for about 40% of the output. The steel can be removed from the solid stream with magnets for recycling. The remaining solid material, often referred to as "char", has had little or no value other than possibly as a low grade carbon fuel. Char is the destroyed remains of the original carbon black used to reinforce and provide abrasion resistance to the tire. The solid stream also includes the minerals used in rubber manufacturing. This high-volume component of tire pyrolysis is a major impediment, although this theme continues to be a source of innovation.

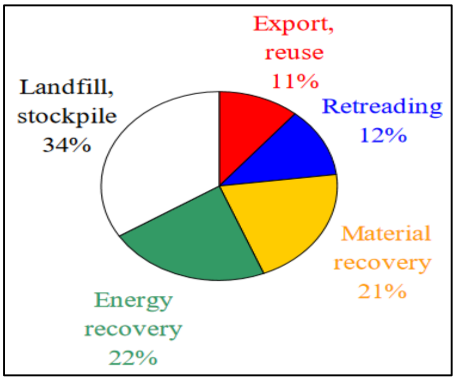

Fig. 1: Statistics of waste tyre recycling

II. LITERATURE REVIEW

Lee et al. (2018) made an attempt to investigate the structural behavior of SFRC beams under various loading intervals/rates. Three type's loads includes static, impact, and blast loadings were considered in this study. In addition, the contribution of SFRC on the shear strength of beam was also analyzed. The results were revealed that the steel fibre increased the ductility performance of the beam and also enhanced the static shear strength of beam.

Luccioni et al. (2017) investigate the static and dynamic behavior of the SFRC slabs. The test results were revealed that the inclusion of fibre enhanced the static bending response of the slab, furthermore, the static bending response of the slab increased with the increase in the fibre content.

Aquib Sultan et al. (2016) studied on Strength Properties of Rigid Pavement Concrete with Use of Steel Fibers and Marble Dust. Materials used in this study are cement, coarse aggregates, fine aggregates, and super-plasticizer, in addition to marble dust and steel fibres. These materials were read in terms of various Indian practices. This paper depicts ongoing researches about the study of rigid pavement concrete strength using steel fibre and Marble dust. Many analysis pertaining to steel fibre reinforced concrete and Marble dust were studied, and their effects were also laid down to a particular conclusion. The conclusion that was drawn out of these studies was that the compressive strength showed an immense increase on use of steel fibre and Marble dust in the rigid pavement concrete, where in marble dust was used as a partial replacement for cement. Also changes were found out in various cases of cube strength, split tensile strength and the flexural strength. It also showed the effect of use of a waste material in the form of waste marble dust being used as a partial replacement material for any cementious compound and ultimately acquiring a strength in particular more than that of a nominal mix.

Ali Amin and Stephen J. Foster (2016) despite the increased awareness of Steel Fibre Reinforced Concrete (SFRC) in practice and research, SFRC is yet to find common application in load bearing or shear critical building structural elements. Although the far majority of studies on SFRC have focused on members containing fibres only, in most practical applications of SFRC construction, structural members made of SFRC are also reinforced with conventional reinforcing steel for shear ligatures. In this paper, results are presented on shear tests which have been conducted on ten 5 m long by 0.3 m wide by 0.7 m high rectangular simply supported beams with varying transverse and steel fibre reinforcement ratios.

Dinesh W. Gawatre et al. (2016) Steel fibers were added to the fractions of volume 0.5%, 1.0%, 1.5% and 2.0%. The reinforced concrete compression strength increased to 1.5% by volume, with a 15.3% improvement over HSC. It also showed the effect of use of a waste material in the form of waste marble dust being used as a partial replacement material for any cementious compound and ultimately acquiring a strength in particular more than that of a nominal mix.

Nitin Kumar et al. (2015) presented the use of steel fibers as reinforcement material with concrete. In this study, the mixing of various materials weather chemicals natural or official for improving the strength and durability of parent substance. Critical investigation for M 40 grade of concrete having mix proportion 1:4:3 with water cement ratio 0.35 to study the compressive strength flexural strength, split tensile strength of steel fibers reinforced concrete containing fibers of 0%, 1%, 2% and 3% volume fraction of hooks the result shown that steel fiber reinforced concrete increase strength toughness ductility and flexural strength of concrete.

Ilker Fatih Kara et al. (2015) developed a numerical method to assess the deflection, curvature and moment capacity of the reinforced concrete beams fabricated with with hybrid FRP/steel reinforced concrete. The predicted test results (moment capacity, curvature and deflection hybrid FRP/steel reinforced concrete beams) using proposed numerical technique was too accurate and the numerical test results were shown that the added to FRP reinforced concrete beams increased the ductility and stiffness of the beam.

III. EXPERIMENTAL PROCEDURE

It comprises the experimental program and the constituent materials used to study the influence of recycled steel fibres form scrap tyres in concrete. As Recycled Steel fibre reinforced concrete (RSFRC) is composite material made of hydraulic cements containing fine and coarse aggregate and using discontinuous discrete recycle steel fibres as raw material. Different methods were used for trail mixes and after selecting the best method many mixes with different percentage of recycled steel fibre were studied compared with the conventional mix.

Properties	Description
Cross Section	Straight, deformed
Diameter	0.23mm
Length	50mm
Density	7800 Kg/m^3
Young's Modulus	2.1 x 10^5 N/mm^2
Melting point	1390^o C
Resistance to Alkalis	Good
Resistance to Acids	Poor
Tensile Strength	500-2000 N/mm^2
Specific Gravity	7.9
Aspect Ratio	50

Table 1: Properties of Recycled Steel Fibers

Mix Proportions:	
Cement	370.43 kg/m^3
Water	151.88 kg/m^3
Fine Aggregate	690.62 kg/m^3
Coarse Aggregate	1156.78 kg/m^3
Chemical Admixture	3.70 kg/m^3
Water cement Ratio	0.41

Table 2: Mix Proportion

IV. RESULTS

A. *Mechanical Properties:*

RSFRC	Compressive Strength		
	7 days	14 Days	28 days
C.C	32.7	42.06	43.5
0.20%	33.74	41.2	41.8
0.40%	34.35	42.42	43.21

0.60%	34.87	42.3	43.5
0.80%	36.38	44.64	46.2
1.0%	37.14	43.22	48

Table 4: Compressive strength of concrete

RSFRC	Split Tensile Strength		
	7 days	14 Days	28 days
C.C	2.3	3.2	3.58
0.20%	2.19	2.6	2.5
0.40%	2.5	2.78	2.89
0.60%	2.54	3.14	3.32
0.80%	2.6	3.45	3.57
1.0%	2.8	3.61	3.7

Table 5: Split Tensile strength of concrete

RSFRC	Flexural Strength		
	7 days	14 Days	28 days
C.C	3.32	3.2	4.86
0.20%	3.16	3.8	4.84
0.40%	4.24	3.78	4.92
0.60%	4.32	4.33	5.08
0.80%	4.8	4.36	5.09
1.0%	4.85	5.02	5.8

Table 6: Flexural strength results

V. CONCLUSION & FUTURE SCOPE

A. Conclusion

To enhance the concrete energy absorption capacity, SFRC was evolved in the early years of 1960s and the SFRCs are increasingly being used in the construction industry to withstand the dynamic, fatigue and blast loading. Since the design guidelines for the SFRC structures are very limited, several attempts have been made to verify the efficiency of RSFRC in structural member application and to establish the several attempts have been made to verify the efficiency of RSFRC in structural member application. From the present experimental work, we can conclude that recycled steel fibres strength have been increased in compressive strength, tensile strength and flexural strength compared to conventional concrete.

The results showed that the compressive strength has been increased with increasing the (0.20, 0.40, 0.60, 0.80, and 1.0) percentage of recycled steel fibres content in the concrete. In the experiment the workability has been reduced due to addition of recycled Steel fibres content. Flexural strength and split tensile were also increased with the addition of recycled steel fibres and results were remarkably better than conventional concrete. Strength has been increased in compressive strength, tensile strength and flexural strength compared to conventional concrete.

REFERENCES

[1] H. Cenan Mertol, E. Baran and H. Jibril Bello, "Flexural behavior of lightly and heavily reinforced steel fiber concrete beams". Construction and Building Materials. Vol. 98, 2015, pp. 185–193.
[2] M. Victor Marcos, M. Alexander, S. Anders, F. Gregor, E. Carola, and S. Torben, "Corrosion resistance of steel fibre reinforced concrete". Cement and Concrete Research Vol. 103, 2018, pp. 1–20.
[3] M. Di Prisco, R. Felicetti and G. A. Plizzari, "Precast SFRC elements from material properties to structural applications". RILEM Publications SARL, Varenna, Italy, BEFIB 2004, pp. 81–100.
[4] S. Abbas, "Structural and Durability Performance of Precast Segmental Tunnel Linings," University of Western Ontario. 2014.
[5] G. A. Plizzari and G. Tiberti, "Steel fibers as reinforcement for precast tunnel segments". vol. 21, 2006, pp. 438–439.
[6] B. Schnütgen and L. Vandewalle "Design of precast steel fibre reinforced tunnel elements". RILEM Publications SARL, Bochum, Germany, 2003, pp. 145–152.
[7] B. De Rivaz, S.W. Meng and C.K. Siong, "Durability issue for SFRC precast segment in tunnelling application". World Urban Transit Conference, Sentosa, Singapore, 2010, pp. 1– 10.
[8] G.T. Halvorsen, C.E. Kesler, A.R. Robinson and J.A. Stout, "Durability and Physical Properties of Steel Fiber Reinforced Concrete". Illinois, US, 1976.
[9] R. Winterberg, "Performance and durability improvements of precast concrete lining segments with fibre reinforcement". Australasian Institute of Mining and Metallurgy, Auckland, New Zealand, 2011, pp. 645–656.
[10] R. Weydert, P. Schiessl, Korrosion von Stahlfasern in gerissenem und ungerissenem Stahlfaserbeton, Abschlussbericht, Bergisch Gladbach (Germany), 1998.
[11] E.S. Bernard, "Durability of cracked fibre reinforced shotcrete". E.S. Bernard, Balkema Publishers, Sydney, Australia, 2004, pp. 59–66.
[12] ACI 318-14. "Building code requirements for structural concrete and commentary", American Concrete Institute, Farmington Hills, Michigan, USA, 2014.