MECHANICAL PROPERTIES OF CONCRETE REINFORCED WITH STEEL FIBERS EXTRACTED FROM WASTE TYRES

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ABSTRACT:*Modernization and advancement in the technology increases not just the human beingcomfort and lavishness but as well as damages the environment. The usage of vehicles in Pakistan are increasing day by day, due to which the dumping of waste tyres to the landfills;a serious issue is being addressed by Environmental Protection Agency (EPA), Pakistan. Still appropriate system for proper recycling and use again of waste tyre by products is lacking in the country. Manually a huge amount of high strength steel fibers are being take out from waste tyres, the main usage of that is manufacturing of new steel or iron alloys.This research study focuses on the utilization of steel fibers extracted from waste tyres in conventional plain concrete with inclusion of different %age dosages to develop cost effective concrete with improved properties. Waste tyre steel fibers were extracted from chips of waste tyres by burning process and cut to 1 inch (25.4mm) length keeping aspect ratio 90. Number of cylindrical specimen of waste tyre steel fiber concrete (WTSFC) with addition of 0%, 0.5%, 1.0%, 1.5%, 2.0% and 2.5% dosages were cast and tested for the compressive and indirect tensile strength.It is obvious from the results that the compressive and tensile strength of concrete with inclusion of WSTF, increases significantly. Specifically keeping in view workability of mix it can be concluded that waste tyre steel fiber concrete with inclusion of 2% WTSF, found to be more usable with improved compressive strength and tensile strength; 26.66 N/mm^2 with 65% increase and 4.28 N/mm^2 with 60% increase, respectively*.

Key words: waste tyre steel fibers (WTSF), waste tyre steel fiber concrete (WTSFC), compressive strength, tensile strength,

1. INTRODUCTION

Facts and figures show that concrete is very common and extensively used for construction as a favorable material all over the world. Even then, there are many deficit characteristics of concrete which limits its applications, as concrete has a low stiffness, low ductility and low energy absorption. Also when concrete is hardened, shrinkage cracks appears on its surface, therefore to improve these deficiencies in concrete, now a day's variety of fiber materials are being used in concrete to improve its applications for best services.

The fibers such as steel, glass, polymeric, natural and plastic fibers mixed with concrete at particular cut length and specified aspect ratio and randomly distributed, can effectively be utilized to overwhelm such deficits. However, in developing countries like Pakistan the major problem to utilize steel fibers reinforced concrete (SFRC) produced from ndustry is it's highly price, which limit its wide use in the construction industry.

The use of steel fiber reinforced concrete (SFRC) is day by day increasing in structural applications because of high stress resistance, toughness and long term strength. The fibers join together in a synchronized manner and become enmeshed to aggregates and substantially fibers tend to reduce the workability of mix, this phenomenon of concrete mix makes it less liable to segregation due to increased cohesiveness.

A recent research conducted in the University of Sheffield on various methods of recycling the used tyres such as shredding process, cryogenic process, pyrolysis process and microwave induced pyrolysis process. The recycled steel fibers were added in concrete mix for investigation of different parameters of concrete. Results were compared with industrially produced steel fibers reinforced concrete (ISFRC). The recycled steel fibers reinforced concrete (RSFRC) gave more improvement in strength.[1,5]. Steel fiber reinforced can improve the fracture toughness, mechanical and the durability related properties of concrete [2]. The inclusion of steel fibers in concrete considerably enhanced the engineering properties of mortar and concrete [3]. By using steel fibers having two different hooked ends and different length to diameter ratios, It was concluded that the compressive strength of concrete with steel fibers of two different dimensions showed approximately the similar result with a little increase with no any change in volume fraction. The compressive strength of 0.5% hook end fibers improved up to 10%, whereas the splitting tensile strength of SFRC for long fibers i.e. 50mm having the same quantity (volume fraction) gave 20% additional splitting tensile strength over short fibers i.e. 35mm in cut length [4]. With the inclusion of steel fibers maximum split tensile strength and modulus of rupture, was observed to be about 40% more than the ordinary concrete [8]. Using a little percentage of steel fibers efficiently improve the load-carrying capability of slabs on ground and significantly improve the slab ductility [9]. With the inclusion of hooked steel fibers with cut length of 6 cm and aspect ratio of 80 and replacement of cement with 0.5%, and 1% improved the mechanical properties of concrete [10]. The results of ultrasonic pulse velocity revealed that the using of small percentage of steel fiber in concrete improved the quality of concrete [11]. The inclusion of steel fibers to HPC increased strength and durability with the enhanced characteristics [12]. The SFRHPC in beam-column joints improves the strength; ductility and stiffness [13]. The addition of steel fibers prevents internal micro cracks of concrete. A major enhancement in the energy absorption and ductility in compression is observed with addition of fibers in concrete [6]. Mechanical properties of concrete having steel cords as reinforcement were improved to the concrete mix having the used tyre chips or crump rubber. The performance of concrete modified with recycled steel cords is found satisfactory. It is observed that concrete mix was found workable up to 4%. [3]. The addition of recycled steel fibers increases ductility of concrete, and prevents propagation of cracks. The substitution of textile fibers decreases deformations due to shrinkage, and beneficially influences durability characteristics of concrete, and therefore this material become an interesting raw material for the preparation in concrete mix and mortars [7].

Figure.1 Used tyres steel fibers

Figure.2 Steel fiber in1 inch cut length

2. MATERIALS AND METHODS

2.1 Materials Used

2.1.1 Cement

Ordinary Portland cement commonly available in market was used.

2.1.2 Fine and coarse aggregate

Locally available aggregates were used; fine aggregate with size retained on 200 number sieve and passing from 4.75mm and coarse aggregate with maximum size of 12mm were used.

2.1.3 Water

Potable tape water was used in mix preparation.

2.1.4 Waste tyres Steel fibers

Waste tyres in Pakistan are the low-priced, economical and in abundance available material. In Pakistan there is a lack of appropriate recycling industry of waste tyres, manually a huge amount of Steelfiber are being taken out which includes a little quantity of rubber particles on their surfaces.In this research study tyre chips were burnt to remove the rubber particles to extract the steel fibers. The steel fibers taken out from waste tyres are used in the concrete mix to form a composite fibrous material. Waste tyre steel fibers were extracted from chips of waste tyres by burning process and cut to 1 inch (25.4mm) length and average diameter of fiber was 0.28 mm keeping aspect ratio 90. As waste tyres steel fibers are uniformly and randomly distributed in different proportions from (0-2.5%) with increment of 0.5% by the dry weight of cement to prepare the different concrete matrix. The chips of waste tyres available in local market; normally they sell those as scrap to scarp industry.

2.2 EXPERIMENTAL STUDY

2.2.1 Mix Proportion of concrete

For the mix proportion of concrete 1:2:4 ratios with 0.55 water cement ratio were used**.** Six different batches of concrete mix prepared for castingcylindrical specimens of 100 mm diameter and 200mm in height. The concrete mix proportions are being tabulated in Table 1.

Table 1: Details of the mix proportions

S. No	Sample ID	Water (kg)	Cement (kg)	F. A. (kg)	C. A. (kg)	Waste tyre steel fibers(WTSF) (g)	Waste tyre steel fibers (WTSF) (%)
1	WTSFC0	3.3	6	12	24	0	(0%)
2	WTSFC0.5	3.3	6	12	24	226	(0.5%)
3	WTSFC1.0	3.3	6	12	24	452	(1%)
4	WTSFC1.5	3.3	6	12	24	678	(1.5%)
5	WTSFC2.0	3.3	6	12	24	904	(2%)
6	WTSFC2.5	3.3	6	12	24	1130	(2.5%)

2.2.2 Casting of Specimens

Total 72 cylinders were casted, for compressive and tensile strength test. Cylindrical specimens of length 200 mm and diameter 100 mm casted with 0%, 0.5%, 1%, 1.5%, 2% and 2.5% with used tyre steel fibers by dry weight of cement. Specimens made of concrete mix thoroughly compacted in molds on table vibrator and taken off from the molds after 24 hours. All the specimens were kept for 28 days curing in a water tank under a room temperature.

2.2.3 TESTING OF SPECIMEN

Compressive and split tensile strength tests were conducted on cylindrical specimens using Universal testing machine (UTM) in the laboratory as per ASTM C 39 and ASTM C496-86

3. RESULTS AND DISCUSSION

3.1 Compressive Strength

The results of the tests for compressive strength performed on the samples are shown in table2.

Table 2: 28 days compressive strength of cylindrical specimen

S.No.	(WTSF) Content (%)	Average Compressive Strength (N/mm^2)	Percentage Increase (%)
1	0	16.15	…
2	0.5	20.73	28
3	1.0	21.15	31
4	1.5	25.87	60
5	2.0	26.66	65
6	2.5	28.12	74

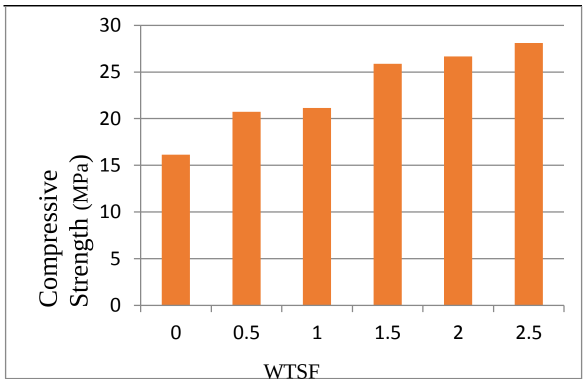

Figure 3.Comparison of compressive strength of ordinary and WTSF concrete

It is apparent from the results presented in table 2 and figure 3, that the compressive strength of concrete reinforced with WTSF significantly increases with the increase of WTSF content. The maximum 74% increase i.e. 28.12 N/mm^2 as compared to conventional concrete; at addition of 2.5% WTSF is witnessed. Almost same trend of compressive strength is observed in research published by Mostafa Jalal [2] and vikrant *et al.* [4].

3.2 TENSILE STRENGTH

The results of the indirect tensile strength tests performed on the samples are shown in table 3.

Table 3: 28 days indirect tensile strength of cylindrical specimen

S. No	*WTSF content (%)	Average Tensile strength (N/mm^2)	Percentage Increase (%)
1	0	2.67	…
2	0.5	3.05	14
3	1.0	3.42	28
4	1.5	3.52	32
5	2.0	4.28	60
6	2.5	4.21	58

* WTSF: waste tyre steel fibres

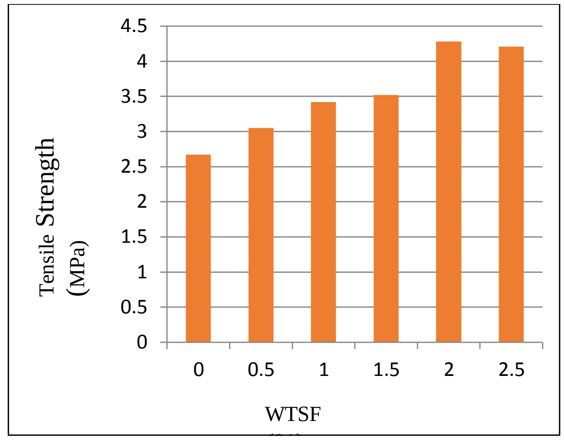

Figure 4. Comparison of tensile strength of ordinary and WTSF concrete

It is obvious from the results captured in table 3 and figure 4 that with the increase in WTSF content from 0% to 2%, the tensile strength of concrete significantly increases as compared to the conventional concrete. The maximum tensile strength with the addition of 2.0% of WTSF is 4.28 N/mm^2, which is 60% increment as compared to conventional concrete.

Further, it is observed that on addition of 2.5% WTSF, the tensile strength decreases, this was due to the balling action of steel fibers, resulting in decrease of load transfer from fiber to fiber. It was also observed that with balling action and formation of lumps the mix was not so workable. Almost same trend of tensile strength is presented by Vikrant et al. [4].

5.1 CONCLUSIONS

On the basis of conducted study it can be concluded that:

By inclusion of WTSF in plain concrete, the compressive strength increases significantly, at addition of 2.5% WTSF, maximum compressive strength, 28.12 N/mm^2 i.e. 74% increase as compared to conventional concrete is observed.

With addition of 2% WTSF, the maximum tensile strength; 4.28 N/mm^2 i.e. 60% increase as

Compared to plain concrete is found, whereas on further increase of WTSF tensile strength decreases.

The concrete mix containing more that 2% WTSF shows balling effect and found less workable. On the basis of tensile strength; 4.28 N/mm^2 (i.e. 60% increase) and compressive strength; 26.66 N/mm^2 (i.e. 65% increase), 2% dosage of WTSF can be considered as optimum to successfully reinforce plain concrete strength.

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