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Original Research Article

Study on flexural Strength of Concrete Beams by Using Steel Fibers Extracted from Wasted Tyres in Pakistan

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Abstract: This is well known fact that Concrete is dominantly used in construction almost in all type of structures but still there are many defective characteristics due to which the use of this material suffer. Moen joDaro is the oldest historical place in the history of Civil Engineering which contributes the skill and knowledge of Engineers. Still, Engineers are finding new creations by research in the field of Civil Engineering. The use of Steel fibers to reinforce and improve the properties of construction materials (cement or concrete) goes back at least 3500 years, when straw was used to reinforce sun-baked bricks in Mesopotamia. Cement-bound products have been reinforced by various types of (Natural and artificial) fibers at least since the beginning of the last century and steel fibers and synthetic fibers have been used to improve the properties of concrete mix for the past 35 or 45 years. Fibers also improve the properties of many natural as well as engineered materials. Concrete is a mixture of cement, aggregates and water. Concrete plays an important role in the development of infrastructure Viz., industrial structures, bridges, highways and buildings. Leading to utilization of large quantity of concrete. West Tyre Steel Fiber addition in to concrete significantly improved the abrasion resistance of concrete. Abrasion resistance was found to increase with the increase of volume steel fiber. Although addition of west tyre steel fibers to concrete mix did not significantly improve its ultimate compressive strength, the addition of WTSF and increasing the volume fractions of steel fiber increased flexural tensile strength. Concrete is good in compressive strength but today west tyres steel fibre reinforced concrete is perhaps one of the most realistic possibilities to develop the use of concrete in load bearing structures. Structural members are used to support the structure by mean of carrying and transferring the load of structure as well as self-load to under lying provided surface. For improving the mechanism of structural members it is very important to strengthen the material used in structural member by keeping in view its function and purpose. Chuff was used in mud mortar to increase the bonding and strength in material in civilized period in history, same as in our re-search we try to increase the internal stresses in Beam (structural member) by means of finding Flexural strength in it by providing West Tyres Steel Fibers, providing fibers by keeping in view behavior, bending, crushing, environmental effect, process of provision of WTSF, effect on properties of Concrete. Its results shows some flexural strength. This research study was concentrated to improve such deficiencies of concrete by introducing steel fibers extracted from waste tyres and will be investigated by comparing results with conventional concrete. Also, due to the development leads increasing vehicles in our country, the used tyres are day-by-day going to increase and is becoming a main source of solid waste, and that abundant amount of waste tyres is harmful to our environment. Research work is focusing on the use of steel fibers extracted from waste tyresand mixed in concrete with different proportions to produce a concrete more strong than ordinary concrete. Different concrete specimens were casted and tested in universal testing machine in Laborite to find flexural strength. Steel fibers are added as 0.5%, 1%, 1.5%, 2% and 2.5% in Concrete mix. Result shows that the flexural strength of concrete with 2.5% fibers improved up to 20%.

Keywords: Waste tyre steel fibers, Concrete, Flexural Strength, Moment of Inertia, Modulus of Elasticity, Results and Discussions

INTRODUCTION

Over view:

Structural members are used to support the structure by mean of carrying and transferring the load of structure as well as self-loadto under lying provided surface, for improving the mechanism of structural members it is very important to strengthen the material used in structural member by keeping in view its function and purpose. Chuff was used in mud mortar to increase the bonding and strength in material in civilized period in history, same as in our re-search we try to increase the internal stresses in Beam (structural member) by means of finding Flexural strength in it by providing West Tyres Steel Fibers, providing fibers by keeping in view behavior, bending, crushing, environmental effect, process of provision of WTSF, effect on properties of Concrete.Some by products are being made by these used tyres such as rubber which

was used in many applications and steel cord, which is disposed of to landfills or transported to scrap industry.

Fiber reinforced concrete is being usedto improve all weak parameters of concrete. In this regard fibers of steel, glass, polymeric, natural and plastic having specified cut length and randomly distributed can successfully be used in the concrete mix to overcome such deficiencies.

History of fiber reinforced concrete:

Using steel fibers as reinforcing material in not the new concept but since ancient time steel fibers were being used as reinforcing material. Historically, straws were used in mud of bricks and animal hair in mortar. In 1900's asbestos fibers were introduced in concrete. In the era 1950s the concept of *composite material* came into being, therefore fiber-reinforced concrete became one of the topics of interest. Sooner health risks regarding with asbestos were discovered. So, there was need to find a replacement in concrete and other structural materials. For this purpose steel, glass (GFRC) and synthetic fibers such as polypropylene fibers were used by the 1969s in concrete. Still research on the different aspects of fiber-reinforced concrete continues today.

This research is used to measure the characteristics of a beam regarding to its behavior, bending and crushing on Flexural Strength, while adding an special material of Steel fibers extended from used tyres. Up to date, various fibrous materials are being used in concrete to improve its Flexural strength for best services. This research also helps to minimize the Environmental Impact due to west tyres.

Steel fibers:

The steel fibers used in tyres are the high tensile strength wires, which by cutting in specific length and can be used in the concrete successfully. Fiber-reinforced composite consist of fibers (from wasted tyres) of high strength and modulus embedded in or bonded to a matrix with distinct boundaries in between them. In this form, both fibers and material retain their physical and chemical properties, they combined produce a combination of properties that cannot be achieved with either of the constituents acting alone. In general, fibers are the principal load-carrying members, while the surrounding matrix keeps them in the desired location and orientation and acts as a load transfer medium between them and protects them from external damages due to elevated temperatures and humidity, for example. Thus, even though the fibers provide reinforcement for the matrix, the latter also serves a number of useful functions in a fiber-reinforced composite material.

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AIMS AND OBJECTIVES OF RESEARCH

The main Aim & Objective of this research is to introduce utilization of waste tyres steel cord wire as fibers in concrete in Pakistan and to provide additional environmental benefits by reducing solid waste.

- To investigate the compressive and tensile strength of waste tyres steel fibers reinforced concrete.
- To produce strong and low-cost concrete as compared to ordinary concrete with optimum proportion of waste tyres wires.

LITERATURE REVIEW

Introduction to WTSF:

Recently in Pakistan a research conducted regarding mechanical properties of concrete by using steel fibers extracted from waste tyres, the results shows that the compressive and tensile strength are significantly improved. Internationally a few researches are also conducted on different aspects of waste tyrefibers.

Steel fibers reinforced concrete an overview:

Adding a small quantity of steel fibers into an ordinary concrete mix does not require special tools or working procedures, nor does it significantly affect concrete workability and productivity. However, a notable increase in performance may be expected in its hardened state (Lok, T. S. *et al.*, 1999).

The results of the laboratory work showed that replacement of fly ash with cement reduced abrasion resistance of concrete; however, inclusion of the steel fiber improved the abrasion resistance of concrete. Using polypropylene fiber did not improve abrasion resistance of concrete made with or without fly ash (Atis, C. D. *et al.*, 2009).

Recently some research has been devoted to the use of granulated rubber and steel fibers recovered from waste tyres in concrete. In particular, the concrete obtained by adding recycled steel fibers evidenced a satisfactory improvement of the fragile matrix, mostly in terms of toughness and post cracking behaviour. As a consequence RSFRC (recycled steel fibers reinforced concrete) appears a promising candidate for both structural and non-structural applications (Aiello, M. A. *et al.*, 2009).

Steel fibers recovery from used tyres:

In the past decade, considerable research programs have been conducted to validate the application of FRP composites in the construction industry, and recently, structural applications of FRP materials have begun to appear in different types of the concrete structures (Padmarajaiah, S. K& Ramaswamy, A. (2004).

In particular the concrete obtained by adding recycled steel fibers showed a good improvement of the

brittle matrix, especially in terms of toughness andpost-cracking behavior, as widely already experienced for ISFRC (Industrial Steel Fibers Reinforced Concrete). In fact it is well known that the dispersion of steel fibers in concrete allows a noticeable improvement of the concrete mechanical properties, mostly in terms of dynamic and fatigue resistance, shear and post-cracking strength (Mohamed, H. M. *et al.*, 2010, Kang, S. T., *et al.*, 2011, Centonze, G, *et al.*,2012, Wagan, R. H., *et al.*,2017).

EXPERIMENTAL METHODOLOGY

Introduction:

Concrete is a mixture of cement, aggregates and water. Concrete plays an important role in the development of infrastructure Viz., industrial structures, bridges, highways and buildings. leading to utilization of large quantity of concrete. West Tyre Steel Fiber addition in to concrete significantly improved the abrasion resistance of concrete. Abrasion resistance was found to increase with the increase of volume steel fiber. Although addition of west tyre steel fibers to concrete mix did not significantly improve its ultimate compressive strength, the addition of WTSF and increasing the volume fractions of steel fiber increased flexural tensile strength.

Concrete is good in compressive strength but today west tyres steel fibre reinforced concrete is perhaps one of the most realistic possibilities to develop the use of concrete in load bearing structures.

Research Methodology:

To meet the research objectives, following steps were taken place.

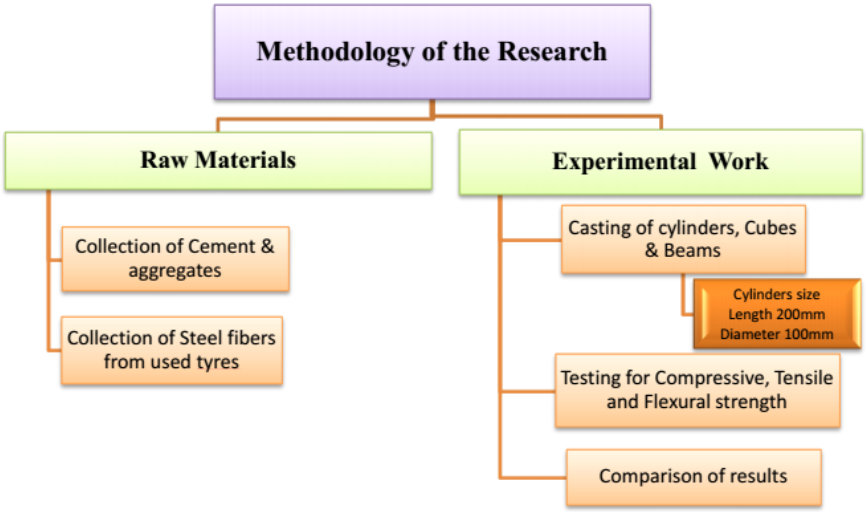

Figure 1 Shows flow chart for the Methodology of Research.

Materials Collection

This is the initial part of our research methodology in which collection of all the raw materials is described in detail and also one of the interesting part for getting the waste tyres steel fibers, its availability in region and method of extraction.Where Ordinary Portland Cement is used as available.

Experimental Program

Second part of re-search includes the details about the total number of specimens; various tests were conducted on specimens and their methods, determination of tensile strength of steel fibers.

Experimental results and discussion

This part includes all the out puts based on the results obtained during experiments. The effect of steel fibers in concrete on various factors analyzed. Compressive and tensile strength improvements, recommended percentage of fibers and factors affecting the strength of WTSF concrete discussed.

Conclusion and Recommendation

At the end of Conclusion, based on the re-search objectives, conclusions are made from the results obtained in experiments for proper judgment and recommendations.

Figure 2 show the tyre chips brought from tyre shops.

Table 1:Data regarding to the steel fibers (Wagan, R. H. *et al,* 2017). The Ultimate Strength was found the Ultimate Strength machine available in Mechanical Department of University.

Serial No	Diameter (mm)	Length (mm)	Ult. Strength (Mpa)
01	0.300	50	1309.34
02	0.260	50	1309.22
03	0.250	50	690.56
04	0.290	50	1161.8
05	0.290	50	1206.33
06	0.300	50	914.1
Average Size:	0.280	50	1098.6

Samples were taken, extracted from tyre chips by burning procedure and samples were extracted from tyre chips by Rubbing rubber particles from the fiber surface and all these samples were presented for tensile strength test on Universal Testing Machine with Five ton capacity.

Table 2:Show details of the mix proportions used in Casted beams(Wagan, R. H. *et al,* 2017)

S.No	Water	Cement	F. Agg.	C. Agg.	Fibers
	(K-g)	(K-g)	(K-g)	(K-g)	(grams)
01	3.3	6	12	24	0 (0%)
02	3.3	6	12	24	226 (0.5%)
03	3.3	6	12	24	452 (1%)
04	3.3	6	12	24	678 (1.5%)
05	3.3	6	12	24	904 (2%)
06	3.3	6	12	24	1130 (2.5%)
07	3.3	6	12	24	1356 (3%)

Casting of Test Specimens:

Procedure of mixing of concrete including WTS fibers is very simple as a plain concrete, putting dry material in concrete mixer and then 0.55 ratio of water with comparing to cement, pH value of concrete were tested for required potable water for concrete. Than mixing ingredients up to 1.5 to 2 minutes (some time according to proper mixing). After proper mixing slump test of plastic concrete for workability should be taken and temperature were also measured for the proper hydration of cement to check the quality of cement, then plastic concrete was putted in mould of Beam on vibration table, placing was done in three layers with ramming by rod (25 times each layer). Total 75 beams were casted.

Each 5 beams of 0%, 0.5%, 1%, 1.5%,2%,2.5% and 3% of 0.5 inch WTS Fibers.

Figure 3 & 4 shows size of beams checked and Placing of Beams in Universal Testing Machine.

SLUMP TEST:

Workability of Concrete is a critical problem to be solve. In fact, workability of fresh wet concrete is largely influenced by the presence of WTSF and using the traditional concrete mixer Machine, the maximum allowable volume ratio of WTS fibers was not higher than 3%. To increase usable WTSF ratios and to avoid bundling of the WTS fibers within the concrete mix, a planetary mixer was also used to prepare the concrete. This technological solution permitted an increase in WTSF ratios up to 0.4% by volume, obtaining at the same time a satisfactory workability and a more uniform distribution of WTS fibers in Concrete Mix (Rabnawazjuj *et al*, 2018).

Table 3: Shows Flexural Strength of specimen at different loads with different percentage of waste tyre steel fibers of 0.5" size(Wagan, R. H. *et al,* 2017). Flexural Strength was conducted on UTM.

Serial No	RATIO USED	Beams	FLEXURAL STR: (MPa)	Load (kg)
		Beam1	0.335	475
		Beam2	0.329	475
1	0% of 0.5"	Beam3	0.325	350
		Beam4	0.325	350
		Beam5	0.325	350
		Beam6	0.4	425
		Beam7	0.375	400
2	0.5 % of 0.5"	Beam8	0.375	400
		Beam9	0.375	400
		Beam10	0.4	425
		Beam11	0.45	475
		Beam12	0.45	475
3	1% of 0.5"	Beam13	0.45	475
		Beam14	0.45	475
		Beam15	0.45	475
		Beam16	0.45	475
		Beam17	0.45	475
4	1.5% of 0.5"	Beam18	0.45	475
		Beam19	0.45	475
		Beam20	0.45	475
		Beam21	0.39	325
		Beam22	0.381	325
5	2 % of 0.5"	Beam23	0.325	350
		Beam24	0.354	325
		Beam25	0.382	350
		Beam26	0.4	425
		Beam27	0.425	450
6	2.5 % of 0.5"	Beam28	0.4	425
		Beam29	0.4	425
		Beam30	0.425	450
	3% of 0.5"	Beam31	0.4	425

7	Beam32	0.4	425
	Beam33	0.375	400
	Beam34	0.4	425
	Beam35	0.4	425

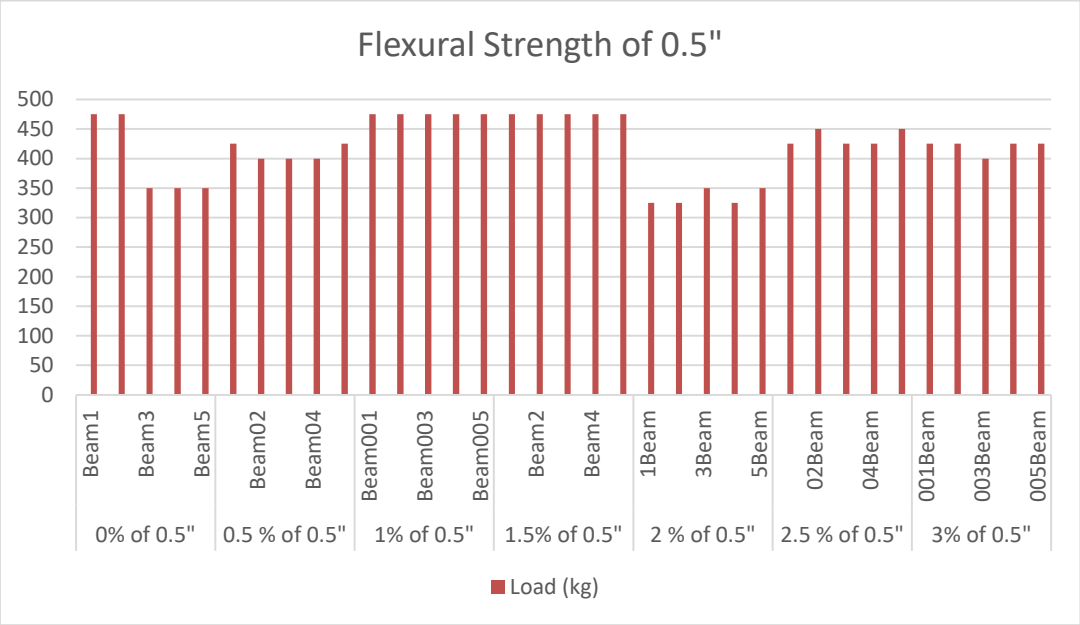

Figure 5: shows Flexural Strength of specimen at different loads with different percentage of waste tyre steel fibers of 0.5" size.

Failure Mode:

The failure of almost all the beams of WTS Fiber-Concrete under fatigue loading was due to the initiation of a single crack in the middle of the beam specimen.

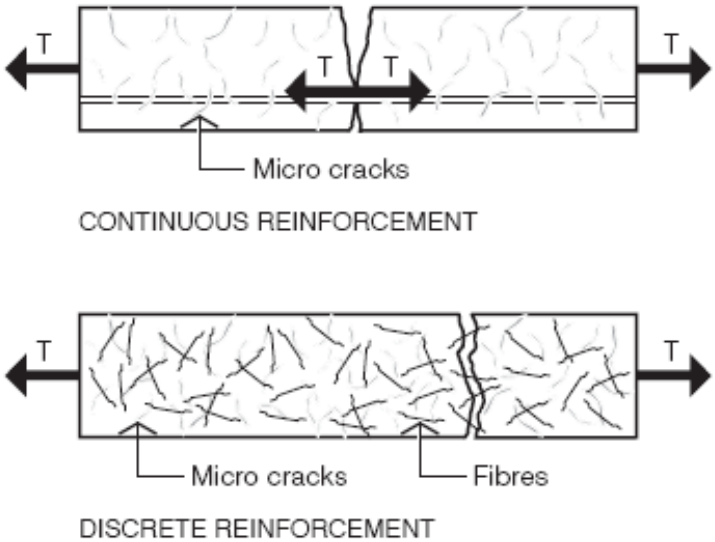

Figure 6 shows behavior of beam with and without fibers

These results shows that steel fibers (from waste tyres) may be a promising candidate for obtaining fibre& reinforced concrete, even further experimental and theoretical research is needed.

EXPERIMENTAL RESULTS AND DISCUSSION

Table 4: Shows average flexural strength. Related to Table No 3.

Percentage of WTSF	*Average Flexural Strength (Mpa)
0	0.33
0.5	0.385
1	0.40
1.5	0.45
2	0.3664
2.5	0.35
3	0.34

* Average of 5 samples

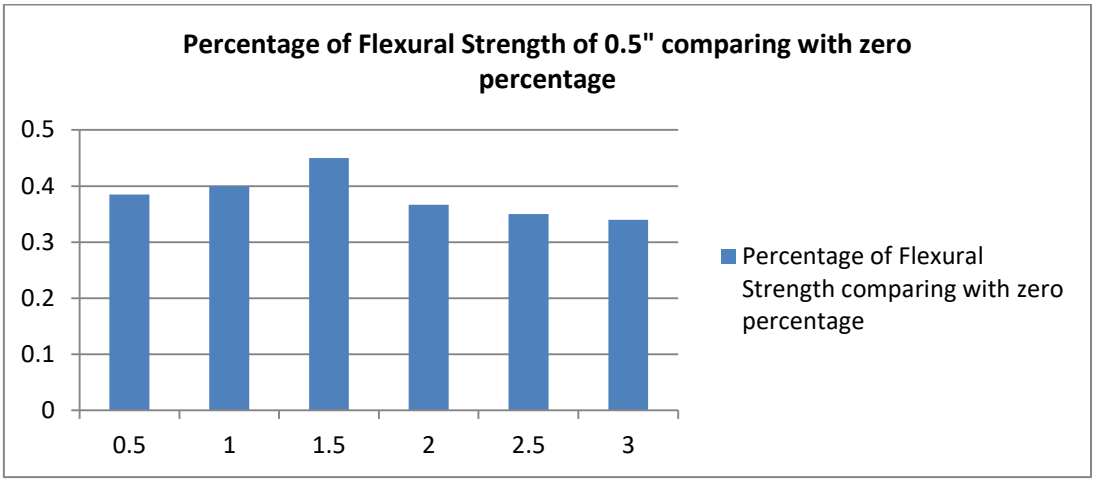

Figure-7: Shows Percentage bar columns of Flexural Strength

Results:

- Using 0.5 inch length ,at 1 and 1.5 % of WTSF max Flexural strength 0.45 Mpa was observed which is 20% more than the ordinary concrete.
- Using 0.5 inch length, At 1% of WTSF Deflection is minimum which is 28 % less than the ordinary concrete.
- Using 0.5 inch length Also at 1.5 and 2 % of WTSF, 26 % less deflection was measured as compared to ordinary concrete.
- At 0.5 % of WTSF Deflection is minimum which is 38 % less than the ordinary concrete

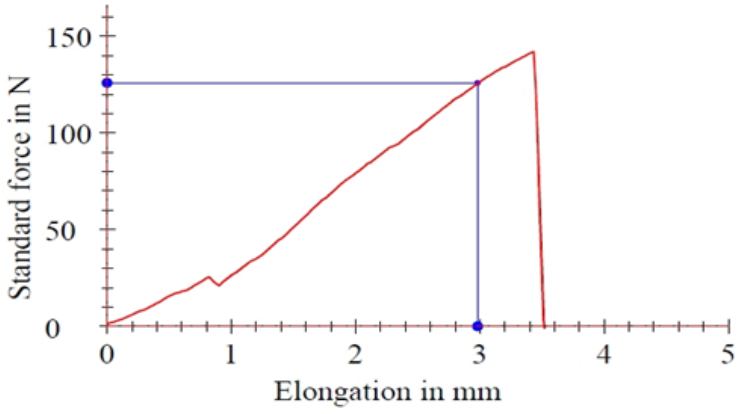

Figure 8: Show average of 3% of 0.5" tensile strength VS the elongation.

Suggestions:

- Research can be improved by washing extracted material from solid waste with chemicals.
- Further study of these kinds of research is more helping to improve the strength of concrete for heavy structures like Dam, Bridges also for the strip of run way.
- We can also control shear stress by increasing the length of wires.
- To increase strength of joints at different parts of buildings this extracted material waste from tyres is more effective.

Recommendations:

It can be observed from the results of this research work based on the objectives, the use of waste tyres steel fibers (WTSF) in concrete have improved the properties of concrete. Hence the recommended fiber content is 1.5% for both compressive and tensile strength point of view.

The results which are obtained from the experiments of this research study is recommended that WTSF concrete can be used successfully in the variety of structural applications such as impact barriers, over hanging beam, in the foundations of heavy machinery, dams, road pavements of heavy load and retaining walls.

Possible outcomes of research:

- This research will be advantageous to produce concrete with improved strength and low cost from waste steel fibers of tyres.
- Weak areas of concrete; the tensile and flexural strength would possibly be improved to reasonable extent.

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