Effect of Tyre Rubber on the Mechanical Properties of Concrete

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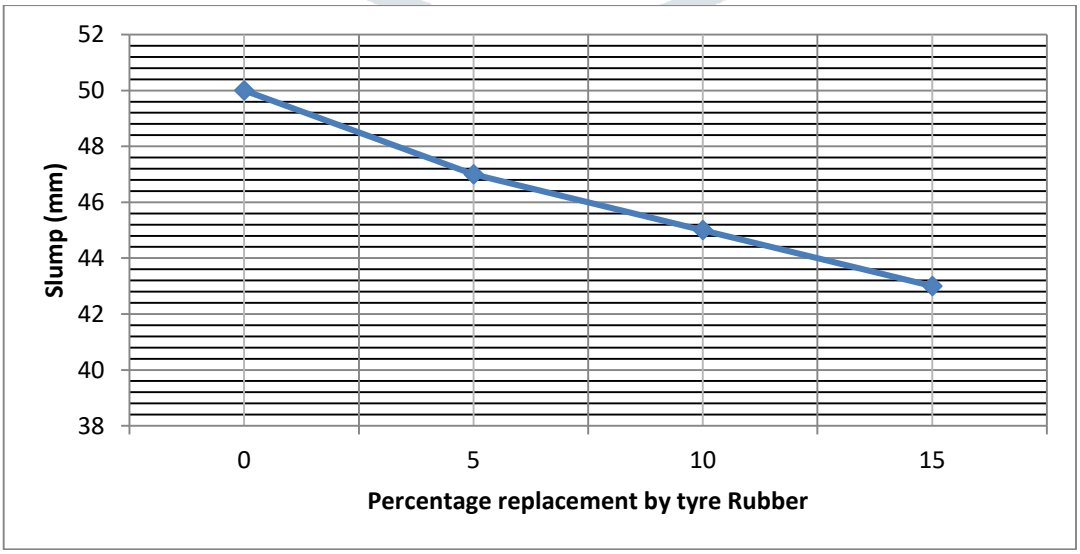
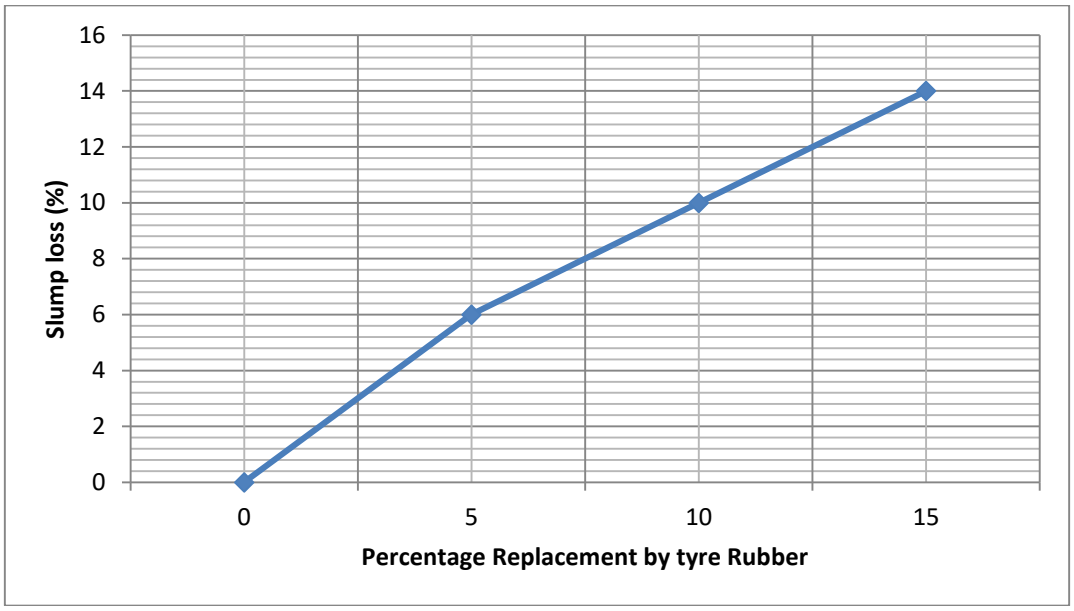
Abstract: In this paper effect of tyre rubber on the mechanical properties of concrete have been studied. The tyre rubber has been added in the plain concrete at percentages of 5%, 10% and 15% as replacement of course aggregates. The concrete is tested for slump in fresh state while as tests like compressive strength test, split tensile strength and flexural strength are conducted on hardened concrete after the age of 28 days. The test results are then analyzed and it is observed that the workability has decreased with the addition of tyre rubber in concrete. The mechanical strength parameters of concrete are also showing a decrease with an increase in the percentage of tyre rubber in concrete. The reason for this decrease is the lack of bond between the tyre rubber and ingredients of concrete. So it is recommended that in order to use the tyre rubber in concrete there is a need of giving some surface treatment to the tyre rubber so that the tyre rubber can be efficiently used in concrete.

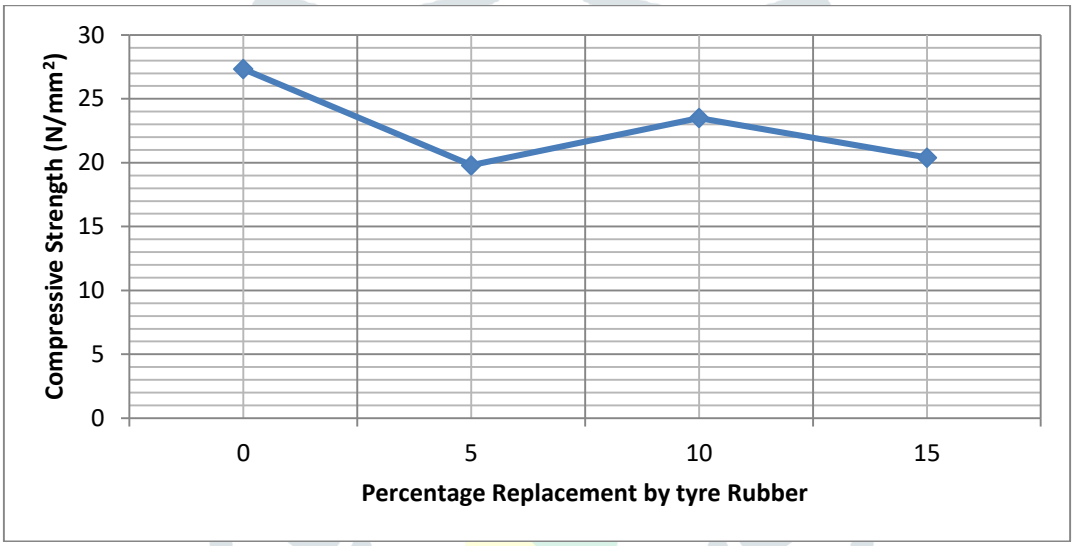
Index Terms **– Artificial aggregates, Rubbercrete, Tyre rubber, Waste management.**

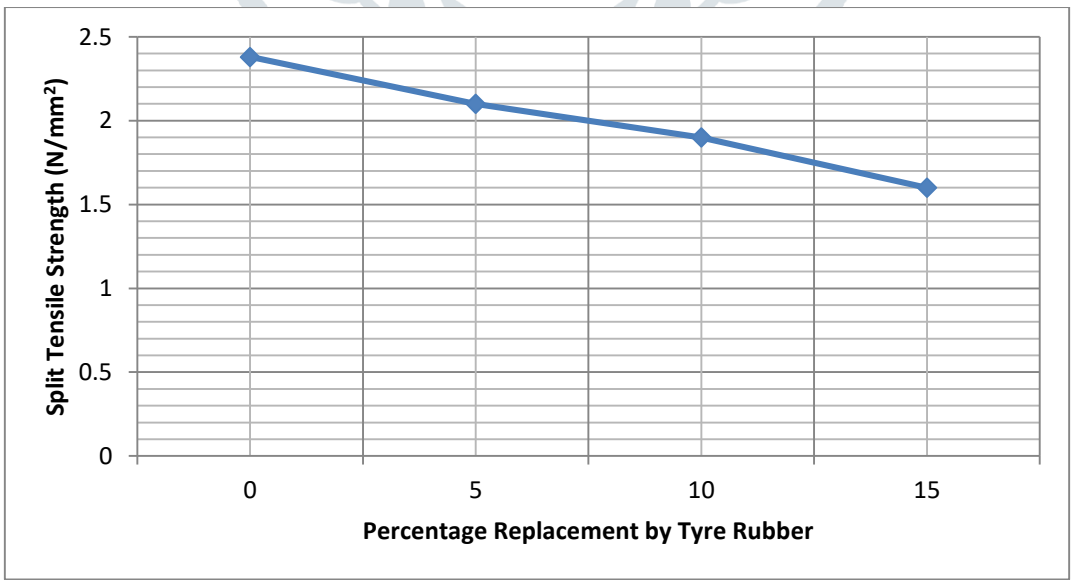
I. INTRODUCTION

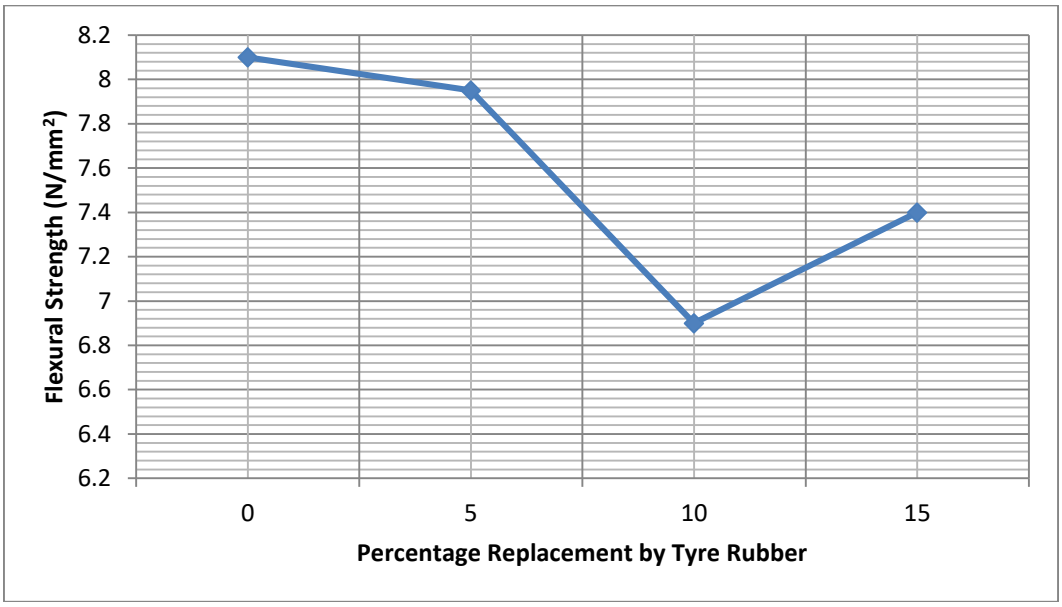
The scrap tyres is one of the major wastes in our environment as every year more than 1000 million tyres are thrown away in landfills or are stockpiled[1][2]. As tyre rubber is a non-biodegradable material it is posing a great threat to the environment. If the tyres are kept as such they will accumulate rainwater inside their cavities which will result in breeding of mosquitoes resulting in spread of many diseases like malaria[1,2,4]. However if these rubber tyres are burnt it will result in emission of harmful gases in the atmosphere thus causing air pollution the ash left behind after burning tyres will result in soil pollution and even water pollution if this ash gets washed to the water bodies [5]. So it is the need of the hour to use these scrap tyres in some application in order to save the environment from its ill effects. One of the best use of these scrap tyres is to use them in construction industry. In construction industry large volume of concrete is usually cast, involving excessive use of aggregates. This will also result in the decrease in the cost of concrete. The tyre rubber can be used in concrete in many forms. If finely shredded it can replace some percentage of sand [6-13], if coarsely shredded it can replace some percentage of coarse aggregate [14,15].




Slump loss (%)
16
14
12
10
8
6
4
2
0
0
5
10
15
Percentage Replacement by tyre Rubber


Compressive Strength (N/mm²)
30
25
20
15
10
5
0
0
5
10
15
Percentage Replacement by tyre Rubber


Split Tensile Strength (N/mm²)
2.5
2
1.5
1
0.5
0
0
5
10
15
Percentage Replacement by Tyre Rubber



II. EXPERIMENTAL PROGRAM

In this experimental investigation four different mixtures of concrete were prepared. Among the four mixes one was control concrete with 0% of rubber content and rest of three mixes were prepared by replacing some percentage(by weight) of coarse aggregates with shredded tyre rubber. The three rubber based concrete mixes were prepared by replacing some percentage of coarse aggregate by shredded tyre rubber. The shredded tyre rubber was used at percentages of 5%, 10% and 15% by weight of concrete. For all the mixes the cement content, grading of fine aggregates and water cement ratio was kept constant. The properties of the concrete were determined in fresh state as well as hardened state. Tests conducted on fresh concrete included slump test while as that on hardened concrete included compressive strength test, flexural strength test and split tensile test. All these tests were conducted at an age of 28 days.

A. Material

Materials used in this experimental investigation included 53 Grade OPC, river sand, confirming IS grading zone III , crushed aggregates in sizes of 20 mm and 10 mm, tap water and shredded scrap rubber of tyres.

B. Mixture Proportioning

In this experimental study the mixture proportion given in Table 1 was used. Hand mixing on a non absorbing platform was carried out to prepare all the concrete mixes.

Table 1. Mix proportion of concrete

S.No	Mix ID	Cement (kg/m3)	Fine Aggregates (kg/m3)	Course Aggregates (kg/m^3)		% Replacement	w/c
				Gravel	Tyre Rubber		
1	PC	436	654	1309	**0**	**0**	0.45
2	TR-5	436	654	1243	66	5	0.45
3	TR-10	436	654	1178	131	10	0.45
4	TR-15	436	654	1112	196	15	0.45

Where;
PC represents control concrete
TR -5 represent concrete having 5% of shredded rubber as partial replacement of course aggregates.
TR -10 represent concrete having 10% of shredded rubber as partial replacement of course aggregates.
TR -15 represent concrete having 15% of shredded rubber as partial replacement of course aggregates.

C. Preparation of samples:

All samples were prepared in the Concrete Laboratory at IUST. Cube samples of size 150mm, prisms of size 500mmX100mmX100mm and cylinders of size 100mmX200mm were cast for conducting compression strength, flexural strength and split tensile strength tests respectively.

III. RESULTS AND DISCUSSIONS

The results of the tests conducted on fresh concrete and hardened concrete are shown in Table 2 & Table 3.

Table 2: Slump Test results.

Sample	**Slump** (mm)	**Slump loss** (%)
PC	50	0
TR-5	47	6
TR-10	45	10
TR-15	43	14

Table 3: Strength tests on hardened concrete

Sample	**Compressive Strength (N/mm^2)**	**Split Tensile Strength** (N/mm^2)	**Flexural Strength** (N/mm^2)
PC	27.33	2.38	8.1
TR-5	19.8	2.1	7.95
TR-10	23.5	1.9	6.9
TR-15	20.4	1.6	7.4

From the test results it is clear that there is decrease in the slump of fresh concrete with the increase in the percentage replacement of coarse aggregates by rubber.
The comparative analysis of slump has been done using percentage slump loss factor.

Where,

$$Slump\ loss\ \% = \frac{(s_o - s_f)}{s_o} 100$$

s_o = slump in mm of control mix;
s_f = slump in mm of rubber based concrete mix.

With the increase in the percentage replacement of coarse aggregates by rubber there is an increase in the percentage slump loss. At 5% replacement the slump loss is 6% which further increases to 10% and 14 % at 10% &15% replacements respectively. This low workability of rubber based concrete is due to the hindrance in the movement of concrete particles by rubber particles and lack of adhesion between cement paste and rubber particles

From the test results of hardened concrete it is clear that compressive, flexural and split tensile strength of concrete have decreased by the partial replacement of coarse aggregates by rubber.

Under compression testing there was brittle failure in control concrete while the rubber based concrete specimens didn't shown brittle failure. In control specimens there were inclined cracking, while as in rubber based concrete specimens there were horizontal cracks. Compressive strength tests clearly show that the addition of rubber to concrete caused a decrease in the compressive strength of concrete. The decrease in the compressive strength of rubber based concrete is due to lack of proper bonding between cement and rubber particles, low adhesion between rubber and cement matrix, low strength of rubber particles than concrete matrix and large difference of elastic modulus between rubber and other ingredients of concrete. Thus when force is applied, the cracks first of all appear in contact zone of rubber and concrete matrix.

After 28 days curing, the percentage decrease in compressive strength of rubber based concrete mixes relative to reference concrete were 27.6%, 14% and 25.4% at 5%, 10% and 15% replacements of coarse aggregates by rubber respectively.

Flexural strength values show that concrete with rubber exhibited decreasing flexural strength with increase in percentage of rubber. At 5% replacement by rubber the decrease in the flexural strength was very less and was comparable to the control concrete. This is because at low percentage the rubber aggregates help

in bridging the gaps caused due to the flexural loading Thus the specimen is able to withstand additional load after cracking. At higher percentages of rubber there is remarkable decrease in the flexural strength of concrete due to improper bonding between rubber aggregates and cement paste.

After 28 days curing, the percentage decrease in flexural strength of rubber based concrete mixes relative to reference concrete were 1.9%, 14.8% and 8.6% for 5%, 10% and 15% replacements of coarse aggregates by rubber respectively.

Splitting tensile strength values show that concrete with rubber showed a significant decrease in splitting tensile strength with an increase in percentage replacement of coarse aggregates by rubber.

After 28 days curing, the percentage decrease in splitting tensile strength of rubber based concrete mixes relative to reference concrete were 11.8%, 20.16% and 32.8% for 5%, 10% and 15% replacements of coarse aggregates by rubber respectively

From Figure 11 it is clear that there is increase in the mid span displacement with the replacement of coarse aggregates by rubber, with maximum value at 5% replacement. Thus, it can be concluded that the toughness of concrete increases with the replacement of coarse aggregates by rubber.

IV. CONCLUSION & RECOMMENDATIONS

From this experimental investigation in can be concluded that the mechanical strength of concrete gets reduced on addition of tyre rubber as partial replacement of coarse aggregates. The reduction in strength is more for higher percentages of tyre rubber in concrete. This reduction in strength is because of the lack of proper bonding between ingredients of concrete and tyre rubber. So it is recommended that some sort of surface treatment should be given to tyre rubber so that the bond between tyre rubber and other ingredients of concrete is improved.

PHOTO GALLERY

Fig 3.1: Different Stages of the Project- Manual Shredding of Tyre Rubber, Mixing of Concrete, Casting and Compaction of Samples, Curing and Testing of the Specimens.

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