A Technical and Economical Assessment of Replacement of Coarse Aggregate By Waste Tyre Rubber In Construction

Warudkar A.A
Prof: Imperial college of engineering and research, wagholi, pune- 412205, India
abhijit.icoer@gmail.com

Valekar N.S
Imperial college of engineering and research, wagholi, pune- 412205, India
navanathvalekar@gmail.com

***Abstract*—** At present days the disposal of waste tyres is becoming a major waste management problem in the world. One of the major environmental challenges facing municipalities around the world is the disposal of worn out automobile tyres. To address this global problem, several studies have been conducted to examine various application of recycled tyres rubber (Fine crumb rubber and coarse tire chips). It is estimated that 1.2 billion tons of waste tyres rubber produced globally per year. It is estimated that about 60 percent of waste tyres are disposed via unknown routes in the urban as well as rural area. This leads to varies environmental problem which include air pollution associated with open burning of tyres (Particulates, odor, visual impact, and other harm full contaminants such as polycyclic aromatic hydrocarbon) and aesthetic pollution.

Therefore, it is necessary to utilize the waste effectively with technical development in each field. The waste tyres can be used as well sized aggregate in the it is cut in the form of aggregate and can be called as rubber aggregate. This not only minimizes the pollution occurred due to waste tyres but also minimizes the use of conventional aggregate which is available in exhaustible quantity. In this context, our present study aims to investigate the optimal use of waste tyres rubber as coarse aggregate in concrete composite. This paper focuses on engineering property of rubber concrete mixture. This includes workability, compressive strength. This paper presents an overview of the research carried out in an effort to utilize scrap tyres in Portland cement concrete. A concrete cubes are casted of M20 grade by replacing 1%, 2%, 5%, percent of tyre aggregate with coarse aggregate. Fresh and hardened concrete strength were identified.

***Keyword**: - Tyre, Rubber, Recycled, Compressive strength, Workability. Environmental, Pollution.*

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INTRODUCTION

Solid waste management has gained a lot of attention to the research community in recent days. As concerned solid waste, accumulated waste tyres, has become a problem of interest because of its non- biodegradable nature [Malladi, 2004]. Most of the waste tyre rubbers are used as a fuel in many of the industries such as thermal power plant, cement kilns and brick kilns etc .unfortunately, this kind of usage is not environment friendly and requires high cost. Thus, the use of scrap tyre rubber in the preparation of concrete has been thought as an alternative disposal of such waste to protect the environment. It has been observed that the rubberized concrete maybe used in places where desired deformability o toughness is more important than strength like the road foundations and bridge barriers. Apart from these the rubberized concrete having the reversible elasticity properties may also be used as a material with tolerable damping properties to reduce or to minimize the structural vibration under impact effects [Siddique *et al.*2004]. The difficulties associated to investigations to identify the mechanical properties of the rubberized concrete have necessitated the need for the experimental investigations on rubberized concrete .Therefore, in this study an attempt has been made to identify the various properties necessary for the design of concrete mix with the coarse tyre rubber chips as aggregate in a systematic manner.

In recent decade's worldwide growth of automobile industry and increasing use of car as a means of transport has tremendously boosted tyre production. This has generated massive stockpiles of used tyre. Big tyre amount of used rubber tyres cumulate in the world each year-275 million in the United States and 180 million in European Union. About 33 million vehicles are being added to Indian roads in last three years. In industry large amount of waste tyres are utilized as fuel, in bitumen pastes, roof and floor covers and for paving industries. One of the where these scrap tyres can be used is rubberized concrete. Concrete though a popular construction material has some limitation. Several studies performed earlier shows that the application of recycle tyre rubber in concrete might improve these properties. However by use of this granulated rubber with Replacement of coarse aggregate can make concrete cheaper and useful for some application. Such type of concrete is usually used in manufacturing of reinforced pavement and bridge structures.

LITERATURE REVIEW

Many books and Journals are refer to Carried out this work .references playing vital role are highlights below.

1) Zheng *et al.* 2008 worked on rubberized concrete and replaced the coarse aggregate in normal concrete with ground and crushed scrap tyre in various volume ratios. Ground rubber powder and the crushed tyre chips particles range in size from about 15 to 4 mm were used. The effect of rubber type and rubber contenton strength, modulus of elasticity were tested and studied. The stress – strain hysteresis loops were obtained by loading, unloading and reloading of specimens. Brittleness index values were calculated by hysteresis loops. Studies showed that compressive strength and modulus of elasticity of crushed rubberized concrete were lower than the ground rubberized concrete

2) Taha *et al.* 2008 used chipped tyre rubber and crumb tyre rubber to replace the coarse and fine aggregate respectively in the concrete at replacement levels of 25%, 50%, 75%, and 100% by volume. The tyre rubber was chipped in two groups of size 5 to 10mm and 10 to 20 mm. the crumb tyre rubber of size 1 to5 mm was used. These were mixed with a ratio of 1:1.

3) Khallo *et al.* 2008 determined the hardened properties of concrete using different types of tyre rubber particle as a replacement of aggregate in concrete. The different types of rubber particles used were tyre chips, crumb rubber and combination of tyre chips and crumb rubber. These particles were used to replace 12.5%, 25%, 37.5%, and 50% of the total mineral aggregate by

volume. The results showed that the fresh rubberized concrete had lower unit weight and workability compared to plain concrete. Result showed large reduction in strength and modulus of elasticity in concrete when combination of tyre rubber chips and crumb rubber were used as compared to that when these were used individually. It was found that the brittle behavior of concrete was decreased with increased rubber content. The maximum toughness index indicated the post failure strength of concrete with 25%rubber content.

4) Ganjian *et al.* 2008 investigated the performance of concrete mixture incorporating 5%, 7.5% and 10% tyre rubber by weight as a replacement of aggregate and cement. Two set of concrete mix were made. In the first set chipped rubber replaced the coarse aggregate and in the second set scrap tyre powder replaced cement. The durability and mechanical test were performed. The result showed that up to 5%replacement in both sets no major changes occurred in concrete characteristic.

3) Methods of analysis:

The methodology for this work depends on the objectives. This study work which has an objective of achieving M20 grade of concrete with maximum utilization of tyre rubber as aggregate and natural sand in concrete contains extensive experimental work

Flow diagram-

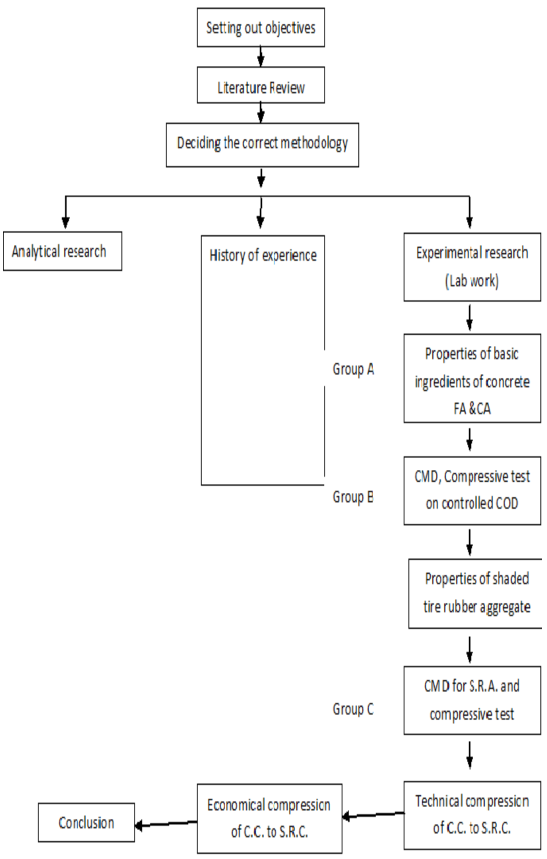

Fig: Methodology Chart

Experimental Research Program

An experimental program is undertaken which consist of testing on basic ingredients and rubber tyres and properties with fresh and hardened concrete specimens.

The methodology of the project is divided in various groups.

Group A Test

1) Group A deals with the properties of the materials used in the study. A detail study on the following properties is done. Table gives the data of the properties to be study with the relevant IS codes. The materials used in the current project are Cement, Natural fine aggregate, Coarse aggregate, Shredded rubber (SR), and water.

Properties of Materials

Properties	Natural sand	Coarse aggregate	Shredded rubber
Specific gravity	2.78	2.86	1.13
Fineness modulus	3.45	-	-
Water absorption	1.76	1.42	0.99

Table no 1

Group B Test

2) In Group B of set, mixes were designed with the materials tested in Group A. In this group mixes were designed using IS 10262:2009, with cement, Natural fine aggregate, coarse aggregate -20mm, and water. The mixes were designed with W/C as 0.45. These mixes were denoted as controlled mixes.

Group C Test

3) Group C consisted of designing of mixes with percentage replacement of SR in 1%, 2%, and 5% mixes with W/C of 0.45. The mix with best result of Compressive strength, for further investigation, SR tested for Compressive strength.

4) The mixes are designed in each of the group were tested for fresh and hardened properties of concrete. The properties study for the concrete are 3, 7, 14, and 28 Day compressive strength of concrete, 28 day.

MIXES DESIGN:

- Conventional Mix(M-20): -

Cement =437.77Kg/m³

Coarse Aggregate – 20mm = 1141.14 Kg/m³

Shredded Rubber =1%, 2%, and 5% mixes.

Fine Aggregate = 739.48 Kg/m³

Water Cement Ratio = 0.45

Mix Design Proportion – 1:1.68:2.60

Experimental program

1. Workability aspect,
2. Compressive strength

4) RESULTS AND DISCUSSION

The results obtained from the experimentation as per the methodology. The major results from each group of experimentation are discussed below.

4.1. RESULTS FOR GROUP A:

Group A of experimentation comprises of experimentation to know the physical and mechanical properties of materials used in the project. The materials used in the project are cement, Natural fine Aggregate (NFA), coarse aggregate (NA-20mm), and water.

4.1.1 Cement

The properties of materials are as follows:

Cement: The table below shows the properties of cement used. OPC- 53 grade cement was used. Cement is used as a binding material in concrete. The cement used in the project is OPC-53 Grade cement purchased from local vendors. The properties of cement are shown in table below established using relevant IS codes.

Table Properties of Cement

Sr. No	Property	Values	Relevant IS -Code
1	Specific Gravity	3.15	IS4031:1988(PART V)
2	Initial setting Time	30 min	IS4031:1988(PART V)
3	Final Setting Time	600 min	IS4031:1988(PART V)
4	Fineness of Cement	1.23	IS:269.1989
5	Standard Consistency	32%	IS 4031. 1988(Part IV)
6	Compressive strength	54.4 MPa	IS 269:1989 & IS 2269:1987

Table no 2

4.1.2 SHAPE AND SURFACE TEXTURE:

Surface texture is the property, the measure of which depends upon the relative degree to which particle surfaces are polished or dull, smooth or rough. Surface texture depends upon hardness, grain size; pore structure. Surface texture affects water cement ratio, workability and strength of the concrete.

4.1.3 FLAKINESS AND ELONGATION INDEX:

Shape of an aggregate goes hand in hand with the texture of the aggregate as it too contributes towards the strength characteristics and workability characteristics of concrete. The flaky and elongated particles tend to orient in one plane and cause laminations which adversely affect the durability of the concrete. The test followed IS: 2386(Part I)-1963.

Table of Flakiness and elongation Index of Aggregates

Property of aggregate	NA-20mm
Flakiness Index	14.70%
Elongation Index	34.82%

Table no 3

4.1.4. Specific Gravity and water Absorption

With reference to the previous studies higher the specific gravity of aggregate harder and stronger the aggregate will be. With reference to IS: 2386(Part III)-1963.

Property of aggregate	Specific Gravity
Natural Fine Aggregate	2.78
Conventional Coarse Aggregate -20mm(NCA-20mm)	2.86
Shredded rubber(SR)	1.13

Table No-4

4.2. RESULT AND DISCUSSION FOR GROUP B MIXES:

The mixes were designed with an attempt of optimization of cement content for the mixes. These mixes are designed with W/C 0.45 with conventional aggregates and are treated as control mixes without any SR and CR. The below table shows the results obtained for 3,7,14 and 28 day compressive strength of concrete.

RESULT FOR GROUP B MIXES

Table: Test Results of Conventional Mix

Batch no.	%Replaced	W/C ratio	Slump mm	Compressive Strength 7 days N/mm^2	Compressive Strength 28 days N/mm^2	Split Tensile Strength
1.	0	0.45	100	12.29	28.15	

Table No-5

4.3. RESULTS AND DISCUSSION FOR GROUP C MIXES

Group C mixes were designed with an attempt to check the utilization of SR in concrete with W/C 0.45 Percentage replacement of SR was 1%, 2%, and 5% done to coarse aggregates. The table below shows the results obtained for the Group C mixes.

Methodology	W/C ratio	SLUMP	Compressive strength (N/mm2)			
			3 days	7 days	14 days	28 days
1% SR	0.45	60	8.16	12.10	17.07	27.62
2 % SR	0.45	50	8.04	11.92	16.81	27.30
5% SR	0.45	30	7.87	11.67	16.46	26.74

Table No-6

5)COMPARISON OF RESULT:

5.1 CONVENTIONAL MIX

In conventional mix, rubber is not added at all. Concrete is designed as per regular concrete. These results are taken from average of three cubes. As the designed concrete is of M20, 28days strength of cubes with both w/c ratios is OK.

Table: Test Results of Conventional MixFig.

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Batch no.	%Replaced	W/C ratio	Slump mm	Compressive Strength 7 days N/mm^2	Compressive Strength 28 days N/mm^2
1.	0	0.45	100	12.29	28.15

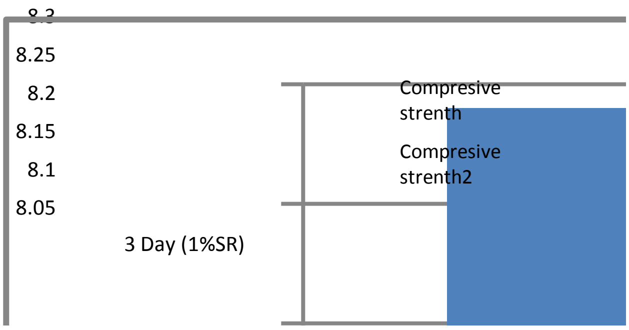
Table no 7

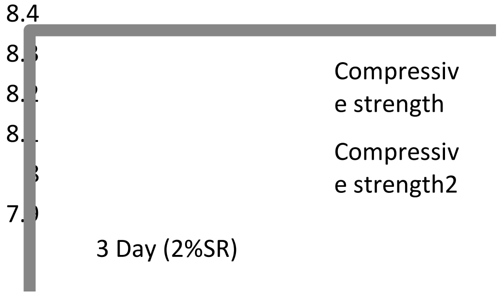
5.2 COMBINATION WITH SHREADED RUBBER

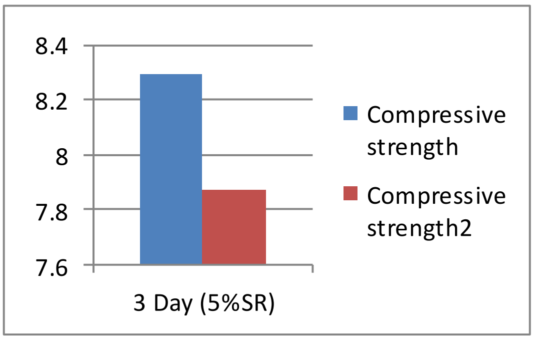
Table: Test results for 1% 2% & 5% replacement of shredded rubber to CA

Batch no.	% Replaced	W/C ratio	Slump mm	Compressive Strength 7 days	Compressive Strength 28 days
1	1% SR	0.45	60	12.10	27.62
2	2% SR	0.45	50	11.92	27.30
3	5% SR	0.45	30	11.67	26.74

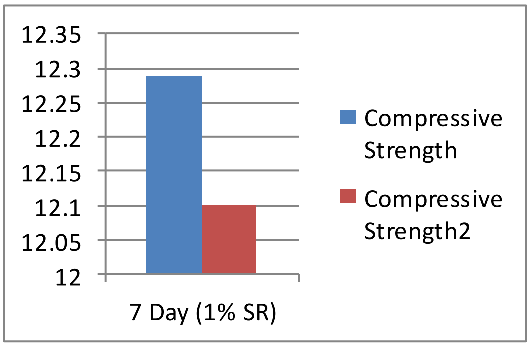
Table No-8

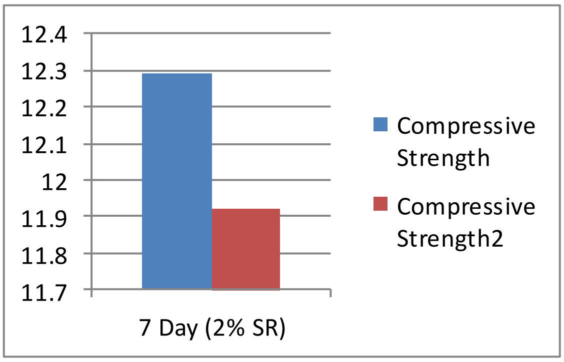


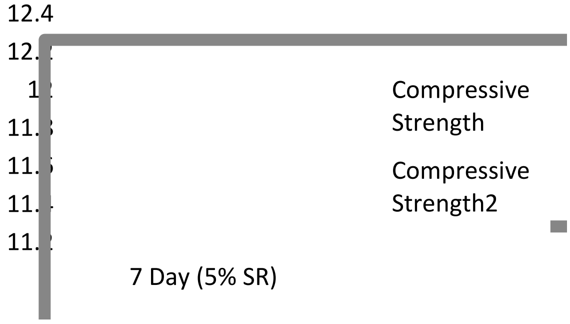




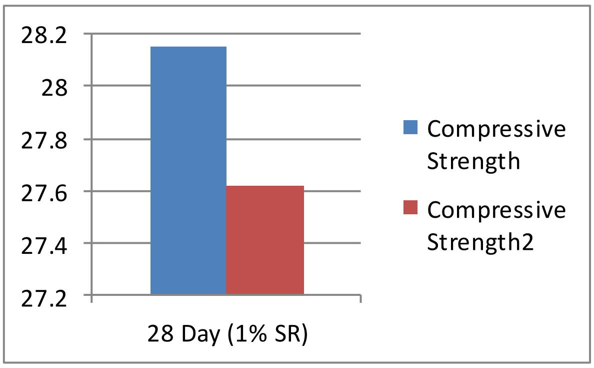
As observe to above graphical presentation it shows that 1% , 2% , 5% , SR having 1.56,3, 5.7 % respectively less compressive strength than CC.

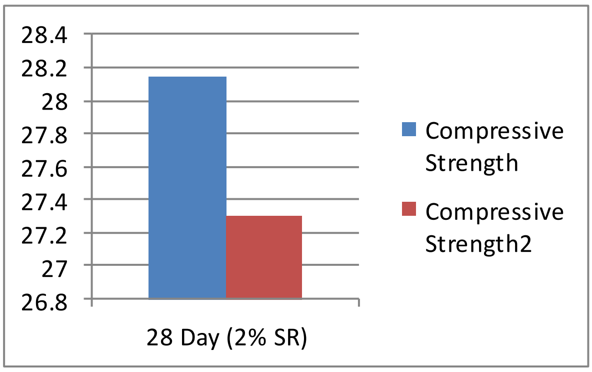


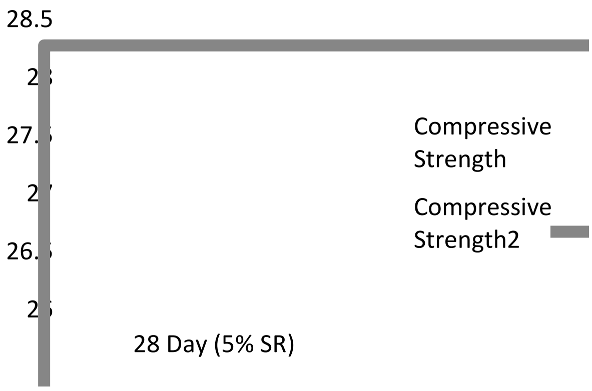




As observe to above graphical presentation it shows that 1% , 2% , 5% , SR having 1.55, 3.01,5.04. % respectively less compressive strength than CC.







As observe to above graphical presentation it shows that 1% , 2% , 5% , SR having 1.88,3.02,5.01 % respectively less compressive strength than CC.

CONCLUSION:-

1) From the experimental study we conclude that the reduced compressive strength of rubberized concrete in comparison to conventional concrete. But it s strength is within acceptable limit.
2) There is a potential large market for concrete products in which inclusion of rubber aggregate would be feasible which will utilize the discarded rubber tyres the disposal of which, is big problem for environment pollution.
3) Rubberized concrete cost is less as compared to conventional concrete.
4) The light unit weight qualities of rubberized concrete may be suitable for architectural application stone baking ,interior construction ,in building as an earthquake shock wave absorber ,where vibration damping is required such as in foundation for machinery and railway station.
5) Conventional stone aggregate can be saved to a certain quantity.

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