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

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Abstract— Solid waste management is one of the majar environmental concern in the world .The promotion of automobile Industry has accompanied with increase in prevalent waste material such as waste tyre.The undegradable nature of the rubber and consequent disposal problem has lead to a serious environmental issue in the recent decades. To overcome this problem ,many innovative solution have been proposed. The using this waste material in concrete can be solve these problem. It is estimated that 60 percent waste tyres are disposed via. Unknown routes in the urban as well rural area. This leads various environmental problem.

The concrete is one of the most widely used construction material in the world. Cement and aggregate which are the most important ingredient in concrete production are then vital material needed for construction industry. This inevitably led to a continuous and increasing demand of natural material used for their production .Parallel to need for utilization of natural resources emerges a growing concern for protecting the environment and a need to preserve natural resources (such as aggregate) by using alternative material which are recycled waste material.

In these research a study was carried out on the use of recycled rubber tyre as a partial replacement for the coarse aggregate in concrete construction using locally available waste tyre.This leads to various environmental problem which include air pollution ,open burning of tyre. The concrete mix design are prepared using IS method for M-20 grade concrete. The specimens were cast percentage replacement of coarse aggregate 1%,2%and 5% by the shredded rubber aggregate. The prepared samples consist of concrete cubes ,cylinder, beams. The list of tests conducted are slump, workability , compressive strength ,Tensile strength ,Flexural strength. The data collection was mainly based on the tests conducted on the prepared specimens in the laboratory.

Keywords- Tyre , compressive strength , Tensile strength , Flexural strength.

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.

Waste tire rubbers are materials that do not decompose and disintegrate in the nature; so they are considered as environmental pollutants. With the growth of automobile industry, and the subsequent increase in tire production rate in recent decades, tire waste has created abundant difficulties. Many innovative solutions have been proposed to solve this problem. Rubber particles are applied as a last circulating material in petroleum industry, also in asphaltic pavement and recently in Portland cement concrete. The latter case is under consideration in this study Since waste rubber properties and its weight percent influences the physical properties and durability of concrete, their applications should be limited to the results obtained in the same physical and application terms In recent decade, associated problems with waste tire have been considered more than before and this caused to do some investigation on properties of concrete having waste rubbers.Each year, over 270 million automobile and truck tires are removed from service and scrapped in the United States. According to the United States Environmental Protection Agency (USEPA), the need to manage scrap tires has given rise to numerous scrap-tire management programs and brought about laws or regulations in 49 of 50 states [USEPA, 1999]. Scrap tires have been beneficially utilized in many states.

For a country like India an efficient road network is necessary for national integration, industrial development and as well as for socio-economic development. Due to improvement in living standards of the people, the use of vehicles has increased over a last few years, giving rise in the vehicular density on roads. As vehicles are used frequently the wear and tear of their tires is obvious. Due to wear and tear of tires the life of tire reduces and at last it becomes useless. The disposal of these tires has become a serious problem. These tires are disposed easily by either burning or by dumping. Disposal by burning causes air pollution and dumping causes valuable land to be wasted for stacking up the tires.

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

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

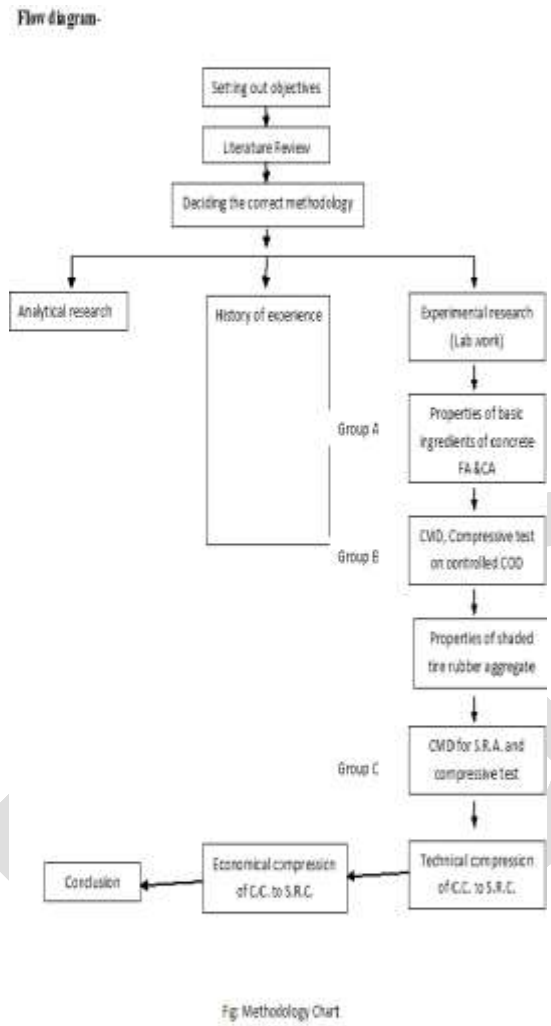


Fig: Methodology Chart

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
3. Split tensile strength
4. Flexural 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	NA-20mm
Flakiness Index	14.7%
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.

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

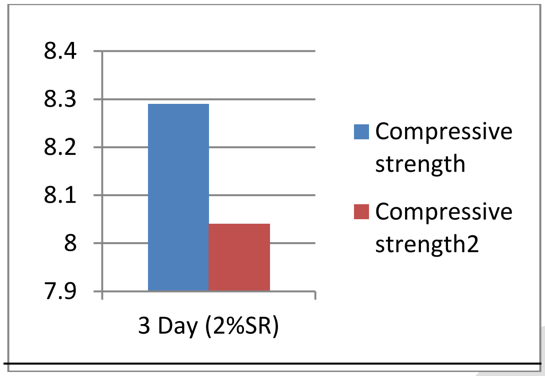
5.2 COMBINATION WITH

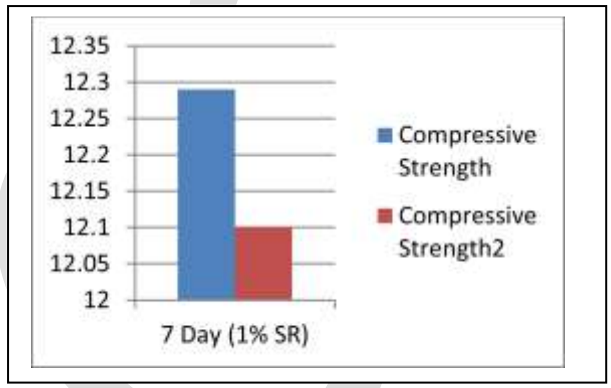
SHREADED RUBBER

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

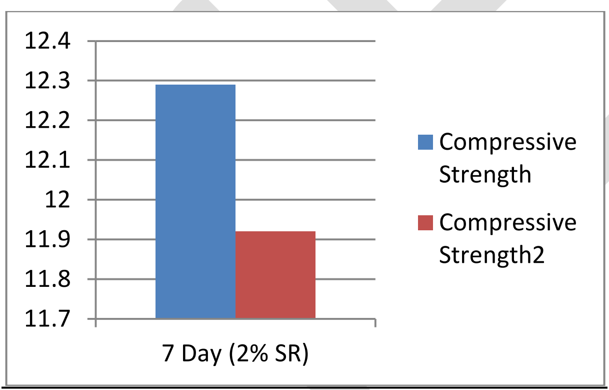
Batch no.	% Replaced	W/C ratio	Slump mm	Compressive Strength 7 days	Compressive Strength 28 days
1	1% SR	0.45	60	12.10	27.62
2	2% SR	0.45	50	11.92	27.30
3	5% SR	0.45	30	11.67	26.74

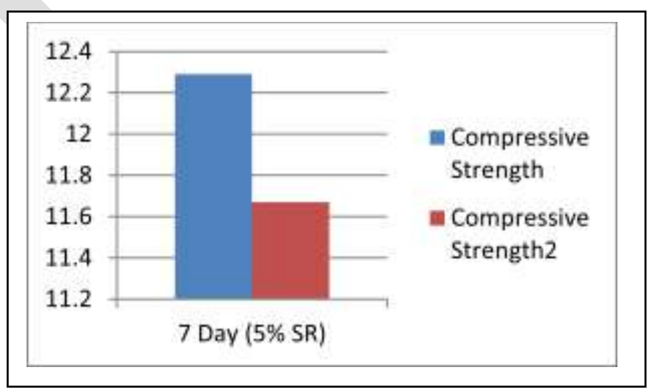
Table No-8



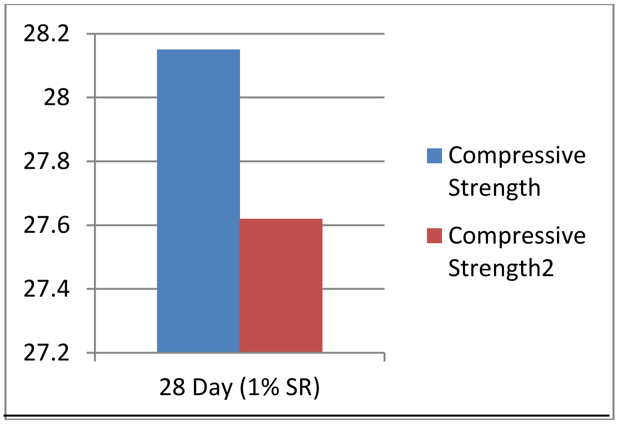


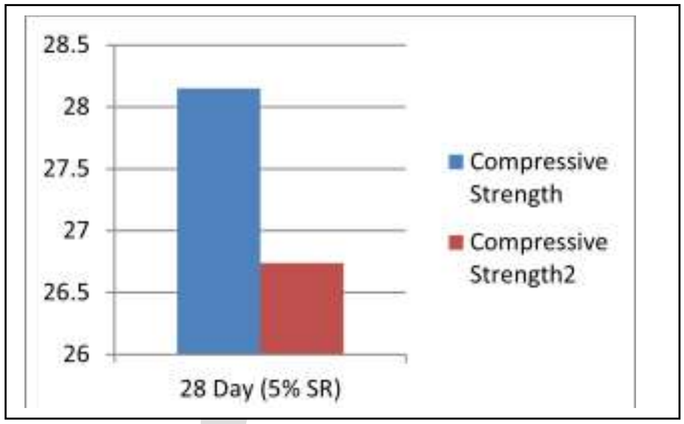
As observe to above graphical presentation it shows that 1% , 2% , 5% , SR having 1.56,3, 5.7 % respectively less compressive strength than CC.





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

NORMAL SPLIT TENSILE STRENGTH TEST RESULT

Batch no.	%Replaced	W/C ratio	Slump mm	Split tensile strength for 7 days N/mm^2	Split tensile strength for 14 days N/mm^2	Split tensile strength for 28 days N/mm^2
1	0	0.45	100	1.90	2.48	3.11
				1.84	2.55	3.18
				1.90	2.55	3.18
Avg. of Split tensile strength in N/mm^2				**1.88**	**2.52**	**3.16**

Table No-9

Shredded Rubber For 1%

Batch no.	%Replaced	W/C ratio	Slump mm	Split tensile strength for 14 days N/mm^2	Split tensile strength for 28 days N/mm^2
1	0	0.45	100	2.40	3.18
				2.48	3.11
				2.55	3.11
Avg. of Split tensile strength in N/mm^2				**2.48**	**3.13**

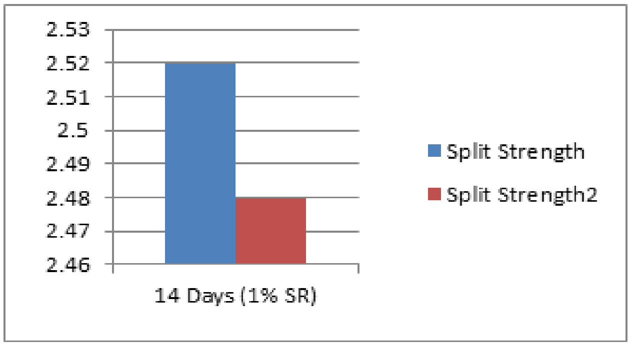
Table No-10

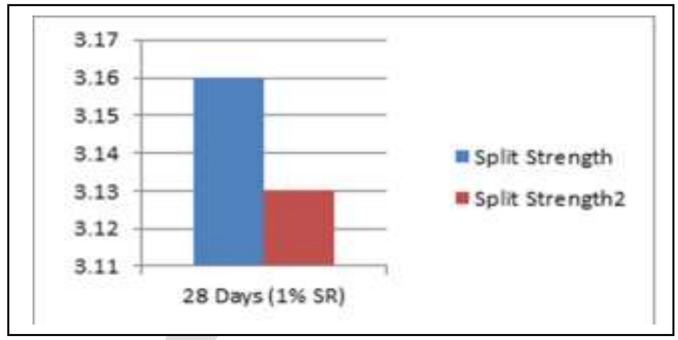
Shredded rubber 2%

Batch no.	%Replaced	W/C ratio	Slump mm	Split tensile strength for 14 days N/mm^2	Split tensile strength for 28 days N/mm^2
1	0	0.45	100	2.40	3.04
				2.40	3.04
				2.40	2.97
Avg. of Split tensile strength in N/mm^2				**2.40**	**3.02**

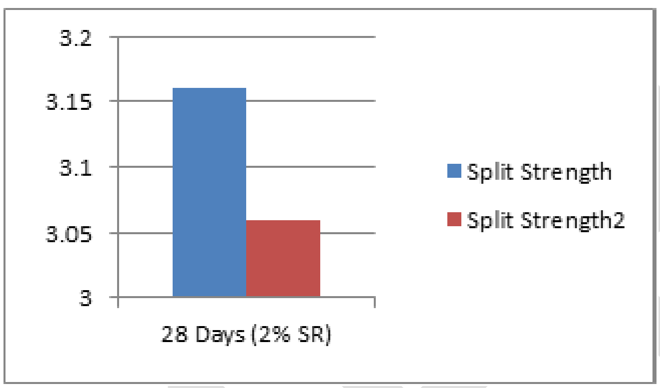
Table No - 11

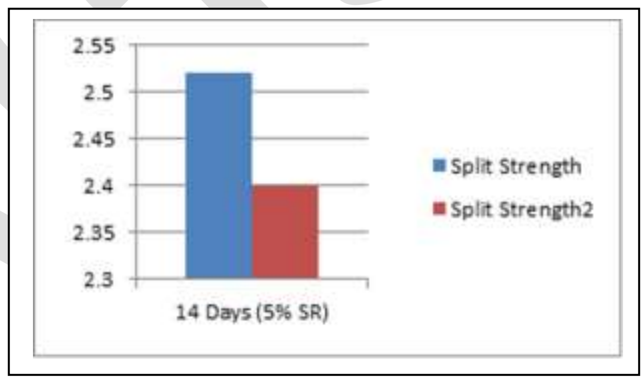
Shredded Rubber For 5%



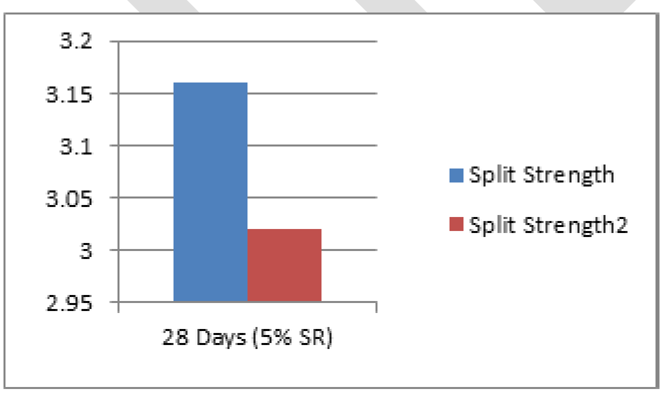


As observe to above graphical presentation it shows that 1% SR for 14days and 28days having 1.58% & 0.95% respectively less Split Tensile Strength than CC.





As observe to above graphical presentation it shows that 2% SR for 14days and 28days having 3.57% & 3.06% respectively less Split Tensile Strength than CC.



As observe to above graphical presentation it shows that 5% SR for 14days and 28days having 4.76% & 4.43 % respectively less Split Tensile Strength than CC.

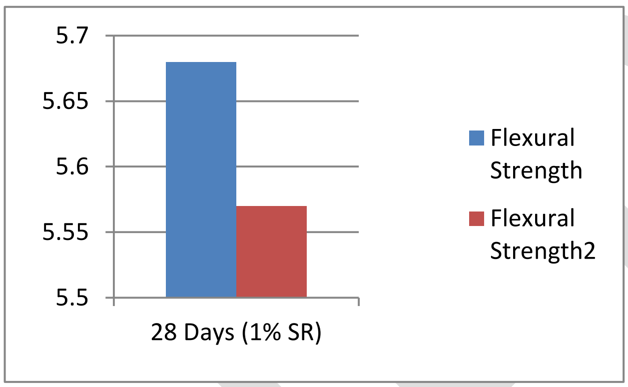
FLEXURAL STRENGTH

Batch no.	%Replaced	W/C ratio	Slump mm	Flexural strength for 7 days N/mm^2	Flexural strength for 14 days N/mm^2	Flexural strength for 28 days N/mm^2
1	0	0.45	100	3.73	4.62	5.51
				3.91	4.97	5.86
				3.91	4.97	5.69
Avg. of Flexural strength in N/mm^2				3.85	4.85	5.68

Table No-12

Batch no.	%Replaced	W/C ratio	Slump mm	Flexural strength for 14 days N/mm^2	Flexural strength for 28 days N/mm^2
1	0	0.45	100	4.76	5.69
				4.59	5.51
				4.76	5.51
Avg. of Flexural strength in N/mm^2				4.70	5.57

Table no -13

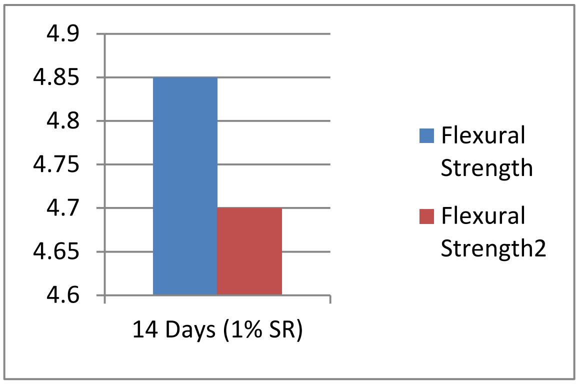


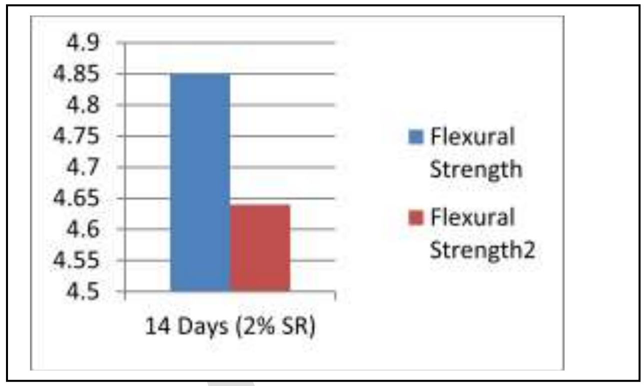
Batch no.	%Replaced	W/C ratio	Slump mm	Flexural strength for 14 days N/mm^2	Flexural strength for 28 days N/mm^2
1	0	0.45	100	4.76	5.69
				4.59	5.51
				4.59	5.33
Avg. of Flexural strength in N/mm^2				4.64	5.51

Table No-14

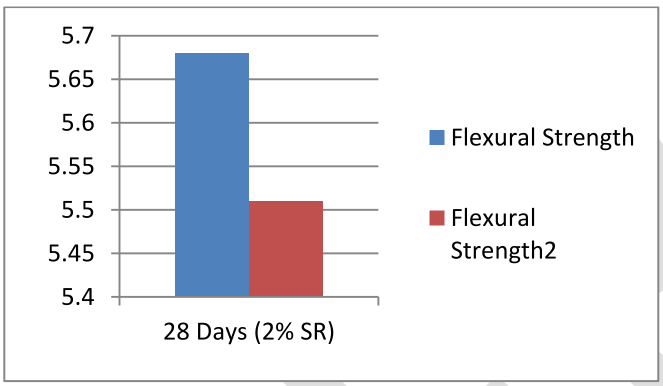
Batch no.	%Replaced	W/C ratio	Slump mm	Flexural strength for 14 days N/mm^2	Flexural strength for 28 days N/mm^2
1	0	0.45	100	4.42	5.33
				4.59	5.51
				4.76	5.51
Avg. of Flexural strength in N/mm^2				4.59	5.45

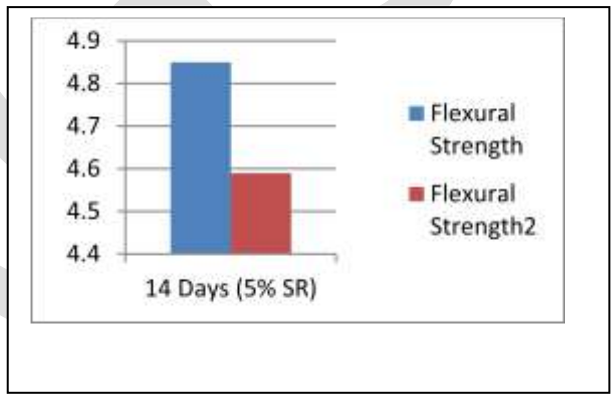
Table no - 15





As observe to above graphical presentation it shows that 1% SR for 14days and 28days having 3.02% & 1.93% respectively less Flexural Strength than CC.





As observe to above graphical presentation it shows that 2% SR for 14days and 28days having 4.19% & 3.00% respectively less Flexural Strength than CC. As observe to above graphical presentation it shows that 5% SR for 14days and 28days having 5.36% & 4.04% respectively less Flexural Strength than CC.

CONCLUSION:-

1) Rubber aggregates are feasible solution for Concrete production , economically and environmental
2) This Study provides a solution for disposal of rubber tyre which can be used as a aggregate certain limit.
3) This experimental study conclude that the reduced compressive strength of rubberized concrete in comparison to conventional concrete within acceptable limit.
4) This experimental study we conclude that the reduced Split tensile strength of rubberized concrete in comparison to conventional concrete.
5) This experimental study we conclude that the reduced flexural strength of rubberized concrete in comparison to conventional concrete.
6) Rubberized concrete cost is less as compared to conventional concrete.
7) Concrete produced is light weighted by 0.99% than conventional concrete.
8) 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.

9) Conventional stone aggregate and expenses on it can be saved to a certain quantity.

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