AN EXPERIMENTAL INVESTIGATION OF PARTIALLY REPLACED CRUMB RUBBER WITH FINE AGGREGATES IN CONCRETE

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ABSTRACT— This report presents the experimental study for "rubber concrete". Mixes of concrete requires a high need of replacing fine aggregate as the natural resources are depleted which is a concern to the environmental balance. Rubber materials are widely are researched in industries for the applications like asphalt pavement, water proofing systems membrane liners etc. By using this type of choice it leads to wider possibilities and provides better options in the field of construction industries. These technologies relating to sustainability is not only the important for its expansion of eco responsive in construction but also to deal with higher amount of waste with no durability negotiation. It is also considered that the concrete acts as binder when the rubber is mixed with it that leads to higher flexibility and surface smoothness. Due to the grave danger posed on the environment by the non-biodegradable and hazardous tires which are dumped in the landfills there is a great need to protect the environment by making optimum use of the waste rubber tires. The properties of durability and the mechanical properties were studied by replacing the fine aggregates with crumbled rubber tires. The mix design was made with respect to IS10262 – 2009 for M30 grade. In this research the sand is replaced partially with percentages of 0%, 5%, 10%, 15%, 20%, 30% & 40% respectively. Tests for example compression test and split tensile test have been conducted. Tests result shows with increase in rubber percentage, significant decline in the compression & split tensile strength also reduces. Slump test was likewise done.

INDEX TERMS — Crumb rubber, fine aggregate, coarse aggregate, rubberized concrete, compressive strength, split tensile strength, flexural strength, durability.

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1. INTRODUCTION

About one crore vehicles are added to the Indian roads every year. There is a huge increase in the amount of discarded rubber tires every year, which causes environmental imbalance. Discarding of waste tires is an environmental hazard[16]. Most of the discarded tires are buried in the landfills. Only few tires are reused or recycled in the country. Burial of scrap tires is waste and ineffective. Since burial of whole tires is hazardous it is banned in most of the landfills, so the tires are crumb. Instead of burying the tires it is more economical and efficient to reuse them as construction materials as it is a more efficient way of reusing them as well as we can bring out the certain useful properties in them. In this setting, utilizing crumb tire under manufacturing field for lightweight material is measured a potentially substantial boulevard. So, utilization of the waste tires into concrete production process, actually the requirement than desire. Utilization of the waste tires into concrete is perception apply widely throughout globe[17] [18]. Utilization of the crumb tire rubber into common strength concrete be innovative method used during concrete mix design also if it is apply on a huge scale it would lead to a revolution in the construction industry via bringing down the pr oduction price also growing tired tire dumping.The main aspiration behind this research is to utilize the aggregate as finer material as crumbled rubber in cement concrete.

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2. LITERATURE REVIEW

N SHANMUGANTHAN, In this research the waste crumb tyre rubber was utilized as the replacement of fine aggregates for different proportions. The grade of concrete used was M25. The consequence of this investigation gives different estimations of compression test, flexural quality and split elasticity for substitution of disintegrated elastic substitutions in fine aggregate. The consequences of this trial, such as compressive, split also flexural tests for substituted material shows high values for 8% replacement[1].

YOGENDER ANTIL, In this study various tests like compressive quality, flexural quality and effect resistance of rubber treated cement are done. Different proportions ranging 5 to 20% of rubber were used for this study. The review demonstrates that upon increasing rubber the strength decreases however it meets the criteria of light weight solid which fullfils the quality necessities according to Neville in 1995. The split rigidity diminishes with increment in elastic substance. The compressive strength of rubber reduces by 35% with 20% elastic substance [2].

S.SELVA KUMAR, R.VENKATKRISHNAIAH,
Some tests were performed for determining the properties of aggregate for variety of proportion of substitution casted. For the 5% substitution of crumb rubber the comp. strength is 38.66 N/mm2 which is greater when compared to ordinary mix i.e. 36.73N/mm2 for 28 days, but for 10% substitution of rubber, the result is satisfactory strength of 33.47 N/mm2. Upon conduction of split tensile and flexural tests, rubcrete resulted lesser strength compared to normal ordinary concrete mix. With these tests it concluded that crumb rubber contains the poor bonding capacity that affects the concretes strength[3].

3. MATERIALS ANALYSIS, METHODOLOGY AND MIX DESIGN

3.1 Materials[11]

Cement

The cement used in this study was ordinary Portland cement (OPC 43 grade) of Coromandal Cement brand confirming to IS: 8112. The characteristics of cement indicated in table 1[15].

Fine Aggregate

River sand validating zone II as said by IS 383:1970 was used. The fine aggregate was procured from Gumpa, Bidar district, Karnataka. The properties of fine aggregate are indicated in table 1[12].

Coarse Aggregate

Crushed angular basalt aggregate of down size 12mm was used for the study. The properties of coarse aggregate are indicated in table 1[12].

***Table 1**: Represents the Characteristics of Rubber, Cement, Fine aggregate and Coarse aggregate*[11]

Rubber	Cement	Fine aggregate	Coarse aggregate
Specific gravity = 1.753	Specific gravity = 3.1	Specific gravity = 2.84%	Specific gravity = 2.8%
Water absorption = 0.806	Normal consistency = 29%	Water absorption = 1.8%	Water absorption = 0.3%
Sieve analysis = ZONE II	Initial setting time =60minutes	Sieve analysis = ZONE II	Shape of aggregates = angular
Fineness modulus = 4.783%	Final setting time =360minutes	Fineness modulus = 2.9%	Fineness modulus = 5.8%

3.2 Methodology

1. The mix design was made with respect to IS10262.
2. Standard moulds of 100x100x100 mm were used.
3. OPC 43 grade cement was used.
4. 12mm down size coarse aggregates was used.
5. Natural sand passing from IS 4.75mm sieve is utilized
6. like fined aggregate.
7. Powdered rubber was used in place of fine aggregates in the composite blocks.
8. The test of Slump be carried out for every mixture of concrete before casting the moulds.
9. Moulds were made after substitution of rubber with sand in increments by 5 percent upto 40 percentage.
10. Moulds made will be tested in the lab for compression, split tensile & durability tests.

3.3 Mix Design[10]

Design combinations for the casting of various mix of concrete was done as per IS: 10262-2009 for conventional concrete The mix design was done as per IS 456-2000 to make M30 grade concrete. Results for mix design:-

- Target strength= 38.25 N/sq.mm
- Cement = 462.22 kg/cum .
- Water = 208 litres.
- Fine aggregate = 820.476 kg.
- Coarse aggregate = 988.68 kg.
- W/C Ratio = 0.45.

As there is the replacement for 7different proportions (0%, 5%, 10%, 15%, 20%, 30% and 40%) so for each proportion there are to make the 9 cubes (3cubes for 3days, 3cubes for 7days, 3 cubes for 28days) for compression and for flexural and split tensile 6beams and 6cylinders for 7 and 28days are designed and casted. The ratio obtained was 1:1.78:2.14.

4. EXPERIMENTAL PROGRAM

In this experimental program it involves studying of properties like fresh state properties, mechanical properties to assess the strength and durability of Rubber Concrete. Slump tests, Compression tests, Split Tensile strength tests & Flexural strength test also Durability test like Sorptivity tests were conducted.

Fig. 1 Sieve analysis

Fig. 2 Compression testing of cubes

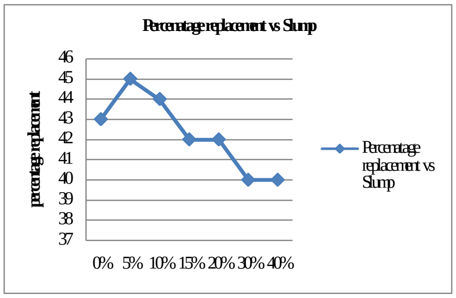
Fig. 3 Split tensile testing of cylinders

Fig. 4 Flexural testing of beams

5. RESULTS

5.1 Slump cone test

The consequences of the slump cone test which indicate the workability of fresh concrete mix is shown in graph below. It was clear that upon addition of rubber the workability increases upto 5% and then decreases upto 40%.



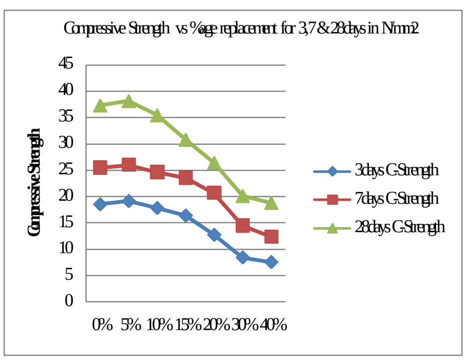
Graph 1: Represents Slump cone test results.

5.2 Compressive strength test[13]

For calculating the compression strength cubes were tested for three different ages such as 3, 7 and 28days. The result shows that there was a significant increase in strength upto 5% upon adding up of rubber and thus decreases further for the rest proportions upto 40%. The compression test values are indicated in below table and graph.

***Table 2**: Represents Compressive Strength*

Mix proportions	Average compressive strength (N/mm^2)		
	3 days	7 days	28 days
0%	18.56	25.5	37.36
5%	19.19	26	38.20
10%	17.87	24.63	35.50
15%	16.43	23.53	30.83
20%	12.76	20.70	26.45
30%	8.45	14.46	20.13
40%	7.57	12.36	18.83



Graph 2: Represents the compression strength

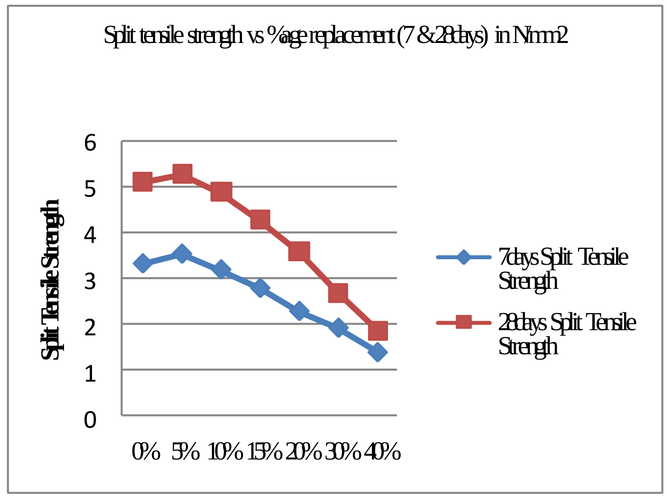
From the above data it can be concluded that 5% rubber replacement shows the increased strength results thus for further addition of rubber upto 40% it shows decrease in strength for 3 different ages of 3, 7 and 28days.

5.3 Split tensile strength test [14]

The test was performed for all the cylinders at 2 different ages. The result shows that there has been decrement in strength upto 5% rubber addition. The optimum content of rubber was 5%, which remarkably increased the strength. The table and graph below shows Split-Tensile Strength of cylindrical specimens of mixes for 2 different ages of 7 and 28 days.

***Table 3**: Represents Split Tensile Strength for 7 & 28days*

Mix proportions	Average split tensile strength (N/mm^2)	
	7 days	28 days
0%	3.32	5.11
5%	3.53	5.27
10%	3.19	4.88
15%	2.79	4.29
20%	2.29	3.60
30%	1.93	2.71
40%	1.40	1.89



Graph 3: Represents the split tensile strength

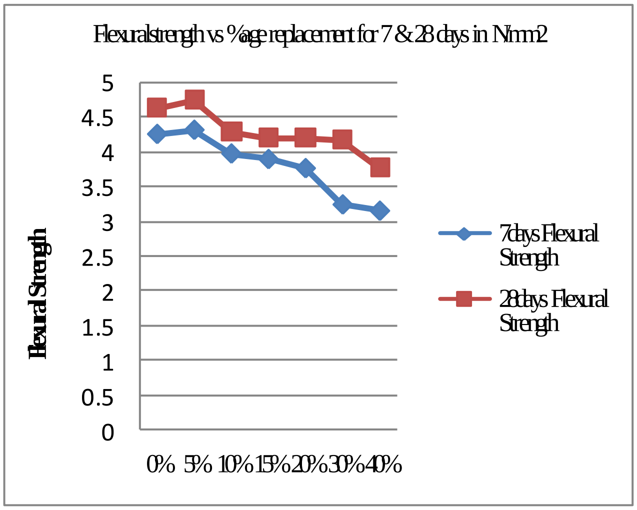
From the above data it can be concluded that 5% rubber replacement shows the increased strength results thus for further addition of rubber upto 40% it shows decrease in strength for 2 different ages of 7 and 28days.

5.4 Flexural strength test[13]

Beam specimens having depth and width 100mm and total length 500mm was tested to achieve the flexural-strength. The specimens were tested for 2 different ages 7 and 28 days using two point loading method.

***Table 4**: Represents Flexural Strength for 7 and 28 days.*

Mix proportions	Average flexural strength (N/mm^2)	
	7 days	28 days
0%	4.24	4.63
5%	4.30	4.74
10%	3.96	4.29
15%	3.88	4.20
20%	3.75	4.19
30%	3.23	4.17
40%	3.14	3.77



Graph 4: Represents flexural strength for 7 and 28 days

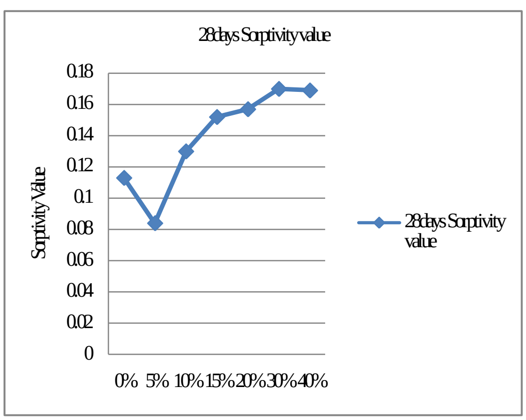
From the above data it can be concluded that 5% rubber replacement shows the increased strength results thus for further addition of rubber upto 40% it shows decrease in strength for 2 different ages of 7 and 28days.

5.5 Sorptivity test

After the samples casting and treatment, samples were taken out and their dry weight and wet weight were taken. The sorptivity values were then found out. The result of sorptivity is shown in below table.

***Table 5**: Represents Sorptivity Test Results*

Mix proportions	Average sorptivity value
0%	0.113
5%	0.084
10%	0.130
15%	0.152
20%	0.157
30%	0.170
40%	0.169



Graph 5: Represents the sorptivity for 28 days

6. CONCLUSIONS

6.1 CONCLUSIONS

Test outcomes show that, replacement of sand with rubber is of great potential. Percentages of natural sand varying 5-40% were used depending upon which can be concluded as:

1) Designed concrete strength with rubber contents are decreased when the rubber percentages are high however when the percentages are reduced to a subsequent amount results are quite satisfactory and also fulfils the standard requirement.
2) The compressive strength of rubber for 5% substitution is 38.2MPa; it is greater than strength of normal concrete 37.36MPa. Compressive strength of higher replacement were not desirable.
3) The compressive strength of 10% replacement is acceptable strength that is 35.5MPa.
4) Upon adding up the rubber proportion, concretes strength also rises. Also upon crumb rubber increment for 1-10% gives the increase in the slump for the concrete that is replaced.
5) For both normal and rubberised concrete, the failure in compression and split tests resulted that rubber has higher toughness.
6) By replacing rubber in place of sand results for split tests shows the decline in its strength by 30%. Similarly for 5% substitution, flexural strength it is 4.74, split strength it is 5.27 and sorptivity it is 0.084 for water absorption is good and sufficient.
7) Also, compressive strength gets lessen upto 37% as the rubber replacement with fine totals and it is observed the most favourable proportion for sand which could be replaced with rubber is 5% as the compressive and for 5% rubber substitution the split tensile strength observed to be higher than required strength.
8) It is observed that at 10% replacement, compression and split tensile strength is acceptable and matches by way of IS 10262 standards.
9) Similarly for flexural and split tensile for 10% is acceptable according to IS 516 and 5816.
10) Resistance to water absorption is studied by immersing cement mortar in water (5% of total weight of water) for about 28 days and little absorption of water by weight is observed.

6.2 FUTURE SCOPE OF THE STUDY

1. As there are many methods for production of rubber concrete like replacing with coarse aggregates and also addition of admixtures etc, one can opt this method for production of rubcrete.
2. In this research, crumb rubber is utized with substitution of finer aggregate in concrete, thus can make use for revising impact on rubber concrete.
3. One can alter percentage swapping of rubber and investigate the causes on concrete particularly durability features.

4. This existing self-regulating study involves M_{30} concrete grade. Superior grade concrete can be deliberated along with light materials for production of rubber concrete of higher strength.
5. The compression split tensile, flexural strengths and durability values can be increased by integration of different proportions of rubber.

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