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Studying the properties of rubberized concrete

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Abstract: *Accumulation of waste rubber tyres increases day by day. This is one of the main causes of land pollution. The rubber tyre is non-biodegradable waste that cannot decompose even after a long period. Researchers are suggesting various ways to manage rubber tyre waste. Rubberized concrete is one of them prepared by using a shredded rubber tyre. This research study was conducted by using a shredded rubber tyre for the replacement of the coarse aggregate in the normal concrete mix. The variation in properties of rubberized concrete with variation in percentage replacement of coarse aggregate with rubber tyre is presented in the results. All the replacements are done on M_{25} grade concrete.*

Keywords: Rubberised concrete, Compressive strength, Slump value, Workability.

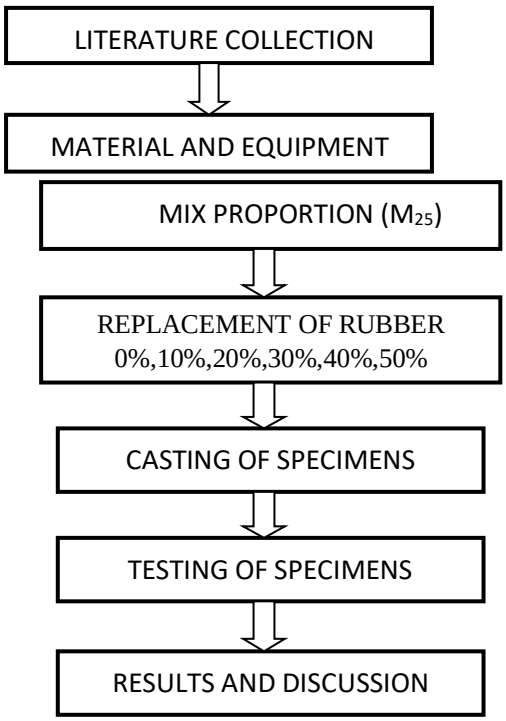
I. INTRODUCTION

Every year a large amount of used rubber tyres is accumulated in the world.180 million in the European Union and 275 million in the united state. India is the second-largest producer of waste rubber tyres after china. The rubber tyre is non-biodegradable waste that cannot easily decompose even after a long period. Landfilling of the tyre may cause soil pollution and stockpiles of tyres have the risk of fire hazard and provide a breeding site for mosquitoes and rats. Scrap tyres are used as fuel in cement industries but the burning of the tyre is not eco-friendly.

One such application of waste rubber tyre is rubberized concrete. In normal cement concrete coarse aggregate is replaced by shredded tyre chips commonly known as rubberized concrete. The use of tyre chips may alter the properties of concrete. Properties of rubberized concrete also depend on the size and percentage of tyre used in concrete.

The objective of this study is to evaluate the fresh and harden properties of concrete produced by replacing part of course aggregate with shredded rubber tyre aggregate.

II. METHODOLOGY



III. MATERIAL INVESTIGATION

The properties of a concrete mix depend on the properties of ingredients of concrete mix i.e. cement, fine aggregate, and coarse aggregate. The material investigation gives the optimum amount of material required for a desirable strength and workability of concrete.

A. Cement

Cement is used as binding material in the concrete mix. 53 grade Ordinary Portland Cement (OPC) was used for this experiment.

Initial setting time :- 10 min
Final setting time :- 10 hr
Density :- 3150 kg/m^3

B. Fine aggregate

Aggregate range from .075mm to 4.75mm is known as fine aggregate. Angular coarse-grained sand used for this project because it produces a good interlocking mix and hence produce good and strong concrete. The specific gravity of sand is 2.65.

C. Coarse aggregate

Crushed stone and natural gravel are the common material used as coarse aggregate. For this project crushed stone passing from a 20mm sieve and retained on a 30mm sieve is used for concrete mix.

D. Rubber aggregate

In this research, I have used manually cut chips of the scratched tyre of heavy load vehicles. All chips of tyre range from 20mm to 25mm. Before using rubber aggregate it was immersed in water for 24 hr until all particles were fully saturated.

- Physical properties of rubber

- Specific gravity : 1.06-1.1
- Specific heat : .28-.35 cal/^{O}C
- Molecular weight : 1×10^5-3×10^5
- Hydraulic conductivity : .2-.85 cm/s
- Thermal expansion : 5.9-7.9$\times10^{-4}$/^{0}C
- Density : 120 kg/m^3
- Moisture absorption : 2-4%

- Chemical properties of rubber

- Angle of friction : 15-32^0
- Cohesion : 349-394 N/m^2
- Total organic carbon : 22.7-3.1 ppm
- Turbidity : 99-254 NTU
- Softening point : 38-125^{0}C
- Breaking point :12-30^{0}C

IV. TESTING AND RESULT

1. COMPRESSIVE STRENGTH TEST

The compressive strength test is performed to determine the strength of concrete under uni-axial compressive stress. For this experiment cubic specimen with 150×150×150 mm dimension was constructed. A total of 6 specimens was constructed by replacing coarse aggregate with rubber chips. The percentage of replacement was 0%, 10%, 20%, 30%, 40% and 50%. These cubes are kept in curing for 14 days. After 28days they were tested for compressive strength. For the compressive strength test, we used a CTM machine. The result of the test is present in the table: 1 below.

Table: 1 Test result of compressive strength test

S. NO.	Specimen	Replacement ratio (%)	Compressive strength of specimen (N/mm^2)	Reduction in compressive strength
1	A1	0	26.558	
2	A2	10	23.716	10.7%

3	A3	20	19.182	27.77%
4	A4	30	15.412	41.96%
5	A5	40	9.518	64.16%
6	A6	50	6.54	75.78%

aggregate with rubber chips. The objective of this experiment is to know the optimum quantity of rubber to design a low-weight concrete with good strength. The result of the test is present in the given table.

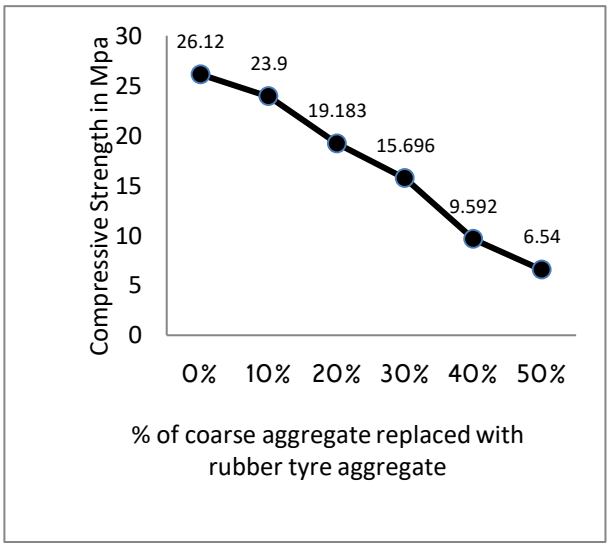


Fig 1: Chart representing compressive strength v/s % replacement with tyre aggregate

We notice that as we increase the percentage replacement of coarse aggregate with rubber aggregate, compressive strength gets reduced. On 0% to 50% replacement compressive strength reduces 26.12 MPa to 6.54 MPa. Using manually chipped rubber tyre particles to replace coarse aggregate result in the reduction in 28 days compressive strength by 10.7%, 27.77%, 41.96%, 64.16 % and 75.78% for replacement levels of 10%, 20%, 30%, 40% and 50%. From the above analysis, it is clear that as we increase the percentage of rubber in concrete the reduction in compressive strength also increases.

2. DENSITY

The specific gravity of rubber aggregate is less than gravel aggregate. It was expected to decrease in density of rubberized concrete as replaced coarse

Table: 2 Result of density test

S. NO	Specimen	Replacement ratio (%)	Weight of specimen (kg)	Density of specimen (Kg/m^3)	Reduction in density
1	A1	0	8.05	2385	
2	A2	10	7.166	2123	10.98%
3	A3	20	6.657	1972	17.32%
4	A4	30	6.152	1822	23.61%
5	A5	40	5.826	1726	27.63%
6	A6	50	5.484	1625	31.87%

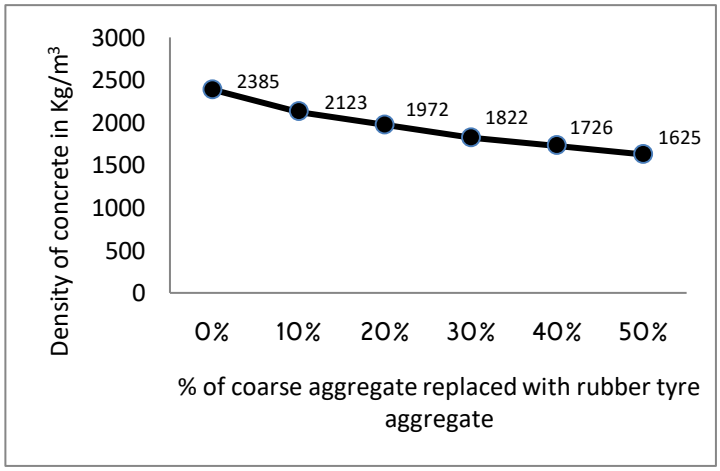


Fig 2: Chart representing density v/s % replacement with tyre aggregate

We notice that on an increasing percentage of replacement from 0% to 50% the density of concrete reduces from 2385 Kg/m^3 to 1625 Kg/m^3. Almost 31.87% reduction in density. For replacement level increase from 0% to 10% the reduction in density was 10.98% and for replacement level increase from 10% to 20% the reduction in density was 7.11%.

S. NO.	Specimen	Replacement ratio (%)	Slump value (mm)	Reduction in slump value
1	A1	0	85	
2	A2	10	69	18.82%
3	A3	20	47	44.71%
4	A4	30	26	69.41%
5	A5	40	14	83.53%
6	A6	50	7	91.76%

3. SLUMP CONE TEST

This test is performed to determine the workability of concrete. Workability defines as the ease with which concrete can be mixed, transported, and placed. To perform this test slump cone apparatus was used. The result of the test is present in table 3 given below.

Table: 3 Result of slump cone test

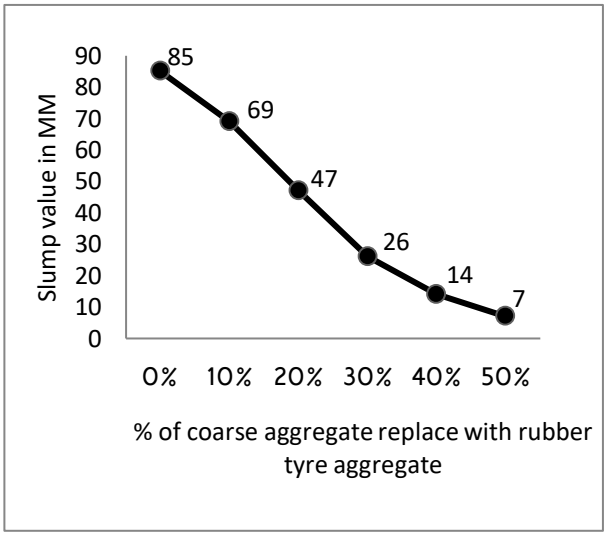


Fig 3: Chart representing slump value v/s % replacement with rubber tyre aggregate

Workability continuously reduces on increasing the replacement level. On replacing coarse aggregate from 0% to 50% with rubber tyre aggregate the slump value falls 85 mm to 7 mm. Almost 91.76% reduction in slump value registered. For replacement level increase from 0% to 10% the reduction in slump value was 18.82% whereas replacement level increase from 10% to 20% the reduction in slump value was 31.88%. Rubberized concrete with 40% to 50% rubber tyre coarse aggregate shows very low slump value and become very harsh. Such type of concrete is not used for any type of construction work.

V. CONCLUSION

The general objective of the research was to evaluate the fresh and hardened properties of concrete produced by replacing part of natural coarse aggregate with shredded tyre rubber chips

- The increase in the use of rubber tyre aggregate had an adverse effect on the workability of fresh concrete represented by a significant loss on slump value. On replacing 10% to 20% coarse aggregate with rubber tyre aggregate we get medium workable concrete having slump value between 69mm to 47mm which may be used for beams and slabs. Further on adopting replacement level 20% to 30%, we get low workable concrete having slump value between 47mm to 26mm which may be used for road construction and lightly reinforced section of the structure.

- The compressive strength of rubberized concrete depends on the type, size and percentage of rubber aggregate. It is observed that the compressive strength of the control mix was reduced by the replacement of coarse aggregate with rubber aggregate. Also observed that reduction percentage increases with increase in the level of replacement. There is reduction in compressive strength by 10.7%, 27.77% , 41.96% , 64.16 % and 75.78% on replacement percentage of 10%, 20%, 30%, 40% and 50%.

- Rubberized concrete up to 10% rubber aggregate has good strength and may utilize for the construction of parking areas, ground flooring, road with low traffic, etc. On using 10% to 20% rubber tyre aggregate as coarse aggregate we get concrete with slightly low compressive strength which may be used for lintel beam, bathroom slab and lean concreting of foundation
- Density will reduce by increasing the percentage replacement of tyre rubber aggregate in place of natural coarse aggregate. It was found that it will reach 10.98% to 31.90% when coarse aggregate was replaced with tyre rubber chips from 10% to 50%. Lightweight concrete reduces the transport cost and handing cast of the project. Therefore it was suggested to replace 10% to 20% coarse aggregate with rubber tyre aggregate. On further increasing the replacement level giving low strength concrete, therefore, it was recommended to replace maximum of 20% of coarse aggregate with rubber tyre aggregate.

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