PARTIAL REPLACEMENT OF COARSE AGGREGATE WITH CRUMB RUBBER CHIPS IN THE PREPARATION OF CONCRETE

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ABSTRACT

This experimental study is conducted to analyze the behaviour characteristics of rubberized concrete where tire rubber is partially replaced with coarse aggregate. It is estimated that more than 270 million scrap-tires are arising each year. In India the disposal of waste tire in landfills is a major issue handled by local municipalities and government sectors. This waste being non-biodegradable possess severe fire, environmental and health risks. A side from tire derived fuel, the most promising use of tires in engineering applications as artificial reefs, erosion control and aggregates for asphalt and concrete. The use of recycled tire rubber as partial aggregate in concrete has great potential to positively affect the properties of concrete in a wide spectrum. Concrete is one of the most popular construction materials. Due to this fact, the construction industry is always trying to increase its uses and applications and improving its properties, while reducing cost. M30 grade concrete has been chosen as the reference concrete specimen. Scrap tire rubber chips has been used as coarse aggregate with the replacement of conventional coarse aggregate. This will not only allow the sustainable use of aggregates available to us but also provide an effective and mass management of rubber tire waste. The rubber tire waste is split into coarse chips and then this crumb tire aggregate is added as 5%, 10%, 15% to replace the coarse aggregate. In this study, workability and compressive of rubberized concrete was evaluated to investigate the optimal use of crumb rubber as coarse aggregate in concrete.

Keywords: Compressive strength, workability, crumb rubber, rubberized concrete, M30 grade concrete.

1. INTRODUCTION

1.1 General

A very large amounts of used rubber tyres cumulate in the world every year out of which 275 million in the India and around 180 million in European Union. One of the most popular methods to get rid of this rubber waste is to pile these tyres in landfills, and since they have low density and poor degradation, we cannot burry them as landfills. These tyres are also placed in a dump or disposed of by simply piling them in large holes in the ground. And these dumps serve as a great homage to mosquitoes and these mosquitoes spread many diseases, this becomes a serious & dangerous health hazard. However, this rubber waste's higher amounts can be utilized as fuel, pigment soot, in bitumen, roof and floor covers etc. One of such applications that could use old rubber tyres effectively is rubberized concrete. Concrete can be made cheaper by replacing a fixed percentage of coarse aggregate with granulated rubber crumbs from rubber waste.

These granulated rubber crumbs can be achieved through a process called continuous shredding, which is done to create crumbs small enough to replace aggregates as coarse as gravel effectively. Such kind of concrete can be used in manufacturing process of reinforced pavement and bridge structures because this has better resistance to frost and ice thawing.

In present scenario, the disposal of waste tyre rubber is a major concern in waste management throughout the world. It is estimated that around 1.2 billion of waste tyre rubber is produced per year around the world. It is also estimated that around 11% of tyres are exported post consumption and 27% are piled as landfill, stockpiled or dumped illegally and only 4% of it is utilized for civil engineering works. Hence, efforts have been made to identify the potential of this waste tyre rubber in civil engineering projects.

Partial replacement of rubber tyre aggregates in concrete has the additional advantage of saving in natural aggregates used in the production of concrete which are becoming increasingly scarce. Waste tyre rubber mixture is more workable compare to normal concrete and also it is useful in making light weight concrete (El-Gammal, 2010).

1.2 Crumb Rubber

Crumb rubber is defined as the coarse pieces of rubber obtained from vehicle tires. This type of rubber is obtained by a process called Ambient Grinding. This type of grinding is a multi-step process and uses car or truck tires in the form of shred, or sidewalls, chips, or treads. By following the process, the rubbers, metals and textiles are separated out sequentially. After this, the tires are passed through a shredder, where the tires are broken into smaller chips. The small chips are then supplied into a granulator that breaks them further into even more smaller pieces while removing steel and fibre in the process.

2. LITERATURE SURVEY

Mohammed Mustafa Al Bakari. A. Syed NuzulFazl S.A, Abu Bakar M. Dand Leong K.W (2007) "Comparision of rubber as aggregate and rubber as filler in concrete"

This research will attempt to use rubber waste replacement of coarse aggregates to produce early age concrete. It carries out two different type of concrete which are rubberized concrete and rubber filler in concrete. In rubberized concrete, rubbers were used to replace coarse aggregates and river sand as fine aggregate. Coarse aggregate usually gravels or crushed stone and shredded rubber as filler in concrete.

The compressive strength was reduced in rubberized concrete for several reasons including the inclusion of the waste tyres rubber aggregate acted like voids in the matrix. This is because of the weak bond between the waste tyres rubber aggregate and concrete matrix. With the increase in void content of the concrete, there will be a corresponding decrease in strength.

Portland cement concrete strength is dependent greatly on the coarse aggregate, density, size and hardness. Since the aggregates are partially replaced by the rubber, the reduction in strength is only natural.

Mavroulido.M and Figueiredo.J (2010) "Discarded tyre rubber as concrete aggregate: a possible outlet for used tyres"

It can be concluded that despite the observed lower values of the mechanical properties of concrete there is a potential large market for concrete products in which inclusion of rubber aggregate would be feasible. These can also include non-primary structural applications of the medium to low strength requirements, benefiting from other features of this type of concrete.

Even if the rubber tyre aggregate was used at relatively low percentages in concrete, the amount of waste tyre rubber could be greatly reduced due to the very large market for concrete products worldwide. Therefore, the use of discarded tyre rubber aggregates in concrete shows promise for developing an additional route for used tyres.

3. OBJECTIVE OF THE STUDY

The objectives of the work are stated below:

i) To develop mix design methodology for mix 30MPa

ii) To study the effect of adding different percentages (0% - 15%) of crumb rubber (Coarse size 20mm-12.5mm) in the preparation of concrete mix.

iii) To determine the workability of freshly prepared concrete by Slump test and Compaction factor test.

iv) To determine the compressive strength of cubes at 7, 14, 28 days.

4. EXPERIMENTAL PROGRAM

4.1 Mix Design

The grade of concrete adopted for this paper M30

Table. 1: Quantities of materials for 1 m^3

Material	Quantity (kg/m^3)
Cement (grade 53)	438.13
Fine aggregates	643.47
Coarse aggregates	1128.88
Water	197.16
Water: cement	0.45

The final mix proportions are:

Cement: fine aggregate: coarse aggregate = 1**: 1.48: 2.57**

4.1.1 Mixed design proportions for rubberized Concrete

- In this research work 15 Standard cubic specimens of size 150mm (nine sample for each percentage of crumb rubber) were casted for the compressive strength of concrete and it was kept under curing for 7, 14 days & 28 days of age. Total cubes for compressive strength testing were 36 (9 cubes * 4 proportions).
- Mass of ingredients required will be calculated for 9 no's cubes assuming 10% wastage
- Volume of the Cube = $1.1*(0.15)^3$ $=0.037969$ m^3

Table. 2: Quantities of materials in preparation of 1 cube.

MIX (%)	CEMENT (kg)	FA (kg)	CA (kg)	CRUMB RUBBER (kg)	WATER (lit)
0%	1.62	2.38	4.18	0	0.731
5%			3.971	0.209	
10%			3.762	0.418	
15%			3.553	0.627	

4.1.2 Experimental Design

Basically, the test is divided into 2 major series; the first series was the conventional concrete with 0% addition of Coarse size rubber(control) mixture to be designated as S_1 mix.

The second series was by adding or replacement of the coarse aggregate with 5%, 10%, and 15% (S_2-5, S_2-10, S_2-15) Coarse rubber by volume coarse aggregates and designated Concrete mix. A mix design of M_{30} and water to cement ratio of 0.45 w/c was adopted and used.

4.1.3 Sample Production

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The cement, fine and coarse aggregates were weighted according to mix proportion of M_{30}. All are mixed together in a bay until mixed properly and water was added at a ratio of 0.45. The water was added gradually and mixed until homogeneity is achieved. Any lumping or balling found at any stage was taken out, loosened and again added to the mix.

For the second series of the mixture, the modified rubber powder was added at 5%, 10% and 15% by volume coarse aggregate. Immediately after mixing, slump and compacting factor test were carried out for all the concrete series mixture. A standard 150×150×150mm cube specimens were casted. The specimens were covered with gunny immediately after placing in the mould for complete moisture retention. The samples were then stripped after 24hours of casting and are then be ponded in a water curing. As casted, a total of (36) 150×150×150mm cubes specimens were produced.

4.1.4 Curing

The method of curing adopted was the ponding method of curing and produced samples were

cured for 3days, 7days, and 28 days.

4.2 Test for Fresh Properties of Concrete (Workability Test)

4.2.1 Slump Test

which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability, nor is it always representative of the placability of the concrete. It is not a suitable method for very wet or very dry concrete. It does not measure all factor contributing to workability.

The slump test was carried in accordance with B.S:1882 PART2:1970.

4.2.2 Compacting Factor

The compacting factor test was conducted in accordance with B.S 1881: PART 2:1970. The

compacting factor was computed using: -

$$\text{Compacting factor} = \frac{\text{Weight of freely fall of sample}}{weight\ of\ compacted\ sample}$$

Fig. 1: Compaction factor test.

4.3 Testing

4.3.1 Compressive Strength of Concrete

The compression test was conducted according to IS 516-1959. This test helps us in determining the compressive strength of the concrete cubes. The obtained value of compressive strength can then be used to assess whether the given batch of that concrete cube will meet the required compressive strength requirements or not.

For the compression test, the specimen's cubes of 15 cm x 15 cm x 15 cm were prepared by using crumb rubber concrete as explained earlier. These specimens were tested under universal testing machine after 7 days and 28 days of curing. Load was applied gradually at the rate of 140kg/cm2 per minute till the specimens failed. Load at the failure was divided by area of specimen and this gave us the compressive strength of concrete for the given sample.

Fig. 2: Compressive strength test of cube samples in CTM.

5. RESULTS AND DISCUSSIONS

As per experimental programme results for different experiments were obtained. They are

shown in table format or graph, which is to be presented in this chapter.

5.1 Workability Test

Slump Test

The Slump test was performed on the rubberized concrete to check the work ability of it at different replacements viz. 5 %, 10 %, 15% and the following results were obtained, according to which it can be concluded that with the increase in % of rubber from 0 to 15 %, workability decreases. Theoretical maximum value of Slump can be 100 to 175. The results obtained for Slump test are shown below in Table. 3.

Table. 3: Results of Slump test.

S. No	% Of rubber	Slump value (mm)
1	0%	55
2	5%	42
3	10%	34
5	15%	28

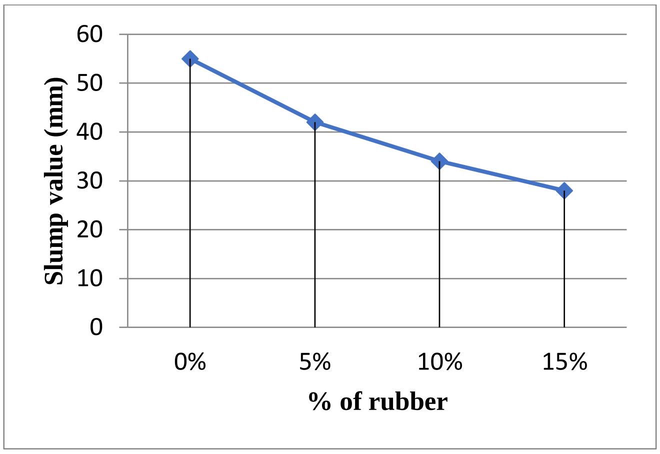

Fig. 3: Slump test results.

The above fig. 3 shows the slump results. It was observed that, the slumps decreased as the rubber content were increased in the mix. It was a Low Slump (25 – 50mm). It was suitable for Low Workability mixes used for foundations with light reinforcement. Roads vibrated by hand operated machines.

Compacting Factor

The compaction factor test was performed on the rubberized concrete to check the work ability of it at different replacements viz. 5 %, 10 %, 15% and the following results were obtained, according to which it can be concluded that with the increase in % of rubber from 0 to 15 %, workability decreases. Theoretical maximum value of compaction factor can be 0.96 to 1.0. The results obtained for compaction factor test are shown below in Table. 4.

Table. 4: Results of compaction factor test.

S. No	% Of rubber	Wt. of partially compacted concrete (kg)	Wt. of fully compacted concrete (kg)	Value of compaction factor (%)
1	0%	9.63	11.83	0.81
2	5%	10.43	12.00	0.87
3	10%	9.52	11.69	0.82
5	15%	8.76	10.92	0.80

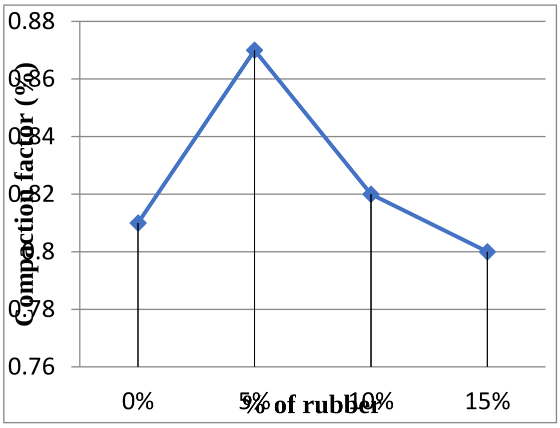

Fig. 4: Compacting factor test.

The above fig. 4 shows the results of the compacting factor. The results show that, the compacting factor decreased as the rubber content was increased.

5.2 Compressive Strength Test

The compressive strength test was performed on the cubes of size 15 cm x 15 cm x 15 cm to check the compressive strength of rubberized concrete and the results obtained are given in Table 5.

Table. 5: Results of compressive strength test.

S. No.	% Rubber	Compressive strength of cubes (Average results)		
		7 days (N/mm 2)	14 days (N/mm 2)	28 days (N/mm 2)
1	0	26.03	30.62	36.75
2	5	29.34	35.48	38.73
3	10	28.53	33.89	37.46
4	15	26.67	29.76	35.63

From the above results it was observed that with the increase in percentage of crumb rubber from 0% to 15% in concrete the compressive strength decreased.

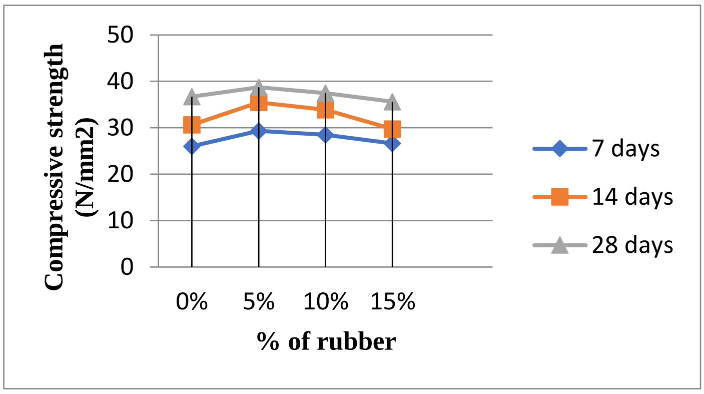

Fig. 5: Compressive strength v/s % of rubber.

6. CONCLUSIONS

- Utilization of waste tyres in the study process has been focus to reduce tyre wastes economic, environmental management.
- Concrete with higher percentage of crumb rubber possess low workability i.e., with increase in percentage of crumbed rubber the concrete workability decreases.
- Test results of 28 days rubberized concrete shown 5% to 10% replacement of rubber in coarse aggregate gives high compressive strength than conventional concrete (0% rubber) specimens.
- Test results of 28 days rubberized concrete shown 5% to 10% replacement of rubber in coarse

aggregate gives high Flexural strength than conventional concrete (0% rubber) specimens.

- With the addition of the crumb rubber, the reduction in strength cannot be avoided. However, these data provide only preliminary guideline for the strength-loss of locally produced modified concrete in comparison with the conventional concrete of 30 MPa targeted strength.
- Rubberized concrete is also used for insulation work like insulation from noise and heat. So, it can be used as an insulating material in walls in residential as well as commercial buildings and as a noise insulator in theatres, cinema halls, noise proof rooms and auditoriums etc.
- Rubberized concrete is also a Light Weight Concrete. Fast growing world motor vehicle usage is increasing in every year, Promisable future product for replacement of coarse aggregates. Alternative to coarse aggregate to recycle tyres helping the conservation of the environment. Reduce the natural source utilization, improve to use modified materials.

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