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Partial Replacement of Coarse aggregate in Concrete by Waste Rubber Tire

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Abstract

Throughout the world, the disposal of used tires is a major environmental problem causing environmental hazards such as breeding ground for mosquitoes, producing uncontrolled fire and they are contaminating the soil and vegetation. Therefore, there is an urgent need to identify alternative outlets for these tires, with the emphasis on recycling the waste tire. Concrete is an excellent structural material and considered as essential for the modern civilization and human society. Now, the use of waste tires in concrete has become technically feasible and the concrete is being considered as light weight concrete. This study reviews the feasibility of using waste tires in the form of chips with different sizes in concrete to improve the strength as well as protecting the environment. In this study, we outline the use of rubberized concrete in structural and non-structural members and show how it is suitable for the concrete, its uses, barriers and benefits to future study.

Keywords — **Compressive strength, Rubber concrete, slump value, coarse aggregate.**

1.INTRODUCTION:

Concrete is one of the most widely and continuously using as a construction materials in the world wide in which cement and aggregates are the most vital constituents. Further, these aggregates have been customarily treated as inert filler in concrete but in fact, aggregates not truly inert but its physical, thermal, and sometimes chemical properties influence the concrete. Due to tremendous demand of concrete as a construction material from society, it is need to preserve the natural coarse aggregates by using alternative materials which can obtain from recycled or waste materials. Therefore, the best management strategy for scrap tires is the recycling which leads to utilization of scrap tires with minimizing environmental impact and maximize the conservation of natural resources. Over the two decades, researchers have underscored to use waste tire rubbers in concrete and were remarked that recycling of waste rubber tire is most viable in concrete as a partial replacement to mineral coarse aggregates. The twofold advantage that is, it can prevent the depletion of scarce natural resources and the other will be the prevention of different used materials from their severe threats to the environment. Partial replacing the coarse aggregates of concrete with recycled waste tire aggregates can improve the qualities such as low unit weight, high resistance to abrasion, durability, absorbing the shocks and vibrations, high ductility etc. It was estimated that in India alone, more than 13 millions car and truck tires are being discarded annually which becomes one of the major environmental challenge the world facing because waste rubber is not easily biodegradable even after a long period of landfill treatment. In recent past, decrease in slump with increasing in rubber aggregate contents by total aggregate volume and results show that for rubber aggregate content of 40% then slump is close to zero.

Further, increasing the size of rubber aggregates decreases the workability of mix and subsequently reduction in the slump value. Further, slump values of mixes containing long, angular rubber aggregates were lower than those for mixes containing round rubber aggregates. The results of low and high volumes of rubber aggregates indicated that concrete densities were reduced to 87% and 77% of their original values, respectively. It has been also observed that reduction in compressive strength by 85% but showed the ability to absorb a large amount of plastic energy under tensile and compressive loads. Through the series of experiments using partial replacement of rubber tire aggregates in concrete causes decrease in compressive strength but which will be compensated by adding Nano silica. It is also noted that there is still a possibility of improving the compressive strength by using de-airing agents. Therefore, rubberized concrete has widely used for the development related projects such as roadways or road intersections, recreational courts and pathways and skid resistant ramps. With this new property, it is projected that these concretes can be used in architectural applications; panels that require low unit weight, rail-roads to fix rails to the ground, roofing tiles etc. Significant problem of rubber tire waste disposal and other side shortage of natural coarse aggregates in construction field then to overcome these issue, it is essence to use recycled waste tires as an aggregate which can provide the solution for two major problems, that is, environmental problem created by waste tires and depletion of natural resources by aggregate production consequently the shortage of natural aggregates in some countries.Shredded rubber reduces weight of the concrete.With the increase in construction activities, there is heavy demand on concrete and consequently on its ingredient like aggregate also. So waste tire rubber can be used as an alternative to this demand.However, our objective of the project is to study and compare the strength behavior of concrete using shredded rubber as a replacement material.

2.LITERATURE REVIEW

Eldin et al., conducted on rubberized Concrete behaviour, using tire chips and crumb rubber as aggregate substitute of sizes 38,25mm and 19mm exhibited reduction in compressive strength by 85% and tensile splitting strength by 50% but showed the ability to absorb a large amount of plastic energy under tensile and compressive loads.

In Biel and Lee have used recycled tire rubber in concrete mixes made with magnesium oxychloride cement, where the aggregate was replaced by fine crumb rubber up to 25% by volume. The results of compressive and tensile strength tests indicated that there is better bonding when magnesium oxychloride cement is used. The researchers discovered that structural applications could be possible if the rubber content is limited to 17% by volume of the aggregate.

Schimizze developed two rubberized concrete mixes using fine rubber granulars in one mix and coarse rubber granulars in the second. While these two mixes were not optimized and their design parameters were selected arbitrarily, their results indicate a reduction in compressive strength of about 50% with respect to the control mixture. The elastic modulus of the mix containing coarse rubber granular was reduced to about 72% of that of the control mixture, whereas the mix containing the fine rubber granular showed a reduction in the elastic modulus to about 47% of that of the control mixture. The reduction in elastic modulus indicates higher flexibility, which may be viewed as a positive gain in rubberized PCC (RPCC) mixtures used as stabilized base layers in flexible pavements.

I.B. TopÇu in investigated the effect of particle size and content of tire rubbers on the mechanical properties of concrete. The researcher found that, although the strength was reduced, the plastic capacity was enhanced significantly.

Zaher*et al* concluded that RPCC mixtures can be made using ground tire in partial replacement by volume of CA and FA. Based on the workability, an upper level of 50% of the total aggregate volume may be used. Strength data developed in their investigation (compressive and flexural) indicates a systematic reduction in the strength with the increase of rubber content. From a practical viewpoint, rubber content should not exceed 20% of the aggregate volume due to severe reduction in strength. Once the aggregate matrix contains nontraditional components such as polymer additives, fibers, iron slag, and other waste materials, special provisions would be required to design and produce these modified mixes. At present, there are no such guidelines on how to include scrap tire particles in PCC mixtures.

Serge *et al* used saturated NaOH solution to treat waste tire rubber powders. They found that

NaOHsurface treatment increased rubber/cement paste interfacial bonding strength and resulted in an improvement in strength and toughness in waste tire powder modified cement mortar.

Hernandez-olivares*et al*used crumbed waste tire fibres (average length 12.5 mm) and short polypropylene (pp) fibres (length from 12-10 mm) to modify concrete.

Gregory Garrick , shows the analysis of waste tire modified concrete used 15% by volume of coarse aggregate when replaced by waste tire as a two phase material as tire fiber and chips dispersed in concrete mix. The result is that there is an increase in toughness, plastic deformation, impact resistance and cracking resistance. But the strength and stiffness of the rubberized sample were reduced. The control concrete disintegrated when peak load was reached while the rubberized concrete had considerable deformation without disintegration due to the bridging caused by the tires. The stress concentration in the rubber fiber modified concrete is smaller than that in the rubber chip modified concrete. This means the rubber fiber

Modified concrete can bear a higher load than the rubber chip modified concrete before the concrete matrix breaks.

Kamil*et al*, analyzed the properties of Crumb Rubber Concrete, The unit weight of the CRC mix decreased approximately 6 pcf for every 50 lbs of crumb rubber added. The compressive strength decreased as the rubber content increased. Part of the strength reduction was contributed to the entrapped air, which increased with the rubber content. Investigative efforts showed that the strength reduction could be substantially reduced by adding a de-airing agent into the mixing truck just prior to the placement of the concrete.

Guoqiang Li, conducted investigation on chips and fibers. The tire surfaces are treated by saturated NaOH solution and physical anchorage by drilling holeat the centre of the chips were also investigated and they concluded that fibers perform better than chips: NaOH surface treatment does not work for larger sized tire chips: using physical anchorage has some effect. Further efforts will be geared toward the enlarging the hole size and insuring that the hole be through the chip thickness entirely. Fibre length restricted to less than 50mm to avoid entangle: steel belt wires provided positive effect on increasing the strength of concrete.

From the above literature review it is seen that waste tire rubber modified concrete is characterized as having high toughness and low strength and stiffness. Various methods have been tried to improve the strength and stiffness of waste tire modified concrete. However preparing waste tire powders and thin tire fibres is time, effort and money consuming. Sometimes, the cost may be so high that it cannot be justified by its gain in performance. Because larger sized chips or fibres are very easy to produce, it is expected that the cost of larger sized chips or fibre modified concrete will be very low. However, it is not clear if larger sized fibres or NAOH treated chips work or not. Further experimental analyses are needed.

2. EXPREMENTAL PROGRAMME

2.1 MIX PROPORTION

The mix design is done using Iscodal provision for M20 grade concrete

The proportion is 1:1.42:3.17.,Water cement ratio is 0.5

2.2 RUBBER AGGREGATE

The coarse aggregate has to be replaced by rubber aggregate according to 5%, 10% and 15% in conventional concrete. The quantities of rubber aggregate in mix proportion as shown below

Table 1 Mix proportion with different quantities of rubber

Water cement ratio	Replacing percent rubber Particles for aggregates	Cement (kg/m^3)	Amount of rubber aggregate added(kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)
0.50	0 %	383	0	543.67	1215.84
0.50	5%	383	60.79	543.67	1155.05
0.50	10%	383	121.58	543.67	1094.26
0.50	15%	383	182.38	543.67	1033.46

2.3 PREPARATION OF SPECIMENS

2.3.1 FORMWORK

For casting cubes, standard moulds with smooth machined inner faces were used. The inner dimensions of the cube mould were 150X150X150mm. The mould was completely watertight during concreting.

2.3.2 CASTING AND CURING PROCESS

The samples which are made are now placed in cubical moulds, and then these samples of replaced concrete are placed in moulds of dimensions 15*15*15 cm.Cast iron moulds are used for casting. For casting specimen, four different proportion fraction of chipped rubber are 0%, 5%, 10% and 15%. The concrete was mixed by tilting Compaction was done by a tamping rod .The specimens were removed after 24 hours of casting and then cured under water for 7 and 28 days. The specimens were taken out from the curing tank and dried itself of 24 hours before the period of testing. It is noted that slump has been decreased due to increase in percentage of rubber aggregates in all samples of concrete mix. In normal concrete mix, slump is seen to 92 mm and when the coarse aggregates are replaced with 15% tire chips then the slump is about 5 mm which becomes nearly zero slump value.

Table 2 Slump value of various concrete mix

Specimen	%rubber	Unit wt. in Kg	% reduction
A	0	8.541	0.000
A1	5	8.345	2.294
A2	10	7.979	6.580
A3	15	7.317	14.330

2.4 UNIT WEIGHT TEST

From the test, specific gravity of mineral coarse aggregates is of 2.66 respectively. From the observation, it is noted that unit weight of rubberized concrete decreases due to increase in rubber tire aggregates.

Table 3 Unit weight of various concrete mix

Specimen	%rubber	Slump(mm)
A	0	92
A1	5	60
A2	10	29
A3	15	5

3.TEST RESULTS AND DISCUSSIONS

3.1 COMPRESSIVE STRENGTH:

Compression strength test were performed on compression testing machine of 2000 KN capacity. Cube specimens casted were subjected to this test. The ultimate compressive strength was determined from failure load measured from the test.

Compressive stress = load, P / area, A

The table shows that the average compressive strength and percentage reduction in strength loses at 7th and 28th days in conventional and replacement of coarse aggregate by rubber aggregate concrete

Table 4 Compressive strength of various concrete mix

Specimen	% age Rubber aggregates	Actual Comp. Strength (MPa)		Av. Compressive Strength (MPa)		% age Strength loss	
		7days	28 days	7days	28 days	7days	28 days
A	0	17.778	25.778	17.48	27.11	0.00	0.00
		16.889	26.667				
		17.779	28.889				
A_1	5	16.000	17.333	16.15	19.26	20.40	28.95
		16.889	19.556				
		15.556	20.889				
A_2	10	13.333	14.667	13.62	15.48	32.87	42.89
		14.222	16.000				
		13.333	15.778				
A_3	15	10.000	12.667	10.37	12.14	48.89	55.21
		10.667	11.556				
		10.444	12.222				

The test results show that addition of rubber aggregates resulting to significant reduction in compressive strength compared to conventional concrete at 7^{th} and 28^{th} days.

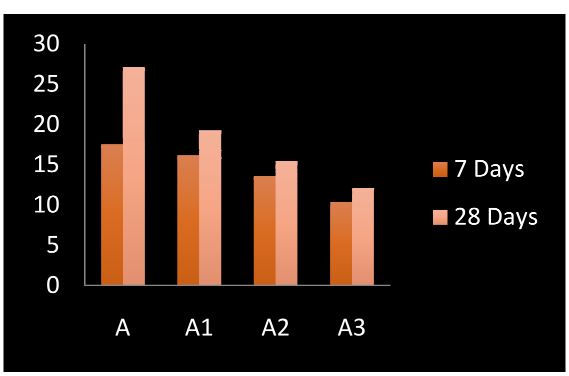

Fig.1 Compressive strength of various concrete mixes

This figure shows that the trend of strength development in different concrete specimens at 7^{th} and 28^{th} days .In X axis the specimen A, A1, A2 and A3 mix.In Y axis the compressive strength obtained in it.This figure shows the comparison of compressive strength of subsequent concrete mix at 7^{th} and 28^{th} days in comparison to conventional concrete.In X axis the concrete mix of 0%, 5%, 10%and 15% of rubber aggregate added in conventional concrete at 7 and 28 days.In Y axis the compressive strength value obtained in it.Here, In X axis curing days and in Y axis the compressive strength obtained in it. Further, gain of compressive strength of various prepared concrete mix with respect to the days from the stage of its curing is shown in this figure. From the scenario of this graph, one can conclude that rapid in strength gain takes place

up to its 7 days of curing later on its gaining rate becomes slower.

DISCUSSIONS:

The reasons for reduction in the strength of concrete when rubber was used are as follows:-

Lack of proper bonding between rubber particles & the cement Paste

Due to replacement of the aggregates by rubber particles, the weight was reduced.

High concentration of rubber particles at the top layer of specimen due to lower specific gravity of the rubber particles.

Due to non-uniform distribution of rubber particles in the concrete, non- homogenous samples are produced, which in turn results in reduction in concrete strength.

The stiffness of rubber is lower as compared to stiffness of coarse aggregate, the presence of rubber particles in concrete reduces the concrete mass stiffness and also decreases load bearing capacity of concrete.

4. CONCLUSIONS

From the above project work, various samples of concrete have been tested; hence the following points have been concluded from the project work

1. Introduction of recycled rubber tires into concrete mix leads to decrease in slump and workability for the various mix samples.

2. Reduction in unit weight of 14.33 % was observed corresponding to 15% by weight of coarse aggregates was replaced by rubber aggregate in sample A_3 which is with a targeted compressive strength of 12.14 Mpa. A much similar trend of reduction in unit weight of rubberized concrete was observed in all other samples containing rubber aggregates.

3. For rubberized concrete, test results show that addition of rubber aggregates resulting to significant reduction in compressive strength compared to conventional concrete which is in the range of 28.95 % to 55.21%. Although the compressive strength is still in the reasonable range for the 5% replacement.

4. The light unit weight qualities of rubberized concrete may be suitable for architectural application, false facades, stone baking, interior construction, in building as an earthquake shock wave absorber, where vibration damping is required such as in foundation pads for machinery railway station, where resistance to impact or explosion is required, such as in jersey barrier, railway buffers, bunkers and for trench filling.

5.Rubberized concrete can be used in non-load bearing members i.e. light weight concrete walls, other light architectural units, thus rubberized concrete mixes could give a viable alternative to where the requirements of normal loads, low unit weight, Medium strength, high toughness etc.

6. One of the possible applications of rubcretemay be its application in rendering of roof top surfaces for insulation andwaterproofing. With proper Mixed Design a 20 mm thick rendering on roof top surfaces may be done with 4.75 mm down rubber aggregate

7. The overall results of this study show that it is possible to use recycled rubber tire aggregates in concrete construction as partial replacement to mineral coarse aggregates.

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