A Comparative Study on Rubber Concrete over Conventional Concrete

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ABSTRACT: Waste tyre treatment is now a serious global threat. Waste tyre dumping, disposal of these materials or burning these tyres cause serious environmental and health problems. One of the solutions suggested is the use of tyre rubber aggregates as additive in cement based material. Waste tyres are cut into small pellets of size matching the nominal aggregate size and are used to replace the coarse aggregate used in concrete. For comparative analysis, concrete mix of M_{30} grade is prepared for various concrete mixes by varying percentage replacement of mineral coarse aggregates by 0, 5, 10 and 15 rubber aggregates and the mechanical properties of rubber concrete are compared with that of conventional concrete. The results showed that despite a great loss in strength, this type of concrete was acceptable for various applications requiring medium to low compressive strength. Hence, this project is selected to reduce the environmental pollution and wastage of natural resources.

KEY WORDS: *Waste tyre rubber aggregate, Mechanical Properties, Mechanical tests, Eco-friendly,concrete*

1. INTRODUCTION

Cement and aggregate, which are the most important constituents used in concrete production, are the vital materials needed for the construction industry. This inevitably led to a continuous and increasing demand of natural materials used for their production. On the other hand, tyre wastes are increasing annually because of the increase in the vehicle usage now-a-days. These tyres are used for various purposes. These wastes are shredded to the size of coarse aggregates to partially replace coarse aggregate in concrete.

The public, governments and industry are all greatly interested in green environment and engineering approaches towards better sustainable development. At the same time, these studies can help to make the environment clean and minimize waste. An emerging use is the production of concrete, in which rubber tyre particles partially replace natural coarse aggregates. This has the additional advantage of saving in natural aggregates and to reduce impact of quarrying dust used in the production of concrete which are becoming increasingly scarce. This experiment investigated a wide range of physical, chemical and mechanical properties of concrete containing recycled rubber tyre aggregates assess its suitability as a construction material.

Millions of waste tyres are generated and stock piled every year in an uncontrolled manner causing a major environmental problem. The disposal of tyres in landfills is the major issue handled by local municipalities and government sectors. As tyres are non-biodegradable, they remain in dump sites with little degradation overtime, presenting a continuing environmental hazard. Dumping or disposal of these materials causes environmental and health problems. Waste tyre management is a serious global concern. Therefore recycling of Waste materials plays a vital role in concrete. One of the solutions suggested is the use of waste rubber as partial replacement of coarse aggregates in concrete which has become highly expensive and also scarce. The utilization of waste tyres has been focused on waste minimization and for environmental management.

Federal regulations classify waste tyres as non-hazardous waste. However, the stockpiles are depleting land resources, and they are vulnerable to fire. The combustion of tyres releases volatile gases, heavy metals, oil, and other hazardous compounds. In addition, the stockpiles disposal provides breeding grounds for rats, mosquitoes, and other vermin. Some innovative solutions have been developed to meet the challenge of waste tyre stockpiling problem.

Whole tires could be used as tyre bales for highway embankments and retaining wall construction. Granulated rubber could be incorporated to asphalt binders for asphalt pavement. It has been successful to incorporate waste tyres in asphalt pavement. Also it is estimated that more than 1.2 billion waste tyre are produced globally every year. This waste being non-biodegradable poses severe fire, environmental and health risks. Aside from tyre derived fuel, the most promising use of recycled tyres is in engineering applications such as artificial reefs, erosion control and aggregates for asphalt and concrete.

For partially replace the coarse aggregate with the waste rubber tyre at different percentages in concrete and to determine its Compressive strength, Split-tensile strength and Flexural strength and to study the properties of concrete by casting cubes, cylinders and beams and to compare the strength of rubber concrete with the conventional concrete.

2. LITERATURE REVIEW

[1]B.Damodhara Reddy, S.Aruna Jyothy, P.Ramesh Babu have performed the study to evaluate the properties of concrete when recycled rubber from automotive tyres were used as a partial coarse aggregate. The percentages of rubber replacement were 10%, 15% by weight of coarse aggregate and tests were performed for all replacement levels of junk rubber aggregate. The replacement of coarse aggregate by junk rubber in concrete was found to result in reduced compressive strength and density. It was also found that the reduction in compressive strength depended on the amount of rubber added.

[2]C.Eldhose, Dr.T.G.Soosan investigated the wide range of physical and mechanical properties of concrete containing waste tyre aggregates and assessed its suitability as a construction material. The waste tyre aggregates were added as 2%, 4%, 6%, 10% and 12% to replace the fine aggregate in M35 mix and investigated the optimal use of waste tyre aggregate as fine aggregate in concrete composite. Test results showed that upto 8% of rubber aggregate can be added to concrete for structural constructions mainly for rigid pavement construction which proves economical and eco-friendly.

[3]K.Nithya, R.Kalpana performed a comparative study on early age concrete with waste rubber aggregate and the conventional concrete. The percentage of replacement of coarse aggregate was 0%, 10% and 12% and the curing was done with acids like HCl and HS2O4. Compressive strength, Split-tensile strength and Flexural strength for specimens with normal curing and acid curing were compared. The test results showed that acid curing and percentage increase of rubber aggregate the compressive strength. However the rubber concrete reduces the environmental pollution and wastage of natural resources. Despite the loss in strength, this type of concrete was acceptable for various applications requiring medium to low compressive strength.

[4]Tomas U.Ganiron concluded that adding cut rubber tyre pellets in concrete mixes significantly reduce the amount of standard coarse aggregates used in concrete which results in more economical and cost efficient project in the future. Further this study aids in the disposal of excess and/or “discarded” transportation vehicle rubber tyres in the environment and help ensure that the construction era of the future will be an environmentally friendly one. Also stated that, the lesser unit weight of the pelletized rubber being added to the concrete mix replacing some volume of gravel reduce the weight of the concrete mix. Reduction is at least within the range of 10% - 20% by weight more or less.

[5]K.Rajendra Prabhu, Subhash C Yaragal and Katta Venkataramana searched for alternative materials, which can replace existing ingredients in cement concrete construction partially or fully, thereby reducing energy consumption and reduced CO2 emission. One of the materials suggested was Waste Tyre Rubber. They concluded the following as advantages of rubberized concrete. Firstly due to less unit weight with high air entrainment, these type of concrete are easily pumped at higher flow rates and provide improved levels of thermal or acoustic insulation and they also improve the insulation of floorings in buildings. Secondly, rubberized concrete provide significantly improved loading behavior and vibration or impact absorption characteristics and also increased toughness, impact resistance and ductility. Also it provides an attractive solution for shrinkage cracking and strain failure.

[6]Kotresh K.M, Mesfin Getahun Belachew identified the potential application of waste tyre rubber in civil engineering projects by casting specimens of M25 grade with 10, 20 and 30 percent of rubber aggregate replacing coarse aggregate and compared the mechanical properties with the regular M20 grade concrete. Also the unit weight of rubcrete were determined at 0%, 5%, 10% and 15% of rubber aggregates. Finally they concluded that rubcrete is best suitated for roof top surfaces in buildings for insulation and waterproofing purposes.

[7]M.Mavroulidou, J.Figueiredo performed slump test to determine the workability of rubber concrete with 0, 10, 20, 30 and 40 percent of tyre rubber aggregate both fine and coarse rubber aggregate. They also made an experimental study to compare the variations in mechanical properties of 7th and 28th day rubber concrete with fine rubber aggregate and rubber concrete with coarse rubber aggregate. Finally they concluded that both cube compressive strength and Split Tensile strength of concrete with coarse rubber aggregate was higher than that with fine rubber aggregate. But the flexural strength test results showed that the strength of rubber concrete with fine rubber aggregate was higher than that with coarse rubber aggregate.

[8]S.M.Dumne carried out the study using tests such as slump, unit weight and compressive strength on different concrete mixes in order to determine properties of concrete mix. For comparative analysis, concrete mix of M20 grade was prepared for various concrete mixes by varying percentage replacement of mineral coarse aggregates by 0, 5, 10 and 15 rubber aggregates. The test results showed that rubberized concrete gave lesser unit weight in addition to the reduction in workability. It was also observed that there was a reduction in compressive strength of rubberized concrete which restrict its structural applications but it preserves some desirable characteristics. Overall, results of experimental test reflected that it is possible to use discarded rubber tyre aggregates in concrete as a partial replacement to mineral coarse aggregates but percentage replacement should be limited in order to restrict its application.

3. METHODOLOGY

3.1 Cement

Cement is one of the most common building materials and plays an important role in the construction field. The cement used is OPC 53(DALMIA). The Ordinary Portland Cement of 53 grade confirming to IS 8112/1989 has been used.

3.2 Fine Aggregate
The sand used for the experimental procedure was locally procured and confirmed to grading zone II as per IS: 383-1970. Fine aggregates passing through 2.36mm sieve is used. Tests were conducted on fine aggregate like specific gravity and fineness modulus.

3.3 Coarse Aggregate

The coarse aggregate is the strongest and least porous component of concrete. Coarse aggregate in cement concrete contributes to the heterogeneity of the concrete and there is weak interface between cement matrix and aggregate surface in cement concrete. This results in lower strength of concrete by restricting maximum size of the aggregate and also by making the transition zones stronger. Coarse aggregate of size 20mm is used. Tests were conducted on coarse aggregate like specific gravity and bulk density.

3.4 Rubber Aggregate

In this study, source of rubber aggregates is the discarded truck tyre which is collected from the local market and rubber tyre aggregates are prepared manually.

3.1 WASTE TYRE RUBBER AGGREGATE

In general, discarded tyre rubber aggregates are available in the range of grading from 0.5 mm to 30 mm. The rubber aggregates used in the present study are prepared manually by cutting the tyre to maximum nominal size equal to 20 mm and kept for air drying after cleaning with potable water.

Parameter	**Values**
Specific gravity	1.06–1.1
Specific heat	0.28–0.85 al/gr/ºC
Molecular weight	3×105-1×105
Hydraulic conductivity	0.2-0.85 cm/s
Thermal expansion	5.9-7.9×10-4/ºC
Thermal conductivity	0.330-0.515×10-3 g-cal/s/cm/ºC
Dynamic viscosity	500-250000 mpa
Ductility	80-158 mm
Flammability	582ºF
Thermal insulation	0.0838-0.147 cal/m-hr-ºC
Moisture absorption	2-4%
Stability temperature	200ºC
Heat temperature	150-316ºC
Density	7.5 lbs/cu.foot

TABLE NO. 3.1 PHYSICAL PROPERTIES OF WASTE RUBBER TYRES

Parameter	**Values**
Angle of friction	15-32º
Cohesion	349-394 N/m2
Total organic carbon	22.7-3.1 ppm
Turbidity	254-99 NTU
Gradation	50-300 mm
Dynamic viscosity	500-250000 mpa
Ductility	80-158 mm
Flammability	582ºF
Thermal insulation	0.0838-0.147 cal/m-hr-ºC
Moisture absorption	2-4%
Softening point	38-125 C
Breaking point	12-30ºC
Penetration	15-2500.1 mm
Chemical degradation	100-300ºC
Mechano-chemical disper	100-200ºC

TABLE NO. 3.2 CHEMICAL PROPERTIES OF WASTE RUBBER TYRES

Samples	**Percentage of rubber aggregate added**
1	0%
2	5%
3	10%
4	15%

TABLE NO. 3.3 PERCENTAGE MIX RATIO OF WASTE RUBBER TYRE AGGREGATE

S.No	**Properties**	**Values**
1	Specific Gravity	2.87
2	Fineness Modulus	3.485

TABLE NO. 3.4 PHYSICAL PROPERTIES OF FINE AGGREGATES

S.No	**Properties**	**Values**
1	Water absorption of aggregate	0.673%

TABLE NO. 3.4 PHYSICAL PROPERTIES OF COARSE AGGREGATES

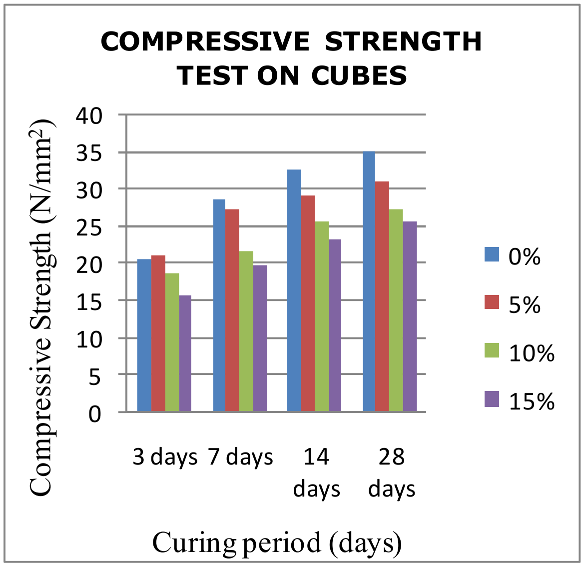
Water	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)
197.16	394.32	759.36	1151.24
0.5	1	1.93	2.92

TABLE NO. 3.5 MIX PROPORTION OF M_{30} GRADE

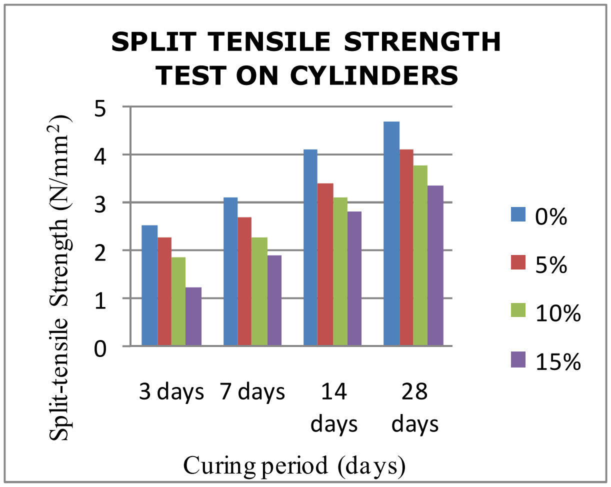
4. RESULT AND DISCUSSION

Initially standard specimens of conventional concrete M_{30} grade were cast. The specimens include cubes(150×150×150mm), cylinders (150mm dia., 300mm height) and prisms(500×100×100mm). They were cured for different periods (3, 7, 14 and 28 days).

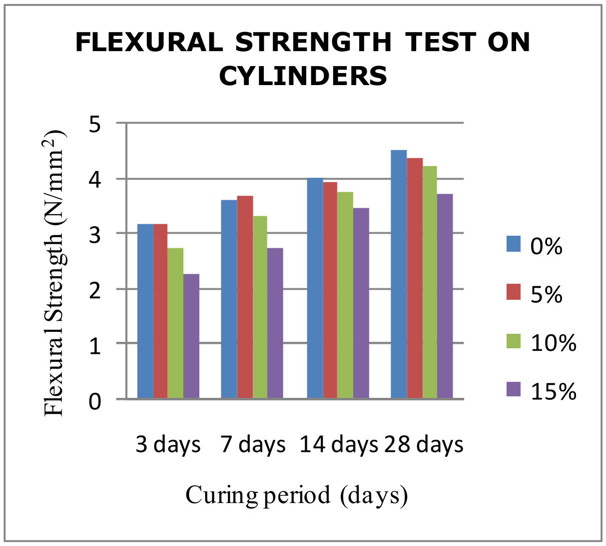
Rubber concrete specimens were prepared by adding 5%, 10% and 15% as increment of rubber aggregates replacing coarse aggregates in concrete and were cured for same curing period to make a comparative study. Then the mechanical tests were conducted on the specimens and the results were plotted in the form of a bar chart as shown in figure.



4.1 COMPRESSIVE STRENGTH TEST ON CUBES



4.2 SPLIT TENSILE STRENGTH TEST ON CYLINDERS



4.3 FLEXURAL STRENGTH TEST ON BEAMS

5. CONCLUSION

From the study we concluded that the compressive strength of specimen with tyre rubber aggregate at the end of 7th, 14th and 28th day reduced by about 10, 20 and 30 percent for every 5% increment of tyre rubber aggregates respectively.

The Split Tensile strength of specimen with tyre rubber aggregate at the end of 7th,14th and 28th day reduced by about 8% for every 5% increment of tyre rubber aggregates respectively. The flexural strength of the specimen at the end of 7th, 14th and 28th day reduced by about 6% for every 5% increment of tyre rubber aggregates respectively. Despite the decrease in the mechanical strength of the specimens this type of rubber concrete is greatly employed in low to medium strength concrete applications which include pavement construction, false facades, stone baking, trench filling and roof top surfaces. Hence it is suitable especially for architectural and secondary structural elements.

Finally the rubberized concrete not only reduces the cost and environmental impacts of concrete, but also it eliminates the waste tyre stockpiles and its potential threats to the environment. Hence this study helps in improved environmental protection and reduction in wastage of the natural resources

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