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Studies on Concrete Replaced with Waste Tyre Rubber as Coarse Aggregate

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Abstract: Concrete is one of the most extensively used construction material in the world and the mineral aggregates used to make the concrete are a finite resource, which is fast dwindling. On the other hand, 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. 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. One of the solutions suggested is the use of tyre rubber aggregates as additive in cement based material. Waste tyre 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_{20} grade is prepared for various concrete mixes by varying percentage replacement of mineral coarse aggregates by4, 6, and 8 rubber aggregates and the mechanical properties of rubber concrete are compared with that of conventional concrete. Different combinations of crumb rubber with traditional coarse aggregate were evaluated based on compression strength and flexural strength tests were conducted according to Indian Standards.
KeyWords: Waste Tyre Rubber; Coarse Aggregate; Mechanical Properties

1. INTRODUCTION

Concrete is one of the most widely used construction materials in the world. Cement and aggregate, which are the most important constituents used in concrete production, are then vital materials needed for the construction industry. Concrete technology has made tremendous growth in the past decade. Concrete is no longer a material consisting of Cement, aggregate, water and admixture but it is an engineered material with several new constituents. The concrete today can take care of any specific requirements under most of different exposure conditions. Thus there is a need for continuous study and research in the field of concrete technology. The American Concrete Institute (ACI) defines high performance concrete as "the concrete that meets special performance and uniformity requirements that cannot always be obtained by using conventional ingredients, normal mixing procedure and typical curing practices". High performance concrete therefore should have at least one outstanding property such as compressive strength, high workability, and enhanced resistance to chemical or mechanical stresses, lower permeability, durability etc., 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. 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. So, 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.

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RUBBER MODIFIED CONCRETE

A mixture composed of ordinary concrete and rubber from there cycled tyres has been presented in technical literature under the name of "Rubber Concrete" or "Rubber Modified Concrete". The literature available also shows that workable rubberized concrete can be made with appropriate percentage of rubber tyre aggregates.

II. LITERATURE REVIEW

Sara Sgobba etal, (2010), the study explores the ameliorative effects of rubber particles on some properties of concrete. The result presented shows that the incorporation of rubber aggregates in concrete, obtained from waste tyres, is a suitable solution to decrease the weight in some engineering manufactures. Though rubberized concrete has proven its applications in various construction fields, still a lot of research has to be done to measure the elastic constants and mechanical properties of rubberized concretes by adding rubber in different volume proportions, water-cement ratios, aspect ratios and in different forms such as fibre chips, powder form, etc. so that the appropriate strength can be explored. Here the study is conducted with varying percentage of scrap pieces of rubber in concrete 4%, 6% and 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 work ability. 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.

III. EXPERIMENTAL PROGRAMME

Compressive Test

The Compressive test is carried out in accordance with IS 516-1959. For the tests, 150x150x150 mm size cube specimens are used. The cubes are casted using M40 grade of concrete. During casting the cubes are manually compacted using tamping rods. After 24 hours, the moulds are removed and the specimens is placed in a curing tank at temperature 27^o 2^{o}C. These specimens are tested by compression testing machine after 7 and 28 days curing (Fig.3). The load is applied continuously at the rate of 140 kg/cm^2 per minute till the specimens fails. Finally, the maximum load applied to the specimen is recorded and type of failure is observed. The compressive strength of the specimen was calculated by using the formula

$$f_c = \frac{P}{A}$$

Where, P = Load at which the specimen fails in Newton A = Area over which the load is applied in mm f_c = Compressive stress in N/m

Splitting tensile test

The splitting tensile test is carried out in accordance with IS 5816-1999 standards conducted on concrete cylinders of 150 mm diameter and 300 mm length. The specimen should be cast and cured in the same manner as for casting of cubes. After 7 and 28 days curing, the specimen is placed longitudinally in the universal testing machine (Fig.4). The load is applied continuously at the rate within, the range of 689 to 1380 K Pa/min until failure of the specimen. The Splitting tensile strength is determined by using the formula

$$f_{ct} = \frac{2p}{\text{p}dl} \text{ Where,}$$

p = Maximum load applied to the specimen (mm) , d = Length of the specimen (mm), l = Diameter of the specimen (mm) f_{ct}= Splitting tensile strength (N/mm^2)

Fig.4 Testing of concrete cylinders

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Flexural test

The flexural test is carried out in accordance with IS516-1959.Forthetests,100x100x500mmsize prism specimens are used. The prisms are casted and tested using 5T capacity Flexural Testing Machine (FTM). The specimen is placed perpendicular to normal axis on the platform of the flexural testing machine. The load is applied gradually until the failure stage. The ultimate load is noted and calculated the flexural strength of corresponding specimen. The flexural strength of the specimen is calculated by using the formula

$$f_b = \frac{p \cdot l}{b \cdot d^2}$$

Where,
b= width of the specimen (mm)
d = depth of the specimen (mm)
l = length of the span on which the specimen was supported (mm)
p = maximum load applied to the specimen (N)

Fig.4 Testing of concrete prisms

4. RESULTS AND DISCUSSION

Compressive test

The compressive strength of concrete with different coarse aggregates is given in Table 1.The compressive strength varied from 25 MPa to 28 MPa for 7 days strength. Also, it varied from 52 MPa to 55 MPa for 28 days. The compressive strength of concrete cubes made with rubber waste coarse aggregate concrete is found to be 8.3% greater than that of conventional concrete. It is found that, there is not much variation in the compressive strength of conventional concrete and rubber waste coarse aggregate concrete.

Fig.5 Failure of cube specimen

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Table1 Compressivestrengthofrubberwaste coarse aggregate concrete and conventional concrete at 7 and 28 days

Specimen- ID	Rubber waste coarse aggregate concrete		Conventional concrete	
	Compressive strength (N/mm^2)			
	7 days	28 days	7 days	28 days
M40	26.5	54	24	51
M40	25	52	22	49
M40	28	55	22.5	48.5

Splitting tensile test

The splitting tensile strength of concrete with different coarse aggregates is given in Table 2. The splitting tensile strength varied from 0.9 MPa to 0.96 MPa at 7 days and 4.2 to 4.5 MPa at 28 days. The modulus of elasticity of concrete varied from 23.4 to 26.1 GPa. It is observed that the splitting strength of ceramic coarse aggregate concrete gave values nearer to that of conventional aggregate concrete.

Table 2 Splitting tensile strength of rubber waste coarse aggregate concrete and conventional concrete at 7 and 28 days

ID	Rubber waste coarse aggregate concrete		E (GPa)	Conventional concrete		E (GPa)
	Splitting tensile strength (N/mm^2)			Splitting tensile strength (N/mm^2)		
	7 days	28 days		7 days	28 days	
M40	0.96	4.5	25.2	1.1	4.8	31.6
M40	0.92	4.3	23.4	1.2	4.5	28.4
M40	0.9	4.2	26.1	1.2	4.6	32.8

Fig.6 Failure of cylindrical specimen

Flexural test

The flexural strength of concrete with different coarse aggregates is given in Table 3. The flexural strength varied from 6.2 to 6.5 MPa. The variations in flexural strength between rubber waste coarse aggregate concrete and conventional concrete are very small.

Fig.7 Failure of prism specimen

Table 3 Flexural strength of rubber waste Coarse aggregate concrete and conventional Concrete at 7 and 28 days

Specimen- ID	Rubber waste coarse aggregate concrete		Conventional concrete	
	Flexural strength (N/mm^2)			
	7 days	28 days	7 days	28 days
M40	3.1	6.5	3.4	6.7
M40	2.9	6.2	3.1	6.4
M40	3.0	6.3	3.2	6.7

5. CONCLUSION

It is clear that the compressive strength of concrete cubes made with rubber waste coarse aggregate concrete is 8.3% greater than that of conventional concrete. The splitting tensile and flexural strength of rubber waste coarse aggregate concrete gave values nearer to that of conventional aggregate concrete. The strength properties of rubber waste coarse aggregate concrete are not significantly different from those of conventional concrete.

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