Partial Replacement of Rubberized Material as Coarse Aggregate in Concrete

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ABSTRACT *- Concrete is one the most extensively used construction material all over the world. Many scientists and researchers are in quest for developing alternate construction material that are environment friendly and contribute towards sustainable development.*

Huge amount of rubber tyres waste is being generated day by day, which creates the disposal problem and has many environmental issues. In present study an attempt is made to partially replace the rubber aggregates as coarse aggregates in concrete.

A modified concrete is prepared by replacing coarse aggregates in concrete with rubber aggregates by varying the replacement proportion of 20% and 25%. cubes and cylinder for each percentage of replacement are casted and tested after 7 days, and 28th days of curing.

Keywords— Rubberized material, Compressive test, Split tenson test, Green comcrete.

I. INTRODUCTION

Concrete is the most adaptable construction material as it can be designed to withstand tough environments. Conventional concrete consist of fine aggregate, coarse aggregate and binder material. Excessive consumption of construction materials roots for the growth in demand of these materials. This massive demand compels the usage of alternate materials in concrete. Another major problem is that newer wastes are generated day by day on a bulk basis. Proper disposal of these waste materials pose a huge challenge and it creates various environmental and health issues. Numerous efforts have been taken to improve the performance of concrete using these by products as replacement material and in some cases even cement is replaced partially. Aggregate occupies 70 % volume of concrete, hence thorough evaluation is necessary before using these waste materials as aggregate. The major advantage is that, in spite of proper utilization of waste materials from industries it also improves the properties of fresh and hardened concrete and reduces the demand for lack of construction materials. Various environmental issues such as aggregate mining and waste disposal can be minimized. At present extensive researches are carried out to explore all possible reuse methods. Various waste materials used in concrete are fly ash, steel slag, rice husk, rubber tyres, plastics wastes, coal ash, agricultural waste, paper mill waste, leather waste, etc.

Every year there is an increase in usage of rubber products all over the world. Now a days rubber is employed in majority of the products because of its flexibility and durability. India is one of the highly populated country in the world. Due to this huge population there is a subsequent increase in usage of vehicles, which results in increased usage of vehicle tyres.

Disposal of these waste tyres that are generated, pose a major problem. Because tires are bulky and 75% of the space a tire is void, so that the land filling of scrap tires especially as whole tyres occupies a large volume of space. Waste tires pose a health hazard since tire piles are excellent breeding grounds for mosquitoes. Because of the shape and impermeability of tires, they may hold water for long periods providing sites for mosquito larvae development. Waste tires also pose a serious fire hazard since waste tires and waste tire stockpiles are difficult to ignite. However, once ignited tires burn very hot and are very difficult to extinguish. This is due to the 75% void space present in a whole waste tire, which makes it difficult to quench the tires with water or to eliminate the oxygen supply. In addition, the doughnut-shaped tire casings allow air drafts to stoke the fire. A large tire fire can smolder for several weeks or even months, sometimes with dramatic effect on the surrounding environment. Several researches have investigated the use of rubber tires as a replacement for aggregates. For this investigation, some of the important literatures were reviewed and presented briefly.

II. OBJECTIVES

The primary objectives of this study are to:

Examine the effects of increasing the coarse aggregate replacement percentage with recycled tire on concrete.

Provide recommendations for the use of recycled tire as a coarse aggregate replacement in a concrete mixture designed for field implementation.

III. SCOPE

- The waste materials from industries can be effectively used in the replacement of coarse aggregate.
- It minimizes the production cost of concrete.
- It reduces the percentage use of conventional aggregates in concrete.
- It can increase the various strength parameters of concrete

IV. MATERIALS AND METHODS

A. Cement

Cement is one of the major ingredient in concrete. It is a binder material, which is capable of bonding material fragments in to solid mass. Ordinary Portland cement of 43 grade was used for this experimental work.

B. Rubber tyre

Rubber tyres may be classified into two major groups as tyres from light vehicle and heavy vehicle. This project is based on the usage of waste rubber tyres from light vehicles such as bikes and cars. Waste tyres were collected from the available local resources.

C. Aggregate

Aggregates are the primary constituents of concrete. In early times aggregates were considered to be an inert material but recent researches proved that they are reactive to some extent.

Well graded coarse aggregate of size 20mm were used in this study. Fine aggregates are obtained from local resources confirming to zone II of IS: 383 – 1970. The sand was sieved through 4.75mm sieve to remove any particle greater than 4.75mm.

D. Water

Another important ingredient of concrete is water. Water initiates the hydration reaction of cement in concrete which provides the binding capacity for cement.

In this study fresh portable water is used for mixing and curing conforming to IS 456 – 2000.

V. MIX PROPORTION DESIGNATIONS

Mix Design can be defined as the process of selecting ingredients of concrete and determine their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible.

VI. METHODOLOGY

- Materials properties
- Mix design
- Casting of conventional concrete
- Rubber replacement sample
- Test for compressive strength
- Test for split tensile strength
- Comparison of results

VII. MATERIALS AND METHODS

Cement

Cement is one of the major ingredient in concrete. It is a binder material, which is capable of bonding material fragments in to solid mass. The Ordinary Portland cement was classified into three grades namely 33 grade, 43 grade and 53 grade. Ordinary Portland cement of 43 grade was used for this experimental work. The properties of cement listed in Table 4.1 was adopted from IS 4031.

Properties of cement

Sl.No	Components	Weight
1	Lime (CaO)	63%
2	Silica (SiO2)	21.9%
3	Alumina (Al2O3)	6.9%
4	Iron oxide (Fe2O3)	3%
5	Magnesium oxide (MgO)	2.5%
6	Sulphur trioxide & loss of ignition (SO3)	1.7%

Rubber tyre

Waste tyres were collected from the available local resources.The tyres were manually chopped into small pieces of required shape and size as shown in Fig. The maximum of the size of aggregate was 20 mm. chopped rubber pieces were thoroughly cleansed with pure water and are sun dried.

Chopped rubber pieces

All the faces of the rubber tyre pieces were roughened manually. Coarse aggregates were replaced with various percentage of discarded tyre rubber. The specific gravity of rubber tyre waste was found to be 2.53.

Coarse aggregate

Aggregates are the primary constituents of concrete. In early times aggregates were considered to be an inert material but recent researches proved that they are reactive to some extent. As aggregates occupies major volume of concrete, changes in their property impose a major influence in the entire property of concrete. Good gradation of aggregates are necessary for producing workable concrete.

Fine aggregate

Well graded coarse aggregate of size 20mm were used in this study. Fine aggregates are obtained from local resources confirming to zone II of IS: 383 – 1970. The sand was sieved through 4.75mm sieve to remove any particle greater than 4.75mm.

Properties of coarse aggregate

Sl. No	Test	Obtained Values	Limited Values	As per Codes	Remarks
1	Specific gravity	2.5	2.5-3	IS 2386-1963 (Part 3)	Satisfied
2	Fineness modulus	7.03	6.5-8	IS 383-1970	Satisfied
3	Aggregate impact value	15%	45%(Not exceeds)	IS 2386-1963 (Part 4)	Satisfied

4	Aggregate crushing value	14.13%	45%(Not exceeds)	IS 2386 -1963 (Part 4)	Satisfied
5	Aggregate abrasion value	18%	30%(Not exceeds)	IS 2386 -1963 (Part 4)	Satisfied

Properties of fine aggregate

Sl. No	Test	Obtained Values	Limited Values	As per Codes	Remarks
1	Specific gravity	2.6	2.6-2.9	IS 383-1970	Satisfied
2	Fineness modulus	2.47	2.2-3.3	IS 383-1970	Satisfied
3	Bulk density	1636.67 kg/m3	1520-1680	IS 383-1970	Satisfied

Water

Another important ingredient of concrete is water. Water initiates the hydration reaction of cement in concrete which provides the binding capacity for cement. Thus proper precautions must be taken regarding the quantity of water used. Water also provides workability in concrete. Quality of water should be maintained to attain desired strength.

In this study fresh portable water is used for mixing and curing conforming to IS 456 – 2000.

MIX PROPORTION DESIGNATIONS

Mix Design can be defined as the process of selecting ingredients of concrete and determine their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. The proportions are either by volume or by mass. The water-cement ratio is usually expressed in mass. Depending upon the level of quality control available at the site, the concrete mix has to be designed for the target mean strength, which is higher than the characteristic strength. The Mix proportion used for the study was M20(1:2.0:2.80:0.50) grade concrete

Mix proportion for M20 grade concrete

Cement Kg/m3	Fine Aggregate Kg/m3	Coarse Aggregate Kg/m3	Water Kg/m3	Tyre Kg/ m3
358	737.5	1016	197	203
1	2	2.8	0.5	20%

PREPARATION OF SPECIMENS

Batching of Concrete

Batching of concrete is the process of measuring concrete mix ingredients either by volume or by mass and introducing them into the mixture. Here, in this project weigh-batching system was adopted. Percentage of accuracy, flexibility and simplicity in usage is more in weigh batching system when compared to volume batching system.

Preparation of moulds

Before mixing of concrete the moulds in which the specimen are to be casted was prepared. The sides of the moulds are properly clamped with nuts and bolts so that the inner faces make 90º with each other as well as with the base plate and to avoid leakage of water from the freshly mixed concrete.

Mould

VIII. Sizes of moulds

Specimen	Size Of Mould Adopted (in mm)
Cube	150 x 150 x 150
Cylinder	150 300

Mixing of concrete

The mixing should ensure that the mass become homogeneous, uniform in colour and consistency. Here, in this project Hand mixing was adopted.

Mixing

IX. CASTINGAND COMPACTING OF CONCRETE

The operation of casting and compacting of concrete are interdependent and are carried out simultaneously. They are most important for the purpose of ensuring the requirements of strength, impermeability and durability of hardened concrete in the actual structure. As for as placing is concerned, the main objective is to deposit the concrete as close as possible to its final position so that segregation is avoided and the concrete can be fully compacted.

IX. Demoulding of specimens

Once the concrete specimen has been casted it is allowed to dry for 24 hours so that, the concrete specimen attains required strength such that it can be demoulded from the mould without causing damage to the sides of the specimen. Care should be taken to ensure the proper removal of mould as any damage can cause decrease in strength of specimen.

Demoulded sample

X. Curing

Curing is the process in which the concrete is protected from loss of moisture and kept within a reasonable temperature range. This process results in concrete with increased strength and decreased permeability. Curing is also a key player in mitigating cracks, which can severely affect durability. Concrete that has been specified, batched, mixed, placed and finished can still be a failure if improperly or inadequately cured. Here in this project once the concrete specimen has demoulded it was kept in ordinary curing tank and cured for 7 and 28 days.

EXPERIMENTAL PROGRAM

Test on fresh concrete

Slump test

Slump test is used to determine the workability or to measure the consistency of fresh concrete.

The internal surface of the mould is thoroughly cleaned and applied with a light coat of oil. The mould is placed on a smooth, horizontal, rigid and nonabsorbent surface.

XI. Tests on hardened concrete

Compressive strength tests

A compression test determines behavior of materials under crushing loads. Once the curing period of particular specimen was gets over they were taken out and allowed to dry for sometimes. Then the cube of size 150mmx150mmx150mm was subjected to test as per IS: 516-1959. A standard compressive testing machine of 1000kN capacity was used in this project. The specimen was placed between the steel plates of compression testing machine.

The compressive strength of the cube specimen was calculated using the following formula:

Compressive Strength, fc = P/A N/mm2.

Where, P = Load at failure in N

A = Area subjected to compression in mm2.

Compression test

Split tensile test

A direct measurement of ensuring tensile strength of concrete is difficult. One of the indirect tension methods is split tension test. The split tensile was carried out on cylinder of 150 mm diameter and 300mm height using universal testing machine. The cylinder which was cured for required days was placed between steel plates longitudinally. Once the specimen was properly placed between the plunger the load was applied gradually as per IS 5816-1999 till it reaches the load in which it fails. The split tensile strength of the cylinder was calculated using the following formula:

XII. Split Tensile Strength = $\frac{2P}{\pi LD}$

XIII. Where, P = Compressive Load in N

XIV. L = Length in mm

XV. D = Diameter in mm

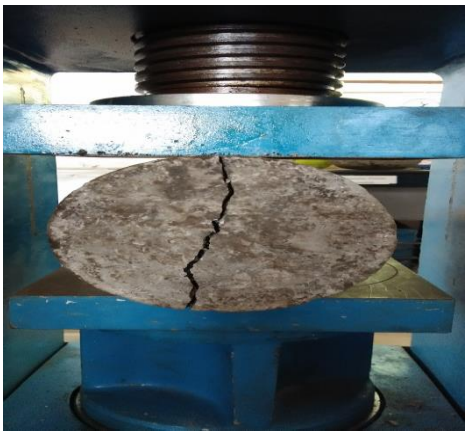

Figure 4.9 Split tensile test

Materials Properties:

1. Specific Gravity for Fine aggregate

Trail 1. G = 2.61

Trail 2. G = 2.62

Cement Kg/m3	Fine Aggregate Kg/m3	Coarse Aggregate Kg/m3	Water Kg/m3	Tyre Kg/m3
358	737.5	1016	197	203
1	2	2.8	0.5	20% &25%

2. Specific Gravity for Coarse aggregate

Trail 1. G = 2.5

Trail 2. G = 2.46

3. Specific Gravity for Tyre

Trail 1. G = 2.6

Trail 2. G = 2.5

4. Consistency Test

25% of water – 34mm

5. Specific Gravity for Cement

G = 3.15

Mix Design:

Grade Destination = M20

Type of Cement = OPC 43

Max. Nominal size of Aggregate = 20mm

Workability = 100mm
Exposure condition = Mild
Degree of Supervision = good

Result:

Cement	=	358Kg/cu.m.
Water	=	197litres
Fine Aggregate	=	737.5Kg/cu.m.
Coarse Aggregate	=	1016Kg/cu.m
W/C	=	. 0.5
Tyre	=	203Kg/cu.m.
Mix ratio	=	1:2.0:2.8

Specimen Preparations:
Sample Pictures,

1. Moulded Sample:

2. Demoulded Sample:

3. Curing Process

Testing Specimen:
After curing specimen ready to test

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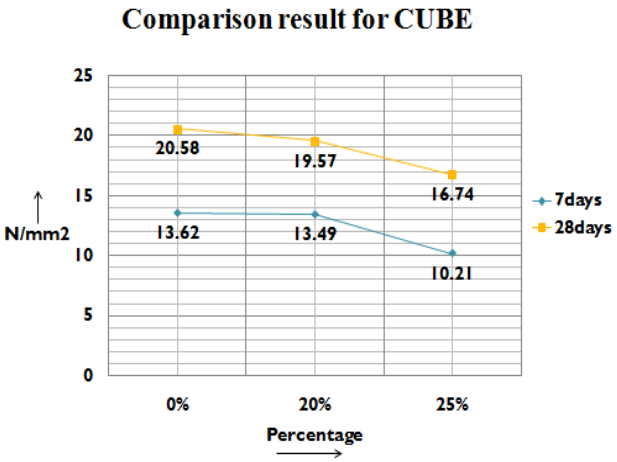
Test Reports:
For Cube,

Comparison result for cubes

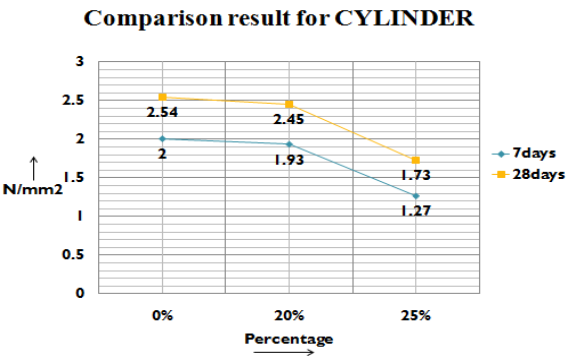
Sl. No.	Percentage of rubber used	Curing days	Compressive strength (N/mm^2)
1	0%	7 Days	13.62
2	20%		13.49
3	25%		10.21
4	0%	28 Days	20.58
5	20%		19.57
6	25%		16.74

Compression Strength Test

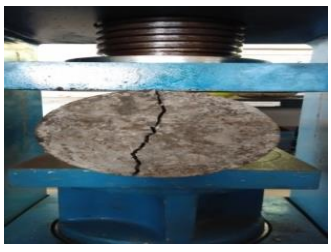


For Cylinder,

Sl. No.	Size of the Cylinder (mm)	Types	Applied Load (KN	Split tensile Strength (N/mm²)	Average Split tensile Strength (N/mm²)
7 DAYS					
1	150x300	0%	140	1.98	2
			130	1.83	
			150	2.12	
2	150x300	20%	140	1.98	1.93
			130	1.83	
			130	1.83	
3	150x300	25%	90	1.27	1.27
			90	1.27	
			90	1.27	
28 Days					
1	150x300	0%	190	2.68	2.54
			170	2.40	
			180	2.54	
2	150x300	20%	180	2.54	2.446
			170	2.40	
			180	2.54	
3	150x300	25%	120	1.69	1.73
			130	1.83	
			120	1.69	



Split Tenion Test



Stage of Project:

- We have completed Casting and Testing of Mould for M20 Grade of Concrete.
- Compressive Strength and Split Tensile Strength for 7days and 28days were determined for the casted concrete specimens.
- In addition of rubber the compressive strength and split tensile strength is attain up to a certain limit.
- Now, we completed our project report.

Conclusion:

The experimental study was performed to determine the characteristics of M20 grade of concrete by partially replacing rubberized material (tyre) as coarse aggregate in concrete.

Addition of rubber tyre shows an increase in compressive and split tensile strength.

Optimum replacement percentage was found to be 20% for rubber tyre in terms of increase in strength.

Maximum compressive strength of cube was found to be 19.57 N/mm2 at 20% of rubber tyre was added by the weight of concrete and it meet same as by the conventional concrete.

Maximum split tensile strength of cylinder was found to be 2.45 N/mm2 at 20% replacement of rubber tyre was added by the weight of concrete and it is similar to that of conventional concrete.

Scope For Further Work:

- The waste materials from industries can be effectively used in the replacement of coarse aggregate.
- It minimizes the production cost of concrete.
- It reduces the percentage use of conventional aggregates in concrete.
- It can increase the various strength parameters of concrete.