Use of Crumbed Rubber and Recycle Aggregate in Production of Concrete

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Abstract— The volume of tyre rubber wastes is increasing at a fast rate. At present the disposal of waste tyres is becoming a major waste management problem in the world. It is estimated that 1.2 billion of waste tyre rubber produced globally per year. The non-biodegradable nature of the rubber and the consequent disposal problem has led to a serious environmental issue in the recent decades. In India the disposal of waste tyre in landfills is a major issue handled by local municipalities and government sectors. Using this waste material in concrete can solve these problems. The use of recycled tyre rubber as partial aggregate in concrete has great potential to positively affect the properties of concrete in a wide spectrum and result in economy. This experimental study is conducted to analyze the behavior of concrete when fine aggregate is partially replaced with crumbed tyre rubber. Compressive strength was measured in concrete mixes with 5%, 8% and 10% substitution of natural fine aggregate by crumbed rubber along with partial replacement of coarse aggregate by recycled aggregates respectively at their optimum levels as known from previous researches.

Key words: Technology, Rubber Concrete, Economy

I. Introduction

Millions of waste tyres are generated and stock piled every year, often in an uncontrolled manner, causing a major environmental problem. Timely action regarding recycling of used tyres is necessary in view to solve the problem of disposal of used tyres keeping in view the increasing cost of raw material, resource constraints and environmental problems including fire and health hazards associated with the stockpiles of the used tyres.

Tyre disposal to landfills is problematic, as waste rubber is not easily biodegradable. Stockpiled tyres also present many health, environmental and economic risks through air, water and soil pollution, littering the landscape, and providing a breeding habitat for various pests. They pose health hazards including diseases due to rodent and mosquito infestation and pollution to land, water, and air.

An emerging field for the reuse of scrap tyres is in the production of concrete, where tyre rubber can be used as a partial replacement to natural aggregates. This has the additional advantage of saving in natural resources. Shredded or crumbed tyres are different to other waste materials with a potential for reuse, because their production method is now well developed. Hence, the reuse of this material in concrete could have both environmental advantages and at the same time ensure economic viability.

The use of recycled tyres as partial aggregate in concrete has been considered for several years. Previous research conducted show dramatic changes in the mechanical properties of concrete when rubber is introduced to the mix. However, for concrete with scrap tyre aggregate to be considered as a construction material, the minimum requirements of strength and durability should be met.

The use of rubber particles in concrete mixes decreases the compressive strength of hardened concrete. It is due to the weak adhesion between the rubber particles and the cement paste. In order to address this issue, the modification of the rubber particles surface has been suggested.

Sodium hydroxide (NaOH), also known as lye or caustic soda, is a caustic metallic base due to its causticity; it is a perfect substance to modify the surface of rubber in order to improve the interfacial transition zone (ITZ) in the concrete matrix

Investigations carried out so far reveal that tyre waste concrete is specially recommended for concrete structures located in areas of severe earthquake risk and also for applications submitted to severe dynamic actions like railway sleepers. This material can also be used for non-load-bearing purposes such as noise reduction barriers. Investigations about rubber waste concrete show that concrete performance is very dependent on the waste aggregates. Further investigations are needed to clarify for instance which are the characteristics that maximize concrete performance.

Previous research has shown that replacing the fine aggregate more than 5% by crumbed rubber leads to major changes in concrete properties. As well, it is found in previous researches the cement can be replaced by 50% by fly ash and coarse aggregate can be replaced by 30% by recycled aggregate without any comparable reduction in compressive strength.

Thus for the use of recycled rubber as aggregate in concrete has not given results that could indicate the possibility of its use as structural material. It is thought that the main cause of the decrease of strength in rubber concrete is due to the weak bond between the recycled rubber particles and the cement. This investigation intents to explore this issue by comparing an OPC control mix with three mixes with different amount of natural fine aggregate replacement (5, 8 and 10%) by treated crumbed rubber along with partial replacement of cement and coarse aggregate by recycled aggregate (30%)

II. Methodology

In this project concrete is prepared using cement, sand, natural aggregate and water along with partial replacement of all the ingredients of concrete, i.e. cement is 30% replaced by fly ash, natural stone(coarse Aggregate) is 40% replaced by recycled aggregate and sand is partially replaced by crumbed rubber with varying percentages of 5%, 8% and 10%.

A. Materials Used:

Materials used to make concrete specimens were fine aggregate, coarse aggregate, cement, fly ash, crumbed tyre rubber, recycled aggregate and water.

B. Cement:

The cement used for research work was ordinary Portland cement of 43 grades.

C. Coarse Aggregate:

The coarse aggregate was selected from natural stone, which was maximum 20 mm in size. The stone used had 2.87 (gr/cm^3) specific gravity in saturated surface state and 0.80 % water absorption. The grades distribution curves for coarse and fine aggregate are given.

D. Fine Aggregate:

Sand of Zone-II as per IS: 383-1970 was used as fine aggregate. It had the specific gravity of 2.75 (gr/cm^3) and 0.70% water absorption.

E. Crumbed Rubber:

Crumbed Rubber was taken from the scrap tyre recycling industries in Bhopal. The recycled crumbed tyre used is treated for surface modification by sodium hydroxide (NaOH) solution. The treatment consisted of soaking the recycled tyre particles in a NaOH solution for a period of 20 minutes, then it was washed under running water and left to air dry at room temperature. It had 0.98 (gr/cm^3) specific gravity and 0.00 % water absorption.

F. Recycled Aggregate:

The recycled aggregate was obtained from the demolished concrete structure, from the remains of beams and columns. It was 20 mm graded aggregates as per IS: 383-1970. It had 3.20 (gr/cm^3) specific gravity in saturated surface state and 1.40 % water absorption.

III. MIX PROPORTION

In this study four different types of mixes or combination are being considered and designed as per Indian Standard Specification IS: 10262(2009). A standard control mix was prepared in conformation with IS code. The other three concrete mixes were made by replacing the fine aggregates with 5%, 8% and 10% of crumbed tyre rubber by volume. The partial substitution of coarse aggregate by recycled aggregate (30%) and cement by was done by volume in the three mixes. Water cement ratio- The water cement ratio of all the prepared mixes was kept at an optimum value of 0.4 according to the grade of concrete chosen and mix design that was done The experimentation consisted of four concrete mixes: one control mix with no replacement of any type and three mixes with 5%, 8% and 10% replacement of natural fine aggregate by recycled crumbed tyre rubber and 40% replacement of natural coarse aggregate by recycled aggregate in all the three mixes. The composition and proportions for all the mixes and the quantities are shown in Table-1.

	CC	**CR5**	**CR8**	**CR10**
Water to cement Ratio	0.4	0.4	0.4	0.4
Size of Coarse Aggregate	4.75 mm-20 mm	4.75 mm-20 mm	4.75 mm - 20 mm	4.75 mm - 20 mm
Size of Fine Aggregate	90 μ-2 mm	90 μ -2 mm	90 μ- 2 mm	90 μ - 2 mm
Water	156 l	156 l	156 l	156 l
Cement		273 kg	273 kg	273 kg
Coarse Aggregate (gravel)		775.12 kg	775.12 kg	775.12 kg
Recycled Coarse Aggregate	-	574.44 kg	574.44 kg	574.44 kg
Fine Aggregate (sand)	703.79 kg	338.58 kg	327.89 kg	320.76 kg
Crumbed Rubber Aggregate	-	6.35 kg	10.16 kg	12.7 kg
Ordinary Portland Cement	M43 Grade	M43 Grade	M43 Grade	M43 Grade

Table 1: Composition of Various Mixes per M^3 of Mix.

A. Casting and Curing:

Mixing and casting of cubic test specimens was performed in accordance with IS Code 516-1959. 9 Cubes of 150 x 150 x 150 mm size of each mix were cast for 7-days, 14 days 28 days testing. A thin layer of oil was applied on all the faces of the mould. The concrete sample was filled into the cube moulds in layers approximately 5 cm deep. Each layer was compacted by means of a suitable vibrating table until the specified condition was attained.

The casted cubes were stored under shed at a place free from the vibration at a temperature 220C to 330C for 24 hours covered with wet gunny sacking. The cubes were removed from the moulds at the end of 24 hours and were immersed in clean water at a temperature 240C to 300C till the 7, 14 or 28-days age of testing. The cubes were tested in the saturated and surface dry condition.

B. Experimental Program:

Cubes were tested for compressive strength at an age of 7, 14, and 28 days from the day of start of curing. A constant loading rate of 140 kg/cm2/min was employed until the resistance of the specimen to the increasing load broke down and no greater load could be sustained. The maximum load applied to the specimen was recorded. The quoted strength values are the averages of three cubes per test in accordance with IS 516-1959 standard test method.

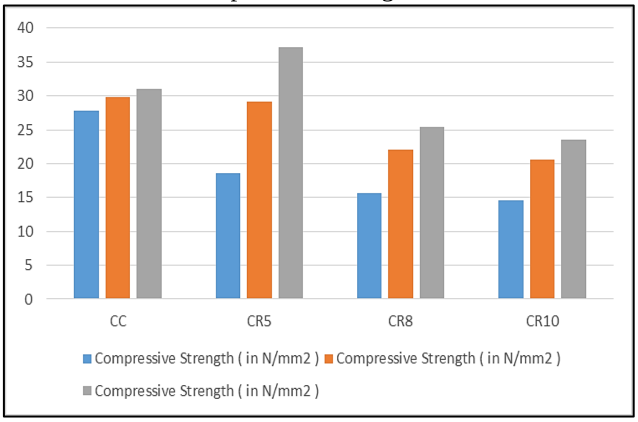
IV. RESULTS

Table-2 shows the compressive strengths of various mixes at 7 days, 14 days and 28 days from the day of curing.

Mix	**Compressive Strength (in N/mm^2)**		
	7 days	**14 days**	**28 days**
CC	27.78	29.77	31.04
CR5	18.62	29.21	37.24
CR8	15.64	22.09	25.47

CR10	14.55	20.56	23.52

Table 2: Compressive Strength Test Results



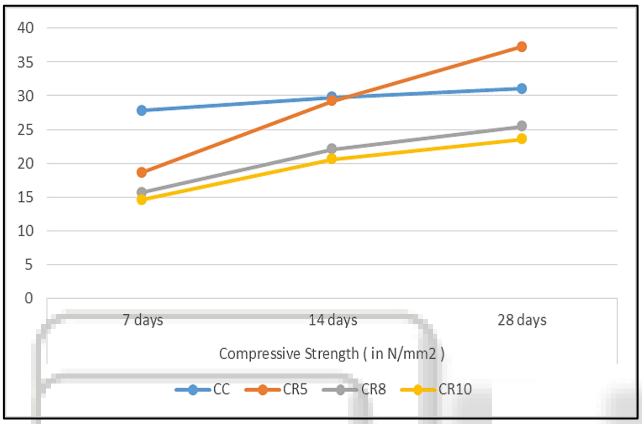


Fig. 1 & Fig. 2: Graph 1 and Graph 2: Co,pressive Strength of Concrete Cubes

V. DISCUSSION

There was a significant decrease in the compressive strength as the rubber replacement amount increased (Figures 1 and 2). Upon examination of broken cubes containing crumbed tire, it could be seen that the concrete broke around the rubber particles and through the interfacial transition zone (ITZ) which has been considered as the weakest zone in concrete. Table 3 shows the percentage change in compressive strength for each mix and age.

In general, it was observed that the stress strain curves (not shown) for each test show an increase in the plastic deformation which translates into an increase of the toughness with a gradual failure, where the pieces of concrete tested tend to stay together linked through the rubber particles.

In general, all testing the specimens did not shattered as the OPC control mix, the rubber containing specimens cracked but the cracks were arrested by the rubber fibers.

VI. CONCLUSIONS

Following Observation is Carried out from the following Study that mix of 5% Crum Rubber and 40% recycle Aggregate gives Maximum Compressive Strength and as we increase percentage to Crum Rubber and compressive Strength of Concrete decrease.

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