

An Experimental Study on Composite Concrete by using Rubber Tyre Waste & Sisal Fibre

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ABSTRACT: Rubber tire waste is one of the most important parts of solid waste management which had historically been disposed of into landfills. It's also causing a severe environmental problem. This study explores the possibility of reusing rubber tyre waste in concrete through enhancing the properties of concrete mix as partial replacement with fine aggregate to produce ideal concrete mix. In this study, rubber tyre waste is used as a recycled material. With a fixed water cement ratio (W/C= 0.4), Sisal fibre will be added by volume in the concrete. Waste rubber tire, which passed the sieve size of 0.595mm, used to replace instead of fine aggregate by 15%, 20% and 25% for producing lightweight aggregate concrete. Fresh and Harden concrete tests were performed at 7,14 and 28 days. Results showed that adding an appropriate amount of recycled materials might improve in their toughness with good approach properties and reduce the cost of additive materials.

KEYWORDS: Solid waste, recycling, waste tires, sisal fibre, improvement of characteristic properties of concrete mix, applications.

I. INTRODUCTION

Today many of the wastes will remain in the environment for several years with larger grows accumulation with a waste disposable crisis, one of the best solution for this problem lies in recycling waste in to useful products with continuous decreasing the number of landfill materials by reusing them again. India has taken step to move forward in infrastructures towards the growth of globalization. Dumping of wastes causes serious health effects and creates environmental problems. Approximately billions of waste tyre rubber produced globally per year. It is estimated that 11% (Appx.) of post-consumer tyres are exported and 27% (Appx.) are sent to landfill, stockpiled or dumped illegally and only 4% (Appx.) is used for civil engineering projects. In past many researchers conducted research and presented the results on this rubberized concrete. The size, shape and gradation play a major role in bonding with the surrounding concrete paste in achieving strength. By increasing the quantity of rubber shreds in concrete it will reduce the crack length and width due to shrinkage and it makes more delay of onset time of cracking. A major reason for the growing interest in the performance of fibers in cement based materials is the desire to increase the toughness or tensile properties of the basic matrix.

Her yung wang et al.,2015^[1] suggested that adding an appropriate amount of recycled materials might improve the durability of lightweight aggregate concrete. Strength values of all waste tire rubber concrete mixtures have a tendency to decrease below the values for the reference concrete mixtures with the increasing of waste tires rubber ratio at all curing age. Falak O. Abas, Enass et al.,(2015)^[2] observed that, the reduction of spalling damage and improve in fire resistance by using tyre rubber in high strength concrete slabs. Swapnil Jain (2014)^[6] observed that rubber incorporated mixes produces very low unit weight mixes and with high air contents. By incorporating rubber in concrete it improves not only dynamic loading behavior but also impact, vibration and absorption characteristics.

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II. RELATED WORKS

1. **Her-Yung Wang et al., 2015**, in this study, waste tire powder and waste liquid crystal display (LCD) glass sand are used as recycled materials. Waste tire powder and waste LCD glass sand, which passed the sieve screen size 0.595mm, were used to replace fine aggregate at 0%, 5% and 10% in producing lightweight aggregate concrete. Harden and durability tests were performed at 7, 28, 56 and 91 days concrete workability and the unit weight decreased after adding rubber powder to concrete. As the replacement rates of waste glass sand and waste rubber powder increase, the compressive strength tends to decrease. At 56 days, the ultrasonic wave velocity of normal concrete was higher than lightweight aggregate concrete; the lightweight aggregate concrete with 10% glass sand provided the highest ultrasonic wave velocity of the lightweight aggregate contents.
2. **Falak O. Abas et al., 2015**, this study explores the possibility of reusing discarded waste tires in concrete. The percent of discarded waste tires substituted in to the concrete mix by weight (0%, 10%, 15%, and 20%) respectively. Two types of waste tires are used as (chips andgrounded shape) applied at 68 experiments and tested their mechanical, physical and chemical properties with 260 test in order to determine the optimal enhancing replacement ratios of waste tires as (dry density, compressive and flexural strength, performing slump, and toughness indices) at curing ages of (3, 7, 28 and 56 days) for standard and improved concrete mix. The results for tests show a decline in compressive strength of the concrete in other hand an increase in their toughness with good approach properties and reduce the cost of additive materials.
3. **Romildo Dias Tolêdo Filho et al., 2015**, The inclusion of fibre reinforcement in concrete, mortar and cement paste can enhance many of the engineering properties of the basic materials, such as fracture toughness, flexural strength and resistance to fatigue, impact, thermal shock and spalling In this review, the general properties of the composites are described in relation to fibre content, length, strength and stiffness. A chronological development of sisal fibre reinforced, cement based matrices is reported and experimental data are provided to illustrate the performance of sisal fibre reinforced cement composites The results show that the composites reinforced with sisal fibres are reliable materials to be used in practice for the production of structural elements to be used in rural and civil construction. This material could be a substitute asbestos-cement composite, which is a serious hazard to human and animal health and is prohibited in industrialized countries. The production of sisal fibres as compared with synthetic fibres or even with mineral asbestos fibres needs much less energy in addition to the ecological, social and economical benefits
4. **Jaspal singh et al., 2015**,This paper deals with the concept of fibre reinforced concrete using natural fibre. Concrete made of ordinary Portlandcement is strong in compression but weak in tension. Also this concrete has little resistance tocracking which limit its use. These limitations can be overcome by blending the concretewith fibrous material, which is termed as fibre reinforced concrete. The addition of smallclosely spaced and uniformly dispersed fibres will improve the overall structural performanceof the concrete. Both of these techniques are hazardous to theenvironment. So adding of these waste fibres in concrete could help to save the environment. Basically natural fibres are of two types. Natural inorganic fibres such as Basalt, Asbestos...etc and the natural organic fibres such as coconut, palm, jute, sisal, banana, sugarcane, bamboo, pine...etc. In this paper, natural fibres are investigated as construction material that can be used in concrete. This study includes the properties and characteristics of the natural fibres. For the same fibre content, the properties may vary using different fibres. The comparison of different natural fibre is studied with context to the properties like compressive strength, tensile strength, flexural strength and durability.

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III. EXPERIMENTAL DETAILS

3.1 Materials

3.1.1 Ordinary Portland Cement

Ordinary Portland Cement (OPC), which conforms to 53 grade of IS 455: 1989, was used. The specific gravity of Ordinary Portland cement was determined as 3.1.

3.1.2 Waste Tyre Rubber Powder

The rubber tyre waste powder will be formed by passing tyre rubber through rotating corrugated steel drums. The obtained material will have very large surface area. It will be useful to replace fine aggregate. The specific gravity of Rubber tyre waste Powder was 0.55.



Fig. 1 Rubber tyre waste Powder

3.1.3 Aggregates

Coarse aggregate from stone crusher having a nominal maximum size of 20 mm was used. The specific gravity of coarse aggregate was 2.74. River Sand was used as a fine aggregate in mix of having a nominal maximum size of 4.75 mm was used. The specific gravity of fine aggregate was 2.64.

3.1.4 Sisal fibre

Sisal fibre is obtained from the leaves of the plants. Leaves are crushed between the rollers and the mechanically scraped. Sisal fibre is coarse and inflexible, and is valued because of its strength, durability, ability to stretch and resistance to deterioration in saltwater.

3.2 Mix Proportion

The mix proportions of different types of percentages of replacement mixes of fine aggregate with waste tyre rubber powder and obtained quantities were presented in Table 1. All mix proportions are designed with a slump ranging from 75-100mm, keeping the water content constant at 157 kg/m³. The water cement ratio of 0.40 was kept as constant for all mixes. Fine aggregate was replaced by Rubber Powder varying from 15% to 25%.

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Table 1. Mix Proportions

Materials		Trial 1		Trial 2		Trial 3	
Cement		493kg		493 kg		493 kg	
Fine aggregate	River sand	85%	555 kg	80%	522 kg	75%	490 kg
	Rubber tyre waste	15%	20 kg	20%	26 kg	25%	33 kg
Coarse aggregate		1065 kg		1065 kg		1065 kg	
Sisal fibre		2%		2%		2%	
Water		0.4		0.4		0.4	

3.3 Preparation and Casting of Specimens

A total of 3 trial mixes were prepared in this study and the numbers of cube samples were casted (150 x 150 x 150 mm) for conducting the compression test. The casted samples were kept curing for 7, 14 and 28 days after they were tested for compressive strength. The cylinders of 150x 300 mm were casted for split tensile strength tests and prisms of 500x100x100 mm were casted for flexural strength tests.

IV. RESULTS AND DISCUSSIONS

4.1 COMPRESSIVE STRENGTH

The cubes were casted and tested after 7, 14 and 28 days of curing period. Table 2 shows the results obtained for the compressive strength of cube. Figure 2 indicated the strength pattern of fine aggregate was replaced with rubber tyre powder. It was observed that, the 25% of compressive strength was reduced with increase of replacement of fine aggregate with rubber tyre powder by 25%. This is due to the weakness of bond between the cement matrix and rubber tyre powder when compared with sand.

Table 2. Compressive Strength at 7, 14 and 28 days

Mix	Compressive strength (N/mm ²)		
	7days	14 days	28 days
Conventional	29.17	35.7	41.1
Trial 1	24.04	31.8	37.1
Trial 2	20.1	28.3	35
Trial 3	18	24.6	31

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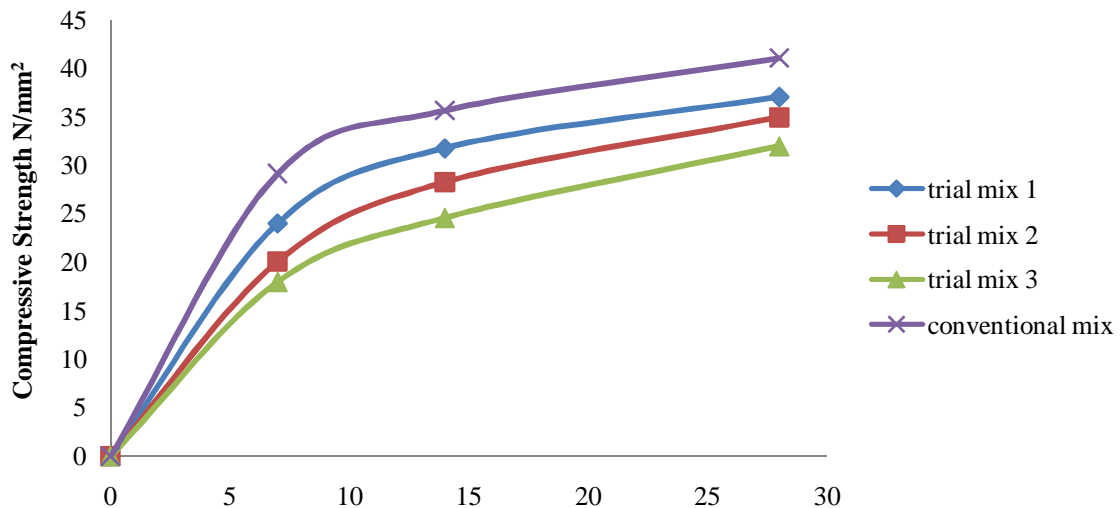


Fig 2. Compressive Strength of various mixes

4.2 Split Tensile Strength

The cylinders were casted and tested in the testing machine after the curing period of 28 days. Results are represented in figure 3. It was clearly observed that, the split tensile strength of trail mix 1 and 2 are more when compared to conventional mix because of sisal fibre and nearly 10% of split tensile strength was reduced by increasing the percentage replacement of sand with rubber tyre powder upto 25%. Interface zone is likely to reduce the bond between the cement paste and the rubber tyre waste.

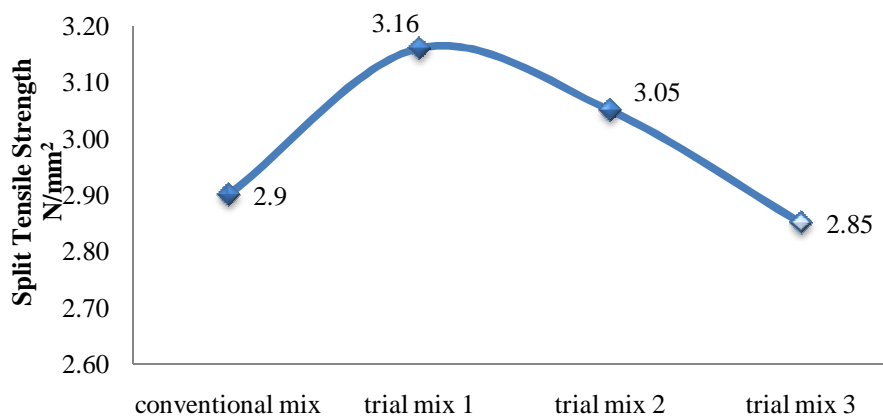


Fig 3. Split Tensile Strength of various mixes

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4.3 Flexural Strength

The results of the flexural strength tests for the rubber tire waste concrete mixes trial 1, trial 2, and trial 3 are illustrated in fig. 4. The results showed that the flexural strength of rubber tyre waste concrete mixes at 28 days curing age was become to decrease with the increase of waste tyre rubber ratio in these mixes. This trend can be attributed to the decrease in adhesive strength between the surface of rubber tyre waste particles and the cement matrix, as well as the hydrophobic nature of waste rubber tyre which may limit the hydration of cement in concrete mix. Therefore the hydration developed slightly with time. The flexural strengths of the rubber tyre waste concrete composites compared to conventional are low.

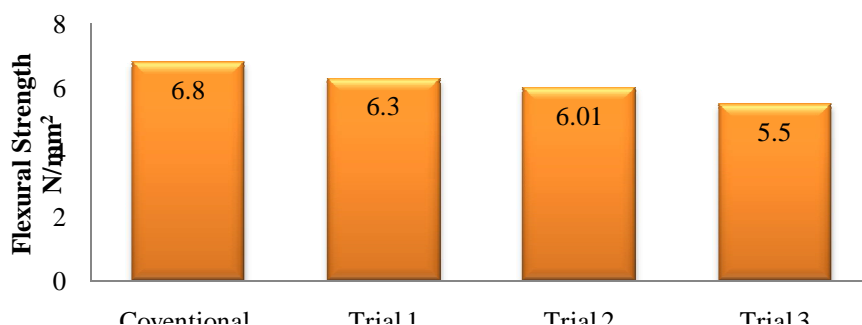


Fig 4. Flexural Strength of various trial mixes

4.4 Density

Density reduced by increasing the percentage replacement of rubber tyre powder in place of sand it was found that it was reached upto 11% when fine aggregate was replaced with rubber tyre powder from 0% to 25%, this is because of rubber tyre powder has lower specific gravity than sand which is shown in fig. 5

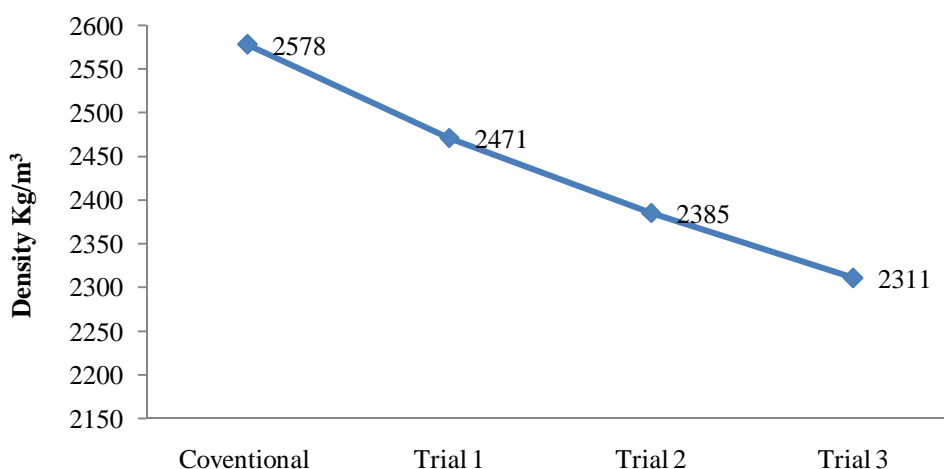


Fig 5. Density variation study for various Trail mixes

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V. CONCLUSION

Based on the results and then analysis, the following conclusions have been arrived it. The compressive strength of concrete decreased as the percentage of replacement of sand by rubber tyre waste increases. According to IS specification the compressive strength of trial mix is $\pm 15\%$ of conventional concrete will be acceptable. Based on this, the compressive strength of trail mix 1 & 2 can be acceptable. From the experimental study, the density was decreased when the percentage of rubber tyre powder was increased for various percentages of mixes. Split tensile strength of trial mix 1 and 2 are more compared to the conventional mix because of sisal fibre. Flexural strength of trial mixes are decreased when the rubber tyre waste are increased because of the bonding between rubber tyre waste and cement is low.

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