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# Review Paper on Experimental Investigation on Use of Tire Rubber in Concrete

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## ABSTRACT

Today's construction industry is growing rapidly at its own pace, new materials are being explored and are being used along with conventional material. The conventional material basically include cement, sand aggregate and water which form a homogenous mix called concrete. It is one of the most popular construction materials. Due to this fact, the construction industry is always trying to increase its uses and applications and improving its properties, while reducing cost. In general, concrete has low tensile strength, low ductility, and low energy absorption. Efforts been made by various researchers all over the world to recycle or reuse the used non-biodegradable material in construction industry such as fly ash, rise husk, plastic bottles and shredded rubber. In the present paper, efforts have been made to modify the property of concrete by using waste tyre rubber. The proportion of the ingredients such as cement, sand and aggregate is partially replaced by the use of tyre rubber of suitable sizes. It is found that with the use of tyre rubber, there is no increase in compressive strength but flexural strength and resilience of concrete is enhanced. Such concrete may be used in the construction of load bearing structures and road construction.

**Keywords :** Tyre Rubber, Concrete, Compressive Strength, Flexural Strength.

## I. INTRODUCTION

It is estimated that more than 250 million scrap-tires weighing more than 3 million tons are produced in the India each year, this quantity is in addition to the more than 300 million scrap-tires that are stockpiled already. Those stockpiles represent a severe fire risk due to lightning, combustion, or just plain carelessness. They also pose other health hazards including diseases due to rodent and mosquito infestation and pollution to land, water, and air. Most landfills are refusing to take anymore tires due to the fact that they are harmful to the environment and are not bio-degradable. New means of disposal or recycling must be used. Aside from tire derived fuel, the most promising use of recycled tires is in engineering applications. A tire is a composite of complex elastomer formulations, fibers and steel/fiber cord. Rubber is the principal element of tire, making up about 85% of the tire where both synthetic and natural rubbers may be used. Natural rubber is an elastic hydrocarbon polymer which occurs as a milky colloidal secretion in the sap of several varieties of plants. Rubber can also be produced synthetically, as a thermoset polymeric material in which individual monomer chains are chemically linked by covalent bonds during polymerization.

Today's construction industry is growing rapidly at its own pace, new materials are being explored and are being used along with conventional material. The conventional material basically include cement, sand aggregate and water which form a homogenous mix called concrete. It is one of the most popular construction materials. Due to this fact, the construction industry is always trying to increase its uses and applications and improving its properties, while reducing cost. In general, concrete has low tensile strength, low ductility, and low energy absorption. Concrete also tends to shrink and crack during the hardening and curing process. These limitations are constantly being tested with hopes of improvement by the introduction of new admixtures and aggregates used in the mix. One such method may be the introduction of rubber to the concrete mix. It is a perfect way to modify the properties of concrete and recycle rubber tires at the same time. Though, number of researchers have used many recycled products so as to manufacture the concrete without affecting the original strength and also enhancing the property of conventional concrete. Decades ago, Metropolitan city like Bangalore constructed roads by using plastic as a waste material and used it along with concrete. Fly ash, pulverised rise husk and other industrial wastes are various materials where researchers successfully proved that the use of such material enhance the property of the concrete, along with that issue of pollution can be avoided. Figure 1 shows the stockpiled tyre rubber on site and small chips of such tyre rubber.

Fig. 1 Stockpiled tyre

Rubber in tyre acts as a gripping source between two surfaces and enhance the shock resisting capacity in vehicles and conveyor belts in industries. Same phenomenon is found to be observed in the concrete, when cement, sand and aggregate is partially replaced by shredded tyre in pieces.

## II. LITERATURE REVIEW:

The performance of concrete that contains rubber aggregate made from used tyres has been studied since the early 1990s. Waste-Tyre rubber is one of the most significant environmental hazards worldwide. Because of the increase in auto mobile production, there is a need to properly dispose the vast amounts of used rubber tyres. Available sites for waste disposals are rapidly depleting. The increasing amount of waste tyres worldwide makes the disposition of tyres a relevant problem to be solved. Efforts are being made to discover the prospective use of waste-tyre rubber in construction technology. Some of the prominent literature reviews being studied so far are as follows.

**Eshmaiel Ganjian, Morteza Khorami and Ali Akbar Maghsoudi (2009)**

They carried out extensive research on the performance of concrete mixtures considering, 5%, 7.5% and 10% of discarded tyre rubber as aggregate and cement replacements was investigated. Two sets of concrete specimens were made. In the first set, different percentages by weight of chipped rubber were replaced for coarse aggregates and in the second set scrap-tyre powder was replaced for cement. Selected standard durability and mechanical test were performed and the results were analysed. The mechanical tests included compressive strength, tensile strength, flexural strength and modulus of elasticity. The durability tests included permeability and water absorption. The results showed that with up to 5% replacement, in each set, no major changes on concrete characteristics would occur, however, with further increase in replacement ratios considerable changes were observed.

**N Segre and Joekes (2000)** carried an extensive experimental analysis on the surface modification of powdered tire rubber to increase its adhesion to cement paste. The particles were surface-treated with NaOH saturated aqueous solutions for 20 min. Scanning electron microscopy , water absorption, density, flexural strength, compressive strength, abrasion resistance, modulus of elasticity and fracture energy measurements were performed using test specimens (water/cement ratio=0.36) containing 10% of as-received or 10% of NaOH-treated rubber. The results of fracture energy and flexural and compressive strength show that the addition of rubber particles improves the toughness and reduces the porosity of the specimens. Electron microscopic examination show that the NaOH surface treatment enhances the rubber–matrix adhesion. The use of thus treated tire rubber particles, as addition, instead of a coarse aggregate, in cement-based materials is promising for applications such as driveways or in road construction.

**Raghavan, et.al (2011)** carried out an investigation to determine workability and mechanical properties of mortar containing shredded automobile and truck tyres. Two different shapes of rubber particles were used as constituents of mortar: (1) granules about 2 mm in diameter, and (2) shreds having two sizes which were, nominally, 5.5 mm×1.2 mm and 10.8 mm×1.8 mm (length×diameter). The geometry of the rubber particles influenced the fracture behaviour of rubber-containing mortar. The addition of rubber led to a decrease in flexural strength and plastic shrinkage cracking of mortar. The crack width and crack length due to plastic shrinkage were reduced for mortar containing the 10.8×1.8 mm rubber shreds compared with a mortar without shreds. The rheological properties of the mortar containing rubber shreds were comparable to those of a mortar without rubber and yielded lower plastic viscosity than a mortar containing 25.4 mm×15 μm (length×diameter) polypropylene fibres. The alkaline stability of rubber in mortar was also evaluated by immersing rubber shreds in NaOH and Ca(OH)2 solutions for 4 mon and the results showed that there is less than 20% change in stress and strain value. They suggested that automobile and truck tyres can be recycled by shredding and incorporating them into mortar and probably concrete for certain infrastructural application.

**Sang S, Hajirasouliha I and pilakoutas K (2011)** investigated the potential of incorporating recycled rubber tyre chips into Ordinary Portland Cement (OPC) concrete. Workability, strength and durability properties of concrete incorporating rubber tyre chips as a partial replacement for the coarse aggregate in the concrete is presented in paper. Plain rubber aggregate and rubber aggregate coated with cement paste were used. The results showed that concrete incorporating rubber aggregate has lower workability and unit weight and exhibited a notable reduction in compressive strength. However, the rubberised concrete did not exhibit a typical failure mode of plain concrete and a beneficial effect on flexural strength was observed.

**Bignozzi M and Sandrolini, F. (2006)** investigated rubberised self-compacting concrete was prepared containing different amounts of untreated tyre waste and their mechanical and microstructural behaviour are investigated and discussed in this paper. The fresh and hardened properties of such materials are compared with those of a typical reference formulation of self-compacting concrete. A comparison of the obtained compressive strengths with literature data confirms that self-compacting technology helps binding rubber phases.

**Azevedo F, Pacheco T, Jesus C, Barroso, J and Camoes A. (2012)**

They carried out study on fly ash and metakaolin by replacing partial cement. The durability performance was assessed by means of capillary water absorption and resistance to sulphuric acid attack. The results show the existence of a synergetic effect between fly ash and mextakaolin that minimizes the strength loss associated to the use of rubber waste. Results also show that is possible to use rubber waste up to 15% and still maintain a high resistance to acid attack. The mixes with 45% fly ash and 15% metakaolin show a much higher resistance to sulphuric acid attack than the reference mix independently of the rubber waste content.

**Aiello M, Leuzzi G, Centonze A and Maffezodi A. (2009)** contributed on the use of of granulated rubber and steel fibres recovered from waste tyres in concrete. In particular, the concrete obtained by adding recycled steel fibres evidenced a satisfactory improvement of the fragile matrix, mostly in terms of toughness and post-cracking behaviour. As a consequence recycled steel fibres reinforced concrete appears a promising material for both structural and non-structural applications. In the present paper results obtained by the experimental work performed up to now are reported. In order to evaluate the concrete-fibres bond characteristics and to determine the critical fibre length, pull-out tests were initially carried out. Furthermore compressive strength of concrete was evaluated for different volume ratios of added RSF and flexural tests were performed to analyze the post-cracking behaviour of RSFRC. For comparison purposes, samples reinforced with industrial steel fibres (ISF) were also considered. Satisfactory results were obtained regarding the bond between recycled steel fibres and concrete; on the other hand compressive strength of concrete seems unaffected by the presence of fibres despite their irregular geometric properties. Finally, flexural tests furnished in some cases results comparable to those obtained when using ISF as concerns the post-cracking behaviour.

**Bravo M, Brito J (2012).**understood the problems associated with dumping of used tyres, which ultimately led to the development of various uses for this industrial waste. The performance of concrete that contains rubber aggregate made from used tyres has been studied since the early 1990s. Past research has dealt mainly with the mechanical characteristics of this type of concrete. This research assessed the performance of CTA in terms of durability. Tests for shrinkage, water absorption by immersion and capillarity, carbonation and chlorides penetration resistance were performed. Concrete mixes were produced in which 5%, 10% and 15% of the volume of natural aggregate (NA) were replaced by aggregate derived from used tyres (TA). The fine and coarse aggregate were replaced both separately and simultaneously. This research also examined the influence of the rubber grinding process. Some concrete mixes were therefore made with mechanically ground aggregate and others with aggregate produced by cryogenic technology.

**Snelson D, Kinuthia, J, Davies P, Chang S (2009)** carried out an investigation to establish the physical, mechanical and chemical characteristics unprocessed pulverised fuel ash waste tyres from a former landfill site, determined the suitability of the fly ash and/or tyres in road construction (embankment and pavement) and also in concrete to be used in the construction of the proposed highway. This paper reports on concrete-based construction using various levels of fly ash as partial replacement for Portland cement (PC), and shredded waste tyres (chips 15–20 mm) as aggregate replacement were subjected to unconfined compressive strength tests to establish performance, hence, optimising mix designs. Strength development up to 180 days for the concrete made with PC–PFA blends as binders (PC–PFA concrete), with and without aggregate replacement with tyre chips, is reported. It has been concluded that the above concrete do not have sufficient early strength, but it tends to improve at the age of longer curing. The lower earlier strength shows that such concrete may not be used for low to medium strength applications such as blinding, low-strength foundations, crash barriers, noise reduction barriers, cycle paths, footpaths and material for pipe bedding.

Meddah A, Beddar M and Bali A (2014). Carried out an extensive study which aims to experimentally investigate the possibility of using shredded rubber tire in concrte. The rubber particles are added to mixes as a partial replacement by volume of some parts of natural crushed aggregates. Unit weight, mechanical properties, modulus of elasticity and porosity are evaluated and compared according to the rubber content in the concrete mix. The effects of compaction energy and roughness of rubber surfaces are also studied. The results obtained showed that the inclusion of rubber particles in concrete mixes will change their characteristics in fresh state as well as hardened state. Even though the mechanical properties decrease when rubber content in the mix is increasing, it should be noted that it is possible to use rubber particles in low traffic pavements project. In the other hand, rubber particles may improve some desired technical characteristics such as; porosity, ductility and cracking resistance performance. Further they concluded that In addition to that, it may be more environmentally efficient to use rubber aggregates in concrete, because this helps to remove some parts of these wastes and protect the environment. The performance of such mix with shredded rubber additions can be improved by modifying the roughness of rubber particle surfaces, when the optimal rubber content depends on technical requirements and the destination of project.

## III. 4. CONCLUSION:

Tremendous research and investigation on the use of waste tyre rubber in an concrete by replacing cement, sand, aggregate is a field of interest for many researchers. From the study of literature review, it has been concluded that optimal use and proper roughness of rubber influences the mechanical properties of concrete. Such concrete may not be used for important construction work where loading is very high. It finds its application in the use of light loading construction such as roads where there is light traffic or in foundation where much strength is not required, which ultimately helps in waste management thus controlling the hazardous damage from stockpiled tyre rubber.

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