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A Study on Using Treated Crumb Rubber Aggregate as a Partial Replacement to Fine Aggregate on Hardened State Properties –A Review

Shahbaz Ashraf Rather
Student

Sumit sharma
AP in Civil Deptt.
(PKG COLLEGE OF ENGG. AND TECH PANIPAT HARYANA)

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ABSTRACT – Unwanted noise is a significant factor in traffic corridor planning , architecture, and development. Architects, structural experts, and traffic designers are looking for innovative methods of minimizing or substantially reducing noise levels.
The challenge is to achieve necessary levels of sound while preserving and improving the visual experience at the same time. At the other hand, rubber waste, especially waste from scrap tyres, is one of the most unmanageable. A very serious ecological issue today is its conservation and use.
The dissertation work namely addition of various percentages of scrap rubber by weight of cement in concrete was. carried forward to its logical end using an analytical and experimental approach. The majority of the projected results were subsequently attained by exploring various milestones such as findings from literature survey, identification of relevant gaps to accomplish the work, validity of the tests, results and discussions to provide an. efficient basis.of the subject for implementing its applications for a coherent use in future prospects. Some of the highlights are mentioned below:
The overall analysis and emphasis of this research work is an eco-friendly approach and at the. same is techno-economical from. the commercial point of view
The depleing trend of the natural. surce like the aggregaes can be reduced to a greater extends by making it sustainable for the judicious use of future generation and reduces various problems associate with environment. The research work shall be further explored by increasing the percentage of rubber as aggregate.
The commercial implications in promoting the implementation of this dissertation work can be little bit on higher side, but the saving of environmental degradation and large land fill area can be considered as the pay back assets.

I. INTRODUCTION

It has been realized that the generation of solid waste and the disposal problem related to it is a standout amongst the most vital issues which our human progress is confronting in present era. Risky and non-biodegradable waste is being produced in boundless amount bringing on genuine danger to our environment, . Population growth, urbanization and the industrialization causes increased growth in the utilization of various sorts of materials which has resulted in the huge amount of solid waste generation, . The generation of non-biodegradable and hazardous waste alongside the consumer population growth has brought waste disposal crisis. Solid waste can be arranged into various sorts relying upon their source: a) Household, b) Industrial (toxic and hazardous) and c) Bio-medical (infectious), . Among industrial wastes, the tyre rubber wastes or scrap tyres are one of the hazardous wastes which are being generated and accumulated on very large scale worldwide every year. As tyre rubber waste is classified as non-biodegradable waste, thus its non-decaying nature creates a huge problem in proper and safe disposal. Every year, more than one billion tyres are manufactured around the world, and equivalent number of tires is permanently expelled from vehicles, getting to be distinctly squandered. The U.S. is the biggest producer of waste tires, around 290 million a year, although increments in new vehicles deals in China and India are quickly adding to waste tire volumes. European Union contributes around 180 million tons to the scrap tyres volume. **India's waste tyres represent around 6-7% of the worldwide aggregate. The waste rubber tyres in**

India are rising with the 12% per annum growth in the local tyre industry, **.**Generally the waste tires are either stockpiled (whole tyre) or land filled (shredded tyre) but this accounts for huge space requirement, moreover, it becomes the home of nesting insects, rats and breeding ground for mosquitoes, which leads to the outbreak of many diseases. Globally, in 2011, just 7% of waste tires were recycled at site, 11% were used for fuel, 5% were sent out for processing somewhere else and the remaining 77% weresent to landfills, stockpiled, or illicitly dumped; the equivalent of some 765 million tyres a year wasted. The danger of tyre rubber wastes catching fire is always there and once tyres start toburn uncontrollably it takes long time to extinguish, also, it leads to the release of toxic smoke in the air and contaminate the soil and water. One of such tyre wastes fire occurred at Heyope in whales where tyre wastes fire started in 1989, about 10 million tyres had been dumped there and it took about 15 years to extinguish this fire, . Thus stockpiling and land filling is not an effective way to dispose the waste rubber tyres as it greatly contributes in degradation of our ecology and causes various health hazards. On realizing the negative impact of waste rubber tyres due to disposal crisis on our society and the other problem related to it, the European Union completely restricted the disposal of all intact tyres into the surrounding ecosystem since 2003 and shredded rubber waste tyre since 2006 as per the norms stated under the Eupropeon Union Directive 199/31 EC.

The conceivable and effective solution of waste rubber tyres disposal crisis is exhibited by applying the philosophy of sustainable development. The application range of sustainable development is for all intents and purposes limitless, considering that the present concept is applicable to all types of human activity. Among various aspects of sustainable development the recycling and reuse of waste products are the major ones, as it helps in reducing the area required for junkyard/ landfills by reusing the waste/scrap. A rubber tyre is a composite of rubberelastomer sheets fortified transversely with steel fibers. Tire recycling makes utilization of interesting traits of natural rubber such as high tensile, shear strength and high fatigue resistance. Some of the best available choices for reusing scrap/waste rubber tires include incineration of waste rubber tires for the production of power and steam. Scrap rubber tires have been utilized effectively in kilns of cement industries for the production of cement, as proposed prior by different researchers . Such applications/implementation in various fields make utilization of attributes like good durability and adhesion of waste rubber tyres. Other effective employments of scrap/waste tires included their utilization in hot mix bitumen as a road construction material . However, a few challenges are related with its application as roadway material, for example, the high viscosity of the rubberized bitumen and the higher temperature for generation of rubberized asphalt .

While these fields of utilizations gave positive outcomes for recycling and reusing scrap tyres, utilization of scrap/waste tires with respect to the present volumes of tyres in landfills is very little. Since, concrete forms the biggest segment of construction materials around the world, it has been recommended to utilize scrap/waste tyres as material in concrete. The yearly production of concrete worldwide consumes around 9 billion tons of aggregate and more than 2 billion tons of cement.

II. OBJECTIVES OF THE STUDY

In the view of gaps identified, the objectives of the present research work are as follows:

- To design a concrete mix in accordance to IS 10262:2009 for developing the reference concrete of M35 grade.
- To develop rubberized concrete mix samples by replacing the fine aggregate (sand) with untreated and treated (with synthetic resin) crumb rubber as aggregate at different percentages.
- To determine the density and slump of rubber modified concrete mix samples havingdifferent crumb rubber content.
- To determine the compressive strength for untreated and treated rubber modifiedconcrete.
- To suggest the optimum dosage of crumb rubber aggregates both treated and untreated based on laboratory test results obtained; and draw conclusions for field application.

III. LITERATURE REVIEW

1. Nadim A. Emira and Nasser S. Bajaba**, "Utilization of Waste Crumbed Rubber Tire As Fine Concrete Aggregate"**, Yanbu Journal Of Engineering and Science, 2012 **[21],** studied the viability of addition of waste rubber tyres aggregate as a replacement for natural aggregates in concrete, moreover, effect of curing time on the engineering properties were studied. Different concrete groups were prepared using plain Portland cement, crumb rubber as replacement for fine aggregates (0%, 10%, 20 % and 30%) by volume. Different sizes of crumb rubber were usedwhich has been divided into three groups namely; (0.01-0.5) mm, (0.5-2) mm, and (2-3) mm.

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The specimens of all the different groups were investigated after different curing time namely; 7, 14, 21 and 28 days. The grade for normal concrete used in the study was M25. Following conclusion has been derived based on results:

- Compressive strength increased for all crumbed rubber sizes as curing time increases.
- Loss of compressive strength increases as crumb rubber content increases, however the loss of strength is more in those specimens having crumb rubber size larger than the other specimens containing smaller size crumb rubber.
- Unit weight of specimen's decreases as rubber tyre content increases.
- Rubber modified concrete can be used for light weight structural concrete members for up to 30 % replacement by crumb rubber.

2. Malek K. Batayneh et al., **"Promoting the use of crumb rubber concrete in developing countries"**, Waste Management, 2008 **[1],** focused its investigation on utilising crumb rubber as substitution for natural aggregates used in concrete mix in Jordan. Size of crumb rubber used in testing varied from 4.75 to 0.15 mm. The replacement is done in different percentages by volume(20%, 40%, 60 %, 80% and 100%). Type I ordinary Portland cement was used. The grade for normal concrete used in the study was M25. Effect on workability, unit weight, compressive strength and split tensile strength were studied, and also, stress strain relationship analysis was also done. Following points had been concluded based on results:

- Compressive strength and split tensile strength reduced as the percentage of crumbrubber content increases.
- Although unit weight of concrete mix decreases, the lower unit weight of rubber modified concrete meets the criteria of light weight concrete for up to 20%(by volume) replacement of fine aggregates.
- The concrete with higher percentage of crumb rubber possessed higher toughness, thus increased its ability to support load even after the formation of cracks, the failure is not abrupt but gradual.
- The increase of the crumb rubber content in the mix resulted in the decrease in the slump of the mixture, However, observations showed that desirable workable mix in correlation to conventional mix was produced when the replacement percentage was 20% (by volume).

3. M. M. Reda Taha et al., **"Mechanical, Fracture, and Micro structural Investigations of Rubber Concrete"**, Journal of Materials in Civil Engineering, 2008 **[27]**, carried out an experimental investigation using chipped and crumb rubber as a partial replacement to coarseand fine aggregates. The size of chipped rubber tyres varies from 5 to 20 mm and that of crumb rubber tyres varies from 1 to 5 mm. The replacement levels were 25, 50, 75 and 100% by volumeof the coarse and fine aggregates. Ordinary Portland cement was used; the grade for normal concrete used in the study was M25. The fresh concrete properties (unit weight, slump, air content) and mechanical properties (compressive strength and impact strength) were examined for different specimens incorporating different percentage of chipped and crumb rubber tyres. The effect on fracture toughness was also studied for chipped rubber tyre aggregates. The following conclusions were made based on the results of the investigation:

- Replacement of natural aggregates with chipped and crumbed rubber tyres resulted in a reduction in the unit weight of the concrete, moreover, the air content increase as the rubber tyre aggregates percentage increases in the concrete mix.
- Workability decreases with the increases in the rubber tyre particles in concrete mix; significant loss of slump has been reported. This effect on workability is more pronounced when chipped rubber tyre particles were used as compared to the crumbed rubber.
- At 25 % replacement level (by volume), the desirable slump and unit weight had been achieved in correlation to conventional concrete.
- Compressive strength reduced as the percentage of rubber tyre particles increases; impact strength enhancement as the energy required for failure increases with the increase in the rubber tyre particles content. This effect is mainly attributed to the higher flexibility of rubber concrete composite due to which it was able to absorb high energy.
- Fracture toughness increases as the rubber tyre particles increases in concrete mix;replacement by chipped aggregates up to 25 to 50 % (by volume) was considered optimalsubstitution.

4. Shanmugapriya M, **"Effects of Concrete By Using Waste tyre Rubber (Solid Waste)"**, International Journal of Applied Engineering Research, 2015 **[24]**, conducted an investigation to check the feasibility on the use of rubber modified concrete in light weight structures. Ordinary Portland cement of 53 grade and rubber tyre aggregates with their size ranging from 12 to 20 mm

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was used. The replacement with tyre aggregates is done in 3, 6, 9 and 12% (by weight). The grade for normal concrete used in the study was M25. The mechanical properties, such as, compressive strength, tensile strength and toughness index were examined, in addition to this, stress strain response was also studied. Following conclusions had been derived based on results:

• Compressive strength and split tensile strength showed decreasing trend in its values as the rubber tyre content increases, however, up to 12% (by weight) replacement with rubber tyre aggregates the criteria for light weight concrete had been satisfied.

• Toughness index value is more for the concrete containing the rubber tyre particles as compared to the normal concrete, this showed that rubber concrete composites are able towithstand the deformation even after the peak load is reached, thus failure is ductile in nature.

• Rubberized concrete can successfully be implemented in light weight structural components like crash barriers, sidewalks and pavement blocks etc.

5. Khalid Battal Najim, **"Workability and mechanical properties of crumb-rubber concrete"**, Construction Materials, 2013 **[28]**, experimentally determined the effect of varying w/c at constant cement content and aggregate specific surface area, on the fresh state properties and hardened state properties of rubberized concrete. Feasibility of designing rubber modified concrete with acceptable workability level was assessed. High strength Portland cement was used; fine aggregates, coarse aggregates and (coarse + fine) aggregates was replaced with rubber tyre particles for different percentages of 10, 20, 30 and 50% (by weight). The following points had been concluded:

• Bulk density decreases due to the low specific gravity of the rubber aggregate in comparison with natural aggregates; reduction in bulk density is higher when natural coarse aggregates were replaced.

• Reduction in slump against increased crumb-rubber replacement for all three reference mixes prepared; for the fixed percentage substitution, replacement of natural coarse aggregates with rubber aggregates showed more reduction in slump as compared to the replacement of fine aggregates.

• Observations showed that desirable workable mix and unit weight in correlation to conventional mix was produced when the replacement percentage was 10% (by weight).

• Reduction in compressive strength and split tensile strength with increasing percentage of rubber aggregate content; replacement of natural coarse aggregates with rubber aggregates showed more reduction in strength as compared to the replacement of fine aggregates.

6. Osama Youssf et al., **"Assessment of the mechanical performance of crumb rubber concrete"**, Construction and Building Materials, 2016 implemented three methods to improve and then assess the mechanical performance of CRC namely, rubber pre-treatment using sodium hydroxide (NaOH) solution, using silica fume additives, and increasing concrete cement content. The effect of the rubber pre-treatment time (0–2 h), silica fume content (0–15%), and cement content(300–400 kg/m3) on CRC slump, short and long term compressive strength, and tensile strength were measured for fifteen concrete mixes prepared with 0% and 20% rubber content. General purpose cement type with specific gravity of 3.15, according to Australian Standard (AS) AS 3972, was used as the binder material in the concrete mixes. The crumb rubber used had two particle sizes of 1.18 and 2.36 mm and was used as a partial replacement of sand byvolume. The variables in this study were; the pre-treatment period of rubber particles using 10%NaOH solution for 0.0 hr, 0.5 hr, 1.0 hr, and 2.0 hr; the SF content as a partial replacement ofcement weight by 0%, 5%, 10% and 15%; and the concrete cement content of300 kg/m3, 350kg/m3, and 400 kg/m3.The concrete mixes were designed according to AS 1012.2.The target compressive strength of the control mix was50 MPa. The following points had been concluded:

• Using non-treated rubber increased the concrete slump in comparison to control mix; pre-treated rubber concrete mix also had more slump than control mix but less than non treated rubber modified concrete.

• Using non-treated rubber particles in concrete mix had reduced the compressive strength and tensile strength, however, the NaOH pre-treatment of rubber was able to recover part of the strength reduction. The most effective strength recovery was observed when using
0.5 h pre-treated rubber.

• Using SF as partial replacement of cement was not useful and showed some negative effects on the concrete slump and compressive strength. It also made negligible improvement on the long term compressive strength.

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- The cement content that most enhanced the CRC performance in this study was 350 kg/m3, The CRC compressive and tensile strengths at 28 day increased by 20% and 7%, respectively, with cement content increase from 300 to 350 kg/m3.

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