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A Review of Environmental Protection-Enabling Building Technologies: Concretized rubber

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Abstract: The disposal of used tyres is a significant environmental issue that contributes to hazards including mosquito breeding grounds, uncontrolled fires, and contamination of the soil and plants. As a result, it is vital to find alternate uses for these tyres, with a focus on recycling the used tyres. Concrete is a superior construction material that is regarded as being necessary for human society and modern civilization. The use of scrap tyres in concrete is now deemed technically feasible and the concrete is seen as being of a lighter weight. In order to strengthen concrete while also preserving the environment, this study examines the viability of employing scrap tyres as chips and fibres of various sizes. By utilising its special qualities and features, it also examines possible field applications. The usage of rubberized concrete in structural and non-structural members is described in this study, along with its applications, drawbacks, advantages, and avenues for future research.

Keywords: used tires, rubberized concrete, environmental protection

INTRODUCTION

It is commonly recognised that growing accumulations of used tyre debris will result in In addition to being an environmental hazard and contaminating soil and plants, the buildup of old tyres at disposal sites poses the risk of uncontrolled fires. An estimated 37 million automobile and truck tyres are wasted annually in the UK alone, and this number is expected to rise. Because waste rubber does not readily biodegrade even after extensive treatment in landfills, this is one of the biggest environmental challenges the world currently faces. One of the alternatives offered is to employ tyre rubber in cement-based materials in place of some of the coarse aggregate[1]. Although being the most widely used building material, concrete has numerous drawbacks, including poor tensile strength, low ductility, low energy absorption, and shrinkage and cracking brought on by the hardening and curing processes[2]. Recent research have indicated that adding recycled tyre rubber to concrete may strengthen some of the weaker aspects of the material.**Rubberized concrete:** The term "rubberized concrete" refers to concrete that has had discarded rubber put into it in various volume amounts. Concrete can gain benefits like low unit weight, great resistance to abrasion, absorbing shocks and vibrations, high ductility and brittleness, and more by replacing some of the coarse or fine aggregate with a certain quantity of small scrap tyre cubesMoreover, adding rubber to concrete increases its resilience, longevity, and elasticity [3–9]. Due to the altered state of its properties, rubberized concrete will be advantageous in structures that are vulnerable to impact effects.

Review on rubberized concrete: Eldin's tests on the behaviour of rubberized concrete[10] revealed that using tyre chips and crumb rubber as an alternative to aggregate in sizes 38,25mm and 19mm resulted in a

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Schimizze[12] developed two rubberized concrete mixes using fine rubber granulars in one mix and coarse rubber granulars in the second. While these two mixes were not optimized and their design parameters were selected arbitrarily, their results indicate a reduction in compressive strength of about 50% with respect to the control mixture. The elastic modulus of the mix containing coarse rubber granular was reduced to about 72% of that of the control mixture, whereas the mix containing the fine rubber granular showed a reduction in the elastic modulus to about 47% of that of the control mixture. The reduction in elastic modulus indicates higher flexibility, which may be viewed as a positive gain in rubberized PCC (RPCC) mixtures used as stabilized base layers in flexible pavements.

I.B. TopÇu in [13] investigated the effect of particle size and content of tire rubbers on the mechanical properties of concrete. The researcher found that, although the strength was reduced, the plastic capacity was enhanced significantly.

Zaher *et al*[14] concluded that RPCC mixtures can be made using ground tire in partial replacement by volume of CA and FA. Based on the workability, an upper level of 50% of the total aggregate volume may be used. Strength data developed in their investigation (compressive and flexural) indicates a systematic reduction in the strength with the increase of rubber content. From a practical viewpoint, rubber content should not exceed 20% of the aggregate volume due to severe reduction in strength. Once the aggregate matrix contains nontraditional components such as polymer additives, fibers, iron slag, and other waste materials, special provisions would be required to design and produce these modified mixes. At present, there are no such guidelines on how to include scrap tire particles in PCC mixtures.

Serge *et al*.,[15] used saturated NaOH solution to treat waste tire rubber powders. They found that NaOH surface treatment increased rubber/cement paste interfacial bonding strength and resulted in an improvement in strength and toughness in waste tire powder modified cement mortar.

Hernandez-olivares *et al*.,[16] used crumbed waste tire fibres (average length 12.5 mm) and short polypropylene(pp) fibres (length from 12-10 mm) to modify concrete.

Gregory Garrick [17], shows the analysis of waste tire modified concrete used 15% by volume of coarse aggregate when replaced by waste tire as a two phase material as tire fiber and chips dispersed in concrete mix. The result is that there is an increase in toughness, plastic deformation, impact resistance and cracking esistance. But the strength and stiffness of the rubberised sample were reduced. The control concrete disintegrated when peak load was reached while the rubberized concrete had considerable deformation without disintegration due to the bridging caused by the tires. The stress concentration in the rubber fiber modified concrete is smaller than that in the rubber chip modified concrete. This means the rubber fiber modified concrete can bear a higher load than the rubber chip modified concrete before the concrete matrix breaks.

Kamil *et al*.,[18], analyzed the properties of Crumb Rubber Concrete, The unit weight of the CRC mix decreased approximately 6 pcf for every 50 lbs of crumb rubber added. The compressive strength decreased as the rubber content increased. Part of the strength reduction was contributed to the entrapped air, which increased with the rubber content. Investigative efforts showed that the strength reduction could be substantially reduced by adding a de-airing agent into the mixing truck just prior to the placement of the concrete.

Guoqiang Li,[19] conducted investigation on chips and fibers. The tire surfaces are treated by saturated NaOH solution and physical anchorage by drilling hole at the centre of the chips were also investigated and they concluded that fibers perform better than chips: NaOH surface treatment does not work for larger sized tire chips: using physical anchorage has some effect. Further efforts will be geared toward the enlarging he hole size and insuring that the hole be through the chip thickness entirely. Fibre length restricted to less than 50mm to avoid entangle: steel belt wires provide positive effect on increasing the strength of concrete.

From the above literature review it is seen that waste tire rubber modified concrete is characterized as having high toughness and low strength and stiffness. Various methods have been tried to improve the strength and stiffness of waste tire modified concrete. However preparing waste tire powders and thin tire fibres is time, effort and money consuming. Sometimes, the cost may be so high that it cannot be justified by its

Challenges in environmental protection: The wastages are divided as Solid Waste Disposal, Liquid Waste Disposal and Gaseous Waste Disposal. There are lots of disposal ways for liquid and gaseous waste materials. Some solid waste materials such as PET bottles, papers, steel, etc can be recycled without affecting the environment. But there is no way to dispose the solid wastes such as waste tires. If the tire is burned, the toxic product from the tire will damage the environment and thus creating air pollution. Since it is not a bio degradable material, this may affect the fertility of the soil and vegetation. Sometimes they may produce uncontrolled fire. Similarly, there is an another challenge to the human society is in the form carbon dioxide emission and green house emission, which are considered as another type of waste, which is threatening the universe.

Need for further research: As seen in the above section the accumulation of used tyres at landfill sites presents the threat of uncontrolled fires, producing a complex mixture of chemicals harming the environment and contaminating soil and vegetation.

There is, therefore, an urgent need to identify alternative outlets for these tyres, with the emphasis on recycling in line with the policy of most countries.

One such possible outlet is to produce tire chips and fibres components for use in concrete as aggregate or filler. Indeed, waste tire chips and fibre is uniquely different to other waste materials, because its production method does not require any sophisticated machineries and easy to handle in economically. Hence, the successful use of waste tire chips and fibres in concrete could provide one of the environmentally responsible and economically viable ways of converting this waste into a valuable resource.

The principal objective is to develop ways of exploiting inherent stability, impact, crack and thermal resistance characteristics that waste tyre rubber can bring to concrete. Based on the number of conclusions that have been reached based on available literature, discussions and consultations with professionals from relevant engineering, research and scientific disciplines, the following three main issues were identified:

- There is growing evidence of the feasibility of substituting waste tyre rubber with a portion of natural aggregate in concrete manufacturing and also adding minerals and chemical admixtures in concrete production
- The need to examine the influence of waste tyre rubber on the fundamental mechanical and durability properties (strength, stiffness, fatigue, impact, thermal, crack and freeze/ thaw resistance) of concrete and concrete products and measure the performance
- The requirement to prepare a technical document that covers guidelines for incorporating waste tyre rubber in concrete; thereby, creating a disposal route for millions of used tyres around the world to improve the performance of Concrete, while reducing the environment impact

Applications and advantages of rubberized concrete over ordinary concrete: The rubberized concretes are affordable, cost effective and withstand for more pressure, impact and temperature when compare it with conventional concrete. It is observed that the Rubber Modified Concrete (RMC) are very weak in compressive and tensile strength. But they have good water resistance with low absorption, improved acid resistance, low shrinkage, high impact resistance, and excellent sound and thermal insulation. Studies shows the CRC (crumb rubber concrete) specimens remained intact after failure (did not shatter) compared to a conventional concrete mix. Such behavior may be beneficial for a structure that requires good impact resistance properties. The impact resistance of rubberized concrete was higher, and it was particularly evident in concrete samples aggregated with thick rubber [18].

Moreover the unique qualities of rubberized concrete will find new areas of usage in highway constructions as a shock absorber, in sound barriers as a sound absorber and also in buildings as an earthquake shock-wave absorber. It reduces plastic shrinkage cracking and reducing the vulnerability of concrete to catastrophic failure.

Currently, the waste tyre modified concrete is used in Precast sidewalk panel, non-load bearing walls in buildings and Precast roof for green buildings[20]. It can be widely used for development related projects such as roadways or road intersections, recreational courts and pathways, and skid resistant ramps[18]. With this new cement-stabilized aggregate bases are needed, particularly under flexible pavements. The other viable applications well suited for use in areas where repeated freezing and thawing occur, and can also be poured in larger sheets than conventional concrete.

The tennis courts can now be poured in a single slab, eliminating 'section' lines which must be smoothed after curing. Roofing tiles and other concrete products can now be made lighter with Rubberized concrete [21]. It may also used in runways and taxiways in the airport, industrial floorings and even as structural member.

Current research: Though rubberized concrete has proven its applications in various construction fields, still a lot of research has to be done to measure the elastic constants and mechanical properties of rubberized concretes by adding rubber in different volume proportions, water-cement ratios, aspect ratios and in different forms such as fiber chips, powder form, etc. so that the appropriate strength can be explored.

A research is underway using the grade of cement 53, to improve the strength, fine sand and coarse aggregate of a combination of 10mm and 20mm. The waste tyre rubber shall be used in the form of chips and fibers by partially replacing the coarse aggregate by 0, 5, 10, 20 and 25%.

The proposed concrete mixture shall be considered as high strength concrete with a ratio of 1:1:2.5. Figure 1 shows the waste tyre chips of size 10mm cubic with a central anchorage hole of 6mm diameter which is for the above research.

Figure 2 shows the proposed waste tyre fibre, which can be used as partial replacement of coarse aggregate in the concrete. The size of the waste tyre fibres shall be 25, 50 and 75mmX7mmX7mm with an anchorage hole of different diameters.

The water-cement ratio in the proposed research is taken as 0.4. It is recommended that to improve the strength characteristics and other mechanical properties of rubberized concrete, some ADMIXTURES (Chemical or Mineral) can be added as a partial replacement of cement. To get more workability and strength enhancement of waste tyre modified concrete, a required quantity of super plasticizer shall be added. The above concrete shall be mixed in a Pan mixer for uniform distribution of waste tyre rubbers in the concrete to avoid balling as well as accumulation of waste tyre rubbers in the concrete.

The proposed concrete will have higher strength, high resistant to acid attacks and high resistance against freezing & thawing. This is called as New Generation Concrete (NGC). No earlier research had explored the possible use of NGC as a structural member material. The scope of this work is limited to the development of the rubberized concrete mixes and evaluation of their basic engineering properties to be used as structural member.

Fig. 1: Waste tyre rubber chips with 6mm diameter hole

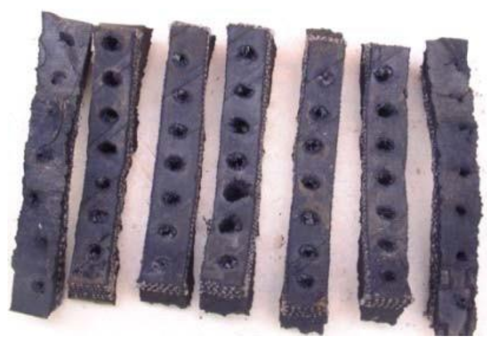

Fig. 2: Fiber Rubber of 75mmX7mmX7mm

CONCLUSION

Recycling technology for concrete has significantly developed in the recent years, making the material sufficiently recyclable [20]. It is evident that from the above discussion, the reduction of compressive and tensile strength can be increased by adding some super plasticizers and industrial wastes as partial replacement

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