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A Review on use of Waste Tyre in Cement Concrete Pavement by Replacing Coarse Aggregates

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ABSTRACT

One of the primary construction material that is used worldwide is concrete. For the development trading the most important materials that are used are aggregates and cement, these materials makes the primary and significant constituents for the production of concrete. As for concrete production the natural materials are being used in a greater demand. In a similar context that is required for natural resources utilization has been emerged as an increasing issue for protecting the environment as well as requirement for preserving the natural resources like aggregates that are being exploited through several materials that were actually recycled by the area unit. In this analysis, the study focuses on the replacing the coarse aggregate partially with recycled rubber tyre employment in the construction of concrete along with use of waste tyre that were obtained regionally. The initial sections of this particular study has discussed the background of the study along with the matter extent. The literature review section provides the review or discussion of the various relevant literatures that were performed for in the earlier times in this particular subject area. In this study, various tests were applied on the raw materials to investigate their suitableness and properties for this experimentation study. Three concrete grades that is M15, M20 and M25 are combined to prepare the concrete styles area units. To prepare the specimen, the coarse aggregates is used with different proportion replacement of 10, 25, and 50 for exploiting the mixture of rubber. Furthermore, to perform a comparative analysis, a bearing is developed without any coarse mixture replacement. The samples that were prepared includes beams, cylinders and cubes. After that these concrete samples were tested in the laboratory. The various tests that were performed are as: flexural strength, impact resistance, lastingness, compressive strength, unit weight, and slump tests. These laboratory tests that were performed on the specimen were primarily supported by the information assortment. Results of these tests were then compared with the various concrete properties and it was observed that the concrete's compressive strength is decreased due to the presence of rubber aggregates. Although, due to this reason there are chances that it cannot be used in some structural applications. Also, along with the decreased compressive strength it has some important characteristics such as increased flexural strength, increased plasticity, higher impact resistance, and lower density. It is shown from the results that recycled rubber tyres can be used in the construction of concrete as coarse aggregates partial replacement. Due to the fascinating rubber aggregates area unit, the replacement proportion should be kept at normal amount as well as applications should be limited for specific cases where it is required to improve the properties.

INTRODUCTION

Being a composite material concrete is embedded in coarse granular material (rigid matrix composed of aggregate or filler) that materials (binder or cement)merges the gap among particles of aggregate sand keep them organized gives brightness (Sydney Maindes, Young JF David Darwin, 2013). In other words, mix of aggregates and paste forms the concrete. Water and Portland cement composes the paste and coarse and fine aggregates surface is coated with it. Concrete is formed by a chemical reaction, namely hydration, which actually provides the strength to this paste and hardens it to make a rock-solid mass (concrete).

One of the primary construction material that is used worldwide is concrete. In all the constructions including commercial, industrial, residential, transport constructions, the concrete's performance and quality has a major significance. Concrete is the only largest manufactured material globally as the requirement of it is approximately 6 billion metric tons yearly. For an example in America the local governments have approximately 1.5 trillion dollars in investment for the civil infrastructure. According to Naik TR & Moriconi G the global use of concrete material is accounted for approximately 780 billion dollars per year.

However, the solid constructions so far are mainly prefer of using pure natural resources. But as the conservation concept of natural resources is limited there is a need of having or searching alternatives. Recycling mechanism is one of the best alternatives as it gives two fold advantages , the first one is it will prevent or control the natural resources 'depletion as well as another one is due to recycling of the material it will help in preventing severe threats to the nature and ultimately to the environment. As per the statistical data drawn from the sources approximately 1 billion automobile tyresare being produced per annum worldwide. If we see at our traditional ways of the reusing the tyres was mainly shoe making but nowadays nobody is utilizing the used tyres in shoe making so the reusing of the used tyres is decreased. This can be considered as one of the prime environmental challenge globally because the waste rubber materials of the used tyres is not a biodegradable material even after treating it for a longer period. Therefore, the recycling is considered as the one of the greatest management strategy for the used tyres. Utilizing these used tires must maximize protection to reduce environmental impact and various natural resources. This problem can be solved if these rubber particles can be incorporated with in the cement based materials. Furthermore, the used or scrapped vehicle tyres can be used in hundreds of products as a raw material after granulation.

Another problem that has been arose after studying is the average construction production motive is ongoing and that leads tonatural resources' depletion. In addition, few countries are dependent on foreign material which is definitely very expensive. A country like Netherland does not produce any material and is importing the material this can be one of the example. So, because of this issue the main concern is towards using the alternative materials instead of using the natural material.

Hence the use of recycled scraped or used tyres granules can help in solving the main two problems first is the environmental threat caused by the scraped tyres and the other is depletion of natural resources.

LITERATURE REVIEW

There are various investigators that uses diverse materials such as recycled concrete, carbon black, steel wires, rubber etc. as coarse aggregate's partial replacement in concrete construction. This section provides the review of various literatures that is discussed as:

1. Eldin and Senouci (2017) stated that good aesthetic qualities are shown by the rubberized concrete. The appearance of the finished surfaces was similar to that of ordinary concrete and surface finishing was not problematic. However, the authors reported that mixes containing a high percentage of larger sized rubber aggregate required more work to smooth the finished surface. They also found that the colour of rubberized concrete did not differ noticeably from that of ordinary concrete.
2. Khatib and Bayomy (2019) examined the rubberized concrete's workability. They observed a decrease in slump with increased rubber aggregate content by total aggregate volume. Their results show that for rubber aggregate contents of 40% by total aggregate volume, the slump was close to zero and the concrete was not workable by hand. Such mixtures had to be compacted using a mechanical vibrator. Mixtures containing fine crumb rubber were, however, more workable than mixtures containing either coarse rubber aggregate or a combination of crumb rubber and tire chips.
3. Senthil Kumaran et al (2018) and Siddique and Naik (2004) performed an overview of some of the research published regarding the use of scrap tyre in the manufacture of concrete. Studies indicate that good workable concrete mixtures can be made with scrap-tire rubber.
4. Eldin and Senouci (2014) described that, generally the Rubberized concrete sets presents acceptable performance in terms of ease of handling, placement and finishing. However, they found that increasing the size or percentage of rubber aggregate decreased the workability of the mix and subsequently caused a reduction in the slump values obtained. They also observed that the size of the rubber aggregate and its shape (mechanical grinding produces long angular particles) affected the measured slump. The slump values of mixes containing long, angular rubber aggregate were lower than those for mixes containing round rubber aggregate. Round rubber aggregate has a lower surface/volume ratio. Therefore less mortar will be needed to coat the aggregates, leaving more to provide workability. They suggested that the angular rubber aggregates form an interlocking structure resisting the normal flow of concrete under its own weight; hence these mixes show less fluidity. It is also possible that the presence of the steel wires protruding from the tire chips also contributed to the reduction in the workability of the mix.
5. Topcu (2015) incorporated rubber aggregate'slow volumes at times ofconcrete preparation, while Rostami et al (2014) appeared to use larger volumes of rubber aggregate. Their results indicated that concrete densities were reduced to 87% and 77% of their original values, respectively, when the maximum amounts of rubber aggregate were used in the investigations.
6. Eldin and Senouci (2018) described a density reduction of, up to 25% when ordinary aggregate was replaced by coarse rubber aggregate. Li et al (2018) found that the density of Rubberized concrete was reduced by around 10% when sand was replaced by crumb rubber to the amount of 33% by volume.
7. Ali et al. (2019) stated that there was a considerable increase in air content nearly about 14% when rubber aggregate was mixed with the concrete.
8. Khatib and Bayomy (2018) and Fedroff et al (2017) studied that the air content increased in Rubberized concrete mixtures with increasing amounts of rubber aggregate. Although no air-entraining agent (AEA) was used in the Rubberized concrete mixtures, higher air contents were measured as compared to control mixtures made with an. The higher air content of Rubberized concrete mixtures may be due to the nonpolar nature of rubber aggregates and their ability to entrap air in their jagged surface texture. This increase in air voids content would certainly produce a reduction in concrete strength, as does the presence of air voids in plain concrete
9. (Benazzouk et al 2017). Since rubber has a specific gravity of 1.14, it can be expected to sink rather than float in the fresh concrete mix. However, if air gets trapped in the jagged surface of the rubber aggregates, it

could cause them to float . This segregation of rubber aggregate particles has been observed in practice.

10. Goulias et al (2016) performed an experimental study that incorporates crumb rubber, with Portland cementas fine aggregate. Further, the modifications were shown by thetest results in the concrete's brittle failure, which indicates that rubber concrete specimens exhibited higher ductility performance than normal concrete. Results showed large deformation without full disintegration of concrete.
11. It is found by Chou et al (2017) that for many applications concrete was replaced with rubber due to its good result. Physical properties degrade by mixing of rubber particles specially the concrete compressive strength.
12. Chung et al (2018) proposed the concrete with rubber aggregate by making use of waste tyre rubber through dry process. 89MPa was the concrete with rubbers' compressive strength. 5.5% is the ratio of Poisson that is the compressive-to-tensile strength ratio.
13. Eldin and Senouci (2017) performed many researches for the examination of toughness along with compressive strength of rubberized concrete mixtures. Three sets of experiments were performed, the first set using coarse rubber aggregate (chipped tyre) of 19-38 mm size and the second and third sets using smaller diameter chips of 6 mm and 2 mm respectively. The results found that the specimen containing rubber when loaded in compression exhibits more gradual failure, either of a splitting (for coarse rubber aggregate) or a shear mode (for fine crumb rubber).
14. Toutanji (2016) performed many experiments to check the bad effects of replacement of coarse aggregate by rubber aggregate. Four different contents of rubber aggregate with a maximum size of 12.7 mm were used to replace the coarse aggregate at 25, 50, 75 and 100% by volume and discovered that the incorporation of the rubber aggregates in concrete produced a reduction in compressive strength of up to 75% and a significantly smaller reduction in flexural strength of up to 35%. The reduction in both strengths increased with increasing the rubber aggregate content. It is observed that the specimens containing rubber aggregate exhibited a ductile mode of failure as compared to the control specimens.
15. Schimizze (2017) proposed two Rubberized concrete mixtures in which coarse rubber granular is mix with fine rubber granular. Parameters of these design has been selected randomly as well as they did not optimize. The results show that the compressive strength of these mixtures was decrease by 50% w.r.t. mixture of control as well as coarse rubber granular elastic modulus was also decreased by 72%. While the elastic modulus of fine rubber granular was reduced by 47% w.r.t. mixture of control. Reduced elastic module show that it has high flexibility that might be a positive or optimistic gain in the mixture of RPCC.
16. Topcu (2018) examined 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.
17. Gregory Grrick (2014), showed 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 resistance. But the strength and stiffness of the rubberized 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 tyre. 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.
18. Tantala et al (2016) investigated the toughness (toughness is also known as energy absorption capacity and is generally defined as the area under load deflection curve of a flexural specimen) of a control concrete mixture and Rubberized concrete mixtures with 5% and 10% buff rubber by volume of coarse aggregate. They reported that toughness of both Rubberized concrete mixtures was higher than the control concrete mixture. However, the toughness of Rubberized concrete mixture with 10% buff rubber (2 to 6 mm) was lower than that of Rubberized concrete with 5% buff rubber because of the decrease in compressive strength. Based on their investigations on use of rubber shreds (having two sizes which were, nominally, 5.5 mm to 1.2 mm and 10.8 mm to 1.8 mm) and granular (about 2 27 mm in diameter) rubber in mortar,
19. Raghavan et al (2016) reported that mortar specimens with rubber shreds were able to withstand additional load after peak load. The specimens were not separated into two pieces under the failure flexural load because of bridging of cracks by rubber shreds, but specimens made with granular rubber particles broke into two pieces at the failure load.

CONCLUSIONS

The main aim of this study was to calculate the hardened and new properties of the concrete mixture which was formed after partial replacement of aggregate using a material gathered from an easily available local and waste recycled tire which was exposed to local weather conditions. Outcomes of test sample when compared with the respective properties of conventional concrete, the below mentioned conclusions were made:

- There was a significant increase in workability and slump when the recycled rubber tire was introduced with the mixture of concrete. It was noted that with increase in rubber percentage the slump is also equally increased in every tested sample.
- The outcomes also stated that when the 50% of the coarse aggregate volume was replaced with rubber aggregate in the tests sample 15M4, there was reduction of 22% in the unit weight. However, with 10% of replacement of rubber aggregate in 15M2 and 25% replacement of rubber aggregate in 15M3 showed a reduction of 4% and 10% respectively. In second sample category M20, for 10%, 25% and 50% replacement of rubber aggregate, resulted in a reduction of 5%, 8%, and 20% unit weight respectively. In M25 the third sample of the study, with 10%, 25% and 50% replacement of aggregate with rubber resulted in reduction of 4%, 6% and 16% unit weigh respectively. Hence it can be said that by using rubber material in the concrete cement results in a decrease in concrete weight.

- For rubberized concrete, the final output depicted that by adding the rubber aggregate, decreases the complete compressive strength of the concrete as compared to the control concrete. With the increase in rubber aggregate percentage, there is an equal decrease in strength. The compressive strength loss of 8% (15M2), 13.79% (20M2), 18.64% (25M2) is noted when 10% rubber aggregate was used in the total volume. The observed losses of strength when 25 % of coarse aggregate was replaced by rubber aggregate were 28.66 % (15M3), 28%(20M3), 35.5%(25M3). Loss of 53.79% (15M4), 62.81% (20M4), 58.46% (25M4) were noticed when the 50% of rubber aggregate was replaced in the total sample concrete. However the value of compressive strength decreases considerably when pieces of waste tire was added, its values still lie in an acceptable range for 10% and 25% of replacement values as the required values of compressive strengths: 15Mpa, 25 Mpa, 30 Mpa, and 40 Mpa are achieved.
- According to the results, when compared with the 10% rubber aggregate control mix for the lower strength of concrete classes that is 15M2, 20M2 there was an increase in flexural strength. In these concrete classes, with mixing of 25% and 50% rubber aggregate with the content a reduction in flexural strength was noted when matched with the properties of control concrete mix. It shows that flexural strength will only increase when there is only small amount of rubber content mixed with the concrete. Whereas for M25 mix, the flexural strength is reduced as observed in all samples of concrete mixed with rubber parts. For 10%, 25% and 50% of the mixed content of rubber there was 7.48%, 22.83% and 48.03% loss respectively when observed in M25. Hence it can be said that with the increase in rubber content in the mix, there is a reduction in relative flexural strength whereas an increase in medium and high strength compressive values in the concrete is observed. However, it can be viewed as an advantage as higher flexural strength is achieved by lowered concrete strength of class M15 and M20 and by fixing the value of replacement to 10% of the coarse aggregate only.
- There is a great increase in the impact resistance of any concrete by mixing the aggregates of rubber with concrete in lower amount of 10% or 25% as shown by the results. Hence, his feature of rubber concrete can be useful in those building that are normally exposed to impact loads and vibrations.
- The reduction in concrete's compressive strength because of the addition of rubber aggregates reduces its structural applications in some specific places. But, it also comes with various other properties like enhanced ductility, toughness resistance, higher impact, lower density, and higher flexural strength in concretes of lower strength.
- There also exist many advantages of using rubber elements from the recycled tyres. Which includes, introducing a different aggregate source to be mixed with concrete, reduced the nature threats to the environment caused with wastes rubber, improving the concrete properties by introducing different ingredient types in place of traditionally used aggregated which helps in preserving the natural resources to some extent. Along with coping with sustainability and recycling objectives, it also aims in producing materials with improved properties for some of the uses.

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