RUBBER AS A PARTIAL REPLACEMENT TO FINE AGGREGATE IN CONCRETE BY WASTE MATERIAL

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Abstract - *Worldwide production of tyre increases due to increase of automobile industry. The process to dispose the waste tyre is very cumbersome and hazardous to environment. Many times, it is used in landfill but availability and capacity of landfill spaces is a major problem. The basic material required in construction of buildings by using concrete are aggregate and cement. The aggregate production from stone quarries is also causing lot of damage. Hence the objective of this study is to introduce crumb rubber, in various proportions to replace sand content used in concrete mix. To improve of compressive strength varying percentage of glass fibre are added to the cement. The main goal of this research is to find means to dispose of the crumb rubber as replacement of the aggregates in cement concrete mix together with glass fibre and provide a final product with good engineering properties.*

Key Words: *Waste tyre crumb rubber in concrete, glass fibre, replacement of aggregates.*

1. INTRODUCTION

In recent decades, worldwide growth of automobile industry and increasing use of car as the main means of transport have tremendously boosted tire production. This has generated massive stockpiles of used tyres. In the early 1990s, extensive research projects were carried out on how to use used tyres in different applications. Scrap tyre is composed of ingredients that are no degradable in nature at ambient conditions. They usually produce environmental mal-effects. One of the methods for utilization of these materials is their use in concrete and other building products. From the macro-economic perspective, the following issues should be compared and evaluated when considering the application of such materials in the concrete:

1. Collection, processing and transport costs of scrap tyres.
2. Reduction in the environmental costs of land filling and increase in landfill voids.
3. Saving in the virgin materials used to make concrete, by substituting tyre rubber.

Rubber waste is a highly durable material and it is highly resistant to most natural environments. As a result, disposal of used tyres is a major concern as inappropriate disposal can lead to significantly environmental and aesthetic problems. This is especially true in developing countries, where environmental legislation is usually the only driving force behind the prudent management of used tyres. Following the implementation of various EU directives, reuse and material recovery are considered as the most environmentally viable ways for managing waste materials. Quantities of waste glass have been on the rise in recent years due to an increase in industrialization and the rapid improvement in the standard of living. Unfortunately, the majority of waste glass is not being recycled but rather abandoned, and is therefore the cause of certain serious problems such as the waste of natural resources and environmental pollution. The fibers of short length and small diameters can be used in concrete to convert its brittle nature to a ductile one.

1.1 OBJECTIVE

Using recycled tire rubber in cement concrete can provide an efficient way of utilizing rubber. In addition to environmental benefits, the use of tire rubber particles could provide a new type of concrete with unique mechanical and fracture characteristics. Although recycled tire rubber has been widely used in highway asphalt, there are limited studies on its application in cement concrete. Some experimental work to examine the strength and toughness properties of rubberized Portland cement concrete.

While concrete containing rubber did not exhibit brittle failure under compression or split tension, their results indicate that there was always a reduction in the compressive strength when aggregates were replaced by rubber. Some studies also show that by replacing a portion of aggregates with fine crumb rubber and tire chips, the compressive strength of the concrete was decreased, while its toughness and ability to absorb fracture energy was significantly enhanced.

Mechanical properties of concrete containing tire rubber particles have been investigated in many studies. Although the strength of rubber-filled concrete was reduced, all of these studies showed that adding waste tire rubber to traditional concrete could result in an increase in the deformability and ductility of rubberized concrete members. Therefore, due to the higher toughness, the waste tire rubber-filled concrete is expected to have higher fracture and cracking resistance.

The objective of this study is to introduce crumb rubber, in various proportions which is replaced by sand content used in concrete mix. For the improvement of compressive strength percentage addition of glass fiber to the weight of cement is to be attempt.

The main goal of this research is to find means to dispose of the crumb rubber by placement of the rubber in Portland cement concrete mix and still provide a final product with good engineering properties for certain specified engineering applications.

1.2 MATERIALS

CRUMB RUBBER (CR):- Crumb rubber (CR) is a commodity made by re-processing (shredding) disposed automobile tyres. Shredding waste tyres and removing steel debris found in steel-belted tyres generates crumb rubber. There are three mechanical methods used to shred apart these tyres to CR: the cracker mill, granulator, and micro mill methods. CR can also be manufactured through the cryogenation method; this method involves fracturing the rubber after reducing the temperature with liquid nitrogen. CR is fine rubber particles ranging in size from 0.075-mm to no more than 4.75-mm. In the concrete mix, CR constitutes a portion of the aggregate in the concrete mix.

1.3 CLASSIFICATION OF THE SCRAP TYRES

Tyres may be divided into two types: car and truck tires. Car tires are different from truck tyres with regard to constituent materials, especially natural and synthetic rubber contents

Table 1 - Typical constituent materials of tyres.

Composition weight (%)	Car tyre	Truck tyre
Natural rubber	14	27
Synthetic rubber	27	14
Black carbon	28	28
Fabric, filler accelerators, and Antiozonants	16-17	16-17
Steel	14-15	14-15

Rubber processing & shaping

1 Production of rubber goods consisting of two basics steps
- Production of rubber itself
- Processing into finished goods

2 Production of Natural Rubber
3 Recovering the Rubber
4 Grades of Natural Rubber
5 Synthetic Rubber
6 Compounding

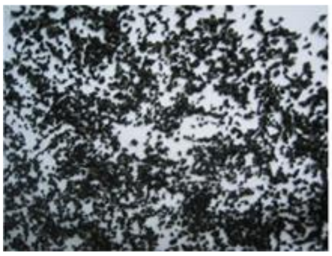
Fig. 1 crumb Rubber


Fig. 2 Glass fibres

Glass fibres: On a specific strength (i.e. strength to weight) basis, glass fibre is one of the strongest and most commonly used structural materials. There are several types of glass fibre with different chemical compositions providing the specific physical/chemical properties. The glass fibre used in this study has following properties as provided by the supplier.

Table.2: Properties of Glass fibres

Length of fire(mm)	Diameter (μm)	Specific Gravity	Failure strain %	Elasticity (GPa)	Tensile strength (GPa)
6	12	2.6	3.0	80	2.5

2. LITERATURE SURVEY

The extensive literature review was carried out by referring standard journals, reference books and conference proceedings. In recent years, study of waste tyre crumb rubber filled concrete is important. Following literature survey relates to the study of different paper related to various aspects of rubber filled concrete. In following papers, the study related to the use of crumb rubber as a replacement for the aggregate to improve the mechanical, thermal and sound etc. properties of concrete are being studied. The major work carried out by different researchers is summarized below:

3.1.1 Camille A. Issa, George Salem (1) in 2013 have discussed in his paper as waste continues to accumulate and availability and capacity of landfill spaces diminish, agencies are increasing application and use of recycled materials such as crumb rubber from tires in construction. The basic building materials in concrete construction are primarily aggregate and cement. The educated use of recycled materials can result in reduced cost potentials and may enhance performance; however, not all recycled materials are well suited for concrete construction applications. The two main reasons for not utilizing a reclaimed material are (1) addition of material is a detriment to performance, and (2) excessive cost. In this study, the performance of recycled materials crumb rubber as valuable substitute for fine aggregates ranging from 0% to 100% in replacement of crushed sand in concrete mixes is investigated. An acceptable compressive strength was obtained with up to 25% by volume replacement of fine aggregates with crumb rubber.

3.1.2 Wang Her Yung a, Lin Chin Yung et.al (2) in his study used waste tire rubber as a recycled material and replaced part of the fine aggregate by waste tire rubber powder filtered through #30 and #50 sieves to produce self-compacting rubber concrete (SCRC). Part of the fine aggregate was replaced with waste tire rubber powder that had been passed through sieves at volume ratios of 5%, 10%, 15% and 20%, respectively, to produce cylinder specimens and obtain the optimal replacement value. Replacing part of the normal sand with waste tire rubber powder of different degrees of fineness at different ratios is discussed. The results showed that when 5% waste tire rubber powder that had been passed through a #50 sieve was added, the 91-day compressive strength was higher than the control group by 10%. Additionally, the shrinkage was higher with an increase in the amount of waste rubber, and reached its maximum at 20%. The ultrasonic pulse velocity decreased when more powder was added, and the 56-day electrical resistance exceeded 20 kX-cm and was increased with the addition of more powder. Meanwhile, both the ultrasonic pulse velocity and the electrical resistance were in a favorable linear relationship with the compressive strength. The addition of 5% waste tire rubber powder brought about a significant increase in anti-sulfate corrosion. Using waste tire rubber powder can enhance the durability of self-compacting rubber concrete.

3.1.3 Feng Liu, Guixuan Chen, Lijuan Li , Yongchan Guo (3) in his paper reported a study on impact resistant performance of rubber reinforced and rubber/steel-fiber reinforced concrete, which involved the use of selected rubber particles of 0.178 mm, 1.11 mm and 2 mm, and the steel fiber of 30 mm in length and 0.5% in volume fraction. The dynamic performance of the concrete containing the rubber particles with weight fraction of 5%, 10%, 15% and 20% were investigated under the impact loads of 0.2 MPa, 0.3 MPa, 0.4 MPa and 0.5 MPa, respectively. As a result, the stress– strain curves related to the rubber reinforced concrete under different impact loads were obtained and used to reflect the associated strain rate levels. Based on the investigation results, the influence of the strain rates, rubber sizes and rubber contents on the impact resistance of the rubber reinforced concretes were discussed. The methods of determining the parameters of improved Holmquist–Johnson–Cook constitutive model were presented, and the improved Holmquist–Johnson–Cook dynamic constitutive model was obtained. The constitutive model of rubber reinforced concrete was developed and the parameters at different strain rates were suggested correspondingly.

3.1.4 F. Pacheco-Torgal, Yining Ding et.al (4) has discussed on the volume of polymeric wastes like tyre rubber and polyethylene terephthalate bottles (PET) is increasing at a fast rate. An estimated 1000 million tyres reach the end of their useful lives every year and 5000 million more are expected to be discarded in a regular basis by the year 2030. Up to now a small part is recycled and millions of tyres are just stockpiled, landfilled or buried. As for PET bottles annual consumption represent more than 300,000 million units. The majority is just landfilled. This paper reviews research published on the performance of concrete containing tyre rubber and PET wastes. Furthermore, it discusses the effect of waste treatments, the size of waste particles and the waste replacement volume on the fresh and hardened properties of concrete.

3. SUMMARY

This study represents the effect of waste tyre crumb rubber particle of size passing through 1.18mm IS sieve and retained on 600 microns IS sieve used in concrete on compressive, flexural and split tensile strength. From the results obtained during investigation and based on literatures review following conclusions can be drawn:

- The NaOH treatment to the surface of rubber particle enhances the bonding between the rubber particle and cement paste.
- Higher content of waste tyre crumb rubber particle in concrete increases workability of concrete.
- Using waste tyre crumb rubber particle replaced to fine aggregate in concrete at 0.5 and 1.0%, It was observed that, there was no effect on compressive, flexural and split tensile strength of concrete when compare with similar normal concrete mix.
- Using waste tyre crumb rubber with 1.5 and 2.0% replacement to the fine aggregate in concrete slightly affects the mechanical properties concrete.
- The loss of strength due to use of crumb rubber at percentages 1.5% & 2% replaced to fine aggregate in concrete was recovered by addition of glass fiber at 0.4% & 0.5% respectively to the weight of cement, when compare with similar normal concrete mix.
- Higher content of waste tyre crumb rubber can produce the light weight concrete.
- Rubber particles with higher dimension in the concrete mix give a high tensile strength because of its natural elasticity.

Further investigation is necessary to improve the hardened properties of rubber filled concrete, to gain the loss strength due to the use of waste tyre crumb rubber at higher content in concrete mix. The use of crumb rubber in concrete mix is very much beneficial to environmental concern and to solve the problem related to disposal of waste tyre rubber throughout the world.

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