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# Mechanical Strength Of Concrete With Crumb And Shredded Tyre As Aggregate Replacement

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## ABSTRACT

**This paper presents a research into the mechanical strength of concrete with shredded tyre and crumb tyre as aggregate replacement. The materials used to make concrete for this experiment are coarse aggregate, cement, sand, shredded tyre, crumb tyre, potable water and Ordinary Portland Cement. A total of fifteen main mixtures were cast as solid bricks with 0% replacement as control then followed by 5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20% separately for both shred and crumb rubber materials. The compressive tests for the concrete cubes were carried out by applying a constant uniform pressure to the cubes of the concrete blocks until failure occurred. The results of the compressive test show that by replacing the aggregate by 2.5 % shredded tyre, the compressive strength increased by about 8.5% but at 5% replacement and beyond, the compressive strength decreased. For the Crumb tyre aggregates, the compressive strength decreased generally as the percentage replacement increased. Thus, crumb tyre is not advisable to be used as aggregate replacement due to its weak compressive strength. Shredded tyre could be used as replacement of aggregates in concrete production up to 2.5% replacement in order to help reduce the cost of concrete production arising from the increasing cost of cement, and reduce the volume of waste generated from unused tyres.**

**Keywords:** mechanical strength, shredded tyre, crumb tyre, compressive tests, concrete, aggregates.

## INTRODUCTION

Concrete is a synthetic construction material made by mixing of cement, fine aggregates, coarse aggregate and water in the proper proportions. Each of these components contribute to the strength their concrete possesses Gambhir, (2004). It is also a well known heterogeneous mix of cement, water and aggregates. But according to Akinwonmi, (2012), in its simplest form, concrete is a mixture of paste and aggregates. The admixtures may be added in concrete in order to enhance some of the properties desired specially. These materials are very expensive and have hindered the development of shelter and other infrastructural facilities in developing countries. The key to achieving a strong, durable concrete rests in the careful proportioning, mixing and compacting of the ingredients. Satish, et al (2011).

According to El-Gammal, et al (2010), recycled waste tyre rubber is a promising material in the construction industry due to its lightweight, elasticity, energy absorption, sound and heat insulating properties. Society finds it difficult to management waste-tyre rubber is because of its non biodegradable nature even after long-period of landfill treatment. However, recycling of waste tyre rubber to be used as aggregates is an alternative to reduce pollution and to reduce expenditures on cement.

In Ghana, a 50 kg bag of cement costs about 10 USD which is very expensive in the production of any concrete. Though, one of the safety priorities in the cement industries is to eliminate cement dust from the working environment since most of the activities result in the discharge of cement dust into the environment which cause environmental pollution, the production of cement is increasing annually and the possibility of this pollutant dusts remain great. The global production of Cement was about 1.3 billion tons in 1996 and while this figure increases yearly, it was gathered that the production of every ton of cement emits carbon dioxide to the tune of about one ton. Because of the significant contribution to the environmental pollution, and the high cost of Portland cement, we have to economize the use of cement by practically replacing cement with supplementary aggregate like the crump tire. Ganjian et al., (2009) in their study showed that crumb rubber is manufactured by special mills in which big rubbers change into smaller torn particles of different sizes of rubber which may be produced depending on the kind of mills used and the temperature generated. Siddique and Naik, (2004) shows that recycled waste-tire rubber has been used in different application, as a fuel for cement kiln, as feedstock for making carbon black, and as artificial reefs in marine environment, while according to Toutanji, (1996), it has also been used as a playground matt, erosion control, highway crash barriers, guard rail posts, noise barriers, and in asphalt pavement mixtures.

The objective of this research is to assess the mechanical strength of concrete with crump tyre and shredded tyre replacement as aggregates if could be used as replacement of aggregates in

concrete production in order to help reduce the cost of concrete production arising from the increasing cost of cement, and reduce the volume of waste generated from unused tyres.

## MATERIALS AND METHOD

### Sample preparation

The materials used to make concrete for this experiment are coarse aggregate, cement, sand, shredded and crumb tyres and potable water. The cement used was Ordinary Portland Cement. The coarse aggregate was selected from crushed stone, which is about 20 mm in size. Natural sand having a fineness modulus of 2.1 was used as fine aggregate. Chip rubber was produced by shredding automobile tyre by an apparatus to 50 – 100 mm in dimension. The wires were removed and later converted into small dimensions of about (10mm) by cutters. Crumb rubber was manufactured by special mills which change big rubbers into smaller torn particles. A total of fifteen main mixtures were cast as solid bricks with 0% replacement then followed by 5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20% separately for both shred and crumb rubber materials. Mixing was done manually, coarse aggregate, sand, rubber aggregate, cement, and water was added gradually and properly mixed until the mixture became homogenous. A shovel was used to mix the mixture to get the required workability. Steel moulds of dimensions 150x150x250 mm, were used for casting which was compacted manually. After 24 hours of casting, the specimens were soaked in water for curing until the age of testing which is 28 days.

### Compressive Test

The compressive tests for the concrete cubes were carried out at the Mechanical Engineering Department, University of Mines and Technology Tarkwa, Ghana in December 2012. Standard test procedures were used for the experiment. A constant uniform pressure was applied by the testing machine to the cubes of the concrete blocks until failure occurs. Cracks were initially noticed on the specimen and the cracks propagated until failure was finally observed when the cube no longer could resist the force applied to it without failure. Results of the experiment are shown on table.1

## RESULTS AND DISCUSSION

Table 1 Data from Compressive Test experiment

| % Replacement | Compressive Strength (MPa) Shredded Tyre | Compressive Strength (MPa) Crumb Tyre |
|---|---|---|
| 0 | 35.0 | 35.0 |
| 2.5 | 38.0 | 30.0 |
| 5 | 31.5 | 27.6 |
| 7.5 | 28.2 | 21.0 |
| 10 | 24.5 | 18.5 |
| 12.5 | 22.0 | 13.0 |
| 15 | 18.7 | 9.0 |
| 17.5 | 15.5 | 6.0 |
| 20 | 12.0 | 5.0 |

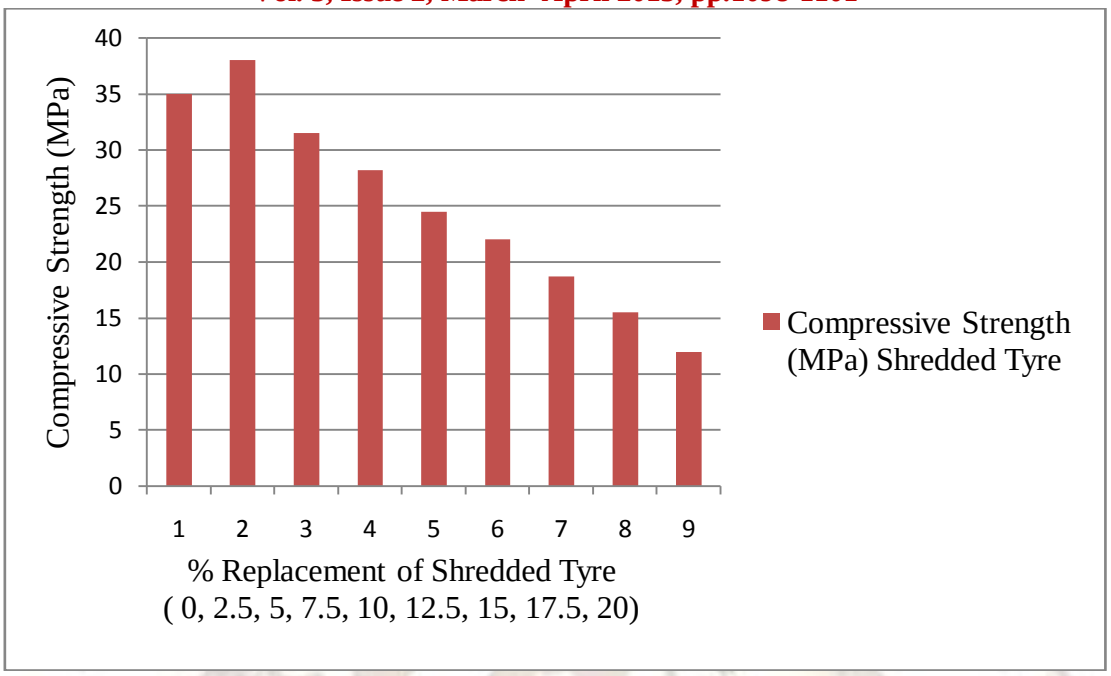


Fig.1 Graph of Compressive Strength against % Replacement of Shredded Tyre

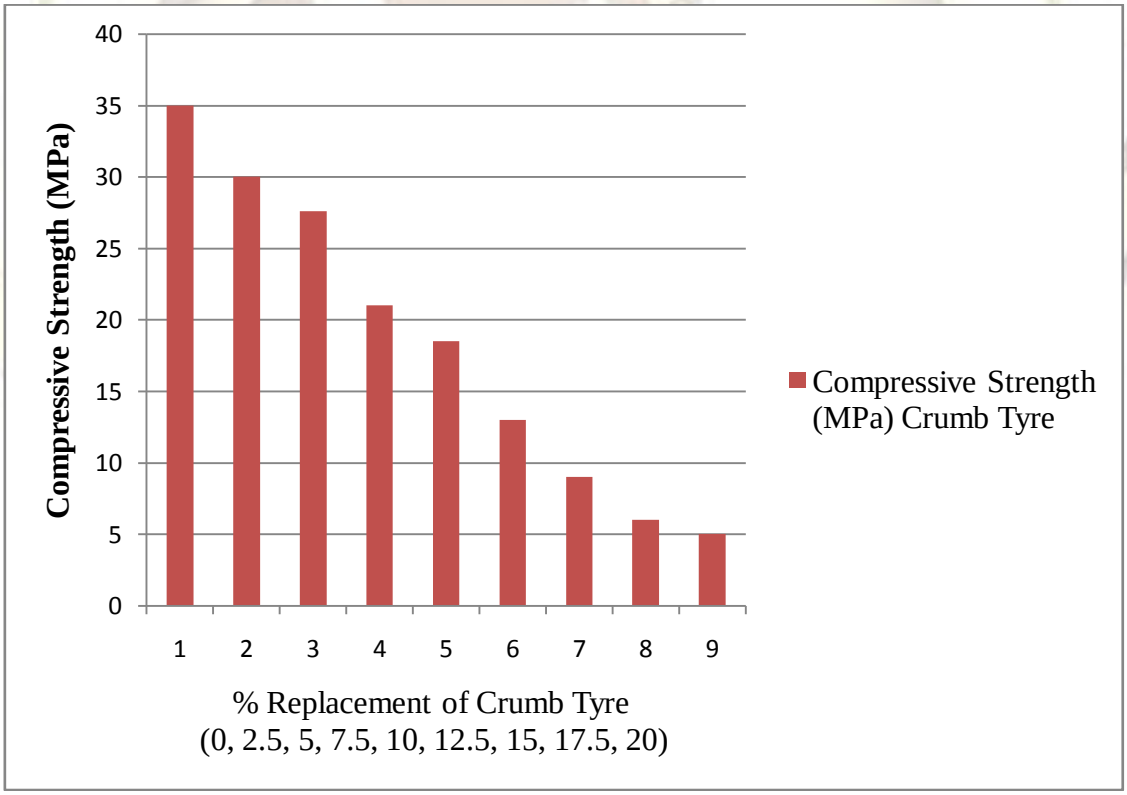


Fig. 2 Graph of Compressive Strength against % Replacement of Crumb Tyre

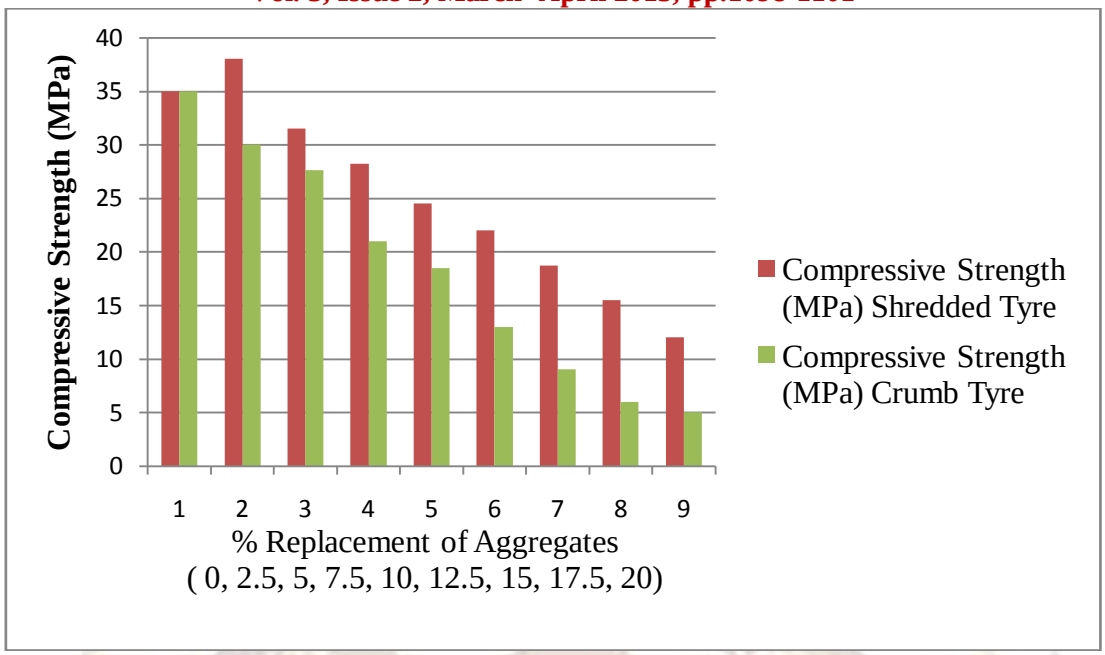


Fig.3 Graph of Compressive Strength against % Replacement of Aggregate

The result of the compressive test as presented in table 1and figures 1 to 3 show that by replacing the aggregate by 2.5 %, the compressive strength for the shredded tyre increased by about 8.5% but at 5% replacement and beyond, the compressive strength decreased. For the crumb tyre aggregates, the compressive strength decreased generally as the percentage replacement increased. This might be due to the powdery and elastic nature of rubber crumb and the weak boundary layers between the rubber and the cement aggregates. This means the size of aggregate and the percentage of aggregate replacement influence the strength of concrete produced. Optimum replacement of aggregate with shredded tyre was found to be 2.5%.

## CONCLUSION

In this study, a total of fifteen main mixtures were cast as solid bricks with 0% replacement then followed by 5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20% separately for both shredded and crumb tyre materials were tested for compressive strength.

The analysis of the experimental results showed that replacing 2.5% of coarse aggregate by shredded tyre slightly increased the compressive strength of the concrete but replacing more than 2.5%, reduces the concrete strength. Crumb tyre is not advisable to be used as aggregate replacement due to its weak compressive strength.

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