# SHREDDED TIRE AS PARTIAL AGGREGATE REPLACEMENT IN PRODUCING HIGH FLEXURAL HOLLOW SECTION BEAM

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## ABSTRACT

Nowadays, sustainable construction had gain wide attention in the engineering community. There are some standards developed to asses any environment impact of new construction projects. Refer to the research and study shown that is possible to use recycled materials to replace some material in concrete product. Rubber tire particles are recycled and currently use in concrete application. This study determines the use of rubber tire particles as partial coarse aggregate replacement for the mixture design of the concrete. There are three hollow section beams with different cavity sizes as specimens for this study to determine the effect of cavity sizes to the hollow section beam. There are three different cavity sizes for hollow section beam, 40mmx100mm, 50mmx100mm and 60mmx100mm. The process included of filling the concrete in the solid and hollow beam section formwork. The materials then undergo consolidation process. Then the sample are removed three day after from the formwork and transferred to the curing process. The beams cure for 28 days. The beam made with the rubber tire particles were testing for its flexural strength. The result showed that hollow section beam with cavity size 60mmx100mm had the higher flexural strength compare with all specimens. In conclusion, the bigger the cavity sizes for the hollow section beams, the higher the load-deflection ratio for the beam. Thus, the bigger the cavity sizes, the higher the flexural strength of the beam.

## ABSTRAK

Pada masa kini, pembinaan yang mampan telah mendapat banyak perhatian di dalam bidang kejuruteraan. Terdapat beberapa piawai dibangunkan untuk menilai sebarang kesan alam sekitar kepada projek pembinaan yang baru. Merujuk kepada beberapa kajian dan pembelajaran, menunjukkan bahawa ada kemungkinan barang yang boleh dikitar semula untuk menggantikan beberapa bahan dalam menghasilkan konkrit. Kini tayar getah dikitar semula dan digunakan dalam pembuatan konkrit. Projek ini dijalankan untuk mengenal pasti kegunaan tayar getah untuk menggantikan sebahagian daripada batu dalam campuran untuk menghasilkan konkrit. Terdapat tiga rasuk yang berongga dengan saiz rongga yang berbeza akan dikaji untuk mengenal pasti kesan saiz rongga terhadap rasuk. Tiga saiz rongga yang berbeza bagi rasuk dalam kajian ini adalah 40mmx100mm, 50mmx100mm dan 60mmx100mm. Proses adalah termasuk mengisi konkrit dalam acuan bagi rasuk biasa dan rasuk berongga. Kemudian campuran dalam acuan tersebut diratakan dan dipadatkan. Sampel rasuk tersebut dikeluarkan daripada acuan tiga hari selepas itu dari acuan dan dipindahkan bagi proses rawatan. Rasuk diawet selama 28 hari. Selepas itu, rasuk yang diperbuat daripada tayar getah itu akan menjalani uji kaji untuk kekuatan lenturannya. Daripada data yang diperolehi rasuk yang mempunyai saiz rongga 60mmx100mm mempunyai kekeuatan lenturan yang paling tinggi berbanding dengan semua spesimen yang lain. Kesimpulannya, semakin besar saiz rongga semakin tinggi nisbah beban-pesongan bagi rasuk yang berongga. Maka makin besar saiz rongga rasuk makin tinggi kekuatan lenturannya.

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| | Title |
|---|---|
| HB1 | Hollow section beam with cavity size 40mmx100mm |
| HB2 | Hollow section beam with cavity size 50mmx100mm |
| HB3 | Hollow section beam with cavity size 60mmx100mm |
| ASTM | American Society for testing and Materials |
| BS | British Standard |
| MR | Modulus of Rupture |

# CHAPTER 1

# INTRODUCTION

## 1.1 INTRODUCTION

Recently solid waste management gained a lot of attention. One of the solid wastes that had been concerned is waste tires as it is non-biodegradable (Malladi, 2004). Tire is non-biodegradable material cause to environmental problem and health risk. Tire can be used as a material with tolerable damping properties to reduce the structural vibration under impact effects due to it reversible elasticity properties (Siddique et al. 2204). Many researches have been done about automotive tire used as partial aggregate in concrete. It can both replace fine and course aggregate partially in concrete.

Other than that, compressive test show that by replacing the aggregate 2.5% shredded tire, the compressive strength increased by 8.5%, but decrease at 5% replacement (Akinwonmi et al. 2013). Thus, in this study only 2% of rubberized tires were used to replace course aggregate in cement concrete for hollow beam section. This beam with rubberized tires cement will be tested only for flexural strength.

In this study shredded used as partial aggregate replacement for hollow section beam production with different cavity sizes. Hollow beam section poses a load carrying capacity approximately equal to reinforced concrete beam (Falah M.Wegian and Falah A.Almottiri, 2007).

This study also carried out to determine the flexural strength of all specimens. Flexural strength is a test to measure the tensile strength of concrete. Flexural strength is expressed as Modulus of Rupture (MR). It can be measure using third point loading and one point loading method.

## 1.2 BACKGROUND OF STUDY

Waste tire needs to be recycled and manage well to reduce environmental problem. Usually, there are three categories of tires such as chipped or shredded tire, crumb and ground rubber. Chipped or shredded rubber is used to replace gravel. It has length of long and width of 100mm to 230mm. Meanwhile, crumb rubber is used to replace sand. It usually about 0.425mm to 0.475mm in dimension is used. Lastly, ground rubber is used to replace cement. Usually, 0.075mm to 0.475mm in dimension for the particles is used (Ganjian et al. 2008).

## 1.3 PROBLEM STATEMENT

Using shredded tire as an aggregate is very beneficial to lower environmental impact and economic cost to shatter the material. It is also can reduce the amount of landfill waste. Other than that, rubber tire particle is lighter than normal aggregate and significantly reduce self-weight of concrete. The mechanical properties and durability performances is comparable to conventional Portland Cement Concrete (PCC). Other than that, solid beam is heavier than hollow section beam. Thus, hollow section beam can help to reduce the quantity of concrete material used and reduce the beam weight itself. Thus, it also helps to reduce cost for the beam production.

## 1.4 OBJECTIVES

This research is to achieve all the objectives as listed below;

i. To determine the ultimate load for all specimens with different cavity sizes
ii. To determine the effects of cavity size for high flexural hollow section beam

## 1.5 SCOPE OF STUDY

This scope of study for this research followed as stated below;

i. Motorcycles tires are used collected from workshop at Gambang, Pahang area. The tires are cut into 20mm in dimension
ii. Only 2% replacement of shredded tires used as coarse aggregate in cement concrete by volume.
iii. There are four beams that conducted for this study. One is control beam and three hollow section beams.
iv. The dimension of hollow section that tested is 300mmx250mmx2000mm with different cavity sizes 100mmx40mm, 100mmx50mm and 100mmx60mm.
v. The steel bar size used for the beam was 16mm, link 8mm and cover was 25mm. The beam cures using wet gunny.
vi. Lastly, the beam will be tested for flexural strength only.

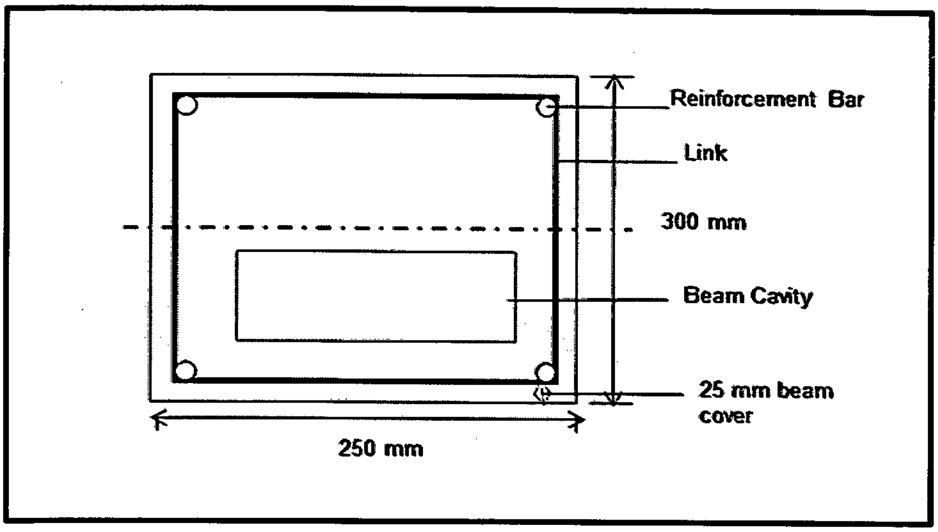



**Figure 1:1:** Cross-section for hollow section beam

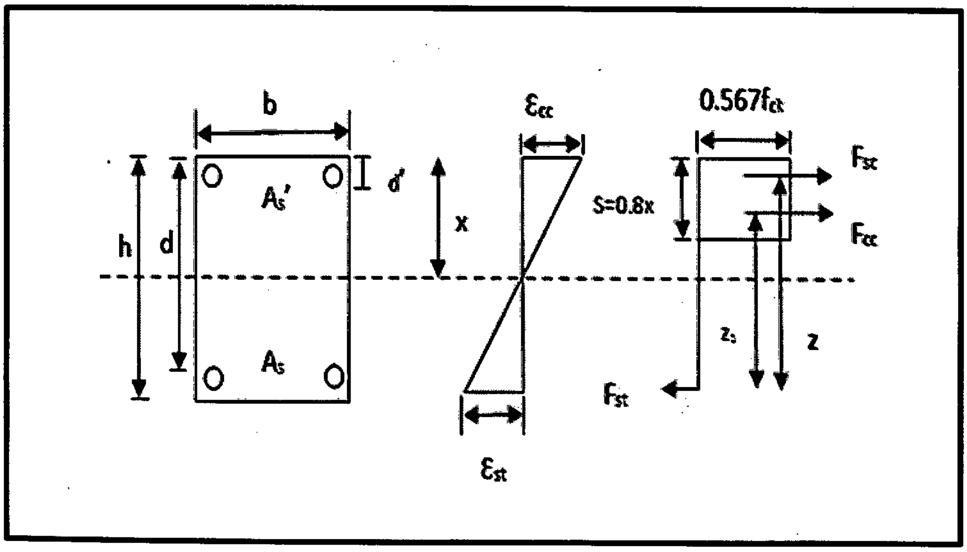



**Figure 1.2:** Stress block for hollow section beam

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

In this chapter, detail explanations about concrete, rubber tire as concrete aggregate replacement, concrete properties such as flexural strength and also factor that affect concrete strength were summarized.

Rubber tire potential as aggregate replacement already had been approved by many researches. It can be used to replace fine and also coarse aggregate in concrete production. Types of tire, sizes, surface textures and percentage replacement are important factor to be considered in order to produce better concrete by replacing aggregate using rubber tire.

Concrete is made of from Portland cement, aggregate and water. There are two types of aggregate, coarse aggregate and fine aggregate. Concrete properties are categories into chemical and mechanical properties. However, this research focus on the flexural strength as all the specimens tested only for flexural strength. Flexural test carried out in order to measure the flexural strength of beam. There are several factors that may affect concrete strength or properties such as curing day, curing methods and also water-cement ratio.

In a nutshell, rubber tire can be used to replace aggregate in producing concrete by study concrete properties itself in order to produce better concrete.

## 2.2 CONCRETE MATERIALS

Concrete is a synthetic construction material made by mixing cement, aggregate and water in the proper proportion. Portland cement is produced by mixing ground limestone, clay or shale, sand and iron ore. This mixture is heated in rotary kiln to temperature as high as 1600 degrees Celsius. Raw ingredients for cement are iron, ore, lime alumina and silica. Finer cements, with their higher surface area, are more reactive at early ages, producing the desired higher early-age strengths (Dale P. Bentz1 et al., 2008).

The aggregate size, shape and surface texture plays a vital role in the design and performance of concrete mixes. The aggregate size has a direct effect on the density, voids, strength and workability of the concrete mixes. It also influence the concrete mix properties such as powder content, air voids, stability and flow values durability of the concrete. Almost all the mix properties depend on the size and proportions of coarse and fine aggregate in the mix (B.Krishna Rao, 2010).

Properties of aggregate affect the durability and performance of concrete, so fine aggregate is an essential component of concrete (Er. Lakhan Nagpal et al.,May 2013). The most commonly used fine aggregate is natural river or pit sand. Fine and coarse aggregate constitute about 75% of total volume. Therefore, it is important to obtain right type and good quality aggregate at site, because the aggregate form the main matrix of concrete or mortar.

Almost any natural water that is drinkable and has no pronounced taste or odor may be used as mixing water for concrete. According to Steinour HH (1960), the principal considerations on the quality of mixing water are those related to the effect on workability, strength and durability.

## 2.3 CONCRETE PROPERTIES

### 2.3.1 Flexural Strength

Flexural strength is one measure of the tensile strength of concrete. The tensile strength of concrete plays a fundamental role in the fracture mechanism of hardened concrete (Guang Li, 2004). Flexural strength is expressed as Modulus of Rupture (MR) and determined by standard test methods ASTM C 78 (third point loading) or ASTM C 293 (center point loading). Center point loading applied in this study. Flexural MR is about 10% to 20% of the compressive strength depending on size, type and volume of coarse aggregate used.

There is some purpose to determine flexural strength such as designer of pavements use a theory based on flexural strength. Therefore, laboratory mix design based on flexural strength test may be required. Besides that, MR is used as field control and acceptance of pavement. There are very few use flexural testing for structural concrete

To undergo the flexural testing, beam specimens must be properly made in the field or laboratory. It needs to consolidate by vibration and cure well. Moreover, flexural tests are extremely sensitive to specimen preparation, handling and curing procedure. Beams are very heavy and can be damaged when handled and transport to the flexural test machine used.

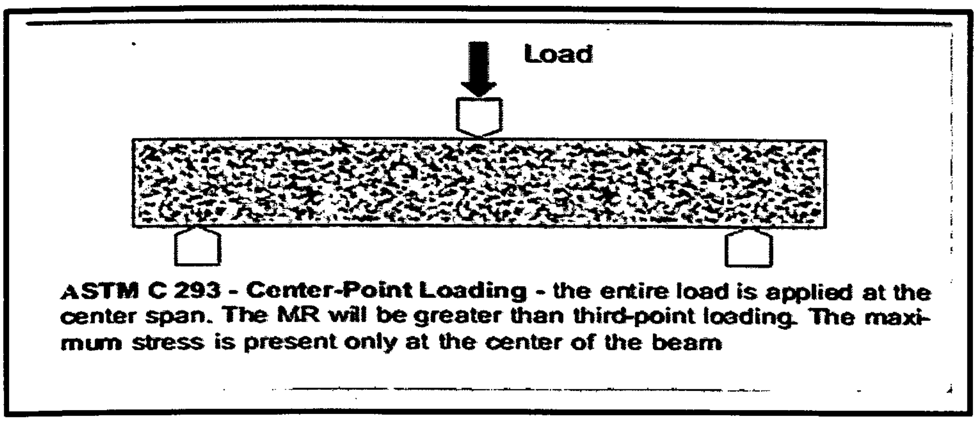



**Figure 2.1:** Center point loading test (W. Charles Greer, 1983)

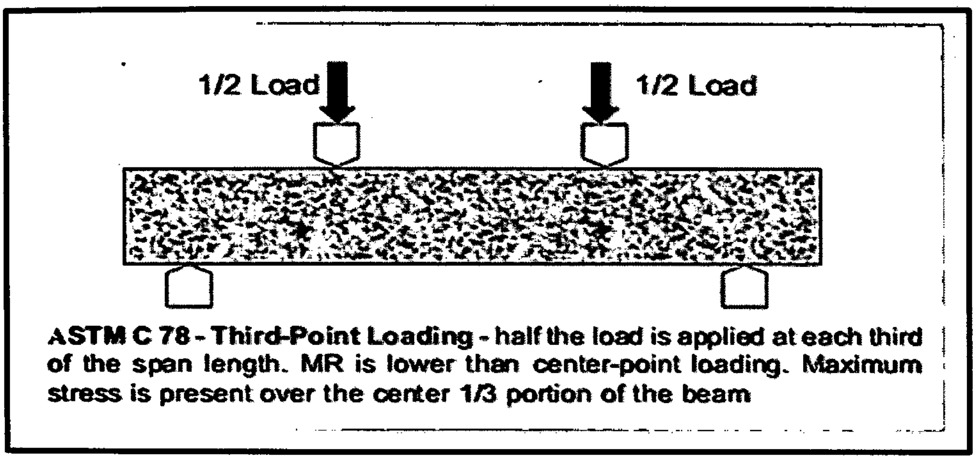



**Figure 2.2:** Third-point loading (W. Charles Greer, 1983)

## 2.4 FACTORS THAT AFFECT CONCRETE STRENGTH

### 2.4.1 Water Curing

All concrete requires curing in order that cement hydration can proceed so as to allow for development of strength, durability and other mechanical characteristics. To obtain good concrete, the placing of an appropriate mix must be followed by curing in a suitable environment, especially during the early stages of hardening. According to Neville (1996), curing is the name given to procedures used for promoting hydration of cement, and consists of a control of temperature and moisture movement from and into the concrete. Curing can be achieved by keeping the concrete element completely saturated or as much saturated as possible until the water-filled spaces are substantially reduced by hydration products (Gowripalan et al., 1992).

### 2.4.2 Water Cement Ratio

Concrete moisture content influenced the concrete strength. When concrete bears load under special environmental conditions, such as high humidity or high temperature, the mechanical properties, the load transmission mechanisms, and the failure modes of the concrete may be much different, compared to the standard conditions specified in the various testing standards (Guang Li, 2004). The strength of concrete is affected partly by the relative proportion of cement and of the fine and coarse aggregates but the water-cement ratio is another important factor.

There is an optimum amount of water that will produce a concrete of maximum strength from a particular mix of fine and coarse aggregate and cement (Lafe, 1986). The workability of concrete also depends on the quality of water used. Greater shrinkage and a reduction in strength will occur when more water than the optimum amount is used (Omotola Alawode et al., 2011).

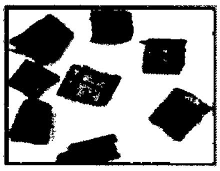
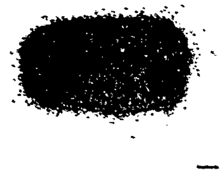
The best water-cement ratio, therefore, depends on the particular concrete mix. High-quality concrete is produced by lowering the water-cement ratio as much as possible without sacrificing the workability of fresh concrete. Generally, using less water produces a higher quality concrete provided the concrete is properly placed, consolidated, and cured

## 2.5 RUBBER TIRES IN CONCRETE PRODUCTION

### 2.5.1 Introduction to rubber tire

Chipped or shredded rubber is used to replace gravel. It has length of long and width of 100mm to 230mm. Meanwhile, crumb rubber is used to replace sand. It usually about 0.425mm to 0.475mm in dimension is used. Lastly, ground rubber is used to replace cement. Usually, 0.075mm to 0.475mm in dimension for the particles is used (Ganjian et al. 2008). Therefore, the tire used in this study was shredded tire with dimension of 20mm roughly. Plus, only 2% replacement of coarse aggregate by volume with shredded tire applied. Table 2.1 shows the three types of the tires and its properties.

**Table 2.1:** Type of rubber tires

| **Tires** |  |  |  |
|---|---|---|---|
| **Type of tires** | Chipped or shredded tire | Crumb rubber | Ground rubber |
| **Replacement** | Coarse aggregate | Fine aggregate | Cement |
| **Dimension** | 100mm to 200mm | 0.425mm to 0.475mm | 0.075mm to 0.475mm |

### 2.5.2 Rubber Tire as Aggregate Replacement

Rubber Manufacturer's Association in 2007 reported 89.3% of scrap tires were used in various ways in technology from research by (Jerry W. Isler, 1984). The research also stated that 13.5% increase in the amount of tires used in 2005. Tire is manufactured from natural and synthetic rubber that sometimes contains steel or fiber cords. At his research rubber tire particles used as fine aggregates. However, compressive test show that by replacing the aggregate 2.5% shredded tire, the compressive strength increased by 8.5%, but decrease at 5% replacement (Akinwonmi et al. 2013). 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.

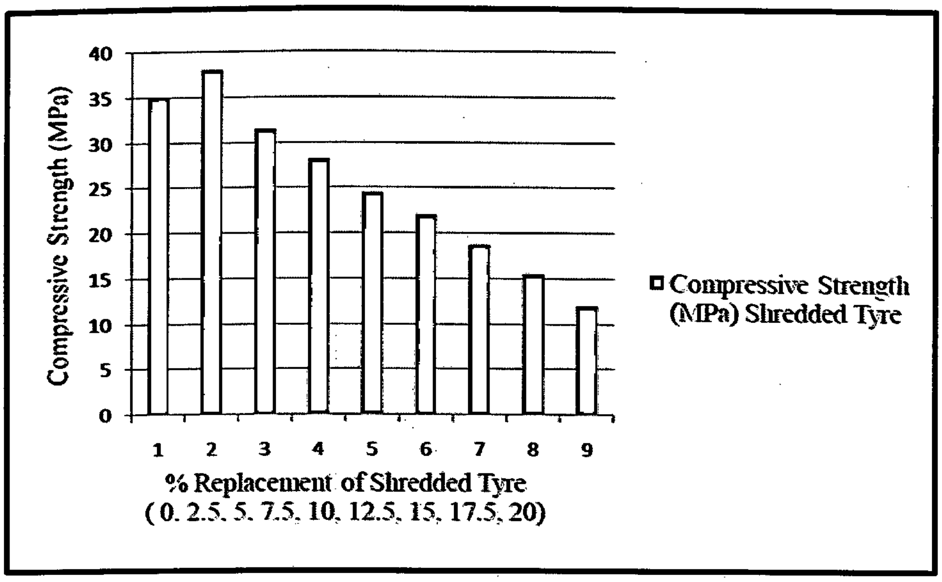



**Figure 2.3:** Compressive test vs % replacement of shredded tire (Akinwonmi et al., 2013)

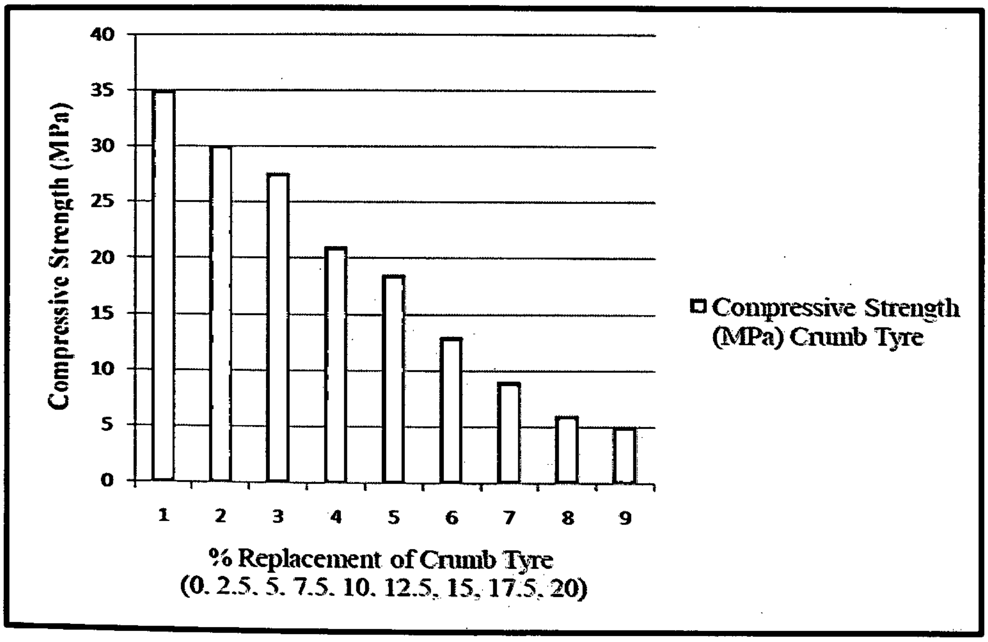



**Figure 2.4:** Compressive strength vs % replacement of crumb tire (Akinwonmi et al., 2013)

Both figures above show the compressive strength versus percentage replacement of shredded tire and crumb rubber by Akinwonmi et al (2013). Other than that, according to Khallo et al (2008), three different types of rubber particles used. The rubber particles used are tire chips, crumb rubber and combination of tire chips and crumb rubber. These particles were used to replace 12.5%, 25%, 37.5%, and 50% of the total mineral aggregate by volume. The results showed that the fresh rubberized concrete had lower unit weight and workability compared to the plain concrete. The result showed large reduction in strength and modulus of elasticity in concrete using combination of tire rubber chips and crumb rubber were used as compared with the rubber particle mixed individually.

Thus, Table 2.2 below shows some of researches that had been done using rubber tire particle as concrete aggregate replacement.

**Table 2.2:** Research gap of rubber tires particles as aggregate replacement

| No | Author | Title | Concrete Material | Replacement (%) | Test |
|---|---|---|---|---|---|
| 1 | Neil N.Eldin and Ahmed B.Senouci (1993) | Rubber-tire particles as concrete aggregate | Rubber-tire | 25 | Compressive strength, tensile strength |
| 2 | Boi oshan Hwang, Guoqiang Li, Si-seng Pang and John Eggers ( 2004 ) | Investigation into waste tire-rubber filled concrete | Rubber-tire | 15 | Compressive strength and tensile strength |
| 3 | Adam John Kardos ( 2007) | Beneficial use of crumb rubber in concrete mixture | Crumb rubber | 10,20,30,40,50 | Compressive strength |
| 4 | Akinwonmi et al. (2013) | Mechanical strength of concrete with crumb and shredded tyre as aggregate replacement | Shredded and crumb rubber | 0,2.5,5,7.5, 10,12.5,15, 17.5,20 | Compressive strength |