Penerbit Akademia Baru

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 4, No.1. Pages 12-18, 2014

# The Use of Rubber Manufacturing Waste as Concrete Additive

*N. F. Isa[a], M. F. Mohammad Zaki[*,b], L. Ahmad Sofri[c], M. Abdul Rahim[d], Z. Md Ghazaly[e], and N. Bidin[f]*

Faculty of Engineering Technology, Universiti Malaysia Perlis, 02100, Perlis,Malaysia
[a]*nurfitriah@unimap.edu.my*, [b]*faizzaki@unimap.edu.my*, [c]*liyanasofri@unimap.edu.my*, [d]*mustaqqim@unimap.edu.my*, [e]*zuhayr@unimap.edu.my*, [f]*nornajihah@unimap.edu.my*

**Abstract** – *The enormous quantity of vehicle nowadays, to some extent, undermined the environment. Increasing the number of cars indirectly produce high volume of waste tires. The presence of waste tires is a major factor that contributes to the risk of breeding places for mosquitoes, while burning tires will cause air pollution. To minimize this problem from becoming more serious, many alternatives have been implemented recently, such as the application of waste tire as a construction material. The main concept is to reduce air pollution and to produce concrete that is environmentally friendly and practical for the construction industry. Based on these objectives, this study was conducted to determine whether rubber tires can act as a concrete additive. Pieces of waste tire replaced the aggregate in the concrete mix design. The size of the tire rubber was in the range between 10 – 20 mm. The mixture of coarse aggregate replacement percentages of rubber tires by weight were 1%, 3 % and 5%. Concrete curing methods consist of wet and dry methods. All of the samples were preserved for 28 days. The results were then compared with the control concrete of mix rubber tires. Based on the research finding, rubber concrete mix has higher workability compared to control concrete mix. However, the compressive strength of rubber concrete mix is slightly lower than control concrete mix, but it is still acceptably strong. The analysis of the experimental results showed that replacing 2.5% of coarse aggregates by shredded tire increased the compressive strength of the concrete slightly but replacing more than 2.5% of coarse aggregates reduces the concrete strength.* 

**Keywords:** Tire rubber waste, Concrete, Aggregate

## 1.0 INTRODUCTION

Modern architectural and construction planning will remain as a plan if concrete construction material does not exist. Concrete is very useful and flexible to be poured in formwork. Since its set, the rigidity and strength of concrete become priority. This is because concrete functions by carrying a loading from dead load and live load. Concrete mix consists of cement, sand and coarse aggregate. Recently, concrete use is becoming prevalent in line with economic growth. Aggregate is the one of the most important components used in the manufacture of concrete. To protect natural resources, the use of aggregate in concrete production can be reduced by using alternative material either recycled or discarded waste. The number of waste tire rubber generated annually in the country was estimated to be 8.2 million or approximately 57,391 tonnes. About 60% of the rubber tires waste is disposed via unknown routes [1]. Advances in the automotive industry have contributed to a large amount of waste tire disposal [2].

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 4, No.1. Pages 12-18, 2014

The use of recycled materials generated from the transportation, industrial, municipal and mining process in transportation facilities is an important issue. The growing amount of solid waste can be reduced by making solid waste as an additive in concrete. Focus on the replacement of waste in concrete mix is an advantage because it has a potential to replace coarse aggregate. The effects of waste material must be considered before being mixed in concrete. This is because the effect will influence the strength and durability in a long-term condition. The use of waste tire rubber has been proposed as an additive in concrete mix to replace aggregate for high resilience against the required strength [3]. Khorami [4] studied the mechanical properties of concrete with waste tire rubber as coarse aggregates. They focused on the influence of using waste tire rubber as a replacement for coarse aggregate according to the percentage weight of aggregates used. According to Aiello and Leuzzi [6], the workability of concrete was slightly affected when rubber shreds were used as the partial substitution of coarse or fine aggregate. In this research, waste tire rubber was cut into 10-20 mm in size, while the maximum size for coarse aggregates was 25 mm. Rubber tire aggregates were replaced by weight in percentage. The percentages were 5, 7.5, and 10%. The cube mould size used for this research was 150x150x150 mm. After casting for 24 h, the samples were kept for curing for 28 days. The compressive test was done after 28 days. When rubber aggregates replaced natural aggregates at various replacement levels, gradual reduction in density could also be observed according to the research carried out by Wang et Al. [7] and Xue and Shinozuka [8].

## 2.0 METHODOLOGY

Concrete mixtures produced by adding a mixture of rubber have different values of compressive strength compared to concrete without rubber mixture. Determining the appropriate materials and standards is a key step prior to concrete mixing. Among the materials needed to produce a concrete mix are cement, coarse aggregate, fine aggregate, rubber tire aggregate, and water. Ordinary Portland cement was used as the cement. Ordinary Portland cement is used in Malaysia and must meet the requirements of BS 1881 (British Institution, 1983). Coarse aggregate used in this study were aggregates with a maximum size of 19 mm. The rubber tire aggregate was cut to the size between 10-20 mm.

The methodology starts with the collection rubber waste as a raw material. Several testing have been conducted to test the strength and durability of the concrete, and the types of tests conducted include slump test, vibration test, compression test and density test. The type of cement used in this study was Portland cement (CEM1). Clinker range of 95-100 % shows a large amount of components in all types of cement and other constituents in determining the amount of cement. Water-cement ratio used in this study was set to 0.5 for all samples for consistency and measured by the weight of water to solidify. Too much water-cement ratio will make the concrete weak and not durable. Water-cement ratio was determined by taking the weight of the water divided by the weight of cement. Lower water-cement ratio will increase the concrete strength. Waste tire rubber is a material used to replace coarse aggregate in this experiment. Waste tire rubber was cut with a hacksaw into pieces measuring 10-20 mm as shown in Figure 1.

**Figure 1**: Preparation of rubber waste sample

Concrete mix designs must be taken into consideration in order to produce quality concrete. The ratio stipulated in the concrete mix is 1:2:4 by weight. A design based on the weight ratio was used to provide equality between aggregate gross weight and the weight of the tire rubber aggregate. The strength and durability of concrete depend on the materials and methods chosen with adequate mixing. By selecting the right mix proportion of concrete, the concrete workability can be achieved. Water-cement ratio adopted in this study was 0.5. The strength of the concrete mixing depends on water-cement ratio. To improve the quality of concrete workability, the water-cement ratio is reduced as much as possible. Mix designs for both groups are similar. A total of 3 samples were prepared in this experiment. For the mixing experiment, samples with rubber tire waste as a replacement for coarse aggregate were determined by weight method. The replacement was done with the addition of different percentages of 1, 3, and 5% by weight of rubber waste.

**Table 1:** Percent replacement of coarse aggregates

| **Samples** | **A** | **B** | **C** | **D** |
|---|---|---|---|---|
| **Percent replacement of coarse aggregates by mass (%)** | 0 | 1 | 3 | 5 |

Wet curing and dry curing approaches were applied for the test. The curing period of this experiment was set up for 28 days. All of the tests procedures are based on established procedures. Four tests were involved, including slump test, vibration test, compression test and density test. The cube sample without the addition of rubber waste acted as a control sample. Sources of error in the sample preparation method including incomplete sample tamping, over vibration, and error in the calibration tests which may result in incorrect application of pressure have been reduced by increasing the number of tests taken to achieve consistent data, thus increasing the accuracy and validity of the test results.

## 3.0 RESULTS AND DISCUSSION

### 3.1 Slump test

Slump test is important to check the workability of concrete. The overall test results are shown in Table 2 below.

**Table 2:** Results of slump test

| Samples | Percentage replacement of coarse aggregates by mass (%) | Slump (mm) |
|---|---|---|
| A | 0 | 70 |
| B | 1 | 70 |
| C | 3 | 75 |
| D | 5 | 75 |

Based on this result, the increase in percentages of tire rubber affects the workability of concrete. This is because of the rubber tires have poor interlocking action between cement and waste tire. Hence, concrete flow easily and its workability is increased compared to the control concrete.

### 3.2 Vibration test

Tests were carried out based on standard BS 1881 Part 104: 1983. The results of the slump test can indicate whether the wet concrete has good workability or not. However, slump test has rather limited use. Usually, reduction is small or zero based on the standard concrete work. The values obtained from the vibration test method are shown in Table 3 below.

From the results of vibration test method, it is shown that there is an increase in the time taken for the concrete to pack in the mould. The research shows that the longer the time taken, the quality of concrete work is lower.

**Table 3:** Vibration test result

| Samples | Percentage replacement of coarse aggregates by mass (%) | Vibration time (s) |
|---|---|---|
| A | 0 | 5 |
| B | 1 | 5 |
| C | 3 | 6 |
| D | 5 | 6 |

### 3.3 Compression test

In this test, a concrete cube of 150x150x150 mm size was used as a compression test cube. The standards of MS EN 12390; 2012 are complied with, which stipulate that the concrete must be filled by three layers in the mould. Figure 2 illustrates the different strength of concrete in terms of strength of concrete and control concrete with additives from the test result after 28 days.

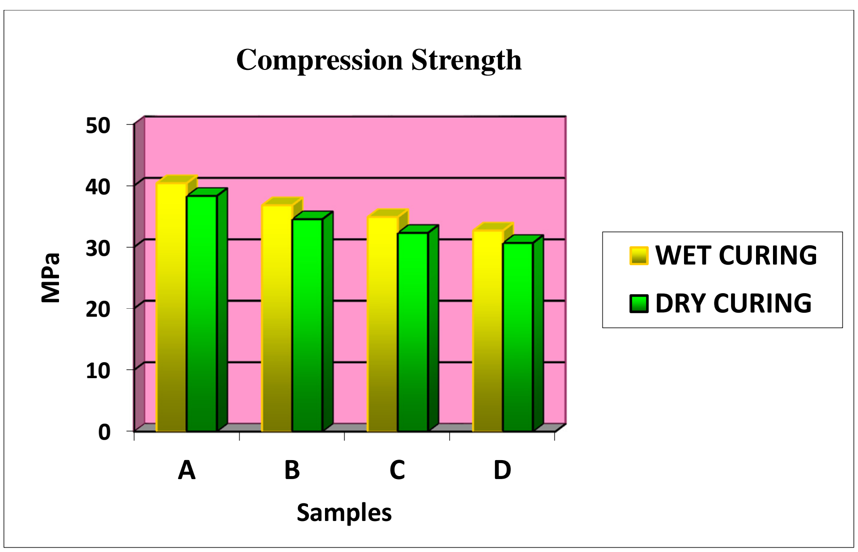


**Figure 2:** Wet and dry curing compression test chart

Wet curing and dry curing affect the strength of concrete in compressive strength. This is reflected by the difference between the compressive strength of wet curing and dry curing. Wet curing produces high strength compared to dry curing. The compressive strength of wet curing is higher as the concrete is affected by water. The water pressure at the surface of wet concrete curing makes the bond stronger. The dry-cured concrete is characteristically brittle because of the exposure to the changing weather. The water in wet concrete curing also lost due to the evaporation that occurred in the concrete cube. Lack of water will affect the compressive strength of concrete. Thus, wet concrete curing is better than dry concrete curing.

## 4.0 CONCLUSION

In this study, the result and analysis show that when rubber tire is added to the concrete mix with increasing percentage, the workability of concrete is increased up to a certain level, which is by 2.5% addition. Further increase in the percentage of rubber tire in the concrete mix will lower the workability of concrete.

Among the reasons for the reduction of compressive strength is due to the increased use of rubber tire aggregates that affect adhesion deficiency in the concrete mix, and soft rubber particles act as voids in the concrete. Rubber tire aggregates are more likely to fill in the pores of concrete mix, which reduces the compression of the concrete. However, the concrete mixtures for 1%, 3% and 5% are still acceptable because they had exceeded 30 MPa in this experiment. The compressive strength of the concrete rubber tire has lower strength compared to the control concrete, but the strength is acceptably strong. The analysis of the experimental results showed that replacing 2.5% of coarse aggregate by shredded tire increased the compressive strength of the concrete slightly but replacing more than 2.5% of coarse aggregate reduces the concrete strength.

## REFERENCES

[1] S.K. Thiruvangodan, Waste tyre management in Malaysia, Degree thesis, Universiti Putra Malaysia, Serdang Selangor (2006).

[2] K. Fukumori, M. Matsushita, Material recycling technology of cross linked rubber waste, R&D review of Toyota CRD2 38 (2002) 39-40.

[3] M. Sidney, J.F. Young, D. David, Concrete, second ed., Practice Hall, New Jersey (2003).

[4] M. Khorami, E. Ganjian, A. Vafaii, Mechanical properties of concrete with waste tire rubbers as coarse aggregate, Islamic University Branch Eslamshahr, Building and Housing Research Center, Tehran, Iran (2009).

[5] British Standard Institution (BSI), BS 1881-104:1983: Vibration test method, BSI, London (1983).

[6] M.A. Aiello, F. Leuzzi, Waste tyre rubberized concrete: properties at fresh and hardened state, Waste Manage 30 (2010) 1699-1704.

Journal of Advanced Research in Applied Mechanics
ISSN (online): 2289-7895 | Vol. 4, No.1. Pages 12-18, 2014

[7] H.Y. Wang, B.T. Chen, Y.W. Wu, A study of the fresh properties of controlled low-strength rubber lightweight aggregate concrete (CLSRLC), Construction Building Materials, 41 (2013) 526-531.

[8] J. Xue, M. Shinozuka, Rubberized concrete: a green structural material with enhanced energy-dissipation capability, Construction Building Materials 42 (2013) 196-204.