© 2017 IJSRSET | Volume 3 | Issue 1 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Replacing Fine Aggregate with Tire Rubber Pre-Treated In Sodium Hydroxide

Mwaya Temina Sendwa, Mohd Nizam Shakimon

Department of Civil Engineering, Infrastructure University Kuala Lumpur Malaysia

ABSTRACT

There is lack of appropriate discarding of tire rubbers in many countries around the world and this has greatly affected the environment. Many tires are left in damp sites and later pile up causing landfills. The tires are usually burnt and this causes them to release a lot of gases like carbon monoxide leading to air pollution. Apart from that the damp sites cause a breeding site for mosquitoes and rats that can spread diseases to the people in the community. One of the ways in which the tires can be disposed of without destroying the environment can be using them in the partial replacement of aggregate in concrete. Previous researchers have shown that rubber tire aggregate can be added to concrete for structural constructions mainly for rigid pavements. Other uses include partition walls, concrete blocks for architectural applications, culverts, sidewalks, driveways and some road construction applications. This paper studies different volumes of crumb rubber (0%,5%,10%,15% and 20%) being partially replaced as fine aggregate. It investigates how using crumb rubber that is pre-treated with sodium hydroxide (NAOH) in concrete will be able to minimize the loss of flexural, compressive and split tensile strength tests as well as improve the bond between crumb rubbers and cement paste. Different experiments will be carried out to hardened properties of rubberized concrete.

Keywords : Rubberized Concrete, Compressive, Flexural, Crumb Rubber, Split Tensile

I. INTRODUCTION

Most countries in the world today are focusing on finding solutions in which they can eradicate global warming. They are focusing on ideas of sustainability and many technologies that can minimize the damage of nature. Research has shown that the construction industry has contributed to some of the damage of the environment due to the high volume of garbage it produces. Recycling of waste is a possible alternative way of preserving nature. Despite the negative way the construction industry has affected nature in the past, it is a promising sector that can make use of recycled waste materials.

Large portion of solid waste around the world constitute of tire rubber. With the increased number of cars, the disposal of tires seems to have tripled over the years. Tires are non-biodegradable; hence they are burned and in certain countries are used as fuels which pose as a great threat to the health of people in different communities unless carefully considered. In order to reduce the environmental problems being caused by wrong disposal of tires, they can be used in concrete.

Most researchers have shown great interest in the use of tire rubber in concrete production. In the previous studies, it was observed that the size, surface texture and volume of the rubber particles have a great effect in the mechanical properties of the reformed concrete. Researchers have shown a significant decrease in unit weight, compressive strength and flexural strength of concrete as the percentage of rubber particles is increased. The low compressive strength are due to the weak bonding between the cement paste with the rubber particles as well as the low strength of the rubber particles used in replacing the high strength coarse or fine aggregates. The reduction of the properties mentioned above is greatly influenced by the percentage of rubber particles in the concrete. According to (Deshphade, Kulkari, & Gunde) it was stated that when rubber particles are added in cement paste (rubber particle had a size with maximum 500µm), NAOH solution was used in order to decrease hydrophobic nature of rubber surface. At first, the surface of rubber particles were modified by saturated NAOH solution for a few minutes. The rubber particles that were treated by NAOH show an improved bond with cement paste, indicating that there was also an improvement in flexural strength by this procedure.

II. LITERATURE REVIEW

(Khatib and Bayomy 1999) reported that increasing of the crumb rubber content in the mix resulted in a decrease in both the slump and the unit weight of the mixtures. Despite the decrease in measured slump, observation during mixing and casting showed that increasing the crumb content in the mix still produced a workable mix in comparison with the control mix. Despite the decrease in the unit weight of the mix (due to the lower unit weight of the rubber), the unit weight remained within the acceptable range for the total aggregate volume when up to 20% crumb rubber content was used studies have shown that there is an improved bond between cement paste and crumb rubber if the rubber particles have rougher surface or are pretreated. A better and improved bonding may develop with the surrounding matrix, and that may increase compressive strength. Pretreatments differ. Some include washing rubber particles with water to acid etching, plasma pretreatment, and various coupling agents. In acid pretreatment, rubber particles are soaked in an acid solution for a period of 5 minutes, and then rinsed with water. This improves the strength of concrete containing rubber particles through a microscopic increase in the surface texture of the rubber particles.

(Eldin & Senouci) soaked and thoroughly washed rubber aggregates with water to remove contaminants, while (Rostami, et al.) used water, water and carbon tetrachloride solvent, and water and a latex admixture cleaner. The outcome was 16% higher compressive strength compared to the control sample. Amongst the surface treatments tested to improve the hydrophilicity of the rubber surface, a sodium hydroxide (NaOH) solution gave the best outcome. The particles which were surface-treated with NaOH saturated aqueous solutions for 20 minutes, and later on, scanning electron microscopy(SEM), water absorption, density, flexural strength, compressive strength, abrasion resistance, modulus of elasticity and fracture energy measurements were performed using test specimens (w/c= 0.36) containing 10% of as-received or 10% of NaOH-treated rubber. The test results showed that the NaOH treatment improves the bond of tire rubber particles to cement paste, and mechanical properties such as flexural strength and fracture energy were improved with the use of tire rubber particles as addition instead of aggregate. The decrease in the compressive strength was significantly lower than that have been reported in the earlier literature.

III. MATERIALS AND INVESTIGATION

CEMENT: ordinary Portland cement was used M30 of 43 grade according to the British standards with the SP gravity of 3.15.

FINE AGGREGATE: the fine aggregate was river sand and was sieved to a size of 1.18mm with the SP gravity of 2.61 conforming to the British standards.

COARSE AGGREGATE: granite stone aggregates of size between 10mm-20mm were used with an SP gravity of 2.65 conforming to the British standards.

CRUMB RUBBER: Rubber aggregates are obtained by reducing of scrap tires to aggregate sizes using different general processing technologies. The two most used are mechanical grinding and cryogenic grinding. Mechanical grinding is the most common process. This method consists of using a variety of grinding techniques such as cracker mills and granulators to mechanically break down the rubber shred into small particle sizes ranging from several centimeters to fractions of a centimeter. The steel bead and wire mesh in the tires is magnetically separated from the crumb during the various stages. The size used in this experiment was between 1-3mm.

1. PREPARATION OF MATERIALS

To prepare the rubber, it was soaked in (NaOH) solution for 24hours at room temperature , and the rubber was then washed with tap water and dried at the ambient temperature before using. The purpose of this was to enhance the intermolecular interaction forces between crumb tire particles and increase the strengths of rubber concrete. The tires that were used where collected used tires of no specific age from a local company in Malaysia, KEDAH SDN BHD.

Crumb rubber achieved after different processes had a nominal size of 1mm. Some methods that can convert scrap tires to crumb rubber are cracker mill process and granular process. The cracker mill process tears apart or reduces the size of tire rubber by passing the material between rotating corrugated steel drums. The crumb rubber that was used in the concrete mix to partially substitute for fine aggregates (sand) in various percentages of 0%, 5%, 10%, 15% and 20%.

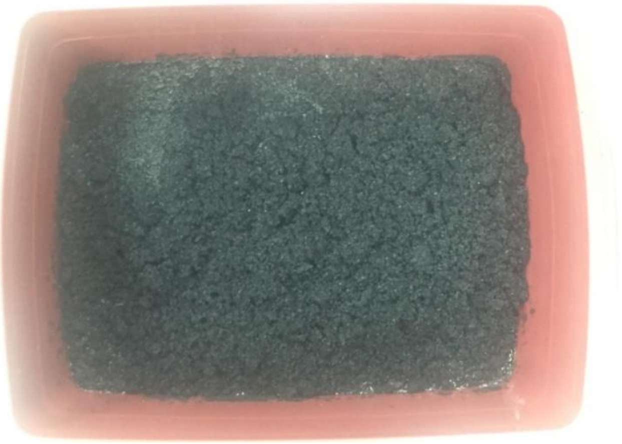

Figure 1: crumb rubber soaked in sodium hydroxide

2. Mix design

Concrete mix was designed as per guidelines BS (DOE method). All samples were prepared using design mix M30 grade of concrete.

Water	cement	Fine aggregate	Coarse aggregate
210 kg 0.5	420kg 1	619.5 kg 1.5	1150.5kg 2.74

Figure 2 : Mix proportioning

Control samples were also included so that the results can be compared. Once the mixing was done, the concrete was casted in cube moulds of 100mm× 100mm×100mm for compressive strength, beams of 100mm× 100mm×500mm for flexural strength and cylinders with 100mm diameter with a length of 200mm. A total of 60 cubes , 60 cylinders and 60 beams were used. Water cement ratio used was 0.5.

Figure 3 : mixing of concrete

After the concrete is dry they are labeled and later left to cure for different number of days. They are left for 7, 14 and 28 days.

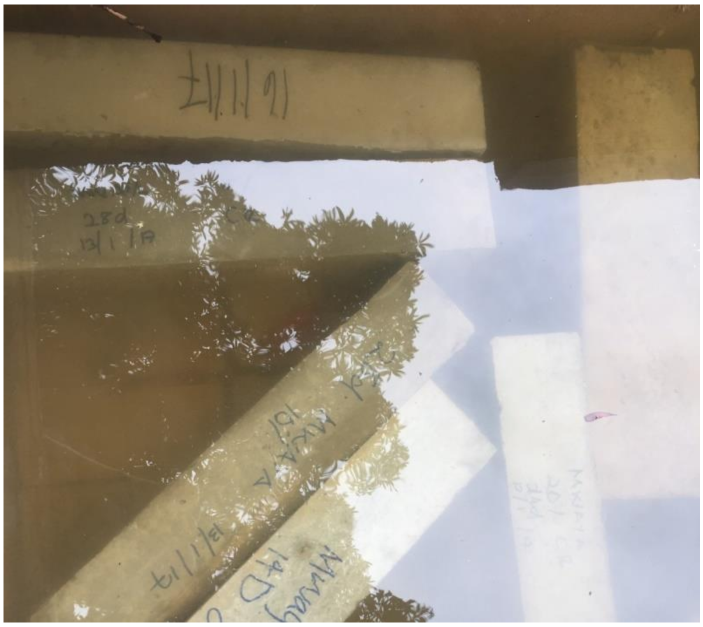

Figure 4 : Beams, cubes and cylinders curing

When all the samples were left to dry for the different days and were left to dry for 20minutes before the different tests were carried out. All the tests conformed to the British standards.

IV. RESULTS AND DISCUSSION

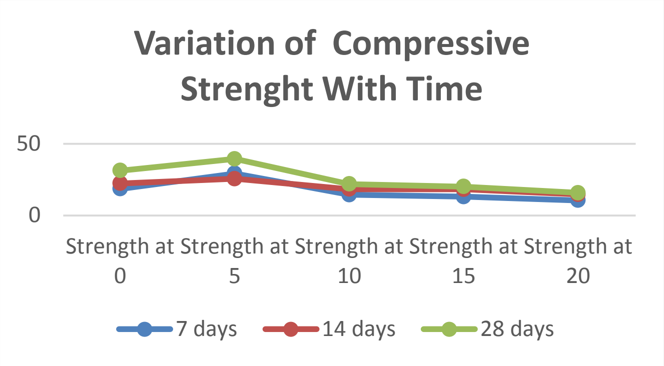

Figure 5: graph showing compressive results at different days

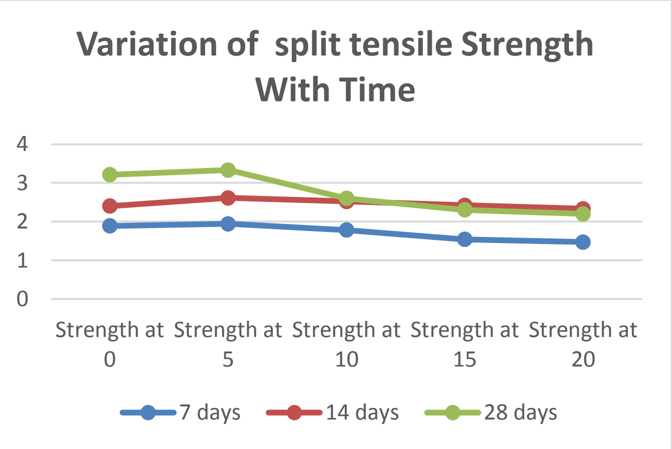

Figure 6: graph showing split tensile results at different days

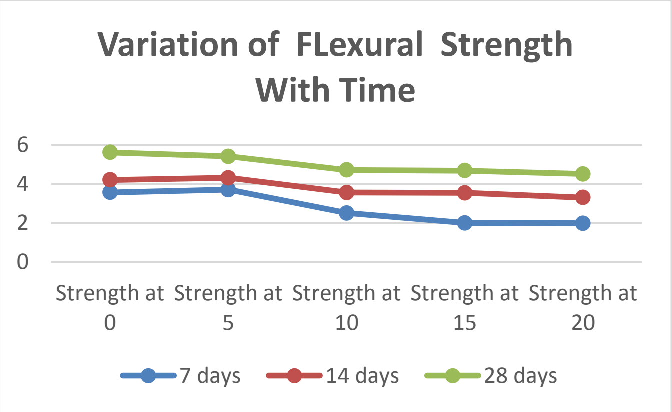

Figure 7: graph showing the results of flexural strength at different days

According to the graphs the results obtained show that compressive, split tensile and flexural strengths increased after adding 5% crumb rubber soaked in sodium hydroxide and reduced as the sodium kept on increasing. The results at 5% were slightly better than the control samples.

V. CONCLUSION

The aim of this paper was to improve the bond between cement paste and crumb rubber so that the hardened properties of concrete (compressive, split tensile and flexural strengths) can be improved. The conclusions are:

- The best results came from adding 5% crumb rubber soaked in sodium hydroxide. The results were better than the control sample. This goes to show that the sodium hydroxide improved the bond between the cement paste and crumb rubber at 5%. The use of NAOH can show a potential of crumb rubber being used in structural application when at least 5% soaked crumb rubber is used to partially replace fine aggregate.
- From the results were more than 5%, crumb rubber was partially replaced, it can be appropriate for architectural applications such as, interior construction, building earthquake shock wave absorbers, false façade baking.
- Rubberized concrete did not show brittle failure under compression or split tension loading. It showed that rubberized concrete is able to absorb a large amount of plastic energy
- Finally using tire rubber as partial replacement of fine aggregate will help to gradually reduce the amount of tires thrown in damp sites improving the environment.

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