COMPARISON OF RUBBER AS AGGREGATE AND RUBBER AS FILLER IN CONCRETE

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ABSTRACT

This research will attempt to use rubber waste (tire rubber) replacement of coarse aggregate to produce early age concrete. An experiment will carry out to determine the strength of early age concrete with rubber waste coarse aggregate to compare with the rubber waste as filler in concrete (with crushed stone coarse aggregate and sand fine aggregate).This research will carry out 2 difference type of concrete which are rubberized concrete and rubber filler in concrete. In rubberized concrete, rubbers were used to replace coarse aggregates and river sand as fine aggregate. Furthermore, in rubber filler in concrete, crushed stone was used as coarse aggregate and river sand as fine aggregate. Coarse aggregate usually gravel or crushed stone and shredded rubber as filler in concrete. The design strength of mixture concrete is 15 MPa for 7 days and water cement ratio are 0.4, 0.5, and 0.7. Lastly; the compression cube test will be test on 7 days. The properties of the aggregate will compared.

Keyword: *Rubber Waste Aggregate, Compressive Strength, Water – cement Ratio*

1. INTRODUCTION

Worldwide, the use of rubber products increases every year. In Malaysia, according to Summary of Monthly Rubber Statistics Malaysia September 2006, production of natural rubber (NR) in September 2006 was 113,209 tones, for the period January – September 2006; total production amounted to 966,519 tones. These numbers keep on increasing every year with the numbers of vehicles, as do the future problems relating to waste tires [Summary of Monthly Rubber Statistics Malaysia**,** 2006].

One application that could serve the recycle triumph and eliminate drawbacks is making rubberized concrete. Concrete can be made cheaper by replacing some of its fine and coarse aggregate with granulated rubber chips from old rubber tires. These granulated chips are achieved through a process called continuous shredding, which is necessary to create chips small enough to replace an aggregate as fine as sand. This would produce a type of concrete that is lightweight and durable, which could be used in applications where great strength is not necessary but resistance to cycles of expansion and contraction is needed.

This research will focus on the study of early age strength of concrete with recycle rubber. This study attempts to use tire rubber as an aggregate as a partial replacement of aggregate to produce rubberized concrete. By using rubber waste to produce lightweight concrete is expected to more durable, less expensive (low material cost and easy to manufacture) and absorb higher energy under impact.

2. EXPERIMENTAL PROGRAMME

This research will study the strength of concrete with rubber waste aggregate. This study attempts to use tire rubber as an aggregate as a partial replacement of aggregate to produce lightweight concrete. The principle target of the experimental was to determine the contribution of the waste rubber aggregate to the improvement of the strength behavior of the lightweight concrete. The experimental program also comprises the following:

a) To study the early age concrete with rubber waste aggregate and compare the respective properties with rubber filler in concrete.
b) To developed the strength of early age concrete with rubberized concrete with rubber filler in concrete.

3. RAW MATERIAL

3.1. Cement

'Blue Lion' brand type I Portland cement was used for the concrete mixes.Type I Portland cement is known as common or general purpose cement.

3.2 Coarse aggregate

Coarse aggregate usually gravel or crushed stone. The coarse aggregates are fed into vibrator sieved to get the required 14-20mm size. The sizes range from 14mm up to 20mm maximum size permitted for the job.

3.3 Fine aggregate

River sand as fine aggregate was used which consisted 600µm or less in size.

3.4 Rubber waste (Shredded rubber tire)

Old rubber tires from light vehicles, such as motorbike were used. The tires were cut by hand and a band saw obtained from the Materials school lab at University Malaysia Perlis. Tires from motorbike did not had smaller and fewer wires than those from car’s tire. They were cut into two types which are:

i. Type I – Use in rubber filler in concrete mix proportional I.
ii. Type II – Use in rubberized concrete mix proportional II.

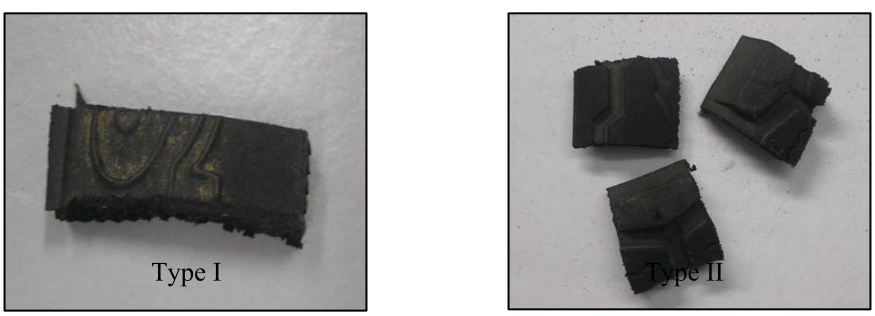

Figure 1: Types I shredded rubbers from rubber tires. (A) Type I -7 x 20mm; (B) Type II - 20 x 25mm

4. MIX PROPORTION

4.1 MIX PROPORTION (I)

The constituents used were divided into different fractions to determine the mix proportions that would yield the compressive strength at a test age of 7 days. The optimum mix proportions included the coarse aggregate, fine aggregate, cement, rubber waste and water to yield a cubic meter of concrete. Three concrete rubber waste samples as extra filler were designed by the volumetric method with different water-cement ratio (0.4, 0.5, and 0.7) and produced total of nine concrete rubber waste samples. Others three conventional concretes mixes were designed with crushed stone coarse aggregate with different water – cement ratio (0.4, 0.5, and 0.7) and produce total of nine samples. The mix proportions (I) of the samples shown in Table 1.

Table 1: The mix proportions (I) of the sample are presented**.**

Mix	Water/Cement Ratio	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Rubber Waste (g)
RF1	0.4	522	1218	7
RF2	0.5	809	1029	7
RF3	0.7	839	1113	7

Note: C = Conventional concrete
RF = Rubber filler in concrete

4.2 MIX PROPORTION (II)

The constituents used were divided into different fractions to determine the mix proportions that would yield the compressive strength at a test age of 7 days. The optimum mix proportions included the shredded rubber as coarse aggregate, fine aggregate, cement, and water to yield a cubic meter of concrete. Three rubberized concretes were designed by the volumetric method with different water- cement ratio (0.4, 0.5, and 0.7) and total produced nine samples. The mix proportions (II) of the samples shown in Table .2.

Table 2: The mix proportions (II) of the sample are presented**.**

Mix	w/c (by weight)	Cement (kg/m^3)	Proportions (by volume) C:FA:CA*	Water content (kg)
R1	0.4	516	1:1.6:2.5	1.6
R2	0.5	516	1:1.6:2.5	2.0
R3	0.7	516	1:1.6:2.5	2.8
R4	0.4	606	1:1.7:2.7	1.9
R5	0.5	606	1:1.7:2.7	2.6
R6	0.7	606	1:1.7:2.7	3.3

Note: R = Rubberized concrete

5. PROCEDURE

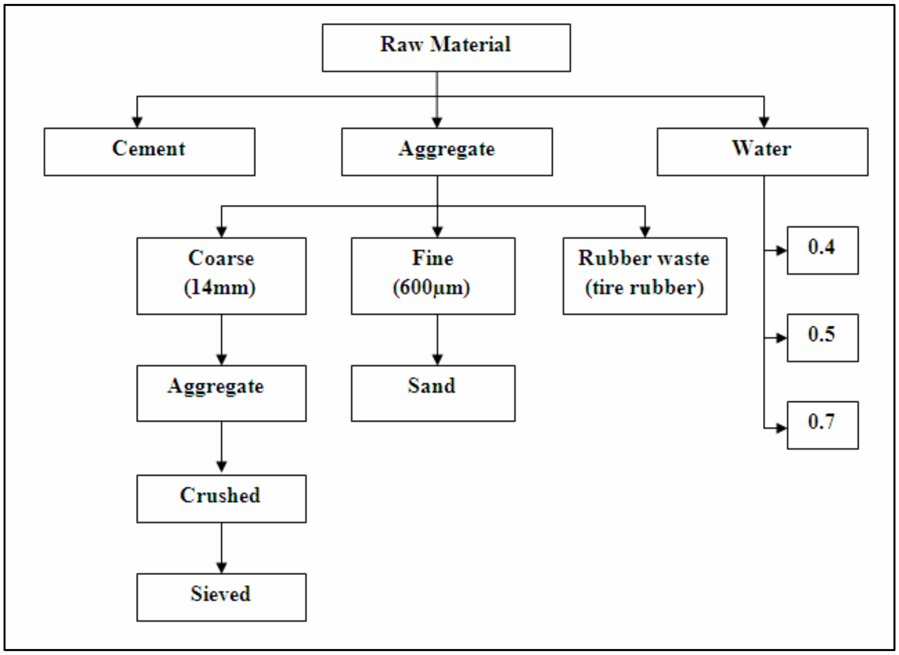

Figure 2: Flow chart of the raw material process.

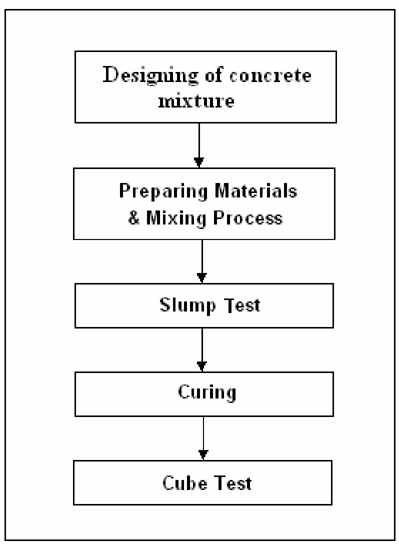

Figure 3: Flow chart of concrete mixing process.

Figure 2 and 3 indicates the flow chat of the whole process of raw material and concrete mixing process. Concrete ingredients consist of raw materials that are aggregate, Portland cement and water. The aggregate are divided into three types which are coarse aggregate, fine aggregate and rubber waste. The ratio for each model was based on volumetric method. The measurement used in this research is kilogram/meter cube (kg/m^3). Coarse aggregate usually gravel or crushed stone. The sizes range from 14mm up to 20mm maximum size permitted for the job and sand as fine aggregate consist 600µm or less in size.

The raw materials i.e. water; Portland cement and aggregate were mixed. After the mixing process, the entire models were measured using the slump test. Then, the concrete mixtures were samples in the cube mold with size (150x150x150) mm for mix proportion (I) and cube mold with size (150x150x150) mm for mix proportion (II). For every mix proportions, 3 samples were made. After a day, the samples were opened from the mold and then were cured in the water. All desirable properties of concrete are improved by proper curing process. The concrete which is moist was cured for 7days. After 7 days. The cube test was carried out using universal testing machine (UTM) to measure the strengthening for each.

6. RESULT AND DISCUSSION

6.1 Workability

The workability of rubber filler in concrete reported that there is a decrease in slump with increase in rubber waste tire content as a percentage of total aggregate volume. The decrease of slump also can observe when increase water -cement ratio.

The workability of rubberized concrete showed a decrease in slump with increase of volume waste tire rubber content of total aggregate volume. It was observed that mixtures made with convention concrete were more workable than those a combination of tire chips. The replacement of coarse aggregates by waste tire rubbers was effect on the workability of concrete. The properties slump and workability of concrete is mainly related to the water-cement ratio. When water-cement ratio decreases, the slump and workability of concrete will increases. Figure4 and Figure 5 shown the higher slump with water-cement ratio with 0.7 compared with other water-cement ratio which water-cement ratio 0.7 has high workability.

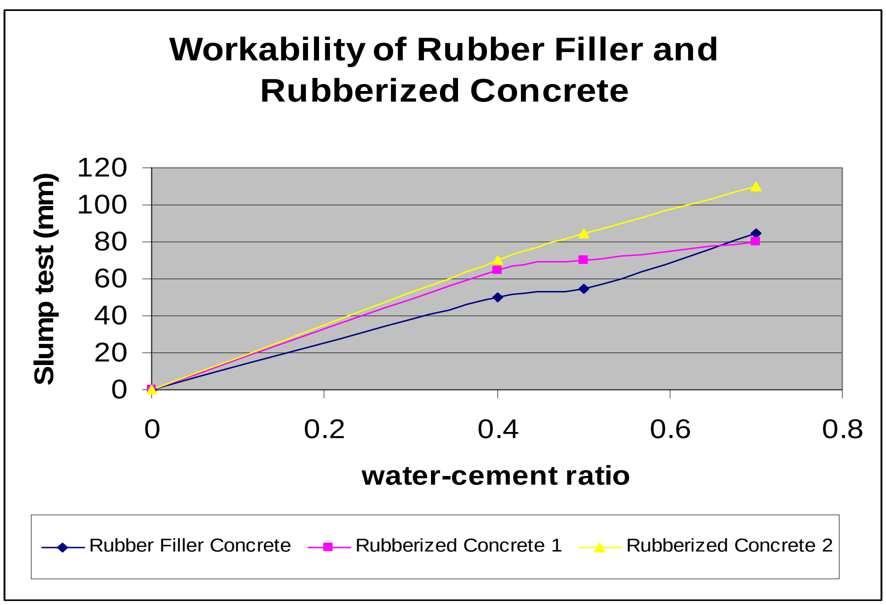

Figure 4: Workability of rubber filler concrete and rubberized concrete

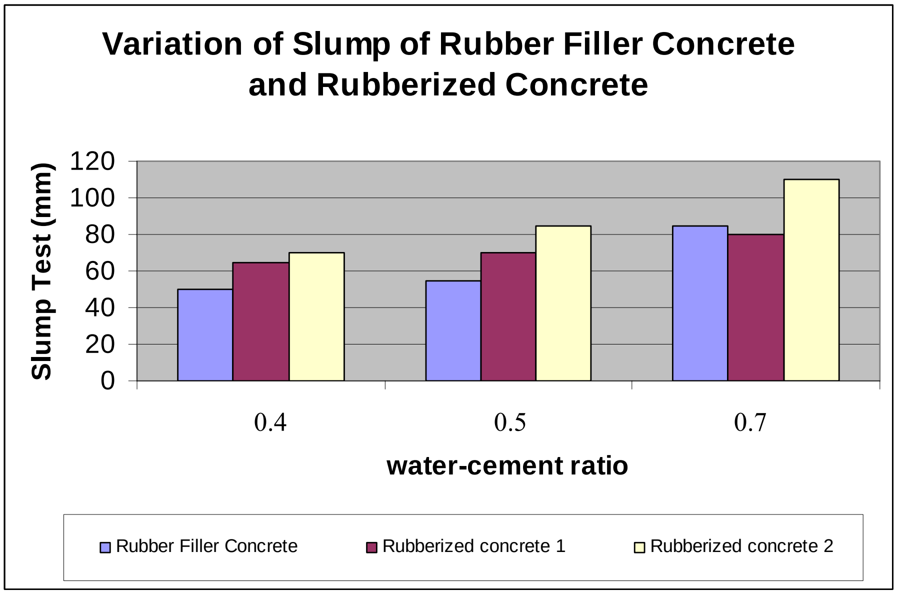

Figure 5: Slump range description for slump test for rubber filler concrete and rubberized concrete

6.2.1 Density of concrete

Density (formally know as unit weight) is very important as a part of the design process of concrete because unit weight of concrete will classified the categories of concrete. Factors affecting concrete density include aggregate density, air content, and the water and cement content in the design.

From the observation, there is constant in unit weight of early age concrete of mix proportion (I) of rubber filler concrete in 7 days. The average unit weight of the rubber filler in concrete is 2400kg/m^3. It is because the rubberized concrete use tire rubber chips (1% in weight of paste) as addition to cement paste with contained 70g (7g per piece) of tire chips. In this mix proportion it can classify as normal weight concrete which weighting 2400kg/m^3.

The decreasing in unit weight of rubberized concrete when rubber content is lower than 10-20% of total aggregate volume [Khatib and Bayomy, 1999]. In mix proportion (II), a lower unit weight of was obtained because of low specific gravity of rubber chips, unit weight of mixture containing rubber decreases with increasing in the percentage of rubber content. The average unit weight of the rubberized concrete use tire rubber chips as replacement aggregate addition in concrete is 1800kg/m^3. It can classify as lightweight concrete which weighting 1800kg/m^3. The unit weight of conventional concrete and rubberized concrete is shown in Table 3.

Table 3: Density of rubber filler and rubberized concrete

Mix Proportional	Concrete	Average of mass (kg)	Average of volume (m^3)	Density (kg/m^3)
I	Rubber filler	8.1	0.15	2430
II	Rubberized	1.8	0.1	1800
II	Rubberized	1.8	0.1	1800

6.3 Compressive strength analysis

Table 4: The result of mix proportions (I)

Mix	Water/ Cement Ratio	Fine Aggregate (kg/m^3)	Coarse Aggregate (kg/m^3)	Rubber Waste (g)	Compressive Strength (N/mm^2)
RF	0.4	522	1218	7	22.02
RF	0.5	809	1029	7	20.37
RF	0.7	839	1113	7	15.79
Average:					**19.39**

Note: RF = Rubber filler in concrete

Table 5: The result of mix proportions (II)

Mix	Water/ Cement Ratio	Cement (kg)	Fine Aggregate (per cube)	Rubber Waste Coarse Aggregate (per cube)	Water content (kg)	Compressive Strength (N/mm^2)
R1	0.4	4	1.6	2.5	1.6	6.960
R2	0.5	4	1.6	2.5	2.0	6.646
R3	0.7	4	1.6	2.5	2.8	6.189
Average:						**6.598**
Mix	**Water/Cement Ratio**	**Cement (kg)**	**Fine Aggregate (per cube)**	**Rubber Waste Coarse Aggregate (per cube)**	**Water content (kg)**	**Compressive Strength (N/mm^2)**
R4	0.4	4.7	1.7	2.7	1.9	7.757
R5	0.5	4.7	1.7	2.7	2.6	7.547
R6	0.7	4.7	1.7	2.7	3.3	5.669
Average:						**6.991**

Note: R = Rubberized concrete

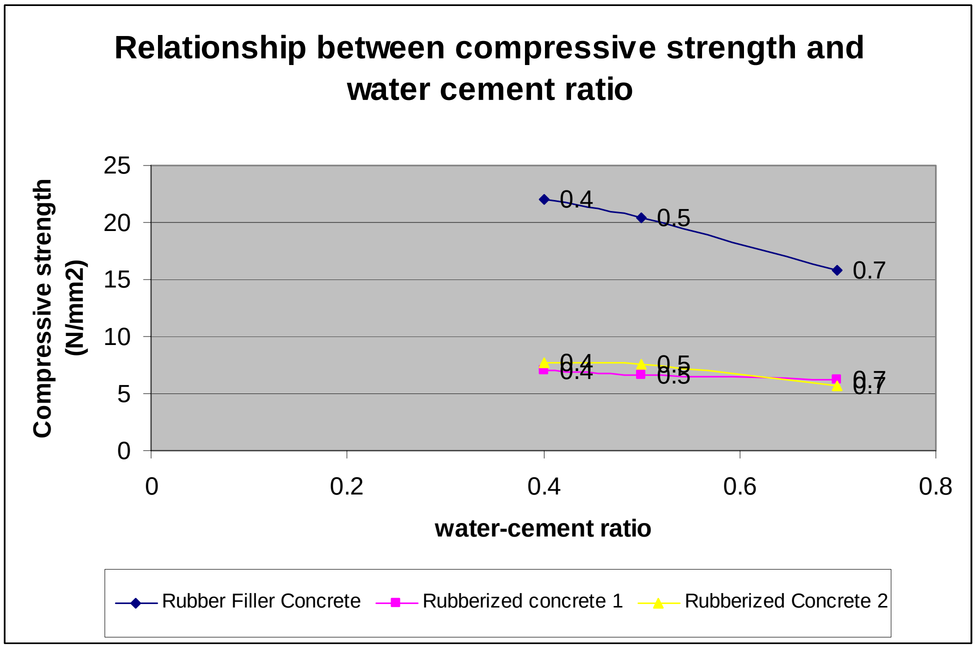

Figure 6: Relationship between compressive strength and water – cement ratio for rubber filler concrete and rubberized concrete

The compressive strength is mainly related to the w/c ratio. As the w/c ratio decreases, the compressive strength increases. From the Table 4, the water-cement ratio 0.4, 0.5, 0.7 are used to prepare the rubber filler concrete and rubberized concrete. The highest compressive strength is rubber filler concrete resulted average 19.39N/mm^2 compared to compressive strength of rubberized concrete which is 6.598N/mm^2 and 6.991N/mm^2. The concrete mixtures with tire waste rubber aggregate exhibited higher compressive than rubberized concrete. There was approximately 5% increase in compressive strength in mix proportion (I) when coarse aggregate mix with little amount of 70g waste tire shredded rubber. The results of compressive strength of rubberized concrete mixtures are affected by the size, proportions, and surface texture of rubber particles, and type of cement used in such mixtures. There was approximately 80% reduction strength in mix proportion (II) when coarse aggregate was fully replaced by waste tire rubber aggregate. Figure 6: Relationship between compressive strength and water – cement ratio for rubber filler concrete and rubberized concrete.

The compressive strength was reduced in rubberized concrete for several reasons including the inclusion of the waste tires rubber aggregate acted like voids in the matrix. This is because of the weak bond between the waste tires rubber aggregate and concrete matrix. With the increase in void content of the concrete, there will be a corresponding decrease in strength. Second reason is waste tires rubber aggregate act as weak inclusions in the hardened cement mass and as a result produced high internal stress that are perpendicular to the direction of applied load. Third reason is Portland cement concrete strength is dependent greatly on the coarse aggregate, density, size, and hardness. Since the aggregates are partially replaced by rubber, the reduction in strength is only natural. Last reason is the failure of the sample is also because of the waste tire being more elastically deformable than the matrix. When the samples were loaded the cracks form first at the softest areas. The site of the inclusion of rubber is where these sites appear.

7.0 CONCLUSION

From the test result and discussion, the following conclusions are drawn from the study on early age strength of concrete with recycle rubber.

Rubber can be added to cement based materials without any difficulties. By varying mix proportions and rubber content, the engineer can tailor new concrete mixes to suit different applications. However, the potential of this material has not been realized, as further research is needed.

The addition of rubber to cement based materials resulted in reduced compressive strengths and densities. The reductions in compressive strength and density depended on the amount of rubber added, and the trends of compression test results were consistent with those obtained. For Mix proportion (I) which concrete containing the little amount of added rubber, the density and compressive strength was approximately 5% increased respectively, when compared to ordinary concrete. For Mix proportion (II) which concrete containing the little amount of added rubber, the density and compressive strength were reduced by nearly 80% respectively, when compared to ordinary concrete.

Finally, it is clear that further work is needed to characterize the rubber in terms of origin, size, shape, grading, density and amount and type of fibre present. Also, to study the influence of each of these parameters on the properties of concrete.

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