Crumb Rubber Tire as Partial Replacement for Fine Aggregates in Concrete Hollow Blocks

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Abstract

The study aims to investigate the feasibility of crumb rubber material derived from waste rubber tires to partially replace fine aggregates in the production of concrete hollow blocks (CHB). Three mixtures in the proportions of 20%, 40% and 60% crumb rubber replacement were evaluated for compressive strength of CHB at curing age of 7 days, 14 days and 28 days respectively. A conventional CHB was also prepared to serve as basis for comparing compressive strengths. Results revealed that all mixtures did not attain the standard minimum requirements specified on NSCP on compressive strength of conventional load bearing concrete hollow blocks. Results from this experimental investigation showed that by increasing percentage replacement of fine aggregates with crumb rubber aggregates created proportional reduction of the compressive strength making the CHB unable to attain required strength for load-bearing structures.

***Keywords**:* crumb rubber tire, CHB, alternative fine aggregates

1. Introduction

The demand of raw materials especially in the construction industry has increased greatly due to growing demands brought by progress and development of the country. While development for economic prosperity of a country is welcomed, there is a need to re-evaluate usage of natural resources to ascertain sustainability in long term applications.

In response to global sustainable usage of natural resources such as sand and gravel for concrete materials, many studies have been conducted to develop new programs and standards involving recycled materials. Buildings and

construction activities worldwide consume three billion ons of raw materials or 40 percent of the total use (Roodman and Lenssen, 1995). It is thereby appropriate to look into possible replacement materials in preparation of concrete products without jeopardizing its quality and strength in order to provide sustainable environment.

Researches in concrete mixtures have shown that it is possible to replace some of the traditional ingredients with other materials such as those collected from recycling processes. This feature of concrete mixtures when found feasible, would present unique opportunities to use materials that otherwise might be placed in landfill and being wasted.

One of the recommended alternative materials for concrete aggregate is scrap tires which when improperly handled i.e. burning may be a threat to environment and health. By using size reduction technology, scrap rubber tire is being shredded or grinded into various sizes of rubber aggregates that partially or wholly replaced either fine or course aggregates in concrete mix (Reschner, 2008).

Some studies conducted utilizing coarse and rubber aggregates for concrete mix have been found with varied results. The study conducted by Kotresh and Mesfin (2014), incorporated scarp rubber tire as partial replacement for coarse aggregate in concrete mix in 10%, 20% and 30% by weight of scrap tire, with a maximum size of 20 mm. The result shows a slightly reduced compressive and flexural strength compared to normal concrete mix. The study proved that the more scrap rubber tire incorporated in the mix, the more increased in reduction of unit weight of concrete.

The research investigation conducted by Shirule and Hussain (2015), utilized rubber tire aggregates to partially replace fine aggregates by 3%, 6%, 9%, 12%, 15% and 18 % by weight of concrete mix. Results revealed that concrete displayed a greater tensile, compressive and flexural strengths compared to the traditional mix. Siddique and Naik (2004), reported that there is approximately 85% reduction in compressive strength and 54% reduction in splitting tensile strength when coarse aggregate is fully replaced by course crumb rubber chips. However, a reduction about 65% in compressive strength and up to 50% in splitting tensile strength is observed when fine aggregate is fully replaced by fine crumb rubber. Both of these mixture demonstrated a ductile failure and have the ability to absorb a large amount of energy under compressive and tensile loads.

Having observed that crumb rubber tire aggregates can provide potential usage for concrete mix as partial replacement, this study conducted an experimental investigation using crumb rubber aggregate as partial replacement for fine aggregate in the production of load bearing concrete hollow block (CHB).

2. Methodology

This study used experimental method with standard size CHB as test specimens whose mixture is composed of cement, fine sand, choker aggregates, water and crumb rubber tire. Crumb rubber tire replaced certain volume of fine aggregates by weight at different level of percentage with constant volume of cement and water ratio. A control mix of cement and fine aggregates without crumb rubber tire aggregates is also produced to compare results.

Crumb rubber tire were mixed as weight-for-weight replacement of fine aggregate at 20%, 40% and 60% to prepare concrete hollow. The study adopted the standard concrete masonry unit dimensions set by the National Building Code of the Philippines and National Structural Code of the Philippines for load-bearing walls with dimensions 6” x 8” x 16” and must weigh 30 lbs/block. The CHB is classified as Type 1 Class A conforming to ASTM C90 (2009). A ratio of 1:2:4 (cement: fine aggregate: gravel) as per ASTM C-90 and water-cement ratio of 0.45 ASTM C150 (2007). The minimum compressive strength is 54.41 MPa (800 psi) for individual concrete hollow block. .

Sieve analysis were performed on aggregates to determine the gradation or distribution of aggregates within a given sample.

The crumb rubber tire replacement is presented in Table 1. Designation of samples is also shown to consider in this experimental investigation.

Table 1. Crumb Rubber Tire Replacement

Sample Designation	Content of crumb rubber aggregates (%)	Content of sand and choker
A (control Specimen)	0	100
B	20	80
C	40	60
D	60	40

The actual proportion of cement, fine aggregates, crumb rubber tire and 3/8" choker used during the production of different design mixtures of concrete hollow blocks specimens are presented in Table 2.

Table 2. Actual proportion of cement, aggregates and crumb rubber

Percentage of crumb rubber and fine aggregates	Water (L)	Crumb rubber (Kgs)	Cement (Kgs)	Aggregates	
				Fine sand	3/8 " Choker
0% crumb rubber – 100% fine aggregates	9	0	20	40	80
20% crumb rubber – 80% fine aggregates	9	8	20	32	80
40 % crumb rubber – 60% fine aggregates	9	16	20	24	80
60% crumb rubber – 40% fine aggregates	9	24	20	16	80

The specimens were divided into three groups of 12 specimens in each according to the number of days of curing. The distribution in each level of percentage replacement to the specimens is presented in Table 3.

Table 3. Number of specimen at different percentage of crumb rubber replacement

Group	Number of specimen at different percentage mix				Total
	0%	20%	40%	60%	
7 days	3	3	3	3	12
14 days	3	3	3	3	12
28 days	3	3	3	3	12

The specimens were cured using wetting method for 7, 14 and 28 days respectively. Then each series of molded CHB was tested for compressive strength using the compression testing machine. The CHB were taken out from curing and were allowed to dry for 24 hours in open air.

3. Results and Discussion

Using the compression testing machine, the different design mixtures of 0%, 20%, 40% and 60% crumb rubber tire aggregates were tested at corresponding age of curing of 7 days, 14 days and 28 days respectively. Table 4 presents the compressive strengths obtained by the specimens.

Table 4. The Compressive Strengths Obtained by CHB Specimens (Area of CHB = 39.31 in^2)

Design Mix (crumb rubber)	Curing Age	Specimen 1 (psi)	Specimen 2 (psi)	Specimen 3 (psi)	Average
0% (control)	7	349	332	452	377.67
	14	546	412	429	462.33
	28	829	858	935	874.00
20%	7	129	112	109	116.67
	14	110	120	129	119.67
	28	149	140	143	144.00
40%	7	86	57	91	78.00
	14	91	80	86	85.67
	28	97	98	103	99.33
60%	7	51	46	46	47.67
	14	51	69	57	59.00
	28	69	69	80	72.67

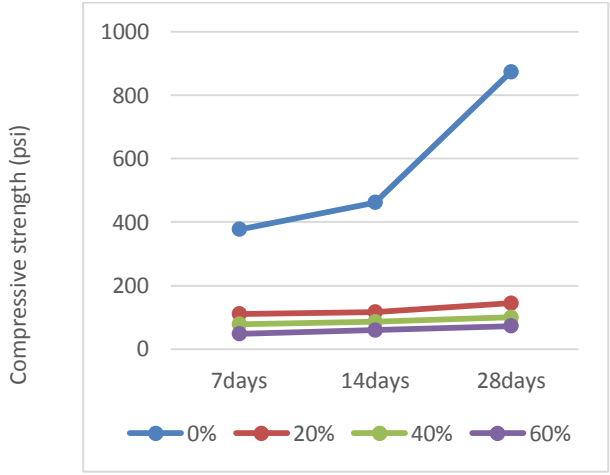

Figure 1. Comparison of Compressive Strengths obtained at different design mixtures of CHB

Graphical representation of data on Table 4 is shown in Fig. 1. It is observed that CHB produced with crumb rubber aggregate replacement obtained very low compressive strength compared to the control specimens. At 28 days, the 20% crumb rubber CHB specimen has a compressive strength of 730 psi difference compared to the control specimen, while 40% and 60% rubber crumb CHB specimen obtained 775 psi and 802 psi respectively. These results revealed that replacement of crumb rubber to fine aggregates for CHB weakens the strength of the concrete hollow blocks by 83%.

4. Conclusions and Recommendation

The study aims to determine the feasibility of partial replacement of crumb rubber from scrap tires in order to utilize industrial waste materials for possible construction application such as concrete hollow blocks production. Results of this experimental investigation provided important information to researchers who wished to undertake such investigation using scrap rubber tires for CHB.

The findings showed unfavorable acceptance of crumb rubber as partial replacement to fine aggregates in concrete hollow block production because results revealed that compressive strength is reduced by 83%, thereby producing a very weak CHB product.

This study endeavors to inform researchers who may be interested to use rubber crumb from scrap tires as a concrete material. Having obtained such findings, crumb rubber should not be recommended for fine aggregate replacement to concrete hollow blocks production.

5. References

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