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Concrete Mix with Laminated Rubber Strips for Residential Concrete

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Abstract*: *This study investigated the mixing of rubber to residential concrete mixtures to reduce the use of aggregates that will soon deplete natural resources. The rubber was laminated with steel before adding it to the concrete mix in order to improve its strength and stability. Using scrap tires for this experiment will not only help reduce the rubber waste in a country but also reduce the overall weight of a residential building to help ease the effects of an earthquake. Four concrete samples were made with 0, 5, 7.5 and 10 percent replacement by volume. The compressive strength and weight of the concrete mix was measured in this study to determine its practical application. The product exhibited minimal compressive changes and weight changes as the replacement was increasing. Although the strength decreased, beneficial weight change was observed since it will be less rigid when structurally used. The compressive strength of the samples with laminate rubber strips were more than 20 MPa and this suggests that it could be used for residential concrete like slabs, footings, pavements, and concrete stumps.

Keywords*: *Laminated Rubber, Recycled Rubber Tires, Compressive Strength, Concrete Mix

I. INTRODUCTION

The urban population keeps on growing in a rapid and uncontrolled way especially in developing countries. As the population grows more and more residential houses are being built. Most of these residential houses are made out of concrete. Even though concrete houses cost more than traditional houses, many still choose to have concrete due to its high resistance to high winds, pests, and fire. However, the costs of concrete houses have been increasing because the costs of the materials that are used are also increasing. The impending dearth of the materials in building residential houses is the reason for the increasing cost of these materials. An example of these materials is the aggregates.

The aggregates used in construction are very important since it will provide additional strength to concrete. Many studies are being carried out with the intention of finding a substitute for the aggregates [2] used in construction. This is because quarrying aggregates from mountains and rivers deplete its source and at the same time harm the environment. When natural resources are depleted, it typically takes a long time to be renewed and so aggregates that come from natural resources should be substituted with something that is abundant or recyclable waste materials.

Rubber is a non-biodegradable material, so components in a tire are problems to the environment. Disposal of waste tire rubber is an environmental issue since it can consume valued space in landfills [3]. When discarded tires are accumulated, environmental issues will arise because it takes longer for tire rubbers to degrade. The deposition of tire rubber will also be a problem when these materials are accumulated [4-5]. Used tires are burned by some people just to get rid of them that could produce harmful gases that result in air pollution and can cause a serious health problem for inhaling it. Scrap rubber tires accumulate water whenever it rains; thus, making mosquitoes more productive which could lead to a widespread epidemic [6].

Due to these problems, researchers explored with the recycling of rubber. Rubbers have good resilience, high tensile strength, and high tear strength. Recycling rubber is made possible and an example is with the use of scrap rubber tires as concrete aggregates [7]. Using rubber in construction industry as partial aggregates will add strength to the concrete mix due to its favorable features like its good elasticity to act as shock absorbing medium and relatively low weight. It can also be more useful if combined to other base materials. For example, laminated rubber bearings [8] can have considerable vertical load-carrying capacity, restoring force capability, and lateral flexibility.

This study focused on fusing the properties of rubber to concrete mixture to reduce the amount of aggregates. In order to fully strengthen it, the rubber was laminated with steel alternately before adding it to the concrete mix. Lamination using steel strips will improve the rubber's strength, stability and reduce maximum displacement; thus, making it stronger and better. Moreover, using scrap tires for this experiment will not only help reduce the rubber waste in the country but will also reduce the overall weight of a structure which is just what a structure needs to reduce the effects of earthquake. This is based on the idea that the forces due to earthquake on a structure are directly proportional to the overall weight of the structure.

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II. MATERIALS AND METHOD

Fig. 1 shows the materials utilized in the production of laminated rubber strip (LRS) concrete mix. Samples were made with different partial replacement percentage as shown in Table 1. The rubber used in the study is a used truck tire that was left out along the street. The galvanized iron sheets were collected from the trash which was typhoon remnants. The truck tire was exposed to sunlight for a few hours to easily cut it.

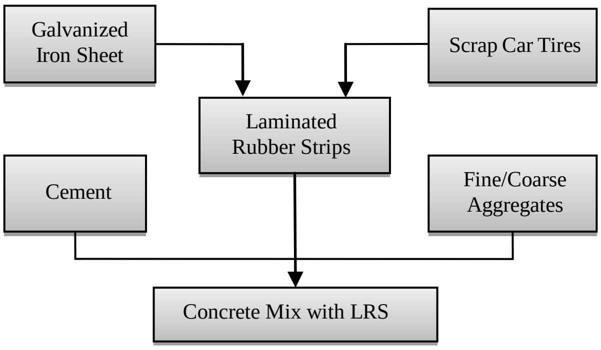

Fig. 1. Components of the concrete mix.

The rubber tire was cut into its desired shape using steel saw. The galvanized iron sheet was also cut using a steel cutter into its right proportions as shown in Fig. 2. The rubber dimension is 0.6 inches x 2 inches while the steel strips are 0.1 inches smaller. Using a hammer and a nail, holes were made on both the rubber and steel and used the steel wire to tie them together as shown in Fig. 3.

Table- I: Percentage of Laminated Rubber Strips in the Concrete Mix Samples

Samples Name	Percentage
LRSCM-0	LRS Concrete Mix with 0% replacement
LRSCM-5	LRS Concrete Mix with 5% replacement
LRSCM-7.5	LRS Concrete Mix with 7.5% replacement
LRSCM-10	LRS Concrete Mix with 10% replacement

Fig. 2. Galvanized iron sheet placed between rubber.

Fig. 3. Laminated rubber strips.

The concrete mixture was made by mixing cement, aggregates, LRS, and water. All the samples had undergone slump testing in order to test its workability. After passing the test, the mixtures were placed in the mold and be kept at the laboratory to be manually water cured for 7, 14 and 21 days until they were tested. A 6-inch diameter mold was used for all the samples.

Fig. 4.Laminated rubber strips.

Testing of samples was done in a Universal Testing Machine (UTM). This machine has the ability to test the tensile and compressive strength of materials. The samples have undergone a compressive strength test as shown in Fig. 4 where it was gradually loaded until the sample reaches its rupture point. The data in the form of pressure and stress-strain diagram were then collected and compared with each sample that was also tested.

III. RESULTS AND DISCUSSION

A. Compressive Strength Test

In designing structures, the most common measure of performance is getting the compressive strength of concrete. Compressive strength of the four samples is shown in Table II. The strongest results were obtained on the 21st day of curing with LRSCM-5 having the highest compressive strength among the other samples with coarse aggregate replacement.

The control sample without LRS still has a higher compressive strength than that of the samples with LRS however, it is only minimal. A gradual reduction from the compressive strength of the samples can be observed with the increase of the percentage of replacement of the gravel. It can also be observed that the compressive strength increases by 14% to 16% as the sample concrete ages.

All of the samples with LRS have a compressive strength of more than 20 MPa which is a standard [9] for residential concrete. They can be used specifically for residential slabs and footings [10], residential pavements [11], and concrete stumps [12].

Table- II: Compressive Strength of the Different Samples

Samples Name	Curing Period		
	7 Days	*14 Days*	*21 Days*
LRSCM-0	16.2 MPa	18.4 MPa	23.6 MPa
LRSCM-5	15.8 MPa	18.2 MPa	21.4 MPa
LRSCM-7.5	15.3 MPa	17.8 MPa	20.9 MPa
LRSCM-10	15.1 MPa	17.6 MPa	20.4 MPa

B. Mass of the Samples

Table III shows the average mass of the four samples. The average mass of the three samples in each mixture is presented in Table 2. A reduction of mass was noticeable on every sample. LRSCM-5 mass was reduced by 6.34% while LRSCM-7.5 was reduced by 11.27%. The most significant reduction was observed in LRSCM-10 with 14.79% reduction. The mass of the samples significantly decreases as the replacement percentage of coarse aggregate increases which was similar to other researches [13-15].

Table- III: Average Mass of the Samples

Samples Name	Average Mass (kg)
LRSCM-0	14.2
LRSCM-5	13.3
LRSCM-7.5	12.6
LRSCM-10	12.1

The weight of the concrete mix decreased since the rubber has low specific gravity which is a good thing for a structure. The lighter a building is the better for it to be more flexible, less rigid for earthquake strength.

C. Savings Using LRS

The total savings when using LRS as a partial replacement for aggregates are shown in Table IV. The price of one truckload of aggregates during the conduct of the study is 1,300.00 PHP. The volume of the aggregate used in the control sample LRSCM-0 was 2.5397x10-3 m3. This volume was reduced in three samples with LRS; thus, making them little economical. LRSCM-5 shows a 5% decrease in price per truckload, LRSCM-7.5 shows a 7.5% decrease in price per truckload and LRSCM-10 shows a 10% decrease in price per truckload.

Table- IV: Savings per Truckload of Aggregates

Samples Name	Volume (m^3)	Savings (PHP)
LRSCM-0	$2.5397x10^{-3}$	-
LRSCM-5	$2.4127x10^{-3}$	65.008
LRSCM-7.5	2.349210^{-3}	97.51
LRSCM-10	2.285710^{-3}	130.02

IV. CONCLUSION

As the percentage replacement was changed, there was a minimum compressive strength change. Comparing the concrete with no replacement to the ones with laminated rubber strips, the one without anything added to it is stronger, but considering the weight of each, it could do something potentially. The production cost of the concrete will decrease since the coarse aggregates are replaced with laminated rubbers in percentages. The researchers recommend using the mixture to parts of residential concretes where strength is not a factor. Due to the non-availability of some equipment, tests regarding its response to an earthquake is still a question; so, further researches and tests should be done to fully investigate the possibilities of using laminated rubber in the concrete mixture.

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