Multidisciplinary Applied Research and Innovation Vol. 4 No. 3 (2023) 24-30

MARI

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/mari
e-ISSN :2773-4773

The Compressive Strength of Mortar Mixed With Crumb Rubber as Partial Replacement in Fine Aggregate

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DOI: https://doi.org/10.30880/mari.2023.04.03.004
Received 01 March 2023; Accepted 01 May 2023; Available online 30 June 2023

Abstract : Rubber crumb may be utilised as a building material, notably as a replacement for fine aggregates, with significant environmental and sustainability benefits. Normal concrete, on the other hand, has limited properties such as low ductility, low impact energy absorption, and low fracture resistance. This study focus on the new mixed mortar with rubber crumbs as partial replacement of fine aggregate and to determine the compressive strength and water absorption. To produce new mixed mortar with rubber crumbs as partial replacement and to determine the compressive strength and water absorption for new mixed mortar then be compared to a control sample. The research was done by comparing average control sample water absorption percentage and compressive strength with mortar mixed with crumb rubber 5%, 10% and 15% for 7 days and 28 days each sample. This research also includes water absorption testing and compressive strength testing to identify the percentage of water absorption and compressive strength for the fresh mixed concrete. Rubber crumbs also provide less water absorption since the substance utilised has a lower proportion of water absorption. Finally, waste rubber disposal is a severe environmental problem all over the world due to health concerns and difficulties in land filling. By recycling rubber and using it as a partial fine replacement in mortar, we can create a new improved mortar with a higher water absorption and compressive strength percentage.

Keywords: Crumb Rubber, Mixed, Strength, Mortar, Concrete

1. Introduction

Recycling as a response to environmental issues, as well as the use of recycled and waste materials in architectural applications, is becoming more important [1][2]. The United States creates more than 250 million wasted tyres each year. Scrap tyres may be used as a construction material, particularly as

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a substitute for limited natural aggregates, with considerable environmental and sustainability advantages when utilised to manufacture new mixture of mortar. According to [3], poor adhesion of rubber particles to cement paste adds to the loss of mechanical strength found in rubberized cement composites, which has been a key hurdle to the widespread reuse of scrap tyre waste in cement and concrete applications. Recycling waste tyres as crumb rubber (CR) in concrete has so emerged as one approach for maintaining environmental balance while also delivering economic benefit [4]. Rubberized concrete is also known as rubber tyre concrete, elastic concrete, crumb rubber concrete [5], rubber concrete[3], and rubber concrete [6] [7]. The goal is to add a certain number of flexible components to the original multi-component concrete to increase its performance so that it may be utilised to produce new mixture of mortar [8].

Scrap tyres, rubber belts, hoses, wires, cables, industrial rubber goods, and other waste rubber are used to make rubber aggregate [9]. The goals of this research are to create new new mixture of mortar with rubber crumbs and to measure the compressive strength and water absorption of new new mixture of mortar. Because of the health dangers and issues associated with land filling, waste rubber disposal is a serious environmental issue all over the globe [3]. Due to the high expense of disposal and the need for a big dump site, waste rubber is typically disposed in an indiscriminate and unlawful manner [10]. Concrete must be improved due to issues such as excessive pricing, poor bond behaviour, and poor durability in order to build a new concrete that is better than before [11].

Much research has been done on the use of crumb rubber concrete (CRC) made from broken down waste tyres in various sizes, including fine (1–6 mm) and course (6–19 mm), to replace a portion of natural aggregates in concrete mixes. However, due to significant strength reductions, the use of CRC in many structural applications is impractical, according to the literature [5], [12], [4]. Despite CRC's limited mechanical properties, non-structural concrete products with medium to low strength requirements have a market. Crumb rubber has also been mixed into concrete blocks to create a lighter, more flexible, and long-lasting absorbing material that replaces 20% of the fine aggregate . The use of air entraining admixtures increases the durability of CRC against freeze thaw action, according to research conducted in various environments .

The strength characteristics, sort, and quality of the components used in the concrete mix affect the strength, ductility, and quantity of post-cracking behavior of the concrete. Many various types of materials have been available in the concrete industry in recent years, each with their own set of qualities, benefits, and downsides. The planned usage of the concrete heavily influences the material selection. Two recently identified elements that might be used in concrete are crumb rubber from tire waste and polystyrene beads. These materials are used and discarded in large quantities.

2. Materials and Methods

The materials and methods section, otherwise known as methodology, describes all the necessary information that is required to obtain the results of the study. The main issue that need to be tackle is producing a good new mixture of mortar. When talking about mixture of mortar, it is generally composed by concrete, metal and plastic that are meant to keep the rain out.

2.1 Materials

Raw materials are utilised in a wide range of goods and come in a variety of shapes and sizes. A raw material is a goods or product that a company wants to use to make a finished product. Mortar and crumb rubber are two materials that will be discussed as they are required for this study [13]. The mortar was design based on the 1:4 ratio which is 1 part for cement and 4 part of sand for the control sample which is the sample that was compared to other sample mixed with crumb rubber. As an example for the preparation of mortar mixed with crumb rubber, 5% of the sand will be replaced with crumb rubber as partial sand replacement. The process continue for the other percentage such as 10% and 15%. The crumb rubber that were being used was ranging from 0.075 to 5mm shreds as shown in **Figure 1**.

Figure 1: Crumb rubber

Figure 2 shows the cement as afine aggregate that have been processed can be acquired in the Concrete laboratory as UTHM Pagoh Campus. Crumb rubber and silica fume are used as additional to increase compressive strength. Ordinary Portland Cement (OPC) was used in this study. OPC id primarily used for soil stabilization and performed best in sandy soil.

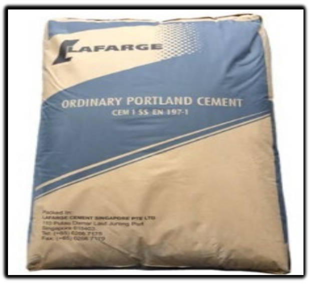

Figure 2: Ordinary Portland Cement Mortar

The test duration of all experiment sampling were 7 days for 3 samples of each percentage and 28 days for 3 other samples of each percentage. The result for 28 days shows better result in the effect of the test thus, the reason of the different duration of time was to compare the result between 7 days and 28 days.

2.2 Mechanical Testing

Mechanical testing is often performed at the ending of an experiment. Mechanical testing for our project includes the compressive machine, density, and water absorption tests. Each sample is made up of 3 samples with different percentages of crumb rubber, 0%, 5%, 10%, and 15%, but the same quantity of silica fume, 5%. It is critical to take 3 of each percentage measurements in order to get an average reading of the data.

2.2.1 Water absorption test

Figure 3 show the process of mortar water absorption test. This is a technique for limiting the amount of moisture lost from concrete during the hydration process. Concrete takes 24 to 48 hours to dry, but it reaches its maximum strength after 28 days. For curing laboratory samples, immersion curing is the most effective method. The water absorption from the cube can be determined using this method. After mortar samples hardened, all of the sample of different percentage of crumb rubber 0%, 5%, 10% and 15% were all put in the same curing tank for 7 days and 28 days duration of time. The weight dry weight and wet weight of each samples were recorded to include in the formula to calculate (**Eq.1**) the water absorption percentage.

Figure 3: **Process of water absorption test**

$$R = \frac{(W_a - W_b)}{W_b}(100) \qquad \textbf{Eq.1}$$

Water absorption % = [(W_a-W_b) / W_b] x 100

Where, W_b = mass of the dry tile, in kg

W_a = mass of the wet tile, in kg

2.2.2 Compressive Strength Test

The compressive machine that was used for the mechanical testing. The ability of a material or structure to withstand loads that cause it to shrink in size is known as compressive strength, also known as tensile strength. When designing structures, compressive strength is a significant consideration. To determined the compressive strength of each cube, the compressive machine test was used. The machine automatically determined the compressive strength in kN/m^2 unit of each samples. The machine was at UTHM concrete laboratory and the lab staff gave all the guidance on how to use operate the machine. The unit of the result need to be change by using the formula of compressive strength which is load divided by cross-sectional area.

2.2.3 Concrete Slump Test

Figure 4 show the slump test that had been done. (ASTM C 143-90 1990) The slump test is the most widely used single-point test, however it, like most other comparable tests, is limited to a narrower range of workability than that utilised in construction. The compaction factor test, for example, may differentiate 0 percent deterioration combinations used in precast construction (BS1181 Testing Concrete 1983). At the other end of the strength and durability spectrum, the use of plasticizers has aided in the use of flow concrete for ease of installation, as well as more recent breakthroughs such as self-compacting concrete when mixed with cement replacement materials. All mixtures were flow tested, and the breadth of the cylinder was measured before and after shock; these are referred to as the initial and final flows, respectively. All diameters in the spreadsheet for both the falling flow and the flow test are, in fact, the ratio of two measurements made at right angles to each other and given to the nearest 5 mm.

Figure 4: Slump Test

2.2.4 Density Test

The wet weight of each samples of different percentage were recorded for the calculation of the density of each cube. The average of each percentage for 7 days and 28 days were compared to determine the different in density of new mixed mortar with rubber crumb and control sample. The sample was placed in the curing tank at the Concrete Technology Laboratory on the UTHM Campus Pagoh for curing. To get the value of each sample density, the formula given was used to calculate. The formula is mass (kg) divided by volume (m^3). For the mass, the saturation weight from sample was used and for the volume was fixed to the size of cube test that was used which is 50 mm x 50 mm x 50 mm.

3. Results and Discussion

Our finding about rubber as recycled materials used in mixture of mortar showed that the compressive strength decreases as we mix the crumb rubber with the concrete. The water absorption value decreases and eventually increase again meanwhile the compressive strength decrease as the amount of rubber crumb increase. This corresponds with the use of CRC literature [4], [14], [5] that state there are significant strength reduction but used to create a lighter and more flexible material that replace 20% of the fine aggregate [15].

3.1 Results

Based on the result achieved, it showed that replacing 10% fine aggregate with rubber crumb in concrete mixture lowered the water absorption while increasing the compressive strength (shown in diagram **Table 1** and **Table 2**). That demonstrate that 10% rubber crumb is the most ideal value, resulting in the lowest water absorption and highest compressive strength among the samples and also shows that adding other material also have its own pros and cons.

Table 1: Average water absorption and compressive strength value for 7 days

	Control Sample	5% Rubber Crumb	10% Rubber Crumb	15% Rubber Crumb	Average Value
Water Absorption	8.92	7.81	5.77	9.08	7.9
Compressive Strength	4.27	2.05	5.38	1.67	3.34

Table 2: Average water absorption and compressive strength value for 28 days

	Control Sample	5% Rubber Crumb	10% Rubber Crumb	15% Rubber Crumb	Average Value
Water Absorption	11.08	11.69	7.81	9.88	10.12
Compressive Strength	8.28	2.3	5.69	1.57	4.46

Supar *et al*., [16] also found that water absorption increased when the percentage of crumb rubber higher as in **Figure 5**.

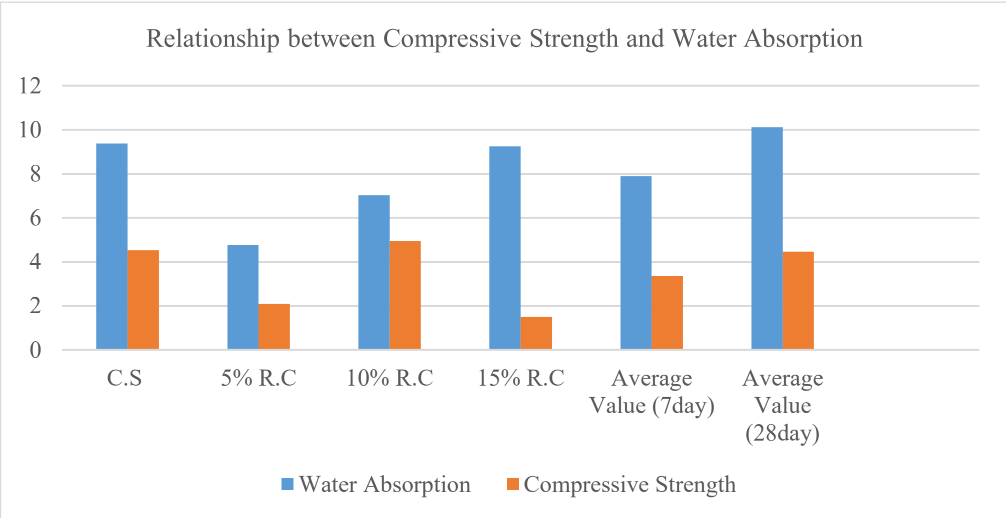

Figure 5: Relationship between Compressive Strength and Water Absorption

4. Conclusion

This research examined at the strength of mortar combined with crumb rubber for mixture of mortar in the context of worldwide development. We chose crumb rubber over coarse aggregates since it has some characteristics that are adequate and will address all of our industry's existing issues. To verify that the amount and quantity of moisture loss from concrete during the hydration process was regulated, all samples for each test were cured for 7 and 28 days. Based on the data, we can conclude that polystyrene beads have both benefits and drawbacks when employed in our industry's. This may assist in resolving some of the issues encountered in the control sample. There are still a lot of things that can be learned from this study. To achieve a better combination in the future, utilize greater mortar. Ascertain that the mixture calculations meet the requirements of the mortar production standards. Furthermore, all cubes should be immersed in water during the curing process to guarantee that the results obtained are correct.

Acknowledgement

The author would like to thank Research Fund (TIER 1 Vot. H856), Research Management Centre, Universiti Tun Hussein Onn Malaysia in providing financial support for this project work.

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