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UTILIZATION OF TIRE AND DEMOLITION WASTE IN CONCRETE BRICKS

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ABSTRACT

The manufacturing of rubber tires has contributed to an increase in the amount of waste rubber materials over the course of history. These massive garbage mounds contribute to environmental damage. As a result, environmentally friendly replacements are required to reduce the negative impact. Reusing these materials in various alternatives has been studied for several decades; yet, substantial outputs in the structural construction material sectors remain dismal. This study focuses on the reuse of crumb rubber in concrete by replacing 5%, 10%, 15%, and 20% of the sand aggregate volume. Fresh properties like workability, setting time, and air content are experimented and analyzed with hardened properties like compressive strength, splitting tensile strength, flexural strength, and unit weight. A high voltage test was also carried out. Based on the impulse voltage test findings, it is possible to conclude that tire concrete has better electrical insulating capabilities than control concrete. Furthermore, in terms of long-term durability performance, rubber-based concrete beat natural aggregate-based concrete, opening up the possibility of using this building material in difficult environments.

I. INTRODUCTION

The creation of tires is a vital cog in the machine that is the automotive industry. Along with providing sufficient traction for the vehicle's mobility, the quality and strength of the tires also provide cushioning, which helps to absorb the shocks that the vehicle encounters. The creation of tires often begins with the gathering of several raw materials, including synthetic rubber, polyester, rayon, steel, carbon black, silica, and vulcanization accelerator. Tires are made in a wide range, each type catering to a specific use, in order to meet the needs of individual customers. In 2019, the global tire industry is expected to manufacture around 19.25 million tons of tires; with an annual growth rate of 3.4%, this number is expected to increase to 22.75 million tons in 2024. Around 15 billion dollars will be spent by the tire business all over the world in 2019. When considered in conjunction with the production rate, the yearly growth rate in production is 3.3% [1]. There are a number of various variables, such as increased productivity, variations in size and designs, that contribute to the market for tires' ability to produce a diverse array of tires [1]. These forces contribute to an increase in the variety of tires that are currently accessible on the market, which results in an increase in the quantity and quality of these tires. The same as in the other nations the manufacturing of tires in Saudi Arabia is considerable. Saudi Arabia is the largest automobile tire market in the Middle East with annual growth of 12% [2], and the country produces over 20 million trash tires per year.

Several tires are dumped or buried each year, posing a serious threat to local wildlife. The vast number and consistent shape of used tires make it illegal to dispose of them in landfills. As a result, they are considered an environmental hazard [3]. Waste tires left exposed to the elements collect water, which can provide a favorable environment for the proliferation of fungi, germs, insects, and rodents. Additionally, in the event of a fire, they burn quickly and release hazardous fumes, both of which can lead to significant environmental issues [4]. Governments on every continent are actively working to solve the waste rubber problem. As a result, numerous studies have been conducted to look into potential new applications for recycled rubber. There are many technical uses for rubber tires, especially in the field of civil engineering. Barriers for storm water runoff, boat bumpers at marinas, crash barriers at racetracks, and artificial reefs are just a few of the many uses for recycled tires [5]. Roads, playground areas, sports fields, and pavements could all benefit from using asphalt mixtures including rubber waste [6]. Recycled tire rubber could be used as a partial replacement for natural aggregate in construction projects [7]. By reduced natural resource consumption and the use of a more efficient material, rubberized concrete can help support sustainable construction practices and contribute to the expansion of the civil engineering sector. To achieve this, we recycle byproducts of manufacturing [8]. The addition of elastic

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rubber to rigid concrete, as reported by Pacheco-Torres et al. (2018) [9], changes the material's overall performance in addition to its brittleness and ductility [10].

II. LITERATURE SURVEY

Since the beginning of the industrial revolution, people have been able to live better lives. The beginning of the Industrial Revolution marked the beginning of a significant transition in society, as it led to the development of technology and factories that facilitated the manufacturing of commodities. The subsequent step was the introduction of a variety of hazardous waste products that were generated during the production process and posed a threat to both human life and the natural environment. One of the wastes consisted of tires. The problem of used tires as garbage became a contentious topic in the late 1970s [11]. The development of the car industry in the middle of the nineteenth century brought increased focus to the manufacturing of tires. Problems with public health, the ecology, and aesthetics resulted from the fact that tires were produced in the same places where people used them, and as the tires' useful lives came to an end, the garbage they produced was heaped up [12]. The problem of used tires that have been thrown away is an important one because of the tremendous impact they have on the environment [13]. To put it another way, as can be seen in Figure 1, the use of these tires on motor vehicles will result in the generation of a great deal of waste tires and will do major damage to the environment.

About 17 million tons of used tires are generated annually from the world's estimated 1.5 billion annual tire production [7,14]. The rate at which tires are produced is continuing to increase as the demand for them in developing countries increases at a rapid rate. If we are serious about fixing the environmental damage caused by the improper disposal of used tires, we need to implement environmentally friendly vaporization procedures. In addition, there is a growing need for renewable energy and fuel to lessen the world's dependency on fossil fuels [15]. These days, it's a dilemma for the environment and the economy to find a place to put the world's ever-increasing surplus of used tires. Their demand in less developed countries is always growing [16].

Figure 1: Waste rubber tires.

At the moment, a motor vehicle is an essential component of our lives, and it would be challenging to get by without one. This is especially true in Arab countries, and particularly in Saudi Arabia. Because public transportation isn't always available and, even when it is, it's often inconvenient, the value of owning a car has skyrocketed in recent years. This is especially true in cities that have grown and expanded in recent decades. A private car is the appropriate alternative for those who believe that commuting by public transportation is an unprecedented requirement for effective time management, and that the shift in the ever-growing all-class living style, in addition to the quick pace of life, forces people to be in a hurry all the time. In the past ten years, the population of Saudi Arabia has increased by a factor of four, which has led to the development of enormous urban areas and, most importantly, the proliferation of motorized vehicles. On the other hand, automobile dealers and corporations have implemented new strategies in selling their automobiles, such as easy payment and car financing systems, which have made it much easier to acquire a car in the market. This has resulted in increased competition among automobile manufacturers [18].

III. ENVIRONMENTAL CONCERNS OF TIRES

Tires are huge goods that take up a lot of space in landfills, and are resistant to deteriorate. They are stacked or left behind in a variety of locations, posing hazards to human health and the environment. Open and unplanned dumping of waste tires generates significant environmental problems, and there is no centralized management strategy for the efficient disposal of waste tires. These waste products need to be managed and repurposed in an appropriate manner. Getting rid of tires is tough due to their resistance to being broken down by physical, chemical, and biological means.

Crum Rubber aggregates in cement mortar

The practice of dumping used tires was the most frequent form of waste tire disposal in Europe. The process of discarding trash has become increasingly difficult due to the depletion of garbage disposal facilities, leading to a waste of raw resources and a risk of contaminating groundwater. Studies have revealed that tires can leach contaminants into the water they are stored in, such as zinc, heavy metals, synthetic rubber and rubber compounds, and more. There should be restrictions on tire use and each area should be evaluated separately to ensure the product is appropriate for the local conditions.

Smaller pieces of discarded rubber, often called ground rubber or crumb rubber, can be used for sand or other fine aggregate in cement mortar. Rubber grinding describes this process [19]. Prior research has substituted crumb rubber for fine aggregate using both volumetric and weight-based replacement techniques. The specimens were tested and compared to control samples in terms of their fresh, mechanical, thermal, toughened, and long-lasting qualities. There was a significant drop in compressive strength in all of the trials, but there was a favorable outcome in terms of thermal and durability considerations [20].

Crumb rubber was used to create the lightweight flowable fill, which had a density of 1.2-1.6 gm/cc and was then investigated [21]. It had a compressive strength of 0.02 to 0.09 MPa and a very flowable consistency. Flowable fill can be used to fill in bridge abutments, ditches, and foundations, to name a few applications. In a second approach, tire rubber ash, also known as TRA, which is the residue left over after tire rubber chips are burned at 850 degrees Celsius under controlled conditions, was used to make mortar. The product's compressive, tensile, and flexural strengths were excellent, and it had a delayed initial and final setting time. Increased TRA, on the other hand, has a significant negative influence on workability [22].

Cement-concrete rubber aggregates

The most practical means of reusing discarded rubber products as aggregate are found in the concrete manufacturing sectors. The traditional filler materials, such as gravel and sand, can be partially or completely replaced with rubber particles, and as a result, it is possible to manufacture rubber concrete that possesses some features that are superior to those possessed by ordinary cement concrete. According to Mohd Mustafa Al Bakri et al. (2007), due to the material's considerable decrease in compressive strength, it was deemed an inferior building material with very limited applications [23], the majority of which were non-structural aspects [24]. Coarse aggregate, such as TDAs, is typically used in concrete, but fine aggregate, such as crumb rubber with a size distribution of 1 mm - 5 mm, is more prevalent [24]. The procedure for making recycled rubber tires into concrete is illustrated.

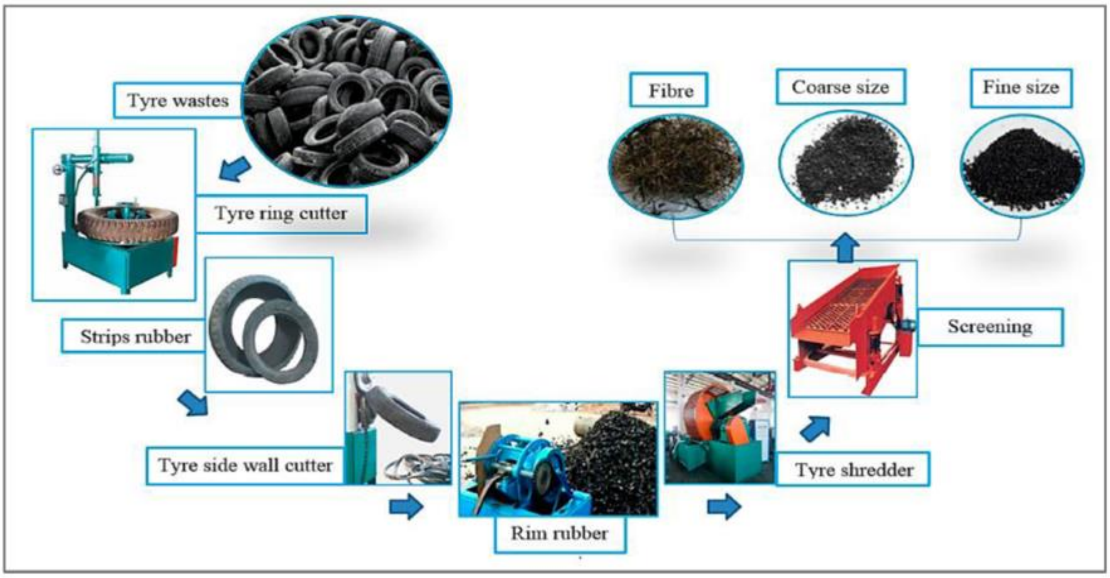

Figure 2: Garbage rubber tire flow chart from waste to concrete [27]

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Previous research has highlighted the need of repurposing waste rubber materials by incorporating them into rubber concrete pavement blocks (RCPBs). While more than this amount of rubber can be used in playgrounds and walkways, nor et al. (2010) state that less than 20% of the rubber component in RCPBs can be utilized for trafficked pavement that requires extra strength [25]. Researchers also developed equations using statistically relevant factors to predict the behavior of rubberized pavement blocks. However, significant inconsistency in the results was found despite the researchers' efforts [26].

Properties of Rubber Mortar and Rubber Concrete

The volume of concrete is at least three-quarters occupied by aggregates, which take up the majority of the space. Because of this, the quality of the aggregates used in concrete is of the utmost importance, despite the common belief that they are neutral and have no impact on the finished product. In addition, aggregates that have undesired properties have the potential to lower the strength of concrete, in addition to having a negative impact on its durability and other mechanical features. There is a lack of both technical standards and suggestions for the production of rubber-based mortar and concrete due to the relative newness of the study of waste rubber aggregate as a potential building material. As a result of this, academics from all over the world are doing in-depth research on this subject in order to discover the qualities of concrete that incorporate waste rubber components as aggregate.

IV. MATERIALS AND METHODS

For the purpose of this investigation, concrete specimens were made by combining water, cement, sand, and crumb tire (in the role of fine aggregate) (Figure 3). Sand that was readily available in the area was utilized for this study. In order to achieve the desired uniformity, elements with larger dimensions were removed from the mixture. Both discarded and recycled waste tire rubber was employed in this study as a source of crumb rubber, and the study also made use of goods that are currently on the market. Table 1 provides a summary of the material's various physical parameters, including its specific gravity, water absorption capacity, fineness modulus, and bulk density.

Figure 3: Crumb tire, Sand and Cement

Table 1: Crumb tire, Sand and Cement

Variables	Sand	Crumb Rubber
Bulk dry specific gravity	2.56	
Bulk SSD specific gravity	2.60	1.15
Apparent specific gravity	2.67	
Water absorption capacity (%)	1.52	1.20
Fineness modulus	2.24	3.68
Bulk density (kg/m3)	-	-

V. SUMMARY

The accumulation of garbage on a global scale, together with an increase in the quantity of waste rubber materials, contributes to deterioration of the natural environment. In order to make effective use of waste rubber products, various routes are investigated; nevertheless, applications in civil engineering have received significantly less attention. In addition, increased urbanization results in a significant increase in the demand for easily accessible concrete as a building material. Rubber crumb has the potential to become a recycled supply of aggregates that may be utilized in the production of concrete, which would have the effect of lowering the concrete's carbon footprint.

In this investigation, varying percentages of crumb rubber were used in place of sand as the fine aggregate, and the behavior and properties of the resulting concrete examples were investigated. The primary areas of focus for this inquiry were the fresh and hardened properties of the concrete sample. The researchers looked at five different concrete samples. After that, the effectiveness of the rubber-based concrete was evaluated and contrasted with that of the control mix. The findings of the study are broken down into sections and recapped in this chapter. In addition to that, suggestions for directions for further research are provided.

VI. CONCLUSION

A variety of crumb tire replacement levels in concrete were tested to see how they affected the mechanical and electrical qualities of the concrete. The following is a condensed summary of the findings that emerged from this investigation: A variety of crumb tire replacement levels in concrete were tested to see how they affected the mechanical and electrical qualities of the concrete. The following is a condensed summary of the findings that emerged from this investigation:

1. Lower slump values were observed in rubber-based concrete as a result of an increase in the proportion of crumb rubber present in the mixture. The volume of air, on the other hand, increased in proportion to the growing number of rubber particles. These occurrences were brought about because shredded rubber repelled water and trapped air within the spaces it created, respectively.
2. When crumb rubber was employed in concentrations higher than 10%, a discernible drop in compressive strength was seen. An increase in the amount of rubber present in the matrix led to the formation of interfacial connections that were inadequately strong between the cement matrix and the rubber particles. Despite this, both 5% and 10% crumb rubber gave values that were comparable to those of the control batch, which meant that they both exceeded the specified strength of 35 MPa. Up to 10% of the crumb rubber had to be replaced for the projected design criteria to be met, despite the fact that there was a considerable drop in strength. In order to increase the amount of environmentally friendly rubber-concrete that is used on a large scale, the federal and provincial governments could offer financial incentives to the concrete sector as well as to consumers.
3. The strain capability of concrete made with crumb rubber, on the other hand, was shown to be superior to that of concrete made with no rubber at all. In light of this, rubber-based concrete had a greater degree of deformation prior to its total breakdown when compared to ordinary aggregate-based concrete. Because of this event, the collapse of the concrete occurred in a slow and progressive manner, which indicates that the material possesses positive properties.
4. The splitting tensile strength and the flexural strength of rubber-based concrete samples decreased when there was an increase in the amount of crumb rubber used as a replacement. However, when compared to the control sample (R0), the sample with 5% crumb rubber replacement exhibited a superior performance, demonstrating enhanced tensile strength capacity. In addition, the drop in tensile strength was far less severe in comparison to the reduction in compressive strength.
5. While the unit weight of crumb rubber-based concrete exhibited a decreasing trend with increasing crumb rubber content, water absorption capacity showed an increasing trend with increasing crumb rubber content. The lower relative density of the crumb rubber led to a considerable reduction in the unit weight of the concrete. On the other hand, the enhanced water absorption capacity was caused by the entrapped air voids.
6. Based on the results of the impulse voltage test, it can be concluded that tire concrete has better electrical insulation properties compared to control concrete. These results can be used to support the design and evaluation of electrical components and systems that incorporate tire concrete, and to guide future research in this field.

VII. RECOMMENDATION

Concrete made from shredded rubber clearly qualifies as an environmentally friendly option for the responsible production of building materials. The findings of this study would increase academics' interest in working toward a time where there is no waste. The demand for aggregates derived from natural sources might go down if crumb rubber becomes more widely used. Because of increased demand in the concrete industry, natural sources of aggregates are becoming increasingly difficult to come by across the globe. Since the incorporation of rubber into concrete is still a relatively novel idea, additional research must be conducted before the product can be recommended as an alternative to concrete that is based on natural aggregate. Some possible topics for further research are as follows:

a) The decrease in compressive strength makes it difficult to use crumb rubber-based concrete for structural purposes. It is possible for surface modifications to be made to crumb rubber by the use of chemical treatment, plasma treatment, and ozone treatment. This could become an important area of research. These techniques could potentially increase the contact angles between the cement paste and the rubber, which would result in improved bonding.

b) In order to boost the mechanical strength of concrete without resorting to the use of cement as a binder, fly ash and cement can both be employed, albeit in varying proportions, as an alternative.

c) Utilizing recycled rubber-based concrete as recovered coarse aggregates (RCA) is one potential new line of inquiry that might be pursued.

d) Here we need to add the uses of rubber as a track for horses and also in the roofs of buildings as a thermal insulator - and also as a water insulator

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