MANUFACTURE OF CONCRETE STRUCTURAL BLOCKS WITH RUBBERS FOR THE WASTE TIRE

MANAS RANJAN DAS

*Research Scholar, Department of Management, Siksha 'O' Anusandhan (Deemed to be University),
Bhubaneswar, Odisha, India*

ABSTRACT

Growing industry is a major user of natural resources and is directly tied to the country's technological and industrial development. Different segments of society have turned to sustainability principles, finding alternatives to reduce the impacts caused by the use of, in most cases, infinite raw material and the large volume of waste produced, including waste tire rubber. As well as reducing the use of natural resources such as sand and gravel, the use of waste as raw materials in construction can also minimize the accumulation of such tailings in urban areas, making it also a technological solution providing benefits to buildings such as: Reduced density, increased ventilation, and better thermal and acoustic insulation properties. The purpose of this work is to demonstrate the use of waste tire rubber as an aggregate in concrete building blocks, showing the relationship between the term sustainability and the application, by testing their physical and mechanical properties through the collection of bodies of evidence generated in the laboratory.

KEYWORDS: Concrete Block Construction, Tire Rubber Residue, Sustainability

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INTRODUCTION

The quest for solutions to environmental issues is now widespread, especially with regard to the sustainable reuse of solid residues such as recycled materials in the building industry. Rubber tyres are highlighted because of the articulate volume produced from the many different solid residues. 70.7 million units sold in Brazil in 2016 alone. The refurbished fraction of the used tyres were wrongly disposed of in dumps, forest areas, highway margins and metropolitan riverbanks. The alternative aggregate diminished to industrial residues, with promising results from its reuse.

In the present day, the use of emerging technology and the optimization of resource usage allow the construction industry to plan and implement projects that meet the guidelines for sustainability. In parallel with the advancement of concrete technology, by adding new components and additional minerals, it is observed that the composition and production of concrete blocks is going through a significant phase of change[1], [2]. The possibility of introducing building and demolition residue and tyre rubber residue which are used in partial or complete replacement of the small and large aggregates is one particular improvement procedure. The substitution is made dependent on the final properties of the material that must be obtained.

Due to the inherent properties of this material, such as lightness, elasticity, energy absorption and thermal and acoustic properties, the recycled rubber aggregates are a promising alternative in the construction industry[3]–

[5]. That the concrete made using recycled rubber improved some of the concrete properties, such as thermal and acoustic insulation, decreased density and increased durability. Because of the great abundance of tyre residues, it is important to reuse this material sustainably in civilian construction. As an alternative aggregate to concrete, a widely explored usage of tyre rubber reuse[6]–[9].

2. WORK DESCRIPTION

The purpose of this work is to check, using physical and mechanical behaviors, and the technological feasibility of using tyre rubber residues as alternative aggregates in the composition of a structural concrete block. The basic goals are:

- Tyre retreading residue collection;
- Tyre residue characterization;
- Characterization of the products that will make up the concrete;
- Dosage analysis using the ACI / ABCP method (Brazilian Portland Cement Association's ABCP dosage system, adapted from the American Concrete Institute's ACI dosage system);
- • Concrete production with addition of concrete.

3. MATERIALS AND METHODS

In this section are described the methodology used in the development of this work.

3.1. Collection of Tyre Re-Treading Residues

The tyre rubber residues were collected from a re-treading company, Real Cap, located in the city of Machado, Minas Gerais. On Figure 1, it is presented a sample of the re-treading residues[10], [11]. The residues were collected from a pile of rejected material in random points, on the border, core and top of the pile, totalling 250 litres.

Figure 1: Rubber Residues.

3.2. Tyre Residue Characterization:

The tyre residues were characterized only by its granulometric composition, according to the ABNT NM 248:2003 specifications. A mechanical sieved, alongside the standard sieve series was used. A precision balance was used in order to quantify the fraction of the mass accumulated in each mesh.

3.3. Characterization of the Materials That Will Compose the Concrete:

In this section are presented the methodology used for the characterization of the concrete components.

3.4. Cement:

The cement used in the work, a CP-V ARI, produced by Itaú, was characterized only via the determination of its specific mass, using the Le Chatelier vial.

3.5. Sand:

Initially, the sand sample was dried in a oven and then, the granulometric distribution essay was conducted, using a mechanical sieve, the standard sieve series and a precision balance in order to assess the fraction of accumulated mass in each mesh. The specific mass determination essay was conducted using a precision balance and a Chapman's vial. The loose state unitary mass was also determined, using a scale up to 50 kg, a recipient with known mass and volume and a temping rod to pave the sand in the top of the recipient.

3.6. Granitic Gravel:

Granitic gravel was used and, it was initially dried in an oven and then was subject to the granulometric distribution essay. In this essay a mechanical sieve, a sieves set and a precision scale, in order to measure the accumulated mass of each mesh, were used. In addition, the specific mass determination specifications the compact state unitary mass determination.

3.7. Concrete Dosage Study:

For the concrete dosing study, the dosing method ACI/ABCP was used. The method consists in the optimization of the consumption of the small and large aggregate, specifically aiming in the reduction of the small aggregate in order to reduce the wetting specific surface.

3.8. Production, Moulding and Cure of the Concrete Block Samples:

The concrete was produced in the laboratory of the Centro Universitário do Sul de Minas. The production used a scale, a recipient to weight the component of the concrete and a concrete mixer. After that, the concrete block samples were moulded into cylinders of 10 x 20 cm. After 24 hours, the concrete blocks were unmoulded and the blocks were taken to the immersion tank for curing.

3.9. Compression Strength:

The compression strength determination of the concrete was conducted standard. The determination used a manual hydraulic press with electronic load visor, neoprene discs for a better load distribution in the sample concrete block.

3.10. Tensile Strength by Diametric Compression

The tensile strength by diametric compression essay was conducted. The determination used a hydraulic press and steel parts for a better load distribution on the sample concrete block.

4. RESULTS

The results of the residue's granulometric distribution with fine sand addition of 20 %, 25 %, 30 %, 35 %, 40 % and 50 % are presented. After verification of the ideal mixing between the fine sand and the recycle product, the preferred mixing range was used with 35 % fines and for the recovery process, which was the mixture of residue and sand that was the closest of the optimum area of use of ABNT NBR 7211: 2009, promoting in this case a better packaging of the grains and

consequently increasing the compactness of the concrete.

During the Development of the Final Mixtures, Based on the Dosing Studies Via The ACI / ABCP Method, Acronyms Were Used For Each Mixture Developed, Being Those:

- CRB 1 – Concrete with rubber residue1;
- CRB 2 – Concrete with rubber residue2;
- CR 1 – Reference concrete 1.

The concrete was dosed in order to achieve the minimum compression strength of 35 MPa, as established [15].

During the concrete production, it was observed that the rearing residues had influences in the work ability. When compared to the mixture CRB 1 and CR 1, it was verified that with a same A/C relation, the CRB 1 concrete had a lower abatement due to the geometry of the rearing residue particles, which increased the specific wetting surface and thus, had influence in the work ability.

4.1. Compression Strength

After the sample concrete blocks were cured by immersion for 7 days, compression strength essays were conducted. A comparison was made between the mixtures CRB1 and CR1, once they had the same cement per cubic meter consumption, the same A/C relation. An 80% drop in the strength compression was observed when the results are compared, which could be caused by the geometry of the residue particles. The results are shown in Figure 4 and are an arithmetic average of 6 essays.

Even though a significant drop in the compression strength was observed, the concrete with the addition of rearing residues had an increased tenacity during the axial compression essays. It was observed that before breaking, the concrete with rubber deformed significantly and, when the breaking occurred, it happened less abruptly when compared to the conventional concrete. This tenacious behavior of the concrete is due to a decreased elastic modulus, compared to the conventional concrete, which can be explained by the high deformation capacity of the tyre rubber, present in the cement mixture. Considering that the elasticity modulus of the concrete is directly linked to the compression strength, a higher deformation in the concretes containing rubber means a lower elasticity modulus, which means a drop in compression strength. The tenacious behavior of the concrete blocks samples with addition of rubber can be observed in Figure 2 and Figure 3.

The essay of the determination of the tensile strength by diametric compression was conducted [14]. A decrease of 66 % was observed in the tensile strength when the mixtures CRB 1 and CR 1 were compared. The decrease is proportionally lower than the decrease observed in the compression strength results.

Figure 2. Test Specimens after Axial Compression

Rupture.

4.2. Tensile Strength by Diametric Compression

Figure 3: Test Specimens after Compression Rupture.

5. CONCLUSIONS

The results of the analyses and tests conducted on concrete properties with the addition of rubber showed that the decrease in mechanical resistance and the rise in water absorption were directly affected by the tire residue geometry. During the research it was confirmed that there is a decrease in mechanical resistance when rubber is used which also affects the work ability.

After the test, it is highlighted that when compared to conventional concrete, the ability of the concrete with rubber addition to absorb the load through deformation was significantly greater. This trait is an important point when it is necessary to execute concrete with greater tenacity. As contrasted with traditional materials, the use of concrete with rubber addition may be an option in reducing cracks in the concrete. In general, it can be inferred that the concrete with the addition of rubber is a feasible solution for the development of structural blocks from the perspective of the mechanical properties analysed. On the basis of the results obtained, positive results will emerge from the use of rubber residues in civil building, along with resolving environmental problems and thereby providing physical, economic and social improvements.

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