

## Use of RCDs in the Making of Interlocked Pavements with Waste Collected at the Federal Institute of Amazonas – CMC

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### Abstract

The area of construction is responsible for a large portion of non-renewable natural resources that generate environmental impacts, since the extraction of materials and extend in large scale as waste from renovations, works and demolitions, causing construction and demolition waste, known as RCDs. The aim of this study is to analyze the feasibility of reusing recycled waste from mortars, concrete and ceramic bricks in civil construction, as aggregates in the manufacture of interlocking blocks, in order to simulate the reality of the conventional block produced in the civil construction sector. For the tests, 6 concrete load specimens were molded with coarse aggregate and fine aggregate percentages, respectively: 50% and 25%, following the parameters of NBR 5738. It was possible to conclude that the interlocking pavement made with RCDs is useful. to improve the permeability of land, sidewalks and streets, enabling ordinary people within their homes to produce and apply them.

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# **Use of RCDs in the Making of Interlocked Pavements with Waste Collected at the Federal Institute of Amazonas – CMC**

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## **Abstract**

*The area of construction is responsible for a large portion of non-renewable natural resources that generate environmental impacts, since the extraction of materials and extend in large scale as waste from renovations, works and demolitions, causing construction and demolition waste, known as RCDs. The aim of this study is to analyze the feasibility of reusing recycled waste from mortars, concrete and ceramic bricks in civil construction, as aggregates in the manufacture of interlocking blocks, in order to simulate the reality of the conventional block produced in the civil construction sector. For the tests, 6 concrete load specimens were molded with coarse aggregate and fine aggregate percentages, respectively: 50% and 25%, following the parameters of NBR 5738. It was possible to conclude that the interlocking pavement made with RCDs is useful. to improve the permeability of land, sidewalks and streets, enabling ordinary people within their homes to produce and apply them.*

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## **1. Introduction**

The Civil Construction is one of the major responsible for impacts on the environment today, the CONAMA resolution [1], aims measures to mitigate the problems caused by the incorrect disposal of construction waste, these wastes, according to [2], mostly come from demolitions, repairs and civil works. In the city of

Manaus the problems caused by the improper disposal of the RCDs is imminent, representing about 40 to 70% of solid waste, due to the lack of a National Solid Waste Policy directed exclusively to these problems [3] [4]. Currently, the application of techniques and reuse of materials at construction sites and systems implementation in the city of Manaus, is an activity that is being carried out through the Construction Solid Waste Management Plan (PGRSCC). With [5], the generator of a waste can distinguish the risk potential of the same, as well as distinguish alternatives for its final destination. Based on bibliographic surveys, the study aimed to analyze the reuse of recycled aggregates for paving in concrete blocks, interlocking pavements. Through this survey it was possible to apply the recycled aggregate, originated from mortars, concrete and ceramic bricks, collected at the Amazonas Federal Institute - CMC (Campos Manaus Centro), located in the city center of Manaus, where this application contributed to obtain interlocked pavement prototypes, being analyzed and tested as an aid in the waste reuse process in civil construction.

## 2. Theoretical Referential

In Brazil, the use of recycling construction waste in paving began in the 1980s [6]. In Europe and the United States this kind of work began after World War II, but it was no longer attractive. During the 1990s, recycling plants were installed in cities in Brazil, being managed by city halls and private companies. In several European countries, the disposal of construction waste to landfills has been less and less tolerated; As a way to inhibit it and encourage recycling, new laws have been introduced and a landfill tax policy has been adopted [7]. Environmental issues and the scarcity of natural resources are directly linked to the economic development of the country, and Manaus is among the capitals with the highest growth rate in the construction industry [3]. In the capital of Amazonas, the most common waste construction waste is ceramic bricks, mortar, ceramics, tiles, paint materials and concrete blocks from demolitions and constructions. It is noteworthy that in Manaus it is common to find waste deposited in inappropriate places, such as clandestine boots, on vacant lots far from the city and on the banks of streams. This generates siltation of watercourse margins, as well as clogging of culverts and galleries, producing environmental and social problems [3].

## 3. Methodology

To carry out this study, the production of the prototypes was divided into two stages, collection and preparation of construction and demolition waste (RCDs), and preparation of specimens (cylindrical and hexagonal shape) with percentage of recycled aggregates. The residues were obtained from the collection of samples in the site of the Federal Institute of Amazonas - CMC of Manaus city, having as aggregates: ceramic bricks; mortar and its components; and concrete blocks. All samples were milled using the Los Angeles machine (figure 1).



Figure 1 - Los Angeles Machine.



Figure 2 – Mechanical Peneirament

After grinding the samples, their characterization was performed. Where they were separated by size by the sieve method with the mechanical sieves (figure 2) of sizes respectively: 9.5, 4.8 and 2.4 mm, being 9.5 and 4.8 mm coarse sieve (figure 3 and 4) and 2.4 mm fine aggregate (figure 5), respecting the determination of the fineness mode established by Standard 248 - Determination of particle size composition. According to [8], mechanical agitation of the set should be promoted for a reasonable time to allow the separation and prior classification of the different grain sizes of the sample.

Figure 3 – Graded aggregate  
- 9.5 mm.Figure 4 – Graded aggregate  
- 4.8 mm.Figure 5- Mud aggregate -  
2.4 mm.

For the tests, 6 concrete load specimens were molded with coarse aggregate and fine aggregate percentages, respectively: 50% and 25%, following the parameters of [9]. The preparation of the specimens was obtained through the composition of the residues by the tactile-visual characterization process that determined the composition of the residues. The water / cement factor tested initially was 0.5, but the mixture was dry, later to have a better use it was used the water / cement factor of 0.8 which showed a good behavior in the mixture of the trace.

For the production of interlocked was adopted the 1: 3: 3 dash (in volume). The choice of this trait was made because it is a very usual and efficient in practice, something that would facilitate the use in case of interest for its execution.

One of the most important performance parameters of a structure and therefore of pavers is the compressive strength test [10]. The pieces were submitted to this test in the Materials Testing Laboratory of the Federal Institute of Amazonas (IFAM-CMC), Manaus-AM.

#### 4. Analysis and Discussion of Results

With the completion of sample preparation, the specimens were removed from the submersion to perform

the tests according to established concrete cure reference standards [9]. The specifications conclude the usual 28-day cure for compressive strength, and the results achieved at 28 days of this study were used in the analysis. Checking Tables 1 and 2, it is possible to observe that none of the prototypes reached the minimum resistance of 35 MPa, established by [11]. Regarding the results, after the compression tests, it was possible to analyze that the maximum compressive strength obtained in the samples reached 4.73 MPa, for the cylindrical specimens, as observed in Table 1. All the tests were established by [12], which has as a parameter to determine and define the test of compression of the specimens, in order to evaluate its resistance in relation to the molds already established by [9].

Table 1. Characteristics of cylindrical specimens.

Pattern	Age	Breaking force	Section	Breaking stress
RCD 01	10	2.657 (kgf)	31,17 (cm <sup>2</sup> )	3,32 (MPa)
RCD 02	14	3.294 (kgf)	31,17 (cm <sup>2</sup> )	4,11 (MPa)
RCD 03	28	3.785 (kgf)	31,17 (cm <sup>2</sup> )	4,73 (MPa)

Characteristics of cylindrical specimens after compression tests for three cure periods - 10, 14 and 28 days.

In municipalities where recycling facilities are in place, the results have been positive and most of the tailings are used for paving, but they can still be successfully applied in erosion control, drainage layers, landfill cover, etc. rip-rapetc [13].

Evaluating the results obtained, according to Table 2, it was observed that the compressive strength was higher in the samples contained in hexagonal forms, reaching 7.50 MPa when compared to those contained in specimen cylinders, this is due to these pieces have a larger diameter.

Table 2. Characteristics of hexagonal specimens.

Pattern	Age	Breaking force	Section	Breaking stress
Bloco RCD 01	10	1.538 (kgf)	31,17 (cm <sup>2</sup> )	4,84 (MPa)
Bloco RCD 02	14	2.038 (kgf)	31,17 (cm <sup>2</sup> )	6,41 (MPa)
Bloco RCD 03	28	2.383 (kgf)	31,17 (cm <sup>2</sup> )	7,50(MPa)

Characteristics of cylindrical specimens after compression tests for three cure periods - 10, 14 and 28 days.

It was observed that the higher the proportion of substitution by recycled aggregate, the greater the resistance reduction, ie, the 40% substitution always resulted in lower resistance values when compared to the 20% substitution values [14] [15]. .

The substitution for recycled aggregates in the study was 75% being divided and placed as small and large aggregates. According to figure 6 it is possible to verify that the use of recycled aggregate was higher than 40%, percentage obtained through the study according to [14], as follows: Ceramic brick: 32%; Mortar and its components: 15%; Concrete blocks: 28% [16]. Even though the results obtained through this substitution



and the mechanical resistance were not promising in relation to the rupture stress described by the standard [11], it is possible to use RCDs to make pavers, that is, there is no impediment to that there is the production of these floors.

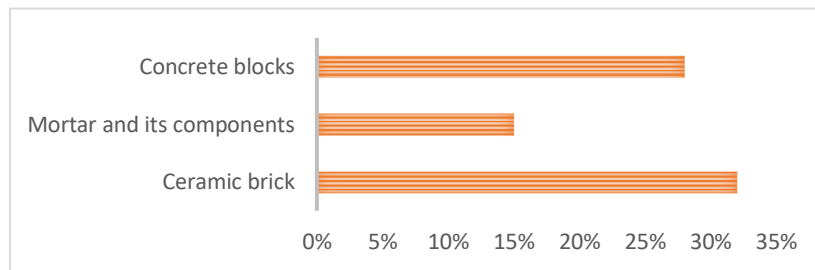


Figure 6. Quantification of RCDs in specimens.

Because it is concrete, its use for the manufacture of interlocking pavements for use in sidewalks, slow-moving streets, gardens and for architectural increments, should not be influenced by compression tests that did not have a minimum resistance of 35 MPa, according to [11] [17].

## 5. Conclusion

In view of the arguments presented, it was observed that the generation of waste happens on a large scale, especially when it comes from major demolitions and renovations, since the aggregates exhibit good behavior when they are reused in the process of “pavers”. The study aimed to simulate the reality of the conventional block produced in the construction sector and to demonstrate to the population the environmental impacts that are caused by its incorrect disposal.

Environmental awareness about RCDs is slowly taking place [18], policymakers have more reason to think about recycling because cities do not have space to store waste, and have perspective on recycling budget gains, and are able to higher marketing if they invest in environmental protection.

Therefore, although interlocking blocks used as prototypes do not achieve good strength, their application can still be useful for improving the permeability of terrain, sidewalks and streets, enabling ordinary people within their homes to produce and apply them. correctly by collaborating with the community and encouraging the implementation of less impermeable soils.

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