INVESTIGATION OF CDW HETEROGENEITY IN BRAZIL: A PROPOSAL OF LOW-COST RECYCLING PLANT

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ABSTRACT

Construction & Demolition Waste (CDW) is not homogeneous in terms of composition, particle size distribution and porosity. In many Brazilian recycling plants, gypsum and cement asbestos is visually identified without certain diagnose capable to quantify the importance of such secondary components. This paper analyzes some important characteristics of CDW (grain size distribution, composition, density distribution) from different regions in Brazil (states of Sao Paulo, Rio de Janeiro and Alagoas) carried out on samples obtained from a large sampling campaign. Based on these characteristics, a laboratory processing study was done to establish the most efficient hand sorting procedure to be combined with a low-cost recycling plant proposal (without crushing system).

Keywords: Heterogeneity, Construction & Demolition (C&D) Waste, Characterization, Processing, Low-cost C&D recycling plant.

1. INTRODUCTION

Different from US and European housing constructions, pre-cast concrete panels or structural concrete masonry is scarcely used in Brazil. Quality of structural reinforced concrete in Brazil is governed by the number of storeys. It is difficult to distinguish visually when mixed with low-strength masonry concrete or red ceramic blocks (< 5 MPa), depending of regional availability, and with poor quality concrete from external floor.

So, Construction & Demolition Waste (CDW) is not homogeneous in terms of composition, particle size distribution and porosity both in Brazil and abroad [1, 2]. In many Brazilian recycling plants, gypsum and cement asbestos are visually identified without certain diagnose capable to quantify the importance of such secondary components.

Concrete pieces usually require crushing; however, it can be not necessary for small pieces of masonry blocks, a very common material in Brazil [3]. A recycling plant that does not
require crushing will significantly reduce investment and operational costs, improving economical feasibility of recycling for small municipalities. The amount of pure concrete waste that can be received in a recycling plant is usually unknown here.

There are nowadays around 26 CDW recycling plants operating in Brazil [4]; mostly of them without quality control of the resulting aggregates and trying to implement the simplest way of C&D recycling application (road subbases and bases). These facts make heterogeneity of CDW be treated like a secondary problem even though such aspect is the key for recycling process success. Decontamination procedures of CDW are scarcely discussed in the literature [5] even though it is especially important when mixed CDW is the main material available, like in Brazil.

This paper analyzes some important characteristics of CDW (particle sizes, composition, density distribution) from different regions in Brazil (states of Sao Paulo, Rio de Janeiro and Alagoas) carried out on samples obtained from a large sampling campaign (126 containers of 5 m³). Based on these characteristics, a lab processing study was done to establish the most efficient hand sorting procedure to be combined with a low-cost recycling plant proposal (without crushing system).

2. MATERIALS AND METHODS

2.1 Sampling of CDW

CDW samples were collected in three Brazilian cities (Macae-RJ, Sao Paulo-SP and Maceio-AL). In Macae, 52 CDW containers (4-5 m³) were collected; the waste was reduced to size lower than 20 cm, approximately, by a sledgehammer. 1/3 of the volume of each container was alternately shoveled by a backhoe loader and, then, homogenized by a horizontal pile. Such procedure reduces sampling errors [6]. After homogenization, 500 kg of each CDW sample was taken for characterization essays. The same sampling procedure was repeated for waste from the other cities, but, in these cases, 47 and 27 containers were collected at Sao Paulo and Maceio, respectively.

2.2 Characterization of CDW samples

In the laboratory, the 500 kg samples were sieved at 80 to 25.4 mm screen apertures, generating the following size fractions (in mm): +80; -80+25.4 e -25.4. The fraction lower than 25.4 mm was homogenized again and, then, was reduced to 1/10 of total volume. In the sequence, the sample was sieved in 4.8 mm sieve aperture, generating two other size fractions: -25.4+4.8 mm; -4.8 mm.

The material components of the near 5 kg of C&D aggregates (-25.4 + 4.8 mm) were visually divided in different groups by hand sorting. Contaminants were divided in the following materials: glazed tiles/glass, wood, gypsum, cement asbestos, and others. The main components were divided in cement/rock and red brick particles. The mass of all components were determined and expressed in percentage.

Furthermore, around 5 kg of C&D aggregates (-25.4 + 4.8 mm) was submitted to new tests of sequential sink-float separations (in a Denver® pilot-scale cone) as schematically...
illustrated in Figure 1, using ferro-silicon powder water suspensions with densities of 1.9; 2.2 and 2.5 g/cm³ [7].

![Figure 1. Schematic representation of the sequential sink-float separation.](image)

Finally, part of CDW was composed in around 5 samples with different contents of contaminants (tiles/glass, wood, gypsum) inside; 1 ton each. Such samples were submitted to lab simulated hand sorting decontamination procedures (Figure 2): a) in conic pile, b) spreading CDW in a plan area simulating usual sorting in recycling plant and c) in large conveyor belts.

![Figure 2. Lab procedure to evaluate efficiency of hand sorting procedures.](image)
The efficiency of hand sorting procedures was evaluated by the mass recoveries [8], expressed by the Eq. 1.

\[
\text{Recovery}(\%) = \frac{C_{\text{sorted}}(kg)}{C_{\text{all}}(kg)} \quad (\text{Eq. 1})
\]

where:

\( C_{\text{sorted}} \) – contaminants sorted, in kg.
\( C_{\text{all}} \) – all contaminants, in kg.

3. RESULTS AND DISCUSSIONS

3.1 Grain size distribution

Figure 3 shows the CDW grain size distribution attained by wet sieving from three Brazilian cities. The average grain size distribution of the waste from each city is represented by continuous line while the upper and lower limits are shown in dashed lines. This variation demonstrates the compositional variability of the CDW, some of them with large pieces of concrete (>50mm) and some with high content of intermixed soil.

Since concrete waste is scarce in Brazilian waste, it is observed a high proportion of material below 50 mm (50 – 70% in mass), which can be used directly as aggregate for subbase of pavement without the necessity of crushing in accordance with this specific characteristic.
3.2 Compositions of CDW aggregates

Compositions of CDW aggregates are presented in Figure 4. The most important contaminant material is glazed ceramic/glass: 1.85; 3.06 and 3.34 % (average), respectively. In the city of Macae, the average content of gypsum is very high, around 1.91 %. For all cities, cement asbestos was found in almost all characterized lots, 0.18-0.63 % on average. Due to the absence of selective practices of sorting in renovation sites (the most important source of CDW in Brazil), decontamination of C&D aggregates is the most important activity, especially due to the presence of glazed tiles, gypsum and cement asbestos. The presence of pure structural concrete waste is rare for all cities. Mixed aggregates with variable contents of red ceramic are the consequence: 13-26 % on average. Pure red ceramic aggregates are rare.

Figure 3. CDW size fractions (average-line; max/min – dashed lines) in Brazil:
   a) Macae-RJ, b) Sao Paulo-SP, c) Maceio-AL.
3.3 Density distributions of CDW aggregates

Figure 5 presents the density distributions of CDW aggregates from Brazil. There are large variations in the following density classes (kg/dm$^3$): $d< 1.9$ and $d> 2.2$. The lowest density class is mainly influenced by the content of red ceramic and represents aggregates with the highest porosity. The highest density class is related to the presence of structural concrete and composed by the lowest porosity aggregates.
3.4 Decontamination of C&D aggregates by hand sorting procedures

Figure 6 shows the efficiency of decontamination of C&D aggregates by different hand sorting procedures (in pile, in area and in conveyor belts). For all procedures, on the investigated range, the mass recoveries by hand sorting increase in accordance with the increase of contaminants contents. The most efficient procedure of hand sorting is decontamination in conveyor belts (80% of mass recovery, on average). The worst one is decontamination in conic piles (30 % of mass recovery, on average) and it is also the most common procedure in Brazilian CDW recycling plants.
Adopting the average mass recoveries in the two mentioned hand sorting procedures, the average contaminations in C&D aggregates from three Brazilian cities can be expected (Table 1). The decontamination in conic piles (the most common procedure in Brazil) would result in contaminated C&D aggregates, not feasible to be applied in road bases or subbases (ABNT, 2004). By decontamination in conveyor belts, the use of C&D aggregates would become possible.

Table 1. Contamination (% in mass) expected in C&D aggregates according to hand sorting procedures.

<table>
<thead>
<tr>
<th>City-State</th>
<th>Before hand sorting</th>
<th>After hand sorting</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>In Pile</td>
</tr>
<tr>
<td>Macae-RJ</td>
<td>5.34</td>
<td>3.74</td>
</tr>
<tr>
<td>Sao Paulo-SP</td>
<td>3.74</td>
<td>2.62</td>
</tr>
<tr>
<td>Maceio-AL</td>
<td>4.45</td>
<td>3.12</td>
</tr>
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4. CONCLUSIONS

Based on characterization of CDW samples from three Brazilian cities and the use in road base and subbases, some conclusions can be remarked:

a) 50 – 70 % of CDW in mass is bellow 50 mm and has appropriate grain size to be used directly in pavement sub-base without the necessity of crushing in the recycling plant.

b) A recycling plant without crushing equipment will drastically reduce investment and operational costs, improving economical feasibility of recycling for small municipalities.

c) Decontamination of C&D aggregates is the most important activity, especially because of the high contents of glazed tiles, gypsum and cement asbestos.

d) The decontamination in conic piles (the most used procedure in Brazil) would result in contaminated C&D aggregates, not feasible to be applied in road bases or subbases.

e) By sieving and decontamination in conveyor belts, the use of C&D aggregates may become possible for road bases or subbases. Other important pavement essays such as CSI (California Support Index), aspect ratio etc should be done to conclude about this technical feasibility.

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6. REFERENCES


