EXPERIMENTAL ANALYSIS OF THE REUSE OF WASTE FROM PREFABRICATED CONCRETE PILES: CASE OF A PORT WORK

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ABSTRACT

Construction waste in large works is poorly studied. Port works have peculiar characteristics and it is interesting that designers have indicators of waste generation. In this work, the generation of waste from the activity of logging concrete piles and their reuse process was analyzed, generating indicators for the project. The research methods covered the quantification of the reuse of piles in the activity itself and the quantification of waste intended for disposal. Results showed that 49.2% of piles used leftovers, which represented 12.98% of the total length driven (242210 m). The study showed that the average apparent density of concrete waste from piles comminution is 0.47 ± 0.02 tons.m⁻¹ on average. For the metal scrap 0.70 tons m⁻². The results showed the great potential for reuse of materials that has the activity of driving concrete piles, which is environmentally desirable. It is concluded that the indicators obtained are an important instrument for waste area designers, especially in the area of port buildings, where there are few data available in the literature.

INTRODUCTION

Over the last thirty years, both researchers and practitioners have paid growing attention to the negative environmental impacts (air pollution from factories and traffic, marine pollution and industrial wastewater, ship-generated pollution such as oily wastes, numerous solid wastes, underwater noise, and ballast water) of port operations and development (Di Vaio et al., 2019; Mohee et al., 2012). Ports tend to assume poorly managed waste, which requires that a comprehensive and updated knowledge of the several solid wastes streams be obtained from as many as of the waste generators (Zuin et al., 2009). The construction industry, a major generator of direct and indirect jobs, has a significant participation in global economic development. It is estimated that the volume of construction and demolition waste (CDW) in Brazil represents approximately 67% of the total municipal solid waste (MSW) generated in the country (Schamne and Nagalli, 2018). This situation stems from the low efficiency of the management process of the CDW, which ultimately provides inadequate treatment and disposal of waste (Schamne and Nagalli, 2018). Research on construction and demolition waste has been increasing significantly (Yuan, 2013). As the generation of construction and demolition waste is inevitable, in urban environments, during the consolidation of cities, during periods of population expansion efforts need to be permanent and necessary to carry out further management in the construction and demolition sector (De Melo et al., 2011). One of the strategic sectors for the economy of a country is the port, responsible for the flow of materials and goods. Some
The retroarea in which the concrete piles were spiked was 150018.70m², with 7424 reinforced concrete piles with an average length of 32.63m. In the expansion work, there was a very large variation in relation to the length of the piles, which even measured between 23.0m to 49.0m deep. The elements had 11.0m, so it took scrap cuts in the stakes so that they could reach the project quotas. Only the first longitudinal line of the stakes mine service, the reuse of pile pieces was studied; (ii) the generation of waste from unused pile pieces. Centrifugal concrete piles were prefabricated with a standard length of 11.0 meters. Metal gloves were used as tips, with a height of 80cm, thickness of 5mm and with locking pins for better fixation. As the total length of the piles ranged from 23.0 to 49.0m, these were amended as needed, razing them in the project quota. The research consisted of evaluating the technical criteria for reusing these piles and their impact on waste generation. An engineer and two quality officers performed the sorting of pile leftovers, using various methods to verify the integrity of elements and piles with less than two meters were automatically discarded. The second research front consisted of assessing the quantity and characteristics of construction waste generated when pile pieces could not be reused. The technique adopted in the work was to break up such pieces of piles and turn them into concrete aggregates for landfilling and steel for recycling. In this stage, 20 samples of pile remains were selected. The samples were measured and then ruptured separately with the aid of a hydraulic backhoe with a breaker. For each pile, concrete steel was separated. By means of a backhoe, the broken material was introduced into a 5m³ stationary bucket. Then the stationary bucket containing the waste was hoisted through a Model SANY 70t crane and weighing through the crane's own scale was performed. The weight of the cables, lifting straps and the weight of the bucket were discounted and equated to 2t. The sequence of activities in this stage of the survey can be seen in Figure 2.

Methodological approach: Aiming at the generation of quantitative indicators of waste applicable to the concrete pile stake mine service, the reuse of pile pieces was studied; (ii) the generation of waste from unused pile pieces. Centrifugal concrete piles were prefabricated with a standard length of 11.0 meters. Metal gloves were used as tips, with a height of 80cm, thickness of 5mm and with locking pins for better fixation. As the total length of the piles ranged from 23.0 to 49.0m, these were amended as needed, razing them in the project quota. The research consisted of evaluating the technical criteria for reusing these piles and their impact on waste generation. An engineer and two quality officers performed the sorting of pile leftovers, using various methods to verify the integrity of elements and piles with less than two meters were automatically discarded. The second research front consisted of assessing the quantity and characteristics of construction waste generated when pile pieces could not be reused. The technique adopted in the work was to break up such pieces of piles and turn them into concrete aggregates for landfilling and steel for recycling. In this stage, 20 samples of pile remains were selected. The samples were measured and then ruptured separately with the aid of a hydraulic backhoe with a breaker. For each pile, concrete steel was separated. By means of a backhoe, the broken material was introduced into a 5m³ stationary bucket. Then the stationary bucket containing the waste was hoisted through a Model SANY 70t crane and weighing through the crane's own scale was performed. The weight of the cables, lifting straps and the weight of the bucket were discounted and equated to 2t. The sequence of activities in this stage of the survey can be seen in Figure 2.

Table 1. Results of the second stage of the investigation

<table>
<thead>
<tr>
<th>Stationary Bucket ID</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the pile leftover (m)</td>
<td>3.65</td>
<td>3.09</td>
<td>3.34</td>
<td>2.90</td>
<td>3.15</td>
</tr>
<tr>
<td>2.79</td>
<td>4.25</td>
<td>3.39</td>
<td>2.68</td>
<td>3.61</td>
<td></td>
</tr>
<tr>
<td>3.16</td>
<td>4.35</td>
<td>2.70</td>
<td>2.79</td>
<td>3.48</td>
<td></td>
</tr>
<tr>
<td>3.25</td>
<td>3.07</td>
<td>2.95</td>
<td>3.89</td>
<td>3.06</td>
<td></td>
</tr>
<tr>
<td>Σ Length (m)</td>
<td>12.85</td>
<td>14.76</td>
<td>12.38</td>
<td>12.26</td>
<td>13.30</td>
</tr>
<tr>
<td>Waste Mass (tons)</td>
<td>6.2</td>
<td>6.5</td>
<td>5.6</td>
<td>5.8</td>
<td>6.4</td>
</tr>
<tr>
<td>Mass / Length relation (tons / m)</td>
<td>0.48</td>
<td>0.44</td>
<td>0.45</td>
<td>0.47</td>
<td>0.48</td>
</tr>
</tbody>
</table>

As the waste volume of a stake overstock was lower than the volume of the stationary bucket, as many piles were ruptured as necessary for the complete filling of stationary buckets.

Figure 2. The sequence of activities of the second stage of investigation: A) breaks; B) load; C) weighing and D) discharge
About 4 leftover piles per bucket were necessary to perform the procedure. The same procedure was adopted for scrap metal.

RESULTS AND DISCUSSION

The first investigative line showed that the use of pile leftovers in the work was 49.2%.

Of the 7,424 were spiked, 3656 used leftovers from other stakes. The total length of piles spiked in the work was 242210.0 m. Of these, 12.98% (31436.7 m; 3888 pieces) were reused piles. In other words, half of the piles were composed of 11 m pieces devastated in the design quota and the other half of the piles consisted of pieces of piles reused from the razing process. The second line of investigation obtained the results presented in Table 1. From the analysis of Table 1 it is observed that in each of the stationary buckets, waste of 4 pile pieces was introduced, whose total lengths ranged from 11.26 to 13.3 m. Thus, the apparent density of concrete waste of the piles ranged from 0.44 to 0.48 tons.m⁻¹ (0.47 ± 0.02 tons.m⁻¹ on average). The indicator of apparent density per pile linear meter is convenient to the designer, as it allows to predict the waste regardless of the size of the work. The broken concrete waste presented sizes ranging from 0.05 to 0.45 m on average. The results of the metal scrap measurement showed an average bulk density of 0.70 tons m⁻³ (3.48 tons per 5 m³ bucket).

Conclusion

The study showed that the generation of residues in the activity of the concrete pile stake in the analyzed work is significant. However, it was observed that a significant part of the potential waste of the activity is reusable in the process itself. It was possible to calculate indicators of waste generation for the activity, values that can assist designers in future port works. We see the need for further studies to be carried out for other activities of port buildings, and other large works, since they have characteristics of generating waste quite different from buildings, living up to specific indicators.

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REFERENCES


