RECYCLING OF CIVIL ENGINEERING SOLID WASTE TO PRODUCE MODULAR BRICKS

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Abstract: The recycling and reuse of many industrial residues is nowadays one of the most important subjects in environmental preservation. Usually civil engineering solid waste (construction demolition waste or CDW) is composed of inert materials, but it is hazardous to the environment and is produced on a very large scale, mainly in developing countries. In the large cities of Brazil, this kind of residue corresponds to approximately 50 % of all urban solid waste, and in most of them it is dumped in improper places. In this work, the reuse of solid wastes from the civil engineering industry to produce bricks was studied. The assorted material was crushed and sieved (£ 4.8 mm). Lime used to prepare mortar was used as a binding agent. Lime, crushed residue and water were mixed in different combinations and pressed using a uniaxial hydraulic press. The probes (˜ 60mm x 30mm (f)) with up to 21days curing were submitted to mechanical compression tests and to three points flexural strength test (60mm x 20mm x ˜7mm prismatic probes). Water absorption and apparent porosity and density were also determined. The results show that it is possible to produce low-cost bricks with excellent physical properties using CDW.
Keywords: Waste, Civil Engineering, Recycling, Brick, CDW.

1. INTRODUCTION

Construction demolition waste (CDW) is a worldwide problem. In Brazil, it is estimated that more than 70 Mt/year of CDW are produced by construction and demolition activities. The illegally dumped waste in urban areas, nearby creeks, roads and other unprepared places has substantial environmental and economical impacts resulting in financial problems for the community and public administration.
The estimated CDW per capita in Brazil is around 500 kg/year, and it represents the largest amount of municipal solid waste (in mass). Beyond the landscape pollution, illegal dumping has been associated with the proliferation of diseases, rats, poisonous animals, and cockroaches and other insects. In the last years, the Brazilian federal government hás approved new policies about responsibilities, dumping and recycling of wastes in general. Due to them, the situation mainly in the major cities is changing. There are many cities in Brazil that have been implementing recycling plants, but only a small part of the CDW is recovered. There are several processes to recycle CDW and part of the mineral fraction, which is the most representative part of it, is recycled as civil construction aggregates mostly used in pavement activities. There is a comprehensive array of research on the social and financial cost, production, characterization and recycling of CDW (Ângulo et al. 2004, 2005; John et al, 2004; Ulsen et al, 2004). In Brazil, there are many groups studying CDW, and one the most productive and important research centers dealing with CDW is located at the Universidade de São Paulo – USP (PCC, 2007).

2. MATERIAL AND METHODS

This work was performed in the city of Presidente Prudente, São Paulo state, with 210,000 inhabitants, where it is estimated that approximately 6000 ton of CDW is produced monthly. This waste is dumped in urban areas and in the municipal sanitation landfill without any previous treatment or classification. The study was conducted in the laboratory of UNESP/FCT with a small volume of selected samples (~30 kg). The samples were separated manually, to remove organic material and to select refuse which was chosen (mortar, concrete, ceramics and material smaller than 30 mm) such that there was no predominance of one type of residue.

Residue (%)	Lime (%)	Water (%)
72.7	18.2	9.1
68.2	22.7	9.1
63.6	27.3	9.1
59.1	31.8	9.1
71.4	17.9	10.7
70.0	22.3	10.7
62.5	26.8	10.7
58.0	31.3	10.7
69.6	17.4	13.0
65.3	21.7	13.0
60.9	26.1	13.0
56.6	30.4	13.0

Probes (CP), Figure 1, cylindrical (f = 3 cm) and prismatic (60 x 20 x ~7 mm3) were shaped (7 ton) using a manual uniaxial hydraulic press. All the probes were prepared in triplicate and the results were obtained based on the mean of three measurements. After 21 days curing, the CP were submitted to three-points flexural strength tests (F. S.) using an EMIC machine, model LD-2000, and simple compression tests (S. C.) using na EMIC machine (only for applying force) with a pressure cell used to calibrate this equipment. The probes that showed shearing during the compression tests were discarded. Only those with conical rupture were considered (Figure 2).

Figure 1: Photograph of probes.

Figure 2: Photograph of ruptured probe.

Also, tests were performed to determine water absorption, and apparent density and porosity, using an analytical balance (Archimedes method) and caliper.

3. RESULTS AND DISCUSSION

Figures 3 to 6 show the behavior of water absorption, apparent porosity, apparent density and mechanical resistance to simple compression, with concentration of residues. Although the results did not show significant differences, mainly for the lower concentrations of water, it can be seen in the graphs that the worst results were obtained for 13 % moisture, for the highest concentrations (> 62 %) of residue. Observed in this concentration range were higher apparent porosity and water absorption and lower apparent density and mechanical resistance to compression. Table 2 shows the mean values (for all probes), and maximum and minimum values of the five parameters determined.

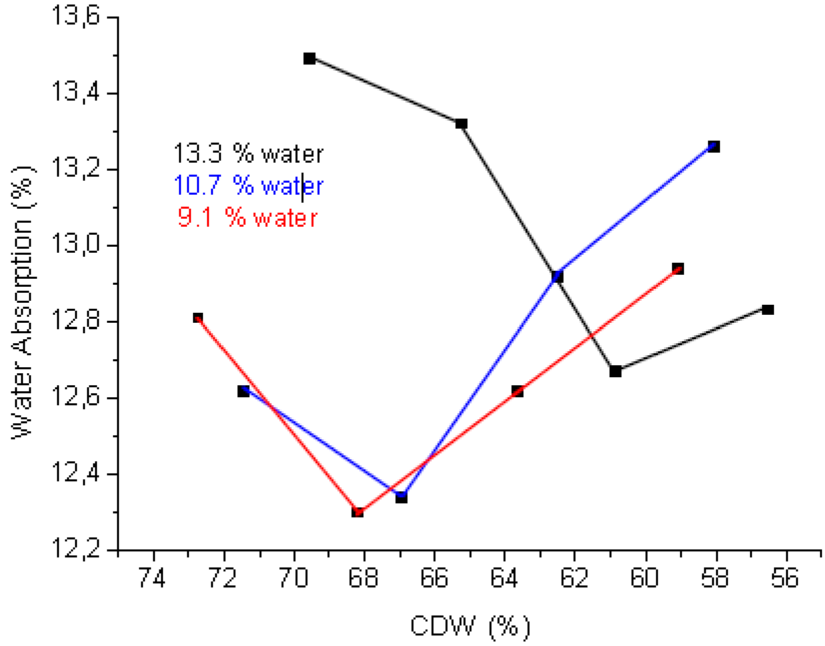

Figure 3: Water absorption with concentration of residue.

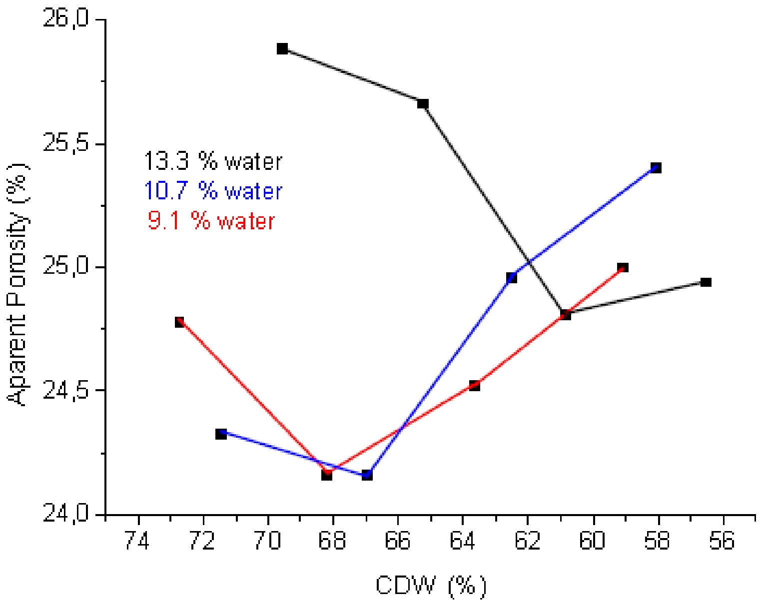

Figure 4: Apparent porosity with concentration of residue.

Table 2: Mean values for resistance to compression, flexural strength, water absorption, and apparent porosity and density, for all probes. Also presented are the maximum and minimum values obtained for each measurement.

	S. C. (MPa)	F. S. (MPa)	W. A. (%)	A. P. (%)	A. D. g/cm^3)
Mean Value	6.2 ± 0.4	3.4 ± 0.7	12.8 ± 0.4	24.9 ± 0.6	1.94 ± 0.02
Maximum Value	7.5	4.1	13.5	25.9	1.96
Minimum Value	5.5	1.9*	12.3	24.2	1.90

* Only one probe.

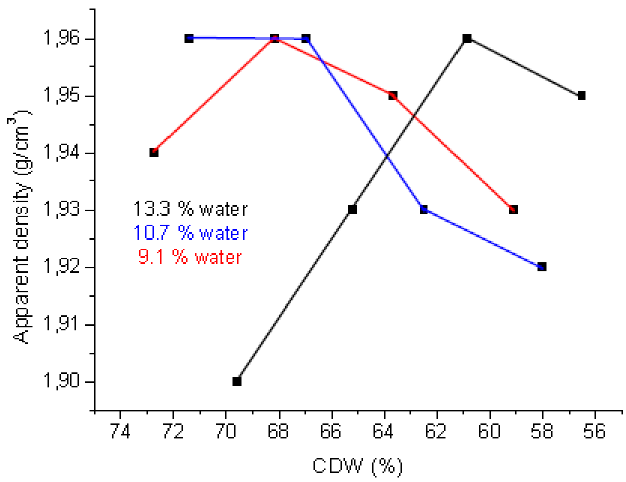

Figure 5: Apparent density with concentration of residue.

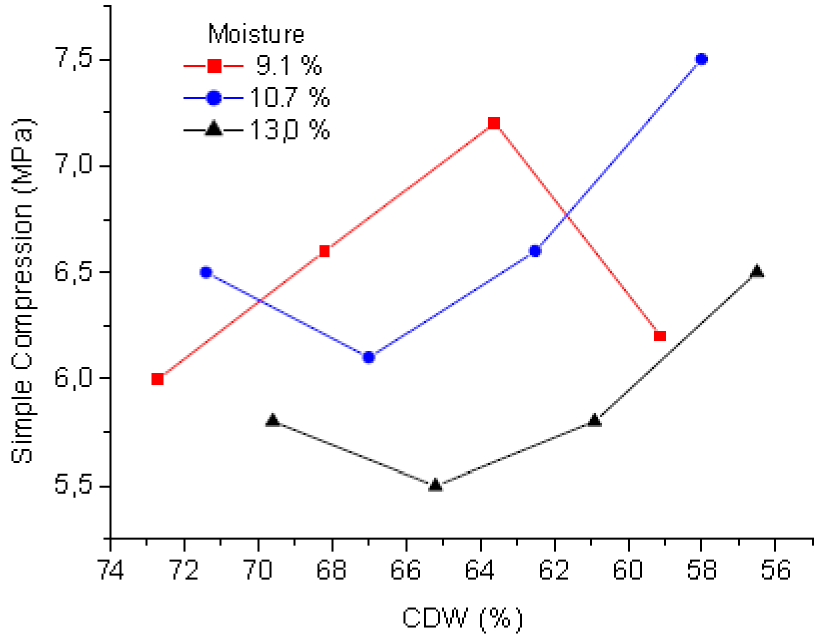

Figure 6: Simple compression with concentration of residue.

When compared with the limit values for water absorption, apparent density and flexura strength, according to Brazilian standards for perforated ceramic blocks (WA < 20%, AD >1.7 g/cm3 and FS > 5.5 MPa), the results are outstanding, that is, all of the values obtained were within the limits except the flexural strength. All of the probes, except one (1.9 MPa) showed a FS value greater than 2.5 MPa. Mechanical resistance to compression was also very good, where all the probes showed values of resistance to simple compression greater than 5.5 MPa and can be classified as class C block (limit value > 4 MPa) (Menezes et al., 2002). Another option for the construction of low-cost housing, employed in Brazil since 1948, is the one that uses soil-cement. It is widely used in rural areas and in poorer regions due to the technical and economic advantages that the material offers. The Brazilian Standards established for soil-cement bricks dictate the following mean limit values: resistance to compression ³ 2.0 MPa and water absorption £ 20 %, after seven days curing (Rolim et al., 1999; Silveira et al., 2005). Therefore, the values obtained for the bricks with residues from construction demolition waste and lime (with 21 days curing) are also better than the limit values established for soil-cement bricks (seven days curing). The predominance of silicates and carbonates, the presence of minerals originating also from burning at low temperature (in general < 900 oC) of clays in the structural ceramics and the high concentration of the fine granulometric fraction, favors the lime reaction, which increases the pH of the material, with the residue forming cementing agents (calcium aluminates and silicates) and improving the physical properties of the probes. Therefore, the use of CDW with lime for the production of bricks with appropriate physical properties is a good option for the use of both the fine fraction present in these residues and the more roughly ground fraction. The results of this study show that it is possible to produce low-cost bricks with residues from civil construction and lime. Besides the social aspect which is very important for developing countries, making it possible to build low-cost housing with modular bricks (LEGO type), the utilization of this residue will contribute to reducing the impacts of civil construction waste discarded in the environment. A more extensive study is necessary to complement these findings and to define parameters for the production of bricks on an industrial scale. Here, we initiated a mineralogical study (x-ray diffraction and thermal analysis) involving a larger volume of samples, a larger number of probes and longer curing times, which will be associated with new physical and chemical characterizations of probes and bricks produced with a manual press.

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