CHARACTERIZATION OF CIVIL CONSTRUCTION WASTE AND ITS INCORPORATION TO MORTAR

G.A. Cunha[1,a] ;A.C.D. Andrade[2,b], ; J.M.M. Souza[3,c] ; A.C.J. Evangelista[4,d] ; V.C.Almeida[5,e]
[1,2,3,4,5] Universidade Federal do Rio de Janeiro - Centro de Tecnologia
Escola de Química- Bloco E sala 206
Ilha do Fundão – CEP 21941-909 –Brasil
[a] pejagabi@gmail.com, [b] antonioeq@gmail.com, [c] joaomonerrat@gmail.com, [d] anacatarina@poli.ufrj.br, [e] valeria@eq.ufrj.br

Keywords: civil construction waste, RCD characterization, mortar.

Abstract

As the preservation of the environment is a big concern nowadays, plenty of studies have arisen in order to decrease the production or reuse the waste from human activities. In this context, the civil construction industry comes up, as it is able to incorporate waste to mortar, being a great alternative for the reuse of solid waste.

The scope of this work has been the characterization of Construction and Demolishment Waste (RCD) and its incorporation to the mortar aiming at the development of alternative construction materials in the future for the economical reutilization of waste discharged in embankments and landfills so far preserving the environment so far.

The experimental studies taken with sample bodies, such as water absorption, resistance to compression, X-ray diffraction, X-ray fluorescence and scanning electronic microscopy, elicits the viability of the partial substitution of cement by RCD mixed waste, taking its different applications into consideration.

Introduction

Civil Construction Waste (RCC) or Construction and Demolishment Waste (RCD) represent serious problems for public health as inappropriate disposals cause serious social environmental impacts, specially in relation to its final disposal. It might generate floods, damages to views, obstruction of public places, proliferation of diseases, transformation of agricultural areas in non-productive, besides representing a significant cost for the collection of this waste disposed illegally.
The content of this construction and demolishment waste is varied, consisting practically of all construction materials leftovers and specially of non-mineral material and its biggest part consists of mortars and in small quantities of stones.
The chemical content is linked with each of the different elements that constitutes it. In a simple way, RCD recycling is a mineral benefit composed by a group of unit operations aiming at obtaining specific characteristics of a raw material as separation of its mineral constituents, adaptation of size etc. [1]
The purpose of this work has been identifying the characteristics of recycled construction and demolishment waste and its influence on mechanical behavior in cement pastes.

Experimental

In the experimental step of this research the materials listed below have been used:

- Demolishment waste – civil construction waste (bricks, ceramic floor, tiles, concretes)
- Portland cement CPII – 32 F Portland Cement

The waste has been collected at random and separately in works, in different particles sizes having been submitted at first to mechanical processes of breaking and grinding.

A roll crusher has been used for that and after, a disc pulverizer. This step has aimed at reducing the size of the waste.

The mineralogical characterization of the waste has been done using X-ray fluorescence, X-ray diffraction, infrared spectrometry and scanning electronic microscopy techniques.

To verify the possibility of using the waste to substitute part of Portland cement test samples with the following proportions have been done:

Table 1: Content of the Body Samples Prepared

Initials	Mixture	Quantity in grams(g)		
		cement	waste	water
C-100	100% cement	4880		1200
C25-RM	75% cement + 25% waste (RM)	3660	1300	1220
C50-RM	50% cement + 50% waste (RM)	2440	2600	1200
C75-RM	25% cement + 75% waste (RM)	1037	3445	1150

The homogenization of the mixture has been done manually. At first cement and powered waste have been mixed and later added to mash water.

The molding of test samples has been done using a cylindric mold, height = 10 cm and diameter = 5 cm, according to the technical standard NBR12024 [2]. The samples have been molded in three mixture layers, with approximately the same thicknesses and 20 hits per layer with a metal crusher. The proportion water/cement + waste around 0,3 has been necessary to assure the mixture homogeneity. After 24h, the test samples have been unmolded and taken to a humid chamber being submitted to curing times of 7, 14 and 28 days. Three test samples have been made for each test day.

The physical and mechanical characterization of the test samples prepared has been after 7, 14 and 28 curing days through absorption and resistance to compression tests.

Results and Discussion

The chemical content of the mixed waste is shown in Table 1.

Table 1 – Elementary Content of the Mixed Waste

Component	% (mass) Mixed Waste	Component	% (mass) Mixed Waste
SiO_2	48,521	**Na_2O**	0,358
Al_2O_3	23,525	**P_2O_5**	0,132
CaO	17,573	**ZrO_2**	0,116
Fe_2O_3	5,351	**MnO**	0,078
K_2O	2,043	**SrO**	0,047
TiO_2	0,863	**ZnO**	0,043
SO_3	0,697	**Rb_2O**	0,013
MgO	0,628	**CuO**	0,01

X-ray fluorescence has shown a high concentration of silica (48,5%), alumina (23,5%), calcium (17,5%), iron (5,3%) and potassium (2,04%). The other elements have concentrations below 1%.

Silica content (SiO_2) shown in the samples is considered high, which is desirable in active materials that have an important role, as thorugh the time, there are reactions that form calcium silicates and aluminates hydrate, which are responsible for mechanical resistance acquired.

Based on the diffractogram shown in Figure1, it is observed that the mixed waste is principally composed of quartz and calcium oxide.

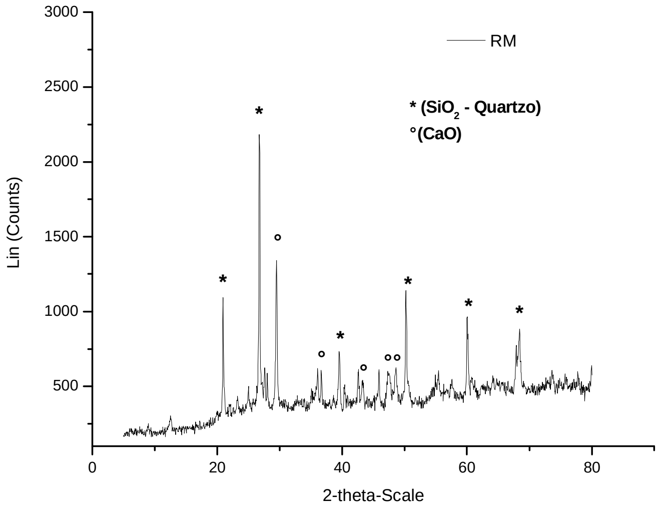


Figure 1 – Mixed Waste Diffractogram

In the diffractogram the presence of quartz can be observed by the peak in 2-Theta at 26,75º, which is confirmed by other two characteristic peaks of quartz, one in 2-Theta at 21,00º and other in 2-Theta at 50,12º. The presence of calcium oxide is also verified, identified by the principal peaks in 2-Theta at 26,75º and 2-Theta at approximately 29,88º. Other characteristic calcium oxide peaks that can be observed are the peaks in 2-Theta at 39,50º and other two ones near 2-Theta at 48º, one in 2-Theta at 39,62º and the other in 2-Theta at 40,50.

The characterization of the mixed waste through infrared spectrometry can be seen in Figure 2.

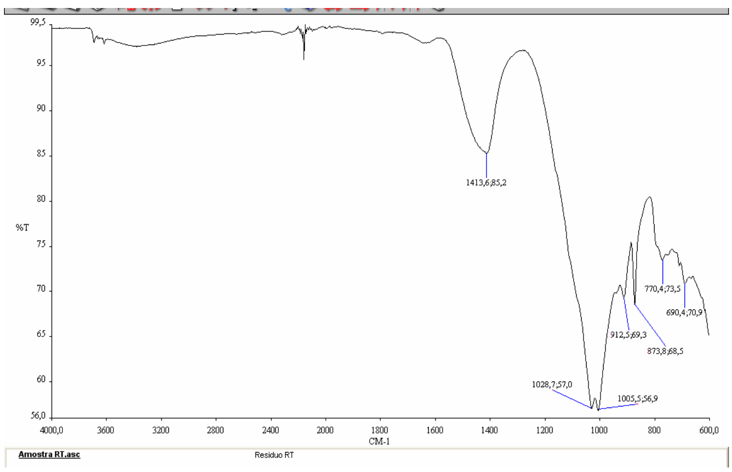


Figure 2 – Mixed Waste Infrared Spectrometry

In the spectrum obtained the stretchings Al-OH characteristic of caulinite between 3700 – 3600 cm^{-1} cannot be observed. At 788, 748, 678 cm^{-1} the bands associated to the deformation of Si-O, the vibrations characteristic of caulinite cannot be seen either.The bands 1027 and 1005 cm^{-1} are associated with the stretching of SiO_2[3].

The photomicrography of the mixed waste is shown in Figure 3.

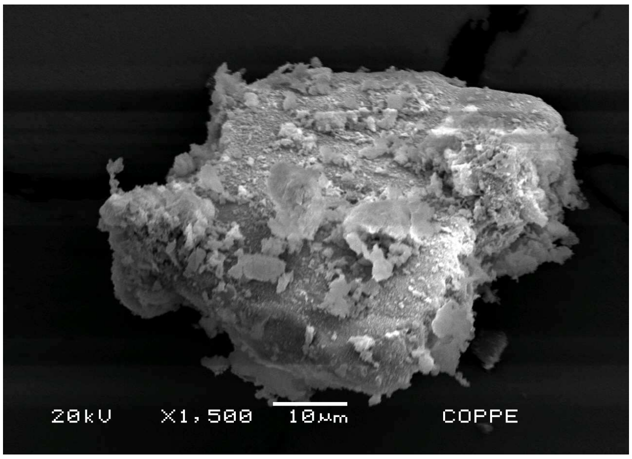


Figure 3 – Mixed Waste Photomicrography

Texture and cristalinity can be observed. The waste shape, characterized by granulometry and texture will influence on the paste properties. Aggregates with long characteristic diameters or in lamellar shape facilitate the formation of a water layer by the aggregate interior surface weakening its bond with the paste.

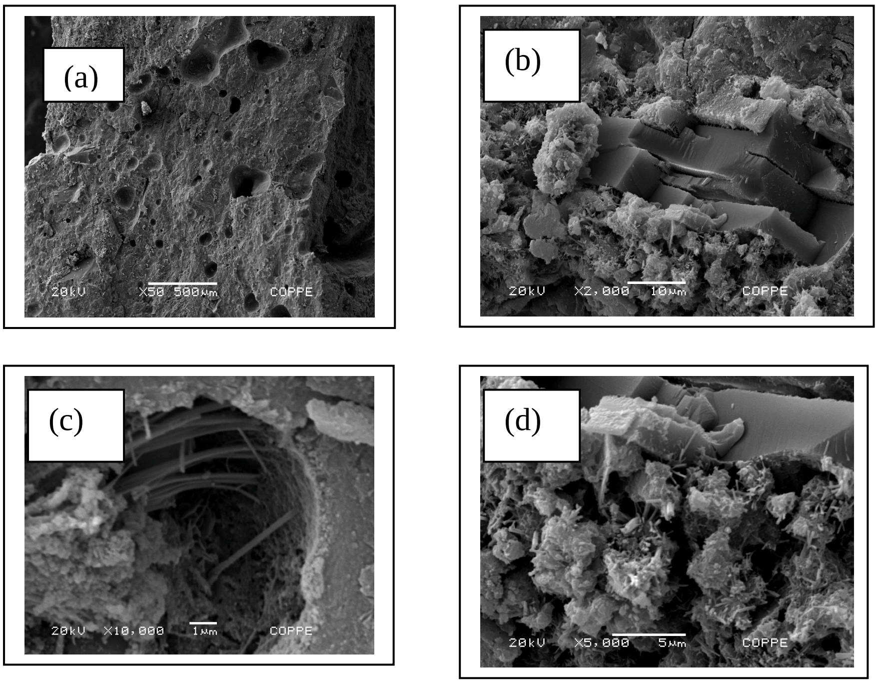
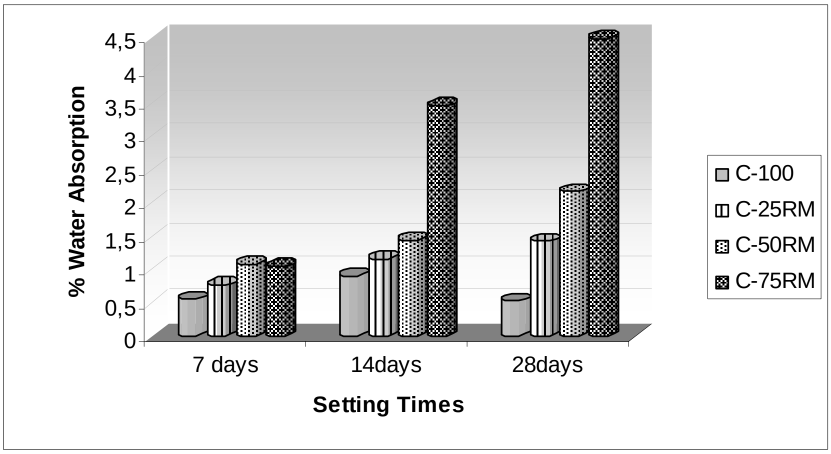


Figure 4 - Photomicrography of the Mixture 50% cement + 50% mixed waste

In Figure (a) it is possible to observe the presence of two types of cavities or empties: pores among the crystals C-S-H some nanometers long, capillary pores among hydrated compounds, bubbles and fissures with sizes varying between 100 and some nanometers. In Figures (b), (c) and (d), it can be seen calcium carbonate which crystalizes in big overlapped hexagonal plaques and etringite which crytsalizes in needle shape. Figure (b) represents the transiction zone of the cement paste with the big aggregate. Normally it shown different characteristics from the rest of the paste. The thickness and characteristics of this zone vary according to the paste and aggregate components. The transiction zone is characterized for being a region with higher porosity and heterogeneity than the rest of the paste.

The absorption test has been conducted in setting times of 7, 14 and 28 days. [4]



Picture 5- Percentage of Water Absorption for the Mixtures Prepared

C-100 = 100% cement; C-25RM = 25% cement + 25% waste, C-50RM = 50% cement + 50% waste; C-75RM = 25% cement + 75% waste

It is verified an increase on the percentage of absorption in all proportions studied. The behavior in general shown for this kind of mixture is similar to the one shown by pure cement. As the test sample used in data acquisition has been the same for the three test days, there has been a mass loss in the test sample from one test day to the other, reflecting on the result found. This happens because the waste on the surface of the test sample loosens when dipped into water, generating pores which cause an increase on the percentage of water absorption.

Data referring to resistance to compression [5] for the mixtures studies are shown in the picture below.

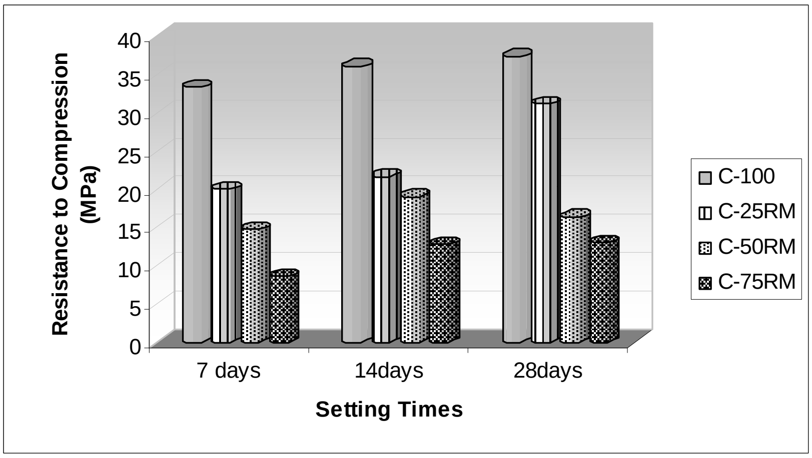


Figure 6 - Resistance to Compression of the Test Samples Prepared

In the resistance to compression data analysis, cement paste (C-100) has been used as comparation standard for the mixtures prepared. The values found for the cement paste are according to the mechanical requirements for this kind of cement, CPII-32F (resistance to compression for 3 days ≥ 10Mpa, 7 days ≥ 20 Mpa and 28 days ≥ 32 Mpa).
In the pastes prepared with mixed waste (C-25RM), (C-50RM) and (C-75RM), it is verified that the higher the waste content is, the lower the resistance to compression. It is also verified that the increase of resistance in the paste with mixed waste (C-25RM) after 28 days has been more significant than for the other pastes, as the lower the quantity of waste in the paste, the richer it is in cement, collaborating to the increase of resistance.
In a general way, the resistance to compression data of the mixtures prepared show values that indicate their possible use as construction material without structural function.

Conclusions

An ensemble analysis of the results reveals that the waste studied shows mineralogical characteristics that classify it as silica-aluminous, in relation to chemical content, responsible for mechanical resistance when hydrated.
The mixtures prepared with mixed waste show satisfactory mechanical performance, able to produce construction elements, although it is susceptible to erosion effect caused by water.
Although mechanical resistance values are fundamental in construction elements, it is essential that the waste which will be used is characterized chemically and physically for it to be able to develop high-quality alternative construction materials.
The recycling of waste generated by civil construction is really promising and might generate low-cost elements, destined to civil works and, besides, its reuse implies on the preservation of the environment and improvement of life quality of the population.

References

[1] -ANGULO, S.C; ZORDAN,S.E.; JHON, V.M. Desenvolvimento sustentável e a reciclagem de resíduos na construção civil, 4o Seminário de Desenvolvimento sustentável e a reciclagem na construção civil,2001, Anais, São Paulo: IBRACON, p 43-56.
[2]- ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 12024:** Solocimento - Moldagem e cura de corpos-de-prova cilíndricos. Rio de Janeiro,1992.
[3] - Miller, A.F., Mayo, D.W., Hannah R.W. Course Notes on the Interpretation of Infrared and Raman Spectra John Wiley & Sons, cap. 11. Inc 2003.
[4] -ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 9777:** Determinação da absorção de água em agregados miúdos. Rio de Janeiro, 1987.
[5] - ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 7215:** Cimento Portland – Determinação da resistência a compressão. Rio de Janeiro, 1996.