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Recycling of construction and demolition waste for producing new construction material (Brazil case-study)

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HIGHLIGHTS

- Low-cost bricks were manufactured using construction and demolition waste (CDW).
- Lime and cement used as binding agents mixed with CDW and water.
- The bricks present better technological properties than standards.
- The use of this waste reduce the raw materials demands and environmental impacts.

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ABSTRACT

Construction and demolition waste corresponds to 50% of all urban solid waste, usually it is dumped in improper places. This work reuses this waste as substitute of natural aggregate to produce bricks. Lime and cement were used as binding agents and were pressed using a uniaxial hydraulic press. After 21 days curing were submitted to compression tests, the probes presented an average resistance greater than 4 MPa, which is higher than standards. Water absorption, 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 as aggregate and lime or cement as additive.

1. Introduction

Construction demolition waste (CDW) is a worldwide problem. The estimated CDW production in Brazil is higher than 70 Mt/year (around 500 kg/year per capita), but this amount is variable and has correlation with the human development index (HDI). CDW represents the largest amount of municipal solid waste (in mass). 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. In the last years, governments have approved new policies about responsibilities, dumping and recycling of waste in general. As a result, the situation in the major cities is changing with the implantation of recycling plants, but nowadays only a small part of the CDW is recovered.

On the other hand, recycling has another environmental and economic advantages, since it reduces the consumption of natural resources. So, there is a comprehensive array of research on the social and financial cost, production, characterization and recycling of this waste [1–4]. CDW recycling plants have been proved to be economically viable [5,6] as well as having a positive environmental impact [7,8].

However, it is essential to absorb the output from these plants by the market. In other words, there is a strong need to diversify the industrial applications of this waste. CDW materials have been evaluated and successfully implemented in recent years in several countries [9,10], and generally, it is used as raw mineral materials in paving projects [11–14], footpaths [15] and pipe-bedding [16]. Some author have focused in recycling CDW for concrete production

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[17–20]. Moreover, others researchers have developed new application as concrete brick [21–22] and concrete block [21,23–25]. Mymrin et al. (2015) have developed a new construction material from CDW and waste from lime production industry with better mechanical properties that Brazilian standards establishes [26]. But there is still a great need for new products, processes and markets, to reduce the volume produced and to recycle most of the CDW [1,3].

In general, CDW mineral fraction is very heterogeneous (mortar, ceramics, concrete, rocks, natural gravel, masonry, sand, soil, etc.) and depends on the characteristics of each construction. Besides, the extent of economic development of each region defines the chemical composition of the waste [27]. Consequently, CDW presents a wide range of porosity and particles size (bulk specific gravity variability from 1.7 to 3.0 kg/dm^3 and water absorption variability from 0 to 20.6%). Essentially, these minerals are mainly made up of silicates from ceramic and natural rocks and carbonates from cement-based particles. Hydrated cement-based phases also must be present. Phyllosilicate content is more relevant in the size fraction below 0.15 mm due probably to soil incorporation [1,4]. Although, the CDW fraction below 4.8 mm obtained in most of the plants is, generally, not used and represents approximately 40% of the total mass [2]. The present work is focused and proposes an alternative use for this fraction.

In view of the above, the main objective of this work was to evaluate the possibility of producing bricks, using lime or cement as binders, to construct low-cost housing, with construction and demolition waste (CDW) with the fraction below 4.8 mm as substitute of natural aggregates. As secondary objective was to evaluate, in term of mechanical behaviour, the different composition of CDW (mixture 50:20:30 (TSC1) and other randomly obtained in a recycling plant (TSC2)). The physical and technological properties of probes were determined and compared with Brazilian, European and American standards, looking for commercial applications for this residue.

2. Materials and methods

2.1. Materials (CDW, cement and lime)

Representative samples of two different types of CDW (Class A) [28] were obtained from two different metropolitan regions of São Paulo State (SP) Brazil, in order to compare the heterogeneity of these samples evaluating the technological properties. Sample 1 (Presidente Prudente County) was collected from the transporting containers disposed at the work sites of construction and demolition. Sample 2 was collected from a CDW Recycling Plant (São José do Rio Preto County). The samples were grounded and sieved through a 4.8 mm mesh sieve and used only fraction <4.8 mm.

According to previous works [29,30], CDW in Presidente Prudente is mainly composed by ceramic (50%), concrete (20%) and mortar (30%). CDW shows a vast array of elements in its composition, majorly containing SiO_2 (40–70 wt.%), CaO (10–25 wt.%), Al_2O_3 (5–20 wt.%), Fe_2O_3 (0.5–8 wt.%) and K_2O (1–4 wt.%). Similar characteristics was also reported in other studies [31–33].

Portland cement (type I) and hydrated lime (HL III) were used as binder. Portland cement type I is composed of clinker and gypsum [34]. Portland cement contains mainly CaO, SiO_2, Al_2O_3 and Fe_2O_3 (60–67, 17–25, 3–8 and 0.5–6 wt.%, respectively) as stated by the Brazilian standards (NBR) [35] and the U.S. National Bureau of Standards (NBS) [36]. The Hydrated Lime (CH III) is a high quality dolomitic lime, meeting the technical requirements of ABNT 7175 [37]. According to Brazilian building quicklime requirements [38], lime had a CaO and MgO content higher than 88–90 wt.%, and contained appreciable amounts of carbon dioxide (up to 12 wt.%).

2.2. Testing samples (TS) preparation

A total of three series of mixtures were prepared in the laboratory trials as test specimens (TS). Series I and series II mixtures were prepared for producing concrete bricks using CDW from Sample 1 and 2 respectively; series III mixtures were prepared for making lime bricks with CDW Sample 1. The details of these three series of mixes are given in Table 1. The mix notations indicate the different types of mixes (with TSC for concrete bricks and TSL for lime bricks), the notations of CDW aggregates (Sample 1 and 2), and the percentages (by weight) of the additive (cement or lime) in the total amount. The materials were mixed manually, moistened and homogenized. The cylindrical TS (ϕ = 30 mm, h ≈ 60 mm), were pressed in triplicate, utilizing a uniaxial manual hydraulic press and load of 7 tonf (tons-force).

Table 1
Composition of the different tests.

	CDW/additive (wt.%)	Water (wt.%)[c]	Nomination
CDW[a] – cement	90–10	13	TSC1-10
	80–20		TSC1-20
	70–30		TSC1-30
CDW[b] – cement	90–10	13	TSC2-10
	80–20		TSC2-20
	70–30		TSC2-30
CDW[a] – lime	80–20	12	TSL1-20
	75–25		TSL1-25
	70–30		TSL1-30
	65–35		TSL1-35

[a] Using classified CDW (50/20/30).
[b] CDW with randomly composition from a recycling plant.
[c] wt% of solid mass.

2.3. Methods

The particle size analysis of CDW was performed by a mechanical shaker using sieves Granutest model (2.40 mm; 1.00 mm; 0.60 mm; 0.30 mm; 0.15 mm and 0.075 mm). The identification of the mineral phases was analysed by the XRD technique (X-ray diffraction) in a Shimadzu diffractometer model XRD 6000, using Cu κα radiation working at 1.2 kW (40 kV e 30 mA). Data were recorded in the 5–60° 2θ range (step size equal to 1°/min).

Major and trace elements were analysed by Energy Dispersive X-ray Fluorescence (EDXRF) with a Bruker spectrometer S2 Ranger LE equipped with an X-ray tube of 50 W (50 kV, 2 mA), anode of Pd, XFlash® Silicon Drift Detector with resolution <135 eV for Mn Kα and 100,000 cps, with cooling system type Peltier (without need for liquid nitrogen) and tool changer primary filters with 9 positions available.

The behaviour of TS was evaluated on the basis of water absorption (WA), apparent specific mass (ASM) and apparent porosity (AP), according to the Archimedes method. The specimens were dried at a temperature of 110 °C for 24 h after immersion in a container of water during 24 h. The TS were weighed dried (dry mass), wet (wet mass) and immersed (mass immersed) using an analytical balance. According to the following equations:

$$WA\ (\%) = \frac{(m_w - m_d)}{m_d} \times 100 \quad (1)$$

$$AP\ (\%) = \frac{(m_w - m_d)}{(m_w - m_i)} \times 100 \quad (2)$$

$$ASM\ (g/cm3) = \frac{m_d}{(m_w - m_i)} \quad (3)$$

where m_w is the wet mass, m_d is the dry mass and m_i is the mass immersed in water.

Compressive strength (σ) was measured using an EMIC apparatus, model DL-2000 on ten test specimens for the three series of TS, with a cell for small test specimen compression.

$$\sigma = \frac{F}{S} \quad (4)$$

where F is the applied force (Kgf) on the test specimen and S is the cross section area (cm^2).

3. Results and discussion

3.1. Materials characterization

CDW elemental composition, shown in Table 2, indicates that this waste is mainly composed of Si (71.74 wt.% as SiO_2), Al (14.17 wt.% as Al_2O_3) and Fe (12.11 wt.% as Fe_2O_3). These results are similar to those reported in other previous studies [29–33]. It is also observed a high concentration in other elements as Mg (3.67 wt.% of MgO), Ca (3.44 wt.% of CaO), Na (2.86 wt.% of Na_2O) and K (2.68 wt.% of K_2O) according to the mineralogical composition. The trace elements are present at concentrations below

Table 2
Average concentrations (n = 10) of major elements (wt.%) and trace elements (mg kg^{-1}). Major and trace elements measured by EDXRF.

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	Mn_2O_3	Fe_2O_3
Major elements											
CDW	0.38	1.68	9.76	75.53	0.04	0.17	0.99	6.10	1.11	0.05	4.18
Soil [a]	2.86	3.67	14.17	61.74	0.16	0.14	2.68	3.44	0.67	0.21	12.11
	Ba	Zr	V	Cr	Y	Rb	Zn	Cu	Sr	Pb	As
Trace elements											
CDW	483	385	81	58	12	32	88	80	177	28	3.8
Soil [a]	584	203	97	92	21	78	67	28	348	17	4.8

[a] Continental crust composition [39].

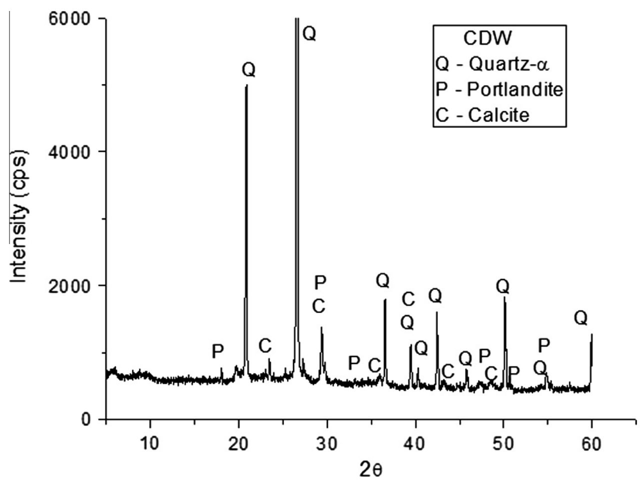

Fig. 1. XRD patterns of CDW.

0.1%. The main trace elements identified in the CDW were Ba, Zr, Sr, Zn, V, Cu, Cr, Rb, Pb, Y and As, in order of abundance. Some trace elements (Ba, Sr, V, Cr, Rb and As) are present in concentrations smaller than uncontaminated soils, but others, such as Zr, Zn, V, Cu and Pb are higher [39].

The mineralogical composition of the CDW is complex due to the wide range of crystalline and amorphous phases of its components: concrete (coarse gravel or crushed rocks, sand and cement), mortar (sand, lime and cement) and ceramics (fired clay minerals and sand). The RXD analysis confirmed the presence of quartz (SiO_2), carbonates as calcite ($CaCO_3$), hydroxides (potlandite, $Ca(OH)_2$) as major crystalline phases and some not identified low intensity peaks, probably due to silicates (Fig. 1). These phases are usually present in natural constituents (stone and sand) and in the used additives (cement and lime). These results are in accordance with the data obtained in other works [29,30,40,41].

Fig. 2 shows the mineralogical composition of some representative test specimens (TSL1-20 and TSL1-30) determined by XRD. The minerals detected included α-quartz (PDF 5-490), calcite and other calcium carbonates (PDF 4-637, $CaCO_3$, PDF 47-1743), portlandite (PDF 76-571, $Ca(OH)_2$) and some peaks not identified are probably associated to silicates. As was expected, the intensity of the quartz peaks decrease with the addition of lime because its concentration decreased. This fact is especially remarkable at 20.8° (2θ). The peaks associated to calcite and portlandite increase with lime concentration, shown principally at 29.7° (2θ). Moreover, the secondary peaks of quartz appear to increase due to the coincidence of peaks of other phases with the quartz or with the preferential orientation of quartz.

Furthermore, other phases of carbonates and hydrated calcium silicates are formed during the reaction between CDW and lime or cement mixed with water. These phases as well as the silicates are responsible for increasing the mechanical strength of the material during the curing process. Likewise, carbonates together with organic matter and free iron oxides are other binding agents [42–44]. Calcium carbonate occurs as coating over or between particles binding them, closing pores and improving the technological properties of the testing samples (probes). Besides, the raw materials used to produce red ceramics are rich in iron oxides (hematite e goethite) and clay minerals (kaolinite and mica). The red ceramics used in this region are produced from kaolinitic clays fired at temperatures smaller than 900 °C [45]. The crystalline structures of the clay minerals are destroyed between 500 and 900 °C and transformed in metakaolinite and hematite when the material is fired

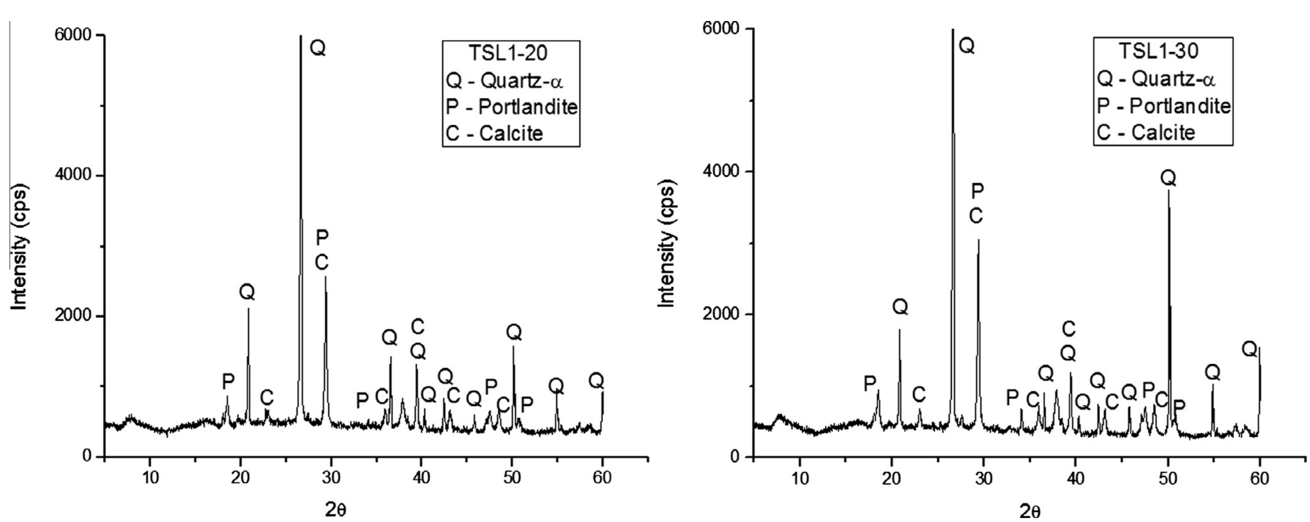

Fig. 2. XRD patterns of TSL1-20 and TSL1-30.

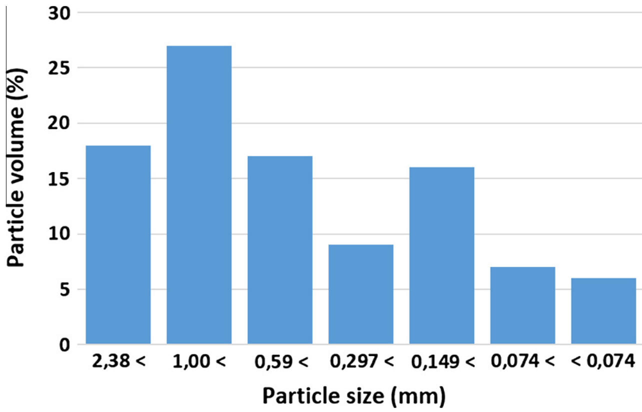

Fig. 3. Granulometric range curve of the CDW.

to produce the bricks (800–900 °C), releasing the amorphous silica and alumina. The reaction of these amorphous phases to mullite phase formation occurs only at temperatures above 900 °C. Thus, after firing there are iron minerals, fine silica and alumina in the powder of crushed red ceramic materials, and a broad class of siliceous and siliceous aluminous materials can be formed, during the cure process. These materials when finely divided (as is the case of nano-metakaolinite) they have pozzolanic activities and have cementitious (binding) properties. Then, the ceramics materials in the CDW have amorphous phases which will contribute to the formation of new phases together with lime or cement and water contributing to improve the physical properties of the TS.

The results of the particle size analysis of CDW are shown in Fig. 3. The granulometric profile of CDW revealed that the sample presented a wide range of particles sizes, with an asymmetric distribution of particles, which can be considered as a sandy material (From 2 to 0.075 mm) according to NBR 7225 [46]. Fig. 3 denotes two mainly populations of particles. The first population has a significant particle number of around 149 μm of diameter. The intermediate fraction is the greatest fraction in this sample; most of the particle distribution in CDW was retained above 1 mm. The mixture of particles with different sizes improves the packing of the particles, decreasing the porosity and water absorption and increasing the TS density.

3.2. Technological properties

The results shown in Table 3 indicate that the apparent porosity decreases with the addition of 20% of cement and increases with the higher cement concentration (30%). TSL has a similar behaviour, the addition of lime up to 25% decreases the apparent porosity and increases with higher lime content (30 and 35%). This physical property is very important, because it is related to the water absorption of the TS [47,48]. Therefore the water absorption also follows this same trend because both properties are directly related, although water absorption is related mostly to open porosity. According to the Brazilian standards [49], the average WA of ceramic components should be at most 22%, for ceramic blocks or at most 18% for roof tiles. Our results in Table 3 agree with this regulations for ceramic blocks (TSC1 and TSC2) and for roof tiles (TSL1). Water absorption should not be greater than 20% by weight according to ASTM C-90 [50] and ASTM C-55 [51] specifications. The maximum water absorption limit is dependent on the weight classification of the brick (light < WA20%; medium < WA15%; normal < WA13%). The result of the water absorption test presented in Table 3 indicates that all the values are agree with the maximum permissible value of 20%. Moreover, the UNE 41170 [52] establishes the test method to determine the water absorption and the UNE 41166 standard [53] classifies concrete blocks and stablishes the maximum water absorption values: Hllow load-bearing block WA < 29%; External non-load Bearing WA < 29%; internal non-load bearing WA < 32%. Table 3 shows that all TS comply with the maximum values established.

The apparent specific mass (ASM) increases with the concentration of cement because its density is higher than CDW and also cement occupy the open pores. On the other hand, with the addition of lime the apparent density presents a wide range of variation.

The compression strength (test to calculate the rupture (collapse) of the test specimens, according to Eq. (4)) increases as the binder (cement or lime) percentage increases (Table 3). This result is likely due to the decrease in the volume fraction of interconnecting open pores, which act as large fracture flaws reducing compression strength [54]. Samples composed with 30% of cement did not fracture because the resistance acquired by these TS exceeded the maximum capacity of the load cell utilized (2000 kgf). In relation to the type of fracture obtained in TS after the compression resistance, these shown a prismatic fracture, which is characteristic of TS that are exposed to a homogeneous distribution of load during the test (Fig. 4).

According to NBR 7170 [55], for ceramic bricks, the axial resistance of massive sintered bricks is classified in the following way: class A < 2.5 MPa; class B 2.5 < 4.0 MPa; class C > 4.0 MPa. Comparing these data with the values in Table 3, all probes can be classified as Class C. Furthermore, the compressive strength required for load-bearing and non-load-bearing walls using concrete blocks were 6.86 and 3.43 MPa respectively, in accordance with ASTM C-90 [50]. Moreover, the UNE 41166 standard [53] that classifies concrete blocks, designates and establishes the requirements, as well as, the complementing 41167 and 41172 UNE standards [56,57], establish the following values in each type of block: Hllow load-bearing block > 6 MPa; External non-load Bearing > 4 MPa; internal non-load bearing > 2.5 MPa.

It was observed that the mean values of simple compression strength in TSC with 28 days of curing were very different for the mixtures TSC-10 and TSC-20, showing resistance around 4 and 8 MPa, respectively. According to TSL1 compression strength results, shown similar mean values for the different mixtures, between 5.31 and 5.65 MPa, obtained the best result in sample TSL1-30. Since there are no particular specifications for bricks with waste added, the results obtained were compared with the limit values for soil-cement bricks and ceramic bricks. The NBR-8491 guidelines [58] state that the mean resistance of soil-cement bricks should be equal to or over 2.0 MPa and that the individual values of the pieces tested cannot be less than 1.7 MPa. Besides, the obtained values were all over the lower limit of 4 MPa for Class C massive ceramic bricks for masonry [55]. Additionally, according to the

Table 3
Technological properties for each composition (after 28 days cure).

	Water Absorption WA (wt.%)	Apparent Porosity AP (%)	Apparent Specific Mass ASM (g cm^{-3})	Compression Strength σ (MPa)
TSC1-10	18.51	32.09	1.72	4.12
TSC1-20	18.06	31.62	1.75	7.39
TSC1-30	19.09	32.11	1.80	No fracture
TSC2-10	18.57	32.06	1.71	4.26
TSC2-20	18.21	31.94	1.80	7.73
TSC2-30	19.24	32.97	1.84	No fracture
TSL1-20	14.45	27.31	1.82	5.31
TSL1-25	13.60	26.03	1.81	5.35
TSL1-30	14.35	27.27	1.81	5.65
TSL1-35	14.26	28.37	1.85	5.57

The values of all mechanical properties were obtained as an average of 10 TS measurements.

Fig. 4. Image of the TS before (left) and after compression test exhibiting prismatic fracture (right).

ASTM C-90 and the UNE 41166 standards [50,53], the compressive strength required for load-bearing are 6.86 and 6 MPa, respectively and in case of non-load-bearing walls using concrete blocks are 3.43 and 4 MPa, respectively. The obtained values were all over the both limits stablished for non-load-bearing walls. In case of TSC-20 and TSC-30, the values obtained was over the lower limit required for load-bearing.

On the other hand, the values obtained in the different composition of TSC1 and TSC2 were very similar, indicating that the mixture of 50:20:30 (TSC1) for waste is a good approximation in term of mechanical behaviour of TSC2 prepared with CDW obtained randomly in a recycling plant. Despite the heterogeneity of CDW depending on its origin, the products have reached very similar technological properties. Consequently, it was proved that this heterogeneity is not a limiting factor, when CDW is formed majority by ceramic, concrete and mortar.

When compared both limit values, water absorption and compression strength, according to Brazilian standards for ceramic block for masonry (WA $\leqslant$ 25% and $\sigma \geqslant 2.5$ MPa) [59], and the apparent density, for ceramic massive bricks (ASM > 1.7 g cm^3), the results are outstanding, all of the values obtained were within the limits. Mechanical resistance to compression was also very good, where all the probes showed values of resistance to simple compression greater than 4.12 and 5.31 MPa in TSC and TSL respectively, both cases can be classified as class C block (limit value $\sigma > 4$ MPa) [30]. All of the values obtained were within the limits stablished in the UNE 41166 standard (WA $\leqslant$ 29% and $\sigma \geqslant 2.5$ MPa) [53] and the ASTM C-90 standards (WA $\leqslant$ 20% and $\sigma \geqslant 3.43$ MPa) [50]. Another option for the construction of low-cost housing, employed in Brazil since 1948, is the one that uses soil-cement [30]. 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 strength $\geqslant$ 2.0 MPa and water absorption $\leqslant$ 20%, after seven days curing [41,60]. Therefore, the values obtained for the TS manufactured with construction and demolition waste and binder additives (cement or lime) are also better than the limit values established for soil-cement bricks.

The predominance of silicates and carbonates, the presence of minerals originating also from burning at low temperature (in general < 900 °C) of clays in the structural ceramics and the high concentration of the fine granulometric fraction, favours the lime and cement reaction, which increases the pH of the material, with the residue forming cementing agents (calcium carbonates and silicates) and improving the physical properties of the TS [61]. Therefore, the use of CDW with lime or cement for the production of bricks with appropriate physical properties is a good option for the use of both the fine fractions present in these residues and the more roughly ground fraction.

3.3. Economic and environmental implications

The best result was exhibited by composition TSC-30; however, from an economic point of view, perhaps it would be possible to choose compositions TSC-10 or TSC-20 and TSL1-20 and TSL1-25 to produce bricks. This consideration is founded on the small difference in strength between the samples and, particularly when compared with the requirements of the limits values. In a economic view, lime as binder can be obtained from some of the nearby industries that produce lime as waste, thus avoiding the costs produced by the use of cement.

On the other hand, CDW is generated in all the cities and therefore it is available in all places where take place construction and demolition works. Consequently, the cost of transporting will be even lower than those produced by the use of natural aggregates, since these are extracted in quarries that are usually located away from the cities. Besides, the use of this residue as substitute of natural aggregates would reduce the cost of purchase raw materials.

Additionally, countries as Brazil which present shortages of natural aggregates, using this waste represents savings cost due to the price of raw material and a solution to this problem of availability. In addition to the environmental benefits in reducing the demand on land for disposing the waste, the recycling of CDW can also help to conserve natural resources and to reduce the cost of waste treatment prior to disposal. Moreover, reducing the polluted areas likewise reduce the spread of disease vectors animals (such as flies, cockroaches, scorpions, rats etc.) attracted by the garbage disposed with the CDW. Another economical result of this action, the city administration will save money spent on cleaning areas with CDW disposed and in health care, with treatment of the affected population.

4. Conclusions

(a) The present experimental work confirms the possibility of using residues from civil construction (CDW) and binding agents (cement and lime) as raw materials in the manufacture of new construction material as low-cost bricks for masonry walls. Especially, the samples TSC2-20/30 and TSL1-30/70 present the best technological properties. Moreover, the highest values were obtained with cement as binder.

(b) According to the technological properties, all the proposed compositions show higher compressive strength values than Brazilian, European and American standards. The main values were 5.47 and 7.61 MPa adding lime and cement respectively. These both are in accordance with the requirements for NBR 7170 in the C Category (minimal compression strength of 4 MPa). ASTM C-90 and the UNE 41166 standards, the compressive strength required for load-bearing are 6.86 and 6 MPa, respectively and in case of non-load-bearing walls using concrete blocks are 3.43 and 4 MPa, respectively. The obtained values were all over the both limits stablished for non-load-bearing walls. In case of TSC-20 and TSC-30, the values obtained was over the lower limit required for load-bearing.

(c) The fraction of CDW with a particle size below 4.8 mm, which is used in this research work and generally rejected in most of the recycling plants, was confirmed as possible substitute of natural aggregated.

(d) The initial hydration become lime (CaO) predominantly into portlandite ($Ca(OH)_2$) and calcite ($CaCO_3$) according to XRD analyses. These new minerals together with some hydrated silicates may explain the improving in mechanical resistance.

(e) The typical used CDW composition (50% ceramic, 20% concrete and 30% mortar), is a good proportion as raw material to produce bricks with better mechanical properties that are established by standards.

(f) Similar values of compression resistance in TSC prepared with different samples of CDW (TS1 and TS2), show that the composition of the CDW influences little the mechanical resistance of the TS. This result assures, in principle, that the method can be employed in different recycling units, since it guarantees that the material used is only the mineral fraction contained in civil construction and demolition waste. Furthermore, the present work has shown that construction and demolition waste from different places, with a differentiated composition between them depending on its origin, have achieved the standards according to the technological properties.

(g) In a realistic and economical approximation the use of industrial waste as raw materials would reduce the price of civil construction. A sustainable and environmentally procedure directed to manage the CDW will withdraw the huge volume of this waste discarded in the environment or in landfills and will result in a number of important social and environmental impacts: built low-cost houses; to reduce the raw materials utilization increasing the lifetime of the existing mineral deposits; increase the lifetime of the landfill; protect areas of environmental preservation in the cities neighbourhood; reduce the spread of disease vectors animals (such as flies, cockroaches, scorpions, rats etc.) attracted by the garbage disposed with the CDW in the periphery of cities where the poorest people live. As a result of this action, the city administration will save money spent on cleaning areas with CDW disposed and in health care, with treatment of the affected population.

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