1st Spanish National Conference on Advances in Materials Recycling and Eco – Energy
Madrid, 12-13 November 2009
S04-18

SUSTAINABLE MANAGEMENT OF CONSTRUCTION AND DEMOLITION WASTE: GENERATION, RECOVERY AND APPLICATIONS

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Abstract

The present study aims to establish a classification of different qualities of recycled aggregate (RA) generated from construction and demolition waste (CDW). Likewise, the emphasis is on the recovery of the same suggesting applications, ranging from less demanding benefits, such as fillers, to a highest responsibility, such as recycled structural concrete application. To achieve these objectives, it has been set a waste classification system and a group of tests that will allow characterizing recycled aggregates and the recycled materials obtained with them.

Keywords: CDW, CDA, construction, recycling, concrete, rehabilitation, demolition.

INTRODUCTION

The aim of the research promotes a new concept in the construction sector: Ecological Management of Waste, according to Spanish law [1], at building site. It arises from the need to promote new methods of organization that result in a lesser impact to the environment and an increased profitability in the economy on the new construction, rehabilitation, demolition and deconstruction.

The massive use of natural resources by humanity for his own benefit has been found through the ages, working unconsciously in the gradual degradation and in the progressive deterioration of the environment in which it operates [2].

Recycled Aggregate (RA) is the aggregate obtained by processing the CDW. As shown in Table 1, some European countries have high levels of waste management and Spain is among those who have not yet a good waste management implanted. This will be, henceforth, the purpose of the present research.

Table 1. Generation and management of CDW in some European countries.

Country	Year	Production [mill. tn]	% recycled
Germany**	2004	240	80 (1996)
Belgium**	2002	10.5	85 (1992)
Denmark**	2004	4.5	94
Spain*	2007	34.8	15
Netherlands**	1996	13.7	90

* Ref: II Plan Nacional de RCD y GERD (Spain)
** Ref: “Waste”

EXPERIMENTAL

The properties of the RA mainly depend on the type of the original waste and the technical treatment to which they are submitted. In this sense, they are classified at the entrance to the treatment facilities under the tariff regime to be imposed in each case. Table 2 proposes a new classification method based on the study and analysis of different types of aggregate from some treatment plants in Spain.

Table 2. Proposed classification for the CDW.

Class I or RCD from clean concrete.
Class II or net RCD (high percentage of concrete).
Class III or mixed RCD (with high percentage of ceramic material in addition to stone).
Class IV or gross RCD (with high percentage of improper).
Class V (in which the inappropriate materials exceed the percentage of stone material).
Lands.

The different treatment processes witch are performed to CDW recovery them as RA are shown in Table 3.

Table 3. CDW recovery processes.

CLEANING AND GRADING:
Feeder pre-screener. Separation of iron through electromagnet. Screening or sieving. Manual triage. Automatic triage scanner using spectrometric technologies. Suction of small pieces of paper and plastics. Separation of wood and light materials through aqueous route.

GRINDING:
Primary crushing. Secondary crushing.

RESULTS AND ANALYSIS

1. RA classification of the constituents

The RA used in the investigation is obtained from the treatment of CDW, processed at settled plants using different technologies. The results of the visual separation of components of the RA are shown in Figure 1 [3].

2. RA for stuffs

Tests carried out on various RA, according to the classification as a soil on the Spanish law PG-3, indicates the low sensitivity to moisture in compaction processes [4], showing a linear behaviour for a range of densities between 1.7 and 1.9 t/m^3, as shown in Figure 2.

Also was analyzed the content of soluble salts [5], gypsum [6], and the organic matter [7], these being the most limiting properties for these applications.

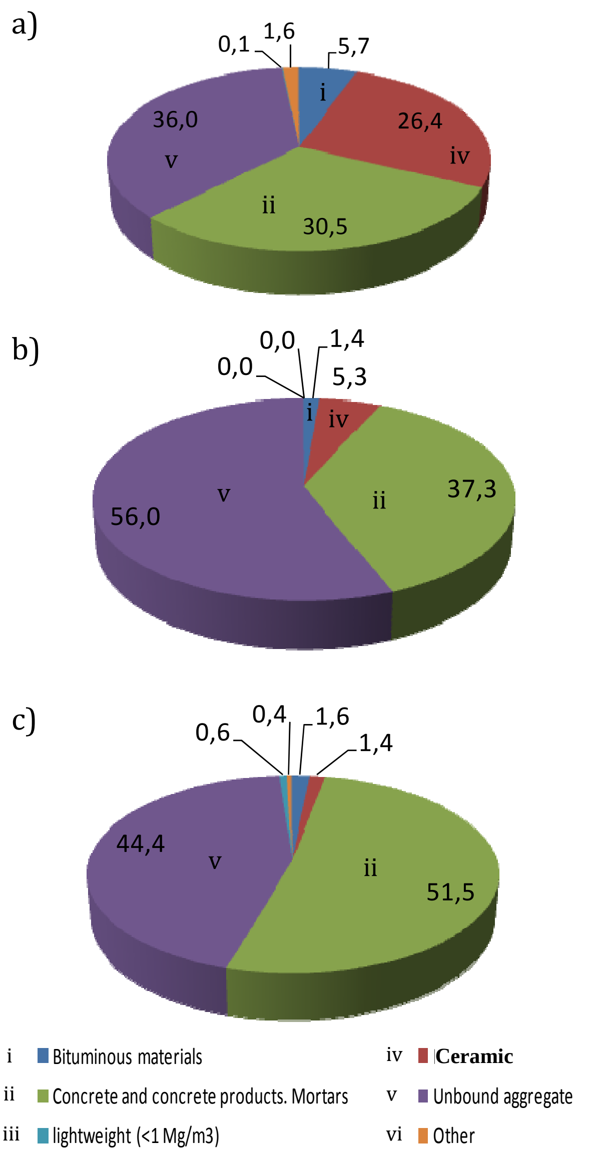

Figure 1. Test results of visual separation of RA for a) stuff, b) granular layers c) structural concrete.

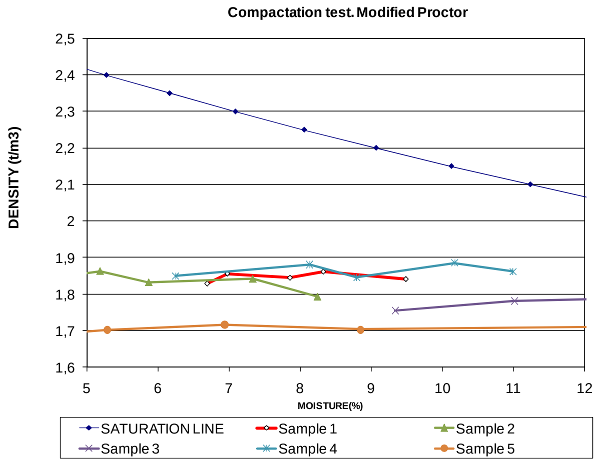

Figure 2. Modified Proctor test results on RA for stuffs.

Table 3. Obtained values for the limit properties.

	Min. %	Max. %	Med. %
Gypsum:	0.07	13	6.7
Salt soluble:	0.7	6.3	3.1
Organic matter:	0.35	1.77	1.07

3. RA for granular layers

The RA produced for use in granular layers of roads, show as limiting properties the resistance to fragmentation [8], with values of Los Angeles coefficient between 31 and 38%, and the thin impurity [9] in which has found a wide dispersion, with values between 26 and 65 of the equivalent of sand, with normal values above 40.

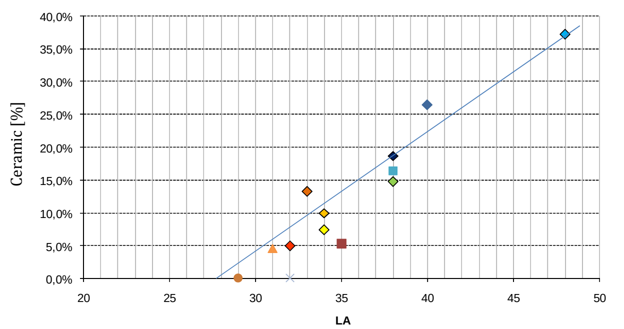

Figure 3. Correlation of the Los Angeles coefficient and ceramic content in the RA.

4. RA for recycled concrete

The particle size [10] of the RA (2 to 20 mm) is adequate for the replacement of part of small gravel (2 to 16 mm) and part of gravel (between 8 and 20 mm).

Simultaneously, it was measured density, porosity and absorption coefficients [11], to compare with those of natural coarse aggregate that will be replaced in concrete recycling. The results are presented in Table 4, which shows that the porosity of recycled aggregate is much higher than that of natural aggregates [12 and 13].

Table 4. Physical properties of the RA and natural gravel.

Property	RA	Small gravel	Gravel
Density [kg/m3]	2242	2716	2693
Absorption [% Weight]:	5.1	1.5	1.5
Porosity [% Vol.]:	11.1	3.6	3.6

4.1. Test specimens

56 tests specimens of standard cylindrical concrete were manufactured, with 4 different dosifications, varying the degrees of replacement of coarse aggregate by RA. Its physical properties are shown in Table 5.

Table 5. Physical properties of recycled concrete with various substitution degrees.

Substitution:	0%	20%	50%	100%
Density [kg/m3]:	2292	2254	2233	2194
Absorption [% Weight]:	4.84	5.55	5.61	5.68
Porosity [% Vol.]:	11.66	13.25	13.27	13.21

As shown in Figure 4, the obtained compressive strength [12, 13 and 14] of recycled concrete is significantly higher than the strength of the reference concrete, increasing it proportionally to the amount of replaced gravel; the main reason in that it is reduced the relationship water/cement of the cementitious matrix because of the higher porosity and absorption of the CDW [15].

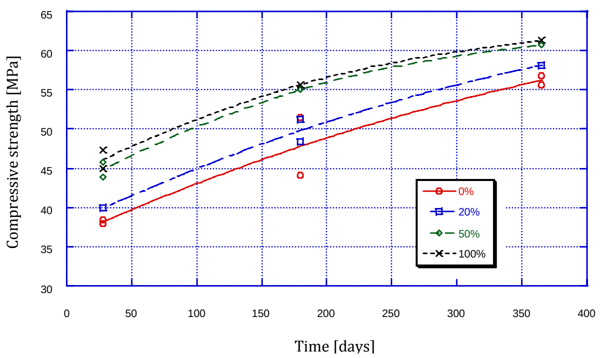

Figure 4. Evolution of the compressive strength of various recycled concretes under study.

CONCLUSIONS

Different test carried out on RA of different treatment plants show that these new materials are suitable for use in stuffs, binder courses and bases for pavements, showing a good behaviour in compaction.

The recycled concrete has better mechanical performance compared to reference concrete (0% recycled) on simple compression tests. The reason can be found in the best properties of the new cement paste.

The results of the study shows the great importance of correct classification, in the building site, of the CDW and the use of the best technologies in the treatment plants, being the two main pillars for the production of relevant RA.

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ACKNOWLEDGMENTS

Thanks to the Ministry of Environment of Spain the funding and, also the coordination by CEDEX, the Project RECNHOR (Ref. 111/2006/2-3.2).

Thanks to SADISA GROUP for provide economically the Investigation Project “Plan Integral para el Control de Residuos en Obras de Construcción” and for the materials used in some of the studies.