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Main Results of the Questionnaire for Portuguese Entities Potential Users of Construction and Demolition Recycled Materials (C&DRM)

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Abstract
Within the framework of the activities of the working group GT1 of the Portuguese Commission on Transportation Geotechnics – *Promote the use of non-traditional materials in embankments and structural layers* – a questionnaire addressed to potential national entities as construction and demolition recycled materials, C&DRM, producers/users was designed. The main objective was to collect information about the various types of C&DRM produced/used, its main characteristics and respective fields of application, in particular for civil engineering works and transport infrastructures.
The answers to the survey provide insight into the national distribution of different types of C&DRM and respective applications both in terms of type and in terms of amount of material applied and in the near future could be used to elaborate a map of recycled aggregates in Portugal.

Keywords: Construction and demolition recycled materials (C&DRM), Transport infrastructures, Questionnaire, National distribution

1 Introduction

Recovered waste is a resource and recovering is excellent to improve resource efficiency, one of the flagships of the Europe 2020 Strategy, while ensuring growth and jobs (EC, 2011). In this context, waste from the construction and demolition activities, representing about one third of the overall waste, is particularly relevant. Within the European Member States, the annual construction and demolition waste (CDW) production estimation is 460 million tonnes and this number excludes the

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excavated materials (BIOIS, 2011). This waste comes from numerous sources and processes, namely cleaning of the work site and earth movements, materials rejected and discarded during demolition and construction operations, as well as maintenance and rehabilitation activities of existing constructions. When this waste is adequately processed, it can generate recycled aggregates to be used in civil engineering works.

The total European aggregates production is 2.6 billion tonnes and data from 2013 shows that only 8% are recycled aggregates, as indicated in Figure 1. Hence there is a large margin for increasing the market share of these aggregates.

Figure 1: European aggregates sources (UEPG, 2015)

In Portugal, the average annual production of aggregates is estimated to be 29 million tonnes (UEPG, 2013), mostly consumed by construction and maintenance activities. In the last three decades, the transport infrastructures have been an important consumer of these materials although a relevant decline was observed in recent years. Portugal has significant sources of natural aggregates (eg. basalt, granite and limestone) however their transport to urban areas, where their consumption is higher, affects their costs.

The national annual production of CDW is estimated to be 150 kg per capita and therefore it urges to use the corresponding C&DRM. In fact, most of the constituent materials of CDW are still being disposed of in landfills or in illegally dumped sites (De Melo *et al*., 2011).

In Portugal CDW management is legislated by the Decree-Law no.46/2008, 12 March, which enforces CDW to previous sorting in an attempt to increase the recycling rates and other forms of CDW recovery, thus reducing the landfill amounts. Acknowledging the interest of using C&DRM in construction as a substitute for natural aggregates, National Laboratory of Civil Engineering (LNEC) produced already guides for 4 scenarios for application of C&DRM, which are considered as having a high interest for the Portuguese conditions (Martins and Gonçalves, 2008). It should be mentioned that three of these documents are specific for applications of C&DRM in road construction. Turning CDW into recycled materials to be used in embankments and structural layers of transportation infrastructures is seen as a solution with obvious and important economic and environmental benefits as it allows removing from landfill large quantities of CDW from different origins and reduces the application of natural materials.

2 Questionnaire Presentation

Despite all the importance as far as resource efficiency is concerned, and the long tradition of use in some European countries like Netherlands or Germany, the recycled aggregates continue to be, for reasons related with the production process and the existing industrial context in Portugal, a more expensive material than natural aggregates.

This is due in particular to the presence, fairly widespread, of numerous natural quality rock resources, allowing the acquisition and transport values below those which are charged for the construction and demolition wastes. A fact that does not occur in the countries of Central and Eastern Europe where the scarcity of natural rock forced to search for alternative materials, especially those that, by their composition, mechanical geotechnical characteristics and behaviour, sometimes advantageously substitute the natural aggregates, as is the case of recycled aggregates.

Figure 2: Fixed recycling plants for CDW (Martins, 2013)

The low number of fixed plants for processing recycled aggregates from construction and demolition waste (Figure 2), plus the costs of their production, the transport costs to the work sites, with more or less long distances, and the lack of confidence, hall of these penalize heavily the price per tonne for applied recycled material.

In order to mitigate this, mobile plants for processing these materials on site have been developed, thereby reducing transport costs. Nevertheless, this process leads to extra costs, since it is necessary to install on-site screening appropriate mobile crushing units which should be related with the purpose for the use of the CDW. This may be more or less expensive, depending on the origin of recycled material and also the more or less care on the preparation and cleaning of structures to be demolished with the lowest possible contamination.

Measures to invert all the described situation of the CDW usage, and an environmental and sustainable plan for the natural rock exploitation, reducing the natural impact of these industrial procedures, should be developed. Active actions for the recognition of the recycled materials importance, namely the well-known and already studied CDW, with several scientific investigation projects supporting and defending their high quality, should be the best way to invert the actual situation and develop these specific market with so high environmental impact.

In addition, and given the fact that this is a poor developed industry, centred in some located processing plants, despite its high degree of specialization, where the unknown of its existence is a reality in the construction field. It is essential and even decisive to make a real and credible survey based on recent information from major operators, both in terms of production, or at the application level, also taking into account the type of material in terms of its geographic distribution.

In this context, it was carried out a questionnaire regarding C&DRM production and application in Portugal, by the working group GT1 - *Promote of use of non-traditional materials in embankments and structural layers* of the Portuguese Commission on Transportation Geotechnical (CPGT) of the Portuguese Geotechnical Society (SPG).

2.1 Production and Application of C&DRM

The first part the questionnaire aimed to obtain information from producers/users regarding the application of C&DRM, whether for internal or external use, as well as the quantities produced and how C&DRM are obtained. It was also asked users to give an estimation of the quantities they used in their own works for the 2010-2014 periods.

2.2 Use, Functions and Characterization of C&DRM

Given the importance of the type of infrastructure where C&DRM are currently used, it was asked the users to select within the scope of their activities where C&DRM are applied, for example by selecting among structures such as buildings, bridges and viaducts, foundations, roads, airports. When C&DRM were used in roads it was questioned in which layer(s) – structural or not – they are applied, among layers of bituminous mixtures, bases or sub-bases, or even for the embankment.

Since traditionally in Portugal there is still some lack of specifications for these materials in current requirement documents, users were asked about the characterization and laboratory studies performed on the material, not only regarding its applicability but also the type of properties evaluated (geometrical, physical, mechanical and environmental/chemical), if any.

2.3 User Feedback

In order to inform the user on the current situation in Portugal concerning this matter, four final questions were prepared. These will give in future the user's feedback about the promotion and improvements for the use of C&DRM, including suggestions for promoting the application C&DRM aggregates, selecting from options such as establishing mandatory minimum quantities, tax benefits when applying C&DRM, more inspections, creating rates to be applied in the use of natural aggregates and in disposal in landfills, and creating Eco points for C&DRM, among other options.

It was also asked the producers/users' opinions regarding the main aspects to be improved, with the aim of increasing the application of C&DRM in their activities, selecting among options such as the creation of legislation, technical specifications, processing, reusing/recycling, costs associated with deconstruction and selective demolition, and access to available C&DRM, among others.

The questionnaire ends with an option about the institution's/company's interest and willingness to participate in studies aimed at characterizing the C&DRM produced, the dissemination and discussion of these studies within the technical/scientific community, as well as the form of participation of those interested in doing so (e.g. availability of waste, transport and placement, financing of the studies).

3 Presentation and Analysis of Selected Answers

Taking into consideration the number of answers to the questionnaire received until this moment it is not possible to present a statistical representative analysis. Therefore, the findings put forward only express the data from the current sample. The geographic scope of activity of the companies – regional and national level - and respective aggregate production volumes of C&DRM, were presented and a comparative analysis is performed.

Table 1 presents the most used applications for C&DRM and the type of tests usually carried on to characterise these materials for three companies with different geographic scope of activity.

From the analysis of the data presented in Table 1 there is a broad range of applications of C&DRM - hydraulic works, roads (base and sub-base layers and embankments), buildings, and both access and circulation roads - normally preceded by laboratory characterization of the recycled materials. It is recognized however that the characterization of C&DRM is not complete, and the companies make a selection of the type of characteristics to be assessed - geometric, physical or mechanical. As can be seen, the environmental characterization is not performed showing that this is not an issue of concern.

The classification of CDW was performed according to the European List of Waste, LoW, regarding the origin of the material.

The reported results used only the following LoW codes.

17 CONSTRUCTION AND DEMOLITION WASTES (INCLUDING EXCAVATED SOIL FROM CONTAMINATED SITES

17 01 01 concrete

17 01 03 tiles and ceramics

17 01 07 mixture of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06 being 17 01 06 mixtures of, or separate fractions of concrete, bricks, tiles and ceramics containing dangerous substances

17 03 02 bituminous mixtures containing other than those mentioned in 17 03 01, being 17 03 01 bituminous mixtures containing coal tar

17 05 04 soil and stones other than those mentioned in 17 05 03, being 17 05 03 soil and stones containing dangerous substances.

Figure 3 presents quantities of C&DRM production for the 2011-2014 period for two C&DRM users Id. 2 and Id. 3. The material classified as 17 01 07 presents the major contribution for Id. 3 while for Id.2 the material identified as 17 05 04 (soil and stones) has a major importance, corresponding to about 13000 tonnes of material. Nevertheless, because the material in category 17 05 04 is excluded from the target of 70% defined in Directive 2008/98/EC for CDW recovery by 2020 it can be concluded that the material identified as 17 01 07, corresponding to a mixture of demolition materials, prevails over other categories.

Table 2 presents, for the selected three companies, major factors that were considered to affect the use of C&RDM and some suggestions for promoting its application.

Id.	Questions					
				C&DRM characterization studies		C&DRM application
	Geographic scope of activity	Main activities of company / institution	C&DRM user	Tests performed	Test type	
1	Regional	Collection, reception and recycling/recovery of C&DW; production of C&DRM	No	Yes	Physical	Not applicable
2	National	Construction and public works	Yes	Yes	Geometrical	Hydraulic works; roads (base and sub-base layers); industrial buildings; access paths
3	National	Construction and public works	Yes	Yes	Mechanical	Hydraulic works, roads (base and sub-base layers and embankments), buildings, access and circulation roads

Table 1: Geographic scope of activity and C&DRM characterization and application

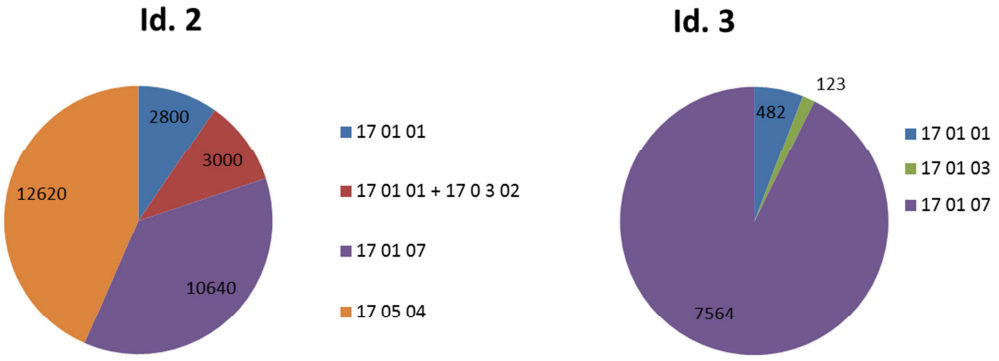

Figure 2: Quantities (in tonnes) of C&DRM production for the 2011-2014 periods for to selected users

Id.	Questions			
	Geographic scope of activity	Main obstacles to the use of C&DRM in construction	Suggestions for promoting the application of the C&DRM	Key issues to improve C&DRM use
1	Regional	Short supply	Tax benefits when applying C&DRM; fee for landfilling	Development of technical specifications
2	National	Awareness of owners and designers; effective market supply and demand; competitive pricing compared to virgin products; lack of standards and specifications for C&DRM use	Rate to be applied for the application of natural aggregates and establishment of a minimum amount of C&RDM to apply	Development of technical specifications
3	National	Absence of the imposition of minimum values for the incorporation of recycled materials in construction; lack of knowledge and awareness among designers and work inspections	Establishment of minimum amounts of C&RDM to apply	Development of technical specifications

Table 2: Factors affecting the use of C&DRM

According to the answers presented in Table 2 the main obstacles to the use of C&DRM in construction are related to some lack of knowledge and awareness among designers and work inspections. This perception emphasises the need for promoting the dissemination of existing information on the characteristics and performance of C&RDM in order to clarify national technicians. It is suggested the application of levy taxes that favour the application of C&DRM and penalize landfill and even the use of natural aggregates.

There is no doubt, according to the received answers, that there is a need for more technical specifications to regulate the C&DRM use in various applications.

4 Final Considerations

Within the framework of the activities of GT1/CPGT a questionnaire was prepared for Portuguese entities while potential producers/users of construction and demolition recycled materials (C&DRM). The main objective was to collect information about the different types of C&DRM produced and their main characteristics and respective fields of application, particularly in civil engineering and in transport infrastructures. The survey sent by email to producers and users, supported by a Google Form, received up to now a low number of answers.

The responses to the questionnaire highlight some information regarding the C&DRM categories and quantities used, in a period of 3 years, by different users. Although, characterization is usually performed by C&DRM users, the environmental aspects do not represent a major concern.

Furthermore, despite the low number of answers received so far it is expected that the questionnaire will allow the elaboration of a map regarding the recycled aggregates production and use in Portugal.

According to the feedback of the companies, the difficulties regarding acceptance and use of C&DRM, rely on the lack of knowledge and awareness among designers and labour inspectorate in construction sector. The development and implementation of technical specifications that support its application is suggested as a benefit.

Quantities of C&DRM production for the 2011-2014 period were presented, corresponding to a total C&DRM of only approximately 40 tonnes for the period 2011-2014. The numbers are far below what is expected based on the data from the Portuguese Environmental Agency for the preceding four-year period. New attempts are underway to obtain a wider participation of the potential producers and users.

References

BIO IS, (2011). *Service contract on management of construction and demolition waste, Final report*. Accessed by from http://ec.europa.eu/environment/waste/pdf/2011_CDW_Report.pdf.

De Melo, A. B., Gonçalves, A.F. & Martins, I. M. (2011). Construction and demolition waste generation and management in Lisbon (Portugal). Resources, Conservation and Recycling. 55: 1252-1264.

EC, (2011), A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy, COM(2011) 21.

Martins, I. M. (2013). Recycling in Portugal: Overview of CDW. In book: Progress of Recycling in the Built Environment, Chapter: 3.8, Publisher: Springer, Editors: Enric Vázquez Editor, pp.134-144.

Martins, I. M; Gonçalves, A. (2008). Portuguese legislation for CDW management. International Conference CDW as Building Material; S. Paulo - Brazil, April 2008.

UEPG, (2013). Estimates of Aggregates Production data 2013. Accessed by from http://www.uepg.eu/statistics/estimates-of-production-data/data-2013.

UEPG, (2015). A sustainable industry for a sustainable Europe. Annual Review 2014-2015. Accessed by http://www.uepg.eu/publications/annual-reviews.