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New quantification proposal for construction waste generation in new residential constructions

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ABSTRACT

In general, the analysis of construction waste quantification estimates the total amount of waste generated considering only the total floor area of the project. However, some countries, where houses are usually sold by units within collective housing buildings, may need to consider other parameters. In this sense, this research states a new proposal to quantify the waste generated in the construction of Mediterranean residential buildings by considering not only the total floor area of the project, but also the number of dwellings. To do this, several newly built residential building works have been analyzed. The results obtained offer two models for estimating –both in weight and volume– the construction waste generated in this type of constructions. Around a 1%–10% mean deviation was found between the model predictions and the data collected in other projects or published in previous research works. Moreover, including other variables, such as the management carried out by the working team or good practices implemented to minimize CDW generation, may result in maximum deviations of the model. Finally, this model can serve construction stakeholders in developing the current Waste Management Plans and Reports required by the regulations, in order to estimate the amount of construction waste generated and therefore optimize its management.

1. Introduction

The intense activity in the construction sector during the last decade has generated huge volumes of construction and demolition waste (CDW) being responsible for around 30% of the total waste generated according to data published by the European Official Statistics (European Commision, 2013). In average, Europe has generated around 890 million tons of CDW per year (European Commision, 2013). However, due to the change in the economic cycle the construction activity has entered a decline phase. This situation has decreased the quantity of CDW generated in Spain, but its management has worsen, as illegal dumping has increased around 20% since the beginning of the crisis (GERD, 2013).

Aware of this situation, some countries are implementing national policies as well as different measures to prevent waste that can be avoided and to promote measures to increase recycling and recovering (Silvestre et al., 2014; Tsai et al., 2014). In particular, the Spanish Royal Decree 105/2008 regulates the production and management of CDW. This Law enforces the drawing up of a waste management Report and Plan for each project. Thus, the new Waste Management Plans and Reports are to promote waste minimization, selective removal and recycling of the unavoidable waste, favoring the reduction of the building environmental impact (Spanish Government, 2008b).

Despite the high potential of CDW recovery, and the existence of different management models, today, professionals continue to prioritize elimination as opposed to recycling or reuse (Shen et al., 2010). According to the 2nd Spanish National Plan of CDW 2007–2015 (II PNCDW), the percentage of CDW recycled did not reach, even in the best cases, 18% of the total waste produced (Spanish government, 2008a).

This situation is mainly due to the type of waste collection system used in the construction of buildings, as it is decentralized by each subcontracted company in the construction work (del Río Merino et al., 2010). This means that the principle of waste reduction is not applied in practice, since it is not considered as an

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activity in the planning of the work. There is therefore, an important lack of planning and on-site implementation of good practices to minimize waste and promote recycling (Coelho and de Brito, 2012; Villoria Saez et al., 2013), although acknowledging that the potential environmental impacts of a construction work can definitely bring business benefits, including reduced costs for waste management (Tsai et al., 2014). Therefore, any tool, setting an estimation of CDW generation, should be considered as an instrument offering real solutions in the field of sustainability.

Indeed, main construction companies are slowly considering environmental issues by implementing Environmental Management Systems (EMS) (Fuertes et al., 2013), not limiting their action to the current legislation, and seeking the implementation of good environmental practices in their works (Qi et al., 2011; Tsai et al., 2013). However, while this fact is a reality for large construction companies, the vast majority of construction companies (small and medium size enterprises) still need to accept this new situation (del Río Merino et al., 2013). Therefore, current EMS should go a step further and include not only procedures for managing CDW, but also tools for estimating CDW which help planning a proper CDW management in order to achieve building construction works with zero waste generation.

In this sense, the concern to establish indicators describing the waste generated –both in new construction and demolition works– has increased in recent years (Mália et al., 2013) (Yuan and Shen, 2011). There are several fields of studies undertaken to quantify the generation of CDW. Among them, two large groups can be distinguished:

- Those aiming at differentiating the percentage of each CDW category of the total generated (Comoglio and Botta, 2012; Lu and Tam, 2013; Spanish government, 2001), and
- Those which establish ratios of CDW generation on site, depending on the type of work: new, demolition or reforms (Bergsdal et al., 2007; Bossink and Brouwers, 1996; Lu et al., 2011; Poon et al., 2004; Skoyles, 1976).

On the one hand, studies that distinguish the percentage represented of each CDW category of the total generated are shown in Table 1.

In addition, studies establishing total ratios of CDW generation in building works are displayed on Table 2. Among them, Mañà i Reixach et al. (2000) developed the method used by Technical Institute of Construction of Catalonia (ITeC) to quantify the CDW generated per total floor area (m^2) according to different construction systems and quantified five different CDW categories according to the different building systems.

Poon et al. (2001) established 0.175 m^3/m^2 as CDW generation ratio in civil works in Hong Kong against 0.250 m^3/m^2 in private works. Lin (2006) analyzed several buildings from Taiwan obtaining ratios of CDW generation of around 0.850 m^3/m^2 built for non-residential buildings and 0.540–0.660 $m^3/^2$ for residential buildings.

In 2010, the study performed by Solís-Guzmán et al. (2009) established a model for the quantification of CDW in Spain based on the project budget. The model quantifies various categories of waste generated, differentiating the waste coming from demolitions, from the material loss during construction and packaging. The following generation ratios were determined: 0.031 m^3/m^2 built for new construction works and 1.268 m^3/m^2 for demolition works.

More recently, Llatas (2011) determined ratios of CDW generation for three types of waste: remains, packaging and earth/soil. The results of the study established the following generation ratios: 0.082 m^3/m^2 built for packaging waste, 0.057 m^3/m^2 for remains and 0.281 m^3/m^2 for earth. Lu et al. (2011) investigated total CDW generation rates by conducting on-site waste sorting and weighing in four ongoing construction projects in Shenzhen city. The results revealed that the total waste ratio ranged from 3.275 to 8.791 kg/m^2 and miscellaneous waste, concrete and timber for formwork and falsework, were the three largest components amongst the generated waste. Finally, Mercader-Moyano and Ramirez-de-Arellano-Agudo (2013) obtained generation ratios for each category of CDW through an analysis of ten residential buildings in Spain.

Furthermore, the previous literature highlights that masonry is the main activity generating CDW (Katz and Baum, 2011; Villoria Saez et al., 2012). Considering this issue, the amount of waste generated during masonry works in two different projects –with the same total floor area—but one designed with big surface dwellings and the other with small studios, will differ –as the latter has more brick interior partitions–.

In general, the total floor area has been widely used for CDW estimation mainly in high density urban areas such as China or Hong Kong where dwellings are sold by gross floor area (Lu and Tam, 2013; Mália et al., 2013). However, regions such as Europe, U.S or Australia may need to consider other parameters such as the

Table 1
Percentage of each CDW category over the total waste generated.

Waste	Author							
	Mañà i Reixach et al. (2000)	Spanish government (2001)	Pereira (2002)	Costa and Ursella (2003)	Bergsdal et al. (2007)	Mercader-Moyano and Ramirez-de-Arellano-Agudo (2013)	Cohelo and Brito (2011)	Llatas (2011)
Earth, stone and rock without hazardous materials	–	9.0	–	–	–	0.2	–	67.0
Mixed concrete and ceramic mat.	85.0	66.0	58.3	84.3	67.2	95.6	82.9	33.0
Concrete	–	12.0	–	–	–	85.1	–	
Tiles & ceramic material	–	54.0	–	–	–	10.5	–	
Mixed CDW	–	–	–	–	–	0.1	–	
Wood	11.2	4.0	8.3	–	14.6	0.6	–	
Paper and cardboard packaging	–	0.3	–	–	–	0.9	1.2	
Plastic	0.2	1.5	0.8	–	–	0.7	0.2	
Plaster	–	0.2	–	–	–	0.8	6.4	
Glass	–	0.5	–	–	–	–	–	
Metals	1.8	2.5	8.4	0.1	3.6	0.7	4.5	
Asphalt	–	5.0	10.0	6.8	–	–	4.2	
Other	1.8	11.0	14.2	8.8	14.6	0.4	–	

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