Estimation of construction and demolition waste in building energy efficiency retrofitting works of the vertical envelope

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1. Introduction

Construction and demolition waste (CDW) represent one of the main waste flows internationally (Coronado et al., 2011). According to the latest data published by Eurostat, in 2014 the EU and Spain generated approximately 868 and 20 million tons of CDW, respectively (European Commision, 2014), representing 35–18% of solid waste generated at European and national level (Máliá et al., 2013).

CDW can be generated throughout the building lifecycle. During the construction stage, CDW can be caused by many factors, such as: unused or incorrect materials, excess of packaging, improper storage of construction materials; execution errors; etc. (Kulatunga et al., 2006). The level of CDW caused during the construction stage of a building generates large volumes of CDW. However, it is estimated that 30–50% of overall construction waste results from renovation activities performed during the use and maintenance of the building (Symonds Group Ltd, 1999). Finally, during the demolition stage, when buildings have completed their operational life, the entire building –materials and components– become waste and thus the amount of waste material generated increases (del Río Merino et al., 2010).

On the other hand, the incidence of construction on global energy consumption is also remarkable. Buildings account for 40% of...
the total energy consumed in the European Union (Pérez-Lombard et al., 2008). In Spain, due to the weather, the percentage of energy consumption is lower (27.7%). Despite of that, the incidence on the global is still to be taken into account to reduce the environmental impact of the buildings (Porias-Amores et al., 2014). For that reason, the EU commission and the Member States have implemented legal measures in order to actively promote the better energy performance of the buildings, as for example the Directive 2002/91/EU on energy efficiency of buildings which establish a strategy for the refurbishment and/or retrofit of the European residential and commercial buildings’ stock, both public and private (European Parliament, 2002).

The terms refurbishment and retrofit are often confused. According to Eames et al. (2014), retrofit can be defined as a process to provide something with an element or feature not fitted during manufacture or to add something that did not have when it was first built (Eames et al., 2014). It is frequently related to the installation of new systems (heating systems) but it may also refer to the fabric of a building such as retrofitting insulation, walls or windows. On the other hand, according to Almeida (2014) refurbishment refers to renovate and redecorate a building, implying an improvement by cleaning, decorating and reequipping and may also include elements of retrofitting (Almeida, 2014).

In particular, in Spain the Royal Decree 235/2013 of Energy Certification requires from existing buildings—which are sold or leased—to have an energy efficiency certificate (Spanish Government, 2013). Moreover, considering that before 2006, when the new Spanish Technical Building Code was enforced, buildings were built without much energy efficiency interests and show high energy consumption levels. The Royal Decree has undoubtedly driven the construction market towards new systems and materials aimed at improving that energy efficiency of the buildings (Spanish Government, 2013). In this regard, in the Spanish National Congress of Environment experts concluded that it is necessary to refurbish and/or retrofit around 400,000 homes a year in order to achieve the energy target set by 2050 (Cuchi and Sweatman, 2011).

Therefore, the new legal scenario will cause a rocket increase of buildings’ renovation and/or retrofitting works in Spain and consequently an increase of CDW. The proper management of CDW contributes one of the main pillars of the framework of EU Strategy 2020, whose objective is to turn Europe in an efficient society regarding the use of resources, based on circular economy criteria following the “3R” principle (recovery, reuse and recycle) (European Parliament, 2008; Yeheyis et al., 2013).

Given the above, it is necessary to have the most information about the CDW generated in building refurbishment and/or retrofitting works to perform a proper CDW management, following circular economy criteria. Such information shall take into account both identification and quantification of the waste generation in order to plan in advance their management and implement best practices for the prevention and segregation of CDW to facilitate their onsite segregation and recovery.

1.1. Building refurbishment and/or retrofitting carried out in the vertical envelope to improve building energy efficiency

The actions to improve the energy efficiency (EE) of a building tend to mainly consider improving the characteristics of the building envelope, through which the greatest energy losses occur, mainly due to lack or insufficient thermal insulation or for lack of tightness in doors and windows (Grisso and Walker, 2009). Among the refurbish and/or retrofit techniques, those conducted in the vertical envelope have a major effect on energy saving, because the vertical envelope represents a greater surface, both in single housing and blocks (Fig. 1).

The different techniques that can be conducted in the vertical envelope of a building to improve its energy efficiency can be classified into:

- Techniques applicable from the outside of the façade.
- Techniques applicable from the inside of the building.
- Injection of insulating material in air chambers.
- Change and substitution of windows and exterior doors.

In general, techniques applicable from the outside of the façade apply a layer of continuous insulation on the outer side of the existing façade, covering the entire building. They are certainly the most efficient solution, providing many benefits such as: the avoidance of thermal bridges and the thermal stability of the façade and structure. There are basically three different systems:

- External Thermal Insulation Composite System (ETICS): An insulation layer is applied on the outer side of the existing façade and then covered by a thin finishing layer, usually of cement mortar. The insulation layer can be applied without removing the existing coating layer of the building (ETICS type I) or after its removal (ETICS type II).
- Cladding system: Insulation panels are adhered to the outer side of the existing façade covered with a cladding of natural or artificial stone. The cladding is usually fixed to the existing wall with anchors.
- Ventilated façade system: It is basically an evolution of the cladding system, in which a ventilated chamber is placed between the insulation and the cladding. Includes a rigid or semirigid insulation attached to the existing masonry and an outer protective sheet separated from the insulation, forming a ventilated air chamber. The protective sheet is anchored to the existing masonry wall with metallic substructures specifically designed.

In some cases it is not feasible to modify the outer side of the façade, being necessary to use other techniques applicable from the inside of the building. The most common systems are:

- Placing a rigid insulation panel lined with gypsum: is equivalent to the ETICS system used on the outside of the façade. It consists of a rigid insulation placed in the interior side of the façade and covered with a gypsum coating reinforced with a polymeric or fiberglass mesh.
- Placing an insulation material and plasterboard: It consists of placing gypsum plasterboards in the interior side of the façade together with an insulation material fixed to the inner partition of the façade.

Fig. 1. Heat loss in buildings (Wacker Polymers, 2013).
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