Resources, Conservation & Recycling 136 (2018) 166–178

Contents lists available at ScienceDirect

Resources, Conservation & Recycling

journal homepage: www.elsevier.com/locate/resconrec

Construction and demolition waste best management practice in Europe

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ARTICLE INFO

Keywords:
Construction and demolition waste
Circular economy
Recycling
Re-use
Best practices
Environmental management
Waste management
Waste logistics
Recycled aggregates
Plasterboard

ABSTRACT

Construction and demolition waste constitutes a large fraction of all the waste generated in Europe. Its specific impact can be considered rather low, but the large generated volume and embodied resource makes this waste stream an important focus of current European policies. The European Commission has proposed new targets and goals for this waste stream in the Circular Economy package, but, given the rather heterogeneous landscape of waste management practice across Member States, new approaches that take into account the entire value chain of the construction sector are urgently required. This paper synthesises core principles and linked best practices for the management of construction and demolition waste across the entire construction value chain. Systematic implementation of these best practices could dramatically improve resource efficiency and reduce environmental impact by: reducing waste generation, minimising transport impacts, maximising re-use and recycling by improving the quality of secondary materials and optimising the environmental performance of treatment methods.

1. Introduction

Currently, the European construction sector produces 820 million tonnes (megagram, Mg, or 1000 kg) of construction and demolition waste (CDW) every year, which is around 46% of the total amount of total waste generated according to Eurostat (Eurostat, 2017). The average composition of CDW shows that up to 85% of the waste is concrete, ceramics and masonry, although CDW can be heterogeneous depending on the origin, and may contain large amounts of wood and plasterboard (Monier et al., 2011; U.S. Environmental Protection Agency, 1998). In any case, CDW inorganic fraction is frequently characterised as "inert" due to lack of chemical reactivity at ambient conditions. Most CDW consists of excavated materials, which are considered to have a low environmental impact upon disposal. If excavated materials are excluded, around 300 million Mg of CDW were generated in 2014 at European construction sites (i.e. EU 28 new construction, demolition or refurbishment activities).

Construction and demolition waste is characterised by its high volume and weight but with probably the lowest environmental burden and the highest inert fraction per Mg of all waste streams. Although the specific environmental impact (per Mg) is low if compared with other waste streams, the associated environmental impacts of such a high amount of CDW is an important concern, mostly derived from its logistics and land occupation. Hence, the management of CDW constitutes a priority for most environmental programmes around the world, especially in Europe. In fact, the European Commission (European Commission, 2015a) has proposed that, by 2020, "the preparing for re-use, recycling and backfilling of non-hazardous construction and demolition waste *excluding naturally occurring material* defined in category 17 05 04" – i.e. soil (including excavated soil from contaminated sites) and stones not containing dangerous substances – "in the list of waste shall be increased to a minimum of 70% by weight". Remarkably, the definition excludes naturally occurring materials but introduces overall recovery targets, while some experts have recommended to introduce separate targets per fraction and to revise the definition of treatment operations, as backfilling (Arm et al., 2014; BioIS, 2016). There is also some concern on the use of weight percentages, since waste managers may focus on the dense mineral fractions rather than on other fractions with potentially higher potential environmental impact (Arm et al., 2014).

Abbreviations: BaU, business-as-usual; BEMP, best environmental management practice; CEN, *Comité Européen de Normalisation*; CO_2e, equivalent CO_2 emissions; CDW, constructionand demolition waste; EMAS, eco-managementand audit scheme; EN, European norm (European standards); PCBs, polychlorinated biphenyls; RA, recycled aggregates; RCA, recycled concrete aggregates; SWMP, site waste management plans; WRAP, waste and resources action programme

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https://doi.org/10.1016/j.resconrec.2018.04.016
Received 26 December 2017; Received in revised form 3 April 2018; Accepted 19 April 2018
0921-3449/

Novel solutions, instruments and approaches are required for the management of CDW. While a recycling rate of 70% for non-hazardous construction and demolition waste can be considered an ambitious target in certain countries, the industry has noticed that national circumstances are heterogeneous across European Member States and that such a target lacks incentive for the industry of those countries or regions where recycling rates already exceed 70% (Craven, 2015).

Against this background, the clear definition and sharing of best practice techniques is an essential approach in the development of new policy and strategic frameworks for the construction sector, contributing towards the implementation of sustainable development strategy (European Commission, 2015b). This approach underpins the sectoral reference documents developed under article 46 of the Eco-Management and Audit Scheme, EMAS, regulation (European Parliament and the Council et al., 2009). These sectoral reference documents include a description of best environmental management practices, BEMPs, underpinned by quantitative benchmarks of excellence, based on sector-specific key performance indicators, that validate high levels of environmental performance. Multi-expert-stakeholder involvement in the process of BEMP definition ensures that BEMPs target those areas with proven improvement potential and economic feasibility. The compilation of priority BEMPs for CDW prevention and management contained in the sectoral reference document for the construction sector therefore establishes a systematic framework to operationalise the circular economy paradigm for important resource flows.

This paper synthesises the main principles underpinning the definition of *best* practices for the management of CDW, reducing waste generation, minimising transport impacts, maximising re-use and recycling by improving the quality of secondary materials, optimising the environmental performance of treatment methods. The authors of this paper draw upon BEMP definition experience and insight gleaned from the development of six sectoral reference documents, and from European stakeholder inputs regarding CDW management for two relevant sectors: the building and construction sector (Joint Research Centre - European Commission, 2012) and the waste management sector (Zeschmar-Lahl et al., 2016).

2. Characteristics of construction and demolition waste (CDW)

CDW is a generic term that defines the waste generated by the economic activities involving the construction, maintenance, demolition and deconstruction of buildings and civil works. The term "site" is, usually, the most appropriate to define a production facility where CDW is generated. Actually, the distributed nature of construction and demolition *sites* is commonly characteristic of the sector in all Member States of the European Union.

The composition of CDW varies widely as a function of the type of site: e.g. road construction generates a huge amount of excavated materials that, if no further use is possible, will become waste, while a building demolition site will generate a large amount of waste concrete. The heterogeneity of construction activities therefore makes impossible to establish reliable consumption patterns of construction materials or waste generation rates per capita, per work or per m^2 floor area. In this regard, several authors have tried to establish quantitative ranges of CDW generation rates in a benchmarking exercise (Mália et al., 2013). These rates link the construction activity and the amount of waste per unit of built, demolished or refurbished area to CDW indicators for different types of structures, construction techniques and traditional practices. For instance, precast and prefabricated structures generate less construction waste, as the manufacturing process is less wasteful and designs are specific for each building. At the same time, the expected amount of CDW and its composition is substantially different if timber or reinforced concrete structures are used. Table 1 provides an overview of the range of components of CDW. Construction of new buildings generate from 18 to 33 kg per m^2 built area of waste concrete when using concrete structures, while timber-based structures generate ten times less waste. However, demolition of residential buildings can generate up to 840 kg of waste concrete per demolished m^2, while timber-based structures generate up to 300 kg per m^2. In general, concrete is the main material in CDW, if excavated materials are excluded, and is categorised under code 17 01 01 in the European List of Waste (European Commission, 2000). Other important CDW waste codes are 17 01 02 bricks, 17 01 03 tiles, 17 02 01 timber, 17 02 02 glass, 17 02 03 plastics, 17 03 02 bituminous mixtures, 17 04 07 metal mixtures, 17 06 04 insulation materials, 17 08 02 gypsum-based construction materials and 17 09 03 construction and demolition wastes (including mixed wastes) containing hazardous substances.

Table 1
Construction and Demolition Waste composition (BioIS, 2016).

Waste Category	%, min–max range
Concrete and Masonry	40–84
Concrete	12–40
Masonry	8–54
Asphalt	4–26
Others (mineral)	2–9
Wood	2–4
Metal	0.2–4
Gypsum	0.2–0.4
Plastics	0.1–2
Miscellaneous	2–36

Although the specific environmental impact (per Mg) is low if compared with other waste streams, the aggregate environmental impacts of the large quantities of CDW are significant, and derive mostly from logistics and land occupation at the waste end of the value chain (and resource consumption upstream). The impact of CDW logistics and treatments is shown in Table 2. The most relevant environmental aspects of CDW generation are influenced by design decisions at the start of the construction value chain; 'designing-out' waste is a term in use for CDW, and refers to design and planning commercially available techniques to avoid the generation of waste. The most popular designing out waste technique is the use of prefabricated modules, which is more common in modern methods of construction. With this approach, more than 80% of total construction waste can be avoided. For instance, the construction of a new residential building where the structure is prefabricated would save around 80–100 kg of waste per 100 m^2 floor area (Mália et al., 2013).

Some European countries already achieved the objective of 70% recycling for CDW. Statistics show that the total mass flow of recovered waste accounts for more than 80% of the total waste generation in Member States as the Netherlands, Germany or Denmark (Eurostat, 2017). However, in some regions there is a significant amount of illegal dumping and a heterogeneous market for secondary materials, which hinders the development of secondary materials market, that may not be reflected in official statistics. For instance, high collection rates of

Table 2
Life cycle environmental burdens for one Mg of Construction and Demolition Waste treated according to different methods (Blengini and Garbarino, 2010).

Treatment	Global warming potential, kg CO_2e/Mg	Primary Energy, MJ/Mg	Land Use*, PDF m^2 a/Mg
Collection	6	100	0.15
Landfill	15	300	0.80
Recycling	2.5	45	0.18

*Potentially Disappeared Fraction [PDF·m^2 y] of species over a certain amount of m^2 during a certain amount of year is the unit to "measure" the impacts on ecosystems. "The PDF m^2 y represents the fraction of species disappeared on 1 m^2 of earth surface during one year. For example, a product having an ecosystem quality score of 0.2 PDF m^2 y implies the loss of 20% of species on 1 m^2 of earth surface during one year." (Jolliet et al., 2003).