IOP Conference Series: Earth and Environmental Science

PAPER • **OPEN ACCESS**

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To cite this article: Christina Ehlert *et al* 2019 *IOP Conf. Ser.: Earth Environ. Sci.* **225** 012003

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 642384.

It's all about planning - pre-demolition audits to inform public calls for tender for enhanced resource management of building materials from deconstruction

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Abstract. Practical tools for the establishment of material inventories prior to demolition were developed to implement requirements of the Luxembourgish waste law. Pilot projects are accompanied to implement material inventories and encourage selective deconstruction to optimize material separation and resource exploitation. In one of the pilot projects, a test deconstruction of a representative unit of the building and a comprehensive material inventory served as basis for the public call for tender targeting the deconstruction. Both the material inventory of components and materials and the analysis of building contaminants during the early phase of the project allowed to define technical specifications and specific award criteria in the call for tender to reinforce state of the art methods for deconstruction and to channel resource management. An environmental assessment of the deconstruction of the building, based on the life-cycle assessment methodology, is currently undertaken to compare its environmental impacts versus those of a business-as-usual demolition scenario. The results will be used to further support the discussion with stakeholders how tender specifications can be adapted to reinforce environmental benefits of deconstruction and revalorization of materials and which steps have to be included in the planning process of deconstruction projects.

Keywords: selective deconstruction, pre-demolition audits, material inventories, green public procurement

1. Introduction

Pre-demolition audits play a vital role for the controlled deconstruction of a building and the resource management. An obligation to establish pre-demolition audits was introduced as a legal requirement in the Luxembourgish waste law, transposing the European Waste Framework Directive (referred to as "material inventories") [1]. In 2018, practical tools for the establishment of material inventories were made available to implement these requirements [2, 3]. These tools are based on and reflect the state of the art for pre-demolition audits as documented by literature, Member States' specific guidelines and standards [4, 5, 6, 7, 8, 9, 10]. Despite legal requirements in some European countries, the level of implementation of pre-demolition audits remains low due to limited awareness of the existing legislation, time constraints and the required expertise [10].

To further enhance the implementation in Luxembourg, material inventories were established for a number of (pilot) buildings to be demolished [11]. The aims were to support collaborative learning of stakeholders in terms of material assessment in the pre-demolition and demolition phases and to demonstrate and inform about the added value of pre-demolition audits in terms of planning and execution of demolition projects, risk and resource management. Several studies and analyses were carried out during the pre-deconstruction phase of the Jean Monnet building, established in the 1970s, consisting of approximately 125,000 m^2 office space and facilities for approximately 2000 staff and located in the city of Luxembourg: i) a test deconstruction of a representative unit and materials of the building, ii) a comprehensive material inventory targeting the quantification of hazardous and non-hazardous material fractions including further characterisation of specific materials occurring in large quantities.

This article describes the approach, methodology and how the information collected in the pre-demolition phase was used during the call for tender for the internal curing of the building [12]. Both, the material inventory and the analysis of building contaminants during the early phase of the project allowed to define technical specifications and specific award criteria in the call for tender to reinforce state of the art methods for deconstruction and to channel resource management. The focus of this article is on the internal curing of the building targeting the recovery of the non-hazardous fractions, whereas the decontamination and the demolition of the structure of the building are not assessed here. Since the deconstruction and the environmental assessment of it are not finalised, the article does not assess the overall environmental performance of the project.

2. Pre-demolition audit

The pre-demolition studies addressed several objectives. From an economical point of view, it was aimed at assessing the economic recovery options for the available resources to obtain a more precise idea regarding the price setting for the deconstruction project as a preparation for the bidding process. From a waste management perspective, the objective was to improve resource management and achieve high grade recycling according to the waste hierarchy. The preparatory phase also aimed at enhancing the technical competence of the involved stakeholders including the building owner, engineering offices and deconstruction companies regarding data collection and assessment in pre-demolition audits.

A <u>detailed description of the building and its materials</u> was established by data collection of existing building plans and by site visits. Information of the material composition of the following parts and components of the building complex and photos were collected: External façade, roof top, external courtyard, windows and interior fittings, suspended ceilings, radiators, curtains, doors and door frames, floorings, sanitary rooms, lightings, separation doors, wall coverings, inner walls, reception area, kitchen, restaurant and cafeteria, sport facilities, technical facilities, underground parking facilities.

A <u>test deconstruction</u> was performed on a representative office and parts of the facilities of the building to assess the methods for dismantling of building materials and components and to support the compilation of the material inventory with the ultimate aim to enhance high quality recycling. The necessary steps to dismantle the individual components and their respective weights were recorded for the following elements of the representative office and parts of the facilities: Windows and internal fittings, suspended ceilings in offices/sanitary rooms/kitchen, radiators, curtains, doors and frames, office/corridor/technical floorings, sanitary rooms, internal corridor doors, internal separation walls, wall covering of plaster, floor slabs, external façade, electric and informatics cables air-conditioning system.

Following the data collection and the results of the test deconstruction, <u>a material inventory</u> was drawn for components and building materials.

Since aluminium was a major material fraction to be generated by the deconstruction, additional analyses were performed to assess the composition of the different aluminium components obtained from the deconstruction test. Since the glass represents an important percentage of the material fraction, the recycling potential of the glass was also assessed, in collaboration with an actor on the glass-recycling market.

3. Background information and award criteria in the call for tender for the internal curing

Information from the pre-demolition audit relevant for the internal curing of the building was included in the call for tender, i.e. description of the building and its surrounding, the results of the test deconstruction, the material inventory, the composition of the aluminium and the potential recycling of glass were included. To enhance the resource management on-site and streamline the high-grade recycling of the fractions, technical specifications regarding the separate on-site collection of 22 material fractions, its monitoring, reporting and documentation were required. Individual prices for the internal curing of the different building elements such as windows, doors, radiators, lamps were requested for the functional parts of the buildings, such as offices and technical facilities, were requested leading to a detailed price.

Award criteria were divided into price (80% weight) and technical value (20% weight). The technical value targeted the evaluation of the solutions presented for the separation of the materials on-site as well as the resource management. The bidders were asked to include a detailed description and justification of the proposed solution which were weighted according to the following grid:

- a master plan of the sorting centre with the number of containers and the different fractions that will be sorted (5 pts)
- a description of the methods and channels for reuse, recycling, other recovery options and landfill (10 pts)
- a draft template for the documentation to be provided at the end of the project with fractions, quantities, waste management options realised (5 pts)

4. Results

An extract of the results of the pre-demolition analyses is presented in the next paragraphs. The review of the plans, site visits and results from analysis of samples allowed to gain a good understanding of the building. The office building was built during the years 1975 to 1978, designed for 2000 employees and 500 visitors with a gross floor area of approximately 125,000m^2 spread over three main complexes (A, B, C) (see Figure 1).

Figure 1. View of the Jean Monnet building. Google Earth 15/05/2017.

The deconstruction tests delivered results on dismantling steps and material composition (Table 1).

Table 1. Quantitative data for materials, generated via the test deconstruction.

Component	Mass	Component	Mass
Window and inner fitting		Radiators	
Glass	10.5 kg	Aluminium	1.0 kg
Window frame	1.5 kg	Copper	0.5 kg
Metal pillar	15.0 kg	Office doors	
Insulation	2.0 kg	Wood/cardboard	18.0 kg
Sealings	0.8 kg	Aluminium frame	13.0 kg
Internal metal covering	4.0 kg	Transom	1.5 kg
Window sill	3.0 kg	Glass	6.0 kg
Transom	3.0 kg	Office flooring (linoleum)	4.0 kg/m^2
Suspended ceilings			
Aluminium plates	2.0 kg/m^2		
Insulation (glass wool)	1.5 kg/m^2		
Metal profiles	0.6 kg/m		
Metal coverings	6.0 kg/m^2		

Figure 2 illustrates the Mock-up office before and after the test deconstruction as well as the deconstruction of building components.

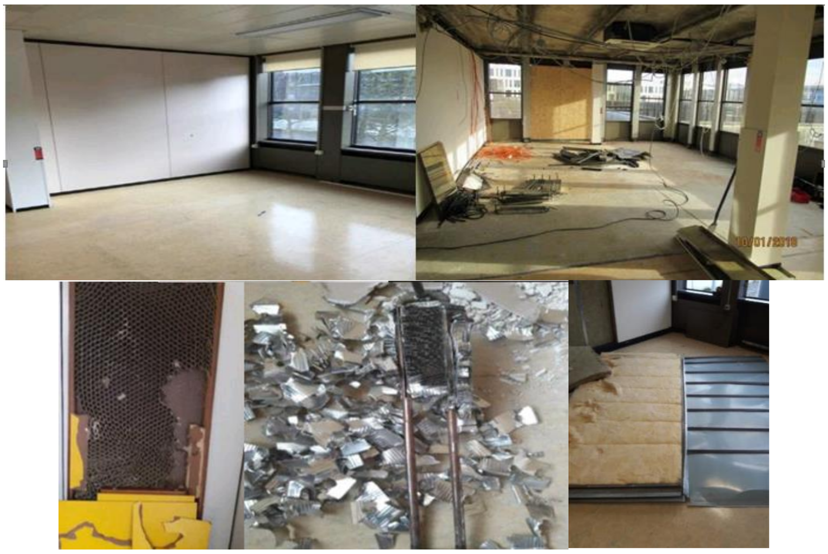

Figure 2. Test deconstruction of a representative unit in the building, from top left to below right corner: View of the office before and after the test. Office door composition. Radiator consisting of aluminium plates and copper bars. Interior wall.

The material inventory of components and building materials can be found in Tables 2 and 3.

Table 2. Extract of the most significant components of the Jean Monnet building.

Component	Amount	Unit
Windows	6,500	pieces
Doors	3,000	pieces
Internal walls	10,000	pieces
Suspended ceilings	115,000	pieces
Radiators	6,500	pieces
Curtains	6,500	pieces
Lamps	7,000	pieces
Insulation	10,000	kg
Plaster	8,000	m^2
Linoleum flooring	95,000	m^2

Table 3. Extract of the material inventory of the most significant material fractions in the Jean Monnet building.

Material	Amount [t]
Linoleum flooring	445
Aluminium	400
Other metals	400
Glass	150
Plaster	65
Wood	45
Insulation (glass wool)	15
Copper (radiators only)	3

Further results can be found in the tender documents for the internal curing [12].

5. Discussion and Conclusions

The pre-demolition phase was used to collect information on materials and to assess economic recovery options for some of them, e.g. for the aluminium and glass fractions. To enable high quality recycling of the materials generated by the internal curing the call for tender specifically asked the separate collection of 22 fractions. The management of the on-site collection as well as the off-site resource management were considered in the award criteria to emphasise the motivation for high quality recycling. Assessment of the "market value" of some of the materials paved the way to identify local recycling companies that further supported the characterisation of the materials and informed about recycling options. Detailed information in the call for tender allowed companies to establish relations for material recovery independently.

An environmental assessment of the deconstruction of the Jean Monnet building, based on the life-cycle assessment methodology, is currently undertaken to compare its environmental impacts versus those of a business-as-usual demolition scenario. The results will be used to further support the discussion with stakeholders how environmental benefits of deconstruction and revalorization of materials can be realised through the systematic planning and execution of deconstruction projects.

Low market acceptance of secondary raw materials to replace primary raw materials, e.g. in construction products, and cost of deconstruction and recycling were identified among the most important local barriers to the recycling of construction materials [13]. To reinforce resource efficiency in the built environment, further integration of specific technical specifications for deconstruction and reinforcing award criteria towards re-use and recycling are needed. For example, to better exploit operations of higher priority in the waste hierarchy such as "preparing for re-use" and material recycling, material inventories for re-use and assessment of the material properties (e.g. as performed for the aluminium) need to be undertaken.

Open and public calls for expression of interest for materials from buildings seem to be a way to bring offer and demand for secondary materials together [14]. The calls for tender will then have to sufficiently incentivise bidders to go beyond common practice and strive for higher quality recovery operations, such as re-use. Several initiatives in the European Union have started to develop technical clauses and inform about the necessary adjustments which need to be done to the common planning process of deconstruction projects to provide sufficient time for realising such recovery operations [14, 15, 16]. These adjustments for the execution phase need to be carefully considered in the planning phase to allow for the recovery of components, equipment and materials. The role of the planning or preparatory phase will thus need to be strengthened if the objective is that re-use and high quality recycling of clean fractions should become a real alternative to the current business-as-usual management of demolition waste, as stipulated by the updated Waste Framework Directive (EU) 2018/851 [17]. The environmental evaluation of the available recovery options for the available resources should be the guide towards a less impacting demolition and recycling industry.

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