SUSTAINABILITY ANALYSIS FOR THE RECYCLING OF MASONRY

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Summary

In Germany, a significant quantity of masonry rubble is generated in the medium term. With regard to a sustainable closed substance cycle waste management, these rest masses have to be recycled if possible. Within the IGF research project “Sustainability Analysis for the Recycling of Masonry”, different recycling options were assessed with regard to their sustainability performance. In doing so, the main kinds of masonry units, their material properties, the processing technologies as well as ecological, economic and social aspects were considered. Based on the results, a web-based tool was developed to assess the sustainability of different recycling options for masonry [1].

Keywords: masonry, recycling, sustainability, LCA, LCC, LCWE

1 Introduction

In Germany alone, up to 10 million tons of masonry rubble (including gypsum plaster boards, renders, mortars and mineral insulating materials) are generated per year [2]. With regard to a sustainable waste management, these rest masses should be recovered, recycled or reused for high-quality recycling products. Within the IGF research project “Sustainability Analysis for the Recycling of Masonry”, different recycling options were assessed with regard to their sustainability performance. In doing so, the main kinds of masonry units (clay units, calcium silicate units, autoclaved aerated concrete units, aggregate concrete units), their material properties and the processing technologies as well as all three pillars of sustainability (ecological, economic and social issues) were considered, by using the methods of Life Cycle Assessment (LCA), Life Cycle Costing (LCC) and Life Cycle Working Environment (LCWE). Based on the results, a web-based tool (web-tool) for operators of recycling facilities and for demolition companies was developed. The web-tool enables the user to identify different recycling options (processing
and application) and assess their sustainability depending on the demolition material (composition as well as chemical and physical properties). Thus, the user gets information about possibilities of the recycling processes of masonry and the corresponding ecological, economic and social benefits.

2 Recycling opportunities

Usually, masonry rubble is a heterogeneous material consisting of building stones, gypsum, insulation materials, steel, plastic and other materials. These as well as economic and technical constraints lead to landfilling or a subordinated utilization on a rather low application level (downcycling) of demolition material. The aim of the project is to recycle demolished masonry into high-quality recycling products and to achieve closed-loop recycling. For doing so, different recycling opportunities are determined. For every recycling opportunity several legal and technical requirements have to be fulfilled. Furthermore to produce high-quality recycling products, the broken masonry has to pass through various processing steps (crushing, sorting, separating, screening, e.g.). A possible basic configuration for a processing plant is exemplary shown in Figure 1.

Within the project, different application options for masonry rubble and necessary recycling processes depending on the material composition (mixed or sorted) were identified. The results were summarised in a recycling matrix as an Excel-tool. Processed aggregates made from masonry rubble can be recycled in the production of new masonry units under certain conditions. Even carefully deconstructed masonry units can once more re-used as masonry units, particularly in the area of the preservation of monuments and historical buildings. In addition, masonry rubble in different processing qualities is applied in earth and road construction, horticulture and scenery construction as well as concrete production. In addition to the recycling applications and processes, the Excel-tool gives information about delivered grain sizes as well as type and quantity of replaceable materials [1–3].

![Fig. 1 Basic scheme of a recycling facility for construction waste](image-url)
3 Sustainability modelling

The modelling of the recycling processes was carried out within the software system „GaBi 5“. With the aid of GaBi 5, the different recycling options can be evaluated concerning ecological, economic and social aspects. Within the evaluation system boundaries are the transportation of the demolished material, processes of the recycling facility and end-of-life credits for replaced primary raw material. The production of masonry units and other materials, their integration into masonry and the on-site demolition of the masonry are not considered. The functional unit for the assessment is one tone of demolished material.

The sustainability modelling comprises Life Cycle Assessment (LCA) according to DIN EN ISO 14040 and 14044, Life Cycle Costing (LCC) and Life Cycle Working environment (LCWE) modelling and evaluation.

The first step of an LCA is to define the goal and scope. Afterwards, inputs and outputs like emissions, resource consumption and wastes of every process have to be calculated. This is the inventory analysis phase, called LCI – Life Cycle Inventory. For the inventory modelling, industry as well as literature data are collected. The LCI results are then classified within the Life Cycle Impact Assessment (LCIA). Within this phase, an allocation to impact categories like Global Warming Potential (GWP), Photochemical Ozone Creation Potential (POCP), Ozone Depletion Potential (ODP), Eutrophication Potential (EP) and Acidification Potential (AP), is implemented. In the final phase, the Life Cycle Interpretation Phase, the results of the LCI and LCIA are considered, checked and evaluated. Significant impacts of the product system and improvement potentials can be identified and summarized. For the modelling of LCC and LCWE, the same system boundaries are applied.

To assess the cost-effectiveness of the recycling products, a life-cycle cost analysis – LCC – was conducted. Within the described project, different costs and proceeds are regarded. Costs contemplated are investment costs mainly for machines, financing costs, cost of operation including maintenance and repair, abrasion, power, fuel and water consumption and costs for infrastructure including site, planning and permissions. Proceeds follow from purchase of demolition material and from sales of broken and recycled material.

With the aid of the Life Cycle Working Environment method (LCWE), social indicators can be assessed in relation to the functional unit Assessable social indicators are qualification level of workers, lethal accidents and non-lethal accidents [4].

4 Principles of the web-tool

Last part of the research project was to develop a web-based tool for operators of recycling facilities and for demolition companies to assess their recycling processes regarding their sustainability performance. Therefore, the described processes were modelled with typical technical datasets, which can be individually modified by the users of the web-tool according to their facilities. Based on the Excel-tool, the user can choose the required recycling processes. It is possible to switch on or off single processes for an individual recycling path. Also several parameters like performance of the processes [kW], transport distance [km], quantity of demolition material [t], composition of the material [percentage allocation], several costs [€/t] and proceeds [€/t] can be adjusted. The
individually adjustable parameters allow a sustainability assessment of every single recycling plant and of every single recycling path depending on the demolished material and the desired recycling product.

5 Conclusion

Finally, the web-tool and the Excel-tool respond several questions about the recycling of masonry: Which possibilities do exist for the recycling of construction and demolition waste? Which processes are required? Where are the important ecological, economic and social benefits? Which applications and processes bear the largest potentials and should be improved in future? Should the material be sorted for achieving higher recycling levels? Is a selective deconstruction worthwhile?

Answering these questions will help to avoid landfilling, to support using demolished masonry for manufacturing recycling products and to enhance the sustainability issue in the construction sector [1, 4].

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