

The BauCycle approach

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Abstract

The fine fraction of construction and demolition waste (C&DW) is a component often not considered in recycling efforts of the material. With five million tons per year (Germany) however the fine material adds up to a noteworthy fraction being landfilled in general. “BauCycle”, an internal Fraunhofer funded project, unites four Institutes while developing new strategies for the fine fraction material. The usage of the fine material for the production of innovative and functional building products is one of the intended goals. However “BauCycle” addresses a more comprehensive consideration of the material’s recycling: Using several tools like the geographic information system (GIS) potential material banks (e.g. sites of demolition) and material needs (e.g. brick producer or cement plants) are integrated in a database.

In addition, information about material logistics and supply chains are taken into account for the development of an internet based market platform. On this behalf the C&DW material can be traded directly from “suppliers” to “producers” in a material quality according to the costumers demand. Another objective of the project team is the development of a sorting technique based on an optical computing approach to enable a chemistry-selective separation of the fine fraction. As a result, for example gypsum particles can be separated from grout, bricks, tiles, sand and other components. In that way costumers are able to buy sustainable raw materials tailored to their requirements. A successful implementation of the BauCycle approach would be an important step to a sustainable reuse of C&DW material.

Key words: BauCycle, fine fraction, upcycling, supply chain, optical sorting

Introduction

The construction sector is one of the most resource-intensive economic sectors in Germany. Each year it consumes approximately 550 million tons of mineral-based raw materials [BBSE-2015]. At around 100 billion tons, the entire stock of buildings is an important store for raw materials which can be recycled at the end of its lifetime: Around 50 million tons of demolition material is generated each year. The fine material (< 2 mmm grain size) adding up to approximately five million tons per year (Germany) is landfilled in general. Only about five percent of the material is suitable for the high-quality recycling on product level [Schnell-2010]. Due to the ongoing discussions on the framework ordinance of the German Government [Utermann-2016], regulating the use of mineral replacement construction materials in technical buildings, the situation is of increasing interest. A suitable recycling process is not yet

available for these fractions, even though landfill capacities are becoming scarce [Haeming-2016] and the primary sources of raw material for fine sand are mined close to its limits.

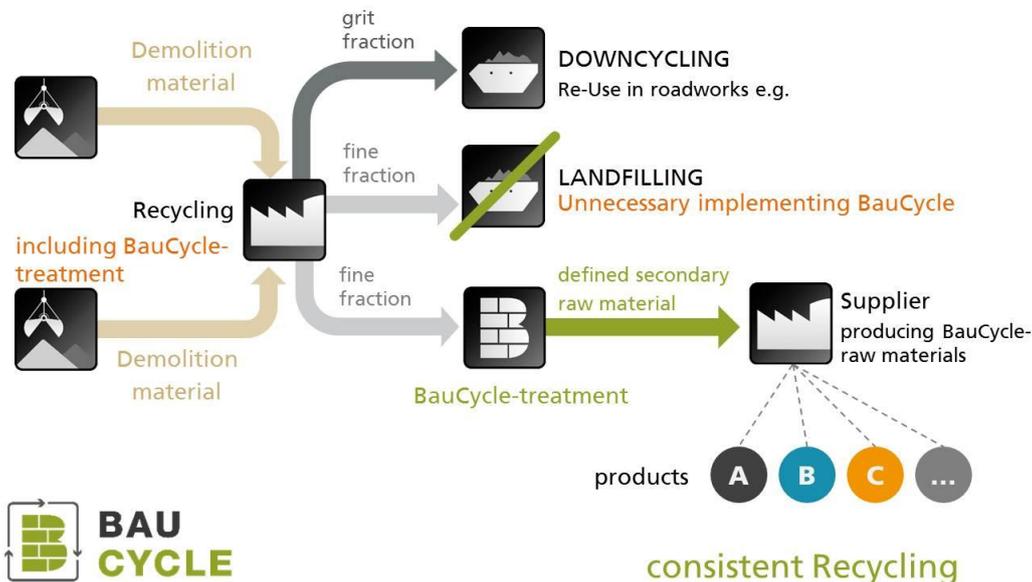


Figure 1: The flow of C&DW after establishing the BauCycle concept

Project idea

A cooperation of four Fraunhofer institutes is working on solutions for the material heterogeneity and the technical as well as safety-related challenges surrounding this flow of material. The recycling of the fine-grained waste fractions into production ensures a resource-efficient and sustainable raw material management and forms the basis of an innovative recycling management. To prevent downcycling applications like road construction, backfilling or even landfilling, the usage of the fine material for the production of innovative and functional building products (e.g. wall plaster, alkaline activated components or autoclaved aerated concrete) is one of the intended goals to reintroduce the raw materials in the production cycle (figure 1).

The main aim of the project is to develop and establish a closed-loop of material in the construction sector. Fraunhofer IOSB is developing optical spectral filters and illuminations for material-specific sorting, Fraunhofer IBP and UMSICHT are aiming for new materials and products consisting of demolition material and Fraunhofer IML pursues a platform-based reorganization of the market. Further the knowledge and expertise of all partners is focused to assess the ecological impact.

Project approach

In a first step “ideal C&DW” will be used by IBP for evaluating different approaches to develop new products. Functional building elements like sound absorbing wall tiles, cement-free binder alternatives or porous lightweight bricks (e.g. AAC) are some of the materials being focused on. Therefore components like concrete, bricks or sand-lime bricks will be mixed in known quantities to serve as the “ideal C&DW”. Afterwards promising approaches will be tested with “real C&DW” collected from different recycling sites. To enable a broad usage of C&DW in the production of new

building materials the performance of the sorting-equipment is essential. Sorting technologies which are used now in plastic or glass recycling will be transferred by IOSB to the construction sector. The demolition material < 2 mm is fed to a flat conveyor or a slope where it is singularized. By using the approach of optical computing a real-time identification of particles should be available in the next years. By a pneumatic system the demolition material is separated and delivered for further handling (see figure 2).

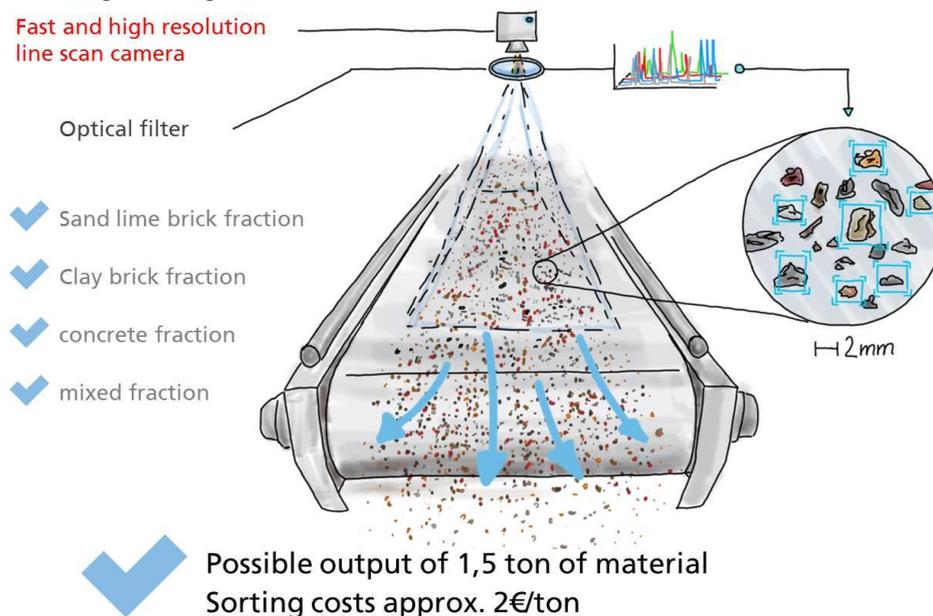


Figure 2: Sorting of the C&DW material by optical computing

As the construction and demolition market is organized locally and regionally the logistics concept has to consider this restriction. Construction material specifically demolition material of concrete walls and floors is heavy, so that long-distance transports are avoided. On one side these transports are expensive on the other they do have a severe impact on the environment.

Fraunhofer IML is developing a marketplace which addresses the synchronization of demolition and construction site using specific simulation algorithms. Once the idea of the marketplace is successfully implemented users will be able to reduce their project costs and reduce the impact of their specific project on the environment. Fraunhofer UMSICHT assesses the evolving new processes. By simulating the impact of the sorting process or the transports for common distances the impact of BauCycle can be estimated.

First Results

In the first year of the project, business and simulation models, sorting procedures and innovative recycled construction materials were conceptualized.

To expand the material flow management with spatial components considering regional aspects a comprehensive analysis of potential material sources and sinks was performed. With the help of a GIS the results were cartographically edited and prepared. For a Germany-wide model we compiled brickyards, producer of

autoclaved aerated concrete, sand-lime bricks, clay bricks or cement, transit-mixed concrete sites and stationary reprocessing plants as stakeholders.

For the beginning a model region, which includes more relevant stakeholders like landfills and deposits of sandstone, gravel, gypsum, clay and limestone will be analyzed.

Afterwards all localized mineral sources and sink locations were linked according to geographical position on significant transport routes. Concerning the development of building materials containing C&DW material in a first step ten mixtures of “Ideal C&DW” were made out of concrete, sand-lime bricks and clay bricks.

For AAC stones a substitution of up to 30 wt.% of quartz powder from the original recipe by using a 50/50 blend of concrete and sand-lime brick was achieved. No drawbacks on mechanical properties like compressive strength were detected. “Ideal C&DW” containing clay bricks and concrete could be used to produce alkaline activated elements. First approaches showed that the resulting properties are comparable with the samples produced with primary raw materials. Figure 3 a shows sample of the RC-AAC and an alkaline activated element.

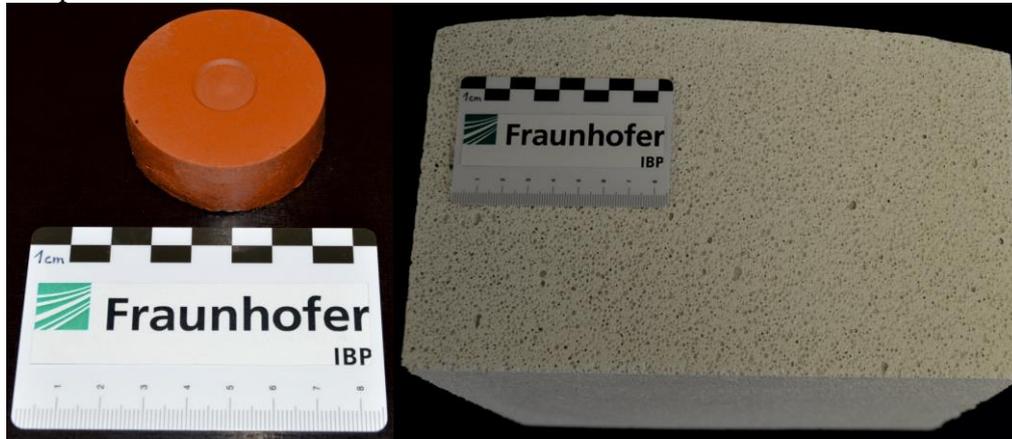


Figure 3: Sample of an alkaline activated component (left) and a RC-AAC (right)

Future Topics

The Baucycle approach points out the challenges in the field of processing and analysis, as well as in the marketing and production of recycled products. Due to the heterogeneity of the materials and the technical and safety-related challenges associated with the fine-grained material flow, the industry requires novel sorting procedures, logistics concepts and product innovations which go far beyond the current technological level. A successful implementation of the BauCycle approach would be an important step to a sustainable reuse of C&DW material and a technological and logistical solution for the circular economy in the building industry in general. Thus other industry branches could benefit from the BauCycle approach in the future.

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