The Future of Construction (*Zukunft Bau*) – SHORT REPORT

Title

Energy and material flows in the production and use of secondary (raw) materials in the building sector – an orientation framework for ten groups of building products to assess recycling options under conflicting objectives (Az: 10.08.18.7-17.45)

Motivation/current situation

The recycling of construction waste can make a vital contribution to resource conservation. One decision of the German Resource Efficiency Program II (ProgRess II) was to investigate the use of natural material resources from an energetic perspective in order to exploit synergies as well as to identify conflicting objectives. While the same considerations apply to secondary materials, it is not yet clear how such a combined approach can be successfully realized.

Objective of the research project

The research project is an exploratory study to investigate the energy expenditure associated with material recycling in the building sector. Previous standard *mass-based* approaches to recycling are here contrasted with the question of energy consumption to determine the extent to which recycling is worthwhile from the viewpoint of energy inputs. This needs to take into account the quality requirements of new areas of application for demolition materials following questions arise.

- On which basis can we compare the potential pathways of material usage from demolition site to their application at a new construction site?
- What are exemplary types of application of secondary materials from demolition material and what are the specific quality requirements to enable their use?
- How much energy is required to meet these requirements for use, and what methods are available to calculate and illustrate these energy needs? What the limitations to these methods of determining energy needs?
- How can recycled materials (and their associated costs) be evaluated in relation to the use of primary materials?

These basic questions are investigated by considering ten groups of building products, namely: *concrete, brick, sand-lime brick, gypsum, flat glass, mineral insulating materials, plastic profiles, other plastics, petroleum-based insulation materials* and *timber*. The material flows of these groups were already investigated in a previous project.

It is necessary to develop a standard evaluation framework to enable a consistent analysis of all ten groups of building products. This allows us to determine the respective amounts of energy consumed in the recycling process. In this way we can compare the groups of recycled products with traditional primary materials.

For each product group, instructive examples of usage are developed in the form of characteristic “continuous” process chains (from the gathering of demolition material to the various options for use generally 2 to 3), analyzed from an energetic perspective in three steps:

1. Processing of the demolition material into secondary material – modular calculation of the energy expenditure required to produce the secondary material.
2. Ensuring functional equivalence (usability as a substitute) by considering differences in the use of primary and secondary materials as end products.

3. A comparison of energy expenditures for the production of substitutes and primary materials.

In step 1, the energy input for the processing of the demolition material into secondary material is quantitatively determined in MJ/kg for each product group for all modelled process chains. Important tasks in this step are: a) identifying typical processing steps for the production of secondary material within the standard process chains for each product group; b) assessing the practical necessity of each processing step (necessary, optional, dispensable); c) specifying which technical components (machine, plant, aggregate) are linked to each processing step and assigning energy values to each of these components; d) an analysis of the removed co-products or by-products and allocating corresponding energy values derived from this analysis.
In step 2, we examine the differences between the "standard manufacturing process" and the "RC manufacturing process" required to ensure secondary materials that are functionally equivalent to the corresponding primary material. These differences are evaluated and quantified by means of divergences in energy expenditure (higher and lower values). The differences in the further processing of the secondary material result from modified recipes, divergent transport costs as well as modified process steps.

In step 3, the energy expenditure for the production (step 1) and additional processing of the secondary material or substitute (step 2) is compared with that of the corresponding primary material in MJ/kg.

Experts from various trade associations, research institutes as well as the industrial and political sectors helped to develop the current methodological approach and analysis of the individual groups of construction products.

Conclusion

In line with the objectives, a standard evaluation framework to assess energy expenditure was developed as part of this exploratory study. The analyses based on this framework have shown that, in general, recycling is associated with lower energy costs than the use of primary materials. However, there are some exceptions. Every building product has its own specific quality requirements and must be considered individually. There are clear differences between mineral materials and plastics; even amongst mineral materials, each building product has its own specific characteristics.

The following were identified as core problems: the lack of characteristic energy values for the various processing steps (technical plant data, consumption data) and the lack of estimates of energy consumption for material transport (transport distances, means of transport).

Project summary

Short title: Secondary raw materials in the building sector

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Total costs:	117,277 euros
Federal grant:	70,131 euros
Project duration:	1 Sept 2017 – 30 April 2019 (20 months)

FIGURES

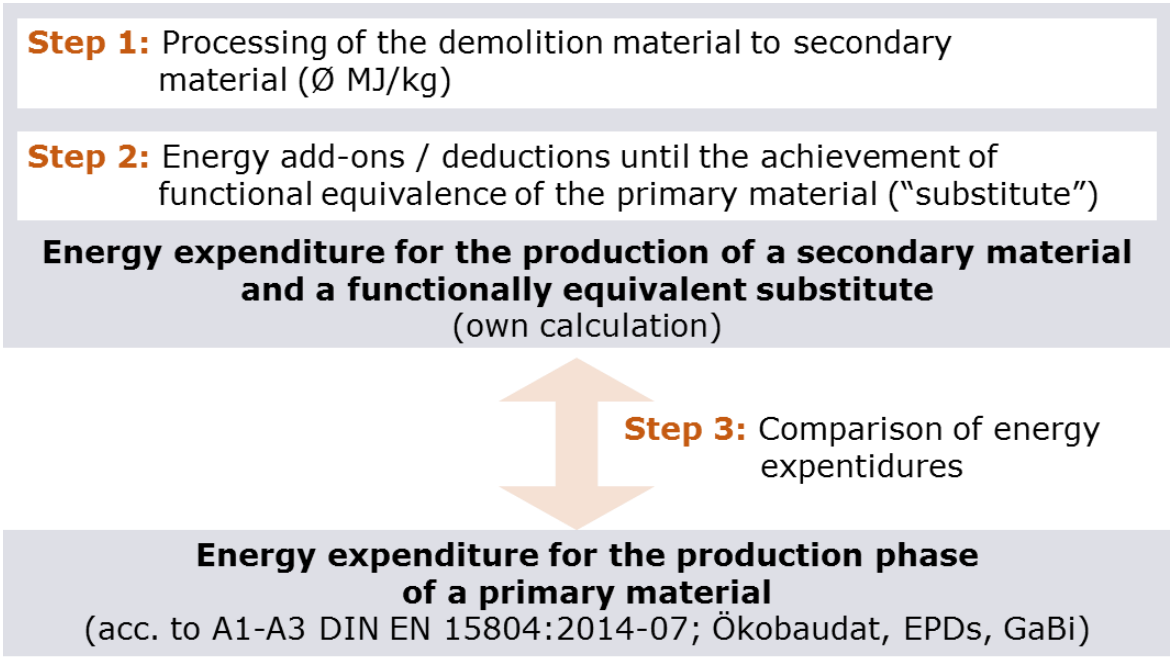

Fig. 1: Evaluation framework – the three main steps

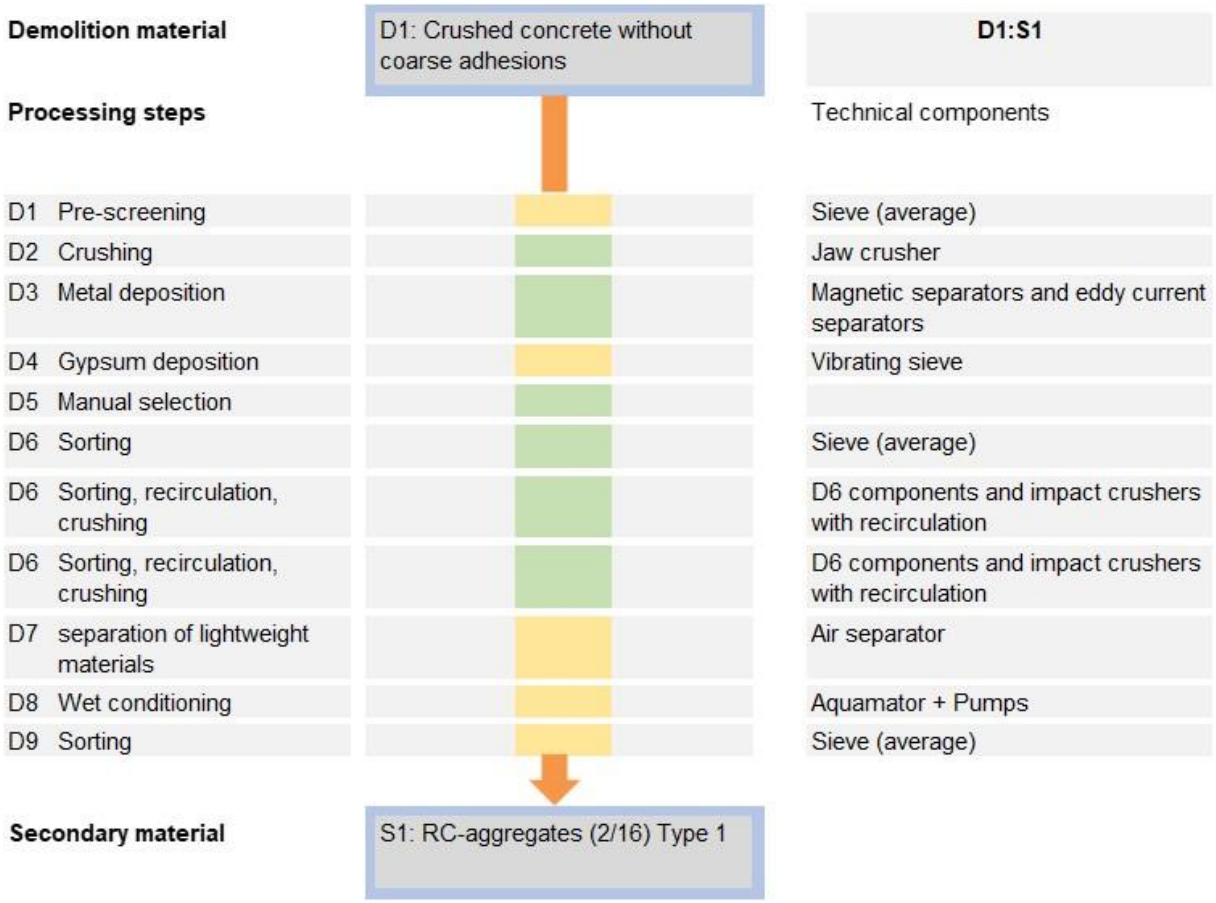

Fig. 2: Step one in the adopted approach – Processing of demolition materials into secondary materials (here: process chain R1-S1-E1 concrete)

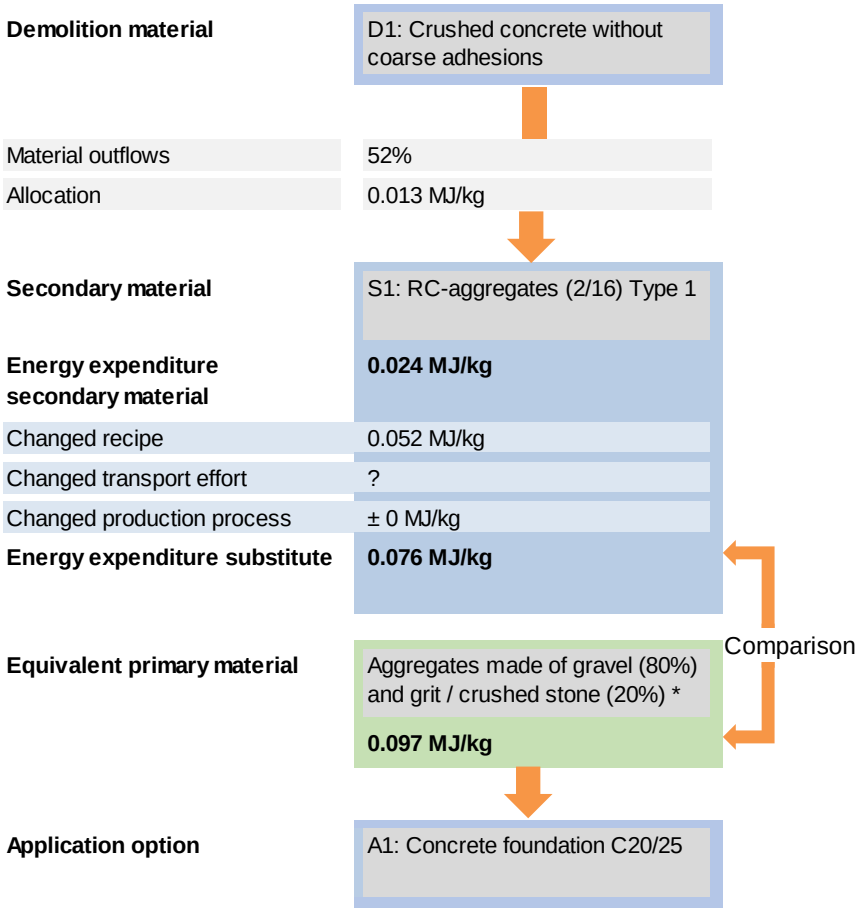

Fig. 3: Steps two and three in the adopted approach – achievement of functional equivalence (suitability as substitute) (here, process chain R1-S1-E1 concrete)

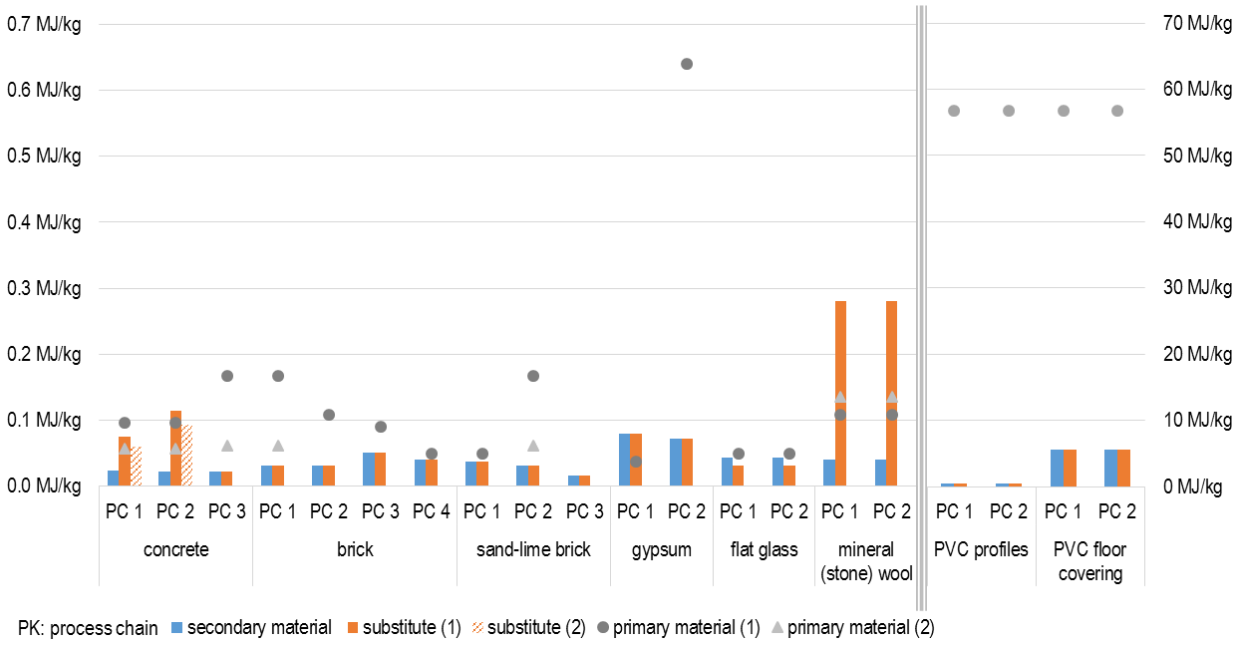

Fig. 4: Energy consumption in MJ/kg – Comparison of the process chains for each group of building products