SHORT TERM SCIENTIFIC MISSION (STSM)
SCIENTIFIC REPORT

This report is submitted for approval by the STSM applicant to the STSM coordinator

Action number: CA17133
STSM title: circular-oriented use of building products in the planning process of a pilot project
STSM start and end date: 01/01/2020 to 29/02/2020
Grantee name: Magdalena Zabek

PURPOSE OF THE STSM:

The aim of participating in the STSM was to link my PhD thesis entitled "Circular-oriented use of mineral building products in the planning process of residential buildings" to the work of international researchers at the Department of Architectural Engineering and Technology at the Delft University of Technology. By joining active networks like the Circular Built Environment Hub (www.tudelft.nl/CircularBE) I gained an insight into the current developments in The Netherlands towards a circular economy on a practical scale. The collaboration with Prof. Dr. Ing. Tillmann Klein, Professor of Building Product Innovation, helped me to structure my work and find a method to transport information about circular building products into the planning process of buildings, and to model a circular planning process. By participating in discussions about the assessment of circularity I could contribute my knowledge about the assessment method developed at the Chair of Reuse in Architecture in Aachen. By comparing current assessment methods, I could optimize the method used in my research, and complete the preliminary investigation for my thesis.

DESCRIPTION OF WORK CARRIED OUT DURING THE STSMS

In the first part of the STSM I completed the preliminary investigation for my doctoral thesis by evaluating the circularity potential of three best-practice buildings in order to proof their suitability as case study objects. To do so, a methodology to investigate the circularity potential has been developed at the Chair of Reuse in Architecture beforehand (Hildebrand & Wemmer, 2019) and has been used on 7 other case studies. The following best practice buildings were assessed:

Name	Nest	Circle House	Recyclinghaus
Architect	Werner Sobek, KIT	3XN	City Förster
Location	Dübendorf, Switzerland	Copenhagen, Denmark	Hannover, Germany
	 *Fig. 1: Nest*	 *Fig. 2: Circle House*	 *Fig. 3: Recyclinghaus*

Tab. 1: Case Studies

As stated in the application, I planned to investigate the circularity potential of the Façade Leasing Project (Azcarate Aguerre et al., 2018) from the Tu Delft. However, after consulting the planner, this project proofed to be quite insufficient for investigation due to its use of material (high amount of metal and glass). Hence, I evaluated that the project does not represent a best practice project of the usage of circular mineral building products and was not investigated. Therefore, three other buildings (Table 1) were investigated based on interviews conducted beforehand.
While getting into touch with other researchers at the Department of Architectural Engineering and Technology I realized the need of a standardized assessment method for measuring the circularity potential. Several researchers like the platform CB'23 (CB'23, 2019) are currently working on a binding regulation of circularity. In order to achieve a standardized assessment method a close look on the current assessment methods is crucial. I reviewed methods that were recently developed and compared these to the method used in my research.
In order to get an insight into product development on a practical scale, I participated in a PhD course entitled 'How a material becomes a product?' on the 11th of February, lead by Angela Sasic Kalagasidis, Professor in Building Physics at the Chalmers University of Technology. This course provided me with knowledge about how innovative building materials become requested products at the market. Especially for recycling products it is quite difficult to enter the market due to minor acceptance among customers and higher prices.

During the second half of the STSM I had several supervision sessions with Prof. Dr. Ing. Tillmann Klein and Dr. Alexander Koutamanis, Associate Professor of Computational Design. We discussed: 1) How can the information about circular building products be transported in a planning process, 2) What model is suitable to model a circular planning process in order to provide a successful information flow? Based on their advice, I conducted a literature review on current practice in the planning process called Building Information Modelling (BIM) that represents the consistent and continuous use of digital information across the entire lifecycle of a building. This idea was originally proposed by researchers in the 1980s but has only recently reached technical maturity and is now being successively adopted by the industry worldwide (Borrmann, König, Koch, & Beetz, 2015). BIM contains modelling method of planning processes (Process Map) and describes the time, content and quality of information, that is being exchanged (Exchange Requirement) (Beetz, Borrmann, & Weise, 2015; Borrmann et al., 2015). Based on my case study research, several scenarios for the use of circular building products had been defined in order to develop a Process Map and Exchange Requirements. For each scenario stakeholders, actors and their respective roles were determined. Following scenarios were developed:

1. Reuse of building products,
2. use of recycled products,
3. building for disassembly,
4. use of non-hazardous substances,
5. use of material passport,

In the second step, processes based on the determined scenarios were developed for each case study and captured in the form of diagrams according to the Business Process Modelling Notation (BPMN) referred to as Process Maps (PM). This step was followed by the creation of a formal program of data exchange specifications referred to as *Exchange Requirements (ER).*

Fig. 4: Group picture being a guest of the Chair of Building Product Innovation at TU Delft (Magdalena Zabek 2nd right)

DESCRIPTION OF THE MAIN RESULTS

While assessing the circularity potential of three best practice projects of circular-oriented buildings, a Life Cycle Analysis had been conducted to measure the resource in-and output as Greenhouse Gas Emissions (CO_2 equivalent). Data was taken from the Ökobau.dat platform (Kerz, 2012).Compared to the other 7 case studies evaluated beforehand in my research, the results were very good. Consequent, these three projects can be viewed as the current leading projects in circularity.
The method to assess the circularity potential of buildings developed at the Chair of Reuse in Architecture(Linda; Hildebrand & Wemmer, 2019) is one of several possible methods. Developed in the 1960'ies, the Life Cycle Assessment (LCA) methodology is a common method to assess the environmental impacts associated with all the stages of the life-cycle of a commercial product, process, or service (Hildebrand, 2014). In fact, the last stages of a product life circle are rarely assessed, and estimations lead to incorrect results. As a consequence several researchers regard this method as insufficient to assess the circularity potential of a product. According to this assumption, further methods had been developed by industry and researchers like the Allen MacArthur Foundation (Foundation; & Design, 2015) in the UK, CB'23 platform (CB'23, 2019) and Madaster Services (Madaster, 2020) in the Netherlands, the Chair of Building Construction, Bergische Universität Wuppertal (Rosen, 2019), Chair of Timber Structure in TU Munich and the Chair Reuse in Architecture (Ebert, Ott, Krause, Hafner, & Krechel, 2020), RWTH Aachen University (Hildebrand & Wemmer, 2019) from Germany. All follow the same approach to divide the material resource flows into in-and output. There are differences in the indicators (Mass, Global Warming Potential GWP) and parameters. In comparison, the method used in my PhD research (Hildebrand & Wemmer, 2019) uses GWP as indicator and 8 parameters and therefore is relatively simple. Hence, this method has potential to contribute to a standardized assessment method which could be implemented in existing regulations as one major step towards a circular building economy.

The second half of the STSM was conducted to the research of process modelling tools and methods in order to evaluate the case study research and to develop an ideal circular-oriented planning process of mineral building products. The first two tasks of sketching a Process Map and defining Exchange Requirements (Beetz et al., 2015) demanded a good knowledge about the case study projects were content was derived from. Interviews lead with the planers of the projects helped to structure the Process Map but were not sufficient enough to develop Exchange Requirements. Fortunately, a literature review about building product information conducted beforehand was beneficial and filled missing information about building products.
The developed documents were created by simple technical tools such as a diagram editor and spreadsheets and therefore did not require technical skills or knowledge of the underlying information models such as the Industry Foundation Classes (IFC). Yet, these information aspects can be mapped in a data model based on the vendor-neutral standard for the description of digital building models IFC. This gives a great opportunity in future research to implement the information about circular planning processes in Building Information Modelling (BIM) and be adopted by the building industry on a global scale.

FUTURE COLLABORATIONS

By joining the Circular Built Environment Hub at TU Delft I got the chance to discuss current circular assessment methods with Charlotte Heesbeen, a PhD candidate and a member of the Architectural Facades and Products research group. She is interested in using the method developed at the Chair of Reuse in Architecture to measure the circularity potential of her case study research projects. The aim is to assess several façade case studies in her PhD thesis. It is planned to write a paper entitled "Current methods of the assessment of circularity and the application on circular façade elements" based on a literature review conducted during the STSM. The goal is to evaluate the circularity potential of several façade case studies in order to find the best circular façade product. It is planned to start working on the paper in May and hand it in the open-access journal of Sustainability (ISSN 2071-1050; CODEN: SUSTDE) by the end of summer 2020.

Another outcome of my stay in Delft is that a PhD workshop will be held in Cologne with PhD candidates of the Chair of Building Product Innovation, led by Prof. Dr. Ing. Tillmann Klein, Chair of Design of Construction, led by Prof. Dr. Ing. Ullrich Knaack from TU Delft and the Chair of Reuse in Architecture led by Prof. Dr. Ing. Linda Hildebrand from RWTH Aachen University. This event will take place in the summer and is a great opportunity to present the outcome of the STSM and discuss the impact on my PhD research.

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Fig.1: https://www.empa.ch/de/web/nest/urban-mining
Fig. 2: https://gxn.3xn.com
Fig. 3: hhtps://haufe.de
Fig. 4: Marcel Bilow