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DOCTOR OF ENGINEERING SCIENCES

of **Camille Vandervaeren**

The public defense will take place on **Wednesday 27th August 2025 at 4 pm** in room **I.0.01** (Building I, VUB Main Campus)

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THE WEIGHT OF CIRCULAR BUILDINGS
ENHANCING THE MATERIAL AND ENVIRONMENTAL IMPACT ASSESSMENT OF REUSE STRATEGIES IN BUILDINGS

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Abstract of the PhD research

To mitigate the environmental impacts of the construction sector, including the quantity of materials used and the waste generated, policymakers, interest organisations, and academia are advocating for the reuse of construction products and systems. Two primary design strategies can enhance reuse throughout the life cycle of buildings: utilising reclaimed products and designing buildings for future deconstruction and adaptability (DfD/A). In order to facilitate the implementation of these strategies, designers require reliable assessment methods and tools to comprehend the consequences of their choices regarding building material flows and associated embodied environmental impacts. Existing life cycle assessment methods have been conceptualised within a linear 'take-use-waste' framework, necessitating adjustments when evaluating buildings and construction systems that enable material reuse. Although they are rarely conducted at the product and building levels, material flow analyses hold promise for understanding the effects of reuse strategies in buildings.

This thesis identifies two key specifications for assessment of material flows and related environmental impacts in buildings. The assessment should (1) consider buildings as time-dependent, multifunctional systems, with evolving physical and functional characteristics, and (2) account for the physical interdependencies of building parts to avoid underestimating significant quantities of waste. These specifications led to an alternative methodological approach developed through four revelatory case studies: two involving built assemblies with reclaimed materials and two involving DfD/A assemblies.
Regarding the first specification, time-dependency and multifunctionality, the thesis proposes adapting the conventional definition of the 'goal and scope' in a life cycle assessment, including the system boundary, functional unit, and use and end-of-life scenarios. A system boundary encompassing the successive and potentially changing uses of building parts aids in understanding the environmental impacts of relocations and reuses. It provides a more comprehensive and practical perspective than a truncated system with impact allocation over different uses.

For the second specification, a method and Building Information Modelling tool have been designed and programmed to refine the bottom-up material flow analysis of buildings, with better consideration of DfD/A parameters. This method converts a built assembly into a network graph, where nodes represent building parts and edges represent the interdependencies between parts. These interdependencies consider the detachability of connections, the durability and accessibility of building parts, and the structural dependencies of the assembly. When applied to the design of a simple pavilion, this method reveals environmental differences between pavilions made with the same building parts but with different connections and spatial configurations. In contrast, the standard calculation method yields the same environmental impacts for all these alternative designs.

The case studies demonstrate how this set of recommendations can enhance the material flow and environmental assessment of reuse strategies in buildings, primarily benefiting life cycle assessment experts, but also indirectly aiding those making design and policy decisions based on the environmental impacts of buildings and products.