

DESIGN FOR ADAPTABILITY AND DISASSEMBLY: A REVIEW TO ACHIEVE BUILDINGS' DECONSTRUCTION

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ABSTRACTION

Reusing and recycling building materials and components are ways of minimizing construction and demolition waste (CDW). Design for Adaptability and Disassembly (DfAD) is a method that enables buildings to be adapted to the needs of users and deconstructed if needed. Even though it allows integration of circular economy (CE) principles into the construction sector, DfAD is little explored in projects and constructions. This study analyzes how the sector approaches DfAD to achieve building deconstruction. Through an integrative literature review, 279 articles were selected and categorically analyzed. The results show the concentration of studies in three major categories. We then proposed a framework that outlines the main circular strategies found in the literature that make it possible to deconstruct and recover components, products, and materials at the end of the building's life. This framework can be used as guidance for academics, professionals, and decision-makers to expand knowledge about the potential applications of the DfAD method. The need for more knowledge on DfAD, better reuse of materials and components, and life cycle tools as decision supports for the material at its end-of-life are crucial steps to make buildings viable material banks.

Keywords: circular economy; sustainable building; DfAD; circular building.

INTRODUCTION

The construction sector is responsible for the highest amount of resource use, waste, and emissions of all industries. To reduce these environmental impacts, strategies have been adopted to reduce construction and demolition waste (CDW). Deconstruction is an end-of-life (EOL) scenario that favors the recovery of construction components, reduces the generation of CDW and greenhouse gasses (GHG) emissions and preserves natural resources.

Design for Adaptability and Disassembly (DfAD) is an ecodesign method that enables the systematic disassembly of the building, reuse/recycling of its parts/materials, and adaptation of the building's layout whenever needed. DfAD seeks to maintain materials at their highest level of utility and value, boosting circular economy (CE) principles in the sector. CE is a restorative economic model that seeks to dissociate economic development from the consumption of finite resources (EMF, 2015).

Despite efforts to mitigate CDW through deconstruction, there is a gap in the literature on deconstruction process information and practices aiming at closing the buildings' material cycle. Through an integrative review, this study sought to propose a framework of the categorized studies to achieve buildings' deconstruction.

MATERIALS AND METHODS

The research strategy consisted of an integrative literature review with explicit and systematic review methods for data processing and analysis. This was done following a succession of six steps, as shown in Figure 1. In total, 279 articles were selected and analyzed. A framework based on the categorized studies was proposed to guide buildings' deconstruction.

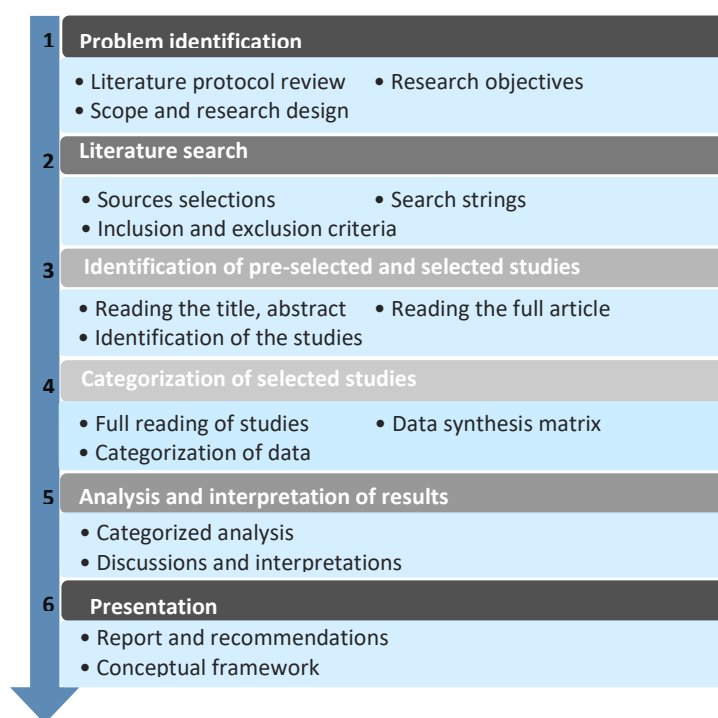


Figure 1. Steps of the integrative review.

Source: The authors, 2022.

RESULTS

The studies were divided into three main categories according to similarity: (i) Design and planning process; (ii) Buildings' end-of-life; (iii) Circular assessments and strategic values. Subcategories with similar elements were grouped in the main categories. Table 1 indicates the categorization of the publications.

Table 1. Categorization of publications analyzed in the review.

Main category (No; %)	Subcategory (No; %)
Design and planning process (107; 38%)	Architectural values (3; 1.1%)
	Assembly/disassembly phase (5; 1.8%)
	Construction principles (52; 19.0%)
	Materials and connections (46; 16.5%)
Buildings' end-of-life (102; 37%)	Building stock potential (8; 2.9%)
	Construction and building renovation (23; 7.9%)
	Material/resource recovery assessment (32; 11.5%)
	Selective deconstruction (23; 8.2%)
Circular assessments and strategic values (70; 25%)	Waste management (16; 5.7%)
	Environmental and cost analysis (29; 10.4%)
	Pilots and case examples (24; 8.6%)
	Transition to circular buildings (17; 6.1%)

Source: The authors, 2022.

a. Design and planning process



This category focused on the design and construction phases of the building's life cycle. The most eco-efficient sustainable strategies for deconstruction are those conceptualized from the beginning of the project, considering the choice of materials, the construction technique, and the needed Information and Communication Technologies (ICTs). The predominance of studies was in steel-concrete structures and precast concrete elements. The use of prefabricated components and materials, modular design, and mechanical joints are the most explored construction principles in the context of DfAD.

b. Buildings' end-of-life

The category emphasized on reusing construction materials and components, the adaptive reuse of buildings, and deconstruction methodologies, avoiding obsolescence, and ensuring the continued use of materials. The reuse of construction materials must overcome challenges related to their insurance, warranty, quality, and performance. The coordination of the design process through Building Information Modeling (BIM) was emphasized in the prevention of waste, in assembly and disassembly plans, in the compatibility of projects, information providing, and in the collaborative process.

c. Circular assessments and strategic values

The category highlighted principles of CE and strategic tools for efficient choices of materials, components, and services that support a closed life cycle. The studies corroborate the importance of the life cycle tools to predict and assess the environmental impacts of different EOL scenarios. There are challenges related to the lack of data and information for the construction, maintenance, retrofit, and reusing / recycling phase of the materials.

DISCUSSION

Figure 2 presents a conceptual framework made out of the categorized studies, related to the stages of the building life cycle. The subcategories indicate areas of activity and research that will promote circular practices to make buildings a bank of materials. The aim is to reinforce that the implementation of DfAD can be a strategic policy for the reduction of GHG emissions in the sector, by favoring the reuse and recycling of building materials and components.

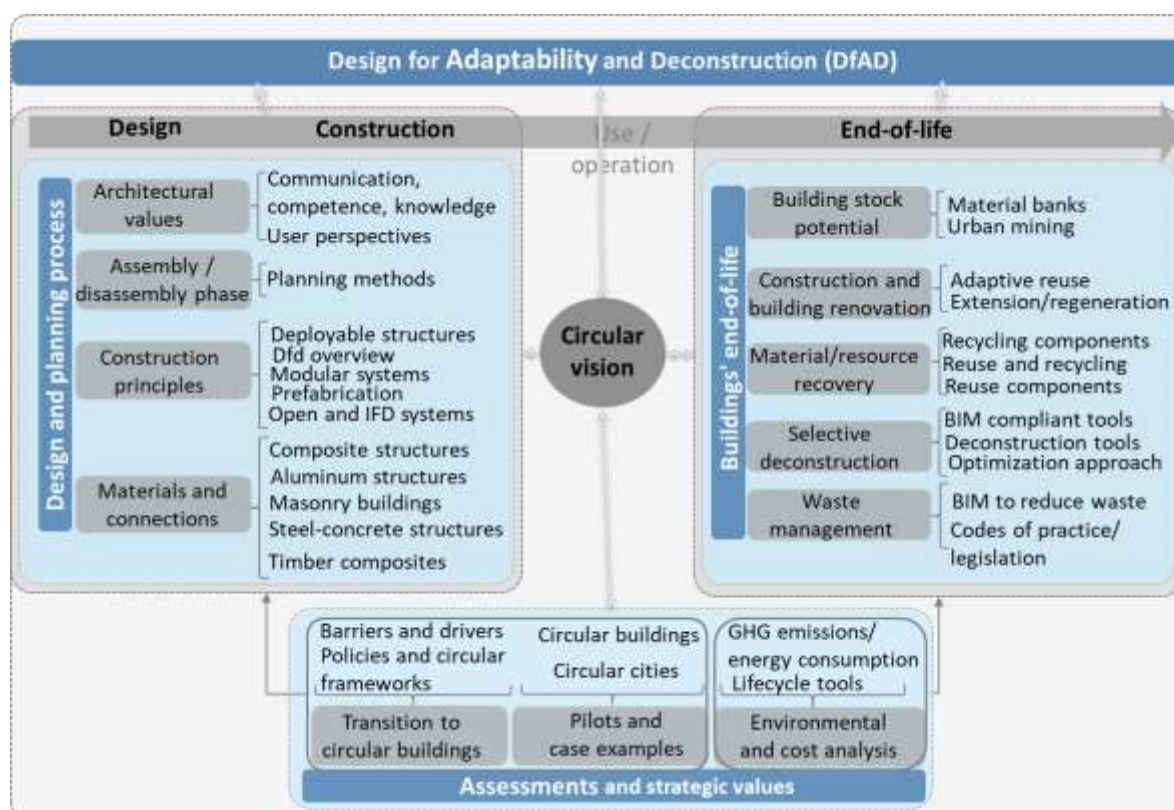


Figure 2. Conceptual framework of categorized studies for the implementation of DfAD in the construction sector.

Source: The authors, 2022.

The starting point of the framework is to consider that DfAD understands that all phases of the building life cycle must be planned in the design phase. The project must be complemented by a CDW management plan. Therefore, clarifying the CE and deconstruction practices to the stakeholders involved in the design phase is crucial to provide a solid basis for the improvement of building deconstruction strategies and to stimulate the production of secondary materials (Munaro et al., 2021).

In the EOL stage, selective renovation or deconstruction gives way to the conventional demolition of buildings. The renovation of buildings is a trend observed in the practices of adaptive use, aiming at seeking energy efficiency and conserving the historical and social values of buildings. Selective deconstruction accompanied by appropriate collection and segregation techniques maximizes efficiency in the recovery of materials and building components and the establishment of secondary material markets (Munaro et al., 2021).

The third category presents tools and examples of applying circular strategies to reinforce the creation of a circular vision in construction value chains. The aim is to reinforce that the implementation of DfAD can be a strategic policy for the reduction of GHG emissions in the sector, by favoring the reuse and recycling of materials (Munaro et al., 2021).

CONCLUSION

The study presented the state-of-the-art of the DfAD method and stressed the importance of modular and prefabricated structures, selective deconstruction, and the use of recovered materials. With the growth of secondary materials markets, urban mining activities, analysis of resource and material flows, and the adaptive use of buildings will be



further explored. The digitization of the sector is indispensable to managing the large volume of data and information on construction materials throughout the life cycle of the building.

The DfAD framework considers the main circular strategies found in the literature that make it possible to deconstruct and recover components, parts, and materials at the end of the building's life. This framework can be used as guidance for academics and professionals to expand knowledge about the potential applications of the DfAD concept. The sector's delay in changing, as well as the lack of knowledge on DfAD and CE principles, are critical barriers. Efficient legislation and public policies that promote the reuse and recycling of building materials are required.

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REFERENCES

Ellen MacArthur Foundation (EMF) (2015). Growth within: a Circular Economy Vision for a Competitive Europe. Ellen MacArthur Foundation. Available at: shorturl.at/yFPW5.

Munaro, M. R., Tavares, S. F., & Bragança, L. (2021). The ecodesign methodologies to achieve buildings' deconstruction: A review and framework. *Sustainable Production and Consumption*, 30 (March 2022), 566-583.