Circularity in modular construction: modular BIM library with digital passport integration

Summary

The construction industry is responsible for the consumption of vast amounts of resources, representing about 50% of all extracted raw material, as well as for over 35% of the EU's total waste generation. Greenhouse gas (GHG) emissions from material extraction, manufacturing of construction products and construction itself are estimated to account for 5-12% of total national GHG emissions. UN reports suggest that an increase in material efficiency could reduce these emissions by up to 80%, and therefore transitioning to a circular economy has been identified as an imperative to reduce these impacts.

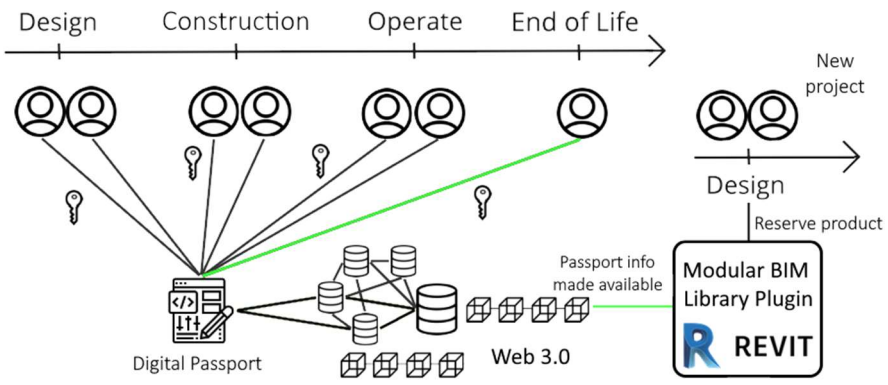
The popularity of modular construction has re-emerged in recent years due to its capacity to adhere to the principles of circularity. Modular structures consist of assemblies whose components are easily disassembled for replacement or reuse, resulting in lower volumes of Construction and Demolition Waste (CDW) and, consequently, significant reductions not only in waste management costs but also in environmental impacts. This has the potential to make modular solutions more competitive in public works tenders, given the current governmental focus in achieving international environmental goals, such as Carbon Neutrality 2050.

One of the main issues with the AEC industry is its fragmentation, not only due to the involvement of a large number of actors but also the long lifetime of constructions. Stakeholders are likely to change during the lifecycle of a building and therefore loss of information about materials and construction products is a major concern given the importance of such information in achieving a circular economy. Digital Product Passports (DPPs) and material passports can have a big impact in capturing this information through the entire lifecycle of these components, but the use of Web2 solutions exposes fragilities related to its heavy reliance on centralized systems for accessing data. Companies or server operators could go out of business during the long lifecycle of buildings, and the change of actors could lead to loss of data access. Web3, on the other hand, enables data access control throughout the entire lifecycle independent of individual actors, and even if individual private keys are lost or some nodes go offline, the blockchain will most likely remain operational.

This research aims to develop a BIM library for modular units that integrates a digital passport system built on blockchain technology and decentralized data storage protocols. The use of these decentralized solutions offers frictionless methods to share information through long periods of time in an open yet optionally private way. It also enables the creation of digital marketplaces that allow sellers to make their data available and designers to search and reserve materials and products that are made available for reuse.

Keywords

Building Information Modelling (BIM), circular economy, construction, digital transition, Life Cycle Assessment (LCA), sustainability, twin transition.



Schematic representation of how web3 and digital passports can bridge the fragmentation of the AEC industry and create marketplaces that empower the adoption of circular economy principles.

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