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INNOVATIONS IN CIRCULAR ECONOMY DESIGN STRATEGIES FOR BUILDINGS

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Abstract
The construction industry faces increasing demands to reduce resource consumption and waste production while simultaneously supporting socio-economic growth. The concept of the Circular Economy (CE) offers a framework to establish new paradigms within the construction sector, enabling the achievement of goals related to environmental preservation and sustainable human habitats. However, this paradigm shift necessitates innovative approaches to building design. Although the application of CE principles to building design is still in its early stages, research on CE implementation and innovative design strategies is rapidly expanding within the scientific community. This research aims to explore innovative circular design strategies for buildings. This paper provides a comprehensive literature review of Circular Economy theories, design strategies, and implementation practices. The findings identify commonly applied design strategies and highlight those with significant potential that require further development. Strategies such as adaptability, prefabrication, cradle-to-cradle design, and others can substantially reduce the environmental impact of buildings. Additionally, this paper discusses future possibilities for advancing the development of circular buildings.
Keywords: *Circular Economy, Building Design, Innovative Design, Construction Industry.*
JEL Classification: R5

1. INTRODUCTION

The construction industry is a cornerstone of global economic development, contributing significantly to GDP and employment. However, it is also one of the most resource-intensive sectors, accounting for approximately 40% of global energy consumption, 30% of greenhouse gas emissions, and 50% of raw material extraction (UNEP, 2023). The linear "take-make-dispose" model prevalent in construction has led to significant environmental degradation, resource depletion, and waste accumulation. In response, the Circular Economy (CE) has emerged as a transformative framework to decouple economic growth from resource consumption by promoting resource efficiency, waste minimization, and the continuous use of materials (Ellen Macarthur Foundation, 2021).

The CE model emphasizes three core principles: designing out waste and pollution, keeping products and materials in use, and regenerating natural systems (Ellen MacArthur Foundation, 2017). In the context of buildings, CE principles translate into innovative design strategies that prioritize longevity, adaptability, and material reusability. These strategies aim to create buildings that function as material banks, where components can be disassembled, reused, or recycled at the end of their lifecycle (Cheshire, 2016). However, the application of CE in building design is still nascent, with challenges such as regulatory barriers, high upfront costs, and a lack of standardized practices hindering widespread adoption (Adams *et al*., 2017).

This paper explores innovative CE design strategies for buildings, focusing on their theoretical foundations, practical applications, and potential for scalability. Through a comprehensive literature review, the study identifies key strategies such as adaptability, prefabrication, and cradle-to-cradle design, and evaluates their environmental and socio-economic benefits. The research also highlights gaps in current practices and proposes directions for future development. The objectives are to: Review CE theories and their relevance to building design; Identify and analyse innovative CE design strategies; Discuss barriers to implementation and future opportunities for advancing circular buildings.

2. LITERATURE REVIEW

2.1. Circular Economy: Theoretical Foundations

The Circular Economy is rooted in industrial ecology, biomimicry, and cradle-to-cradle principles, which advocate for closed-loop systems that mimic natural cycles (McDonough & Braungart, 2002). Unlike the linear economy, which relies on finite resources, CE aims to create value through restorative and regenerative processes. Key frameworks, such as the ReSOLVE model (Regenerate, Share, Optimize, Loop, Virtualize, Exchange), provide actionable strategies for implementing CE in various sectors, including construction.

In the construction sector, CE is operationalized through strategies that extend the lifecycle of buildings and materials. These include designing for disassembly, using renewable or recyclable materials, and integrating digital tools like Building Information Modeling (BIM) to track material flows (Pomponi & Moncaster, 2017). The concept of "buildings as material banks" (BAMB) has gained traction, emphasizing the storage and reuse of materials to reduce waste (*BAMB*, 2019).

2.2. CE Design Strategies for Buildings

Several design strategies have emerged to align building design with CE principles:

- Adaptability: Designing buildings with flexible layouts and modular components allows for reconfiguration to meet changing needs, extending the building's functional life (Geldermans, 2016).

- Prefabrication: Off-site construction of standardized components reduces material waste and enables disassembly for reuse (Jaillon & and Poon, 2008).

- Cradle-to-Cradle (C2C): This approach prioritizes materials that are safe, recyclable, and capable of being reintegrated into biological or technical cycles (McDonough & Braungart, 2002).

- Design for Disassembly (DfD): Buildings are designed to be deconstructed, allowing components to be reused or recycled without significant loss of value (Ostapska *et al*., 2024).

- Material Passports: Digital documentation of a building's materials facilitates tracking and reuse, enhancing circularity (Tuscher *et al*., 2024).

Despite the potential of CE design strategies, implementation faces several barriers. These include a lack of regulatory incentives, high initial costs, and limited stakeholder collaboration (Adams *et al*., 2017). Additionally, the construction industry's reliance on traditional practices and a fragmented supply chain complicates the adoption of circular principles (Pomponi & Moncaster, 2017).

3. METHODOLOGY

This study employs a systematic literature review to explore innovative CE design strategies for buildings. The methodology follows a three-stage process:

Literature Search: Academic databases (Scopus, Web of Science, and Google Scholar) were searched using keywords such as "circular economy," "building design," "sustainable construction," and "design strategies." The search was limited to peer-reviewed articles, books, and reports published between 2010 and 2025 to capture recent advancements.

principles and building design. A total of 85 sources were selected, including 60 journal articles, 15 reports, and 10 books. Screening and Selection: Articles were screened based on relevance to CE

Data Analysis: Selected sources were analysed to identify key CE design strategies, their applications, benefits, and limitations. A thematic analysis was conducted to categorize strategies and highlight gaps in current research.

The review was supplemented with case studies of circular buildings (e.g., Park 20|20 in the Netherlands and the Circular Pavilion in Paris) to provide practical insights into strategy implementation.

4. RESULTS

The systematic literature review and case study analysis revealed a diverse set of Circular Economy (CE) design strategies applied to building design, categorized into commonly adopted strategies, emerging strategies with high potential, and their associated environmental and socio-economic benefits. This section provides an in-depth exploration of these findings, supported by quantitative and qualitative evidence from recent studies and practical implementations. The results underscore the transformative potential of CE principles in addressing the construction industry's environmental challenges while identifying areas for further development.

Authors (Eberhardt *et al*., 2022), systematize design strategies, Figure 1, and the (a) number of the occurences in (b) relation to CE, (c) to project stages, (d) building types, (e) application level and (f) readiness level.

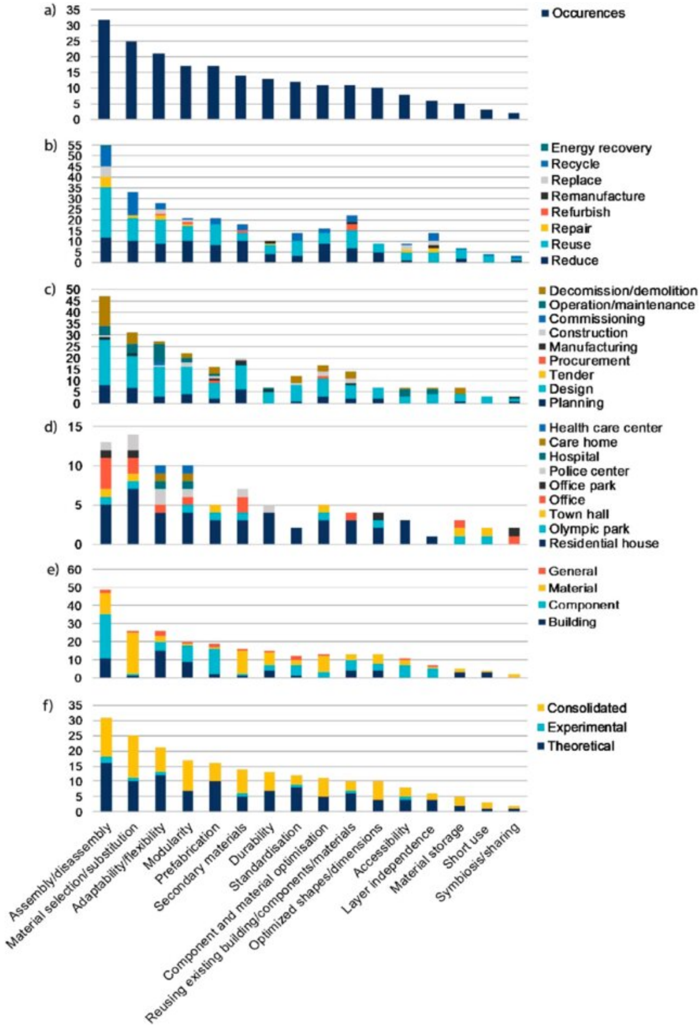

Figure 1. Circular design strategies

Source: (Eberhardt *et al*., 2022)

The findings presented in Figure 1, show that the most encountered strategy in the literature is assembly/disassembly followed by material selection/substitution and material selection/substitution.

4.1. Commonly Applied CE Design Strategies

Adaptability refers to designing buildings with flexible layouts, modular components, and reconfigurable systems to accommodate changing functional requirements over time. This strategy extends a building's lifespan by reducing the need for demolition and reconstruction. Authors (Geldermans, 2016) note that adaptable buildings can achieve up to a 30% reduction in lifecycle carbon emissions by avoiding premature obsolescence. For instance, flexible floor plans and movable partitions allow buildings to transition between residential, commercial, or mixed-use purposes without significant structural alterations.

A notable example is the Allianz Tower in Amsterdam, which incorporates adaptable floor plans and modular façade systems. The building's design allows for internal reconfiguration to meet tenant needs, reducing the environmental impact associated with retrofitting (Geldermans, 2016). Quantitative studies suggest that adaptability can reduce material waste by 20-40% during renovations, as components are reused rather than discarded (UNEP, 2023). However, the strategy requires upfront investment in high-quality, durable materials, which can increase initial costs by 10-15% compared to conventional designs (Adams *et al*., 2017).

Prefabrication involves the off-site manufacturing of standardized building components, which are then assembled on-site. This approach minimizes construction waste, improves quality control, and enables disassembly for reuse or recycling. Authors (Jaillon & and Poon, 2008) found that prefabricated construction can reduce on-site waste by up to 80% and construction time by 20-30% compared to traditional methods. The use of prefabricated timber panels, steel frames, and concrete modules has gained traction in projects seeking CE alignment.

The Brock Commons Tallwood House in Vancouver, Canada, exemplifies prefabrication's potential. This 18-story mass-timber building utilized prefabricated cross-laminated timber (CLT) panels, achieving a 25% reduction in embodied carbon compared to a concrete equivalent. The panels were designed for disassembly, allowing future reuse in other projects. Despite these benefits, prefabrication faces challenges such as limited scalability in regions with underdeveloped manufacturing infrastructure and higher transportation-related emissions (Pomponi & Moncaster, 2017).

Design for Disassembly (DfD) prioritizes building systems that can be deconstructed at the end of their lifecycle, enabling the reuse or recycling of components. DfD employs reversible connections (e.g., bolts instead of welds) and standardized modules to facilitate material recovery. It is estimated that DfD can recover 70-90% of a building's materials, significantly reducing landfill waste (Ostapska *et al*., 2024; Tingley & Davison, 2011). The strategy also supports the concept of "buildings as material banks," where components retain value for future use. Researchers (Lima *et al*., 2023) show that the operationalization DfD in a BIM environment supports the design process and the management of the buildings` deconstruction. Authors (Pristerà *et al*., 2024) propose taxonomy to support users in the identification of available DFD measures in relation to the building material type and to link their impact on the circularity of the building.

The Circular Pavilion in Paris, constructed for the 2015 Paris Climate Conference, is a prime example. The pavilion used modular wooden panels and bolted connections, allowing complete disassembly and reuse of materials in subsequent projects. Life Cycle Assessment (LCA) studies indicate that DfD buildings can reduce embodied carbon by 15-25% over their lifecycle (UNEP, 2023). However, DfD requires precise documentation and skilled labor, which can increase design and construction costs by 5-10% (Adams *et al*., 2017).

Further, BIM provides many possibilities for alleviating the design and construction of circular buildings. BIM that makes it suitable for the circular economy process is its capability to accumulate lifecycle information about a building (Eadie *et al*., 2013). Authors (Akanbi *et al*., 2018) develop BIM-based Whole-life Performance Estimator (BWPE) for value assessment of the salvaged performance of structural components of buildings right from the design stage. Also, BIM is utilized to assess a residential building-related social sustainability assessment framework and its implications for BIM (Ahmad & Thaheem, 2017).

4.2. Emerging Strategies with High Potential

While commonly applied strategies are well-established, several emerging strategies show significant promise for advancing circularity in building design. These include cradle-to-cradle (C2C) design, material passports, and the use of bio-based materials. These strategies are less widely implemented but offer innovative solutions to enhance resource efficiency and regenerative systems.

Cradle-to-Cradle (C2C) design focuses on using materials that are safe, recyclable, and capable of being reintegrated into biological or technical cycles. Unlike traditional recycling, which often downcycles materials, C2C emphasizes upcycling to maintain material value (McDonough & Braungart, 2002). The Venlo City Hall in the Netherlands, a C2C-inspired project, used non-toxic, recyclable materials such as glass, timber, and biodegradable insulation, achieving a 90% reduction in material waste during construction. LCA data suggest that C2C buildings can reduce environmental impacts by 20-30% compared to conventional buildings (Ellen MacArthur Foundation, 2017).

C2C design also promotes regenerative systems, such as green roofs and water recycling, which enhance ecosystem services. However, the strategy is limited by the availability of C2C-certified materials, which are currently less than

5% of the global construction material market lifecycle (UNEP, 2023). Research and development in scalable C2C materials are critical to mainstreaming this approach.

Material Passports are digital records that document a building's materials, including their composition, origin, and potential for reuse. By enhancing transparency, passports facilitate material recovery and circularity. The Buildings as Material Banks (BAMB) project demonstrated that material passports can increase the reuse rate of construction materials by 50% by providing stakeholders with detailed lifecycle information (*BAMB*, 2019). For example, the BAMB pilot project in Brussels used passports to track steel beams and concrete panels, enabling their reuse in new constructions.

Material passports also integrate with Building Information Modeling (BIM), creating a digital twin of the building to streamline deconstruction planning. However, their adoption is hindered by a lack of standardized formats and interoperability across platforms, with only 10% of European construction projects currently using passports (Tuscher *et al*., 2024). Future advancements in blockchain technology could enhance the security and accessibility of material passports.

Bio-based materials, such as hempcrete, mycelium, and bamboo, offer renewable alternatives to carbon-intensive materials like concrete and steel. These materials align with CE's regenerative principle by sequestering carbon and supporting natural cycles (Ellen MacArthur Foundation, 2017). For instance, hempcrete, made from hemp fibers and lime, has a negative carbon footprint and is fully biodegradable (UNEP, 2023). Pilot projects, such as the Hemp House in Cambridge, UK, (Practice Architecture, 2020) demonstrated a 40% reduction in embodied carbon compared to traditional brick construction.

Bio-based materials also enhance indoor environmental quality due to their non-toxic properties. However, their scalability is limited by production costs, which can be 20-30% higher than conventional materials, and regulatory barriers in regions with strict building codes (Pomponi & Moncaster, 2017). Ongoing research into cost-effective production methods could unlock their potential.

4.3. Environmental and Socio-Economic Benefits

The application of CE design strategies yields significant benefits, supported by quantitative data from recent studies.

Environmental Benefits:

- Material Efficiency: Prefabrication and DfD reduce material consumption by 30-50% in modular projects (Jaillon & and Poon, 2008) and Poon, 2014).
- Carbon Reduction: Adaptable and C2C designs lower lifecycle carbon emissions by 20-30% (UNEP, 2023).

- Waste Minimization: DfD and prefabrication can divert up to 80% of construction waste from landfills (Tingley & Davison, 2011).
    - Resource Conservation: Material passports and C2C materials promote the reuse of high-value components, reducing raw material extraction by 15-25% (Ellen MacArthur Foundation, 2017).
- Socio-Economic Benefits:
    - Cost Savings: Long-term savings from material reuse and reduced maintenance costs can offset initial investments, with payback periods of 10-15 years for adaptable buildings (Adams *et al*., 2017).
    - Job Creation: The recycling and remanufacturing sectors associated with CE strategies create 10-20% more jobs than traditional construction (Ellen MacArthur Foundation, 2017).
    - Community Resilience: Adaptable buildings support socio-economic stability by accommodating diverse functions, such as emergency housing during crises (Geldermans, 2016)

The results underscore the transformative impact of CE design strategies on the construction sector. Commonly applied strategies like adaptability, prefabrication, and DfD are already achieving significant environmental and economic benefits, as demonstrated by projects like the Allianz Tower and Brock Commons. Emerging strategies, such as C2C design, material passports, and bio-based materials, offer even greater potential but require further investment in research, policy, and infrastructure. Addressing barriers through stakeholder collaboration, regulatory reform, and technological innovation will be critical to scaling these strategies globally.

4.4. Barriers to Adoption

Despite their potential, CE design strategies face several challenges:

- Economic Barriers: High upfront costs for circular materials (e.g., C2C-certified products) and technologies (e.g., BIM integration) can deter adoption, particularly for small-scale developers (Adams *et al*., 2017).
- Regulatory Barriers: Inconsistent building codes and a lack of CE-specific certifications hinder the use of bio-based materials and DfD systems in many regions (Pomponi & Moncaster, 2017).
- Knowledge Gaps: Limited awareness and training among architects, engineers, and contractors restrict the implementation of advanced strategies like material passports (Tingley & Davison, 2011).
- Supply Chain Fragmentation: The construction industry's decentralized supply chain complicates the coordination required for circular practices, such as material tracking and reuse (*BAMB*, 2019).

4.5. Case Studies

Case Study 1: Venlo City Hall, Netherlands (Cradle-to-Cradle Design)

The Venlo City Hall, Figure 2, completed in 2016, is a flagship example of Cradle-to-Cradle (C2C) design in the construction sector. Designed by Kraaijvanger Architects (Kraaijvanger Architects, 2017), the building incorporates non-toxic, recyclable materials and regenerative systems to minimize environmental impact. Key features include a green façade that purifies air, a closed-loop water system, and materials like timber, glass, and biodegradable insulation that can be reintegrated into technical or biological cycles. The project achieved a 90% reduction in construction waste and a 20% decrease in lifecycle energy consumption compared to conventional buildings.

Figure 2. Venlo City Hall
Source: (Kraaijvanger Architects, 2017)

The C2C approach required extensive collaboration among architects, material suppliers, and local authorities to ensure material traceability and compliance with C2C certification. The building's green roof and photovoltaic panels contribute to biodiversity and renewable energy production, aligning with CE's regenerative principle. However, the project faced challenges, including a 15% higher initial cost due to specialized materials and a limited supply of C2C-certified products. The Venlo City Hall demonstrates the feasibility of C2C design but highlights the need for scalable material solutions and cost reductions to mainstream this strategy.

Case Study 2: Brock Commons Tallwood House, Canada (Prefabrication)

Brock Commons Tallwood House, Figure 3 (Acton Ostry Architects, 2017), an 18-story student residence at the University of British Columbia, is a pioneering example of prefabricated mass-timber construction. Completed in 2017, the building utilized cross-laminated timber (CLT) panels prefabricated off-site, reducing construction waste by 80% and construction time by 25% compared to a concrete equivalent (Jaillon and Poon, 2014). The CLT panels were designed for disassembly, enabling future reuse in other projects, which aligns with CE's principle of keeping materials in use.

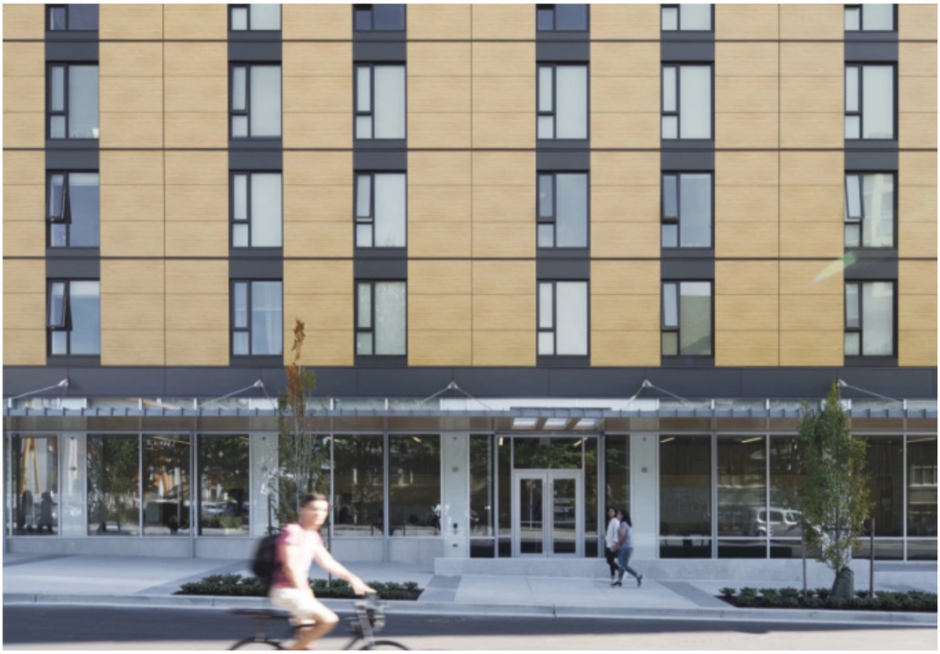

Figure 3. Brock Commons Tallwood House
Source: (Acton Ostry Architects, 2017)

The project achieved a 25% reduction in embodied carbon, primarily due to timber's lower carbon footprint and the efficiency of prefabrication. The use of standardized components also improved quality control and reduced on-site errors. However, challenges included higher transportation costs for prefabricated elements and regulatory hurdles related to fire safety for tall timber buildings. Brock Commons highlights prefabrication's potential to advance CE goals but underscores the need for regional manufacturing hubs and updated building codes to enhance scalability.

Case Study 3: Circular Pavilion, Paris, France (Design for Disassembly)

The Circular Pavilion, Figure 4 (Encore Heureux Architects, 2015), constructed for the 2015 Paris Climate Conference, exemplifies Design for Disassembly (DfD). Designed by Encore Heureux Architects, the temporary structure used modular wooden panels, bolted connections, and reusable steel frames to ensure all components could be deconstructed and repurposed. Post-event, 90% of the pavilion's materials were reused in other construction projects, demonstrating the effectiveness of DfD in reducing waste.

Figure 4. Circular Pavilion
Source: (Encore Heureux Architects, 2015)

The pavilion's design prioritized simplicity and reversibility, with materials sourced from local suppliers to minimize transportation emissions. The project achieved a 15% reduction in embodied carbon compared to a conventional temporary structure. Challenges included the need for precise documentation to track materials and skilled labor for disassembly, which increased costs by 10%. The Circular Pavilion showcases DfD's potential for circularity but highlights the importance of digital tools like material passports to streamline material recovery processes.

5. DISCUSSION

The results and case studies demonstrate that CE design strategies, such as adaptability, prefabrication, DfD, C2C design, material passports, and bio-based materials, offer viable solutions to reduce the construction industry's environmental footprint. Commonly applied strategies are gaining traction due to their alignment with existing practices, as seen in projects like Brock Commons and the Circular Pavilion. Emerging strategies, exemplified by Venlo City Hall, push the boundaries of circularity but face scalability challenges due to cost, regulatory, and technical barriers.

Opportunities for advancement include leveraging digital technologies like BIM and blockchain to enhance material tracking, as demonstrated in the BAMB project. Policy incentives, such as tax breaks for circular construction, could accelerate adoption, while integrating CE principles into architectural education would build industry capacity. However, current research is limited by its focus on developed countries, with insufficient exploration of CE applications in developing regions. Longitudinal studies evaluating the performance of circular buildings over decades are also needed to validate their benefits.

Future research should prioritize cost-effective circular materials, global standards for CE construction, and applications in affordable housing to address socio-economic disparities. Collaboration among architects, policymakers, and industry stakeholders is essential to overcome cultural resistance and drive systemic change.

6. CONCLUSIONS

The transition to a Circular Economy in building design offers a transformative approach to addressing the construction industry's resource and environmental challenges. Strategies like adaptability, prefabrication, and DfD, as demonstrated by Brock Commons and the Circular Pavilion, are already reducing waste and emissions. Emerging strategies, such as C2C design and material passports, exemplified by Venlo City Hall, promise regenerative solutions but require further development. Despite barriers like high costs and regulatory gaps, advancements in digital tools, policy frameworks, and education can unlock the full potential of circular buildings. By fostering innovation and collaboration, the construction sector can lead the way toward a sustainable, regenerative future, ensuring that buildings serve as material banks for generations to come.

References

1) Acton Ostry Architects. (2017). *UBC Brock Commons Tallwood House*. https://www.actonostry.ca/work/education/ubc-brock-commons-tallwood-house
2) Adams, K. T., Osmani, M., Thorpe, T., & Thornback, J. (2017). Circular economy in construction: Current awareness, challenges and enablers. *Proceedings of the*

Institution of Civil Engineers - Waste and Resource Management, *170*(1), 15–24. https://doi.org/10.1680/jwarm.16.00011

3) Ahmad, T., & Thaheem, M. J. (2017). Developing a residential building-related social sustainability assessment framework and its implications for BIM. *Sustainable Cities and Society*, *28*, 1–15. https://doi.org/10.1016/j.scs.2016.08.002
4) Akanbi, L. A., Oyedele, L. O., Akinade, O. O., Ajayi, A. O., Davila Delgado, M., Bilal, M., & Bello, S. A. (2018). Salvaging building materials in a circular economy: A BIM-based whole-life performance estimator. *Resources, Conservation and Recycling*, *129*, 175–186. https://doi.org/10.1016/j.resconrec.2017.10.026
5) *BAMB*. (2019). BAMB. https://www.bamb2020.eu/
6) Cheshire, D. (2016). *Building Revolutions: Applying the Circular Economy to the Built Environment*. RIBA Publishing.
7) Eadie, R., Browne, M., Odeyinka, H., McKeown, C., & McNiff, S. (2013). BIM implementation throughout the UK construction project lifecycle: An analysis. *Automation in Construction*, *36*, 145–151. https://doi.org/10.1016/j.autcon.2013.09.001
8) Eberhardt, L. C. M., Birkved, M., & Birgisdottir, H. (2022). Building design and construction strategies for a circular economy. *Architectural Engineering and Design Management*, *18*(2), 93–113. https://doi.org/10.1080/17452007.2020.1781588
9) Ellen MacArthur Foundation. (2017). *Cities in the circular economy: An initial exploration*. https://www.ellenmacarthurfoundation.org/cities-in-the-circular-economy-an-initial-exploration
10) Ellen Macarthur Foundation. (2021). *Circular economy introduction – Overview*. Ellen Macarthur Foundation. https://ellenmacarthurfoundation.org/topics/circular-economy-introduction/overview
11) Encore Heureux Architects. (2015). *The Circular Pavilion*. ArchDaily. https://www.archdaily.com/778972/the-circular-pavilion-encore-heureux-architects
12) Geldermans, R. J. (2016). Design for Change and Circularity – Accommodating Circular Material & Product Flows in Construction. *Energy Procedia*, *96*, 301–311. https://doi.org/10.1016/j.egypro.2016.09.153
13) Jaillon, L., & and Poon, C. S. (2008). Sustainable construction aspects of using prefabrication in dense urban environment: A Hong Kong case study. *Construction Management and Economics*, *26*(9), 953–966. https://doi.org/10.1080/01446190802259043
14) Kraaijvanger Architects. (2017). *Municipal Office Venlo | Kraaijvanger*. https://www.kraaijvanger.nl/en/projects/city-hall-venlo/
15) Lima, P. R. B. de, Rodrigues, C. de S., & Post, J. M. (2023). Integration of BIM and design for deconstruction to improve circular economy of buildings. *Journal of Building Engineering*, *80*, 108015. https://doi.org/10.1016/j.jobe.2023.108015
16) McDonough, W., & Braungart, M. (2002). *Cradle to Cradle: Remaking the Way We Make Things* (First Edition). North Point Press.
17) Ostapska, K., Rüther, P., Loli, A., & Gradeci, K. (2024). Design for Disassembly: A systematic scoping review and analysis of built structures Designed for Disassembly. *Sustainable Production and Consumption*, *48*, 377–395. https://doi.org/10.1016/j.spc.2024.05.014

18) Pomponi, F., & Moncaster, A. (2017). Circular economy for the built environment: A research framework. *Journal of Cleaner Production*, *143*, 710–718. https://doi.org/10.1016/j.jclepro.2016.12.055
19) Practice Architecture. (2020). *Flat House*. https://practicearchitecture.co.uk/project/flat-house/
20) Pristerà, G., Tonini, D., Lamperti Tornaghi, M., Caro, D., & Sala, S. (2024). Taxonomy of design for deconstruction options to enable circular economy in buildings. *Resources, Environment and Sustainability*, *15*, 100153. https://doi.org/10.1016/j.resenv.2024.100153
21) Tingley, D. D., & Davison, B. (2011). Design for deconstruction and material reuse. *Proceedings of the Institution of Civil Engineers - Energy*, *164*(4), 195–204. https://doi.org/10.1680/ener.2011.164.4.195
22) Tuscher, M., Hanák, M., Navrátilová, V., & Tichá, A. (2024). Usage of Building Passports and BIM in Multi-Criteria Evaluation. *Procedia Computer Science*, *239*, 1086–1094. https://doi.org/10.1016/j.procs.2024.06.273
23) UNEP. (2023). *Global Status Report for Buildings and Construction*.