



CURRENT STATE OF CIRCULAR ECONOMY PRACTICES IN MALAYSIA’S CONSTRUCTION INDUSTRY

**Nur Izieadiana Abidin¹, Muhammad Idlan Mohamed Narozi²,
Nadirah Darus³, Suzila Mohd⁴, Chai Chang Saar⁵**

*^{1,2,3,4}Department of Structure and Materials, Faculty of Civil Engineering,
UNIVERSITI TEKNOLOGI MALAYSIA
⁵School of Architecture, Building and Design,
Faculty of Innovation and Technology,
TAYLOR’S UNIVERSITY MALAYSIA*

Abstract

Despite growing interest in sustainable construction, the adoption of Circular Economy (CE) principles in Malaysia remains limited due to various challenges, including regulatory gaps, lack of awareness and economic constraints. By contrast, the CE framework aims to reduce waste and maximise resources by closing material loops, aligning with global efforts toward sustainable development. This paper examines the current adoption of CE in Malaysia’s construction sector. A questionnaire survey was randomly distributed to 250 contractors ranging from G1 to G7. The data were analysed using the Statistical Package for the Social Sciences (SPSS), applying reliability tests and factor analysis to rank the significant results systematically. The results showed that reversible and dismantled connection methods are the most effective CE strategies, allowing for greater flexibility and sustainability. However, a lack of understanding and awareness about rapidly evolving technologies and practices emerged as a key obstacle. To address this, the paper recommends updating guidelines on dismantling structures and reusing materials, providing clearer standards to support more sustainable construction approaches, which have not been sufficiently explored in previous research. These insights can help to drive improvements in CE practices for policymakers and construction industry stakeholders, encourage meaningful progress, and advance long-term sustainability in Malaysia’s building sector.

Keywords: Circular Economy, Malaysia, Construction, Contractors

¹ Corresponding author. Email: izieadiana@utm.my

INTRODUCTION

A significant portion of construction and demolition (C&D) waste ends up in landfills, creating a range of environmental, social, and economic challenges, including the loss of land space, resource depletion, and pollution (Ilmi et al., 2024). Despite Malaysia's growing emphasis on green and sustainable building practices (Yadegaridehkordi et al., 2020), there is still a pressing need to understand and enhance how industry players view and implement Circular Economy (CE) concepts in local development (Mustaffa et al., 2021). CE emphasize the reuse, repair, and recycling of construction materials to improve sustainability, aligning with global policies to decrease environmental impact and preserve natural resources (Akhimien et al., 2021; Norouzi et al., 2021).

Implementing CE principles in construction mainly involves cutting down on on-site waste and using materials that can be reused or recycled (Salleh et al., 2022). However, the industry still faces several hurdles, such as a shift in mindset, limited support within organisations, outdated procurement models, consumer behaviour challenges, poor collaboration, inadequate government backing, and intense competition centred on low bids. In a study by Ahmed et al. (2023), it was found that most of the leading players—organisational managers, clients, consultants, and contractors have only a small understanding of CE, with a few consultants showing moderate experience. Additionally, the sector's reliance on a linear model makes it challenging to adopt circular methods—particularly when many stakeholders are still learning about these principles and their benefits. CE draws on ideas from various fields, such as economic ecosystems, the 3Rs, cleaner production, and cradle-to-cradle design (Norouzi et al., 2021).

In light of these issues, this paper explores how CE concepts are used in the construction industry. The main goals are to analyse current practices, pinpoint obstacles, and recommend ways to increase sustainability by prioritizing material reuse, repair, and recycling—thereby reducing environmental impact and improving resource efficiency.

LITERATURE REVIEW

Circular Economy Practices to be Adopted in Construction

The construction industry currently faces significant challenges in managing its waste, calling for a more sustainable approach. One way to address this issue is by applying Circular Economy (CE) principles, such as “design for disassembly.” Disassembly involves systematically removing individual building components like wall cladding, non-structural panels, flooring, and interior finishes—so that these parts can be reused or repurposed in new constructions (Dams et al., 2021).

A key tool in this process is the Disassembly and Deconstruction Analytics System (D-DAS), which uses information modelling to support sustainability at a building's end-of-life stage. By promoting thoughtful material

selection from the start, D-DAS helps reduce waste and align with CE goals of minimising new materials through smarter resource use and reuse (Akanbi et al., 2019).

Further reinforcing CE principles is the concept of “design out waste,” which involves creating lighter structures that rely on fewer materials (Diemer et al., 2022). This lowers costs and energy demands and minimises environmental impact across the entire building lifecycle. Factoring in disassembly from the beginning encourages ongoing reuse and recycling of materials, ultimately boosting a building’s overall sustainability (Mattaraia et al., 2021). Additionally, integrating lean production methods like just-in-time (JIT) processes and design for disassembly into the manufacturing chain helps curb material waste (Minunno et al., 2018). Circular Modular Construction Projects (MCPs), which emphasise sustainable material choices, waste reduction, and resource recovery, also reflect these CE ideals by keeping resources in a continuous loop (Wuni & Shen, 2022).

Another core strategy for advancing CE in the built environment involves carefully selecting materials and components to fit into a closed-loop system (Rahla et al., 2021). While current standards often focus on recycled content and recyclability, inventive approaches are needed to expand the circularity (Rahla et al., 2021). New rules setting targets for reuse and recycling could significantly boost circularity by incentivising creative ways to reclaim and repurpose construction and demolition waste (Ghaffar et al., 2020). For example, turning debris into recycled aggregates can help establish a closed-loop cycle in multiple building projects (Maury-Ramírez et al., 2022). Another promising route is to enhance the quality of secondary materials, including through upcycling, so they meet the same performance requirements as raw materials, allowing for repeated reuse and recycling which strengthening the circular economy’s core principles (Ma et al., 2023).

The Barriers Faced by Construction Organisations in Implementing Circular Economy Principles in Malaysia

A lack of awareness, understanding, and insight within the construction industry remains as a key obstacle to embracing Circular Economy (CE) concepts (Munaro et al., 2020; Wuni, 2022), further reflected in the limited technical expertise and stakeholder familiarity with circular materials and architectures (Marek & Krejza, 2024). A significant part of the problem stems from limited CE expertise, technical know-how, and practical experience, compounded by insufficient stakeholder awareness of circular materials, products, services, and initiatives. In particular, gaps in knowledge about building design, especially around material quantities, quality, and availability, hinder the use of reusable components. Without reliable information on existing structures and materials, making informed decisions and implementing CE technologies becomes difficult. An additional challenge is the lack of robust data on the origin and supply of

reused materials, which can lead to inefficiencies across the supply chain (AlJaber et al., 2023; Groenewald, 2024).

Insufficient CE training programs for contractors may also discourage the adoption of environmentally friendly methods in construction projects. The innate complexity of building projects, including multi-layered systems, steel-reinforced concrete components, concealed joints, and design modifications over time, further complicates the integration of circular practices.

Identifying how to reuse recyclable components, particularly steel, can be complex, with common design difficulties such as the scale of building materials, jointing procedures hindering disassembly, and intricate material composition. Challenges also arise in detaching bricks, especially when mixed with Ordinary Portland Cement, and recycling reinforced concrete components. The complexity of building data management further complicates efficient life cycle assessment (LCA) during the end-of-life phase due to missing or incorrect data during the design phase (AlJaber et al., 2023).

Construction organisations also grapple with the lack of standardisation assurance, making monitoring and comparing performance challenging. Circular practices necessitate standardised materials and explicit rules, but their absence complicates the assessment of circularity in buildings. Trust concerns may also arise without recognised certifications for circular products, impacting stakeholders' confidence in the long-term reliability of reused or recycled materials. Understanding materials' origin, lifespan, and traceability is crucial for accurate appraisal and reliable reuse or recycling, which is challenging without proper traceability. A lack of standardised methods and tools impedes incorporating strategic sustainability into the construction sector. Design for Disassembly (DfD) faces challenges due to a lack of tools compatible with Building Information Modelling (BIM), with sensors and radio-frequency identification identified as essential digital instruments for identifying reused parts (Munaro & Tavares, 2023).

Solutions for Best Practices Circular Economy Implementation for Construction Organisations in Malaysia

Facilitating the transition to CE necessitates a robust focus on awareness and research and development (R&D). Various governmental parties should champion enterprises to engage in R&D & Innovation, fostering collaborations between research centres, universities, and businesses. Joint efforts and networks are vital forums for exchanging knowledge, experiences, and best practices. At the same time, case studies contextualise business models, establishing credibility and trust in circular methods (Munaro & Tavares, 2023b). CE education and training programs are pivotal for equipping stakeholders with the necessary skills, and academic research contributes to new methods, technologies, and policies for CE adoption, providing evidence for policymakers. Raising awareness about CE

practices can be accomplished through workshops, seminars, conferences, and media channels. Campaigns also play a crucial role in developing fundamental understanding and encouraging stakeholders to embrace circular practices, amplifying the positive impact of CE on businesses and the environment (AlJaber et al., 2023). A well-defined roadmap that engages all stakeholders and construction experts is vital for encouraging the broader use of recycled materials in the building sector (Osei-Tutu et al., 2022). To address the economic barriers that often limit the marketability of reused materials, awareness forums can highlight the financial and environmental advantages these materials offer, helping to counter their relatively low market value. Increasing landfill disposal fees also discourages unnecessary waste, nudging the industry toward resource reuse (Osei-Tutu et al., 2022). When these awareness efforts are coupled with updated legislation and supportive funding measures, they can effectively tackle economic concerns, enhance public perception, and pave the way for a more circular and sustainable construction industry (AlJaber et al., 2023).

From a practical standpoint, contractors can bridge skill gaps by leveraging advanced technologies like Building Information Modeling (BIM). BIM's digital project management capabilities streamline the reuse of complex building elements and improve planning for waste management. Meanwhile, ongoing innovation in circular construction tools ensures that repurposed materials meet established quality standards. Another promising strategy is to create building guidelines that facilitate deconstruction and material reuse, thereby boosting market acceptance of reclaimed components. Revising regulations to allow the use of such materials in new projects further reinforces their legitimacy. These design guidelines also serve an educational role, clarifying key CE ideas and demonstrating how to apply them in practice—ultimately strengthening professionals' confidence in circular methods. Lastly, ensuring reclaimed materials carry appropriate certifications boosts trust and increases their likelihood of being adopted in construction projects, especially where safety is paramount (AlJaber et al., 2023; Osei-Tutu et al., 2022).

METHODOLOGY

A questionnaire survey was developed through Google Forms and designed based on a summarisation of the extensive literature review. The online questionnaire survey involved the types of circular economy practices that can be adapted in construction, barriers faced by construction organisations and proposed solutions for best practices in Circular Economy implementation for construction organisations in Malaysia. While past studies often rely on qualitative reviews or case studies, the questionnaire survey in this study is designed and randomly distributed to construction contractors in grades G1– G7, providing statistically validated insights. This methodological advancement offers a more structured and data-driven assessment of the CE transition challenges, setting this study

apart from earlier works. The targeted study area is in Johor and Kuala Lumpur only, and the Krejcie Morgan approach was utilised to choose 250 samples from Johor and Kuala Lumpur-based organisations. Kuala Lumpur was selected due to its status as Malaysia's capital, serving as the construction hub with large-scale infrastructure projects and high contractor engagement. On the other hand, Johor is experiencing rapid urban development and cross-border construction investments, making it a key area for studying CE adoption. The questionnaire has three sections that involve Likert scale questions based on a level of agreement of 1-5 points. Section A's questions are designed to identify the types of circular economy practices that can be adapted to construction. In Section B, the respondents are questioned on investigating barriers construction organisations face to transition from linear to circular economy to accomplish the second objective of this study. Finally, in Section C, the respondents are asked to propose solutions for best practices in circular economy implementations for construction organisations in Malaysia.

The data collected from the online questionnaire survey was analysed using the software Statistical Package for the Social Science (SPSS). To ensure data reliability and validity, the analysis involved three key steps (1) Cronbach's Alpha for internal consistency, (2) KMO and Bartlett's test for sampling adequacy, and (3) Factor Analysis for identifying the type of CE, barriers and solutions for best practice CE. The Cronbach's alpha coefficient test α used to measure the internal consistency to assess the reliability of the data for further analyses. Cronbach's alpha coefficient ranges from 0 to +1. An acceptable value of Cronbach's alpha is 0.7, while 0.8 indicates a very good internal consistency.

To evaluate the level of agreement for each criterion, Factor Analysis (FA) was employed to identify and assess the most influential criteria. Hence, this study differs from previous research by employing Factor Analysis to assess and rank barriers to CE adoption systematically. FA is a statistical method used to compute subsets of variables, serving as a traditional and widely recognised approach for analysing data involving multiple factors. It simplifies a large dataset into smaller, more meaningful components without altering its fundamental structure. In this study, FA was conducted using Principal Component Analysis (PCA), which generates Factor Loading (FL) values for each factor (i.e., sub-criteria) in the form of a rotated matrix. The rotation of factors helps clarify relationships between variables, distinguishing high relationships from low ones while maintaining the structure. A varimax rotation method was applied to obtain the FL values for each sub-criterion, where higher FL values indicate the most influential factors. According to previous studies, FL coefficient values between 0.5 and 0.69 are considered significant, while values between 0.7 and 1 are deemed very substantial.

Conducting FA involves several preliminary steps to ensure data suitability. First, the correlation matrix must be tested for significance to confirm

the variables are appropriate for factoring. Bartlett's Sphericity test, based on Chi-square, is performed for this purpose, with a value of 0.005 or less, which is considered satisfactory. Next, the Kaiser-Meyer-Olkin (KMO) test is conducted in SPSS to examine data adequacy. The KMO value ranges from 0 to 1, with values closer to 1 indicating a more considerable common variance, making the data suitable for FA. A value of 0.5 is typically regarded as acceptable to proceed with the analysis.

RESULTS AND DISCUSSION

Types of Circular Economy Practices That Can Be Adapted in Construction

Factor Analysis is used to analyse the results of types of circular economy practices that can be adapted to construction. Figure 1 shows that "Reversible and Disassembled Connections" (T-C1), with an FL value of 0.844, is the top-ranked practice, emphasising its ability to facilitate deconstruction and material reuse for future projects. These findings align with Dams et al. (2021), who emphasise that reversible construction methods extend building lifespan by allowing dissembled components to be repurposed, reducing demolition waste and promoting sustainability. Furthermore, this result is supported by Wuni & Shen (2022), who highlight that Circular Modular Construction Projects (MCPs) play a crucial role in preserving natural resources, optimizing material efficiency and maintaining building components in continuous use cycles. This reinforces the argument that modular and reversible construction methods contribute significantly to the sustainability of the built environment by reducing material wastage and enhancing circularity in construction practices.

Following closely is "Creation of Information Modelling" (T-C2) with FL value of 0.829. This refers to the integration of digital tools such as Building Information Modelling (BIM) to improve construction resources. BIM enhances material tracking, enables predictive maintenance and supports disassembly planning by providing real-time insights into the building's components, ensuring that materials can be efficiently reused or repurposed after demolition. Similarly, "Modular or Prefabricated Component" (T-A3) also shares an FL value of 0.829. Prefabrication aligns with circular modular construction principles, which aim to minimise material waste while maximizing efficiency in production and installation. Modular construction not only accelerates project timelines but also reduces the demand for raw materials, making it a viable approach for sustainable construction practices. Next, "Systematic Dismantling" (T-A6) ranks third with an FL value of 0.725 and is rated as the third potential circular economy practice to be adopted. In Circular Economy models, Benachio et al. (2020) emphasise the significance of methodically deconstructing end-of-life building materials, changing them into valuable resources that serve as material banks for new construction.

Besides, Practices related to material selection, including “Emphasizing the Use of Recycled Materials and Promoting Recyclability” (T-B1) and “Quality of Secondary Materials” (T-B2), are also highly rated, with similar FL values of 0.694. The effectiveness of these strategies depends on regulatory policies that mandate recycling targets encouraging resource recovery from construction and demolition waste (Ghaffar et al., 2020). Other notable practices include “Remanufacturing” (T-A5), “Reused of Salvaged Materials” (T-A4) and “Structures with Reduced Material Input” (T-A1) with a similar FL value of 0.654 also being found to be potential practices to be adapted in construction. This shows that respondents perceive these approaches as equally promising and practical for implementation in the construction industry. In contrast, their effectiveness and suitability for incorporation into construction processes align with circular economy principles.

Lastly, “Lean Production Optimising the manufacturing chain for scrap and raw materials” (T-A2), with a value of 0.644, ranked as the least potential circular economy practice. This ranking indicates that, while Lean Production is recognised for its ability to optimise resource use and reduce waste in manufacturing chains, it may face perceived challenges or be less immediately applicable in circular economy practices tailored specifically for construction. Further investigation and understanding of these problems may aid in the refinement of its execution and perception within the industry.

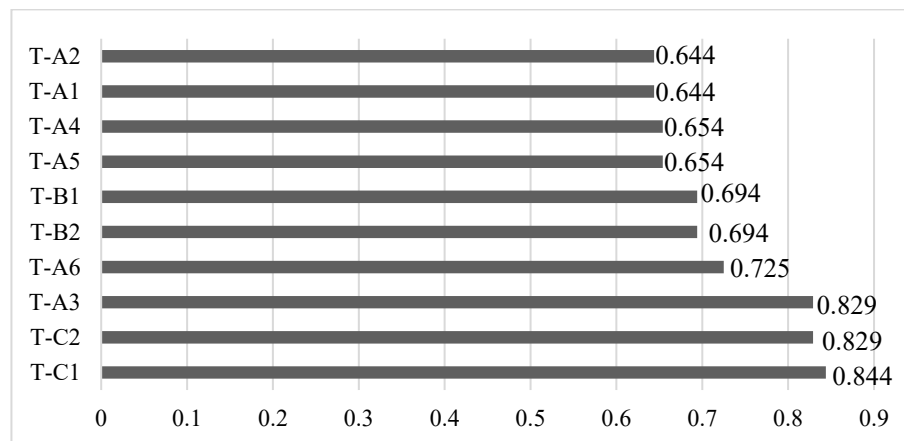


Figure 1: Type of Circular Economy

Barriers Faced by Construction Organisations When Transitioning from A Linear to A Circular Economy Practice.

Figure 2 illustrates the barriers construction organisations face. “Insufficient Comprehension and Insight” (B-A2), holds the highest factor loading (FL = 0.854). Based on findings from Munaro et al. (2020), this challenge stems from

insufficient awareness, comprehension, and insight regarding the Circular Economy in the building industry. As a result, many professionals struggle to grasp the long-term benefits of circular practices, leading to hesitation in adopting CE-based construction methods and resistance to shifting from traditional linear models. The second largest barrier, shared by all four factors, suggests that “economic aids and marketability” (range from B-B1 to B-B4) substantially impact the implementation of Circular Economy Principles, with an FL value of 0.784. This agrees with Guerra and Leite's (2021b) study, which highlighted budget, schedule, and regulations as significant barriers. The high initial cost of CE technologies, such as material recovery systems and modular construction techniques, often discourages adoption, especially among smaller contractors. Additionally, the lack of strong financial incentives, such as tax benefits or subsidies, makes it difficult for companies to justify the transition to circular method. “Inadequate of Information in Building Design” (B-A3) with an FL of 0.745 ranked as the third factor impacting the transition from a linear to a circular economy practice. This indicates that the absence of data on the number, quality, and availability of building materials and components causes a fundamental barrier to their reuse.

Four additional barriers which is “Unfamiliarity of Circular Economy Concept” (B-A1), “Inadequate Knowledge in Building Design” (B-A4), “Inadequate Knowledge on Current Structure and Materials” (B-A5) and “Lack of Standardization Assurance” (B-C2) each hold an FL value of 0.742, reflecting broad industry recognition of these challenges, though they are considered slightly less pressing than the top-ranked barriers.

The least significant barriers faced by construction organisations are "Lack of Data Accessibility and Origins of Reused Materials" (B-A6) and "Lack of Availability of Training Programs for Contractors" (B-C1). The first point emphasises the difficulty in obtaining and validating the source and quality of recycled materials, which affects project planning and execution. The last point indicates a lack of learning resources and skills development opportunities for contractors, which may limit their ability to adopt new techniques and technology.

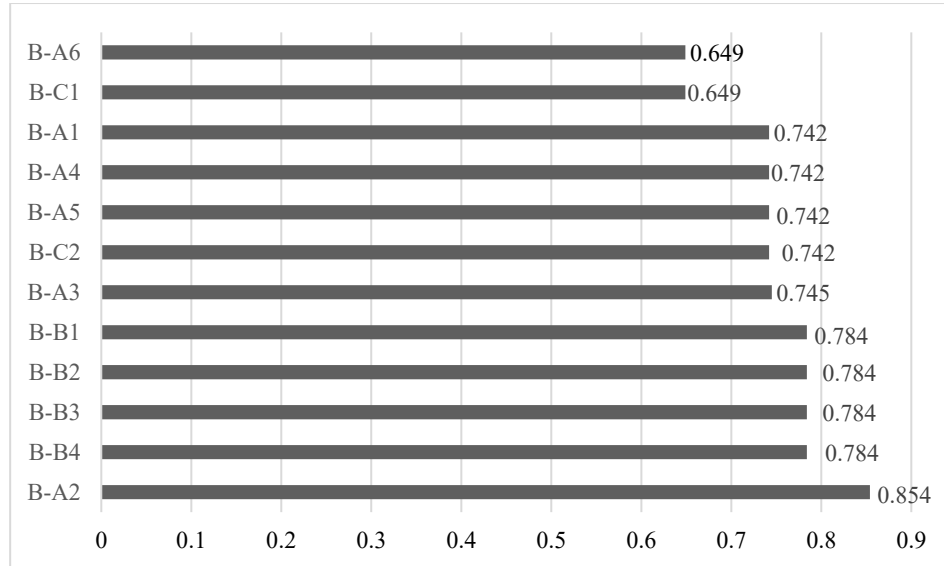


Figure 2: Barriers Faced by Construction Organisation for Circular Economy

Solutions for Best Practices Circular Economy Implementation for Construction Organizations in Malaysia

Figure 3 shows the data analyzed using Factor Analysis on the Solutions for Best Practices Circular Economy Implementation for Construction Organizations in Malaysia. The most highly ranked solution is “Establishment of Updated Guidelines: Deconstructing Structures and Reusing Materials” (S-B2), as the best solution with an FL value of 0.748. Design guidelines alleviate the lack of understanding of CE by acting as instructional materials that clarify CE ideas and show how they may be implemented realistically in building projects. Updating the present regulations for new construction to allow reused materials in new construction projects will broaden the market acceptability of recovered materials (Osei-Tutu et al., 2022).

“Education and Training Programs” (S-A3) follows closely with an FL value of 0.743 is also a significant solution as implementing CE education and training programs may provide stakeholders with the necessary skills to execute CE principles. The third highest ranked solutions are “Advance Technology Implementation” (S-B1) and “Innovation in Circular Building Tools (S-B3), with a same FL value of 0.644. Advanced technology such as BIM can successfully cope with building complexity by digitizing information that stakeholders may access throughout the project's life cycle, and thus, with such information, disassembly or probable reuse of a complicated building structure becomes a more plausible alternative (AlJaber et al., 2023).

Ranking fourth, with an FL value of 0.615, are “Joint Efforts and Networks” (S-A2), “Legislative Actions” (S-C2)” and “Economic Incentives” (S-C4). These findings suggest that a combination of awareness forums, legislative actions and financial support mechanisms is essential to address economic barriers and promote the public perception of recycled materials in construction, encouraging a more sustainable and circular construction industry. Moreover, by cutting prices and enhancing the attraction of circular structures, economic incentives can substantially impact modifying consumer behaviour (AlJaber et al., 2023). Furthermore, all interested parties and construction experts must be included in developing a roadmap to encourage using recycled materials in the building sector (Osei-Tutu et al., 2022).

Besides, “Large Amount of Research and Development” (S-A1) and “Campaign on Fundamental Knowledge of Circular Economy Practice” (S-A5) are both ranked fifth in the data with an FL value of 0.542. Case studies are also required to contextualize business models and establish credibility and trust in circular methods (Munaro & Tavares, 2023b). Apart from that, Campaigns, by definition, aid in developing fundamental knowledge of CE and its advantages, pushing stakeholders to embrace circular practices and boost the beneficial impact of CE on the surroundings (AlJaber et al., 2023).

“Awareness Forums” (S-C1), as part of the Economic and Marketability solutions, ranked sixth in the data with an FL value of 0.509. This suggests that awareness forums are recognized as a helpful solution for improving economic viability and marketability in the construction industry. They are viewed as less crucial than other options. Next, according to the respondents, “Workshops, Seminars Conferences, Social Media and Print Media”, with an FL value of 0.503, is considered the second lowest option for solution for best practices circular economy implementation for construction organizations. This could be due to issues like limited reach, engagement difficulties, or the perceived impact of different platforms in producing significant change in the industry.

Lastly, the “Financial Support Mechanism” (S-C3) is considered the lowest viable solution in this study, with an FL value of 3.94. This indicates that respondents perceive financial support mechanisms as less effective or less prioritized than other solutions for implementing best practices in the circular economy within construction organizations.

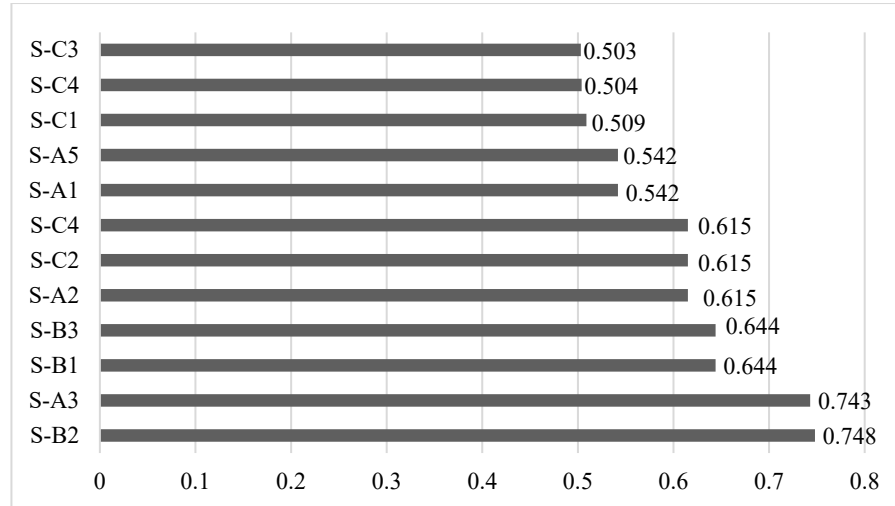


Figure 3: Solutions for Best Practices Circular Economy Implementation

CONCLUSION AND RECOMMENDATION

Malaysia's construction sector is at a pivotal juncture, requiring long-term strategies that reduce environmental impacts while improving resource efficiency. This paper sheds light on the state of circular economy (CE) practices in the industry, fulfilling key goals: identifying which CE approaches can be adapted to construction, examining barriers that organizations face when shifting from a linear to a circular model, and providing best-practice solutions for CE implementation.

A standout finding was that "Reversible and Disassembled Connection" emerged as the most promising CE practice, thanks to its emphasis on easily dismantling building components for reuse. In contrast to conventional linear methods—where materials are often thrown away—this approach preserves material value and conserves new resources by allowing parts to be reintroduced elsewhere. Yet the study also revealed that "Insufficient Comprehension and Insight" is the main hurdle to fully embracing CE. This underscores the need for robust awareness and training programs so that stakeholders can become more comfortable with CE techniques and justify their investment.

Looking ahead, "Establishment of Updated Guidelines: Deconstructing Structures and Reusing Materials" stands out as an essential recommendation for industry-wide best practices. By introducing clear standards and incentives—such as procurement procedures that integrate CE criteria, regulatory certifications, and shared best-practice initiatives—stakeholders will be better positioned to adopt circular approaches.

In conclusion, this paper recommends broadening the range of stakeholders involved, increasing educational outreach, and updating regulatory

frameworks to speed up CE acceptance in Malaysia's construction industry. Featuring real-world case studies of successful CE adoption could help address the current gaps in understanding. Additionally, integrating CE benchmarks into procurement and fostering active knowledge-sharing will create a more supportive environment for the adoption of circular practices.

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DISCLOSURE STATEMENT

The authors declare that there is **no conflict of interest** related to this research.

REFERENCES

- Ahmed, S. A., Majava, J., & Aaltonen, K. (2023). Implementation of circular economy in construction projects: A procurement strategy approach. *Construction Innovation (London)*, 24(7), 204–222.
- 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. *Resource Conservation and Recycling*, 129, 175–186.
- Akhimien, N. G., Latif, E., & Hou, S. (2021). Application of circular economy principles in buildings: A systematic review. *Journal of Building Engineering*, 38, 102041.
- Aljaber, A., Martinex-Vazquez, P., Boniotopoulos, C. (2023). Barriers and enablers to the adoption of the circular economy concept in the building sector: a systematic literature review. *Buildings*, 13 (11), 2778.
- Benachio, G. L. F., Freitas, M. D. C. D., & Tavares, S. F. (2020). Circular economy in the construction industry: A systematic literature review. *Journal of Cleaner Production*, 260, 121046.
- Dams, B., Maskell, D., Shea, A., Allen, S., Driesser, M., Kretschmann, T., Walker, P., & Emmitt, S. (2021). A circular construction evaluation framework to promote designing for disassembly and adaptability. *Journal of Cleaner Production*, 316, 128122.
- Diemer, A., Nedelciu, C. E., Morales, M., Batisse, C., & Cantuarias-Villesuzanne, C. (2022). Waste management and circular economy in the French building and construction sector. *Frontiers in Sustainability*, 3.
- Ghaffar, S. H., Burman, M., & Braimah, N. (2020). Pathways to circular construction: An integrated management of construction and demolition waste for resource recovery. *Journal of Cleaner Production*, 244, 118710.
- Groenewald, E. (2024). Circular economy strategies in supply chain management: towards zero waste.. *pst*, 48(1), 464–480. <https://doi.org/10.52783/pst.291>
- Ilmi, H. S., When Yee, J., Jhun Kam, K., & Shwan Lim, T., Tatt Soon, L. (2024). Implementation of Zero Waste Concept in Malaysia: From Contractors' Perspective. *Planning Malaysia*, 22(3), 486–501.
- Ma, W., Tian, L., Hao, J. L., Wu, W., & Gu, X. (2023). Towards a circular economy for

- construction and demolition waste management in China: Critical success factors. *Sustainable Chemistry and Pharmacy*, 35, 101226.
- Marek, M. and Krejza, Z. (2024). Sustainable building: circular economy as a key factor for cost reduction. *E3s Web of Conferences*, 550, 01009. <https://doi.org/10.1051/e3sconf/202455001009>
- Mattaraia, L., Fabricio, M. M., & Codinhoto, R. (2021). Structure for the classification of disassembly applied to BIM models. *Architectural Engineering and Design Management*, 19(1), 56–73.
- Maury-Ramírez, A., Illera, D., & Mesa, J. A. (2022). Circular Economy in the Construction Sector: A Case Study of Santiago de Cali (Colombia). *Sustainability*, 14(3), 1923.
- Minunno, R., O'Grady, T., Morrison, G. M., Gruner, R. L., & Colling, M. (2018). Strategies for applying the circular economy to prefabricated buildings. *Buildings*, 8(9), 125.
- Munaro, M. R., Tavares, S. F. (2023). A review on barriers, drivers and stakeholders towards the circular economy: The construction sector perspective. *Cleaner and Responsible Consumption*, 8, 100107.
- Munaro, M. R., Tavares, S. F., & Bragança, L. (2020). Towards Circular and More Sustainable Buildings: A systematic literature review on the circular economy in the built environment. *Journal of Cleaner Production*, 260, 121134.
- Mustaffa, N. K., Isa, C. M. M., & Ibrahim, C. K. I. C. (2021b). Top-down bottom-up strategic green building development framework: Case studies in Malaysia. *Building and Environment*, 203, 108052.
- Norouzi, M., Chafer, M., Cabeza, L.F., Jimenez, L., Boer, D. (2021). Circular Economy in the Building and Construction Sector: A Scientific Evolution Analysis. *Journal of Building Engineering*, 44, 102704.
- Osei-Tutu, Ayarkwa, Asibey, D. O., Osei-Asibey, D., Nani, G., & Afful, A. E. (2022). Barriers impeding circular economy (CE) uptake in the construction industry. *Smart and Sustainable Built Environment*, 12(4), 892-918.
- Rahla, K. M., Mateus, R., & Bragança, L. (2021). Selection Criteria for Building Materials and Components in Line with the Circular Economy Principles in the Built Environment—A Review of Current Trends. *Infrastructures*, 6(4), 49.
- Salleh, H., Ying, C. K., Hanid, M., Abdul Samad, Z., Mohamed Sabli, N. A., & Syed Khuzzan, S. M. (2022). Development of Guidance for the Adoption of Circular Economy in Construction and Demolition Waste Management. *Planning Malaysia*, 20(5), 415–427.
- Wuni, I. Y., & Shen, G. Q. (2022). Developing critical success factors for integrating circular economy into modular construction projects in Hong Kong. *Sustainable Production and Consumption*, 29, 574–587.
- Yadegaridehkordi, E., Hourmand, M., Nilashi, M., Alsolami, E., Samad, S., Mahmoud, M., Alarood, A. A., Zainol, A., Majeed, H. D., & Shuib, L. (2020). Assessment of sustainability indicators for green building manufacturing using fuzzy multi-criteria decision-making approach. *Journal of Cleaner Production*, 277, 122905.

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