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OPTIMISING MATERIAL SELECTION FOR DESIGN FOR DECONSTRUCTION: A KANO MODEL-BASED EVALUATION OF DOORS AND WINDOWS

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ABSTRACT

The construction industry faces a major challenge due to its waste generation and resource depletion leading to environmental impacts. To mitigate these the circular economy (CE) offers a solution by repurposing construction waste as raw materials. This approach can be further enhanced by integrating eco-design strategies, particularly Design for Deconstruction (DfD). Material selection is a crucial aspect of successful deconstruction. However, current research lacks specific focus on material selection for deconstruction feasibility within a CE framework, especially for joinery components. This study addresses this gap by identifying crucial criteria for material selection in DfD, specifically targeting doors and windows to promote circularity. The study uses a mixed-method approach, involving preliminary interviews with 5 interviewees followed by a questionnaire survey with 50 respondents based on the Kano Model where the content analysis and the Kano Model were used to analyse the collected data. Purposive sampling was used to select samples for the preliminary interview and questionnaire survey. Finding reveals that the "avoid toxic and hazardous materials" as the most critical criteria for material selection in DfD for doors and windows, while "maintain updated as-built drawings and material inventories with disassembly instructions" remain the least concern criteria among the identified seven crucial criteria. Ultimately, this research contributes to improving decision-making when selecting materials during the construction design phase to foster circularity and reduce the environmental impact of the construction industry. Additionally, the results of the study can be recommended to policymakers to incorporate in the standards such as GreenSL rating system and further research promotes other eco-design methods and policy formulation.

Keywords: *Circular Economy; Construction; Design for Deconstruction; Kano Model; Material Selection.*

1. INTRODUCTION

The construction industry generates a significant amount of waste, contributing to a high percentage of landfill waste (Ajayi et al., 2015). Statistics indicate that this waste volume

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accounts for 30% to 40% of the total solid waste generated in the global context (Li et al., 2024). Akanbi et al. (2019) suggested that the activities executed at the end of the building's useful life, particularly during building demolition, produce 50% of the solid waste generated from total construction demolition waste (CDW) globally. Conversely, the construction industry consumes a substantial quantity of raw materials, accounting for 40% of natural resources used (Valentini, 2023). This leads to resource depletion where the natural resources are consumed faster than they can be replenished (Baldassarre, 2025). Thus, the CDW and resource depletion are substantial challenges to the construction industry due to the associated environmental impacts (Ruiz et al., 2020).

To mitigate the environmental impacts of the construction industry, waste generated from this sector can be repurposed to reduce the need for raw material extraction and to decrease landfill waste (Akhtar & Sarmah, 2018). This can be achieved through waste management processes such as 3R (Reducing, Reusing, and Recycling), which assist in recovering materials (Cruz-Rios & Grau, 2020). Nevertheless, the main obstacles to adopting these technologies are the costs and time associated with operations, along with the low demand for reused materials (Akhtar & Sarmah, 2018). However, Ruiz et al. (2020) argued that the CE model is better suited to address inefficiencies compared to the traditional reduce, reuse, and recycle model. According to Rahla et al. (2021) the CE is characterised as "an economic system that replaces the 'end-of-life' concept with efforts to reduce, alternatively reuse, recycle, and recover materials throughout production, distribution, and consumption processes" (p. 2). This CE model aims to minimise waste generation and material consumption by keeping resources in circulation and maximising their value (Benachio et al., 2020). Moreover, adopting a CE approach can lead to significant economic and environmental benefits, such as the upcycling of outdated buildings (Akinade et al., 2019). The application of CE practices can be enhanced through the use of eco-design methodologies, such as DfD (Munaro et al., 2022).

DfD is an approach that considers the deconstruction of a building during the early design phase (Crowther, 2018). This strategy challenges the traditional view that demolition is the inevitable endpoint for a building. Instead, it emphasises the potential to recover building materials from end-of-life (EOL) (Arisya & Suryantini, 2021). DfD approach influenced by factors such as material selection, construction connections, disassembly procedures, assembly hierarchy, health and safety considerations, and deconstruction planning (Machado et al., 2018). A thorough understanding of material properties and careful selection are necessary for evaluating the life cycle impact of materials, which ultimately enhances environmental performance by improving material recovery and reducing waste generation supporting CE (Benachio et al., 2020; Rahla et al., 2021).

Conversely, many studies have been conducted on DfD, primarily focusing on its adaptation (Ostapska et al., 2024), its connection to CE practices (Akanbi et al., 2019; Akinade et al., 2019; Bertino et al., 2021), and the development of frameworks and guidelines that outline DfD criteria (Akinade et al., 2019; Machado et al., 2018). However, the application of these principles has not been extensively studied (Machado et al., 2018). Although research has addressed material selection in relation to CE (Bertino et al., 2021; Rahla et al., 2021), there has been limited exploration of material selection specifically for deconstruction feasibility supporting CE. In this context, Zoghi et al. (2021) developed a hybrid multi-criteria decision-making model for material selection in DfD, considering all building components. However, the availability of studies to address the deconstruction feasibility for joinery components is not examined despite its potential to hinder the deconstruction due to adhesive connections and the use of composite materials (Joustra et al., 2021; Krišťák & Réh, 2021). Moreover, Rahla et al. (2021) and Zoghi et al. (2021) indicated that current material selection methods do not adequately prioritise deconstruction feasibility. According to Akanbi et al. (2019), incorporating DfD criteria into material selection during the design stage necessitates a more technical and practical understanding of the various characteristics of materials. Despite the considerable research available on DfD, including various multi-criteria decision-making models for material selection relating to all components, a significant gap persists in prioritising DfD principles for joinery components, particularly doors and windows (Joustra et al., 2021; Machado et al., 2018; Zoghi et al., 2021).

This study addresses the identified gap by investigating the crucial criteria for material selection in DfD, for doors and windows, ensuring the circularity. To achieve this aim, the research will pursue three objectives: first, to identify the general criteria from existing literature; second, to pinpoint the criteria specifically related to doors and windows in material selection for DfD; and third, to identify and rank the crucial criteria for material selection in DfD for doors and windows. Hereinafter, the paper comprises a literature review (2), methodology (3), findings (4), discussion (5), and conclusions (6.0).

2. LITERATURE REVIEW

2.1 CONCEPT OF CIRCULAR ECONOMY (CE)

The CE is an economic system designed to eliminate waste and pollution, keep materials in the loop and regenerate the natural system (Ellen Macarthur Foundation, 2015). The definition of CE is advancing beyond the traditional 3R principles (Rahla et al., 2021). Additionally, the implementation of the CE in the construction industry represents an ideal opportunity due to its potential to reduce waste, conserve resources, and enhance productivity (Varsha et al., 2025).

2.2 APPLICATION OF CE IN THE CONSTRUCTION INDUSTRY

In the construction industry, CE principles can be applied through Value Retention Processes (VRPs) and end-of-life (EOL) scenarios (Ellen Macarthur Foundation, 2015). VRPs, which include reuse, repair, remanufacturing, and refurbishment, contribute directly to the CE by extending the lifespan of materials and products (Tolio et al., 2017). Moreover, recycling or recovery becomes crucial at EOL, particularly when value retention processes are not feasible (Eberhardt et al., 2020). As noted by Eberhardt et al. (2020), selecting the right materials is a key strategy for implementing CE principles in the construction industry. Additionally, many studies underscore the importance of integrating CE principles in material selection to address the environmental challenges posed by the construction sector (Ruiz et al., 2020). As discussed, CE practices in the construction industry can be effectively facilitated through VRPs, EOL scenarios, and efficient material selection during the design phase (Rahla et al., 2021). To combine these strategies, eco-design methodologies can serve as a vital enabler (Benachio et al., 2020).

2.3 ECO-DESIGN METHODOLOGIES IN THE CONSTRUCTION INDUSTRY

Eco-design approaches aim to integrate sustainable practices into construction activities, thereby improving the environmental performance throughout the lifespan of buildings, minimising environmental impacts, and fostering economic and social aspects (Munaro et al., 2022). Despite the challenges in the construction industry, such as the complexity of the building process, diverse stakeholders, and the duration of construction projects, applying eco-design practices in this field is both feasible and suitable (Kuo et al., 2018). Furthermore, numerous eco-design concepts have been embraced in the literature to ensure their adaptability to the construction industry (Munaro & Tavares, 2023). The idea of "Design for" has become a common method, with "X" representing the specific design goal related to the EOL situation of a building. This approach encompasses strategies like Design for Disassembly, Design for Recycling, and DfD (Arisya & Suryantini, 2021; Munaro et al., 2022). Furthermore, concepts such as Design for Reuse and Design for Adaptability help maintain value before the building reaches the end of its life cycle (Tolio et al., 2017). These strategies highlight how eco-design practices can support CE principles by prolonging the service life of buildings and maintaining the flow of materials in continuous circulation (Munaro & Tavares, 2023).

2.4 DESIGN FOR DECONSTRUCTION

DfD is the planned separation of building elements to recover and reuse the materials at the EOL (Zoghi et al., 2021). This concept is primarily applied considering building design, material selection, and connection methods to enable efficient deconstruction and material recovery (Machado et al., 2018). DfD is a critical concept when comparing with other eco-design methodologies because it optimises the recovery and reuse of high-value secondary materials (Ostapska et al., 2024) and reduces the overall environmental footprint through the repurposing of high-energy embodied building materials (Kanters, 2018). Further, this supports the transition toward CE. Additionally, the factors supporting DfD have been widely documented in the literature as general criteria as illustrated in Table 1.

Table 1: General criteria that enable DfD

Category	Sub-Categories and Criteria	References
1. Building Materials and Components	1.1 Material Selection and Use: Use reusable, recycled, recyclable materials, Avoid toxic and hazardous materials, Minimise variation in materials, parts, and components, Avoid composite materials and inseparable subassemblies, Use durable materials, Avoid secondary finishes that reduce reusability, Provide permanent identification for material types. 1.2 Modular and Prefabricated Components: Use prefabricated, mass-produced standardized building components, Design for modularity to enhance flexibility, Use framing techniques, Consider handling logistics for materials and components	[1], [2], [3], [4], [5], [7], [8], [9], [10]
2. Structural Systems and Interface Coordination	2.1 Layer Separation, Standardisation, and Modularity: Facilitate the separation of building layers (structure, services, cladding), Provide access to all building parts and components, Use simple and standardised building forms, Minimise inter-system interactions. 2.2 Handling, Logistics, and Flexibility: Ensure components are sized for easy transport and assembly, Use simple tools for assembly/disassembly, Provide realistic tolerances for manoeuvring during disassembly, Dedicate specific volumes for each system, Ensure spaces are adaptable to changing needs, Use	[1], [2], [3], [4], [8], [10]

Category	Sub-Categories and Criteria	References
	lighter components suitable for manual disassembly, Use larger parts to reduce total components for mechanical disassembly	
3. Joint Systems, Assembly, and Disassembly Processes	3.1 Mechanical Connections and Accessibility: Use mechanical fasteners rather than adhesives or chemical bonds, Avoid joints or screws that hinder reuse, Minimize the number of fastener types, Ensure joints are durable and reusable, Design connectors to withstand repeated usage, Make joints accessible for easy disassembly. 3.2 Assembly Sequencing and BIM Integration: Use open building systems for flexibility, Enable parallel rather than sequential disassembly, Organize components based on lifespan, Systematize assembly for easy maintenance and replacement, Maintain updated as-built drawings and material inventories, Identify disassembly points permanently, Use BIM to simulate disassembly processes, Provide adequate assembly/disassembly instructions	[1], [2], [3], [4], [5], [6], [9], [10]
4. Life Cycle Coordination and Human Collaboration	4.1 Planning for Reuse and End-of-Life: Plan deconstruction/demolition from the design stage, Design retractable foundations to reduce demolition impact, Use eco-labelled, natural, or minimally packaged materials. 4.2 Circular Economy and Environmental Impact: Support research on the benefits of salvageability, Provide training on environmental, social, and economic benefits of DfD, Ensure safety in all deconstruction activities. 4.3 Safety and Team Coordination: Promote collaboration among team members, Engage contractors early in the design process, Provide training on DfD practices. 4.4 Knowledge Sharing and Training: Involve stakeholders in disassembly planning, Share knowledge on material inventories and design updates	[3], [4], [5], [8], [10]

[1] - (Machado et al., 2018), [2] - (Zoghi et al., 2021), [3] - (Ostapska et al., 2024), [4] - (Akinade et al., 2019), [5] - (Bertino et al., 2021), [6] - (Kanters, 2018), [7] - (Cruz-Rios & Grau, 2020), [8] - (Akanbi et al., 2019), [9] - (Munaro & Tavares, 2023), [10] - (Sadafi et al., 2014)

The general criteria can be categorised ranked according to direct influence (durability, toxicity, reusability and recoverability, security measures, as-built drawings) influence on the ease of the process (modularity, connections, material identification system) and influence on prolonging the life (Machado et al., 2018). The application of DfD criteria is crucial for material selection at the microscale, with implications for the macroscale building, indicating the interdependency of these factors (Munaro & Tavares, 2023).

2.5 MATERIAL SELECTION IN DESIGN FOR DECONSTRUCTION

DfD enables planned deconstruction at the end of a building's life (Crowther, 2018). Consequently, the incorporation of material selection during the design phase for DfD is essential, as it will directly affect the viability of resource recovery at the EOL, thereby supporting CE practices (Akinadé et al., 2018). Additionally, to assist in material selection at the design stage, literature has identified factors such as ease of disassembly, non-toxicity, modularity, and compatibility (Akanbi et al., 2019). For example, durability and recyclability are crucial for maintaining the integrity and value of resources throughout multiple usage cycles (Akinade et al., 2019). The concepts of the CE can be integrated with DfD, which ultimately reduces waste and conserves resources by keeping materials in circulation within the construction sector (Eberhardt et al., 2020).

2.6 KANO MODEL

The Kano model, created by Noriaki Kano in the 1980s, classifies customer requirements into three categories: basic, performance, and excitement attributes, depending on how they influence satisfaction (Cho & Kim, 2022). Moreover, the main aim of the Kano model is to pinpoint and rank features that offer the greatest value to customers, thus directing resource allocation and design efforts (Slevitch, 2024).

The Kano model classifies customer needs into six primary categories. **Must-be qualities (M)** are fundamental expectations that, if not met, result in dissatisfaction; however, exceeding these does not greatly increase satisfaction (Cho & Kim, 2022). **One-dimensional qualities (O)** have a direct linear relationship with satisfaction, indicating that improved performance leads to greater satisfaction. **Attractive qualities (A)** are surprising features that boost satisfaction but do not lead to dissatisfaction if they are absent (Zoghi et al., 2021). **Indifferent qualities (I)** have no effect on customer satisfaction, independent of their presence (Cho & Kim, 2022). **Reverse qualities (R)** lead to dissatisfaction when they are present (Zoghi et al., 2021). Furthermore, a **Questionable category (Q)** consists of responses that can be ambiguous due to differing individual tastes (Slevitch, 2024). The Kano model assist to eliminate and prioritize key criteria, offering a clear framework for decision-making for subsequent works and its data-driven nature enhances objectivity (Cho & Kim, 2022) Thus, it is identified as the preferred quantitative analysis method in this study over other methods such as MoSCoW or RICE which rely on estimates and subjective judgment (Slevitch, 2024).

3. METHODOLOGY

This study utilises a mixed-methods approach to determine and rank the crucial criteria for material selection in DfD for doors and windows. As suggested by Creswell (2014), mixed methods utilised strengths of both quantitative and qualitative research, and this combination will provide an expanded understanding of the research question. Thus, the research employs a mixed-method approach to address the research question.

3.1 DATA COLLECTION METHODS

In the first phase (Qualitative), preliminary interviews were conducted with interviewees who have knowledge of DfD and CE principles. This is to fulfil the second objective, which is to identify the material selection criteria in DfD for doors and windows based on the criteria outlined in Table 1, which was completed upon achieving the first objective. To facilitate this process, an interview guideline was prepared that incorporated all the criteria from Table 1, as well as those specifically related to material selection for doors and windows identified by the researcher. By analysing these two documents, the interviewees provided their opinions and made relevant changes to the shortlisted criteria. The study employed semi-structured interviews for preliminary interviews due to their appropriateness for addressing exploratory research questions (George, 2023). This facilitates an in-depth exploration of new concepts such as DfD. For this phase, the "purposive sampling" method was used, which is categorised under nonprobability sampling methods, because this approach can align the research sample with the research aim, ensuring the reliability of data (Campbell et al., 2020). This can be further justified because the data collection targets specific group the experts who have knowledge of DfD and CE. According to Creswell (2014), smaller sample sizes are often used for preliminary interviews to gain insights before the full-scale study. As a result, the sample size was considered as 5 interviewees for the preliminary interviews.

In the second phase (Quantitative), the purpose was to achieve the third objective which is to identify and rank the crucial criteria for material selection in DfD for doors and windows. For this purpose, a questionnaire was prepared using the results of the first phase and distributed among professionals within the construction industry who were engaged in the design process, including architects, engineers, quantity surveyors and academic researchers who are aware of the DfD and CE. The structure of the questionnaire included functional (FQ) and dysfunctional (DFQ) questions for each criterion, and responses were collected on a five-point scale (Like, must be, Neutral, Live with, Dislike) based on the Kano model questionnaire (Zoghi et al., 2021). In addition, the data collected from this questionnaire were subsequently analysed utilising the Kano model. Similarly, for the second phase "purposive sampling" was used, and according to Zoghi et al (2021) a sample size of 50 responses was considered adequate to acquire meaningful results in Kano model. In addition, the sample size of 50 professionals, provides a balance between feasibility and the need for reliable results (Cho & Kim, 2022). Thus, the sample size was considered as 50 for the second phase.

3.2 DATA ANALYSIS METHOD

Content analysis is a method where researchers systematically code and interpret data to identify patterns, themes, and meanings (Krippendorff, 2019). Thus, the preliminary interview data were analysed using content analysis. Consequently, in the second phase, Shapiro-Wilk normality test and Kruskal-Wallis test was utilised to signify the independence of the responses from their different professions. Then, each response will be evaluated based on the Kano evaluation table (Table 2) and categorised into distinct categories to identify the crucial material selection criteria in DfD for doors and windows.

Table 2 : Kano evaluation table

Criteria		Dysfunctional question (-)				
		Like	**Must be**	**Neutral**	**Live with**	**Dislike**
Functional question (+)	Like	Q	A	A	A	O
	Must be	R	I(Q)	I	I	M
	Neutral	R	I	I	I	M
	Live with	R	I	I	I(Q)	M
	Dislike	R	R	R	R	Q

According to Table 2 each response was evaluated, and based on the frequency of the responses, the criteria will be divided into different groups. For instance, if a responder answers, "live with" for a functional question and "dislike" for a dysfunctional question, the category was determined as "M - must be." After completing these steps, the criteria identified as "M-must-be" and "R-reverse" were selected as crucial criteria and ranked accordingly for material selection in DfD for doors and windows, as the criteria identified as “M-must-be” are essential requirements, while “R-reverse” could adversely impact material selection in DfD for doors and windows. Then the ranking was done based on the frequency of the responses towards the selected category prioritising “M” over “R”.

4. ANALYSIS

This section analyses the data collected in the first and second phases.

4.1 PHASE 01

Initially, preliminary interviews were conducted to shortlist criteria related to material selection in DfD for doors and windows based on the identified broader criteria associated with DfD. Five interviewees who have knowledge of the DfD and CE, along with significant experience within the construction industry, were interviewed. The profiles of these respondents are detailed in Table 3.

Table 3 : Preliminary interview respondents' details

ID	Current Designation	Experience related to the research area
PIR1	Researcher/Lecturer	Having experience in the construction industry (10+ years) and experience in the research area
PIR2	Researcher	Having research related to CE and experience in the research area
PIR3	Researcher/Lecturer	Having research related to CE and DfD
PIR4	Researcher	Having research related to CE and experience in the research area
PIR5	Lecturer/ Industry	Having experience in the construction industry (30+ years)

As a result, 14 criteria were identified as crucial criteria for material selection in DfD for doors and windows. A summary of the preliminary interview findings is illustrated in Figure 1. In addition, for the analysis each criterion was coded (A1, B1...etc.) as illustrated in Figure 1.

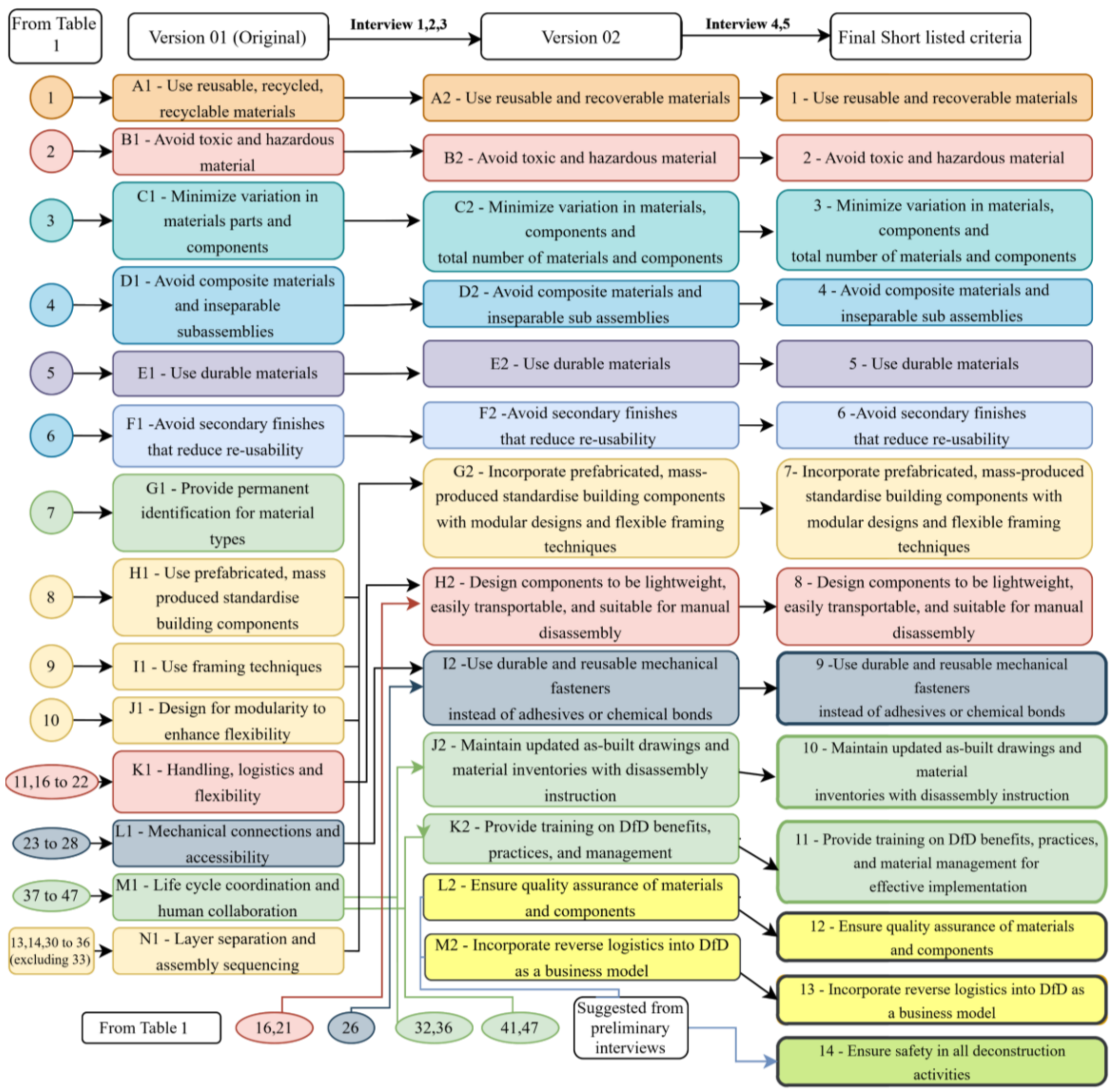

Figure 1 : Summarised findings of preliminary interviews

In the interview with **PIR 1**, all the criteria were deemed significant. In the case of PIR 2, A1 changed to use reusable and recoverable material since recoverable material covers a broader aspect. Furthermore, both **PIR 2** and **PIR 3** proposed to integrate H1, I1, and J1. **PIR 2** mentioned, *"We have to think about the construction before deconstruction, modularity facilitates that aspect, and it is better to merge all criteria related to modularity"*, and **PIR 3** verified that in a subsequent interview. Additionally, **PIR 2** emphasised the importance of quality assurance in DfD as *"Quality assurance is also important because otherwise people will not buy it for reuse, and it also helps to have better market values for components"*. Similarly, the importance of reverse logistics was highlighted as *"Reverse logistics will add more value to the DfD concept since it transfers the material and component to the starting point"*. Additionally. **PIR 3** indicated that 32 and 36 should be included as J2, highlighting that *"Documentation is critical in DfD as the demolition contractor needs to have adequate information when demolishing and dismantling the components"*. Regarding criterion K2, **PIR 4** specified, *"For careful deconstruction, this is a requirement because we do not just throw them to the landfills"*. However, **PIR 5** argued that *"Training is not mandatory to all people but people who are* *involved in the process."* Thus, the criterion was rephrased, adding effective implementation to indicate the success of the process utilising training. Additionally, **PIR 4** suggested including safety stating, *"Safety as a crucial criterion in the deconstruction aspects"*.

4.2 PHASE 02

A questionnaire survey was conducted based on insights from preliminary interviews to identify the crucial criteria related to material selection in DfD for doors and windows. The survey yielded a response rate of 77%, after sending it to 66 local industry professionals and academic researchers with familiarity regarding DfD, successfully achieving the required sample size for the study.

4.2.1 Statistical Analysis of the Data Set

The Shapiro-Wilk test was conducted on both functional and dysfunctional questions using SPSS software, with the null hypothesis stating that *"The data sample (FQs or DFQs) follows a normal distribution"*. According to the results, the $p \leq 0.05$ for all FQs and DFQs, rejecting the null hypothesis. This indicated that the data were not normally distributed. As a result, the Kruskal-Wallis test was used as a non-parametric test to identify whether there are any differences among the three professional groups. Then, the Kruskal-Wallis test was performed on every functional and dysfunctional question, utilising SPSS software. For this test, the null hypothesis is stated as *"The distribution of sample (FQs or DFQs) is the same across the categories of the designation"*. As per the test result, the $p > 0.05$, retaining the null hypothesis for all FQs and DFQs. This suggests that the respondents' answers are not influenced by their professions. This further implies that the sample size does not have to be uniform across each profession.

4.2.2 Kano Model

The responses from the participants for each question (FQ and DFQ) for each criterion were evaluated using the Kano evaluation table (Table 2), and the category was assigned subjectively to each respondent as displayed in Table 4.

Table 4 : Results of the Kano model evaluation

Criteria	A	M	O	I	R	Q	Total	Category
Criteria 1	11	18	10	10	2	0	51	Must be
Criteria 2	4	29	8	8	2	0	51	Must be
Criteria 3	16	5	13	15	2	0	51	Attractive
Criteria 4	11	9	6	19	3	3	51	Indifference
Criteria 5	8	20	13	8	1	1	51	Must be
Criteria 6	11	2	8	26	2	2	51	Indifference
Criteria 7	26	3	7	11	3	1	51	Attractive
Criteria 8	15	8	19	8	0	1	51	One-dimensional
Criteria 9	14	11	12	11	2	1	51	Attractive
Criteria 10	12	15	10	13	0	1	51	Must be
Criteria 11	12	16	10	13	0	0	51	Must be
Criteria 12	6	19	16	10	0	0	51	Must be

Criteria	A	M	O	I	R	Q	Total	Category
Criteria 13	15	5	12	18	0	1	51	Indifference
Criteria 14	1	28	13	8	0	1	51	Must be

M – Must be, O – One dimensional, A – Attractive, R – Reverse, I -Indifference, Q - Questionable

According to Table 4, the category with the highest frequency from this assessment was used to assign a general category to the criterion. The findings revealed that seven criteria (1, 2, 5, 10, 11, 12, and 14) were classified under the "Must-be" category, indicating they are critical baseline requirements. In addition, no criteria were primarily categorised as "reverse." Based on this evaluation crucial criteria can be ranked as 01 - Avoid toxic and hazardous materials, 02 - Ensure safety in all deconstruction activities, 03 - Use durable materials, 04 - Ensure quality assurance of materials and components, 05 - Use reusable and recoverable materials, 06 – Provide training on DfD benefits, practices, and material management for effective implementation, 07 - Maintain updated as-built drawings and material inventories with disassembly instruction based on the number of responses.

5. DISCUSSION

The materials selection during the design stage for DfD is crucial, as it will have a direct impact on the feasibility of resource recovery at the end of their life cycle, thus supporting CE initiatives (Akinadé et al., 2018). According to Machado et al. (2018), although there are principles related to DfD, the applications have not been extensively explored in the literature, and there is a notable gap of research addressing the deconstructability of joinery components (Joustra et al., 2021). Consequently, this study seeks to bridge that gap by specifically examining material selection within the framework of DfD.

5.1 RELATIONSHIP OF THE FINDINGS WITH THE EXITING LITERATURE

Akanbi et al. (2019) stated that non-toxicity is an essential requirement for selecting materials in DfD, and this was further validated by the study ranking it as the top criterion. Additionally, Akinade (2019) indicated that durability and recyclability are vital for preserving the integrity and value of materials across multiple usage cycles. This was ascertained by the identified crucial criteria, including the use of durable materials and the use of reusable and recoverable materials. Eberhardt et al. (2020) proposed that thoughtful selection of materials in building construction can further improve VRPs and EOL scenarios within CE practices. This was substantiated indicating ensuring the quality of materials and components as a crucial requirement. This criterion not only facilitates deconstruction at the EOL but also enhances the VRP. This was confirmed by PIR2, mentioning that *"quality assurance is also important because otherwise people will not buy it for reuse, and it also helps to have better market values for components"*. According to Kuo et al. (2018), the complex nature of the construction process, varied stakeholders, and the duration of building projects pose obstacles in the construction sector. Nonetheless, the implementation of eco-design methods remains viable and appropriate. This can be explored with the key criteria identified, including safety, providing training, and maintaining documentation in DfD, which directly address the noted challenges. PIR 3 reiterated this by stating, *"documentation is critical in DfD as the demolition contractor needs to have adequate information when demolishing and dismantling the components"* Furthermore, PIR 4 indicated that *"safety is a crucial criterion in the deconstruction* *aspects" supporting* how these criteria can indirectly aid in overcoming challenges in construction, thereby making the use of eco-design concepts beneficial.

5.2 UNDERLYING DRIVERS AND PATTERNS IN FINDINGS

The adhesive connections and the use of composite materials potentially hinder the deconstructability of doors and windows, as suggested by existing global literature (Joustra et al., 2021; Krišťák & Réh, 2021). However, this study does not identify these factors as crucial criteria within the context of the Sri Lankan sector. Furthermore, the established criteria can effectively address the identified issues related to reuse and recycling, such as low demand, as noted in the global literature (Akhtar & Sarmah, 2018). For instance, the implementation of quality assurance measures can significantly enhance the demand for reused materials. In addition, the general criteria for DfD can be categorized into three groups based on their significance: direct influence, influence on the ease of the process, and influence on the ease of the process (Machado et al., 2018). The study ranks these criteria according to these patterns, further identifying their relationship to existing global literature and validating them.

6. CONCLUSIONS

The research aimed to identify key criteria for material selection in DfD specifically for doors and windows. This was achieved through a literature survey, preliminary interviews, and a questionnaire based on the Kano model. Initially, 47 criteria were found in the literature, which were then narrowed down to 14 criteria during the preliminary interviews. After the Kano evaluation, 07 criteria were identified as crucial criteria and ranked based on the frequency of response. According to the results, avoid toxic and hazardous materials was identified as the most crucial criterion, while maintaining updated as-built drawings and material inventories with disassembly instructions was recognised as the least important criterion among the identified seven criteria.

This study significantly contributes to making an informed decision for the designers at the design phase when selecting materials for doors and windows to facilitate deconstruction. Consequently, material circularity can be promoted in line with CE within the construction sector, supported by DfD, in order to reduce the environmental effects associated with the construction industry from a wider environmental and social viewpoint. The findings of the study hold significant practical implications that can inform the development of sustainability-oriented policies, including the GreenSL rating system. Furthermore, from a theoretical standpoint, there is an opportunity for further research to investigate the market acceptability of reused and recycled components, as well as the potential for eco-design methodologies to enhance policy formulation in waste management within the context of Sri Lanka. As limitations of the study, the research does not consider a specific type of construction project type, as the existing literature only outlines criteria applicable to all construction projects in general. Furthermore, the research specifically addresses doors and windows, which may limit the applicability of the findings to other building components. Additionally, it is important to recognise that the data collection was conducted within the context of Sri Lanka.

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