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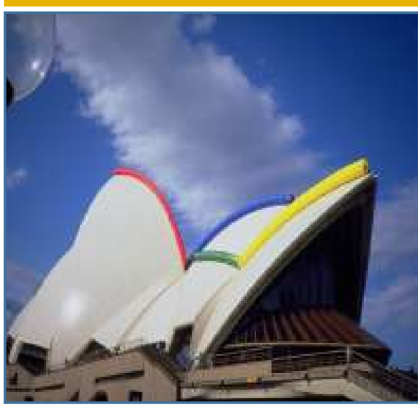
Confluence of Research, Theory and Practice in the Built Environment

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EVALUATING EFFECTIVE DECONSTRUCTION TECHNIQUES FOR SUSTAINABLE CONSTRUCTION IN NIGERIA

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ABSTRACT

The limited awareness and adoption of deconstruction practices in Nigeria's construction sector contribute to excessive waste and resource inefficiency. This study systematically identifies and evaluates effective deconstruction techniques, focusing on maximising material recovery, reducing environmental impact, and enhancing sustainability. A comprehensive literature review informed the development of a questionnaire survey distributed to construction professionals in Nigeria. The data were analysed using statistical tools such as percentages, frequencies, and the Kruskal-Wallis test. The results indicate that selective deconstruction, component reuse, manual disassembly, material segregation, and mechanical deconstruction are the most effective techniques. Significant differences in opinions were found among construction professionals on three out of fifteen identified techniques. By highlighting efficient methods for building deconstruction, this study provides a framework for construction professionals, policymakers, and stakeholders to optimise material reuse and recycling. The findings promote a shift from traditional demolition to eco-friendly deconstruction, supporting the circular economy in the construction sector.

Keywords: Deconstruction Techniques, Sustainable Construction, Resource Efficiency, Circular Economy.

INTRODUCTION

The construction industry generates over one-third of global waste, including concrete, wood, metals, gypsum, and plastics (Guerriero *et al*. 2024). It consumes vast amounts of virgin resources and significantly contributes to waste (Boukherroub *et al*. 2024). Rethinking waste management strategies, such as incorporating circular economy principles into deconstruction, is essential (Balogun *et al*. 2024). However, despite efforts to reduce waste, deconstruction techniques have seen limited adoption (Pittri *et al*. 2024).

Deconstruction dismantles structures to salvage materials for reuse, extending their lifecycle, reducing waste, conserving raw materials, and lowering energy consumption (Mcneil-Ayuk and

Jrade, 2024; Balogun *et al*. 2024). As noted by Victar and Waidyasekara (2024), the construction industry is composed of diverse, loosely integrated organisations across building and civil engineering projects. Deconstruction also involves material management, refurbishing salvaged materials, and designing for future reuse (Guerriero *et al*. 2024). Neglecting deconstruction leads to non-recyclable waste accumulation (Pittri *et al*. 2024). Governments are recognising its benefits, developing policies to increase disposal costs or restrict reusable material disposal (Boukherroub *et al*. 2024; Allam and Nik-Bakht, 2024).

In Nigeria, studies have highlighted the potential for responsible materials management, reducing the need for virgin materials by reusing demolished materials in future projects (Olubambi *et al*., 2024). Bello *et al*. (2024) examined barriers to circular economy adoption, while Balogun *et al*. (2024) evaluated current practices, challenges, and opportunities. Abdullahi *et al*. (2023) developed a systematic approach to minimize landfill waste by processing salvaged materials from structures in Kano State, Nigeria. This study aims to address a gap in the Nigerian construction industry by identifying and ranking the most effective deconstruction techniques. The focus is on maximizing material recovery, minimizing environmental impact, and promoting sustainability. This study offers practical strategies for construction professionals, policymakers, and researchers to reduce waste, promote circular economy practices, and reuse salvaged materials in future projects by providing a ranked list of effective deconstruction techniques. Ultimately, this study contributes to the body of knowledge by delivering actionable insights into sustainable deconstruction techniques for the Nigerian construction sector. It is a valuable resource for policymakers seeking to improve waste management policies, construction professionals integrating sustainability into their projects, and researchers furthering the study of deconstruction in developing nations. By identifying effective deconstruction techniques, the research directly addresses Nigeria's waste management challenges, promoting both environmental and economic sustainability.

LITERATURE REVIEW

Current Practices of Deconstruction in the Nigerian Construction Industry

Deconstruction is gradually gaining recognition in Nigeria's construction industry, though its adoption remains limited (Zuofa *et al*. 2023; Obi *et al*. 2021). Despite its benefits, careful dismantling of buildings to recover materials is not yet widespread (Akinade *et al*. 2019). Olubambi *et al*. (2024) note that some firms are experimenting with deconstruction, but it is mostly seen in small-scale projects. These practices focus on recovering steel, timber, and concrete for reuse. Balogun *et al*. (2024) observed that traditional demolition is still dominant, being faster and perceived as more cost-effective. A lack of expertise, training, and awareness also hinders broader adoption (Akinade *et al*. 2019). The regulatory frameworks supporting deconstruction remain underdeveloped, with limited government incentives for sustainable construction (Bello *et al*., 2023). However, there is growing awareness of its environmental and economic benefits, particularly in cities like Lagos and Abuja, where land scarcity is pushing developers to explore alternative methods (Abdullahi *et al*., 2023). Abdullahi's research highlights how salvaged materials can reduce landfill waste, but stresses that policy support and investment are crucial to advancing deconstruction. Although progress is being made, the practice is still emerging in Nigeria, requiring more training, policy support, and awareness campaigns (Davies and Davies, 2017).

Effective Deconstruction Techniques in the Construction Industry

As sustainability gains prominence, deconstruction techniques that recover, reuse, and recycle materials are increasingly important. Component reuse extends the lifecycle of large structural elements like beams, reducing the need for new resources (Akbarnezhad *et al*. 2020). Manual disassembly, though labour-intensive, achieves high recovery rates for materials such as wood and metal (Rodrigues *et al*. 2021). This is often paired with material segregation to maximise recycling potential (Silva *et al*. 2023). Selective deconstruction (soft strip) focuses on removing high-value items like windows and doors for resale or reuse, promoting resource efficiency (Chini, 2021). Mechanical deconstruction, using machinery like excavators, is effective for large projects, speeding up the process while preserving materials for reuse. Hybrid deconstruction combines manual and mechanical methods to balance efficiency and material recovery (Adams *et al*. 2021). On-site crushing and recycling allow concrete and bricks to be reused in new projects, reducing transportation needs and emissions (Koskela *et al*. 2023).

Floor-by-floor deconstruction, common in tall buildings, enhances the safety and coordination of material recovery (Buchanan *et al*. 2022). Prefabricated buildings benefit from modular deconstruction, enabling reuse in other projects (Jaillon *et al*. 2023). Facade deconstruction focuses on the careful removal of exterior components like cladding, facilitating their reuse (Gálvez-Martos *et al*. 2022). Deconstruction also supports heritage conservation by salvaging historic or architectural elements like masonry or woodwork, which can be financially rewarding in older buildings (Mazzucchelli *et al*. 2021). Techniques like de-nailing and salvaging lumber prepare wood for reuse, particularly important in sustainable wood supply chains (Rodrigues *et al*., 2021). Hazardous material removal ensures safe recovery and worker safety (Chini, 2021). Finally, material trading networks facilitate the sale and purchase of salvaged materials, supporting the circular economy (de Wolf *et al*. 2022). In conclusion, effective deconstruction techniques aim to reduce waste, promote recycling, and maximise material reuse. Their integration into mainstream construction is key to advancing sustainability in the built environment.

RESEARCH METHODOLOGY

Research Approach and Compilation of Deconstruction Techniques

This study aimed to systematically assess the most effective deconstruction techniques in the construction sector, focusing on material recovery, reducing environmental impact, and promoting sustainability. Lagos State was chosen as the study area due to its rapid urban growth and its status as a technological hub, representing Nigeria's evolving construction landscape (Arungwa *et al*. 2018). Lagos is one of the fastest-growing regions in Nigeria, with notable economic and construction activity (Oke *et al*. 2023). A thorough literature review was conducted to compile a list of deconstruction techniques. A screening process removed duplicates and irrelevant techniques, resulting in 15 deconstruction methods deemed suitable for the Nigerian context. A quantitative research methodology was used, with a questionnaire distributed to construction professionals (Moyanga *et al*. 2024).

Respondent Selection and Sample Sizing Strategy

Purposive and snowball sampling methods were used to ensure diverse, relevant participation. Purposive sampling targeted professionals with expertise, while snowball sampling expanded the participant pool (Etikan *et al*. 2016). Reports from professional bodies identified a population of 3,780 members (1,032 architects, 1,627 engineers, and 1,121 quantity surveyors). The sample size, calculated using the Yamane formula with a 5% margin of error, was 363 respondents.

Questionnaire Design and Data Collection Process

A pilot study tested the clarity of the questionnaire (Quiles *et al*. 2019). The final survey had two sections: the first collected respondents' background information, while the second evaluated the effectiveness of 15 deconstruction techniques using a 5-point Likert scale (1 = Not effective, 5 = Extremely effective). Google Forms was used to distribute the survey, resulting in a 54% response rate, with 194 completed questionnaires out of 363 distributed.

Data Analysis and Statistical Techniques

Data were analysed using SPSS. Cronbach's alpha measured the internal consistency of the survey, with a high score of 0.856 indicating strong reliability (Christmann and Van Aelst, 2006). Respondents' background information was summarised using frequency and percentage distributions. The Kruskal-Wallis H-test identified significant differences in opinions across respondent groups (Pallant and Bailey, 2005), with a p-value below 0.05 indicating statistical significance. Mean values for each deconstruction technique were also calculated.

RESULT

Respondent's Background Information

The study collected background information from the respondents, which included their academic qualifications, professional credentials, years of experience, and professional membership status presented in Table 1.

Table 1: Background Information of Respondents

Category of the Respondents	Frequency	Percentage (%)
Academic Qualification of Respondents		
(HND) Higher national diploma	47	24.2
(B/Tech/BSc) Bachelor's degree	70	36.1
(M/Tech/MSc) Master's degree	53	27.3
(OND) Ordinary National Diploma	24	12.4
Total	**194**	**100**
Profession of respondents		
Architect	48	24.7
Engineers	85	43.8
Quantity Surveyor	61	31.4
Total	**194**	**100**
Years of experience		
1-5 years	67	34.5
6-10 years	49	25.3
10-15 years	31	16.0
16-20 years	28	14.4
Above 21 years	19	9.8

Total	**194**	**100**
Membership status		
Probationer	40	20.6
Graduate	64	33.0
Cooperate	46	23.7
Fellow	44	22.7
Total	**194**	**100**

Evaluating Effective Deconstruction Techniques for Sustainable Construction

Table 2 presents the evaluation of all effective deconstruction techniques in the dataset using the Kruskal–Wallis H-test, a robust non-parametric statistical method, to assess the various techniques for sustainable construction among professionals (Architects, Quantity Surveyors, and Engineers). A mean value threshold of 3.5, as recommended by Aliu and Oke (2023), was applied to determine the effectiveness of each technique. Techniques with mean values above this threshold are deemed highly relevant and effective, while those below it indicates lower relevance. This threshold serves as a benchmark for evaluating the applicability of each technique in deconstruction processes. Selective deconstruction emerged with the highest mean score of 4.12, highlighting its significant recognition and relevance among industry professionals. Component reuse followed with a mean score of 3.91, demonstrating its strong presence in the sector. Other techniques, such as manual disassembly (mean = 3.87), material segregation (mean = 3.71), and mechanical segregation (mean = 3.63), also showed considerable relevance, underscoring their impact on driving innovation and effectiveness in the deconstruction process. Out of the 15 techniques evaluated, 9 achieved mean scores above the 3.5 threshold. The Kruskal–Wallis H-test revealed significant differences in three techniques: Materials trading networks ($p = 0.014$), De-nailing and salvaging lumber ($p = 0.042$), and Mechanical segregation ($p = 0.032$). These results suggest that these techniques possess distinct attributes or functionalities, offering valuable insights for industry professionals aiming to optimize deconstruction strategies for sustainable construction.

Table II: Kruskal-Wallis Test on Effective Deconstruction Techniques for Sustainable Construction

	ARC			QS			ENG			OVERALL			Kruskal Wallis Test	
Variables	**M**	**SD**	**R**	**M**	**SD**	**R**	**M**	**SD**	**R**	**M**	**SD**	**R**	**Chi**	**Sig.**
On-Site Crushing and Recyling	3.45	0.87	10	3.70	0.43	5	3.63	1.65	5	3.59	1.11	6	5.679	0.024
Manual Disassembly	3.79	0.87	3	3.85	1.01	3	3.97	0.63	3	3.87	0.45	3	3.789	0.567
Deconstruction of Prefabricated Buildings	3.40	0.77	11	3.61	0.88	6	3.59	0.8	8	3.53	1.07	8	12.087	0.732
Salvage of Historic/Achitectural Elements	3.51	0.89	9	3.41	1.25	9	3.61	0.73	6	3.51	1.29	9	4.620	0.098
Material Trading Networks	2.13	0.93	15	2.86	1.02	14	2.06	1.17	15	2.35	0.69	15	12.905	0.014*
Selective Deconstruction	3.98	1.34	1	4.14	0.65	1	4.25	1.65	1	4.12	0.35	1	3.789	0.103
Material Segregation	3.62	1.24	7	3.98	1.06	2	3.54	0.32	9	3.71	0.56	4	10.675	0.066
Floor by Floor Deconstruction	3.67	1.89	6	3.42	0.47	8	3.60	0.73	7	3.56	0.37	7	2.678	0.308

De-nailing and Salvaging Lumber	3.76	0.73	5	3.27	1.11	10	3.25	0.31	12	3.42	0.65	11	12.652	0.042*
Hybrid Deconstruction	3.08	1.07	14	2.83	0.98	15	3.03	1.31	14	2.98	0.87	14	13.702	0.321
Façade Deconstruction	3.28	0.76	12	3.09	0.23	12	3.54	1.04	10	3.30	1.14	12	1.678	0.098
Mechanical Segregation	3.60	1.22	8	3.61	0.45	7	3.78	1.35	4	3.63	1.24	5	4.567	0.032*
Component Reuse	3.89	0.36	2	3.73	1.12	4	4.13	0.68	2	3.91	0.74	2	9.072	0.154
Mechanical Sorting for Recyclables	3.77	0.99	4	3.24	1.32	11	3.41	0.65	11	3.47	0.46	10	3.567	0.079
Hazardous Material Removal	3.16	1.14	13	2.98	1.32	13	3.20	0.49	13	3.11	1.35	13	5.295	0.065

DISCUSSION AND IMPLICATION OF FINDINGS

This study aimed to evaluate the most effective deconstruction techniques for sustainable construction in Nigeria, drawing from insights provided by industry professionals. From the analysis, selective deconstruction, component reuse, manual disassembly, material segregation, and mechanical segregation emerged as the top five techniques.

Selective deconstruction, which received the highest mean, has been widely acknowledged in the literature for its ability to recover valuable materials and minimize waste. For instance, Yang *et al*., (2021) noted that selective deconstruction is critical for minimizing environmental impacts by reducing landfill waste and promoting material recovery findings consistent with the results. The component reuse technique aligns with findings from Kim and Lee (2022), who identified it as a key technique in promoting circular economy practices within the construction sector. Manual disassembly, another top-ranking technique has been recognized by Fletcher *et al*., (2021) for its precision in recovering materials without damaging them, making it a crucial method for sustainable construction. Material segregation is essential for separating recyclable materials on-site, a technique emphasized by Adeola and Fakolujo (2023), who noted its importance in improving material recovery rates. Mechanical segregation was noted by Ahmed *et al*., (2019) as a highly efficient method in large-scale projects, enhancing material separation and reducing labor time, thus reinforcing its effectiveness in this study.

The Kruskal–Wallis H-test revealed three deconstruction techniques with significant p-values below 0.05: materials trading networks ($p = 0.014$), de-nailing and salvaging lumber ($p = 0.042$), and mechanical segregation ($p = 0.032$). Materials trading networks, which facilitate the exchange of reusable materials, align with Wilson and Harper (2022) findings that such networks are crucial for minimizing construction waste. De-nailing and salvaging lumber, as discussed by Brown *et al*., (2020), was noted for its efficiency in material recovery, particularly in wooden structures. The significant p-value for mechanical segregation aligns with Jones *et al*., (2021), who highlighted its importance in optimizing deconstruction efficiency. The five identified deconstruction techniques highlight the shift toward sustainable construction practices. Theoretically, they reinforce concepts like circular economy and resource efficiency. In practice, these methods call for improved training and adoption to reduce environmental impact, lower material costs, and increase project efficiency. Societally, they contribute to reducing landfill waste, conserving natural resources, and promoting eco-friendly building practices. Overall, these techniques play a crucial role in advancing sustainable development in Nigeria's construction sector.

CONCLUSION AND RECOMMENDATIONS

This study aimed to evaluate effective deconstruction techniques for sustainable construction in Nigeria. The techniques were identified through a comprehensive review of extant studies ensuring that only current and relevant methods were included. A Kruskal–Wallis H-test was employed to statistically evaluate the effectiveness of these techniques based on feedback from construction professionals. The findings revealed that selective deconstruction, component reuse, manual disassembly, material segregation, and mechanical segregation were the top five techniques. These techniques are crucial for promoting sustainability, reducing waste, and optimizing material recovery within the construction industry. The study emphasizes the importance of adopting these methods for enhancing sustainability practices in the Nigerian construction sector.

Furthermore, this study recommends that construction stakeholders should prioritize the implementation of selective deconstruction and component reuse to minimize environmental impact. Second, there is a need for continuous professional training on deconstruction methods to improve skillsets and efficiency. As a suggestion for further study, future research should explore the economic feasibility and scalability of these deconstruction techniques across different regions in Nigeria, considering varying local contexts and resource availability. This would provide a broader understanding of how these techniques can be effectively implemented nationwide.

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