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Exploring the Circle of Consumption Around Reused Construction Demolition Waste: Evidence from Construction Sites

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Abstract
Reuse of construction materials/components from dismantled structures is an economic sector that is scarcely regulated and highly fragmented. Research into the reuse of components or materials extracted tends to focus on maximising the benefits when deconstructing building or civil structures. However, investigations that explore the dynamics involved in dismantling a built structure, trade and reuse of materials or components extracted with multiple actors is limited. This study aims at exploring the circle of consumption around reused materials or components extracted from dismantled structures. The study adopted a mixed method approach, and data was obtained from observation, interviews and structured questionnaires of stakeholders involved in deconstruction works. The results revealed that there are patterns in consumption of extracted components from demolished structure that should be regulated involving construction supply chains. The study argues that construction practitioners actively shape the way components extracted from demolished structures are repurposed and reused in subsequent construction works. The study contributes to the literature on circular economy and deconstruction by focusing on the dynamic relationship between members of construction supply chains and the reuse construction materials or components.

Keywords: extracted components, demolition, deconstruction, reuse and supply chains.

1. Introduction

Reuse of construction materials/components from dismantled structures is an economic sector that is scarcely regulated and highly fragmented. Some authors present the reuse of materials from the construction as extending the life of materials. For example, Wuyts *et al.* (2019) focused on extending the life of construction material from residential buildings in Japan. Other authors present the reuse of materials in construction as the creative use of construction waste or upcycling. For example, Gnatiuk *et al.* (2022) compared recycled and upcycled waste from the construction sector. This shows that reused construction materials is viewed differently in the construction management literature.

Research into reused components or materials tends to focus on maximizing the benefits when deconstructing building or civil structures. However, investigations that examine the dynamics involved in dismantling a built structure, trade and reuse of materials or components extracted with multiple actors is limited. This study aims to explore the circle of consumption around reused materials or components extracted from dismantled structures. Specifically, (1) to examine the nature of dismantling or deconstructing adopted, (2) the examine the type of components or materials extracted from the dismantled structure (3) to investigate where components or material extracted from dismantled structures are reused.

2. Circular Economy

The circular economy is an economic system that focuses on minimising waste and maximising benefits from available resources (Chukwuebuka, 2023; Rakhshan *et al.*, 2020). The implication is that emphasis is placed on activities such as reusing, recycling, reducing and recovering materials to work towards a target. Furthermore, activities in the circular economy aim at extending the lifespan of building materials by designing them for reuse, repair, and recycling to create new economic opportunities for the construction industry by developing new services, components and products (Rose and Stegemann, 2018). The implication is that jobs are created when built

structures are dismantled and repurposed. This reduces the likelihood of pollution of the environment, cost associated with disposing waste and encourages economic activities in local communities where the waste is generated.
Construction work contributes significantly to a nation's economy (Olubajo and Daniel, 2024). This is because construction work involves hiring workers over a long or short term to select and transport construction materials, the assembling of the materials onsite or offsite, and erection or dismantling of structures (Olubajo *et al.*, 2017; Olubajo and Daniel, 2024). The implication is that there is a circle of consumption involved in construction work that requires waste minimisation and the maximum use of construction resources. This raises questions on what waste can be minimised in construction work and what are the construction resources or materials that are often maximised on construction sites.

2.1 Waste generating activities

Waste is often generated from five main sources in construction work namely: excessive ordering of construction materials i.e. ordering above or more than what is required, damaging construction materials due to poor handling or malhanding, left-over construction materials also known as off-cut, insufficient or poor storage of construction materials, and unnecessary packaging of construction materials (Mbote, 2018; Hung and Kamaludin, 2017). This implies that multiple actors will likely be involved in causing, handling or dealing with the generation of different forms of construction demolition waste in the supply chain. Other studies argue that waste in construction work can be produced or generated from dismantling activities i.e. demolition or deconstruction of a built structure (Ponnada and Kameswari 2015; Rakhshan *et al.* 2020). This raises questions on the nature of dismantling approaches adopted on construction sites and the type of components or materials extracted from dismantled structures.
This waste produced or generated on construction site can be seen as a threat to the natural environment as pollution or an economic opportunity when repurposed, reused, upcyled or recycled for construction works (Gnatiuk *et al.* 2022: Rakhshan *et al.* 2020). The implication is that the decision to dispose or repurpose materials waste extraxted from construction depends on judgement of construction practitioners involved on the site, the volume of the waste, space available on the site.

2.2 Construction demolition waste

Demolition of built structures is a growing trend in urban communities that has been described as the process of tearing or pulling down a structure that has reached the end of its life (Rakhshan *et al.* 2020; Rose and Stegeman 2018). The implication is that demolition works offers the opportunity of extending the life of extracted materials when reused. This demolition process usually involves the disconnection of electrical and plumbing or removal of harzardous substances that can pose a danger to construction practitioners (Ponnada and Kameswari 2015). The implication is that demolition works usually involve some elements of deconstruction or stripping out.
The nature or approach to demolition tends to vary on construction sites. For example, some authors put forward two main approaches to demolition namely: the conventional and selective demolition or deconstruction (Coelho and de Brito, 2011). This classification focuses on the economic decision of extracting or not extracting components from demolished structure. Other authors argue that demolition works can be classified based on the method or technique namely: traditional and mechanised or thermal, hydraulic and explosive demolition (Pun *et al*. 2006; Menon and Jayaraj, 2017). The implication is that construction practitioners have a variety of demolition options to achieve their project objectives.
Deconstruction or selective demolition has been described as a process of reversing construction or engineering (Kanter 2018). This approach is gaining popularity because it enables construction practitioners to extract or salvage components for reuse. This raises questions on the type of components or material extracted from demolished structures and where these extracted components are reused.

2.3. Reuse of extracted components and materials

Reuse of extracted materials from demolished structures is a growing trend in developing and developed economies (Rakhshan *et al.* 2020; Rose and Stegeman 2018). One reason for this is because resources devoted to construction work are limited and the ambition of construction practitioners are to minimise cost and maximise profits wherever possible. However, one challenge with the reuse of materials/components extracted from demolished structures is that it is an economic sector that is scarcely regulated and highly fragmented. This is due to the fact that the entire process of stripping out, extraction, trade and reuse of components involves multiple actors that is not formally or officially documented. This raises questions on actors dealing or benefiting from extracted components from demolition and the places they are utilised.

3. Research Method

The study adopted a mixed method approach with a case study that involved observations, interviews and a questionnaire survey to explore the circle of consumption around reused materials or components extracted from dismantled structures in Nigeria. A pilot study was conducted on a four-storey building in Abuja that collapsed and was subsequently demolished. This structure was completed in 2021 and was attached to a hotel before collapsing in 2024. The site for this collapsed and demolished structure was chosen because of the potential of finding components extracted from the demolished structure that will be reused in other construction sites. The purpose of the structure was to provide lodging and office related services to people and this structure had an escalator and a swimming pool. This structure had 200 rooms that were used to lodge guests before collapsing in July 2024.

Insights on the nature of demolition and extraction of components from the collapsed structure were obtained at the site using observations and interview with construction practitioners involved or present at the site. The observations were carried out over a period of two days and an interview with an Engineer and Builder responsible for the demolition was conducted afterwards. The insights from the pilot study were then used to enrich the design of a structured questionnaire to examine: the nature of demolition adopted, the type of components or materials extracted and where components or material extracted from demolished structures are reused.

A total of 120 questionnaires were administered by hand and online to construction practitioners and stakeholders, and a total of 100 responses were received/returned. This indicated a remarkable 83.3% response rate. The questionnaire was divided into five parts. The first part focused on obtaining data on the characteristics of the respondents. The second part focused on obtaining data on the level of adoption of demolition techniques or method on site. The level of adoption was measured using a 5-point Likert scale as follows: 5- Always, 4- Often, 3-Sometimes, 2- Rarely and 1-Never. The third part of the questionnaire focused on obtaining data on the nature of components extracted from demolished structures. The nature of components extracted from demolished structures was measured using a 5-point Likert scale as follows; 5-Always, 4- Often, 3-Sometimes, 2- Rarely and 1-Never. The fourth part focused on the location where extracted components are usually reused in constructing a building. The location where extracted components are reused was measured using a 5-point Likert Scale as follows:

5-Always, 4- Often, 3-Sometimes, 2- Rarely and 1-Never. The fifth part of the questionnaire focused on dealers involved with the reuse of extracted components from demolished structures. The type of dealers involved with the reuse of extracted components from demolished structures was measured using a 5-point Likert scale as follows: 5-Always, 4- Often, 3-Sometimes, 2- Rarely and 1-Never. The data obtained on the nature of demolition, type of components extracted, locations where extracted components are reused and construction practitioners that deal with extracted components was analysed using mean item score and ranking.

4. Results

The paragraphs, pictures and tables below present the findings on the nature of demolition adopted, the type of components or materials extracted and where extracted components from dismantled structures are reused.

Observations from the collapsed and demolished four storey building:

In July 2024, the owner of the fourstorey building hired a construction firm to demolish further the collapsed structure and clear the site. The firm sent a builder and an engineer to execute the demolition. These two professionals disconnected the supply of water and electricity to the collapse structure to avoid electrocution and hired two operators with backacter excavators and 15 labourers to assist the operators in tearing apart the debris of the collapse building i.e., concrete columns, slabs and beams that were scattered on the ground.

The Engineer confirmed a reason behind the collapse of the building when he said:

'' .... It is suspected that the cause of the collapse is as a result of injuries incurred on the building while renovations were on going. This is the reason why many components were completely destroyed e.g. glass, bricks and masonry, floor tile materials......''

This statement shows that there was not enough room for the team of professionals on site to dismantle or deconstruct carefully the many components before the building collapsed. Due to the unexpected collapse of the structure, many reusable components that were fragile were damaged and scattered on site such as glass windows, aluminium frames and electrical fittings. They operators used the arm of the backacter and discharge bucket to dig into the collapse debris, break further the concrete elements into rubble and move the reinforcements to a set location with the assistance of the labourers. This is evidenced in figure 3 below. The fragile or shattered component such as broken glass, broken blocks, broken tiles and concrete rubble were packed together and heaped at the designated places on the site. This is evidenced in Figure 1 and 2 below.

Other components that were not fragile and survived the impact of the collapse were carefully removed by the labourers and kept openly on site because they had potentials of being reused. The labourers sorted out the items the recovered items into three main categories: wood/furniture were placed in a specific point; reinforcement rods were placed at another point and utility components were placed at another point.

Figure 1, 2 and 3: Pictures showing two operators with the backacter excavators demolishing and clearing

Survey results:

The characteristics of the respondent is presented in Table 1 below. The result showed that 40% of the respondents were site engineers, 24% of the respondents were site managers, 10 % of the respondents were site supervisors and 26 % of the respondents were store keepers.

The result showed that 35% of the respondents were builders, 32% were engineers, 20 % were estate managers, 7% of the respondents were architects and 6% were quantity surveyors. The finding also revealed that 2% had PhD, 9% of the respondents had MSc, 84% of the respondents had BTech/Bsc, 4%, had HND, while 1% had ND. The result further show that a higher percentage of respondents (81%) had 0-10 years of working experience, 6% of the respondents had 11-20 working experience, 5% of the respondents had 21-30 working experience, 4% of the respondents had 31-40 and 4% had above 40 years of working year experience. The results also showed that 68% of the respondents were male and 32 % of the respondents were female.

Table 1: Respondent characteristics

Item	Description	Freq.	%
Position in Firm	Site Engineer	40	40.0
	Site Manager	24	24.0
	Site Supervisor	10	10.0
	Store Keeper	26	26.0
	Total	100	100
Professional Affliation	Builder	35	35.0
	Engineer	32	32.0
	Estate Surveyor	20	20.0
	Architect	7	7.0
	Quantity Surveyor	6	6.0
	Total	100	100
Educational Background	PhD	2	2.0
	Msc	9	9.0
	BTech/B.Sc	84	84.0
	HND	4	4.0
	ND	1	1.0
	Total	100	100.0
Work Experience In years	0-10	81	81.0
	11-20	6	6.0
	21-30	5	5.0
	31-40	4	4.0
	Above 40 yrs	4	3.0
	Total	100	100
Gender	Male	68	68.0
	Female	32	32.0
	Total	**100**	**100**

The result in Table 2 presents the nature or type of demolition. The results indicate that a higher volume of respondents adopted mechanical demolition with a means score of 3.53 that ranked first. This could be because a mechanical demolition saves time in getting the job done. The result further showed that a selective demolition or deconstruction ranked second with a mean item score of 3.15. The results showed that a manual demolition ranked third with a mean item score of 3.1. Further results showed that an explosive demolition ranked 4th with a mean item score of 2.69. The results also showed that thermal demolition ranked 5th with a mean item score of 1.91. The result further showed that the hydraulic demolition ranked sixth with a mean item score of 1.79.

Table 2: Level of Adoption of Demolition Technique

Demolition type	MIS	Rank	Decision
Mechanical demolition	3.53	1st	Often
Selective demolition or deconstruction	3.15	2nd	Sometimes
Manual demolition	3.10	3rd	Sometimes
Explosive demolition	2.69	4th	Rarely
Thermal demolition	1.91	5th	Never
Hydraulic demolition	1.79	6th	Never

The results in Table 3 present the nature of components often extracted from demolished structures. The results show that wood is the most material extracted component from dismantled structure with the highest mean items score of 3.90. The results also showed that reinforcements ranked second as the next most extracted item with a mean item score of 3.87. The results further showed that electrical fittings ranked third with a mean item score of 3.80. The result showed that furniture/cabinets ranked fourth with a mean item score of 3.73. This could be because furniture components are not fragile and can be reused. The results showed that plastics ranked fifth with a mean item score of 3.60. The results also showed that broken blocks ranked sixth with a mean item score of 3.58. The results further showed that plumbing fittings ranked seventh with a mean item score of 3.42. This could be because plumbing fitting can be reused again. The result showed that flooring materials ranked eighth with a mean item score of 3.35, while glass ranked last as the ninth with a mean item score of 3.28.

Table 3: Nature of Extracted Components

Extracted components	**MIS**	**Rank**	**Decision**
Wood	3.90	1st	Always
Reinforcements	3.87	2nd	Always
Electrical fittings	3.80	3rd	Always
Furniture and cabinets	3.73	4th	Often
Plastics (PVC pipes)	3.60	5th	Always
Broken blocks	3.58	6th	Always
Plumbing fittings	3.42	7th	Sometimes
Flooring materials (tiles)	3.35	8th	Sometimes
Glass	3.28	9th	Sometimes

Table 4 below presents the location where extracted component from demolished structures are often reused. The results below showed that windows and doors ranked highest with a mean item score of 4.48. The result also showed that furniture and cabinets ranked second as the location where extracted are usually reused with a mean item score of 3.39. The results further showed that roofing and landscaping ranked third and fourth with mean item scores of 3.32 and 3.29 respectively. This could be because they are most accessible.
The results showed that decorative elements and the foundation ranked fifth and sixth as locations where extracted components are reused with mean item score of 3.23 and 3.21 respectively. The result also showed that interior fixtures and flooring ranked seventh and eighth with mean item scores of 3.20 and 3.17 respectively. The result further showed that walls ranked last as ninth with a mean item score of 3.04 as the least location where extracted materials is reused.

Table 4: Location Extracted Components are Reused

Location reused	**MIS**	**Rank**	**Decision**
Windows and doors	4.48	1st	Often
Furniture and cabinets	3.39	2nd	Sometimes

Roofing	3.32	3rd	Sometimes
Landscaping	3.29	4th	Sometimes
Decorative elements	3.23	5th	Sometimes
Foundation	3.21	6th	Sometimes
Interior fixtures	3.20	7th	Sometimes
Flooring	3.17	8th	Sometimes
Walls	3.04	9th	Sometimes

The results in Table 5 presents the dealers of components of extracted from demolished structures. The results showed that artisans and craftmen ranked first as the practitioners that buy or sell components with a mean item score of 3.63. The result also showed that scrap dealers ranked first with a mean item score of 3.63. This is followed by recyclers who ranked third with a mean item score of 3.58. The result further showed that Furniture makers ranked fourth as practitioners that often buy components extracted from demolished structures. This could be because furniture makers work with timber that is not fragile like other components.

The results showed that construction firms ranked fifth with a mean item score of 3.2. This is followed by parent companies/online dealers that ranked sixth with a mean item score of 3.12. This could be because the manufacturers of construction materials or components are in the best position to restore a damaged component for reuse. The results also show that real estate developers ranked last as seventh with a mean item score of 2.99. This could be because developers tend to put forward the best to the clients and would not want to be seen as offering cheap products.

Table 5: Dealers that Buy and Sell Components Extracted from Demolition Structures

Dealers of extracted components	MIS	Rank	Decision
Artisans and Craftsman	3.63	1st	Sometimes
Scrap Dealers	3.63	1st	Sometimes
Recyclers	3.58	3rd	Often
Furniture makers	3.22	4th	Sometimes
Construction firms	3.20	5th	Sometimes
Parent companies/Online dealers	3.12	6th	Sometimes
Real estate developers	2.99	7th	Sometimes

5. Discussion of Results

The results presented above shows some similarities and differences in the nature of demolition adopted, the type of components extracted and where those extracted components from dismantled structures were reused on site. The results showed that the mechanical method of demolition (involving equipment) adopted in figure 1-3 aligns with the results presented in Table 2 as this method ranked highest amongst others. This is evidenced as glass components were indicated as the least component to be extracted because utilising the mechanical method of demolition would most likely damage glass installations.

The results in Table 3 also showed that wood, reinforcements and electrical fittings were the three most ranked components to be extracted from demolished structures. This aligns with the observations in the case study of the collapsed structure as the same components were the components that were removed and stored. The results in Table 4 also showed that windows, doors, furniture, cabinets and roofing are places or locations that ranked highest where the extracted components are often reused. This aligns also with the results observed in the case of the collapse structure. A similar finding was observed in Ponnada and Kameswari (2015) study in India as bricks, wood and metals were retrievable.

The results in Table 5 further showed that artisans, scrap dealers and recyclers ranked highest amongst the construction practitioners that buy and sell components extracted from the demolished structures. This is not a surprise as it was observed in the case of the collapsed structure that 15 labourers were engaged to assist in the demolition process and clearing and are sometimes rewarded with the damaged items.

The results in Table 2 showed that manual demolition ranked third as a method that is sometimes adopted. This result contradicts as artisans often resort to the manual method instead of the mechanical method of demolition because it is less expensive and affordable for low and medium income earners. A similar finding was observed in Menon and Jayaraj (2017) study as the chemical demolition was preferred over the traditional demolition approach for implementation. The results also showed that selective demolition or deconstruction ranked second. This contradicts the findings in the case as it was observed that the structure collapsed and there was little or no opportunity to carefully dismantle or deconstruct the fragile components that can be reused.

The results also showed that a higher amount of the salvage components (reinforcements) was not reused in location for structural elements of a buildings. This is contradicting because some reinforcements that were extracted from demolished were traded cheaply and find their way into new construction work that may potentially be the cause of recurrent building collapse in developing or developed economies.

The results further showed in Table 5 that of online marketplaces ranked very low amongst other avenues for buying and selling components extracted from demolished structures. This is contradicting as second hand goods and components are often sold online and there are various digital platforms dedicated for components that can be reused.

The results suggests that multiple actors are involved in the circle of consumption of components extracted from demolished structures. These actors collectively play a role formally or informally in the reuse of components extracted from demolished structures and actively shape the circular economy in the way the components are repurposed for subsequent construction works. The results indicate that there are patterns in consumption of extracted components from demolished structure that should be regulated to avoid building collapse.

6. Conclusion

This study aimed at exploring the circle of consumption around reused materials or components extracted from dismantled/demolished structures. The objectives of the study focused on exploring the nature of demolition types adopted, the type of components or materials extracted and where extracted components from dismantled structures are reused. The study adopted a mixed method approach with a case study that involved observations, interviews and a questionnaire survey. The results revealed that there are similarities and differences in the nature of demolition adopted, the type of components or materials extracted and where extracted components from dismantled structures are reused in Nigeria. The results also indicate that there are patterns in consumption of extracted components from demolished structure that should be regulated to avoid building collapse. The study argues that construction practitioners actively shape the way components extracted from demolished structures are repurposed and reused in subsequent construction works.

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