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Evaluation of Materials Waste Reuse Methods on Construction Sites in Ibadan Metropolis, Nigeria

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Abstract

The construction industry is affected by the continuous generation of waste and poor waste management. Thus, waste management has become a major concern in the industry, as waste cannot be eliminated due to off-cuts of materials from the irregular shape, change in design during construction cause diverse waste. This study, therefore, assesses material that is prone to waste and identifies methods of reuse on construction sites. A pilot survey on registered building construction firms in which head-offices are located within the Ibadan metropolis was conducted based on the list of top construction companies obtained from the Bureau of Public Procurement in Oyo State, Nigeria. "Five" construction firms confirmed they practice waste management and shared their experience on worksites. A qualitative research approach was used to evaluate the objectives of the study. Content analysis and frequency were used as the basic analytical tool of the study. Results show that repurpose, remanufacture and salvage methods are proactive reuse methods to achieve low waste generated on construction sites. The study concluded that the use of reusable construction materials waste on construction sites will promote quality materials usage and save time taken to purchase new materials.

Keywords: Construction sites, materials, waste, reuse, methods

1.0 INTRODUCTION

Planning and management of available resources promote successful project delivery. The importance of materials in the construction industry is inevitable, as it constitutes the highest percentage of the total cost of construction (Cheng & Ma, 2013). This amounts to about 30% - 70% of the total construction cost (Patel & Vyas, 2011). Construction is seen as one of the key sectors in the nation's economy that is susceptible to problems related to waste of materials (Alwi et al., 2002). Yahya and Boussabaine (2006) defined construction materials waste as materials that are unusable for its original purpose and therefore discarded for many reasons. Wastage also occurs when materials available are surplus to requirement (Oyeniyi, 2011). Al-Hajj and Hamani (2011) defined waste as the difference between purchased and actual use. Kareem et al. (2015) identify materials waste as a product that must be either disposed of or re-used or recycled. Hence, materials that are no longer needed on a project has become waste for that particular project.

Wastage of construction materials poses a great threat to the construction industry at large which can affect the contractor's profit. Nzeadibe and Anyadike (2010) and Ezeah (2010) ascertained that waste management governance in the cities of Nigeria has failed. Braungart (2013) observed that a country's economy and environment are affected by the continuous generation of waste and poor management. Ojuola (2017) stated that the Nigerian construction industry has greatly contributed to the amount of waste generated in the country. Previous studies have also established that the adoption of material waste management techniques (reduction, reuse, and recycle) has been a big challenge in various countries (Hossain et al., 2017; Huang et al., 2018; Idris et al., 2017). Huang et al. (2018) added that there is a limitation to assessing materials waste that can be reuse and recycle. This shows that the market for waste generated in the construction industry is at barest minimal and waste management in the construction sector has not improved substantially.

Even though materials waste cannot be avoided on construction sites where different construction activities are carried out, Nigeria as a developing country still focused on waste reduction and avoidance techniques (Arijeloye & Akinradewo, 2016; Idris et al., 2017). According to Braungart (2013), the use of waste management techniques on construction sites has not been predominant. This implies that emphasis has not been placed on other techniques which in turn affect the turnover of the industry. Recently, Ojuola, (2017) established that the best waste management technique employed on construction sites was reuse. However, inadequate technical know-how in Nigeria affects the reuse of construction waste (Ojuola, 2017). This study aims to assess construction materials that are prone to waste as well as the methods of reuse employed to promote sustainable development in the studied area.

■2.0 LITERATURE REVIEW

2.1 Construction Materials Waste

In every construction, materials, labour, and plant used are most essential for successful project delivery. Alwi et al. (2002) listed material waste, labour waste, and time waste are three categories of construction waste. Waste generated on the construction site was grouped into two streams; upstream and downstream. Downstream wastes are residue obtained from cutting of materials and upstream are caused by improper material handling and construction operation respectively (Wang et al., 2008). Polat et al. (2017) and Cheng and Ma (2013) established that waste occurs throughout the entire lifecycle of a building project; construction, renovation, and rehabilitation. According to Poon et al. (2004) and Al-Hajj and Hamani (2011), timber, reinforcement, bricks, blocks, metal, and tiles are subjected to frequent cutting. Begum et al. (2006) established that concrete aggregate; sand, granite, and cement are prone to waste in construction. Recently, Yates (2013) added that floor tiles, ceiling tiles, roofing tiles, doors, windows are frequently subjected to wastage in renovation projects. Ge et al. (2017) identified furniture, fittings, and fixtures as examples of waste product in rehabilitation projects. According to Yuan et al. (2012), construction industries consume about 40% of the natural resources around the world annually. Also, the advancement in construction activities has increased the number of resources and materials usage and equally led to a rapid increased in waste generated in the industry.

2.2 Construction Materials Waste Management

Waste management techniques are an attempt made to solve the problem of wastage in the construction industry. The 3Rs (reduce, reuse and recycle) are the identified techniques used for materials waste management (Akinkurolere et al., 2013; Ameh & Itodo, 2013; Arijeloye & Akinradewo, 2016; Dajadian & Koch, 2014; Dania et al., 2007; Duran et al., 2006; Ojuola, 2017; Poon et al., 2004). From the planning stage, the reduction technique is reported as the most effective means of managing waste (Patel & Vyas, 2011). Though, materials waste generated during execution cannot be eliminated (Cheng & Ma, 2013). Hence, the reuse of such materials either for the same or different purposes would be employed (Dajadian & Koch, 2014). Similarly, reusable or recycle waste served as a substitute for a new product, it also reduces money incurred on new materials and helps the contractor to maximize profit (Akinkurolere et al., 2013). Waste management techniques are further explained below:

2.2.1 Reduce:

Al-Ansary et al. (2004) defined ‘reduce’ as a precautionary technique aimed at minimizing the waste generated from the source before it becomes a physical problem. According to several commentators (e.g. Cheng & Ma, 2013; Poon et al., 2004; Tam & Tam, 2006), reduction technique is seen as the most effective and efficient waste management because it is a means of eliminating the cost of waste transportation and disposal problems. The process of reduction includes effective communication, detailed design, proper planning, and specification (Cheng & Ma, 2013; Dajadian & Koch, 2014; Dania et al., 2007; Polat et al., 2017). Therefore, reduction serves as a convenient way of dealing with waste right from the design stage and predominantly profit-motivated.

2.2.2 Reuse:

The residual waste during transportation, off-cuts, and low quality of materials has led to waste generation on construction sites thereby limiting reduction techniques effectiveness on sites. Al-Ansary et al. (2004) defined ‘reuse’ as the re-employment of materials to serve the same or lower function depending on its application. However, the effectiveness of the reuse technique is solely based on the sorting of waste generated (Saez et al., 2013). This implies that, before waste can be useful for any consumption sorting is essential. Materials sorted are then stored either on-site or off-site.

Furthermore, salvage, repair, remanufacture, repurpose and refurbish of discarded product and reusable materials are methods of reuse on construction sites (Duran et al., 2006; Ge et al., 2017; Huang et al., 2018; Kirchherr et al., 2017; Polat et al., 2017; Saez et al., 2013). Also, reuse is more beneficial on construction sites because it does not require an additional cost on transportation, it promotes quality materials from manufacturers, most effective in materials handling, and has a unique way of waste stream diversion.

2.2.3 Recycle:

Al-Ansary et al. (2004) defined the ‘recycle’ technique as utilizing waste as raw materials in another application. According to Akinkurolere et al. (2013), very little construction waste materials are recycled worldwide. Hence, recyclable materials are in turn sold or returned to suppliers and used for other products. Recycle activities can be successfully utilized during the completion phase of a project because of the time incurred (Sapuay, 2016; Yates, 2013). Recycled materials are seen as a substitute in the secondary materials market after application of tests and approval has been carried out, although the possibilities to guarantee a certain quality of the product are impossible (Saez et al., 2013).

The benefits derived from the recycling of materials are extensive such as; cost-effectiveness of using recycled products, job creation, minimization of the resource consumption, utilization of waste, and conservation of precious land areas (Akinkurolere et al., 2013). Therefore, materials waste collection, separation, and processing have successfully kept materials out of the landfill into new products.

2.3 Construction Materials Waste Reuse Methods

Reuse of construction materials waste is the most durable option for waste management on construction sites and enhances the conversation of resources in any economy (Roper, 2006; Sapuay, 2016; Yates, 2013). Hence, reuse and recycling of waste on construction sites will lead to zero waste (Roper, 2006). The following are the reuse method employed on construction sites.

2.3.1 Salvage Method:

Salvage is the act of managing or rescuing something from a difficult situation by keeping and storing. The United State Environmental Protection Agency (US-EPA, 2007) stated that salvage materials are recovery gotten from demolition or construction waste and subsequently reuse or sold for another facility. Yates (2013) defined salvage as the act of saving things that have been or are likely to be damaged or lost. Materials preserved from external disasters and accidents are often salvaged. Kirchherr et al. (2017) buttressed it that, salvage method is a means of utilizing construction materials waste on sites, reserve the unused new materials, reduces materials that end up in the landfill, and creates a cleaner working environment for construction workers.

Therefore, the salvage method helps to stop waste materials from the waste stream by passing the goods stored to others. The process of salvage includes; cleaning of material, packing the material, storing the material in a secure area until installation/use, protect the material from damage during storage or transportation, and reusable material should comply with the requirement/specification (Huang et al., 2018).

2.3.2 Repair Method:

Repair of waste materials is another method that promotes reuse on construction sites. Repair means maintaining a defective product and use for its original function (Kirchherr et al., 2017). It is a method used for making an item, which may appear to have lived its useful life and fixing it so that it can still be productive (Kralj & Markič, 2008). According to Roper (2006), repair reduces expenditure for materials to be purchased and eliminate waiting time for delivery of materials. This implies that the repair of construction facilities will enhance the contractor's performance as waiting time for ordering, supply, and fixing of equipment will be eliminated. Similarly, repair helps to maximize the efficient use of resources while minimizing wastage due to an increased demand for infrastructure and housing in cities (Polat et al., 2017). US-EPA (2007) encouraged that equipment used for construction activities is of high value (expensive) and therefore should be repaired than being discarded. Hence, repair helps to avoid delays caused by reordering and repurchasing of materials.

2.3.3 Remanufacture Method:

This reuse technique means to find a secondary use of the waste product (Ge et al., 2017). This method includes redirecting reusable or recyclable materials back to the manufacturing process. Kirchherr et al. (2017) defined remanufacture as the means of using parts of discarded materials (waste materials) to produce a new product with the same function. Roper (2006) buttressed that, remanufacture helps to meet present needs without compromising the quality of life for the future generation. This is a result of a reduction in the volume of natural resources that will be used. Also, the method maintains economic growth while producing an absolute minimum amount of pollution, producing less waste, and extending opportunities to live in a pleasant and healthy environment. However, Al-Hajj and Hamani (2011) observed that materials waste remanufacturing/recycling is rarely practiced and that reuse should be implemented more efficiently on construction sites.

Similarly, remanufacture increase efficiency in product use by consuming fewer resources/materials e.g. scrap from steel saved 1.4tons of iron ore for the production of one new steel (Yates, 2013). Therefore, remanufacture promote sustainable development putting into consideration the environmental impact, energy use, and resource quality.

2.3.4 Refurbish Method:

Refurbish method is most common for composite items such as furniture, doors, and windows. According to Kirchherr et al. (2017), refurbishment is an act of restoring an old product into an up to date one. Painting with non-toxic finish material and treated chemicals that will prevent the formation of harmful mould and mildew are preferable materials used for refurbishment (US-EPA, 2007). Besides, Yates (2013) observed that construction materials that are reused could be with minor refurbishment or without having undergone any type of reprocessing to change the intended use. The method involves the reuse of existing building structures, equipment, and furniture to serve the same purpose or functions. Roper (2006) suggested that it is better to refurbish if the material/item or product is of high quality than to purchase new ones of lesser quality.

2.3.5 Repurpose Method:

Kirchherr et al. (2017) defined the repurpose method as the means of using discarded product or material or its parts to make a new product/material with a different function. According to Duran et al. (2006), off-cuts gotten from wood or steel are used for the bracing area with shorter length; cut corner steel bars are used for shelves. According to Al-Hajj and Hamani (2011), granite or stones poured and remaining on the ground are used for the base to receive landscape; removed covering sheet is used on the construction of temporary office shelves, demarcation of a construction site for security purpose. Therefore, the repurpose method is seen as the most efficient materials waste

reuse method on construction sites because no additional cost and energy is required. The summary of materials waste reuse methods from literature is as shown in Table 1.

Table 1 Material waste reuse methods from the literature review

Materials	Methods of Reuse on Construction Sites					Authors
	Salvage	Refurbish	Repair	Repurpose	Remanufacture	
Concrete			√	√		Al-Hajj and Hamani (2011); Hossain et al. (2017); Ojuola (2017); Roper (2006); Yates (2013)
Timber	√			√	√	Al-Hajj and Hamani (2011); Duran et al. (2006); Hossain et al. (2017); Ojuola (2017); Roper (2006); Yates (2013)
Block			√	√		Al-Hajj and Hamani (2011); Duran et al. (2006); Hossain et al. (2017); Ojuola (2017); Roper (2006); Yates (2013)
Reinforcement	√	√		√	√	Duran et al. (2006); Hossain et al. (2017); Ojuola (2017); Roper (2006); Yates (2013)
Tiles (Wall and Floor)	√			√	√	Al-Hajj and Hamani (2011); Roper (2006); Yates (2013)
Mortal		√		√		Al-Hajj and Hamani (2011); Duran et al. (2006); Hossain et al. (2017); Ojuola (2017); Roper (2006); Yates (2013)
Marine Board	√	√	√	√		Ge et al. (2017); Hossain et al. (2017); Yate (2013);
Paint	√			√		Ge et al. (2017); Yates (2013)
Plastic	√			√		Al-Hajj and Hamani (2011); Ge et al. (2017); Hossain et al. (2017); Yates (2013)
Doors and windows	√	√	√	√	√	Al-Hajj and Hamani (2011); Roper (2006); Yates (2013)
Fittings	√		√			Ge et al. (2017); Yates (2013)
Roof Covering	√		√	√	√	Al-Hajj and Hamani (2011); Duran et al. (2006); Ge et al. (2017); Hossain et al., (2017); Ojuola (2017); Roper (2006); Yates (2013)
Metal/Steel	√	√		√	√	Al-Hajj and Hamani (2011); Duran et al. (2006); Hossain et al. (2017); Ojuola (2017); Roper (2006); Yates (2013)
Glass	√			√	√	Hossain et al. (2017); Roper (2006)

■3.0 METHODOLOGY

A pilot survey was conducted in this research. Registered building construction firms headquartered in Ibadan metropolis were accessed based on the list of top construction companies obtained from the office of the Bureau of Public Procurement in Oyo State, Nigeria. This is because the city is recognized as a major city, with a high population of professionals within the built environment; characterized by several ongoing construction projects. During the pilot or reconnaissance survey, "Five" out of "Twenty Four" registered construction firms affirmed to share their experience. The feedback from the pilot survey helps to identify "Seven" construction sites in the early stage and mid-stage of construction where materials waste reuse was practiced. The census method was adopted for the sampling technique because the 22 buildings on the 7 sites were within a manageable population.

A qualitative research approach was adopted for the study. The interview was conducted personally through face and voice dialogue to discover the opinion of the respondents. This provided the opportunity of asking the respondents about management practices that could reduce waste generation on construction sites. According to Ajayi and Adedire (2013), the essence of the interview is that the interviewer guides the conversation and takes the process through stages to ensure the success of the interview. The interview is the best in this type of research because it creates natural involvement, shows understanding, gets facts, and basic descriptions and close interview with appreciation. The respondents had a least 10 years of experience in the construction industry. Content Analysis and Frequency were used to analyse the collated data for this study.

3.1 Content Analysis:

According to Pashakhanlou (2017), content analysis is a research method for studying documents and communication artifacts, which might be a text of various formats, pictures, audio, or video. Content analysis involves systematic reading or observation of texts or artifact that has assigned a label (code) to indicate the prance of interesting, meaningful pieces of content. The study adopted Bhattacherjee's (2012) interpretive data analysis protocol for phenomenological research, this consists of five sequential steps, following the transcription of the interviews as listed below:

i) Read interview transcripts to get a sense of the whole.
ii) Identify units of significance to establish parts.
iii) Assign values to units of significance by reliving a participant's subjective experience.
iv) Develop themes to tie together units of significance into layered meaning.
v) Identify and reconcile deep structure.

Content analysis was used to establish various ways of reusing construction material waste on each site relating it to the identified methods reviewed in literature and the frequency distribution was used to classify the frequency of selected methods for materials susceptible to sites. The researcher also observed of the reuse and repurpose method during the site visit. According to Angrosino (2012), observation is conducted in the settings in which people are found in found of their own accord. The researcher goes to the place where people work, play, worship, or conduct the myriad other tasks of daily life. The observation was used as confirmation of the interview conducted. Angrosino (2012) opined that data from observation are often presented in the form of tables, charts, and graphs for easy understanding.

■4.0 RESULTS

Specific reuse methods can vary from one site to another, depending on the type of material waste and required specification. From the seven sites visited, "four" sites were at the mid-stage while "three" sites were at the early stage. The construction of the hospital, lecture theater, convent center (hall, offices, and chalet), an office complex with a basement, and associated external works. During the data compilation, several site visitations and discussions were made with the supervising architect, quantity surveyor/project managers, and site engineers in other to identify materials that are prone to waste and examine possible ways of reuse either for the same or different function on construction sites. Though the understanding that the identified methods in the literature are aimed at reducing material waste on sites, some of the site managers suggest management measures that encourage the reuse of construction material waste on sites.

These measures include the provision of the central cutting area, purchase of quality, reliable and durable materials with the guaranteed life cycle, effective waste collection and sorting, proper documentation of unused materials from excess purchase, large storage area and recognition of the market for reusable building materials will contribute to more sustainable structure in the future. However, surplus material and change in design during construction are said to promote waste on sites hence, site managers had to engage in taking-back schemes for expensive materials and ascertained firm design decision was considered for waste minimization. The site engineers added that tangible and intangible benefits are attained in waste management, during the visit to worksites it was observed that valuable material wastes were moved to store without considering the transportation cost while waste that is no longer reusable becomes scrap and sold to local manufacturers as a by-product and the returns were used for workers' welfare.

4.1 Methods of Construction Materials Waste Reuse on Construction sites

The collection and sorting of construction materials waste on worksites give opportunities for reuse, which encourage the conservation of resources from the environment and contribute to sustainable construction activities. For instance, waste management in building works involves the reuse of concrete, reinforcement, timbers, metal and some others were observed. The conversion of concrete into aggregates for new work on worksites, remnants, and residual during mixing are often gathered and remix with adhesive. The importance of safety cannot be overemphasized on construction site as littered granite during supply helped the workers to move freely on sites because of the sleepy nature of the soil, already used timbers placed on the floor for movement and broken concrete served as rubbles to fill and level environment for external works. Doors remove from one construction site was braced, repaint and install for the storage house and temporary site office. These doors were brought from the company store alongside the furniture whereas provision had been made for temporary structure in the preliminary bills of quantities hence, the contractor making an additional profit which in turn helps to improve the company's profit on the project.

The reuse of construction material waste requires little energy, less resource, and less labour. Reuse has more advantages over other waste management techniques on worksite because it limits the use of new resources and environmentally friendly. The broken block was

used to fill up openings when plastering for a smooth surface, cement bags were laid on the floor to receive fall off mortal and remixed for proper usage. Kept unmixed paint was used as the first coat where the colour and product specified are the same. To reduce the burden on the budget, reuse does not only attain the low-cost of materials, it also reduces the amount spent on transportation. Reinforcement off-cuts are used in areas where its length is applicable, it was also used for setting out structure instead of purchasing peg and profile board. Reuse is a means to prevent waste disposal and increase citizen wellbeing of citizens, aluminum and metal waste were seen to bring returns as remnants and off-cuts are sold to the local manufacturer. Already used aluminum roof covering stored were brought and fix to serve as a demarcation for privacy and security purpose on sites. Residual waste and off-cuts from tiles were used for making terrazzo floor finish in the toilet, broken tiles due to inappropriate package and poor access road was used in areas where the shapes are irregular. The off-cuts from timbers were used for bracing, planks were severally reused for formwork.

Furthermore, the project manager stated that reuse generally is not the function cost but the durability of the product. It was less expensive to buy used marine boards than new and to serve the purpose because of the material strength. Besides, plastic paint buckets were used for measuring and placing aggregate on sites, conduit pipe, and fittings remaining from an excess purchase on one site were brought and used to complete electrical installation on another site. Partitioning glass was removed and used to construct an aluminum glass door for the toilet due to the change in design.

Finally, respondents added that adequate supervision and site management are steps taken to achieve effective reuse waste management during construction, stating that it is a difficult process because most of the construction workers are not educated. Besides, Table 2 shows construction materials that are susceptible to waste with their methods of reuse on construction sites from the in-depth interview while Table 3 shows the summary of the reuse method carried out on construction sites for sustainable development.

Table 2 Materials waste reuse on construction sites

Materials Waste	Method of Reuse	Construction Sites							Sub-Total	Total	Rank
		1	2	3	4	5	6	7			
Concrete	Repurpose	√				√	√	√	4		
	Remanufacture	√				√	√	√	4	8	5
Timber	Refurbish				√		√		2		
	Repurpose	√	√	√	√	√	√	√	7		
	Remanufacture	√	√	√	√	√			5	14	2
Blocks	Salvage							√	1		
	Refurbish						√	√	2		
	Repurpose	√	√	√	√	√	√	√	7		
	Remanufacture					√	√		2	12	3
Reinforcement/steel	Salvage	√	√	√	√	√	√	√	7		
	Refurbish	√				√	√		3		
	Repurpose	√					√		2		
	Remanufacture	√	√	√	√	√	√		6	18	1
Tiles (Wall and Floor)	Salvage	√	√			√	√		4		
	Repair	√	√			√	√		4		
	Repurpose	√	√			√	√		4	12	3
Mortal	Refurbish		√						1		
	Remanufacture		√						1	2	11
Marine Board	Salvage	√		√					2		
	Remanufacture	√		√					2	4	10
Paint	Salvage	√							1		
	Remanufacture	√							1	2	12
Plastic	Salvage	√				√			2		
	Repurpose	√				√			2		
	Remanufacture	√				√			2	6	7
Doors	Salvage	√							1		
	Refurbish	√					√		2		
	Repair	√					√		2		
	Remanufacture	√					√		2	7	6
Aluminum/Glass	Refurbish						√		1		

	Repurpose				√	1	2	12
Wood (MDF; Plywood)	Salvage		√			1		
	Remanufacture		√			1	2	12
Fittings	Salvage	√		√		2		
	Repurpose	√		√		2		
	Remanufacture	√		√		2	6	7
Ceiling Board	Repurpose				√	1	1	16
Metal	Salvage			√		1		
	Refurbish				√	1		
	Repair				√	1		
	Repurpose				√	1		
	Remanufacture			√	√	2	6	7

Table 3 Summary of reuse methods carried-out on construction sites

Materials	**Methods of reuse on construction sites**				
	Salvage	**Refurbish**	**Repair**	**Repurpose**	**Remanufacture**
Concrete				4	4
Timber		2		7	5
Blocks	1	2		7	2
Reinforcement	6	3		2	6
Tile (Wall and Floor)	4		4	4	
Mortal		1			1
Marine Board	2				2
Plastic	2			2	2
Paint	1				1
Doors	1	2	2		2
Aluminum/Glass		1		1	
Wood (MDF, Plywood)	1				1
Fittings	2			2	2
Roof Covering	2			2	
Asbestos (Sheet)				1	
Metal	1	1	1	1	2
Total	**24**	**12**	**7**	**33**	**30**

It was established that the different reuse methods can be employed to achieve zero waste for each material. Findings show that cutting wastes are the major site-based waste on worksite hence, making the materials useful for different functions (Repurpose) and serving the same function with little or no energy added to it (Remanufacture) were mostly practice. As observed, the quality of reusable materials was put into consideration before usage to achieve sustainable structures. However, the reuse of construction materials waste might be difficult to achieve on sites if there are no storage facilities and enough working space for sorting and storing reusable materials. Respondents pointed out that the extent of storage and reuse on worksites is determined by the durability of materials. The salvage method helps the contractor to keep materials from been stolen, rotten under weather conditions, and kept for usage without reducing the value. In addition, proper documentation and inventory of reusable materials promote waste segregation hence, aid reuse on construction sites. From Table 3, repurpose, remanufacture and salvage methods were mostly employed on sites which decreased the huge amount of waste generation on construction sites. However, refurbish and repair methods were less practice on worksites, the reason being that the methods require little or no reprocessing activities, which can reduce the material life-cycle and may cause delays in project delivery when not properly handled.

5.0 DISCUSSION

The study identified 16 materials that are prone to waste and the result of the assessment shows that the 5 topmost among these materials were reinforcement/steel, timber, concrete, and blocks/tiles. The result also indicates that the material that experienced the least waste is the ceiling board. This is in line with Poon et al. (2004) and Al-Hajj and Hamani (2011), timber, reinforcement, bricks, blocks, metal, and tiles are subjected to frequent cutting. According to the analysis carried out, repurpose, remanufacture and salvage method of materials waste

reuse were frequently adopted on sites and it aligns with many prior works (e.g. Duran et al., 2006; Huang et al., 2018; Kirchherr et al., 2017; Sapuay, 2016; Yates, 2013) that reusable materials stored would serve its original function or different function depending on its application. Also, Roper (2006) established that leftover and off-cuts on construction sites are used for the same purpose or otherwise.

The study similarly indicates that the reuse of construction materials waste on-site helps to reduce resource consumption thereby, increase the company's profit and help to protect the environment from a toxic element. Also, selling off unused materials instead of exposing it to damages gives a comfortable working environment; while stipends gotten from sold scrap are used for upkeep on-site thus, increase productivity. This aligns with Kralj and Markič (2008) that the use of waste management techniques that rely on the reuse of materials have proven to have economic and environmental benefits in the construction industry. It was established that repair and refurbish methods are not frequently employed on construction sites based on the fact that they require minor or major reprocessing.

However, repair and refurbish help to reduce the time spent on placing an order for equipment and reduce additional expenses on a project and it aligns with previous studies (Al-Hajj & Hamani, 2011; Kirchherr et al., 2017; Kralj & Markic, 2008; Roper, 2006) that upgrading of materials waste reduce purchase expenditure and eliminate waiting time. The importance of adequate supervision cannot be overemphasized based on the fact that most construction workers are not educated hence, site engineers added that reusable materials should be prevented from damages, theft, and weather conditions. Hence, salvaged materials must be properly handled, this understanding was in line with Polat et al. (2017) stated that handling and documentation of materials stored for reuse promote waste management practices on construction sites.

■6.0 CONCLUSION

In the construction industry, several activities take place at the same time within a confined environment hence, these activities will always produce waste. The study indicates that reinforcement/steel, timber, blocks/tiles, and concrete were the major materials that are inclined to waste. Construction materials waste generation on-site has a significant impact on the country's economy. It implies that the five materials assessed as main materials that are prone to mischief should be scrutinized before disposal to determine any reuse and recyclable to ensure zero waste and sustainable development on construction sites. The study also affirms that repurpose, remanufacture, and salvage methods of reuse were common practices use to curtail waste on construction sites; hence, it helps the contractors to save cost and time taken to acquire new material.

Finally, the study recommends that the government should encourage and sponsor research by academia and professional bodies that are involved in the construction activities on how to ensure zero waste to guarantee sustainable development. The essence of this study is to secure the adequate and proper management of materials on construction sites to minimize waste and improve productivity through a reduction in labor and equipment idle time thereby reducing the overall construction cost. This research has been able to contribute to knowledge by showing empirical evidence as regards reuse methods on construction sites. The implication is that this paper will serve as a source of information for future study and contractors will also use the data as a guide for the implementation of future projects. The study covers the Ibadan metropolis; further study should be carried out in the six geo-political zones of Nigeria to be to generalize the outcome of the study.

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