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AUTOMATION IN CONSTRUCTION MATERIALS HANDLING: THE CASE STUDY IN NORTH CENTRAL NIGERIA

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Automation in construction material handling system is a method of utilising material handling equipment. It could be the basis of cost reduction or wasteful expenses if not efficiently planned. However, there is limited understanding of construction material handling process utilised by the manufacturing industry in Nigeria. Thus, the aim of this study is to evaluate the efficiency of automation in material handling by the manufacturing industry in North Central Nigeria. A quantitative method and case study research approach was adopted, six construction material manufactured and distributed within the North-central region of Nigeria were selected for this study. A purposive sampling method was used for the selection of the ten construction material manufacturing companies used in the research. The study employed non -participant structured observation and measurement template for the data collection. The material handling processes observed includes, order picking method, material handling equipment, storage equipment, loading and offloading equipment. The descriptive method of data analysis was employed using percentage and results presented in a form of bar charts and interpreted directly. The study concluded low utilisation of automation in the combined processes of order picking, handling, storage, loading and offloading. But used more manual labour that involved multiple handling. This low adoption of automation in material handling by the manufacturing industry leads to inefficiency. This in turn have a negative influence such as poor management, low throughput, prone to error, long lead time and high labour cost. These have the implication of increasing construction cost and cause project delay. This study was conducted using observations which is one of the limitations of this study.

Keywords: automation, construction materials, efficiency, material handling, warehouse

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INTRODUCTION

Construction material is a basic constituent in construction projects and can make an important contribution to the cost effectiveness of projects (Abhilin and Vishak, 2017). Research has revealed that the cost of construction material is usually about 50%-60% of the total cost of a project (Duiyong, Shidong and Mingshan, 2014). Apart from the direct cost, the costing of material also includes handling cost. It is often said that material handling only adds to the cost of a product, it does not add to the value of a product (Kay, 2012). Poor manual handling practices may be evident in warehouses where high levels of productivity are expected of pickers(Webster, Dalby, Fox, and Pinder, 2014). The on-site materials tracking and locating are made difficult due to manual tracking process which is labour intensive, mistake inclined, resulting in the delay in timely execution and increase in cost of construction project (Kasim, Liwan, Shamsuddin, Zainal and Kamaruddin, 2012).

Automated material handling could be a basis of cost savings or excessive cost if it is not efficiently planned (Bouh and Riopel, 2015). Jang and Skibniewski (2009) opined that the advancement in technology and innovation in the construction industry should make it, in fact, reasonable to execute an automated monitoring and tracing system for material. Even though the construction industry in Nigeria has advanced to the point of executing big and complex projects, they still largely operate manually(Jang and Skibniewski, 2009). Time and effort cannot be wasted through the labour-intensive processes of reporting and documentation, and communication from site through the present manual handling systems, especially as the construction projects increase in size and scope (Equere and Tang, 2010). It becomes imperative, therefore, that material handling and tracking be automated to efficiently manage further anticipated growth.

However, industries that manufacture construction materials are external to the organisation of the project and are thus observed to be of lesser significance in the project approach. Consequently, the material handling function of manufacturing industries, even though critical, has been largely ignored. Hence, there is limited knowledge and understanding of the automation in construction material handling in Nigeria. The research question was, how efficient is the construction material handling utilised in the selected manufacturing industries situated in North Central Nigeria? The aim of this study was to evaluate the efficiency of automation in material handling by the manufacturing industry in North Central Nigeria.

LITERATURE REVIEW

Automation Principle of Material Handling

Automation principle of material handling is that the operations should be "mechanised and/or automated where feasible to improve operational efficiency, increase responsiveness, improve consistency and predictability, reduce operating costs, and to eliminate repetitive or potentially unsafe manual labor"(Material Handling Institute (MHI), 2000). At the point when a warehouse or distribution centre is automated, it activates the systems upon dispatch at the same time as bring up-to-date the records automatically, consequently orders are placed on time (Kim, 2006). So, there is a necessity for efficient materials handling with the purpose of control, productivity and cost in construction projects (Patel, Pitroda and Bhavsar , 2015). However, there are monetary trade-offs between high capital costs of mechanised systems, and increased labour costs in manual systems and types of manual handling that occur in such places (Webster etal., 2014). The next section focused on the sub-themes, automation and manual order picking, material handling equipment and storage equipment

Automation and Manual order picking

The factors that impact the measure of manual handling inside warehouses and distribution centres are multifaceted and inter-locking. The main element is the strategy of the order picking system, especially how much automation is utilised and whether pickers move between pick spaces or whether items are automatically delivered to them (Webster et al., 2014). Order picking typically account for 50-75% of the total operational expenses for a warehouse (De Koster, Le-Duc, and Roodbergen, 2007). Any inefficiency in order picking can lead to unsatisfactory service and high operational expenses for the warehouse, and the entire supply chain (De Koster, Le-Duc and Roodbergen, 2007).

Manual order picking methods are slower as the picker must handle and read the paper, while if picking orders are given by a pick by voice method, this operation is removed. Systems, for example, pick to light, that show automatically where the picker can expect to locate the next item to pick, are likewise faster since they remove the operation of searching for the correct pick slot (Webster et al., 2014). Where order pickers need to move from the storage area, the movement time is an increasing dimension of the travel distance (De Koster, Le-Duc and Roodbergen, 2007). In addition; the conventional manual method utilised occasionally gives unreliable information with respect to the materials. Problems concerning the monitoring and locating of materials on-site have become an incredible concern in construction industry as materials always come in bulk without proper identification (Kasim et al., 2012).

On the other hand, bar coding alludes to the fixing of computer decipherable codes on items, cartons, containers and trucks. These bar codes increase efficiency in three ways: speed, accuracy and reliability (Sople, 2010). In addition, automated methods are beneficial, as the processes of both order pickers and operatives moving new stock to storage locations are documented by the Warehouse Management System (WMS). Most importantly, Aberdeen Group (2009) observed that 70 % of best-in-class organisations are more probable than other organisations to accept products without utilising paper documents. All have moved to the utilisation of barcodes, RFID or voice technology. In a similar study by Gwynne (2014) it was shown that various producers have presented a joined voice and automated guided vehicle (AGV) or laser guided forklift truck system. By implementing both systems simultaneously, productivity improved by up to 70%. A related investigation by Tambovcevs (2012) establishes that Enterprise Resource Planning (ERP) system merchants need to work with manufacturing and construction industry professionals to improve more customised results for manufacturing and construction companies. In addition, the recommended that the application of ERP can give considerable benefits (Tambovcevs, 2012).

Material-Handling Equipment (MHE)

Many researchers have discussed warehouse automation from different perspectives. These include warehouse technology, workshop equipment, warehouse systems and factory equipment (Kay, 2012). For the maximum benefits of specialisation to be achieved, handling equipment at the nodes ought to offer fast loading and offloading of material to make best use of the quantity of full vehicle load kilometre per unit of time (Pienaar ,2016). Furthermore, economies of density require the optimal use of big, strong equipment over as long period as possible. These include automatic loaders, high level cranes, forklifts, manual, loader shovels, excavators, overhead gantries and utilisation of saddle carriers (Hannan , 2011). These vehicle equipment permits additional grades of movement for handling unit loads. It should be noted that efficiency of offloading processes could be enhanced by 61% with information system automated (Andrejić and Milorad , 2016).

An investigation by Baker and Perotti (2008) into the kind of equipment used in UK warehouses established a substantial adoption of the picker-to-goods system, with the use of pallet trucks, lift trucks and shelving and racking as storage options. In addition, organisations used a combination of equipment to handle different types of materials and order profiles. The significance of appropriate utilisation of MHE cannot be overemphasised. As indicated by Rajes and Subbaiah (2015), the utilisation of MHE helps in reducing the labour of workers by reducing forces in lifting, handling, pushing and pulling material. Furthermore, it increases efficiency, control costs, and optimise productivity (Bouh and Riopel, 2015). In addition, there is reduction in damage to material through human error and negligence, and a reduction in fatigue and injury when the environment is insecure or inaccessible (Kay, 2012). But the more times material is handled, the more the overall logistics costs add up as the process still comprises both equipment and human effort (Michael, 2015). Despite the benefit of picking equipment, Peerless Research Group (2012) study revealed that 70 % of the respondents in the United States planned to spend less than 250,000 dollars on warehouse equipment in 2013 with only 11% contemplating the purchase or evaluation of automated systems.

Storage Equipment

Storage equipment is utilised for stockpiling or keeping materials over a period. Some storage equipment may include those used for transporting material such as Automated Storage and Retrieval Systems (AS/RS) or storage carousels. Roodbergen and Vis (2009) recognised that insignificant consideration has been given to the relationship between AS/RS and other material handling systems in production or distribution centres. When no storage equipment is required, then material is block stacked directly on the floor. Storage racks are utilised to give support to a load as well as to make the load accessible (Kay, 2012). But interestingly, even in modern warehouses, the most popular forms of storage noted for the group of companies surveyed was floor storage and standard aisle racking (Baker and Perotti, 2008). The advantages associated with block stacking, include access, damage, stock rotation and space utilisation (Gwynne, 2014). The warehouse height of 15m creates double volume to allow for optimal aisle width for fork lift truck and cube method space utilisation (Gwynne, 2014).

RESEARCH METHODOLOGY

This study is an objective problem in need of observation and measurement; hence a quantitative research method was adopted. A case study research approach was employed, where six construction material (cement, reinforcement bar, ceramic tiles, gravels, hollow sandcrete block and sand) manufactured and distributed within five states capital and Abuja in the North-Central Nigeria were selected for this study. The study used purposive sampling method because the study obtained information from specific group of manufacturing industries. Multistage sampling was used, which comprised of 10 manufacturer's warehouses/plants, 42 distribution centre/ warehouses and retailer stores and 30 construction sites. This is supported by Yin (2009) that a flawless case study should use a research plan including multi-sites to be examined, and different strategies to examine the data collected.

The node versus links method is by far the most suitable way to observe the logistics system in a construction context (Shakantu and Emuze, 2012). Thus, the unit of analysis was the current material handling operations at the manufacturers' warehouse (node) and their transport delivery (link) to the distribution centres/ warehouses, retailers store and sites provided the starting point to understanding the context of the problem. The data was collected using primary records through non-participant observations and measurement of material handling operations in a form of template. This is in consonant with the recommendation by Kamali, (2018) that a different method like the observation could help more to understand how the on time delivery performance is implemented by firms. A modified pallet equipment used in the study by Baker and Perotti (2008) was adopted for material handling equipment and storage equipment.

To conduct a valid field study, the variables used in the research instrument includes; order picking methods, material handling equipment, storage equipment/methods, type of vehicle, actual volume/capacity of vehicle, quantity of material driven per vehicle, vehicle loading and offloading time, loading equipment, the number of staff used for material loading/ offloading, the cost of loading/offloading each vehicle, cost of transport per each delivery and location of delivery. These were for72 orders processed and delivered by transport providers to the various locations within the study area. The descriptive method of data analysis was employed using percentage and results presented in a form of bar charts and interpreted directly.This kind of descriptive study can be informative when there is little knowledge and understanding of a phenomenon (Loeb, Dynarski, McFarland, Morris, Reardon, and Reber, 2017).

ANALYSIS AND RESULTS

The analysis was done using percentage. A percentage is calculated by dividing the number of times a value for a variable observed, by the total number of observations in the population, then multiplying this number by 100. The result is then presented in a form of bar chart which represents the proportional value of the variable. The result of analysis of automation in construction material handling utilised by the material manufacturing companies is presented in this under the sub heading of orders piking method, material handling equipment, storage equipment and method loading and offloading material.

Order Picking Method used in Manufacturers Warehouses
The study sought to find out the method of order picking utilised the in the manufacturer's warehouses. Figure 1 presents the current automation utilised for order picking processes in the manufacturer warehouses. This established that 88% of the companies used the paper picking method, while 12% use an automated method. The paper-based order picking methods are slower as the picker must handle and read the paper, while if automated methods of pick by voice or barcodes would have been faster. The major finding was that most of the companies used the paper picking method, which suggests low adoption of automation.

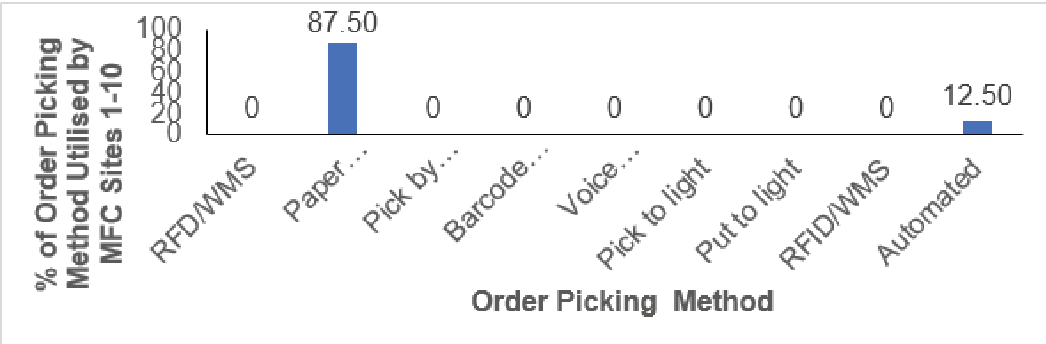

Figure 1. Order Picking Methods adopted in the Manufacturer's Warehouses

Material Handling Equipment used in Manufacturer's Warehouses
In addition, the study evaluates the type of material handling equipment utilised in the manufacturer warehouses as indicated in Figure 2. It established that 13% of the companies used a pay loader, while 6% of the companies used mini automated loaders, high level order picking cranes and forklift trucks. In addition, 69% of the companies did not use any of the order picking equipment. This indicates less automation in material handling to reduce human effort, elimination of offloading charges and improving the counting time at the warehouse. The major finding was that most of the companies did not use any of the material handling equipment.

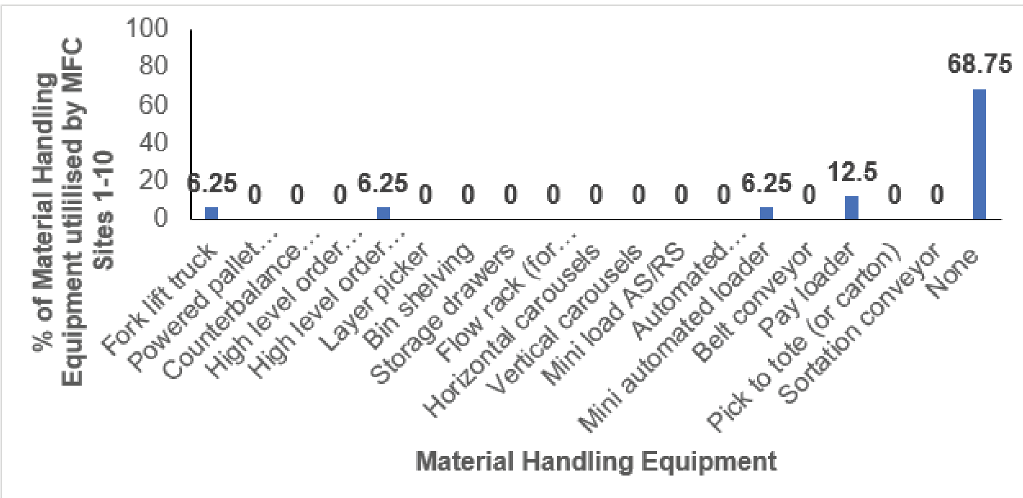

Figure 2 Materials Handling Equipment used in Manufacturer's Warehouses

Storage Equipment used in Manufacturer's Warehouses

Another, impetus for the study was an evaluation of the automation of warehouse, such as types of storage equipment and efficient utilisation of storage space. Pallet storage equipment used in UK warehouse by Baker and Perotti (2008) was adopted for storage equipment. Figure 3 established 88%, 6% and 6% of the companies used floor/ block, double deep and pallet floor racking storage equipment respectively. The major finding was majority of the companies used floor/block storage method which suggest low take up of pallet storage equipment in the warehouses. With the low adoption of storage equipment and racks give less support to loads as well as make the load accessibility and handling problematic.

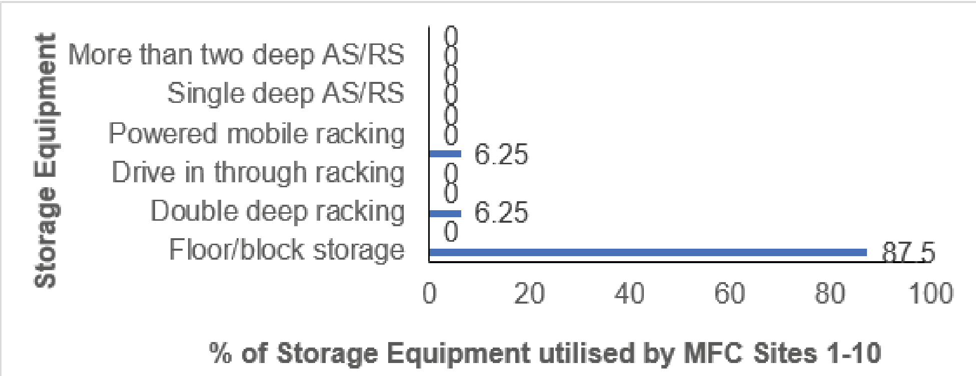

Figure 3 Storage Equipment used in Manufacturer's Warehouse

Method of Loading and Offloading Vehicle

The study sought to understand the type and level of automation adopted to increase efficiency in loading and offloading vehicle. Therefore, data on the method of loading vehicle at the manufacturers warehouses and offloading of vehicles at the Distribution Centres /Warehouses (DC/WH), retailers stores, and construction sites were analysed and presented in figure 4.

The analysis results indicated that 40% of the companies used manual methods of loading at the manufacturer's warehouses and sites. The other companies used pay loaders (16.67%), forklift trucks (14.29%), high level cranes (14.29%) and automatic loaders (14.29%) to load material. The major finding was that more than half (60%) of the company warehouses were automated. This signify operational efficiency, in terms of increase in speed, accuracy and productivity while reducing repetitive or potentially unsafe manual labour.

In addition, the findings established that 75% of DC/WHs, retailer stores and sites used manual methods of offloading material. But, 25% used the tipping method, which was basically for sand and parts of granite. It was also observed that trailers were used to transport granite. Since they cannot tip off, the material was manually offloaded. This signify high operating time, cost, multiple handling and low productivity.

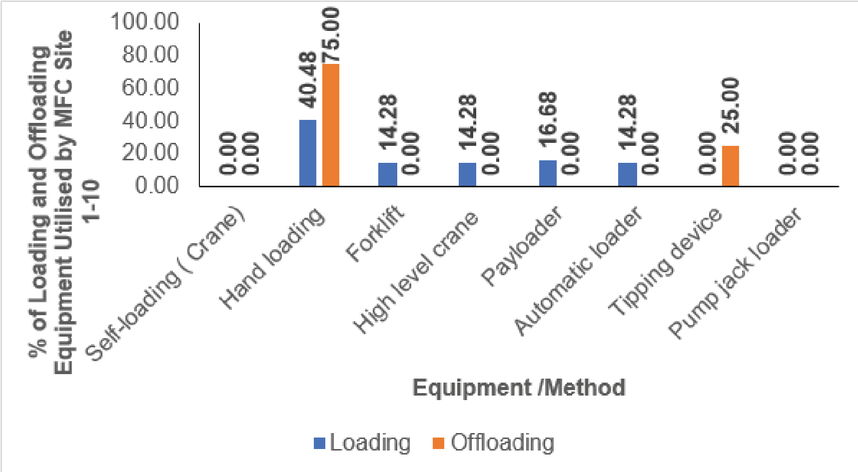

Figure 4 Method of loading and Offloading of Vehicle

Loading and Offloading Time

The economies of density are enhanced by using high capacity technology to handle large bulk loads and minimising loading and offloading time and cost. Therefore, the time of loading and offloading individual materials at the terminals was evaluated.

The analysis of the average time taken to load and offload material per ton is presented in Figure 5. It was established that, for cement, the loading time was 0.02 hours/ton and offloading time was 0.11hours/ton. Records confirmed the average loading and offloading time for reinforcement bars (0.04 and 0.18 hours/ton), ceramic tiles (0.07 and 0.17hours/ton) and granite (0.01 and 0.07hours/ton). It is interesting to note that granite offloading time is higher than its loading time. This is because trailer trucks were also used in the delivery of granite. Since they do not tip off, the material had to be manually offloaded, which led to increased offloading time and cost. The implication is that time and costs are non-value-added costs, this cannot be recovered when one does an invoice for the offloading of material.

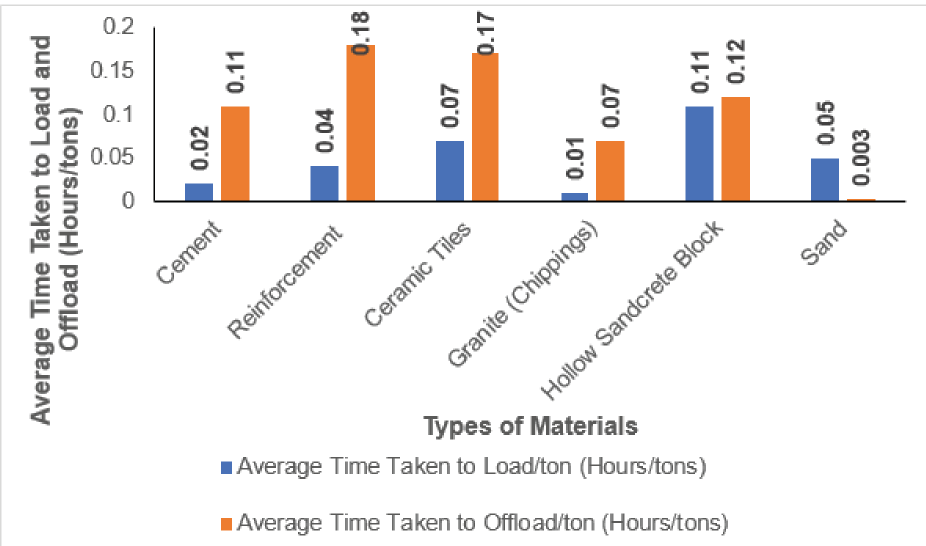

Figure 5 Average Time Taken to Load and Offload Materials Per Ton

Cost of Loading and Offloading material

The relationship of average cost to load and offload individual material per ton is shown in Figure 6. The results confirmed that the average cost of loading per ton at the manufacturer's warehouses were as follows: cement (₦56.62/ton), reinforcement bars (₦425.63/ton), ceramic tiles (₦507.99/ton), granite (₦78.16/ton), blocks (₦179.73/ton) and sand (₦151.66/ton).

In addition, the chart reveals that the average cost of offloading at the distribution centres, warehouses, retailers stores and construction sites were as follows: for cement (₦274.70/ton), reinforcement bars (₦861.24/ton), tiles (₦537.31/ton), granite (₦150.07/ton), blocks (₦179.37/ton) and sand (₦25.53/ton). The average cost of offloading reinforcement bars per ton was the highest, probably because this involves offloading, bending and stacking them. However, it should be noted that ceramic tile companies used both forklift trucks and manual labour when loading at the manufacturer warehouses.

The major finding was that the average cost of offloading materials/ton was higher than the average cost of loading, except for blocks and sand. This may be explained by the fact that blocks are both loaded and offloaded manually. The cost of loading sand is higher because most companies did this manually, but they offloaded mechanically by tipping off.

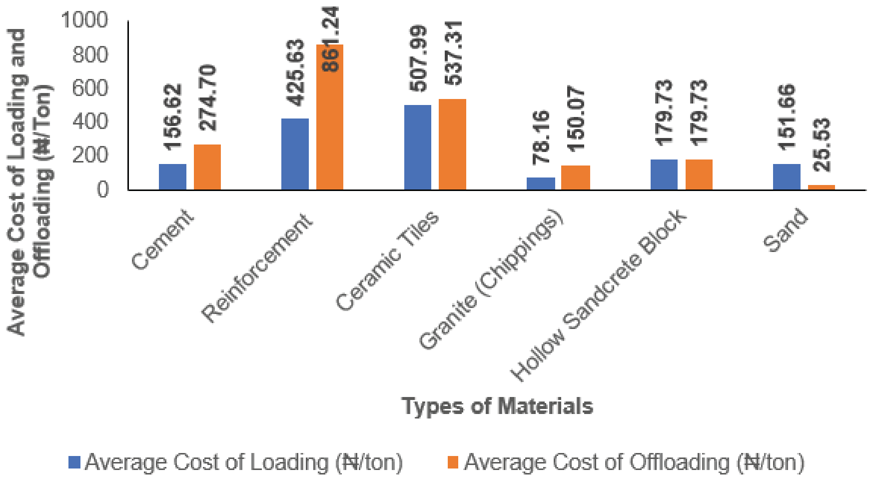

Figure 6 Average Loading and Offloading Cost Per Ton

DISCUSSION OF RESULTS

Order Picking Method Use in Warehouses

The study established that most of the companies used the paper-based picking method. This confirmed submission by Webster et al., (2014) that manual order picking methods are slower as the picker must handle and read the paper. This could lead to error if the writing is illegible or if there is confusion over the way it is written. This all adds time to the operation (Gwynne, 2014). This slow manual operations lead to low throughput, long lead time and high labour costs in the warehouse operations. In addition; it creates problems of monitoring and locating of materials on construction site because materials always come in bulk without proper identification (Kasim et al., 2012). Which is contrary to the use of bar codes that will lead to a reduction in human mistakes, and an increase in the speed, accuracy and dependability (Sople, 2010). While De Koster, Le-Duc and Roodbergen (2007) noted that inefficiency in order picking can lead to unsatisfactory service and high operational expenses for the warehouse and the entire supply chain. Therefore, the inference is that the order picking processes adopted by companies are sub-optimal and inefficient.

Material Handling Equipment Used in Warehouses

The study results revealed that a few companies did use material handling equipment such as pay loaders, mini automated loaders, high level order picking cranes and forklift trucks. Most of the manufacturing companies did not use any handling equipment in their warehouses. The implication is that multiple handling of material causes low productivity in the warehouse. The findings contradict the Baker and Perotti (2008) results on a survey of the type of equipment used in UK warehouses. They found that most companies use a combination of equipment to handle different types of materials. Furthermore, the findings is contrary to the use of MHE to increase efficiency, control costs, and optimise productivity (Bouh and Riopel, 2015). In addition, reducing worker efforts and boost worker's morale (Rajesh and Subbaiah 2015). It also reduces damage to materials, possible through human error or negligence, and reduces fatigue (Kay, 2012). Therefore, it can be deduced that automation of the material handling processes in warehouses was minimal and inefficient.

Storage Equipment Use in Warehouses

The study results established that most of the manufacturing companies used floor/block storage methods in their warehouses. This finding was supported by Baker and Perotti (2008), whose study of the modern warehouses of a group of companies revealed that the most popular form of storage was floor storage and standard wide aisle racking. This finding also confirmed the study by Roodbergen and Vis (2009), which established that insignificant consideration has been given to the utilisation of AS/RS and other material handling systems in warehouses and distribution centres. But the finding is in contrast with Gwynne (2014) submission that most of the mechanical handling and storage equipment manufacturers do have sophisticated systems, including simulation software that can assist companies with planning as to what type of racking and MHE will efficiently suit their operations. The study revealed that the use of storage equipment was minimal and inefficient.

Loading and Offloading Equipment

The study revealed that two-thirds of the manufacturer warehouses used equipment such as automatic loaders for loading cement, high level cranes for loading reinforcement bars, payloaders for loading granite/sand, and forklift trucks for loading ceramic tiles. These findings is supported by the automation principle of material handling that the operations should be mechanised and/or automated where feasible to improve operational efficiency, reduce operating costs, and to eliminate repetitive manual handling of material (Material Handling Institute (MHI), 2000). However, the remaining companies used manual labour in the loading of ceramic tiles (semi-mechanised), blocks, granite and sand. .

Furthermore, the results revealed that offloading was done manually at the distribution centres/warehouses, retailer stores and sites. These findings contradict Pienaar's (2016) assertions that to reap the optimum rewards of specialisation, handling equipment at terminals should be provided for rapid loading and offloading to save time and cost. More so, it also contradicted the view that block manufacturers normally use self-loading vehicles with cranes mounted on the edge or on a removable mounting (Vidalakis and Sommerville, 2013). This truck equipment allows for extra grades of movement for handling unit loads (Hannan, 2011).

It can now be deduced that the use of loading equipment at the manufacturer warehouses was minimal, while there was no offloading equipment at the distribution centres/ warehouses, retailer stores and sites. Hence, loading processes at the manufacturer plant/warehouses, and offloading of vehicle processes at the distribution centres/ warehouses, retailer stores and sites were inefficient.

Load and Offloading Time

The study sought to confirm the average time taken per ton for loading and offloading each material. The results revealed much disparity in the average time taken per ton for loading and offloading each material. It took much lesser time per ton to load at the manufacturer plants where the loading was done mechanically. On the contrarily, it took more time per ton to offload at the distribution centres/ warehouses, retailer stores and sites where most offloading was done manually. These processes combined used fewer machines, but more manual labour that involved multiple handling.

These findings contradict the assertion by Pienaar (2016) that using high capacity technology to carry and handle large bulk loads can help in minimising loading and offloading times. However, the offloading process can be more efficient and enhanced by 61% if it improves its information systems (Andrejić and Kilibarda, 2016). Therefore, the efficiency of loading and offloading processes time per ton is sub-optimal.

Loading and Offloading Costs

The study also revealed much disparity in average cost per ton for loading and offloading individual materials. It costs less per ton to load than to offload in companies where most of the loading was done mechanically at manufacturers warehouse, as against most offloading being done manually at the distribution centres/ warehouses, retailer stores and sites. This findings supports the fact that the use of automation in material handling can increase efficiency, control costs, and optimise productivity (Bouh and Riopel, 2015)

The findings corroborate Michaels' (2015) submission that the more multiple handling of material, the more the overall logistics expense. The implication is that the touch time costs are non-value-added costs that will never be recovered when an invoice is calculated for the load (Niggi, 2017). Thus, for construction material handling, the efficiency of loading and offloading cost per ton were sub-optimal.

CONCLUSION AND RECOMMENDATION

Automation of construction material handling is usually considered as a method of reducing cost. However, the study concluded that the combined processes of order picking, handling equipment, storage, loading and offloading used less automation, but more manual labour that involved multiple handling. This low adoption of automation in material handling by the manufacturing industry leads to inefficiency. This in turn have a negative influence such as prone to error, long lead time and high labour cost. The implication of these findings is increase in construction material price and delay of delivery to prospective customers. These have the impact on increasing construction cost and cause delay in project execution.

It can also be concluded that the average time per ton to load material was much lesser at the manufacturer warehouses where loading was done mechanically. However, it took more time per ton to offload at the distribution centres, retailer stores and construction sites where offloading were done manually. Furthermore, it cost less per ton to load mechanically at manufacturer warehouse as against the cost of offloading manually at the distribution centres, retailer stores and construction site. A recommendation is made for further study to explore why automation is not adopted by these companies, despite its purported advantage. This study was conducted using observations which is one of the limitations of this study. Another limitation of this study is geographical in nature; since this study covered only one out of the six geopolitical zones of the country, other zones should be study and compare the results.

REFERENCES

Aberdeen Group (2009) Warehouse Operations, Increase Responsiveness through Automation, Aberdeen Group, Boston, MA.

Abhilin, G. B. and Vishak, M. S. (2017) 'Effective Material Logistics in Construction Industries', International Journal of Science and Research, 6(3), pp. 910–913.

Andrejić, M. and Milorad Kilibarda (2016) 'Framework for Measuring and Improving Efficiency in Distribution Channels', International Journal for Traffic and Transport Engineering, 6(2): 137 - 148. DOI: http://dx.doi.org/10.7708/ijtte.2016.6(2).02.

Baker, P. and Perotti, S. (2008) U K Warehouse Benchmarking Report, Cranfield School of Management, Cranfield. UK.

Bouh, M. A. and Riopel, D. (2015) 'Material Handling Equipment Selection: New Classifications ofEquipments and Attributes',(October).Available at: https://www.cirrelt.ca/DocumentsTravail /CIRRELT-2015-63.pdf.

De Koster, R., Le-Duc, T. and Roodbergen, K. J. (2007) 'Design and Control of Warehouse Order Picking: A Literature Review.', European Journal of Operational Research, 182(2), pp. 481–501.

Duiyong, C., Shidong, J. and Mingshan, S. (2014) 'Engineering construction project site, logistics management', Journal of Chemical and Pharmaceutical Research, 6(7), pp. 353–360.

Equere, E. and Tang, L. C. M. (2010) Dearth of Automation : The Consequences in Nigeria Construction Industry, Online Retrieved on July 06, 2010 101.

Gwynne, R. (2014) Warehouse Management: A Complete Guide to Improving Efficiency and Minimising Costs in Modern Warehouse. Second. London, U.K.: Kogan Page limited.\

Hannan, S. (2011) 'Physical flow', in Rezar Zanjir Farahani, Shabn, Rezapour, Laleh, K. (ed.) Logistics Operations and Management, Concepts and Models. First. New York: Elsevier, pp. 13–34.

Jang, W. and Skibniewski, M. J. (2009) 'Cost benefit analysis of embedded sensor system for construction materials tracking.', Journal of Construction Engineering and Management, 135(5), pp. 378–386.

Kamali, A. (2018) 'The Way to Optimize On-Time Delivery (OTD) in Logistics - Firms in Bahrain', CiiT International Journal of Artificial Intelligent Systems and Machine Learning, 10(9), pp. 198–204.

Narimah Kasim, Siti Radziah Liwan, Alina Shamsuddin, Rozlin Zainal, and Naadira Che Kamaruddin. (2012) 'Improving on-Site Materials Tracking for Inventory Management in Construction Projects', in Proceedings International Conference of Technology Management , Business and Entreprenuership, pp. 447–452.

Kay, M. G. (2012) Material Handling Equipment, Metal Finishing.

Kim, S. W. (2006) 'Effects of supply chain management practices, integration and competition capability on performance. Supply Chain Management: An International Journal. Volume 11. Number 3. Emerald Group Publishing Limited. http://www.emeraldinsight.com 23.'

Loeb, S., Dynarski, S., McFarland, D., Morris, P., Reardon, S., and Reber, S. (2017) 'Descriptive Analysis in Education: A Guide for Researchers', (NCEE 2017-4023). U.S Department of Education, Institute of Education Sciences. National Center for Education Evaluation and Regional Assistance, pp. 1–40.

Material Handling Institute(MHI) (2000) The Ten Principles of Material Handling, Charlotte, NC: Material Handling Institute.

Michael, B. (2015) 'The Challenge of Construction Logistics', in Lundesjö, G. (ed.) Supply Chain Management and Logistics in Construction: London, New Delhi: The Chartered Institiute of Logistics and Transport, pp. 09–24.

Niggi, J. (2017) 'The-QC-checklist: An essential tool for managing product quality of ceramics', American Ceramic Society Bulletin, 96(3), pp. 50–55.

Patel, H. Pitroda, J. and B. and J. (2015) 'Analysis of Factor Affecting Material Management and Inventory Managemtent : Survey of Construction Firms Using Rii Method', (December).

Peerless Research Group (2012) http://mmh.images/site/MMH12013 SpecRptIndry Outlook EquipSurvey.pdf(accessed 10/09/2013).

Pienaar, W. J. (2016) 'Transport Modal Cost Structures, Competition and Pricing Pricinples', in : Business Logistics Management. Fifth. Cape Town South Africa: Oxford University Press, pp. 376–407.

Rajesh A S, and Subbaiah K M, M. I. (2015) 'Improvement in Material Handling Equipment-An Ergonomic Case Study', International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE), 2(5), pp. 115–117.

Roodbergen, K.J. and Vis, I. F. A. (2009) 'A survey of literature on automated storage and retrieval systems', European Journal of Operational Research, 194(2), pp. 343–362.

Shakantu, W.M. and Emuze, F. A. (2012) 'Assessing Reverse logistics in South African Construction.', in Proceedings for the 20th Annual Conference of the International Group for lean construction. San Diego, California, p. 661.

Sople, V. V. (2010) Logistics Management. Second. New Delhi: Pearson Education.

Tambovcevs, A. (2012) 'ERP System implementation in Latvian Manufacturing and Construction company', Technological and Economic Development of Economy, 18(1), pp. 67–83. doi: 10.3846/20294913.2012.661176.

Vidalakis, C. and Sommerville, J. (2013) 'Transportation responsiveness and efficiency within the building supply chain', Building Research and Information, 41(4), pp. 469–481.

Jennifer Webster, Melanie Dalby, David Fox and Andrew DJ Pinder. (2014) 'Factors in the design of order picking systems that influence manual handling practices'.

Yin, R. K. (2009) Case Study Research: Design and Methods. Third. Thousand Oaks, California.: Sage Publications.