Dearth of Automation: The Consequences in Nigeria Construction Industry

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Abstract. Automation of material handling and tracking processes provides a more accurate and timely working system. With the Global Construction Perspective and Oxford Economics (GCPOE, 2009) reporting that construction growth in Nigeria will be the fastest of all markets by 2020, the impacts of existing material handling and tracking systems become even more important as the size and scale of construction projects increase. This paper examines the challenges and limitations of existing of material tracking systems in the Nigeria construction industry with the view to highlighting potential areas for technology and innovation. A study of a large construction company in Nigeria was carried out through structured questionnaires, face-to-face interviews and participants' observation of company procedures for material handling and tracking. It was observed that material handling and tracking processes were mostly manual and labourious. Eventhough projects seemed to turn out profitable, productive, and successful, these were attained at a high impact on the cost of the projects, project durations, and workers satisfaction. Applicable technologies that could be introduced for basic tracking and handling processes, to enhance efficiency of the Nigerian construction Industry have been suggested, and opportunities have been identified for a technological innovation market for automated material handling and tracking system in the Nigeria construction industry.

Keywords: Nigerian Construction Industry; Automation; Material Handling and Tracking System; Sustainability.

1. Introduction

Construction material handling and tracking is the monitoring and management of materials in a construction project from manufacture, through delivery to site, and installation at the workplace. Proper monitoring and management would aim towards efficient identification, timely delivery, ease of location, confirmed availability, and ensuring the exact installation position within the project. In addition, it would control theft, misuse and misdirection of materials for a project.

Inefficiencies associated with practices of manually tracking of materials, equipment and workers in construction field often cause problems with successful completion of a construction project (Jang & Skibniewski, 2008). With the advanced technologies and innovations in the construction industry, it has become technically viable to implement automated tracking for construction materials (Jang & Skibniewski, 2009). However, the construction industry in Nigeria, having grown to handle very large and complex projects, still largely operates maually. In a global forecast for the construction industry over the next decade, the Global Construction Perspective and Oxford Economics (GCPOE, 2009) reports that construction growth in Nigeria will be the fastest of all markets by 2020. It becomes imperative, therefore, that material handling and tracking be automated in order to efficiently cope with this expected growth, as inefficiencies related to the manual operations of reporting, recording and transferring field data in current tracking systems are becoming even more important as the size and scale of construction projects increase (Jang et al. 2009).

2. Automation of Material Handling and Tracking in Construction

Automation is the technique, method, or system of operating or controlling a process by highly automatic means, as by electronic devices, use of control systems and Information Technologies, reducing human intervention to a minimum.[1] A large project would have to handle and monitor many components of

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[1] Dictionary.reference.com. Retrieved on July 06, 2010

materials from various sources at different stages of the construction works, to be delivered to site according to specification as and at when due. Tracking materials and components on construction projects, therefore, implies primarily identification of location of the material in the supply chain during delivery and receipt of materials to a construction site, and identification of materials within a contractor's laydown yard (Song et al., 2006a), which requires positional accuracy. Torrent and Caldas (2009) noted that craft labour hours are increased by 16 to18% due to material not being ready; based on published works, workers waste up to a third of their working time searching for materials. It is time consuming to gather real time information about the status of all pieces of materials in a plant since that information is recorded by different teams usually in different databases during production, storage and delivery (Ergen, Akinci & Sacks, 2003).

The efficiency in locating, identifying or issuing of materials for the works is what makes the processes of material handling and tracking of benefit to the construction process. However, industry practices still solely rely on the human ability to individually control thousands of these components on the field, and the lack of automation frequently results in critical errors that negatively affect project cost and schedule (Grau et al., 2009a). It is credited to give real-time information, which gives the benefit of speed, accuracy, and reliability (Stukhart 2000 cited Burke 89). Advanced tracking technologies enable the components become intelligent by storing information about their identities, handling, storage and installation instructions and other important information on the component itself.

3. The Construction Industry in Nigeria

Contribution of construction industry to the national economy reduced to a mere 1% of the GDP in 2002 (AfDB/OECD, 2004, as cited by Oladapo, 2007). However, by the April 2004 Report, The Nigeria Statistical Fact Sheet on Economic and Social Development, 1999-2003, showed that building and construction activities picked up considerably in 2003, resulting in nearly 9% growth rate.[2] The Nigerian National Bureau of Statistics further records that building and construction contributed 1.98% to the GDP in 2009.[3] The GCPOE 2009 statistics reports that Nigeria has a nominal GDP (2008) of US$ 183.1bn, with construction being 3.2% of the GDP.

The Nigerian construction industry consists a majority of small and medium enterprise indigenous firms, and a minority of large mostly foreign firms. The few large firms constitute about 5% of the total number of contractors in the formal sector, and control about 95% of the construction market, giving the small firms just about 5% share of the market (Oladapo 2007). Construction materials such as granite, gravel, stones, sand, steel, cement, wood, aluminium, and glass could be obtained locally. But some of these do not come in adequate supply, therefore, materials are usually augmented through importations to meet demands, required standards and current technology. Poor availability has greatly affected the prices of building materials. In a study of inflation dynamics in the construction sector of the Nigerian economy using data on quarterly frequency from 1986 to 2003, it was found that comparatively, the construction industry rate of growth in prices (of construction materials) was higher than the economy wide rate of growth of inflation (Oyediran, 2006). The quarterly growth rate exhibited by selected basic construction material prices ranged from about 6% to about 17% with an average of 9%. The dearth of material manufacturing factories adversely affect the industry.

4. Material Handling and Tracking Practices of the Company

Material scheduling and procurement are carried out well in advance of the commencement of work, due to the extensive length of time involved. This is done using more of manual deductions / calculations directly from the drawings. Special departments cross check Bills of Quantities against error. Scheduling is done according to the project codes and drawing numbers. Codes and numbers guide the procurement of materials. Every item to be procured will have an order number linked with the project code to enable identification and direction to point of use. The corrollation is imputed manually into Excel computer software. Materials

[2] Nigeria Statistical Fact Sheet on Economic and Social Development, 1999-2003 – Federal Office of Statistic (FOS), Abuja, Nigeria, April 2004.
[3] National bureau of statistics

are procured in phases to a central store, from where they are dispatched to the various project sites on specific request by the respective project managers. Each project runs its own project store on its site.

Imported items have order numbers which are checked online to ascertain shipment location from period of order to the port of delivery. Such tracking measure ceases upon receipt of the item by the company within the country. Thereafter items are identified by batch numbers of their containers, and listings of items within the batch. Batches are identified manually to show where the materials are to be delivered, corresponding with the drawing codes by which they were ordered. On receipt and before storage, dates of arrival and batch numbers are manually tagged on the materials. The dates, batch and order numbers are imputed on Excel format into the computer, to aid in material record and distribution to respective project sites.

Materials identification operations and paper works are processed by codes, engraved, handwritten and tagged to construction materials and elements stored in the laydown yard. Such codes show project codes, drawing number, and position of the element on the project. Workers are expected to be conversant with codes and drawing numbers, for location and identification**.** Codes are imputed on the computer for notification of availability and quantity in stock. The use of Excel programmes provide real-time information: quantity of materials procured; number of materials issued; stock and costs; update of inventory every three months; notices of need to re-order or replenish stock. Delivery notes, way bills and receipts are also formatted into Excel programme, unto a database to provide up-to-date information on materials movement. Electronic store material management software links the overseas parent company with all company branches worldwide, and to other possible suppliers along the supply chain. The data are also connected in a network to the central store, the data base of all the materials in stock at any given time.

For Material requisition, project managers issue requisition notes stating order number, type and quantity of material requested, and unit number informed from the project drawing. Requisition detail is fed into the programmed computer software by the store personnel to confirm need, ascertain quantity, order number and available stock. Upon confirmation and allocation, a delivery note (in triplicate copy) with a sequenced delivery number is issued to the transporting personnel, who delivers the materials to the designated site. The delivery note states the type of material and the quantity issued; its final destination and a gate pass number. The issuing store personnel maintains one copy of the delivery note and sends off two copies with the transporter. The transporter is issued with a gate pass to authorise his despatch from the store premises. The security personnel at the issuing central store premises confirms the gate pass to permit the transporter's exit for onward delivery. The security from the issuing store routinely informs the officers at material destination store on radio, of dispatch of materials, time of departure and expected time of arrival. On delivery of the materials, the receiving store keeper verifies and receives the materials. He maintains a second copy of the delivery note and submits the third copy to the project manager. Security personnel at the site of delivery radios back to confirm safe arrival of materials to site. Materials are stored in batches under codes for identification and retrieval Every step is tracked manually, and no step must be ommitted.

The project managers use electronic store material management software which links the overseas parent company with all company branches worldwide, and to other possible suppliers along the supply chain. They are also connected in a network to the central store, the data base of all the materials in stock at any given time.

Strict Monitoring and Security Systems for materials from point of procurement to safe delivery on site is paramount in the system. Extensive manual processes of monitoring and security of materials include internal security checks; under-cover external monitoring/security teams; monitoring check points along long haulage; delivery routes; manually processed delivery notes/ waybills/ requisition notes/ gate passes, and personal vigilance.

Upon analysis of the interview, questionnaires and observed procedures of respondents, predominant variables of the company material handling and tracking practices were derived, and ranked according to their significance within the company. Using Entropy Ranking Analysis as developed by Tang and Leung, 2009, Tang, Leung and Wong 2010), stages more significant to the company were ranked as follows.

- Materials Management Most significant 94%

• Material Scheduling and Procurement	Most significant	82%
• Strict Monitoring and Security Systems	Most significant	82%
• Material Identification / Operations and Paperwork	Very significant	88%
• Use of Information technology	Significant	57%
• Effect of Cost on the Project	Less significant	75%
• Extensive Storage facilities and Space	Less significant	62%
• Automation in the System	Least significant	82%

5. The Challenges and Limitations

The greatest challenge to the company's highly manual material handling and tracking system is the human factor, thus prone to errors and malpractices. Workers have no prior knowledge of the company's system, and would have to be trained. The company's system can be said to be structured around the particular need and circumstance of the company, and not of any universal standard. This would hinder global participation.

Although operated manually, the efficiency rate of the system is expected to be high. This put a lot of pressure on the workers. Workers' dissatisfation also arise from poor government regulations on labour matters, low wages, lack of motivation and work overload. The low welfare situation could cause malpractices. An automation controlled system would monitor materials from the start to point of delivery with little or no human interference between deliveries. With the highly manual process, the system is highly prone to errors, yet workers are required to maintain high efficiency. Mistakes of wrong entries, non-serial despatch of materials from store, material losses amongst others, are severely penalised. This, together with reported poor labour laws and constraints regarding labour laws and workers' wages seem to impose stress on the labour workers. Direct human involvement adversely affects the system through delays, losses and wastages. Responses from the survey tend to signify that unsatisfied workers are prone to engage in smart practices to the detriment of the progress of the material management system, and consequently the project success.

The manual procedures aand processes of the system cause lengthy activity periods, which time adds up to cost of contingencies and overheads on the project. The long periods of material ordering, shipping, clearance from ports and subsequent transportation to the point of use, add to delivery times. Just-in-time deliveries cannot be practiced due to unavailability or inadequate supply of materials. High cost of inflation neccessitate stockpiling. Stockpiling becomes necessary at the prevailing prices to beat inflations. For this reason too, just-in-time deliveries may not be practical.

Stockpiling time of materials cause extended tied down capital that would otherwise have been better invested. Long laydown periods of materials become economically unviable, requiring extensive storage facilities and space. The extra external security, monitoring team and security check points for long distance haulage routes, have their added logistics of fuel supply, vehicle maintenance, salaries, administrative cost and other expenditure.

Traditional purchasing processes done on a paper-based system, have many associated drawbacks: low accuracy, time consumption, labor consumption, loss of data, and high uncertainty (Hadikusumo, Petchpong and Charoenngam 2005). Inefficient procurement practices result in costly delays, loss of profit, and possible litigation.

The survey also reflects concern over government policies on labour and importation as posing difficulties in material clearance at the sea ports and transportation across various sites in the country. To facilitate their process, the company maintains a shipping line, air transportation, and runs a fleets of long haulage heavy duty vehicles for material handling and tracking processes.

Low technology and reluctance to adapt new technology poses a challenge in the face of available and cheap labour. The survey noted responses stated the labour union agitates that the use of extra technology that would bring about the laying off of workers. While automation within the system is very low, the need

for automation is not a high signifant factor for the company. Research and development on construction materials handling and tracking is lacking within the company. The company's system has been structured around the particular system and circumstances of the company, and not of any universal standard, therefore obtaining already trained workers from the job market is difficult.

From the survey, predominant variables of limitations and challenges to existing practices were derived and ranked according to the order of impact on the system as follows:

- Human Factors – Errors, Low Skills — Most significant — 82%
- Stress on Labour — Very significant — 62%
- Stealing / Waste — Very significant — 62%
- Low technology and Reluctance to adaptation — significant — 62%
- Poor Labour laws and Government Legislation — Significant — 30%
- Just-in-Time — Less significant — 82%
- Long Activity period — Less Significant — 68%
- Research and Development — Less significant — 55%

6. Suggested Improvements to the Practice

Acknowleding the high involvement of the human factor in the manual material handling and tracking process, the need for improved remuneration and better welfare for workers was identified as the greatest need to improve the system. Satisfied workers, it was reported, would be more diligent, would not engage in sharp practices, and the urge to misappropriate and divert company materials could be reduced. Constant training and educating workers on the company systems were high requirements. Better storage facilities to protect and preserve stockpiled materials was found to be essential in this system. Accuracy and automation were not very significant factors considered for improvement in the system.

From the survey, predominant variables suggested as improvements to the practice were the following:

- Improved Workers' Welfare — Most significant — 68%
- Qualified Personnel — Most significant — 38%
- Training — Most significant — 32%
- Improved Client Responsiveness — Most significant — 32%
- Better Storage Facilities — Most significant — 32%
- Good Government Regulations and Policies — Most significant — 25%
- Accuracy — significant — 81%
- Automation — Less significant — 50%

7. Recommendations for Future Work

Automation in the industry is not only lacking, but there seems to be very little interest in exploring its benefits. This appears to be as a result of lack of awareness, low level of technology and fear of innovation. Automated processes not only ensure efficient work processes, but are also not complicated to operate. Stages of material handling and tracking processes identified in the system can be automated for efficiency in productivity, profitability and speed with the following recommended systems:

Building Information Modeling (BIM) systems would generate and manage building data during its lifecycle, using three-dimensional, real-time, dynamic building modeling software to increase productivity in building design and construction. Quantities and shared properties of materials can be extracted easily. Relevant information is stored and accessed for analysis and decision making while also allowing continual updating and refinement throughout the life cycle of the model.

Construction material procurement using Internet-based agent system is recommended for use to assist human purchasers to carry out solicitation in identifying suppliers, searching materials, and preparing purchase orders (Hadikusumo et al., 2005). Web Cameras, Electronic sensors and Personal Digital Assistant (PDA) can reduce the use of various manual monitoring and Security systems, tracking of materials, and facilitate data disseminating, data consistency and remove paper dependency. Mobile computing can be

introduced to bridge the gap between indoor and outdoor project delivery processes. Barcodes and RFIDs would enhance material monitoring, location and documentation process, efficient identification and position or situation awareness. Real-time online information on the location of the materials would eliminate the physical follow up of the materials by the security agents. The stages of the process could be further compressed to eliminate duplicity, 'dual chain' management and double handling. The use of other web-based technologies can be explored. A construction research firm, Daratech, has estimated that anywhere from 5 to 10 percent of a construction project's cost can be saved by using Web-based technologies.

8. Conclusions

Consequencies of the dearth of automation in the Nigerian construction industry are greatly manifest in the increased project cost, tedious work processes and low efficiences. Exigencies of low technology, limited management techniques, and low material production capacity have afffected the efficiency of projects thereby making them not truly successful. Successful completion of project should take into consideration the best cost, the best time frame and the best quality of works achievable for the project. In the face of increased scale of construction in Nigeria, the prevailing system of material handling and tracking would be highly unsustainable. However, a wide gap for technology and innovation has been identified in the Nigeria construction industry. Research and development into this sector would benefit construction fiscal output and material development. In the face of increased scale of construction in Nigeria, there would be the need to streamline the material handling and tracking process to avoid superflux.

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