POST-CONTRACT MATERIAL MANAGEMENT AND WASTE MINIMIZATION: AN ANALYSIS OF THE ROLES OF QUANTITY SURVEYORS'

Journal:	*Journal of Engineering, Design and Technology*
Manuscript ID	JEDT-10-2018-0193.R1
Manuscript Type:	Original Article
Keywords:	Quantity Surveyors, Material management, Waste minimization, Post-Contract, Construction project management

Abstract

Purpose

The paper aims to assess the level of awareness of quantity surveyors in material management and their key roles in waste minimization during the post-contract stage of the project with a view of achieving value for money in their roles.

Methodology

This involves administering a questionnaire survey among registered members of Nigerian Institute of Quantity Surveyors (NIQS), the only recognized professional body of quantity surveyors in Nigeria, within Lagos state. The empirical questionnaire survey succeeds a literature review that isolates the key strategies used by quantity surveyors in material waste management at the post-contract stage. The validity of the questionnaire was carried out by two experienced construction industry researchers and three experienced professional quantity surveyors to ensure that the questionnaire was not ambiguous and that it is consists of the right questions in tandem with the research. The respondents were grouped into consultant QS and contractor's QS.

Findings

Key roles of quantity surveyors during the material management process are proper material storage and material inventory and accounting are the most important material management and waste minimization practices during the Institute stage. It revealed that there is a lack of material waste documentation practices during the construction stage. In addition, no statistical significant difference in the responses of the two groups. This may be because there is no clear compartmentalization between the practices of these groups. Also, these two groups had the same education training, as there is no difference between the educational training of the Consultant QS and Contractor's QS.

Originality/value

This study assessed the quantity surveyors' roles with regards to material waste minimization and management; It would add to the scanty research work in this area. The study has also successfully revealed the strategies that are to be adopted by the quantity surveyors to achieve value for money.

Keywords: Quantity Surveyors, Material management, Waste minimization, Post-Contract, Construction Project management.

1.0 Introduction

Cost of construction materials accounts for a huge portion of the construction project cost. It may account for 50% - 80% of the total cost (Gulghane and Khandve, 2015; Patil et al., 2013), it may vary around 20% - 70% (Bossink and Brouwers, 1996; Kini, 1991) or 30% - 80% (Skoyles, 2000; Patel et al., 2011; Muelhausen, 1991). Evidently, it most times accounts for over 50% of the construction (Akinkurolere and Franklin, 2005; Ilesanmi, 1986).

Since material cost accounts for a bigger portion of the construction cost, thus, material wastage poses a great danger to the construction industry at large. However, complete package construction contracts transfer the risk of material wastage expended during the construction to the contractor. Consequently, any cost overrun caused by poor material management is being borne solemnly by the contractor. Wahab and Lawal (2011) confirmed that material waste at the project and corporate levels imply a loss of profit and competitiveness for the contractor. Akinradewo and Arijeloye (2016) corroborated that it poses a serious problem to contractors in realizing a reasonable profit margin. Therefore, for contracting organizations to maximize their profit margin, material management is an important tool for project success; the responsibility which quantity surveyors in such contracting organizations should shoulder.

Formoso et al. (1991) viewed waste as an ineffective over or underuse of resources than the proportion deemed necessary during construction (Nazech et al., 2008). Abdulrahman and Allitresyi (1994) viewed it as unnecessary cost generated that is of no value to the end product in the perspective of the client. Lee et al. (1999) opined that there is a dearth of research on waste because of unavailable appraising tools for it. Material waste on site is on the rise as a result of an increase in standard of living, the natural increase in population and complexity of design

which are harbingers of increase in construction projects. This increase is alarming, and if not controlled, it can jeopardize the future of the construction industry (Dey, 2001). Ineffective management of materials will tell on the core project success metrics; time, cost, and quality (Putra et al., 1999). The estimators/quantity surveyors do add 5 – 7 per cent for waste during tendering, but over the years this has been found to be insufficient (Obiegbu, 2002; Wahab and Lawal, 2001). However, Quantity surveyors in the contracting organization have a role to play in ensuring that such insufficiency is dealt with and properly managed so as not to erode the profit margin.

Previous studies had laid much emphasis on the responsibilities of professionals in the built environment in controlling material wastage at various stages of projects. Others have researched into the impact of construction material wastage on contractors (Gulghane and Khandve, 2015; Albert, 2014; Aiyetan, 2013). However, owing to the significant portion that the cost of materials engulfs in the contract value, quantity surveyors in contracting organizations have a lot of responsibilities to shoulder - in material wastage control, if they want to achieve the desired profit margin for their respective organizations (Bello and Saka, 2017; Alabi *et al*., 2018). This study assesses the level of awareness of quantity surveyors in material management and waste minimization, and identifies the key strategies involved and ranked these strategies in order of importance. Avoidance of material waste is pertinent in having projects completed within cost, time budget and to desired quality (Ayegba, 2013; Kasim, Anumba and Dainty, 2005; Ogunlana et al.,1996).

2.0 Material management

Beyond reasonable doubts, an effective material waste management system can realize benefits for a contractor (Aiyetan and Smallwood, 2013). Wahab and Lawal (2011) regard material management as a reflection of site management. It is common on construction sites to see materials procured which are not eventually incorporated into the building; the common ones are the coarse and fine aggregates, reinforcement bars, timbers etc. This reflects the inefficiency of the material/site management practice of such project teams. Eduardo (2002) described material management as "the system of planning and controlling all the efforts necessary to ensure that the correct quality and quantity of materials are properly specified in a timely manner, and obtained at a reasonable cost, and most importantly, are available at the point of use when required." Ayegba (2013) and Albert (2014) viewed it as "the process that coordinates planning, assessing the requirement sourcing, purchasing, transporting, storing and controlling of materials, minimizing the wastage and optimizing the profitability by reducing the cost of material." From a quantity surveyor's perspective, the in-exhaustible description of material management in the literature revolves around the theme of planning to minimize wastage and maximize profit.

Material management practices is thus divided between the field and the office (Baldva, 1997), Johnston (2001) corroborated this by noting that the selection, pricing, order preparation of schedules and payment accounts are dealt with at the head office, while learning the receipt storage, protection and use of materials, management are dealt with on construction site. In essence, the planning, procurement and logistics surrounding materials are the main focus of the head office, while handling, stock and waste control are being carried out on site. In the same

vein, Gulghane and Khandve (2015) opined that material management consists of activities that are field, and office related; this was supported by Zeb *et al*., (2015).

Material management practices come at a cost. Such cost might include the cost of setting up a monitoring team in the office which will be receiving information from another team on-site / field. Although the cost of putting such monitoring team in to place has to be compared with its' benefit(s), it can be concluded that investment in these practices is of immense benefits (Aiyetan, 2013).

It has been established that the material management process is divided between head office and site (Zeb et al., 2015; Baldva, 1997). Gulghane and Khandve (2015) posit that material management involves planning, purchasing and transportation, handling and waste control. Albert (2014) and Kasim (2008) viewed it to involve planning, procurement, logistics, handling, stock and waste control, which would be adopted by this study:

2.1 Planning:

The material planning aspect lays the foundation for other material management processes. It is thus very important as other subsequent processes depend on it for support. Material planning includes quantifying, ordering and scheduling (Gulghane and Khandve, 2015). This stage consists of creating and updating of inventory (Payne et al.,1996).

2.2 Purchasing/Procurement:

This consists of procuring of necessary resources that are required for a smooth construction project (Barrie and Paulson, 1992). Kasim (2008) viewed it as procurement and sourcing of physical and human resources outside the firms to aid services rendered by the organization.

Akinradewo and Arijeloye (2016) submitted that the motive of this stage is to make specify materials available as at when deemed necessary and within the budget limit.

2.3 Transportation/ Logistics:

This comprises of all activities involved in getting the materials to form the source to the point of usage (Agapiou et al., 1998). Albert (2014) corroborated this and regards it as the stage that involves all activities dealing with moving the materials in its raw form to the finished product to meet customers' requirements.

2.4 Handling:

Tompkins and White (1984) define effective material handling as "using the right method in providing the right amount of the right material, at the right place, time, sequence, position, condition, and cost". It is a very critical stage, as ineffective handling during construction will have effects on the project (Ogunlana et al., 1996) and also influence project cost and time (Putra et al.,1999). Thus, it can make or mar projects (Chan, 2002). Kasim (2008) viewed it as an all-encompassing stage in the movement of materials from source to its destination.

2.5 Stock and waste control:

This involves the availability of materials at the right place and appropriate time of need, and in the necessary quantity. It can include raw materials, processed materials, and components for assembly, consumable stores, general stores, maintenance materials and spares, work in progress and finished products.

Material waste has increased in the last two decades (Katz and Baum, 2011), construction material waste accounts up to 30%-40% in China, 39.27 million tons in Spain, and more than

50% in the UK. (Wang and Li, 2011). Thus, waste minimization and reuse should be of importance (Albert, 2014)

2.6 Importance of material management

Material management and waste minimization is of immense benefits as it set out to as (Albert, 2014; Gulghane and Khandve, 2015): (1) Efficient material planning, (2) Quality assurance, (3) Good supplier and customer relationship, (4) Improved departmental efficiency, (5) Reducing the overall costs of materials and in duplicated orders, (6) Better handling of materials, (7) Materials will be on site when needed and in the quantities required, (8) Improvements in labor productivity and project schedule, (9) Better field material control and better relations with supplier, (10) Reduce of materials surplus and storage of materials on site, (11) Labor and purchase savings, and (12) Better cash flow management.

3.0 Research Methodology

The study employed a quantitative research method. This involved administering a questionnaire survey among registered members of Nigerian Institute of Quantity Surveyors (NIQS), the only recognized professional body of quantity surveyors in Nigeria, within Lagos state. The choice of Lagos was informed by the continuous increase in the number of ongoing construction projects in the state and its status as Nigeria's "most important economic state". Ajanlekoko (2001) eluded that Lagos accounts for 60% of prospective clients that patronize the construction industry in Nigeria. The population of the study is the registered quantity surveyors in Lagos State, Nigeria. An internet-based survey was employed in order to save time, cost and to reach a much larger sample (McDonald and Adam, 2003). Snowballing sampling technique was adopted with reference to the list of registered firms in order to reach a larger number of quantity surveyors in Lagos, state. There are 66 registered quantity surveying firms in Lagos, the emails of these firms were extracted, and the questionnaire link was sent to them. However, some of the email addresses are either incorrect or invalid (thus, the email sent was bounced back) and a low response rate was recorded. The web-link to the questionnaire was then sent to some of the identified respondents on various professional platforms (e.g. LinkedIn, Facebook group pages etc.), also some questionnaire were hand delivered to some of the professionals involved. The respondents were also asked to suggest eligible respondents for the survey. A total of 74 entries submission and questionnaires administered were recorded, out of which 52 entries were complete and valid for data analysis (70% valid response rate).

The empirical questionnaire survey succeeds a literature review that isolates the key strategies used by quantity surveyors in material waste management at the post-contract stage (Table 1). The survey was carried out to achieve the first two objectives namely: to assess the level of

awareness of quantity surveyors in material management and waste minimization; to assess the effectiveness /adoption level of various quantity surveyors' strategies in material waste management at the post-contract stage.

The questionnaire consists of three sections. The first section solicits demographics of the respondents, the second section assessed the level of awareness quantity surveyors in material management while the third category comprises of key strategies used by quantity surveyors in managing material wastes which were extracted from extant literature. The extracted key strategies were then subjected to ranking on the Likert scale by the quantity surveyors and analyzed by using relative importance index. The relative importance index is one of the widely used statistical tools in construction management to evaluate the importance of a set of variables (Chan and Kumaraswamy, 1997), thus it was adopted for the analysis. A pilot survey was carried out prior to the administration of the full survey. Internal validity of the questionnaire was carried out by two experienced construction industry researchers and three experienced professional quantity surveyors to ensure that the questionnaire was not ambiguous and that it is consists of the right questions in tandem with the research.

Table 1: Key strategies used by quantity surveyors in material waste management at the post-contract stage

3.1 Method of Data Analysis

The respondents' Job procedure, educational qualification, professional qualification, years of experience and the number of projects undertaken were also analyzed in percentage and frequency

3.1.1 Cronbach's alpha reliability test

Cronbach's alpha value is useful in assessing a research instrument and to check the internal consistency of the totality of the research instrument (Olatunji, Olawumi and Aje, 2017). Cronbach's alpha value ranges from 0 to 1, and a value of 0.7 is acceptable to further analysis of any research. The alpha (α) value of the is 0.961, which is above 0.7. This implies that further analysis can be carried out on the study and that the scale is reliable.

3.1.2 Relative Importance Index (RII)

The relative importance index method (RII) was used to determine the respondent's perception of material management and waste minimization during the post-contract stage in the construction industry. This calculation puts the factors in rank order and indicates how much the top ranked is more important than the next. The perception of the consultant quantity surveyors and the contractor's quantity surveyors were also ranked separately.

The RII was computed as:

Relative importance index (RII) = $\Sigma w / (A \times N)$ - - - , $(0 \leq index \leq 1)$

Where: w = weighting given to each factor by the respondents and ranges from 1 to 5 where 1 is not significant and 5 is extremely significant, A = highest weight (i.e. 5 in this case), and N = a total number of respondents (i.e. in this case 52).

3.1.3 Mann Whitney U test

The Mann Whitney U test is used because the parametric assumptions were not met. It is a nonparametric test to detect whether there is a statistically significant difference exist in the median value of the same factor under study between two respondent groups (SPSS, 2007; Chan *et al.,* 2010).

Rule: If the probability value (p) is not less than or equal to 0.05, therefore the result is not significant. There is no statistically significant divergence in the responses between the two groups (Consultant quantity surveyor and Contractor's quantity surveyor).

4.0 RESULTS AND DISCUSSION

The respondents were asked to rate their perception of the level of effectiveness of material management and waste minimization measures during the post-contract stage. Similarly, they were asked to rate their level of adoption/usage of the key strategies identified on a five-point liker-type scale (1=Very low, 2=Low, 3=Moderate, 4=High, 5= Very high).

4.1 Presentation of Analysis Results

4.1.1 Respondents' demographics

From the survey conducted on the background information of respondents, it was evident that 48.1 per cent are contractor's quantity surveyors and 51.9 per cent are consultant quantity surveyors. 23.1 per cent of the respondents had Higher National Diploma (HND)/ Postgraduate Diploma (PGD), 50 per cent had Bachelor Degree (BSc/ B.Tech) as their highest academic qualification while 26.9 per cent had Masters of Science or Technology (M.Sc./M.Tech). Professionally, 96.1 per cent of the respondents are members of the Nigerian Institute of Quantity Surveyors (MNIQS), with 2(two) fellows (FNIQS) of the Institute representing 3.9 per cent of the respondents. It was also evident that respondents with years of experience within 5 to 10 years represent the major with 40.4 per cent, followed by those with 11 to 15 years with 26.9 per cent, 19.2 per cent and 13.5 per cent for respondents with less than 5years and more than 15years experience respectively. A larger percentage of the respondent has been involved in between 5 to 10 projects representing 30.8 per cent of the respondents, followed by 28.8 per cent,

21.2 per cent and 19.2 per cent for those that have been involved in less than 5projects, between 11 to 15 projects and more than 15 projects respectively. Evidently, the respondents have sufficient professional experience and educational background to give opinions on the subject matter of the study.

Table 2: Perception of Material waste management

4.1.2 Perception of Material waste management

From Table 2, it was observed that all the respondents perceived 'proper storage of materials on site' and 'checking materials quantities supplied for right quantities and volumes' as the most important material management and waste minimization practices during the post-contract stage; as it was accorded a relative importance index value of 0.838. This was also in tandem with the responses of the Consultant quantity surveyors and Contractor's surveyors analyzed separately. Quantification of material waste was deemed as the least important with general RII of 0.654, Consultant QS RII of 0.667 and Contractor QS RII of 0.640.

Table 3: Mann Whitney U test between the consultant QS and the contractor's QS on material management and waste minimization.

Furthermore, the perception of the consultant quantity surveyors and contractor's quantity surveyors was compared to reveal if there is any statistically significant difference between the responses these two groups (Table 3). When the actual calculated p-value is below the prescribed significance level of 0.05, it means there is statistically significant divergence. None of the p-values is less than the significance level of 0.05 as shown in Table 4, meaning that the consultants and contractor's quantity surveyors are in agreement in their responses as to what

material management and waste minimization connotes. This may be because there is no clear compartmentalization between the practices of these groups, as a Consultant QS might have worked as a Contractor's QS before and vice versa. Also, these two groups had the same education training, as there is no difference between the educational training of the Consultant QS and Contractor's QS.

Table 4: Adoption/Usage of Key Strategies by Quantity Surveyors

4.1.3 Adoption/Usage of Key Strategies by Quantity Surveyors

From Table 4, 'supply management' and 'confirmation of actual quantities required on-site prior to ordering' with RII of 0.815 are the most adopted strategies by the Quantity surveyors during the post-contract stage for effective material management and waste minimization. The consultant and contractor's quantity surveyors are in agreement and ranked the aforementioned strategies as the second most important strategies. 'deduction of cost implication of material wasted by the victim' with and 'preparation of cost implication of wasted materials for management decision' are the least adopted measures/ strategies.

Table 5: Mann Whitney U test between the consultant QS and the contractor's QS on adopted strategies for material management and waste minimization.

From Table 5, the perception of the consultant quantity surveyors and contractor's quantity surveyors was compared to reveal if there is any statistically significant difference between the responses these two groups (Table 5). When the actual calculated p-value is below the prescribed significance level of 0.05, it means there is statistically significant divergence. None of the p-

value is less than the significance level of 0.05 except that of "Overseeing storekeeper / store operational officer activities" with p-value of 0.049 as shown in Table 5, meaning that the consultants and contractor's quantity surveyors are in agreement in their responses as to what strategies are being adopted in material management and waste minimization. The significant divergence as regards "Overseeing storekeeper/store operational officer activities" may be as a result of the difference in the practice of these groups which influences their perception; the Contractor's quantity surveyors are mostly on the construction sites and they do work with the storekeepers as compared to the Consultant quantity surveyors who have little or no relationship with the storekeeper.

Table 6: Material management process and measures

4.1.4 Material management process and measures

The measures of material management and waste minimization strategies are grouped into different phases of material management and ranked according to the responses of quantity surveyors (Table 6). In the planning/scheduling process, 'confirmation of actual quantities required on-site prior to ordering', with RII of 0.815 is the most adopted measure, while 'ordering according to contract bill specifications' with RII of 0.758 is the least adopted. For the purchasing/procurement stage of material management, 'supply Management to ensure materials are delivered as at when needed' with RII of 0.815 is considered the most adopted measure while 'Ordering according to budgeted quantities' with RII of 0.769 is the least adopted measure in this stage. 'Monitoring by following up on all activities on site from the office' with RII of 0.808 is the most adopted in handling/usage stage and it is not surprising that the consultant QS who

spent much time in the office ranked it as the most important in this stage. 'Overseeing storekeeper/store operational officer activities' with RII of 0.770 is the most adopted measure in stock control and it is in agreement with the response of the contractor's quantity surveyors who are mostly on site. The two groups (consultant and contractor's quantity surveyors) are in agreement as regards stock control stage.

5.0 Discussion of findings

The study was able to isolate key strategies/measures that are being adopted by the quantity surveyors during the post-contract stage for material management and waste minimization. These measures include ordering of right quantities, ordering the right quality of materials, prior survey of available materials, efficient overseeing in the flow of materials, adequate support and follow up by office function during the material management stages. These are in agreement with Agyekum et al. (2012), Aiyetan (2013), and Eduardo (2002).

Storing of materials in a conducive environment on site, adequate monitoring of supplies and strong communication link between the store and construction personnel to avoid waste are considered the most significant in reducing material waste, while reuse of waste materials and proper documentation of waste are given less consideration. It was also evident that no deduction of cost implication of material waste by the victim(s) is being carried out and that there is no availability of the cost implication of wasted materials for management decision. This is partly due to the relational mode of project governance adopted by Nigerian contracting organizations as opposed to the more contractual mode adopted in developed countries. However, it is of enormous importance for quantity surveyors who are saddled with the cost related to construction to prepare cost implication of material waste during the post-contract

stage as this will be of great benefit to contracting organizations when making managerial decisions. As affirmed by Ogunlana et al (1996), deducting the cost of materials improperly handled from the victim(s) salaries/wages will deter others from handling the materials improperly thereby leading to efficient waste minimization.

Also, since the material waste minimization and management are divided between the office and site; the quantity surveyors were grouped into consultants (who mostly work from office) and contractor's quantity surveyors (who are mostly time on site) and their responses were analyzed and compared. The Mann Whitney U test also shows that there is no statistically significant difference between the responses of these two groups.

6.0 Conclusion

This study assessed the roles of quantity surveyors as regards material waste minimization and management; It would add to the scanty research work in this area. The study has also successfully revealed the strategies that are to be adopted by the quantity surveyors to achieve value for money.

The findings of this study have practical implication for stakeholders in the construction industry. The firms should consider reuse of waste materials on site which would help to reduce their construction cost and quantification of material waste during construction projects should be properly documented as this would be beneficial for key management decisions as regards material management and waste minimization.

The scope of this research to quantity surveyors in Lagos state, Nigeria (a developing country) constitutes a limitation to this study. Nevertheless, the findings can be extrapolated to other states

and developing countries since the roles and responsibilities of the quantity surveyors are similar; and challenges facing the construction industries of these states/countries are similar.

Further research in this area could adopt a case study approach to assess the material management and waste minimization practices and with focus on reuse of waste materials. Also, material waste quantification on construction sites could be carried out.

References

Abdul-Rahman, H. and Alidrisyi, M.N., 1994. A perspective of material management practices in a fast developing economy: the case of Malaysia. *Construction Management and Economics*, *12*(5), pp.413-422.

Agapiou, A., Clausen, L.E., Flanagan, R., Norman, G. and Notman, D., 1998. The role of logistics in the materials flow control process. *Construction management & economics*, *16*(2), pp.131-137.

Agyekum, K., Ayarkwa, J. and Adinyira, E., 2012. Consultants' perspectives on materials waste reduction in Ghana. *Engineering Management Research*, *1*(1), p.138.

Ajanlekoko, J.S., 2001, October. Sustainable housing development in Nigeria-The financial and infrastructural implication. In *international conference on spatial information for sustainable development in Nairobi, Kenya* (pp. 2-5).

Akinkurolere, O.O. and Franklin, S.O., 2005. Investigation into waste management on construction sites in South Western Nigeria. *American Journal of Applied Sciences*, *2*(5), pp.980-984.

Aiyetan, O. and Smallwood, J., 2013. Materials Management and Waste Minimisation on Construction Sites in Lagos State, Nigeria. In *Proceedings of the 4th International Conference on Engineering, Project, and Production Management (EPPM)* (pp. 1161-1172).

Aiyetan, A.O., 2013. Causes of rework on building construction projects in Nigeria. *Interim: Interdisciplinary Journal*, *12*(3), pp.1-15.

Alabi, T.M., Ijigah, E.A., & Saka, A.B. (2018). Appraisal of project scheduling in Nigeria construction industry: A case study of Ibadan, Nigeria. *International Journal of Research,* 19 (05), 851-860.

Arijeloye, B.T. and Akinradewo, F.O., 2016. Assessment of materials management on building projects in Ondo State, Nigeria. *World Scientific News*, *55*, pp.168-185.

ALBERT, I., 2014. *ASSESSMENT OF PROFESSIONAL'S PERCEPTION ON MATERIALS MANAGEMENT PRACTICES ON CONSTRUCTION SITES IN SELECTED STATES IN NIGERIA* (Doctoral dissertation).

Ayegba, C., 2013. An Assessment of Material Management on Building Construction Sites. *Civil and Environmental Research www. iiste. org ISSN*, pp.2224-5790.

BaldvaSurbhi. (1997): Thesis, Material management in construction industry, CEPT

Barrie, D. S., & Paulson, B. C. (1992). *Professional construction management: including CM, design-construct, and general contracting*. McGraw-Hill Science/Engineering/Math.

Bossink, B.A.G. and Brouwers, H.J.H., 1996. Construction waste: quantification and source evaluation. *Journal of construction engineering and management*, *122*(1), pp.55-60.

Chan, D. W., & Kumaraswamy, M. M. (1997). A comparative study of causes of time overruns in Hong Kong construction projects. *International Journal of project management*, *15*(1), 55-63.

Chan, D. W., Chan, A. P., & Choi, T. N. (2010). An empirical survey of the benefits of implementing pay for safety scheme (PFSS) in the Hong Kong construction industry. *Journal of safety research*, *41*(5), 433-443.

Chan, F.T.S., 2002. Design of material handling equipment selection system: an integration of expert system with analytic hierarchy process approach. *Integrated Manufacturing Systems*, *13*(1), pp.58-68.

Dey, P.K., 2001. Re-engineering materials management: A case study on an Indian refinery. *Business Process Management Journal*, *7*(5), pp.394-408.

Formoso, C.T., Soibelman, L., De Cesare, C. and Isatto, E.L., 2002. Material waste in building industry: main causes and prevention. *Journal of construction engineering and management*, *128*(4), pp.316-325.

Formoso, C.T., Isatto, E.L. and Hirota, E.H., 1999, July. Method for waste control in the building industry. In *Proceedings IGLC* (Vol. 7, p. 325).

Eduardo L., 2002. Material waste in building industry: Main causes and prevention. *Journal of Construction Engineering and management*, 12(4),

Formoso, C.T., Isatto, E.L. and Hirota, E.H., 1999, July. Method for waste control in the building industry. In *Proceedings IGLC* (Vol. 7, p. 325).

Gulghane, A.A. and Khandve, P.V., 2015. Management for Construction Materials and Control of Construction Waste in Construction Industry: A Review. *Int. Journal of Engineering Research and Applications*, *5*(4), pp.59-64.

Ilesanmi, O., 1986. Materials Management as a Tool for Enhancing Produc tivity on Selected Building Construction Sites in South-Western Part of Nigeria. *An Unpublished B. Sc Building Dissertation, Obafemi Awolowo University, Ile-Ife, Nigeria*.

Kasim, N.B., 2008. *Improving materials management on construction projects* (Doctoral dissertation, © Narimah Binti Kasim).

Johnston, J. E., 2001, Site Control and Material Handling Storage and Protection, First Edition, Butter Worth Limited, London.

Kasim, N.B., Anumba, C.J. and Dainty, A.R.J., 2005, September. Improving materials management practices on fast-track construction projects. In *21st Annual ARCOM Conference, SOAS, University of London* (Vol. 2, pp. 793-802).

Katz, A. and Baum, H., 2011. A novel methodology to estimate the evolution of construction waste in construction sites. *Waste management*, *31*(2), pp.353-358.

Kini, D.U., 1999. Materials management: The key to successful project management. *Journal of management in engineering*, *15*(1), pp.30-34.

Lan C., 2008, Materials Management on Building site, 1st Edition, London, The construction Press Lancaster.

Lee, S.H., Diekmann, J.E., Songer, A.D. and Brown, H., 1999, July. Identifying waste: applications of construction process analysis. In *Proceedings of the Seventh Annual Conference of the International Group for Lean Construction* (pp. 63-72).

McDonald, H. and Adam, S., 2003. A comparison of online and postal data collection methods in marketing research. *Marketing intelligence & planning*, *21*(2), pp.85-95.

Muehlhausen, F.B., 1991. Construction site utilization: impact of material movement and storage on productivity and cost. *AACE International Transactions*, pp.L2-1.

Nazech, E.M., Zaldi, D. and Trigunarsyah, B., 2008. Identification of construction waste in road and highway construction projects.

Obiegbu, L.Y., 2002. Materials Management on Sites. B.Sc. Thesis submitted to the Department of Surveying, Ahmadu Bello University, Zaria,Nigeria.

Ogunlana, S.O., Promkuntong, K. and Jearkjirm, V., 1996. Construction delays in a fast-growing economy: comparing Thailand with other economies. *International journal of project Management*, *14*(1), pp.37-45.

Olatunji, S. O., Olawumi, T. O., & Aje, I. O. (2017). Rethinking Partnering Among Quantity-Surveying Firms In Nigeria, *Journal of Construction Engineering and Management*, 143(11), 1- 12. http://dx.doi.org/10.1061/(ASCE)CO.1943-7862.0001394

Patel, K.V. and Vyas, C.M., 2011, May. Construction materials management on project sites. In *National Conference on Recent Trends in Engineering & Technology* (pp. 1-5).

Patil, A.R. and Pataskar, S.V., 2013. Analyzing Material Management Techniques on Construction Project. *International Journal of Engineering and Innovative Technology*, *3*(4), pp.96-100.

Payne, A. C., Chelsom, J. V., & Reavill, L. R. (1996). *Management for engineers*. John Wiley & Son Ltd.

Putra, C. C. W., Ahmad, A., Majid, M. A., and Kasim, N., 1999. Improving material scheduling for construction industry in Malaysia. In *Malaysian Science & Technology Congress* 99, pp.6-8.

Shen, L.Y. and Tam, V.W., 2002. Implementation of environmental management in the Hong Kong construction industry. *International Journal of Project Management*, *20*(7), pp.535-543.

Skoyles, E.R., 2000. Material control to avoid waste. *Building Research Establishment Digest London, UK*, *3*(259), pp.1-8.

Tompkins, J A and White, J A. 1984. *Facilities Planning.* New York: John Wiley and Sons.

Wahab, A.B. and Lawal, A.F., 2011. An evaluation of waste control measures in construction industry in Nigeria. *African Journal of Environmental Science and Technology*, *5*(3), pp.246-254.

Wang, R. and Li, S., 2011, March. Talking about the production and disposing of construction waste from the view of sustainable development. In *Power and Energy Engineering Conference (APPEEC), 2011 Asia-Pacific* (pp. 1-4). IEEE.

Zeb, A., Malik, S., Nauman, S., Hanif, H. and Amin, O.S., 2015, June. Factors Affecting Material Procurement, Supply and Management in Building Projects of Pakistan: A Contractor's Perspective. In *International Conference on Innovations in Civil and Structural Engineering held in Istanbul, Turkey. Retrieved from http://urst. org/siteadmin/upload/2209U0615309. pdf*.

482

Table 1: Key strategies used by quantity surveyors in material waste management at the post-contract stage

S/N	Material Management Process	Material Management measures related to Quantity Surveyors	Quantity Surveyors' role
A	Planning / Scheduling	Tight Estimating (Sawant, Hedaoo and Kumthkar, 2016)	Ordering according to budgeted quantities
		Accurate & good specifications of materials to avoid wrong ordering (Agyekum, Ayarkwa, and Adinyira, 2012)	Ordering according to contract bill
		Access to the latest information about types of materials on the market (Agyekum, Ayarkwa, and Adinyira, 2012)	Material Survey
		Purchasing raw materials that are just sufficient (Agyekum, Ayarkwa, and Adinyira, 2012)	Ordering according to budgeted quantities
			Confirmation of actual quantities required on site prior to ordering.
B	Purchasing / Procurement	Checking material quantities supplied for right quantities and volumes (Agyekum, Ayarkwa, and Adinyira, 2012)	Monitoring and receiving deliveries
		Supplier Coordination / Just in time delivery (Sawant, Hedaoo, and Kumthkar, 2016) and (Agyekum, Ayarkwa, and Adinyira, 2012)	Supply Management
		Purchasing raw materials that are just sufficient (Agyekum, Ayarkwa, and Adinyira, 2012)	Ordering according to budgeted quantities
			Confirmation of actual quantities required on site prior to ordering.
C	Handling / Usage	Determine daily allocation of materials to different operations on site (Aiyetan and Smallwood, 2013)	Resource / material allocation on site based on expected usage

		Good coordination between store and construction personnelto avoid over ordering (Agyekum, Ayarkwa, and Adinyira, 2012)	Resource / material allocation on site based on expected usage
		Weekly materials return to be submitted by the head of operation on site. (Aiyetan and Smallwood, 2013)	Data Base monitoring by office function
		Employing competent & trustworthy hands (Aiyetan and Smallwood, 2013)	Subcontract management
		Weekly monitoring of material usage (Formoso, Isatto and Hirato, 1999)	Monitoring of budgeted and actual material usage
		Quantification of variability of waste rate (Formoso, Isatto and Hirato, 1999)	Preparation of Cost Implication of wasted materials for management decision
		Accurate measurement of materials during batching	
		Weekly programming of works (Agyekum, Ayarkwa, and Adinyira, 2012)	Site Planning
			Monitoring of activities on site
		Careful handling of tools and equipment on site (Agyekum, Ayarkwa, and Adinyira, 2012)	
		Encourage re-use of waste materials in projects (Agyekum, Ayarkwa, and Adinyira, 2012)	Deduction of cost implication of material wasted by the victim
D	Stock Control	Taking Inventory of material before use (Aiyetan and Smallwood, 2013)	Overseeing storekeeper / store operational officer activities
		Monitoring of Physical quantity of inventories weekly (Formoso, Isatto and Hirato, 1999)	Data Base Monitoring by Office function
			Overseeing storekeeper/store operational officer activities

	Proper storage of materials on site (Agyekum, Ayarkwa, and Adinyira, 2012)	Overseeing storekeeper/store operational officer activities

Table 2: Perception of Material waste management

Material management and Waste Minimization	ALL		Consultant QS		Contractor's QS	
	RII	Rank	RII	Rank	RII	Rank
Proper storage of materials on site	0.838	1	0.837	1	0.84	1
Checking material quantities supplied for right quantities and volumes	0.838	1	0.837	1	0.84	1
Good coordination between store and construction personnel to avoid over ordering.	0.8	3	0.793	5	0.808	3
Taking Inventory of material before use	0.788	4	0.807	4	0.768	6
Accurate & good specifications of materials to avoid wrong	0.781	5	0.822	3	0.736	9
Determine daily allocation of materials to different operations on site	0.777	6	0.77	6	0.784	4
Supplier coordination	0.758	7	0.756	8	0.76	7
Access to latest information about types of materials on the	0.746	8	0.719	11	0.776	5
Monitoring of physical quantity of inventories weekly	0.746	8	0.756	8	0.736	9
Precise Estimating	0.731	10	0.748	10	0.712	13
Accurate measurement of materials during batching	0.727	11	0.763	7	0.688	15
Weekly programming of works	0.719	12	0.696	12	0.744	8
Careful handling of tools and equipment on site	0.715	13	0.696	12	0.736	9

Purchasing raw materials that are just sufficient.	0.712	14	0.689	15	0.736	9
Encourage re-use of waste materials in projects	0.692	15	0.696	12	0.688	15
Weekly materials return to be submitted by the head of operation on site.	0.692	15	0.674	16	0.712	8
Quantification of material waste	0.654	17	0.667	17	0.64	17

Table 3: Mann Whitney U test between the consultant QS and the contractor's QS on material management and waste minimization.

Material Minimization and Waste Management	Mean Rank		Z	P value
	Contractor's QS	Consultant QS		
Precise Estimating	24.340	28.500	-1.027	0.304
Accurate & good specifications of materials to avoid wrong	24.240	28.590	-1.088	0.277
Access to latest information about types of materials on the	28.680	24.480	-1.043	0.297
Purchasing raw materials that are just sufficient.	28.040	25.070	-0.741	0.458
Checking material quantities supplied for right quantities and volumes	26.040	26.930	-0.229	0.819
Supplier coordination	27.200	25.850	-0.348	0.728
Determine daily allocation of materials to different operations on site	26.220	26.760	-0.134	0.893
Good coordination between store and construction personnel to avoid over ordering.	27.140	25.910	-0.313	0.754
Weekly materials return to be submitted by the head of operation on site	27.780	25.310	-0.605	0.545
Quantification of material waste	25.520	27.410	-0.467	0.640
Accurate measurement of materials during batching	23.980	28.830	-1.196	0.232
Weekly programming of works	27.500	25.570	-0.472	0.637
Careful handling of tools and equipment on site	27.440	25.630	-0.449	0.653

Encourage re-use of waste materials in projects	26.400	26.590	-0.480	0.962
Taking Inventory of material before use	25.280	27.630	-0.588	0.557
Monitoring of physical quantity of inventories weekly	25.580	27.350	-0.437	0.662
Proper storage of materials on site	25.820	27.130	-0.334	0.738

Table 4: Adoption/Usage of Key Strategies by Quantity Surveyors

Strategies	ALL		Consultant QS		Contractor's QS	
	RII	Rank	RII	Rank	RII	Rank
Supply Management to ensure materials are delivered as at when needed	0.815	1	0.8	2	0.832	2
Confirmation of actual quantities required on site prior to ordering.	0.815	1	0.8	2	0.832	2
Monitoring by following up on all activities on site from the office	0.808	3	0.83	1	0.784	9
Monitoring and receiving deliveries	0.8	4	0.756	9	0.848	1
Subcontract management to ensure competent hands are engaged	0.796	5	0.785	5	0.808	5
Material allocation on site based on expected usage	0.788	6	0.785	5	0.792	8
Site Planning to ensure materials needed for all tasks are well known ahead	0.785	7	0.793	4	0.776	10
Overseeing storekeeper / store operational officer activities	0.777	8	0.726	12	0.832	2
Ordering according to budgeted quantities	0.769	9	0.763	11	0.808	5
Material Survey prior to ordering	0.765	10	0.756	9	0.776	10
Data Base monitoring of budgeted and actual material usage in the office	0.762	11	0.77	7	0.752	12
Data Base periodic monitoring of materials in store	0.762	11	0.719	13	0.808	5
Ordering according to contract bill specifications	0.758	13	0.733	8	0.808	5
Deduction of cost implication of material wasted by the victim	0.692	14	0.644	15	0.744	14
Preparation of Cost Implication of wasted materials for management decision	0.677	15	0.68	14	0.672	15

Table 5: Mann Whitney U test between the consultant QS and the contractor's QS on adopted strategies for material management and waste minimization.

Strategies	Mean Rank		Z	P value
	Site	Consultant		
Ordering according to contract bill specifications	25.780	27.170	-0.346	0.730
Material Survey prior to ordering	26.720	26.300	-0.105	0.916
Confirmation of actual quantities required on site prior to ordering.	26.880	26.150	-0.187	0.852
Monitoring and receiving deliveries	29.540	23.690	-1.472	0.141
Supply Management to ensure materials are delivered as at when needed.	27.680	25.410	-0.579	0.562
Ordering according to budgeted quantities	29.100	24.090	-1.262	0.207
Material allocation on site based on expected usage	26.280	26.700	-0.106	0.916
Subcontract management to ensure competent hands are engaged.	27.000	26.040	-0.244	0.807
Data Base monitoring of budgeted and actual material usage in the office	25.140	27.760	-0.654	0.513
Preparation of cost implication of wasted materials for management decision	25.680	27.260	-0.391	0.696
Site Planning to ensure materials needed for all tasks are well known ahead	25.580	27.350	-0.443	0.658
Monitoring by following up on all activities on site from the office	24.820	28.060	-0.817	0.414
Deduction of cost implication of material wasted by the victim	29.600	23.630	-1.476	0.140
Overseeing storekeeper / store operational officer activities	30.520	22.780	-1.969	0.049
Data Base periodic monitoring of materials in store	29.260	23.940	-1.387	0.165

Table 6: Material management process and measures

	Material management process	ALL		Contractor's QS		Consultant QS	
	Planning / Scheduling Process	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**
A	Confirmation of actual quantities required on site prior to ordering.	0.815	1	0.832	1	0.800	1
	Material Survey prior to ordering	0.765	2	0.776	3	0.756	2
	Ordering according to contract bill specifications	0.758	3	0.808	2	0.733	3
	Purchasing/ Procurement	**RII**	**Rank**				
B	Supply Management to ensure materials are delivered as at when needed	0.815	1	0.832	2	0.800	1
	Monitoring and receiving deliveries	0.800	2	0.840	1	0.756	3
	Ordering according to budgeted quantities	0.769	3	0.808	3	0.763	2
	Handling/ Usage	**RII**	**Rank**				
C	Monitoring by following up on all activities on site from the office	0.808	1	0.784	4	0.830	1
	Subcontract management to ensure competent hands are engaged.	0.796	2	0.808	1	0.785	3
	Material allocation on site based on expected usage	0.788	3	0.792	3	0.785	3
	Site Planning to ensure materials needed for all tasks are well known ahead	0.785	4	0.776	5	0.793	2
	Data Base monitoring of budgeted and actual material usage in the office	0.762	5	0.808	1	0.770	5
	Deduction of cost implication of material wasted by the victim	0.692	6	0.744	6	0.644	7
	Preparation of Cost Implication of wasted materials for management decision	0.677	7	0.672	7	0.680	6
	Stock Control	**RII**	**Rank**				
D	Overseeing storekeeper / store operational officer activities	0.777	1	0.832	1	0.726	1
	Data Base periodic monitoring of materials in store	0.762	2	0.800	2	0.719	2