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

<table>
<thead>
<tr>
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<tbody>
<tr>
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<td>Manuscript Type:</td>
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<tr>
<td>Keywords:</td>
<td>Quantity Surveyors, Material management, Waste minimization, Post-Contract, Construction project management</td>
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</tbody>
</table>
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 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-

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:

\[
\text{Relative importance index (RII)} = \frac{\Sigma w}{(A \times N)} - - - , (0 \leq \text{index} \leq 1)
\]

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 5 years and more than 15 years 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,
247 21.2 per cent and 19.2 per cent for those that have been involved in less than 5 projects, between
248 11 to 15 projects and more than 15 projects respectively. Evidently, the respondents have
249 sufficient professional experience and educational background to give opinions on the subject
250 matter of the study.

251 Table 2: Perception of Material waste management

252 4.1.2 Perception of Material waste management

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

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

262 Furthermore, the perception of the consultant quantity surveyors and contractor’s quantity
263 surveyors was compared to reveal if there is any statistically significant difference between the
264 responses these two groups (Table 3). When the actual calculated p-value is below the prescribed
265 significance level of 0.05, it means there is statistically significant divergence. None of the p-
266 values is less than the significance level of 0.05 as shown in Table 4, meaning that the
267 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.

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

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

Careful handling of tools and equipment on site (Agyekum, Ayarkwa, and Adinyira, 2012) | Monitoring of activities on site

Encourage re-use of waste materials in projects (Agyekum, Ayarkwa, and Adinyira, 2012) | Deduction of cost implication of material wasted by the victim

| 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>
<thead>
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<th>Material management and Waste Minimization</th>
<th>ALL</th>
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<th>Contractor's QS</th>
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<td>Proper storage of materials on site</td>
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<td>0.84</td>
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<td>Checking material quantities supplied for right quantities and volumes</td>
<td>0.838</td>
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<td>Good coordination between store and construction personnel to avoid over ordering.</td>
<td>0.8</td>
<td>0.793</td>
<td>0.808</td>
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<td>Taking inventory of material before use</td>
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<td>Accurate &amp; good specifications of materials to avoid wrong</td>
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<td>Determine daily allocation of materials to different operations on site</td>
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<td>0.776</td>
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<td>Monitoring of physical quantity of inventories weekly</td>
<td>0.746</td>
<td>0.756</td>
<td>0.736</td>
</tr>
<tr>
<td>Precise Estimating</td>
<td>0.731</td>
<td>0.748</td>
<td>0.712</td>
</tr>
<tr>
<td>Accurate measurement of materials during batching</td>
<td>0.727</td>
<td>0.763</td>
<td>0.688</td>
</tr>
<tr>
<td>Weekly programming of works</td>
<td>0.719</td>
<td>0.696</td>
<td>0.744</td>
</tr>
<tr>
<td>Careful handling of tools and equipment on site</td>
<td>0.715</td>
<td>0.696</td>
<td>0.736</td>
</tr>
</tbody>
</table>
Purchasing raw materials that are just sufficient. Encourage re-use of waste materials in projects. Weekly materials return to be submitted by the head of operation on site. Quantification of material waste.

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

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

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

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Mean Rank</th>
<th>Z</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordering according to contract bill specifications</td>
<td>25.780</td>
<td>27.170</td>
<td>0.346</td>
</tr>
<tr>
<td>Material Survey prior to ordering</td>
<td>26.720</td>
<td>26.300</td>
<td>0.105</td>
</tr>
<tr>
<td>Confirmation of actual quantities required on site prior to ordering.</td>
<td>26.880</td>
<td>26.150</td>
<td>0.187</td>
</tr>
<tr>
<td>Monitoring and receiving deliveries</td>
<td>29.540</td>
<td>23.690</td>
<td>1.472</td>
</tr>
<tr>
<td>Supply Management to ensure materials are delivered as at when needed.</td>
<td>27.680</td>
<td>25.410</td>
<td>0.579</td>
</tr>
<tr>
<td>Ordering according to budgeted quantities</td>
<td>29.100</td>
<td>24.090</td>
<td>1.262</td>
</tr>
<tr>
<td>Material allocation on site based on expected usage</td>
<td>26.280</td>
<td>26.700</td>
<td>0.106</td>
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<tr>
<td>Subcontract management to ensure competent hands are engaged.</td>
<td>27.000</td>
<td>26.040</td>
<td>0.244</td>
</tr>
<tr>
<td>Data Base monitoring of budgeted and actual material usage in the office</td>
<td>25.140</td>
<td>27.760</td>
<td>0.654</td>
</tr>
<tr>
<td>Preparation of cost implication of wasted materials for management decision</td>
<td>25.680</td>
<td>27.260</td>
<td>0.391</td>
</tr>
<tr>
<td>Site Planning to ensure materials needed for all tasks are well known ahead</td>
<td>25.580</td>
<td>27.350</td>
<td>0.443</td>
</tr>
<tr>
<td>Monitoring by following up on all activities on site from the office</td>
<td>24.820</td>
<td>28.060</td>
<td>0.817</td>
</tr>
<tr>
<td>Deduction of cost implication of material wasted by the victim</td>
<td>29.600</td>
<td>23.630</td>
<td>1.476</td>
</tr>
<tr>
<td>Overseeing storekeeper / store operational officer activities</td>
<td>30.520</td>
<td>22.780</td>
<td>1.969</td>
</tr>
<tr>
<td>Data Base periodic monitoring of materials in store</td>
<td>29.260</td>
<td>23.940</td>
<td>1.387</td>
</tr>
</tbody>
</table>
Table 6: Material management process and measures

<table>
<thead>
<tr>
<th>Material management process</th>
<th>ALL</th>
<th>Contractor’s QS</th>
<th>Consultant QS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Planning / Scheduling Process</strong></td>
<td>RII</td>
<td>Rank</td>
<td>RII</td>
</tr>
<tr>
<td><strong>A</strong> Confirmation of actual quantities required on site prior to ordering.</td>
<td>0.81</td>
<td>5</td>
<td>0.83</td>
</tr>
<tr>
<td>Material Survey prior to ordering</td>
<td>0.76</td>
<td>5</td>
<td>0.77</td>
</tr>
<tr>
<td>Ordering according to contract bill specifications</td>
<td>0.75</td>
<td>8</td>
<td>0.80</td>
</tr>
<tr>
<td><strong>B</strong> Supply Management to ensure materials are delivered as at when needed</td>
<td>0.81</td>
<td>5</td>
<td>0.83</td>
</tr>
<tr>
<td>Monitoring and receiving deliveries</td>
<td>0.80</td>
<td>9</td>
<td>0.84</td>
</tr>
<tr>
<td>Ordering according to budgeted quantities</td>
<td>0.76</td>
<td>3</td>
<td>0.80</td>
</tr>
<tr>
<td><strong>C</strong> Monitoring by following up on all activities on site from the office</td>
<td>0.80</td>
<td>8</td>
<td>0.78</td>
</tr>
<tr>
<td>Subcontract management to ensure competent hands are engaged.</td>
<td>0.79</td>
<td>6</td>
<td>0.80</td>
</tr>
<tr>
<td>Material allocation on site based on expected usage</td>
<td>0.78</td>
<td>8</td>
<td>0.79</td>
</tr>
<tr>
<td>Site Planning to ensure materials needed for all tasks are well known ahead</td>
<td>0.78</td>
<td>5</td>
<td>0.77</td>
</tr>
<tr>
<td>Data Base monitoring of budgeted and actual material usage in the office</td>
<td>0.76</td>
<td>2</td>
<td>0.80</td>
</tr>
<tr>
<td>Deduction of cost implication of material wasted by the victim</td>
<td>0.69</td>
<td>6</td>
<td>0.74</td>
</tr>
<tr>
<td>Preparation of Cost Implication of wasted materials for management decision</td>
<td>0.67</td>
<td>7</td>
<td>0.67</td>
</tr>
<tr>
<td><strong>D</strong> Overseeing storekeeper / store operational officer activities</td>
<td>0.77</td>
<td>7</td>
<td>0.83</td>
</tr>
<tr>
<td>Data Base periodic monitoring of materials in store</td>
<td>0.76</td>
<td>2</td>
<td>0.80</td>
</tr>
</tbody>
</table>

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