International Journal of Scientific Research and Management (IJSRM)
||Volume||11||Issue||09||Pages||47-58||2022||
Website: https://ijsrm.net ISSN (e): 2321-3418
DOI: 10.18535/ijsrm/v11i9.cs01

The Impact of Materials Management on Waste Minimization on Ghanaian Construction Sites in the Volta and OTI Regions of Ghana

[1]Godfred Tsotorvor, [2]Frank Bentum Mensah, [3]Francis Kodwo Fordjour, [4]Engr.Michael Tsorgali

[1]Department of Building & Construction Technology,Kpando Technical Institute.
[2]Department of Technical Education, Komenda College of Education
[3]Department of Technical Education,Komenda College of Education
[4]Department of Construction and Wood Technology Education,
Akenten Appiah Minkah University of Skill Training and Entrepreneurial Development (AAMUSTED)

Abstract:
Minimizing waste of materials on the construction sites contributes greatly to the general cost of the building the result of improper supervision on sites towards storage, handling and usage of materials. However, the cost of providing building materials required to complete any construction project is greatly high perhaps amounting to 55%-60% of the tender figure. The research was aimed at ensuring effective and efficient storage and handling of construction materials at construction sites in Volta and Oti Regions to ensure waste minimization harnessed with the needed productivity, in relation to construction material management.

To effectively carry out this project, a survey method through the use of techniques such as questionnaire, observation and interviews were undertaken to actually determine what took place on the construction site in terms of material management that is storage and handling of materials on construction sites. Population for the study covered 25 construction companies in both Volta and Oti Regions. Quota sampling technique was adopted to distribute questionnaires to 200 respondents and stratified random sampling techniques for selection of 50 operatives on sites visited. Furthermore, interviews were conducted for 15 interviewees and also 35 operatives were observed. The method used to analyze the data was descriptive statistics in percentiles through the use of tables and charts. The results shows that, building materials are not properly kept, space allocated for material storage was not enough, poor transportation of materials to site, inadequate record keeping among others. It is hereby recommended that Contractors, Site Supervisors and Storekeepers in the construction industries needs adequate education on the technical knowhow of material storage and handling on site. Prompt delivery of material on sites, good documentations and transportation of materials, coupled with proper supervision during batching and mixing of building materials, and finally, appropriate site layout plans mostly showing location of building and also space allocated for material storage should be applied on most Ghanaian construction sites.

Keywords - Material Management, Construction Waste, Management techniques, Economic Relevance, Existing Situation.

Introduction

Construction material comprises an extensive cost component in any construction work. The cost of materials constitutes about 50% to 70% of the total cost of any project depending on the type of projects (Gulghane & Khandve 2015; Patil & Pataskar 2013). Also materials handling has not received much attention from researchers over the year (Donyavi & Flanagan 2009). These studies stated that materials should be readily available at the points where they are needed so as to increase the successful completion of the construction work within the minimum possible time.

Many studies proposed various kinds of definitions for construction material management or administration. Thus, Kanimozhi and Latha (2014), define materials administration as a process of planning, executing and controlling field and office activities during construction. Zeb *et al*., (2015), also, another study define material management as a procedure for executing, planning, and controlling construction site activities in the course of the project(s). Donyavi and Flanagan (2009) divide material administration into five categories namely, measurement and specification, procurement and purchasing process where the product is transmitted to the supplier, delivery to site and logistics of checking the item, off-loading, and storage, administrative and financial process of payment and using the materials in production on the job site and removing the waste. Materials management system also attempt to ensure that the quality and quantity of materials are selected in accordance with the right requirement, purchased, delivered and handled on site in a timely and at a moderate cost.

One of the serious problems in construction industry is material waste. This refers to the difference between the estimated and actual consumption of an individual item. Donyavi and Flanagan (2009), stated that common problems associated with material administration on construction site includes; failure to order construction materials on time which delays the projects, non-delivery of materials on time which interrupts the work schedule, over purchasing, ordering wrong materials or error in direction of materials requiring re-work, stealing of materials meant for production and double handling of materials because of inadequate material.

The advantages of materials management/administration systems are important and there is need for an integrated material handling procedure from the design stage to the usage of materials on sites for fast-track and timely projects delivery (Kasim & Anumba, 2005). Quite apart from responding to the need for infrastructural accommodation and industrial facilities, its development has also been suggested as the key to economic development for most developing countries (Griffith & Sidwell 1995). It is of a turn that material makes up the infrastructure and needed a proper structured storage system. From analysis and experience, it has been observed that material use on construction site account for the largest proportion of the contract sum of a project. About 60% of the contract sum, according to working paper on the national policy for the manufacturers of indigenous building material and their utilization, material storage and handling ought to be critically considered in planning and organization of construction site (Mulcahy ,1999).

Research indicates a wide variation in wastage rates of between 5%-27% of total materials purchased for construction projects in Ghana (Kpama & Ajei-Kumi 2012). The effects of construction materials waste generation on site include; increased cost of construction and delay in completion (Gulghane & Khandve 2015; Patil & Pataskar 2013). The current liberal global economic order makes it challenging for Ghanaian building industries to remain competitive worldwide. The industry must therefore strive to deliver valuable products and services at the minimum possible cost for their customers in order to remain in the business. In order to achieve minimum cost in construction, the Ghanaian building industry must appreciate the difference between waste and value and how to eliminate waste in the projects which are carried out. Therefore, this study was carried out to explore the relationship between different material management processes practice and project delivery in terms of cost overrun and delay.

Review of Related Literature

Material management in construction project

Material management involves the logistics of the materials component for a supply chain which involves the process of planning, implementing and controlling of the movement and storage of raw materials, work-in-process inventory (Felea & Albăstroiu, 2013). The management of materials should be considered from the phases of the construction process and throughout the construction period. Generally, construction materials are bulky, expensive and are supplied in large amounts to construction sites according to (Kasim, 2008). Bailey and Farmer (1982), define material management as a concept concerned with the management of materials until the materials have been used and converted into the final product. Activities include; cooperation with designers, purchasing, receiving, storage, quality control, inventory control, and material control.

Gossom (1983), indicates that a material management system should have standard procedures for planning, expediting, transportation, receipt, and storage to ensure an efficient system for materials control. Cavinato (1984), states that material management involves the control of the flow of goods in a firm. It is the combination of purchasing with production, distribution, marketing and finance. Construction materials

consist of various raw materials extracted from different markets. Sadly, the prices and availability of these materials are highly vulnerable to the turbulences of the varying market conditions (Christopher, 2011). Thereby making the construction materials a highly uncertain component in the construction project. Below is a typical materials management in contraction in Figure 2.1.

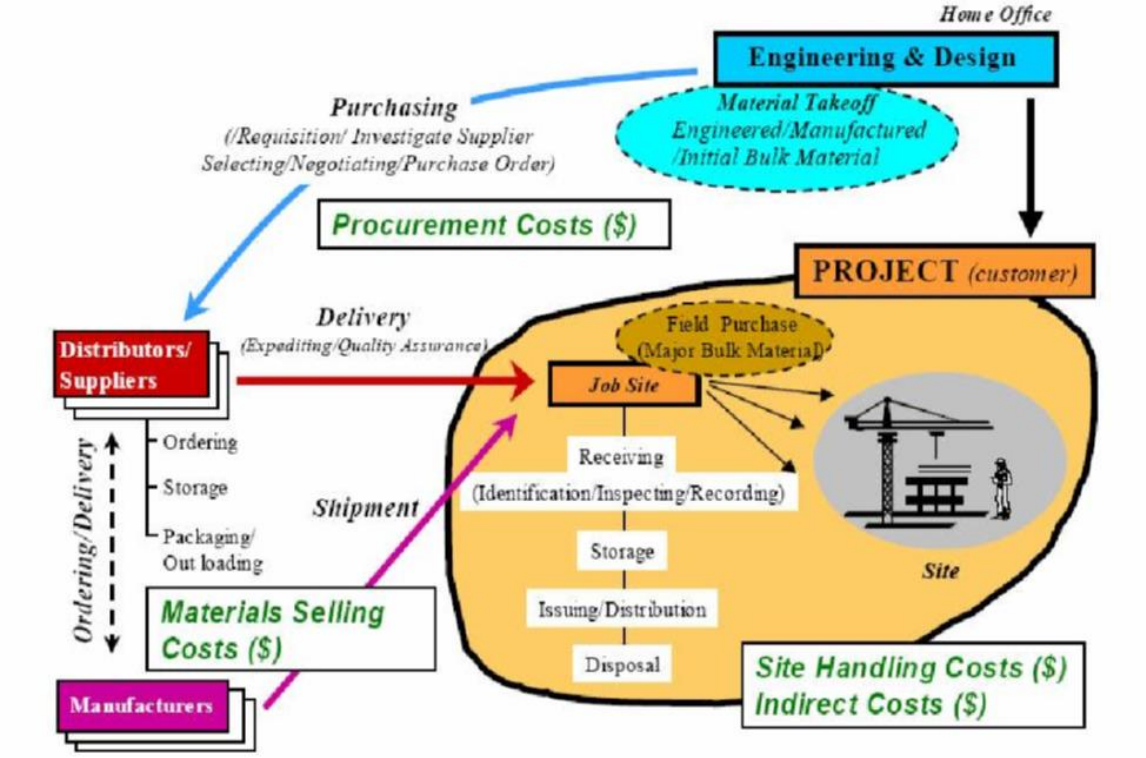

Figure 2.1: Typical Materials Management in Construction (Source: Thabet, 2001)

Importance of Materials for a Project

Problems related to managing the flow of materials can be found in every organization. The efficient management of materials plays a key role in the successful completion of a project. The control of materials is a very important and vital subject for every company and should be handled effectively for the successful completion of a project. Materials account for a big part of products and project cost. The cost represented by materials fluctuates and may comprise between 20-50% of the total project cost and sometimes more. Some studies concluded that materials account for about 50-60% of the project cost (Stukhart, 1995 and Bernold and Treseler, 1991). Provisions should be made to handle and store the materials adequately when they are received. Special attention should be given to the flow of materials once they are procured from suppliers. It is obvious that materials should be obtained at the lowest cost possible to provide savings to the company (Damodara, 1999).). In the late 1970's, construction companies experienced an increase in costs and a decrease in productivity. Owners of these companies thought that these increases in cost were due to inflation and economic problems. Further research concluded that these companies were not using their resources efficiently and that the decrease in productivity was also attributable to poor management (Stukhart, 1995). Material management has been an issue of concern in the construction industry. 40% of the time lost on site can be attributed to bad management, lack of materials when needed, poor identification of materials and inadequate storage (Baldwin et. al, 1994).

Better material management practices could increase efficiency in operations and reduce overall cost. Top management is paying more attention to material management because of material shortages, high interest rates, rising prices of materials, and competition. There is a growing awareness in the construction industry that material management needs to be addressed as a comprehensive integrated management activity.

Benefits of Material Management

An effective material management system can bring many benefits to a company. Previous studies by the Construction Industry Institute (CII) concluded that labor productivity could be improved by six percent and can produce 4-6% additional savings (Bernold & Treseler, 1991). Among these benefits are:

i. Reducing the overall costs of materials
ii. Better handling of materials
iii. Reduction in duplicated orders
iv. Materials will be on site when needed and in the quantities required
v. Improvement in labor productivity
vi. Improvement in project schedule
vii. Quality control
viii. Better field material control
ix. Better relations with suppliers
x. Reduce of material surplus
xi. Reduce storage of materials on site
xii. Labor savings
xiii. Stock reduction
xiv. Purchase savings
xv. Better cash flow management

From a study of twenty heavy construction sites, the following benefits from the introduction of materials management systems were noted (Stukhart & Bell, 1987):

i. In one project, a 6% reduction in craft labor costs occurred due to the improved availability of materials as needed on site. On other projects, an 8% savings due to reduced delay for materials estimated.
ii. A comparison of two projects with and without a material management system revealed a change in productivity from 1.92 man-hours per unit without a system to 1.14 man-hours per unit with a new system. Again, much of this difference can be attributed to the timely availability of materials.
iii. Warehouse costs were found to decrease 50% on one project with the introduction of improved inventory management, representing a savings of $ 92,000. Interest charges for inventory also declined, with one project reporting a cash flow savings of $ 85,000 from improved material management.

Against these various benefits, the cost of acquiring and maintaining a material management system has to be compared. However, management studies suggest that investment in such systems can be quite beneficial.

Material Management Steps

There are several steps within the scope of material management and each of these steps can give rise to potential problems. The more the responsibility is divided, the more potential problems that exist. Figure 2.1 shows the steps in material management and the pertinent action related to these steps. Some actions are described in terms of the documentation produced, such as receiving report and vendor data (Ahuja et al, 1994) as numerated in Table 2.1

Table 2.1: Material Management steps (Ahuja et al, 1994)

Sequence	Contribution action
1-RFQ (Requisition)	Drawings, specifications. Material bills Terms and conditions
2-Bids	Approved bidders list Pre-qualification of bidders Bid evaluations
3-P.O. (Purchase Order)	Bid clarification Notice of award
4-Expediting	Vender data Manufacturer inspection Delivery

	Routings
5-Transport	Carrier and route Ownership en route Custom
6-Receiving	Inspection and acceptance Receiving report Storage
7-Inventory	Dispersal (i.e. material handling) Inventory level

Stock and waste control

Material waste is a significant factor in construction cost, Calkins (2009), states material waste is 9% by weight in the Dutch construction industry and 20-30% of purchased materials in the Brazilian construction industry. Material waste are caused by several sources such as design, procurement, material handling, and operation and so on. Shen et al (2003), defined building material wastages as the difference between the value of materials delivered and accepted on site. Moreover, material waste has been recognized as a major problem in the construction industry and it can also implicate inefficiency in project delivery. Adopting a proper stock control will help to increase the productivity and also can be one of the ways to improve waste control in the construction site. By introducing minimizing strategies to reuse materials in both design and construction phase can be a means to reduce waste (Dainty & Brooke, 2004).

Some authors simplify these stages into distinctive phases. As a matter of fact, one of the researches done by Manteau (2007), on the material management practices in Ghana explains that the current material management phases in Ghanaian construction industry are bidding phase, sourcing phase, material procurement phase, construction phase and post construction phase. A study conducted in India by Patel and Vyas (2011) has summarized the material management processes into 8 main parts. They were planning, benchmarking, purchasing, receiving, inspection, storage, issuing material and inventory control.

Therefore, it is very evident that in various countries these processes are carried out in different ways. There can be many factors that might influence these processes such as culture, work environment, belief and so on. Moreover, different groups have learnt to deal with uncertainty in different ways, often because they find themselves faced with different levels of uncertainty. Adams (1965), writes on 'risk thermostat in relation to individuals' ability to deal with comfortability when exposed to risk. Therefore, already established material management processes that are being practiced by other countries can be used to identify the processes that are being practiced and those that are neglected in the Ghana construction industry.

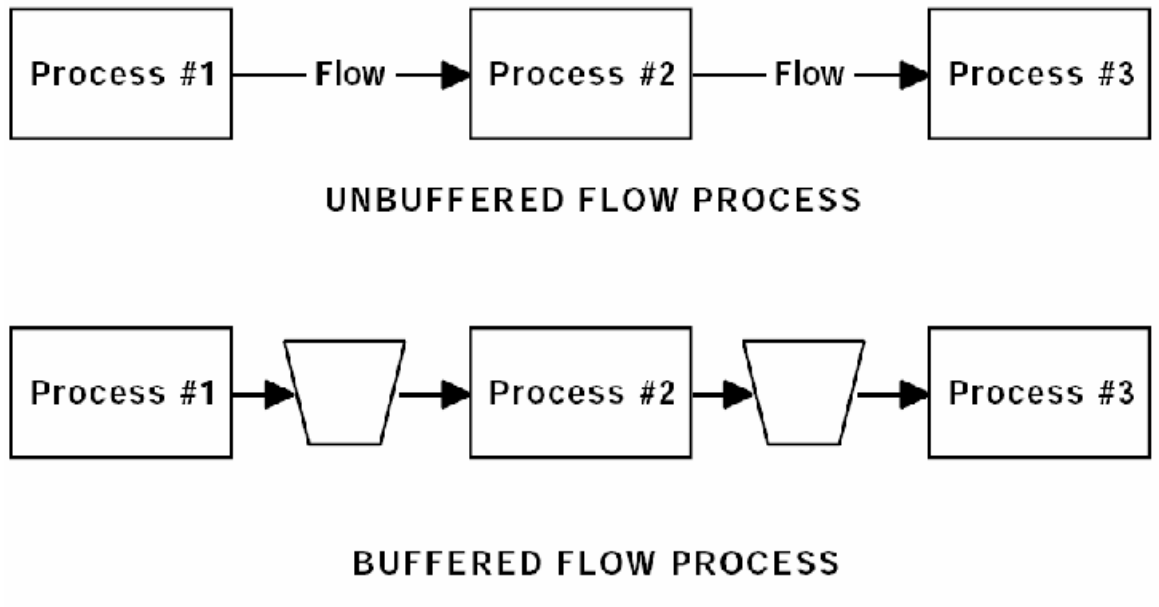

Figure 2.6: Types of construction buffers (Howell et. al., 1994)

Material Storage and Protection

The major resources on site are materials, personnel and plant, Ultimate responsibility for their control lies with the site manger but he will delegate the responsibility to resource managers to cover each sector. Materials are likely to be supervised by the store personnel and the assistant site manager (Greeno, 1986).
Walter (1984), defined material storage as, the provision of adequate space, protection and control for building materials and components held on site during the construction process. This is a more important element where material wastage can increase substantially if care is not exercised in the selection of suitable points.
Pre-planning is essential and the site supervisor who fails in this and decides where to store materials when they have already arrived on-site is not operating in the way for which he/she was employed. The failure in this case would cause a great damage to the company in terms of material and quality of work.
At commencement of a contract, a site Layout Plan should be drawn up to outline the construction working areas and to show all the site faculties (huts etc) and materials storage areas which are codified for the various key bulk or valuable materials. A storage compound layout would also serve to highlight to everyone concerned where the various delivered materials are to be place for safe keeping. This will ensure that if the site supervisor is occupied when there is a delivery, other supervisors, store men etc, may be able to direct the delivery drivers to appropriate unloading points by referring to the site Layout Plan retained in the main site office. This will prevent double handling of material when the delivery drivers are directed to the correct points.
Moreover, any storage facility required for any particular building material will depend upon the following factors in order to allocate appropriate place for the type and the rate of use of materials.

Methodology

Mixed methods strategy was adopted as the research strategy which involved the combination of both quantitative and qualitative methods into a single study in order to provide a broader and more complete vision of a problem. A cross-sectional survey design was employed as the research design for the study. This is a type of observational study, or descriptive research that involves analyzing information about a population at a specific limited point in time as expected in an academic work. It aims to describe a variable, but not to measure it. Descriptive research design is a theory-based design, where the researcher is primarily interested in describing the topic that is the subject of the research. It is applied to case studies, naturalistic observations and surveys. This was undertaken to actually observe what took place on the construction site in terms of material management, that is storage and handling in the Volta and Oti Regions of Ghana. The advantages of the survey technique are; reduction in cost, help cover larger population and quick way of obtaining reliable information. This type of approach is the most comprehensive and systematic one that could produce a reliable result for the research.

Results and Discussion From Observation

The research was carried out at a number of construction Sites to ascertain the first-hand information about selected areas in the Volta/Oti Region as indicated in the observation guide and things to be observed. The results from observation revealed that the key materials, which are wasted most on construction sites, are concrete, cement, coarse aggregate, sand reinforcement steel, formwork, bricks and HCB (blocks). During the visit, a number of revelations were made and below are discussion on some relevant ones.

Results of Observation at Ho construction sites on storage of blocks

Blocks are most commonly used as walling materials on building construction sites. Observations made during a visit to construction sites in Ho and its environs showed that many of these blocks are not properly stored on site; typical evidence shown in Figure 4.1 and Figure 4.2.

Figure 4.1: Wastage of CHB on building construction sites due to poor handling at Ho-Poly. Source: Field research

Figure 4.2: Wastage of HCB on building construction sites due to change orders at Ho-Poly. Source: Field research

Results of Observation on construction sites on storage of Steel reinforcement (Iron Rods) at Hohoe

Steel reinforcement bars are common materials used in building. Controlling the use of steel reinforcement in building sites is relatively difficult because it is cumbersome to handle due to its weight and shape. Observations Shown that the, main causes of wastage of steel are as a result of cutting, damages during storage and design change in Figure 4.3.

Figure 4.3: wastage of steel reinforcement bar due to Non- optimized cutting of bars and design change.
Source: Field research

Results of Observation at construction sites on handling and storage of Concrete making materials at Jasikan

Observation has revealed that storage of concrete making materials on construction sites is a major problem. Some of these materials are not stored appropriately resulting in the severe wastage of materials on site. Coarse and fine aggregates and cement should be properly stored, batched, and handled to maintain the quality of the resulting concrete as presented in the photographs in Figure 4.4.

Figure 4.4: Poor handling of fine aggregates (sand) on construction sites Jasikan
Source: Field research

Observation revealed that both fine and coarse aggregates materials are stored at the same platform shown in Figure 4.4 which eventually mixed up due to lack of mechanism to protect or divide them.

If the aggregate that are not properly stored, it will limit the strength of the concrete work on a building project, it could also affect the durability and structural performance of the building. Aggregates should be stored where it will not have direct contact with the lateritic soil, which may reduce the quality of the concrete or cause void on the surface of the concrete. Common problems in storing aggregates:

- Segregation of aggregate (example: large particles of aggregate roll down the side of a tall cone pile)
- Degradation of aggregate (example: end loaders or trucks on pile crush the aggregate)

- Contamination of materials by deleterious substances (example: trucks track clay and mud onto aggregate)
- incompatible or undesirable moisture content (example: materials are not wetted or allowed to drain properly)

Figure: 4.5 Poor handling of Coarse aggregate on construction site at Jasikan
Source: Field research

Results of Observation made on construction sites on wastage arising from mixing and transportation of concrete on site at Aflao

Moreover, it was also revealed that most firms' encounters damage of materials during delivery to site. This problem was as a result of improper packaging and the poor nature of roads leading to sites. Thorough mixing is essential for the production of uniform quality concrete. Therefore, equipment and methods should be capable of effectively mixing concrete materials containing the largest specified aggregate to produce uniform mixtures of the lowest slump practical for the work. The method used to transport concrete depends on which one is the lowest in cost and easiest for the job size. Some ways to transport concrete include a concrete truck, a concrete pump, a crane and bucket, a chute, a conveyor or a hoist. On small jobs, a wheelbarrow is the easiest way to transport concrete. Always transport concrete as little as possible to reduce problems of segregation and wastage as seen in Figure 4.6

Figure 4.6: Wastage of concrete due to Poor transport on site at Aflao
Source: Field research

4.04 Results of Observation at construction sites on wastage of cement through storage and handling at Keta

The effective storage of cement on building projects reduces wastes, project delay and helps to keep the quality of cement in good shape before usage. Analyzing the waste of cement is relatively complex due to the fact that this material is used as a component of mortar and cast - in - place concrete in several different processes, such as brickwork, plastering and floor screed. The effects of poor storage of cement and handling results in cracks and spilling of concrete, which the damage usually starts at the edges and corners of concrete, reduction in quality of concrete and caking of cement was revealed in an observation made at construction sites at Keta shown in Figure 4.7 and Figure 4.8, respectively.

Figure 4.7: Wastage of cement due to poor handling, Lack of control & poor storage Source: Field research

Figure 4.8: Wastage of cement mortar due to chiseling & design change on building Sites. Source: Field research

Conclusion

In addressing the pending constrain of inefficient storage of materials, handling and usage on construction sites, most of the construction firms at the study area could not make good use of surplus construction materials on the sites which causes in some cases congestion and also increase cost of projects. It was also established that the continued existence of poor coordination between site supervisors and other artisans on site contributes greatly to the wastage of materials on site. It reveals that the minimization of materials wastage during the construction phases is important in order to avoid loss of profits. It is observed that

considerable research has been conducted to investigate individual construction waste management strategies at a specific stage of a construction project. Finally, the old-fashioned method of store keeping and absence of other documentations with regards to the control and handling of stock among storekeepers at the various sites is high and needs some urgent solution to educate them to be abreast with the modern and standard techniques of storage, handling and usage of materials on construction sites. The project recommends that, Contractors, Site Supervisors and Storekeepers in the construction industries needed to be given sufficient education on the technical knowhow of material storage and handling according to the codes and standards. Also, appropriate site layout plans mostly showing location of building and also space allocated for material storage should be applied on most Ghanaian construction sites to avoid double handling. Lastly, it requires the research of new technology of recycling waste and reuse of construction materials by maximizing profit margins of construction companies in Ghana, especially in the Volta and Oti Regions of Ghana.

Refernces

1. Gulghane, A. A. & Khandve, P. V., (2015). Management for Construction and Control of Construction Waste in Construction Industry: A Review. *International Journal of Engineering Research and Application,* 5, 59-64.
2. Donyavi, S., & Flanagan, R. (2009). The impact of effective material management on construction site performance for small and medium sized construction enterprises. In *Proceedings of the 25th Annual ARCOM Conference, Nottingham, UK*. 11-20.
3. Kanimozhi, G. & P. Latha (2014). Material Management in Construction Industry. *Indian Journal of Applied research* 4(4): 6-9.
4. Zeb, A., Malik, S., Nauman, S. Hanif, H. & Amin, M.O. (2015). Factors Affecting Material Procurement, Supply and Management in Building Projects of Pakistan: A Contractor's Perspective. *Proceedings of 2015 International Conference on Innovations in Civil and Structural Engineering (ICICSE'15).* Istanbul (Turkey), 170-175.
5. Kasim, N.B, Anumba, C.J & Dainty, A.R (2005). Improving materials management practices on fast-track construction projects. In: Khosrowshahi, F (Ed.), SOAS, University of London. Association of Researchers in Construction Management
6. Griffith, A. & Sidwell, A.C. (1995). Constructability in building and engineering projects. *London, Macmillan Press Ltd.*
7. Mulcahy, D. E. (1999) *Materials Handling Handbook*, The McGraw-Hill Companies Inc., USA *National Safety Council. Accident Facts*, 1989 and 1991 Editions, Chicago, IL.
8. Felea, Mihai; Albăstroiu, Irina (2013) : Defining the Concept of Supply Chain Management and its Relevance to Romanian Academics and Practitioners, *Amfiteatru Economic Journal*, ISSN 2247-9104, The Bucharest University of Economic Studies, Bucharest, Vol. 15, Iss. 33, pp. 74-88
9. Kasim, N. B., (2008). Improving materials management on construction project. Loughborough: Loughborough University.
10. Gossom, W J. (1983). Control of projects, purchasing and materials. United States: Web.
11. Cavinato, J. L. (1984). Purchasing and materials management. *New York West Publishing Company,* pp.4-6.
12. Christopher, M., (2011). Logistics & Supply Chain Management. London: Pearson Education Limited.
13. Stukhart, G. (1995). Construction Materials Management. *Marcel Dekker, Inc.*
14. Damodara K. (1999). Materials Management: The Key to Successful Project Management. *Journal of Management in Engineering,* 15(l), 30-34.
15. Baldwin J.R., W. Chandler C. Le & T. Papailiadis T. (1994). Strategies for Success: A Profile of Growing Small and Medium-sized Enterprises in Canada. Catalogue No. 61-523. Analytical Studies Branch. Ottawa: Statistics Canada.
16. Stukhart G. & Bell L.C. (1987) Costs and Benefits of Materials Management Systems.
17. Ahuja, H. N., Dozzi S.P. & AbouRisk S.M (1994). Project Management; Techniques in Planning and Controlling Construction Projects. *John Wily, New York,* (2).
18. Calkins, M., (2009). Materials for Sustainable Sites. New Jersey: John Wiley & Sons, Inc.

19. Shen, Z. J., Collard, C., & Daskin, D. (2003). A joint Location-Inventory Model. Transportation Science. P.37,40-55
20. Dainty, A. R. & Brooke, R. J., (2004). Towards improved construction waste minimization: a need for improved supply chain integration. Survey Structural, 22(1), 20-29.
21. Manteau K.E., (2007). "The Development of an Information Management System for Materials Management in Large Construction Companies Operating in the Ghanaian Construction Industry", An MSc Thesis Submitted to the Department of Building Technology of the Kwame Nkrumah University of Science and Technology. Kumasi.
22. Patel, K. V. & Vyas, C. M., (2011). Construction Materials management on project sites. Gujrat, B.V.M Engineering College, 2-6.
23. Adams, J. S., (1965). Inequity in social exchange. *Advances in experimental social psychology*, 2, 267-299.
24. Greeno, R (1986), *Principles of Construction,* 2nd Edition UK Longman Group Ltd.
25. Walter, A. (1984) *Project Managements and Accounts,* Seventh Reprint. Delhi-India, Nhanna Publishers.