

A THEORETICAL FRAMEWORK OF LEAN PRODUCTION APPROACH TO MATERIALS MANAGEMENT IN THE CONSTRUCTION INDUSTRY

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Abstract

This paper's target is to increase the understanding of the lean production approach to materials management in the Nigerian construction industry with a view to enhancing site materials management and reduce waste. This is a preliminary study for ongoing PhD research; and was conducted with desk top research method, which made use of existing literature on the lean approach and materials management in the construction industry. As a result, a theoretical framework is proposed, which will be instrumental in the effective materials management in the construction industry. This study adds value to the concept of adopting a new management approach to the construction industry; as well as creating awareness of the lean production approach to materials management. Additionally, it argues that the lean production approach, which is uncommon to the Nigerian construction process, would offer valuable techniques to managing construction activities with improved workflows and a minimised waste generation.

Keywords: construction, design management, framework, Lean, materials management.

Introduction

The Nigerian construction industry has been found to be among the main consumers of resources and energy (Dania, Kehinde and Bala, 2007), and reported to be generating unacceptable levels of materials waste (Wahab and Lawal, 2011). Construction activities which produce waste can be grouped into off-site and on-site operational activities. Off-site activities include, prefabrication, project design (architectural, structural, mechanical and electrical design) and the manufacturing and transporting of materials and components. The on-site construction process relates to the construction of a physical facility which consists of the substructure and superstructure of the building (Wahab and Lawal, 2011).

Wastage on construction sites has become a problem in the Nigerian construction industry and this problem has negatively affected the performance of many projects in the country (Adewuyi and Oтали, 2013). This is the difference between the value of materials that are delivered and accepted on site and those that are properly used as specified and accurately measured in the work after deducting the cost saving of the substituted materials that were transferred elsewhere during which unnecessary cost and time may be incurred through material wastage (Muhwezi *et al.*, 2012). Ameh and Itodo (2013) observed that in every 100 houses built in Nigeria there is sufficient waste materials to build another 10 houses.

Teo *et al.* (2009) noted that extra construction materials are usually purchased due to material wastage during construction. Previous studies have shown that waste represents a relatively larger percentage of production. It therefore follows that the wastage of materials will lead to an increase in the total budget of the building project. This assertion is supported by Teo *et al.* (2009) who believe that building materials wastage on construction sites contributes to cost overruns.

To minimise wastage level of materials in any construction project, the adopted materials management techniques must be sufficient and up to date in eliminating the non-value adding activities in the process (Teo *et al.*, 2009).

Statement of the Problem

As a result of the low level of awareness of the lean production approach to materials management, the techniques adopted by the Nigerian construction sector are poor; and the operational elements that enhance site materials management and reduce waste have rarely been addressed and are little understood.

Literature Review

Materials management in construction projects

The successful completion and delivery of any construction project within time, budget, and quality, in accordance with specifications, and to the satisfaction of stakeholders are important factors for measuring project success. However, the complex nature of most construction projects today creates difficulties for even the best project managers (Duy, Ogunlana and Thi Xuan 2004). Therefore, most construction projects are challenged by materials shortages, delays in supply, price fluctuations, damage and wastage, and lack of storage space (Asmara, 2015). Thus, proper materials management is an important function for improving these challenges in construction.

Managing materials among sub-contractors is an issue on every construction site, as materials have to be moved from one place to another on the site, resulting to additional costs of manpower and machinery (Zeb *et al.*, 2015). Kazaz, Manisali and Ulubeyli (2008) note that poor planning for construction materials and difficulties associated with site transportation as factors leading to a lack of construction materials have had a significant effect on site productivity in both developed and developing countries.

Donyavi and Flanagan (2009) observed that materials management has not received much attention from researchers. In relation to this, Saidu and Shakantu (2016) assert that poor materials management leads to an increase in the total cost of building projects. It is therefore,

important to manage all materials from the design stage to the construction stage of the project, as poor management of materials affects the overall performance of construction projects in terms of duration, budget, quality and productivity (Arijeloye and Akinradewo, 2016). In the same vein, Asmara (2015) reports that the management of materials should be considered during all the phases of the construction project and throughout construction activities. This is because poor materials management can affect the overall construction time, quality and cost. Moreover, it is imperative for both the planning and the control aspect of materials to ensure that the right quality and quantity of materials are appropriately specified in a timely manner, obtained at a reasonable cost and that they are available when needed.

Many construction projects in Nigeria apply manual methods for the tracking of materials, and this involves paper-based techniques which can become problematic due to many human errors (Kasim, Latiffi and Fathi, 2013). This calls for an integrated material handling process, from the design stage to the usage of the materials and this could happen, with good management of materials. A good materials management environment applying lean production approach enables the proper handling of materials on construction sites.

Components of the Theoretical Framework

To understand the lean production approach to materials management in the construction industry, it is necessary to discuss some fundamental concepts underlying the theoretical framework.

Design management

Design management has demonstrated the benefits of using design as a strategic resource and trying to introduce it to companies through sourcing design skills and putting them to work in specific innovation, managing and controlling design processes (Acklin, Cruickshank and Evans, 2013). The issues in design management are identified as optimised design process scheduling, and efficient collaboration, and change management in which different frameworks address these issues in different ways (Chua, Tyagi, Ling and Bok, 2003). In construction projects, creative minds develop the design process into a complex multidisciplinary process that needs to be carefully managed to improve the efforts of many people who represent the interests of their respective organisations (Elmualim and Gilder, 2014). In relation to this, the literature on product innovation proposes that the design management process determines the product design performance and it is an important element of integrated quality efforts (Ahire and Dreyfus, 2000).

Lean principles

Lean production is a management philosophy focused on identifying and eliminating waste throughout a product's entire value stream, extending not only within the organisation but also along the company's supply chain network (Scherrer-Rathje, Boyle and Deflorin, 2009). The lean principles are ways to think about the process that emphasises the business model over the business plan, and encourage a process of customer discovery, development and iteration to achieve the right product/market fit (Blank, 2012). This principle can be achieved by identifying customer value, value stream mapping, achieving flow in process, allowing the customer to pull, and pursuing perfection. Therefore, the adoption of lean production principles in the construction industry and overall helps to reduce/minimise waste in the construction process to achieve optimum value (Gbadamosi *et al.*, 2018). Figure 1

illustrates the five principles that need to be considered when implementing lean construction.



Figure 1 Lean principles

Source: Researcher's construct

Each of the stages is necessary, and once one stage is implemented, impacts are noticed. Therefore, lean principles can only be applied fully and effectively in the construction industry by focusing on improving the whole process, ensuring integration among project team members, and increasing transparency, particularly on issues related to waste elimination.

Supply chain management

Supply Chain Management (SCM) involves the integration, collaboration and co-ordination across organisations throughout the supply chain of such functions as distribution planning, demand forecasting, purchasing, requirement planning, production planning, warehousing, material handling, inventory, packaging, order processing, and transportation, etc., and all these functions are considered as building blocks of SCM in today's business environment (Agus and Shukri, 2012). According to Forbes and Ahmed (2011), supply chain management analyses the impact of facility design on the construction activities and enables project planning and management to avoid the fragmented approach of other methods. Through SCM, all the stakeholders are kept aware of commitments, schedules, and speed up all work as a virtual corporation that can source, produce, and deliver products with minimal lead time and expense.

The implementation of SCM is challenging in construction (Forbes and Ahmed, 2011). Therefore, the core of SCM is lean production which is defined as a set of tools and methodologies that aims for the continuous elimination of waste in the production process with the main benefits of lowered production costs, increased output and shorter production lead times (Agus and Shukri, 2012). The designing of the supply chain and logistics management must consider the issue of quality. Quality assurance is one of the most vital

conditions for the smooth running of the supply chain and one of the ways to ensure this quality is to apply the concept of lean management (Czarnecka, Butor and Halemba, 2017).

Roles of Supply Chain Management

In terms of lean production, SCM is related to lean supply and the basic concept includes tools like Just-In-Time delivery (JIT) and logistics management (Vrijhoef and Koskela, 1999). In another study, Vrijhoef and Koskela (2000) furnished the following roles of supply chain management in construction:

- **Improving the interface between construction site activities and the supply chain:** There should be a focus on the cooperation between suppliers and contractors for improving the total flow of material, whereas traditional treatment of construction logistics and material handling has concentrated on activities on site.
- **Improving the supply chain:** When developing the supply chain, the trade-off between transportation, inventory and production costs should be borne in mind to achieve global improvement. Uncertainty in the supply chain, varying site conditions and varying capacity conditions are the factors that affect productivity and supply chain performance.
- **Transferring activities from the site to the supply chain:** This is another initiative by redesign of the supply chain transferring on site activities off site
- **Integration of construction site and supply chain:** New alternatives ideas have been suggested for the integration of management of the supply chain and the construction site. These include open building and sequential procedure. The benefit of open building is the postponement of the decisions of users regarding the interior of the building which also provides adaptability for the remaining life cycle of the building so that users can arrange the space as their needs change and the idea of sequential procedure is to structure the site work as successive realisations of autonomous sequences. Therefore, the goal of both approaches is to replace construction's usual temporary chains with permanent supply chains (Vrijhoef and Koskela, 2000).

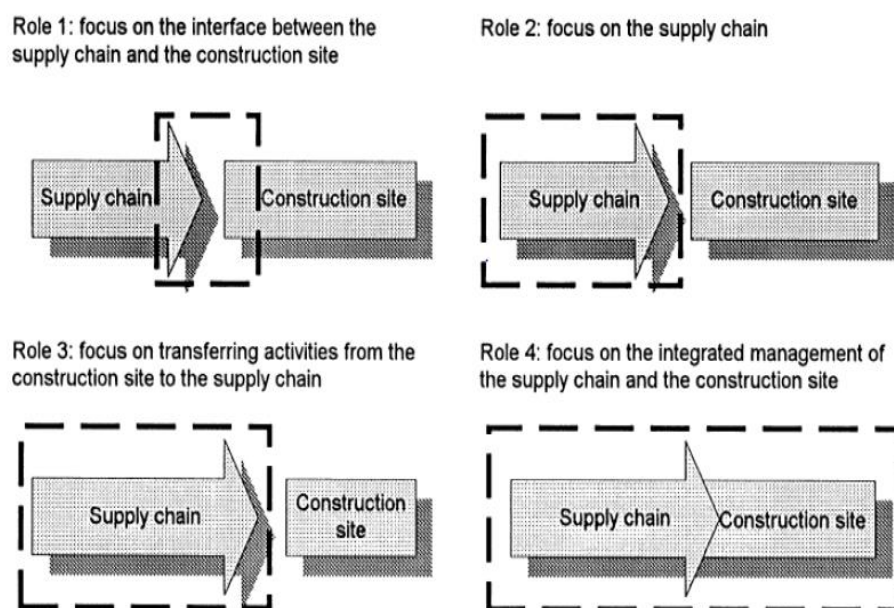


Figure 2 The roles of SCM in Construction

Source: Vrijhoef and Koskela (2000).

Materials supply chain system

Materials purchasing in the construction industry is an important process of supply chain management (Ojo, Mbohwa and Akinlabi, 2014). Therefore, rethinking the role of procurement should be one of the first actions towards a change on how to better deal with supply systems. Procurement teams should take a more proactive role towards a better understanding of supply dynamics and complexity which will make explicit that supply can and should be controlled (people in construction operate as if they cannot control supply) (Arbulu and Ballard, 2004).

In this context, Forbes and Ahmed (2011) assert that the elements of SCM are information flow, order fulfillment, and product development with faster response times, less waste, more effective information flow and small amounts of inventory. Enhancing efficiency in the supply of construction materials can result into cost savings in the resource itself, also in the utilisation of other construction resources (Muya, Price and Thorpe, 1999).

Supply chains can be grouped into three types: the primary supply chain which delivers materials that are incorporated into the final construction product, the support chain which provides equipment and materials that facilitate construction, and the supply chain involve the supply of labour (Muya, Price and Thorpe, 1999). However, different supply chain systems may also have different effect on the cost, time and quality of the project (Oludare and Oluseye, 2015). The objective of material the supply chain system is to be able to get the right products in the right quantities, at the right time with minimal cost (Amade, Akpan, Ubani and Amaeshi, 2016).

Lean supply chain management

Setting up the supply chain means shaping the links in the network of companies, in which are carried out material and information flows and sharing of information. It is important for both SCM and lean construction (Forbes and Ahmed, 2011; Czarnecka, Butor and Halemba, 2017). According to Czarnecka *et al.* (2017), and the following objectives can be achieved by using the concept of lean management in the supply chain:

- Consolidation and restructuring of suppliers and recipients,
- Sharing information,
- Reducing inventory levels and the introduction of just-in-time system,
- The introduction of common solutions to problems and reduction of related costs,
- Implementation of the requirements of the customer associated with the ordered product.

Czarnecka *et al.* (2017) concludes that lean management and its tools can be applied in supply chain management. It can be a great support for the realisation of logistics processes and a useful method in optimisation of processes and waste identification is value stream mapping.

Materials Requirement planning (MRP)

The key role of MRP is in terms of production planning which generates outputs including production orders, capacity requirements, and raw and semi material requirements by using

customer orders, bill of materials, routings for capacity requirements as main data, and inventory records as initial planning status (Büyüközkan and Baskak, 2016).

If materials are not properly managed on site, it could lead to delay of a project. This is the reason it is considered the most critical part of a project and needs serious attention (Zeb *et al.*, 2015). Verma and Nishad (2016) point out that MRP systems use four pieces of information to determine what material should be ordered and when:

- **The master production schedule:** which describes when, each product, is scheduled to be manufactured.
- **The bill of materials:** This which lists exactly the parts or materials required to make each product. It gives information about the product structure, i.e. the parts and raw material units necessary to manufacture one unit of the product of interest.
- **Priority planning and control:** production cycle times and material need at each stage of the production cycle time.
- **Supplier led times:** the latency between the initiation and execution of a process.

The components of the MRP are showed in Figure 3.

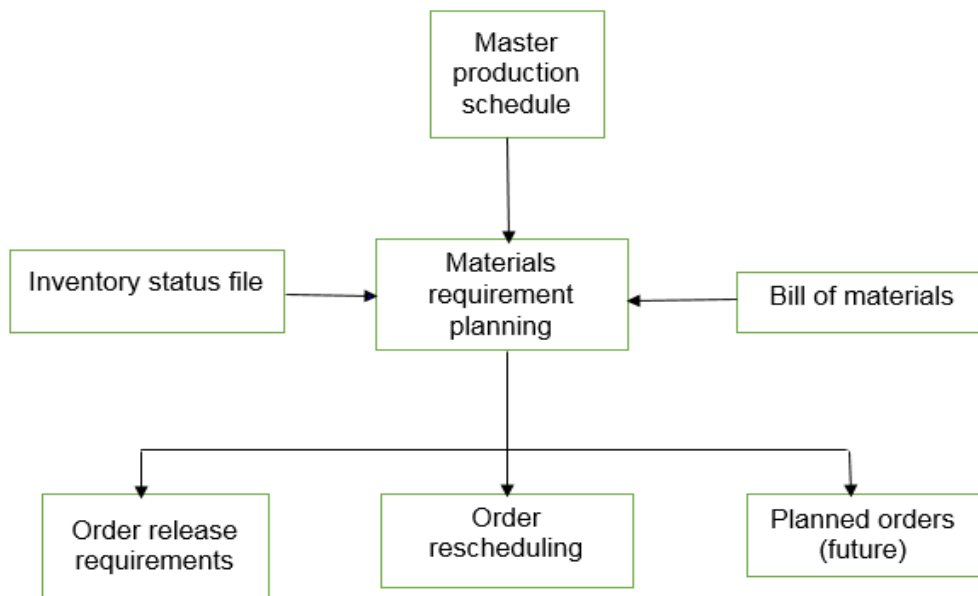


Figure 3 The components of the typical MRP system

Source: Verma and Nishad (2016).

Advantages of MRP systems are: ability to price more competitively, reduced sales price, reduced inventory, better customer service, better response to market demands, ability to change the master schedule, reduced idle time, and reduced setup and tear-down costs (Verma and Nishad, 2016).

Location of Theoretical Framework

The theoretical framework for this research is therefore located at the intersection of the components forming the theory for the research (design management, lean principles, supply chain management, material requirement planning and site materials utilisation

management). The location is shown in Figure 4. The interrelationships between these issues are important towards site materials waste minimisation.

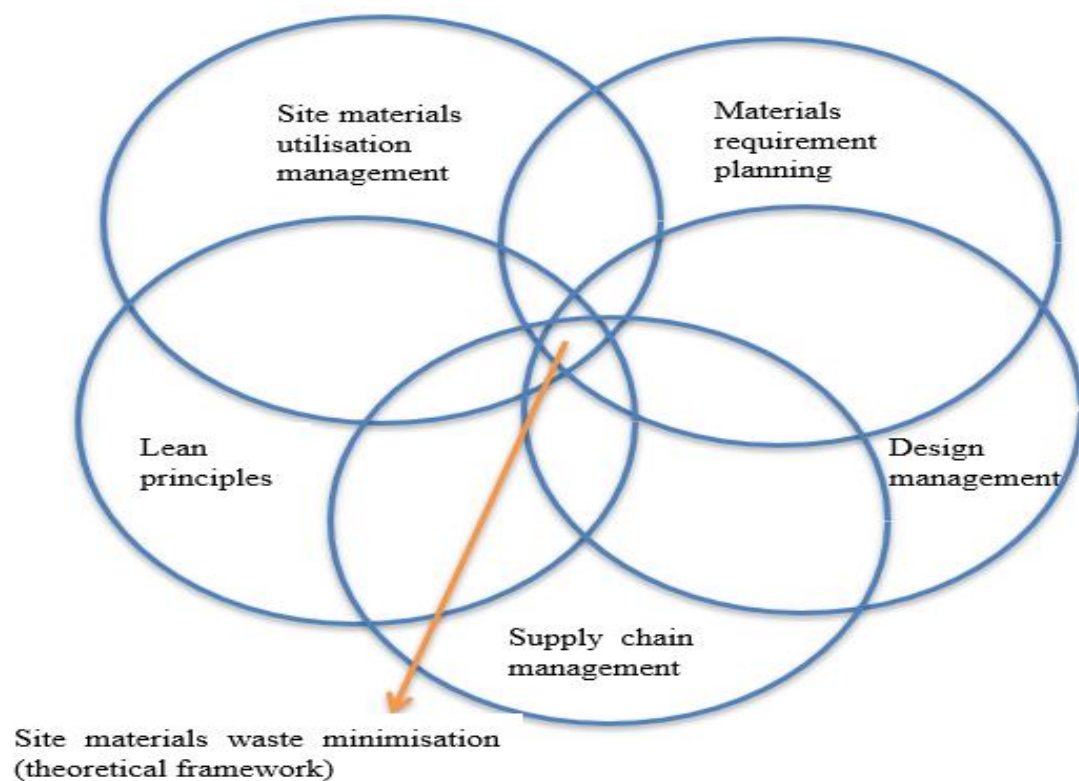


Figure 4 Location of theoretical framework

Research Approach and Methodology

The paper is conducted with an in-depth and critical review of literature relating to the lean principles, supply chain management, design management, materials requirement planning, and site utilisation management. However, the concept of lean production calls for intensive study, as research on lean production approach to materials management in the construction industry has been under researched. Thus, this study is an ongoing PhD research which aims to increase understanding of lean production approach to materials management in the Nigerian construction industry with a view to enhancing site materials management and reduce waste. The current methodology falls within the qualitative research methodology.

Result and Discussion

The research commentators from the critical review of literature on the subject have acknowledged the important role of materials management in the construction industry. This claim resonates with assertion of Hannure and Kulkarni (2014) that the construction process utilises materials which account for about 50 to 60% of the direct cost of a project, with the remaining 50 to 40% being the labour cost. However, the present state of the building construction industry in Nigeria reflects various problems, ranging from wastage of materials, poor quality of work, poor materials flow, delays in project execution/delivery, disputes, displacement of materials on sites, and poor accounting for materials (Emmanuel, Ibrahim and Adogbo, 2014). All these are attributable to the poor materials management techniques adopted by construction practitioners in Nigeria (Idoro and Iyagba, 2008).

To overcome all these challenges, managing construction nowadays requires knowledge of modern management philosophies, techniques and tools. One of the new revolutionary practices which rooted from the industry of car manufacturing is "lean production". Koskela (1992) acknowledges the adaptation of the lean production approach in the construction industry and presents a production management paradigm, where production is conceptualised in three complementary ways: the transformation, flow, and value generation theory of production. This triple view of production has led to the birth of the lean construction as a discipline that subsumes the transformation that has dominated the contemporary construction management. In regard to this, the idea behind the lean production approach is to enable the flow of value by creating work steps while eliminating non-value adding activities, for example waste, by focusing on fast cycle times (Marhani, Jaapar and Bari, 2012). When waste is removed from the production process, cycle times drop until physical limits are reached. Value-adding activities are then improved through internal continuous improvement and the fine-tuning of existing machinery.

Conclusion and Recommendation

This paper reviewed and discussed various theoretical frameworks relating to a lean production approach to materials management in the construction industry. Also, the study has illuminated the importance of materials management in the construction industry; owing to the fact that, the construction process utilises materials which account for about 50 to 60% of the direct cost of a project. However, materials waste is generated in a project from start until completion of construction work. Therefore, the theoretical framework is important because it is the structure that holds or supports a theory of a research study. Thus, this study was based on bridging the knowledge gap on the issue on how to potentially tackle the challenges of materials management. Various researchers have carried out studies on issues confronting materials management in the construction industry, but only limited research study focuses on a lean production approach to materials management.

In a nutshell, this study sought a potential solution to poor materials management through the lean production approach. This study adds value to the concept of adopting a new management approach to the construction industry; and as well as creating awareness on the lean production approach to materials management. More so, the lean production approach, which is uncommon to the Nigerian construction process, would offer valuable techniques to managing construction activities at improved workflows and a minimised waste generation. This study recommends that the top management adopts the culture of training and developing their staff about the new managerial tools and techniques for site materials management, such as the lean production approach.

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