# BARRIERS TO SUCCESSFUL IMPLEMENTATION OF LEAN CONSTRUCTION IN THE GHANAIAN BUILDING INDUSTRY

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## ABSTRACT

Adoption of lean construction in the construction industry will improve quality and efficiency, eliminate waste and increase value for the client. It is a production-based management strategy that enables construction companies to maximise profits by maximising efficiency and eliminating waste of resources. Lean production efforts in some countries have not been successful due to many barriers to its successful implementation. This study identifies and prioritises possible barriers to successful implementation of lean construction in the Ghanaian building industry and measures to overcome potential barriers. The study adopted a structured questionnaire survey of 400 construction practitioners in Ghana. The factors identified as barriers to successful implementation of lean construction and measures to overcome potential barriers to lean construction were evaluated and ranked according to their mean scores. The five strongest barriers to the implementation of lean construction in Ghana are ranked as fragmented nature of the industry, extensive use of subcontractors, lack of long term relationship with suppliers, delays in decision making and waste accepted as inevitable, in that order. Factor analysis using the SPSS Version 16 package enabled the barriers identified to be grouped under six components as 1) lack of proper planning and control, 2) lack of teamwork, 3) poor project management, 4) lack of technical capabilities, 5) lack of financial resources and 5) poor communication between parties. The results enable building organisations to improve construction quality and efficiency through the implementation of the measures suggested to remove potential barriers to the implementation of lean construction. Identification of barriers and measure to overcome potential barriers are steps towards successful implementation of the lean concept in the Ghanaian building industry.

## KEYWORDS

Lean construction, barriers, building industry, Ghana

## INTRODUCTION

The building industry is often described as an industry with many problems and a lack of efficiency (Alinaitwe, 2009; Kpamma, 2009). Several researchers have expressed concern about the continued decline in performance of the construction industry and the increasing challenges facing the industry (Alinaitwe, 2009; Seranatne and Wijesiri, 2008; Beathan et al., 2004; Yasamis and Mohammadi, 2002; Anumba et al., 2002; Abdulhadi, 1997). To deal with this situation, some construction companies have adopted a Total Quality Management (TQM) system and others have tried rightsizing, restructuring and other concepts in order to reverse the trend (Alinaitwe, 2009; Abdul-Hadi et al., 2005). The solution to this problem is said to be in using the concept of lean construction (LC) (Alinaitwe, 2009; Seranatne and Wijesiri, 2008). Lean construction concepts have recently received attention as a modern way to improve construction performance and labour productivity [9]. It is one of the latest management concepts that advocates for minimising waste in the construction process; a change the construction industry needs (Alinaitwe, 2009). The LC concept has been introduced in the construction industry in various countries such as Australia, Brazil, Denmark, Ecuador, Finland, Peru, Singapore, United Kingdom, United States of America and Venezuela (Abdullah et al., 2009; Johansen and Walter, 2007; Ballard and Howell, 2004), and its application within the industry is reported to have resulted in a lot of benefits. In spite of these benefits, the construction industry has generally been slow in taking up lean concepts (Johansen and Walter, 2007; Johansen et al., 2002; Common et al., 2002).

### *Review of lean construction and barriers to its implementation*

Lean Construction (LC) is a way to design production systems to minimise waste of materials, time and effort in order to generate the maximum possible amount of value (Koskela et al., 2004; Koskela and Howell, 2002). The word lean is defined as 'give customers what they want, deliver it instantly with no waste' (Howell, 2001). It is also a holistic design and delivery philosophy with an overarching aim of maximising value to all stakeholders through systematic, synergistic and continuous improvements in the contractual arrangements, product design and method of selection, the supply chain and the workflow reliability of site operations (Abdelhamid, 2004). LC is defined as the continuous process of eliminating waste, meeting or exceeding all customer requirements, focusing on the entire value stream and the pursuit of perfection in the execution of a project (Alinaitwe, 2009; Abdel-Razek et al., 2007; Design for Manufacture, 2005; Dunlop and Smith, 2001). In the opinion of (Mossman, 2009), lean thinking is lean because it provides a way to do more and more with less and less – less human effort, less equipment, less time and less space – while coming closer and closer to providing customers with exactly what they want.

Lean Construction (LC) consists of a series of flow conversion activities (Alinaitwe, 2009). Conversion activities are those operations performed when adding value to the material or when information is being transformed into a product, and flow represents tasks like inspections, waiting, moving and storing (Alinaitwe, 2009). LC is also defined as a concept that incorporates several other concepts from the construction management industry such as Total Quality Management (TQM), Last Planner System (LPS), Business Process Re-engineering (BPR), Concurrent Engineering (CE), Product Circles (PCs) and Team and Value Based Management (Alinaitwe, 2009). Most of the above concepts illustrated in Figure 1 are interrelated and all aim to improve performance while minimising waste (Alinaitwe, 2009).

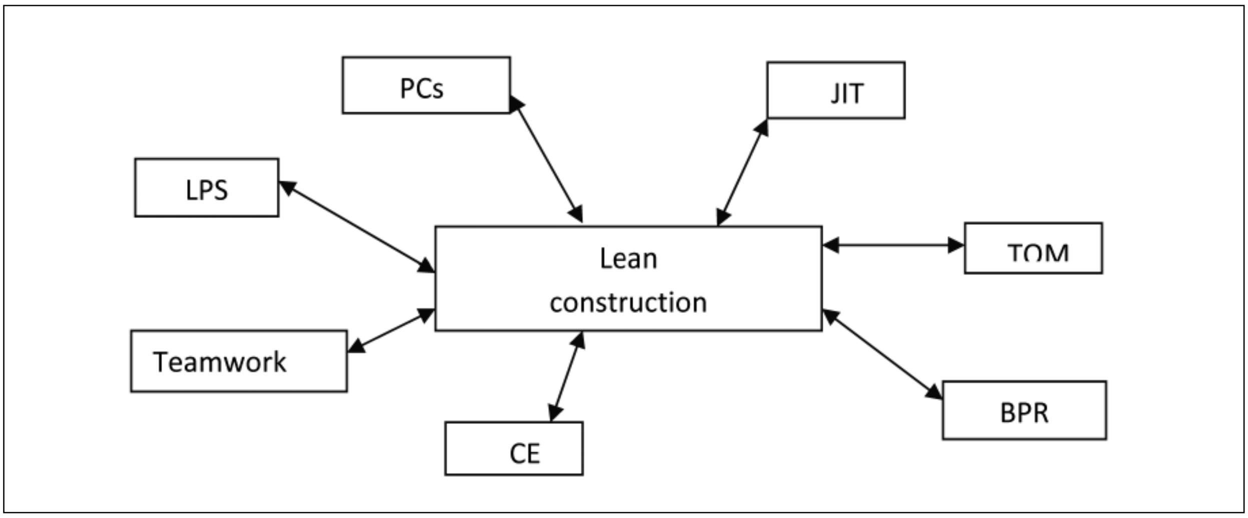


*Figure 1: Key concepts of lean construction (Alinaitwe, 2009).*

As with implementation of other methods or approaches aimed at increasing the performance of the construction sector, the application process of lean principles is sure to encounter various obstacles. Research findings of the Production Management Center (GEPUC) of the Catholic University of Chile, have shown that the application of the LC concept in the industry has faced problems pertaining to time, training, organisational aspects and lack of self-criticism (Alarcon et al., 2008). Furthermore, a major problem with the application of lean construction concept involves aspects of attitude, internal relationships and co-operation. The obstacles within these aspects are related to lack of organisational culture supporting teamwork, lack of group culture, shared vision and shared consensus, inadequate knowledge and skills, etc. (Castka et al., 2004; Cua et al., 2004).

There are various barriers to efforts aimed at sustainable implementation of the LC concept. Forty barriers to the implementation of lean construction and seventeen measures to overcome them were identified from literature (Bashir et al., 2010; Abdullah et al., 2009; Alinaitwe, 2009; Mossman, 2009; Alarcon et al., 2008; Jorgensen and Emit, 2008' Olatunji, 2008; Salem et al., 2005; Forbes and Ahmed, 2004; Castka et al., 2004; Cua et al., 2004; Common et al., 2000).

These barriers refer to attitude, roles, relationships, actions and communications among the respective parties involved in the construction industry such as contractors, subcontractors and the client (Castka et al., 2004). In the Ugandan construction industry, thirty-one factors were identified as barriers to successful implementation of LC (Alinaitwe, 2009), out of which ten were considered easy to overcome. The barriers identified by (Alinaitwe, 2009) include lack of keeping items in the right places, lack of buildable designs, lack of a participative management style for the workforce, not using standard components, lack of communication within teams, lack of steady work engagement, lack of understanding of customer needs, lack of project team skill and lack of well-defined focus for the team. Kpamma (2009) studied the practice of lean thinking at the pre-contract stage of building construction projects by selected Ghanaian firms. The objectives of Kpamma's research among others included identification of the extent of practice of lean thinking and the limitations to the practice of lean construction in Ghana. Inadequate familiarity of the construction firms with the concept of lean thinking was among a number of limitations identified in the possible application of the concept in the Ghanaian construction industry.

Although the factors identified from literature seem relevant to the Ghanaian situation, little has been done to assess how they apply in Ghanaian construction projects. By identifying and prioritising barriers to LC on the basis of their influence and ease of overcoming them, building organisations can undertake waste minimisation efforts with confidence and manage the various barriers with success.

The objectives of this study are to identify and prioritise influential barriers to successful implementation of LC and also measures to overcome potential barriers to LC in the Ghanaian construction industry.

## RESEARCH METHODOLOGY

To identify and prioritise influential barriers and measures to overcome potential barriers to successful implementation of LC in the Ghanaian construction industry, a thorough review of the literature was conducted. Forty barriers and seventeen measures were identified (Bashir et al., 2010; Abdullah et al., 2009; Alinaitwe, 2009; Mossman, 2009; Alarcon et al., 2008; Jorgensen and Emit, 2008' Olatunji, 2008; Salem et al., 2005; Forbes and Ahmed, 2004; Castka et al., 2004; Cua et al., 2004; Common et al., 2000). Since the barriers and measures gathered from the literature had been sufficiently tested and used in similar studies in other countries, they were used as basis for the present study.

A multiple research approach involving semi-structured interviews and a questionnaire survey was adopted for the study. Interviews were carried out prior to the questionnaire survey to examine the relevance of the identified factors in the Ghanaian context. Site managers of building construction organisations registered with the Ministry of Water Resource, Works and Housing (MWRWH) and fully registered consultants in the construction industry were involved in the study. Building construction organisations operating within Ghana register with the MWRWH. The Ministry has four categories of companies: D, K, E and G, based on the nature of work the organisations engage in - building, civil engineering, electrical and plumbing works respectively. There are four financial sub-classifications within these categories - Class 1, 2, 3 and 4 – which set the limitations for companies in respect of their asset, plant and labour holdings, and the nature and size of the projects they can undertake. Class 1 has the highest resource base, decreasing through Classes 2 and 3, with Class 4 having the least resource base (MWRWH, 2011).

The semi-structured interviews were conducted with five executive directors of D1/D2 firms operating in Kumasi and five academics who currently work with D1/D2 firms as project managers. The interviews led to the confirmation of 33 barriers and all the seventeen measures identified from the literature as relevant to the implementation of lean construction in Ghana. These factors were further investigated in the questionnaire survey. The survey targeted classes D1 and D2 building firms as well as consultants from quantity surveying and architectural firms fully registered with the Ghana Institution of Surveyors (GhIS) and the Architects Registration Council of Ghana (ARCG) respectively. The choice of D1/D2 firms was due to lack of reliable information on small scale firms, and also based on the assumption that large and well-established firms have good organisational set up and are more capable of undertaking lean production efforts. The records of the (MWRWH, 2011) indicate that there are 519 D1 and D2 construction organisations in the Ashanti and Greater Accra Regions of Ghana. Available records indicated that the ARCG had 114 architectural firms (ARCG, 2010), and the GhIS had 60 quantity surveying firms (GHIS, 2010) in Kumasi and Accra.

A sample size of 226 site managers of D1/D2 construction organisations was determined using the following formula recommended for such studies by (Israel, 2007).

$$n = \frac{N}{1 + N(e)^2}$$

where:

| | | |
|---|---|---|
| n | = | sample size |
| N | = | population size |
| e | = | desired level of precision (±5%) |

A simple random sampling approach was used to select the 226 D1 and D2 firms.

Closed-ended questions were mainly prepared but options were given for respondents to add to the list of possible answers. The respondents were asked to score the severity of the 33 potential barriers to the implementation of lean construction on the Likert scale of 1 to 5 where 1 = 'Not severe' and 5 = 'Very severe'. The seventeen measures to overcome potential barriers were also scored on a scale of 1 to 5, where 1 = 'Highly unimportant' and 5 = 'Highly important'. Each questionnaire was administered through a face-to-face session which ensured that 188 questionnaires out of the 226 were returned complete and used in the analysis, representing a response rate of 83%. All the 114 architectural firms and 60 quantity surveying firms fully registered with their professional institutions were covered in the study. Out of the 174 questionnaires sent to the consultants, 124 were completed, representing a response rate of 71%.

Data gathered was subjected to factor analysis using SPSS version 16 package. Factor analysis is a statistical technique used to identify a relatively small number of factors that explain observed correlations among variables (Marija, 2003). It is primarily used for data reduction or structure detection with the assumptions that the variables are continuous, normally distributed, have a good linear relation between them and have underlying factors responsible for the observed correlation. Factor analysis is used when people have been measured on several continuous variables and it is wished to see whether these variables can be reduced to a smaller set of variables (Chris, 2004). It can also be used to identify any set of variables that correlate well with each other but less well with other items. It can be used to reduce a large number of correlated variables to a more manageable number of independent factors that can then be used in subsequent analysis (Marija, 2003).

## RESULTS AND DISCUSSION

### *Barriers to implementation of LC*

The barriers identified from literature and confirmed by industry practitioners were ranked according to their mean scores and standard deviations. The results presented in Table 1 show that the five strongest barriers to implementation of LC in Ghana are the fragmented nature of the industry, extensive use of subcontractors, lack of long term relationship with suppliers, delays in decision making and waste accepted as inevitable, in that order. The

*Table 1: Ranking of barriers to implementation of lean construction in Ghana.*

| Barriers | Mean | Standard Deviation | Rank |
|---|---|---|---|
| Fragmented nature of the industry | 4.650 | 0.741 | 1 |
| Extensive use of subcontractors | 4.580 | 0.670 | 2 |
| Lack of long term relationship with suppliers | 4.550 | 0.729 | 3 |
| Delays in decision making | 4.540 | 0.707 | 4 |
| Waste accepted as inevitable | 4.430 | 0.786 | 5 |
| Inconsistency in government policies | 4.370 | 0.835 | 6 |
| Materials scarcity | 4.300 | 0.817 | 7 |
| Lack of long term commitment to change and innovation | 4.290 | 0.837 | 8 |
| Delays in materials delivery | 4.240 | 0.805 | 9 |
| Long implementation period | 4.220 | 0.794 | 10 |
| Less involvement of contractors and specialists in design process | 4.220 | 0.836 | 11 |
| Lack of technical skills | 4.080 | 0.867 | 12 |
| corruption | 4.060 | 0.964 | 13 |
| Lack of client and supplier involvement | 4.050 | 0.784 | 14 |
| Poor communication | 4.040 | 0.791 | 15 |
| Lack of management support and commitment | 4.040 | 0.855 | 16 |
| Inadequate pre-planning | 4.000 | 0.866 | 17 |
| Incomplete designs | 3.990 | 0.833 | 18 |
| Lack of agreed implementation methodology | 3.980 | 0.754 | 19 |
| High dependency of design specifications on in-situ components and materials | 3.970 | 1.023 | 20 |
| Lack of buildable designs | 3.970 | 0.825 | 21 |
| Difficulty in understanding lean concepts | 3.970 | 0.837 | 22 |
| Unsuitable organisational structure | 3.960 | 0.783 | 23 |
| Poor professional wages | 3.950 | 0.893 | 24 |
| Poorly defined individual responsibilities | 3.930 | 0.883 | 25 |
| Lack of standardisation | 3.930 | 0.797 | 26 |
| Lack of technical skills | 3.910 | 0.872 | 27 |
| Lack of training | 3.910 | 0.934 | 28 |
| Lack of equipment | 3.900 | 0.849 | 29 |
| Lack of interests from clients | 3.890 | 0.878 | 30 |
| Poor project definition | 3.880 | 0.907 | 31 |
| Lack of supply chain integration | 3.880 | 0.734 | 32 |
| Inefficient use of quality standards eg. ISO 9000 | 3.800 | 0.826 | 33 |

weakest barriers include inefficient use of quality standards, lack of supply chain integration and poor project definition among others.

Effect of the fragmented nature of the construction industry on the implementation of lean construction has been well documented in the literature (Bashir et al., 2010; Mossman, 2009; Frodel and Josephson, 2009; Abdullah et al., 2009; Bender and Septelka, 2002). The traditional construction process is characterised by its fragmented nature with loosely coupled actors who only take part in some of the phases of the process (Johansen et al., 2002). The success of lean construction is highly dependent on having a cohesive team working towards congruent goals and objectives.

The effect of extensive use of subcontractors on the implementation of LC in Ghana confirms results from literature (Bashir et al., 2010; Abdullah et al., 2009; Forbes and Ahmed, 2004). Subcontractors are mainly responsible for specialists' works and contractors typically hire subcontractors who do not have direct contracts with the client. Most subcontractors work with inadequate resources and have low expertise, thereby often compromising quality (Forbes and Ahmed, 2004). Poor supervision of subcontractors may result in lack of solution to critical problems involved in LC. Extensive uses of subcontractors who often lack technical expertise constitute a serious barrier to lean construction.

The effect of long term relationship with suppliers on the implementation of lean construction has also been well documented (Bashir et al., 2010; Mossman, 2009; Frodel and Josephson, 2009; Abdullah et al., 2009; Bender and Septelka, 2002). Contractors who purchase materials and services up to 70 to 80% of their turnover should realise that the suppliers are part of the delivery (Frodel and Josephson, 2009). They should prioritise the value created by the suppliers in order to increase their competitiveness. The lack of long term relationships of construction companies with their suppliers has also been attributed to the fragmented nature of the construction industry (Frodel and Josephson, 2009).

Many construction industries suffer from delays. Delay means slowing down the work without stopping it entirely. Delays give rise to disruption of work and loss of productivity, late completion of project which can lead to abandonment of the work by the contractor or termination of contract by the client. It is important that management keeps track of the progress of the project to reduce the possible delay.

Table 2 presents the results of the factor analysis carried out on the potential barriers to implementation of LC. A factor is deemed to be significant to the study if it has a mean value of 2.50 or more [36]. Since all the 33 factors have mean rating 2.50 or higher, they were included in the factor analysis. All the 33 factors had communalities of 1.00, indicating their suitability for the factor analysis. The 33 significant factors were further reduced to common factor patterns. This was done to empirically explain the potential barriers to the implementation of LC in the Ghanaian construction industry. In doing this, principal component analysis with Varimax rotation and Kaizer Normalisation was used to determine which factors have empirical significance. Factor retention was by the eigenvalue 1.0 criterion, suggesting that only factors that account for variances greater than one should be included in the factor extraction.

The principal component analysis (Table 2), where linear combinations of observed variables are formed, was the method used to extract the factors. The first principal component is the combination that accounts for the largest amount of variance and the second principal component accounts for the next largest amount of variance and is uncorrelated with the first.

From Table 2, Component 1 has total variance of 9.020, which accounts for 39.381% of the total variance of the 33 factors. Component 2 has total variance of 1.405 accounting for 6.136% of the total variance of the 33 factors, Component 3 has a total variance of 0.988 accounting for 4.314% of the total variance of the 33 factors, Component 4 has a total variance of 0.866 accounting for 3.782% of the total variance of 33 factors, Component 5 has a total variance of 0.834 accounting for 3.643% of the total variance of 33 factors and Component 6 has a total variance of 0.708 accounting for 3.090% of the total variance of 33 factors. These six components constitute 60.345% of the total variance of the 33 factors.

From the 33 factors identified from the literature as potential barriers to implementation of LC, and then confirmed through meetings with practitioners, factor analysis enabled 26 of these significant barriers to be placed under six components as follows:

**Component 1:** Delays in materials delivery, inefficient use of quality standards, long implementation period, waste accepted as inevitable, inconsistency in government policies, high dependency of design specifications on in-situ components and materials, extensive use of subcontractors, lack of long term commitment to change and innovation, lack of long term relationship with suppliers, delays in decision making and materials scarcity.

**Component 2:** Fragmented nature of the industry, lack of interest from clients, poorly defined individual responsibilities and less involvement of contractors and specialists in design process.

**Component 3:** Poor project definition, lack of equipment, lack of agreed implementation methodology and unsuitable organisational structures.

**Component 4:** Lack of buildable designs, incomplete designs and lack of standardisation.

**Component 5:** Poor professional wages and corruption.

**Component 6:** Difficulty in understanding lean concepts and poor communication.

Based on the examination of inherent relationships among the factors under each component, the following interpretations were made to explain the underlining phenomenon linking the factors.

### Component 1: Lack of proper planning and control

The influence of proper planning and control on the success of LC has been well documented (Bashir et al., 2010; Alinaitwe, 2009; Olatunji, 2008). This component identified delays in materials delivery, inefficient use of quality standards, long implementation period, waste accepted as inevitable, inconsistency in government policies, high dependency of design specifications on in-situ components and materials, extensive use of subcontractors, lack of long term commitment to change and innovation, lack of long term relationship with suppliers, delays in decision making and materials scarcity as major barriers to the implementation of lean construction. Despite the significant economic contribution made by the construction sector in various countries, it faces numerous problems relating to improper planning and control.

### Component 2: Lack of teamwork

The effect of teamwork on the success of implementation of LC has also been well documented (Bashir et al., 2010; Mossman, 2009; Frodel and Josephson, 2009; Abdullah et al., 2009; Bender and Septelka, 2002). This component identified the fragmented nature of the industry, lack of interest from clients, poorly defined individual responsibilities and less involvement of contractors and specialists in design process. Teamwork can be defined as 'co-operative effort by the members of a group or team to achieve a common goal' (Bender and Septelka, 2002). It is common knowledge that various parties in the construction industry work as a team (Abdullah et al., 2009). These team members share the common goal of completing the project to the satisfaction of the client, but because of conflicting and competing interests, a project may suffer from lack of teamwork (Bender and Septelka, 2002). These separate interests are due to the fragmented nature of the construction industry. If these parties are incapable of co-operating among themselves, the implementation of LC will definitely be negatively affected as it needs commitment and a strong co-operative network involving all parties concerned. The success of LC is highly dependent on having a cohesive team working towards congruent goals and objectives.

### Component 3: Poor project management

The effect of good project management on the success of LC has been well documented (Alinaitwe, 2009; Alarcon et al., 2008; Forbes and Ahmed, 2004; Common et al., 2000). This component identified poor project definition, lack of equipment, lack of agreed implementation methodology and unsuitable organisational structures as barriers to implementation of LC. The management of every organisation has a major role to play in achieving successful implementation of innovative strategies (Bashir et al., 2010; Salem et al., 2005). The success of lean practice lies in the commitment of management in developing and implementing an effective plan and adequately providing the required resources and support to manage changes arising from the implementation (Bashir et al., 2010). Without the support of management, the professionals involved in construction may face numerous difficulties in adapting the LC concept (Abdullah et al., 2009; Kim and Park, 2006)

*Table 2: Component matrix after varimax rotation.*

| | | Components | | | | | |
|---|---|---|---|---|---|---|---|
| **No** | **Barriers** | **1** | **2** | **3** | **4** | **5** | **6** |
| 1 | Lack of interests from clients | | 0.676 | | | | |
| 2 | Inefficient use of quality standards eg. ISO 9000 | 0.646 | | | | | |
| 3 | Poorly defined individual responsibilities | | 0.669 | | | | |
| 4 | Lack of training | | | | | | |
| 5 | Less involvement of contractors and specialists in design process | | 0.549 | | | | |
| 6 | Lack of management support and commitment | | | | | | |
| 7 | Poor project definition | | | 0.514 | | | |
| 8 | Delays in materials delivery | 0.532 | | | | | |
| 9 | Lack of equipment | | | 0.644 | | | |
| 10 | Materials scarcity | 0.591 | | | | | |
| 11 | Lack of agreed implementation methodology | | | 0.548 | | | |
| 12 | Lack of supply chain integration | | | | | | |
| 13 | Poor communication | | | | | | 0.612 |
| 14 | Long implementation period | 0.676 | | | | | |
| 15 | Inadequate pre-planning | | | | | | |
| 16 | Lack of client and supplier involvement | | | | | | |
| 17 | corruption | | | | | 0.709 | |
| 18 | Poor professional wages | | | | | 0.755 | |
| 19 | Unsuitable organisational structure | | | 0.502 | | | |
| 20 | Lack of technical skills | | | | | | |
| 21 | High level of illiteracy | | | | | | |
| 22 | Waste accepted as inevitable | 0.717 | | | | | |
| 23 | Difficulty in understanding lean concepts | | | | | | 0.804 |
| 24 | Inconsistency in government policies | 0.724 | | | | | |
| 25 | Lack of buildable designs | | | | 0.699 | | |
| 26 | Incomplete designs | | | | 0.661 | | |
| 27 | Lack of standardization | | | | 0.625 | | |
| 28 | High dependency of design specifications on in-situ components and materials | 0.658 | | | | | |
| 29 | Extensive use of subcontractors | 0.690 | | | | | |
| 30 | Lack of long term commitment to change and innovation | 0.579 | | | | | |
| 31 | Lack of long term relationship with suppliers | 0.610 | | | | | |
| 32 | Fragmented nature of the industry | | 0.525 | | | | |
| 33 | Delays in decision making | 0.520 | | | | | |
| | | | | | | | |
| | **Eigenvalues** | **9.020** | **1.405** | **0.988** | **0.866** | **0.834** | **0.708** |
| | **Percentage of variance explained** | **39.381** | **6.136** | **4.314** | **3.782** | **3.643** | **3.090** |
| | **Cumulative percentage of variance explained** | **39.381** | **45.516** | **49.830** | **53.612** | **57.254** | **60.345** |

*Note:*
*Valid N (listwise)= 312*
*Extraction method: Principal Component Analysis*
*Rotation Method: Varimax with Kaiser Normalisation*
*KMO value= 0.925*
*Bartlett's Test of Sphericity Significance level= 0.000*
*Insignificant factor loadings (i.e. < 0.5) are blanked.*

### *Component 4: Lack of technical capabilities*

The effect of technical capabilities on the success of LC has been well documented (Bashir, et al., 2010; Alinaitwe, 2009; Ballard and Howell, 2004; Koskela et al., 2004). This component identified lack of buildable designs, incomplete designs and lack of standardisation as the major barriers to the implementation of lean construction. These barriers are considered technical because they have a direct impact on the success of application of lean construction principles and tools such as reliability, simplicity, flexibility and benchmarking (Bashir et al., 2010). Design oversights and over-adherence to standard design solutions can lead to buildability problems or constrain innovation that might offer more cost-effective solutions. Both of these would hold back the industry's desires to develop 'leaner' approaches to construction (CIRIA, 2010). The designer is paid to produce a design expressed in the form of specifications and drawings. The contractor is expected to use these as a means of communication, and produce the completed facility. This communication often does not work as well as it should (Forbes and Ahmed, 2004). The problem might be due to the fact that the design lacks buildability and so cannot be interpreted.

*Figure 5: Bills of Quantities rating distribution.*

| Component | Initial eigenvalues | | | Extraction sums of squared loadings | | | Rotation sums of squared loadings | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | % variance | cumulative % | Total | % variance | cumulative % | Total | % variance | cumulative % |
| 1 | 9.020 | 39.381 | 39.381 | 9.020 | 39.381 | 39.381 | 4.013 | 17.520 | 17.520 |
| 2 | 1.405 | 6.136 | 45.516 | 1.405 | 6.136 | 45.516 | 2.651 | 11.575 | 29.093 |
| 3 | 0.988 | 4.314 | 49.830 | 0.988 | 4.314 | 49.830 | 2.380 | 10.390 | 39.484 |
| 4 | 0.866 | 3.782 | 53.612 | 0.866 | 3.782 | 53.612 | 1.866 | 8.146 | 47.630 |
| 5 | 0.834 | 3.643 | 57.254 | 0.834 | 3.643 | 57.254 | 1.580 | 6.898 | 54.528 |
| 6 | 0.708 | 3.090 | 60.345 | 0.708 | 3.090 | 60.345 | 1.322 | 5.817 | 60.345 |
| 7 | 0.667 | 2.912 | 63.218 | | | | | | |
| 8 | 0.652 | 2.847 | 66.104 | | | | | | |
| 9 | 0.610 | 2.700 | 68.803 | | | | | | |
| 10 | 0.588 | 2.586 | 71.372 | | | | | | |
| 11 | 0.546 | 2.385 | 73.757 | | | | | | |
| 12 | 0.530 | 2.314 | 76.071 | | | | | | |
| 13 | 0.472 | 2.059 | 78.130 | | | | | | |
| 14 | 0.452 | 1.974 | 80.103 | | | | | | |
| 15 | 0.393 | 1.716 | 81.820 | | | | | | |
| 16 | 0.369 | 1.611 | 83.431 | | | | | | |
| 17 | 0.366 | 1.599 | 85.030 | | | | | | |
| 18 | 0.431 | 1.491 | 86.520 | | | | | | |
| 19 | 0.334 | 1.459 | 87.979 | | | | | | |
| 20 | 0.291 | 1.273 | 89.252 | | | | | | |
| 21 | 0.284 | 1.242 | 90.493 | | | | | | |
| 22 | 0.279 | 1.218 | 91.711 | | | | | | |
| 23 | 0.242 | 1.058 | 92.769 | | | | | | |
| 24 | 0.237 | 1.033 | 93.802 | | | | | | |
| 25 | 0.213 | 0.931 | 94.733 | | | | | | |
| 26 | 0.208 | 0.906 | 95.639 | | | | | | |
| 27 | 0.178 | 0.778 | 96.417 | | | | | | |
| 28 | 0.164 | 0.717 | 97.134 | | | | | | |
| 29 | 0.153 | 0.666 | 97.801 | | | | | | |
| 30 | 0.146 | 0.636 | 98.436 | | | | | | |
| 31 | 0.133 | 0.582 | 99.019 | | | | | | |
| 32 | 0.114 | 0.485 | 99.515 | | | | | | |
| 33 | 0.111 | 0.556 | 100.000 | | | | | | |

*Extraction method: Principal Component Analysis.*

### *Component 5: Lack of financial resources*

The effect of availability of financial resources on the success LC implementation has been well reported in the literature (Bashir et al., 2010; Mossman, 2009; Olatunji, 2008; Common et al., 2000). Innovative strategies like LC require some funds for its adequate implementation. Adequate funding is needed to motivate workers, provide relevant equipment and employ lean specialists to guide both employers and employees in implementing the concept. Financially related issues are among the most common barriers to lean practice across different organisations in various countries. However, the nature of this barrier varies across countries. This component identified poor professional wages and corruption as the major barriers to implementation of LC. Corruption, which includes bribery, extortion and fraud, may damage the implementation of LC by resulting in the cutting of corners, overpricing of projects, using of inferior materials and poor workmanship.

### *Component 6: Poor communication between parties*

The impact of good communication between parties on the success of LC implementation has been reported in the literature (Bashir et al., 2010; Abdullah et al., 2009). This component identified lack of communication and difficulty in understanding lean concepts as the major barriers to implementation of LC. Since LC evolved from the manufacturing industry, it is vital that the parties involved in the construction industry have a full knowledge of the lean manufacturing concept before its implementation. Without this prior comprehension, it is feared that concerned parties will not be able to fully understand the concept of LC. The construction industry is made up of different parties with different opinions (clients, consultants and contractors) who have to come and work together as a team in order to ensure the successful completion of the project. There is therefore the need to establish and improve communication among all parties. In the process of implementing lean principles, poor communication between respective parties will lead to disruption and ineffective delivery and co-ordination process [Abdullah et al., 2009].

## MEASURES TO OVERCOME POTENTIAL BARRIERS TO IMPLEMENTATION OF LC

The respondents were asked to evaluate the 17 measures that could overcome potential barriers to implementation of LC, identified from literature and confirmed through interviews with professionals in the Ghanaian construction industry. Table 4 presents mean scores, standard deviations and rankings of the 17 measures.

All the 17 measures have mean ratings of 2.50 or higher and therefore considered significant (see Table 4 overleaf). The results show that the five most significant measures to overcome potential barriers to implementation of LC in the Ghanaian construction industry are 'management should train employees on lean concepts', 'communication should be improved among players in construction projects', 'construction should ensure or maintain continuous improvement: thus, reduction of costs, increase quality and productivity', 'construction managers should be committed to changes', and 'workers should be able to work in teams'. The findings of this study confirm that in the literature (Bashir et al., 2010). Steps to overcome barriers to implementation of LC in the UK include taking full advantage of staff training on LC at all levels, engaging skilled site operatives, and promoting the LC concept to companies, professional bodies and major stakeholders. The UK construction industry also engaged in funding workshops and research that could generate more literature to guide LC implementation (Bashir et al., 2010).

## CONCLUSION AND RECOMMENDATIONS

From 33 factors identified by the Ghanaian building contractors and consultants as potential barriers to the implementation of LC, factor analysis enabled 26 of them to be placed under six components: 1) lack of proper planning and control comprising delays in materials delivery, inefficient use of quality standards, long implementation period, waste accepted as inevitable, inconsistency in government policies, high dependency of design specifications on in-situ components and materials, extensive use of subcontractors, lack of long term commitment to change and innovation, lack of long term relationship with suppliers, delays in decision making and materials scarcity; 2) Lack of teamwork comprising the fragmented nature of the industry, lack of interest from clients, poorly defined individual responsibilities and less involvement of contractors and specialists in design process; 3) Poor project management comprising poor project definition, lack of equipment, lack of agreed implementation methodology and unsuitable organisational structures; 4) Lack of technical capabilities comprising lack of buildable designs, incomplete designs and lack of standardisation; 5) Lack of financial resources comprising poor professional wages and corruption; 6) Poor communication between parties comprising difficulty in understanding lean concepts and poor communication.

To ensure the successful implementation of lean construction, management should train employees on lean concepts, ability to work in teams and establish proactive measures to prevent defective production, Construction managers should among others be committed to changes, understand client needs and expectations, and maintain continuous improvement (i.e. reduction of costs, increase quality and productivity). Government agencies on their part should embark on applicable policies that could provide critical support to make lean methods feasible. The identified barriers and measures to overcome potential barriers to implementation of LC should provide an enabling environment for construction practitioners to successfully implement lean construction and improve construction quality and efficiency for the benefit of the client.

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*Table 4: Ranked measures to overcome possible barriers to implementation of lean construction.*

| Measures | Mean score | Standard deviation | Ranking |
|---|---|---|---|
| Management should train employees on lean concepts | 4.417 | 0.594 | 1 |
| Communication should be improved among players in construction projects | 4.365 | 0.774 | 2 |
| Construction should ensure or maintain continuous improvement: thus, reduction of costs, increase quality and productivity | 4.346 | 0.658 | 3 |
| Construction managers should be committed to changes | 4.234 | 0.661 | 4 |
| Workers should be able to work in teams | 4.218 | 0.788 | 5 |
| Proactive measures to prevent defective production should be established by firms | 4.141 | 0.680 | 6 |
| Timely delivery of materials to construction sites | 4.134 | 0.688 | 7 |
| Firms should understand client needs and expectations and position themselves accordingly | 4.131 | 0.630 | 8 |
| Companies should be more client focused | 4.106 | 0.878 | 9 |
| Standardised construction elements should be promoted in the industry | 4.080 | 0.816 | 10 |
| Firms should be willing to change organisational cultures that do not promote lean construction | 4.071 | 0.807 | 11 |
| The opinion of employees should be considered in decision making | 4.068 | 0.801 | 12 |
| Government agencies should embark on applicable policies that could provide critical support to make lean methods feasible | 4.067 | 0.924 | 13 |
| Management should monitor inflation risks and pricing levels that could provide the stability that organisations need in order to make lean methods feasible | 4.061 | 0.837 | 14 |
| Management should deal with uncertainties and fears that cause organisations to conceal information instead of sharing it | 4.060 | 0.893 | 15 |
| Partnering should be promoted to maximize team building and development of trust | 4.051 | 0.923 | 16 |
| Team members should be empowered in decision-making to make partnerships meaningful | 3.923 | 0.986 | 17 |


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