Prioritising Lean Construction Barriers in Uganda's Construction Industry

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Abstract: Engaging in lean construction efforts could prove to be highly rewarding for building firms in Uganda. However, lean construction is risky and can be disastrous if not properly managed. Lean production efforts in some other countries have not been successful due to the many barriers to its successful implementation. To enable sound lean construction efforts and to increase the chances of success in eliminating waste, a thorough investigation of the barriers is essential. This study presents 31 barriers and investigates their influence (strength) on the success of lean construction initiatives. Structured interviews were carried out with technical managers of building firms to assess their perception of the barriers to lean production based on their experience at their firms. The strongest barrier is the provision of inputs exactly when required. Additionally, the barriers were ranked according to the ease of overcoming each. The easiest barrier to overcome is keeping the required items in the right place. Finally, a graphical aid is provided to enable decision makers to concentrate their efforts on the influential (strong), yet easy to overcome barriers. A lack of buildable designs and a participative management style for the workforce are the most important barriers to successful waste reduction in terms of strength and ease of overcome. On the other hand, a lack of an organisational culture that supports teamwork, a lack of prefabrication and a lack of knowledgeable and skilled workers are regarded as low in strength, and at the same time difficult to overcome.

Keywords: Lean construction, Building industry, Barriers, Productivity, Uganda

INTRODUCTION

The building industry is often described as an industry with many problems and a lack of efficiency. The solution to all of these problems is said to be in using the concept of lean construction. The word “lean” was defined by Howell (2001) as “Give customers what they want, deliver it instantly with no waste”. The lean construction experience developed by Toyota is, for many people, regarded as the only path for the building industry. Lean construction concepts have recently received attention as a modern way to improve construction performance and labour productivity (Abdel-Razek et al., 2007). Lean production is currently a buzzword in many manufacturing industries (Fellows et al., 2002), and some in the construction sector have tried to adapt it. The proponents of lean construction argue that it has the potential of tapping into new and existing production theories dedicated to minimising wasteful activities. It has the goal of better meeting the

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customers' needs while minimising waste and using fewer resources (Dunlop and Smith, 2004). The term "lean" was coined by a research team working on international auto production and it reflects the waste reduction nature of the Toyota production system and contrasts it with the craft and mass forms of production (Womack et al., 1991). Several researchers have voiced their concerns about the continued decline in performance of the construction industry and the increasing challenges (Orr, 1995; Abdulhadi, 1997). To deal with this unfortunate situation, some construction companies have adopted Total Quality Management (TQM). Others have tried rightsizing, restructuring and other concepts in order to reverse the trend. However, the payoff of these approaches is small compared to the investment (Hansen, 1997). Lean construction is one of the latest management concepts. It advocates for minimising waste in the construction process, a change the construction industry needs.

The Uganda construction sector is affected by a number of factors (Alinaitwe et al., 2007). It experiences problems in productivity, innovation, slipping schedules, rework, mistakes, disputes, and increased construction costs. These are all symptoms of waste in the construction process. Alinaitwe et al., (2006) found out that workers in Uganda only use about 20 percent of their available time to increase the size of the building. Lean construction may be the cure if properly approached. By prioritising lean construction barriers with regard to their influence and ease of overcoming, this research enables Uganda building firms to undertake waste minimisation efforts with confidence.

To reduce the risks associated with waste minimisation, it is imperative that building firms realise, understand, and manage the various barriers to their success. The main objectives of this research are: prioritising influential (strong) barriers to successful lean construction, determining the difficulty associated with overcoming each barrier, and developing a graphical aid that enables decision makers to concentrate on the barriers that are both influential and easy to overcome.

REVIEW OF LEAN CONSTRUCTION AND ITS BARRIERS

The building industry has a large number of specialised areas and disciplines, many based on cyclic processes. Proponents of lean construction argue that it is possible to identify the wasteful activities in the processes and to make concessions for them. This leads to a better understanding of such processes and an improvement in the overall performance (Dunlop and Smith, 2004). The basic improvement rationale is to compress the cycle time by eliminating non-value-adding time (Koskela, 1999). Cycle time includes process time, inspection time, wait time and move time and only process time is when value addition takes place.

Lean construction consists of a series of flow conversion activities (Koskela, 1992). 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 (Harris and McCaffer, 1997). The lean construction system sees production as a flow of material, information, equipment and labour from the raw materials to the product, as shown in Figure 1. In this flow, the material is converted, inspected, waiting or moving. Processing represents the conversion aspects of production; inspecting, moving and waiting represent the flow aspects of production (Koskela, 1992). In essence, the model consists of conversions and flows. The overall efficiency of production is attributable to both the efficiency of the conversion activities performed, as well as the amount and efficiency of the flow activities. While all activities expend cost and time, only conversion activities are value adding. Waste includes overproduction, wait time, transportation, inspection, inventories, movement and production of defective parts and products. To improve on craft and mass production, lean production combines the advantages of both (Sowards, 2006; Koskela, 1992). Waste in the construction process affects worker productivity.

According to Koskela (1992) and Thomas et al., (2002), lean construction includes: practice of just-in-time (JIT), use of pull-driven scheduling, reduction of variability in labour productivity, improvement of flow reliability, elimination of waste, simplification of the operation, and implementation of benchmarking. Lean construction is a concept that incorporates several other concepts from the construction management industry. These concepts include Total Quality Management (TQM), Last Planner System (LPS), Business Process Re-engineering (BPR), Concurrent Engineering (CE), Product Circles (PCs), and teamwork and value based management (Harris and McCaffer, 1997). The key concepts are depicted in Figure 2.

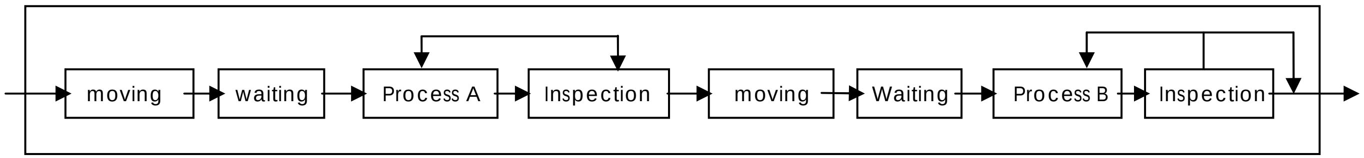


Figure 1. Production as a Process: Simplistic Illustration (Koskela, 1992)

Most of these concepts are interrelated and all aim to improve performance while minimising waste.

The barriers to lean production have been reviewed under the various management concepts that make up lean production. The barriers to teamwork include lack of organisational culture supporting teamwork, an ill-defined focus, teams being out of alignment with other teams, inadequate knowledge and skills, an inability to measure the performance of the team and to gauge the team's progress, individual needs and personal differences of team members and a lack of group culture, shared vision and shared consensus (Castka et al., 2004). The major barriers to TQM include a lack of understanding of the needs of customers, a lack of management leadership, poor communication, inadequate teamwork, and a lack of continuous improvement (Haupt and Whiteman, 2004).

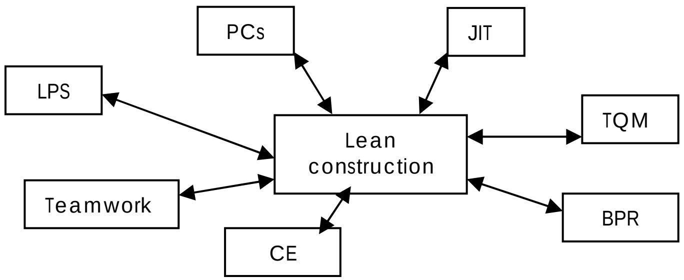


Figure 2. Key Concepts of Lean Construction

The barriers to benchmarking include the fragmented nature of the industry, the cyclic nature of the industry, the diversity of organisational sizes and structures, the ambiguous nature of inputs and outputs and the lack of an agreed upon methodology (Fawcett and Cooper, 2001). The major cause of variability is incomplete designs (Koskela, 1999), whereas complicated designs are a barrier to simplification (Ballard and Howell, 1998). The major barriers to flow reliability are the use of non-standard components, the lack of accurate pre-planning, the lack of prefabrication, and the lack of attention to resources procurement in supply chain networks where best practices are identified and incorporated (Koskela, 1999). The barriers to JIT are: uncertainty in the supply chain, uncertainty in the production process, unavailability of materials in the local market, high inflation rates, discount prices for large amounts of materials, price cuts in case of early purchasing, poor infrastructure in transportation and communications (Polat and Ardit, 2005), inadequate resources, and inadequate planning (Mathews et al., 2000). The barriers to CE are: a lack of knowledge on the implementation, a lack of management support, reward systems based on individual goals, and a lack of client and supplier involvement (Anumba et al., 2002). The barriers to BPR include the lack of committed leadership, unmotivated employees, a negative culture of the organisation and inadequate project team skills (Bechdol, 1995).

Table 1. Summary of Barriers to Lean Construction Concepts from Literature Review

Lean Concept	Barriers to Lean Construction	References
Barriers to teamwork	Lack of organisational culture supporting teamwork Ill-defined focus. Lack of capability of a team to maintain alignment with other teams Inadequate knowledge and skills Inability to measure performance of the team and to gauge the team's progress Individual needs and personal differences of team members Lack of group culture, shared vision and shared consensus.	Castka et al., (2004); Cua et al., (2001); Conte and Gransberg (2001)
Barriers to TQM	Lack of understanding of needs of customers Lack of management leadership Poor communication Inadequate teamwork Lack of continuous improvement	Haupt and Whiteman (2004)
Barriers to benchmarking	Fragmented nature of the industry Cyclic nature of the industry Diversity in organisational sizes and structures Ambiguous nature of inputs and outputs Lack of agreed methodology	Fawcett and Cooper (2001)
Barriers causing variability	Incomplete designs	Koskela (1999); Lamming (1993)
Barriers to simplification	Complicated design	Ballard and Howell (1998)
Barriers to flow reliability	Use of non-standard components Lack of accurate pre-planning; Lack of prefabrication; Lack of attention to resources procurement in supply chain networks where best practices are identified and incorporated	Koskela (1999); Ballard (2000); Pheng and Chuan (2001); Paez et al., (2005); Shmanske (2003)
Barriers to JIT	Uncertainty in the supply chain Uncertainty in the production process Unavailability of materials on local market High inflation rates Discounts of prices of large amounts of materials Price cuts in case of early purchasing Poor infrastructure in transportation and communications	Polat and Ardit, (2005); Pheng and Hui (1999); Womack and Jones (1996)
Barriers to pull scheduling	Inadequate resources Inadequate planning	Mathews et al., (2000); Ballard and Howard (1998); Mader (2003)
Barriers to concurrent engineering	Lack of knowledge on how to implement Lack of management support Reward systems based on individual goals Lack of client and supplier involvement	Anumba et al., (2002); Koskela and Huovila (1997)
Barriers to BPR	Lack of committed leadership Unmotivated people Organisation culture Inadequate project team skills	Bechdol (1995)

METHODS

Questionnaire Design

The study objectives necessitate the identification of the various barriers that influence the success of lean production. A thorough review of the literature was conducted for the purpose of identifying relevant studies. The researcher extracted many of barriers to lean production from previous studies and under different management concepts. The 40 identified barriers were then reduced to 31 through a filtration process that included eliminating redundant barriers and removing others that are not applicable to the improvement of labour productivity. These were then formulated into a data collection guide (DCG). At the end of the DCG, a margin was left for the firms to document their comments and add other barriers not listed by the researcher. The data on strength of barriers and ease of overcoming them were collected via field surveys. A 1 to 5 Likert scale was used to assess the strength of the influence of each barrier to lean production. "Not strong" was represented by 1 and "extremely strong" was represented by 5. The same scale was also used to quantify the effort required to overcome each barrier. "Not easy" was represented by 1 and "extremely easy" was represented by 5.

Pilot Studies

Pilot studies were carried out to ensure the clarity and relevance of the DCG to the contractors. The DCG was shown to two senior researchers in the field of construction management. Based on their feedback, amendments were made to the DCG and the second phase of the pilot study was conducted on four building contractors who were not eligible to participate in the main survey but eligible for the pilot studies. The intention was to use only a small sample size in order to leave more contractors available for participation in the main survey, as the number of contractors that qualify for the surveying is small. Based on the feedback from the contractors, minor amendments were again made to the DCG to remove any ambiguities and discrepancies. This pilot study was conducted to validate and improve the DCG in terms of its format and layout, the wording of statements and the overall content. The draft DCG was revised to include the suggestions of these participants before launching the main survey.

The pilot study also aided in choosing the most appropriate and reliable method of surveying. Due to the deficiency in lean production, structured interviews were suggested as the most reliable way to collect data. Barriers were explained in the same way to all firms in order to have a consistent assignment of weights. Another advantage of interviews is that the surveyor may clarify arising questions and read gestures and body language. Finally, the interviews allowed the researchers to evaluate whether the interviewee was the right choice.

The researchers visited firms at the company locations and, whenever possible, interviewed the top management personnel on the technical side. At the beginning of each interview, the title of the research and the relevant lean production terms and concepts were discussed to ensure mutual understanding. The respondents were asked to rank the 31 barriers with regard to their influence and ease of overcoming.

Sample Selection

The survey gathered data from chief executives of the largest building contractors who are registered with Uganda National Association of Building and Civil Engineering Contractors (UNABCEC), a contractors' association. The choice to use the largest contractors was based on the assumption that large and well-established firms were more capable of undertaking lean production efforts. At the national level, one recognised way of categorising construction companies is by the UNABCEC class. The classification from A to E takes into account the financial strength, size and ability to carry out jobs. Those in class A are the biggest and undertake works of the greatest magnitude and include some multinational companies. It was decided that all of the firms in categories A and B would be the source of potential participants.

For the purposes of this survey, the latest list of contractors was reduced to those in classes A and B that deal in building construction. Owing to the relatively small number of firms within the two categories A and B, all of the 57 building contractors in the two categories were targeted. Of these, only 54 contractors were approached as three of the companies had changed addresses and could not be contacted. For various reasons, nine contractors could not provide responses in time.

Survey Response

A total of 45 DCGs were completed out of the 54 that were taken to contractors, making the total response rate 83 percent, as summarised in Table 2.

Table 2. Summary of Responses from the Contractors

UNABCEC Class	No. of contractors approached	No. of responses	Percentage response
A	38	32	84
B	16	13	81
All	54	45	83

A review of the responses indicated no measurable differences in the respondents' answers to the questions, and, as the number of contractors in group B is small and less than 30, the two groups were combined for the analysis of the results.

Data Analysis

The analysis of the data was done through the SSPS 10.0 packages. The data collected from the survey were coded and entered into the software, which then calculated all of the required statistics (mean, variance) and drew the strength - ease matrix.

The average survival time in the construction market of the firms surveyed is 13 years and the minimum and maximum times are six and 40 years, respectively. This implies that all of the firms have significant experience in the building industry. The average number of permanent workers is 29 and the minimum and maximum numbers are four and 150, respectively. The average number of temporary workers at the time of the survey was 219 while the minimum was four and the maximum was 1500. This implies that most of the firms are established and have a reasonable amount of manpower. Representatives from participating firms were asked to evaluate the various lean production barriers identified in the literature review. Their evaluations were then converted into expected values, variances, and coefficients of variation (COV) as shown in equations 1, 2 and 3, respectively.

$$E(x) = \sum_{i=1}^{n} x_i p(x_i) \quad (1)$$

$$V(x) = E(X - \mu)^2 = \sum_{x} (x - \mu)^2 p(x) \quad (2)$$

$$COV(x) = \frac{\sqrt{V(x)}}{E(x)} \quad (3)$$

E(x) is the expected value of a discrete random variable X, x is the value of the random variable for which p(x)>0, p(x) is the probability distribution, μ is the average, V(x) is the variance of a random variable X, and COV(x) is the coefficient of variation.

RESULTS AND DISCUSSION

The barriers were ranked using their respective COV. The use of COV in ranking has been done before and is considered more reliable than the mean because it considers both E(x) and V(x) (Al-Shumaimeri, 2001). Table 3 ranks barriers from the strongest (most influential) to the weakest, while Table 4 ranks them from the easiest to the most difficult. Barriers with the same COV are given the same rank and subsequent ranks are adjusted to reflect the number of barriers having the same rank.

The 10 barriers with the highest rank in strength relate to a lack of the following:

1. Inputs exactly when required,
2. Infrastructure in transportation and communication,
3. Capability of teams to maintain alignment with other teams,
4. Certainty in the supply chain,
5. Steady prices of commodities,
6. Reward systems based on teams goals,
7. Buildable designs,
8. Participative management style for the workforce,
9. Parallel execution of different development tasks in multidisciplinary teams, and
10. Accurate pre-planning.

The 10 barriers that are easiest to overcome include the following:

1. Keeping needed items in the right places,
2. Lacking buildable designs,
3. Lacking a participative management style for the workforce,
4. Not having compatible management leadership,
5. Not using standard components,
6. Lacking steady work engagement,
7. Lacking communication within teams,
8. Not understanding of needs of customers i.e., internal and external,
9. Lacking project team skills, and
10. Not having a well-defined focus for the teams.

To this point, the barriers were ranked either according to their influence (strength) on the success of BPR efforts or to the chances (ease) of overcoming these obstacles, as in Table 3 and 4, respectively. Figure 3 combines both measures so that the complete picture may be captured. The coefficient of variation of strength (STRENCOV) is plotted against the coefficient of variation of ease (EASECOV).

The barriers that are regarded as strongly influencing workers' productivity and at the same time are easy to overcome are:

1. Buildable designs,
2. Participative management style for workforce,
3. Project team skills,
4. Communication within teams,
5. Capability of teams to maintain alignment with other teams,
6. Parallel execution of different development tasks in multidisciplinary teams,
7. Provision of inputs exactly when required (i.e., pull driven scheduling),
8. Reward systems based on teams goals,
9. Defect prevention, and
10. Certainty in the production process and provision of benchmarks. Most architectural designs lack constructability due to the limited knowledge about construction practices and the separation of design from construction contributes to a breakdown of the production process during construction (Tindiwensi, 2006).

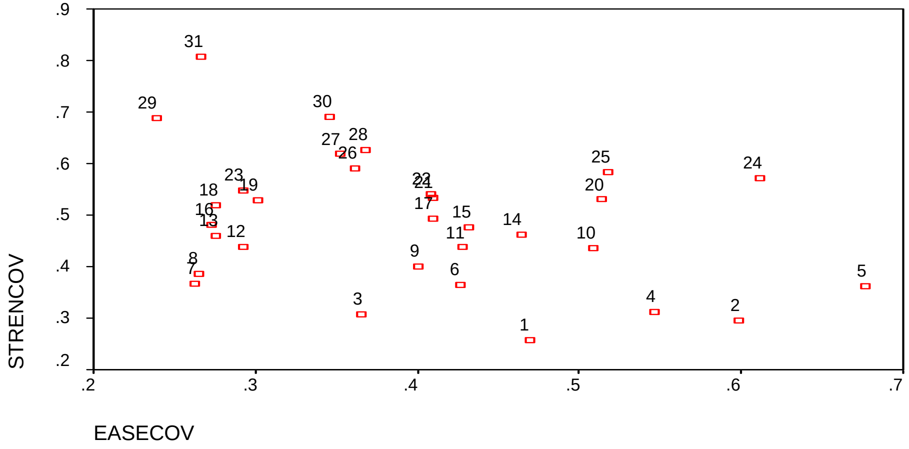
On the other hand, the barriers of lacking organisational culture supporting teamwork, lacking prefabrication and workers lacking knowledge and skills are regarded as the least in strength and, at the same time, difficult to overcome.

Table 3. Ranking of Barriers Based on Strength

Barriers influencing worker productivity	E(x)	√V(x)	COV	Rank
Provision of inputs just when required, i.e., pull driven scheduling	3.8000	0.982	0.258	1
Infrastructure in transportation and communication	3.8889	1.146	0.295	2
Capability of teams to maintain alignment with other teams	2.5778	0.795	0.308	3
Certainty in the supply chain	3.2667	1.018	0.312	4
Steady prices of commodities	3.9333	1.427	0.363	5
Reward systems based on teams goals	3.2222	1.177	0.365	6
Buildable designs	2.4222	0.886	0.366	7
Participative management style for workforce	3.1333	1.209	0.386	8
Parallel execution of different development tasks in multidisciplinary teams	2.4444	0.980	0.401	9
Accurate pre-planning	3.3778	1.468	0.435	10
Defect prevention	2.5556	1.116	0.437	11
Project team skills	2.4444	1.071	0.438	12
Communication within teams	2.5333	1.164	0.459	13
Certainty in the production process, i.e., workflow reliability	3.1778	1.468	0.462	14
Provision of benchmarks	2.5333	1.209	0.477	15
Use of standard components	2.9111	1.401	0.481	16
Multi-functional layout on jobsite	2.6667	1.318	0.494	17
Steady work engagement	2.4000	1.245	0.519	18
Well-defined focus of teams	2.2667	1.200	0.529	19
Knowledge and skills of workers	3.0000	1.591	0.530	20
Group culture, shared vision and shared consensus	3.1778	1.695	0.533	21
Client and supplier involvement	2.4889	1.346	0.541	22
Understanding of needs of customers, i.e., internal and external	2.1556	1.180	0.547	23
Organisational culture supporting teamwork	2.4222	1.386	0.572	24
Prefabrication	3.0667	1.791	0.584	25
Ability to measure performance of the team to gauge the team's progress	2.1556	1.271	0.590	26
Quality materials	3.1333	1.936	0.618	27
Continuous improvement	2.5111	1.574	0.627	28
Keeping needed items in the right places	2.0444	1.407	0.688	28
Documenting agreements and procedures	2.6444	1.825	0.690	30
Management leadership	2.5111	2.028	0.808	31

Table 4. Ranking of Barriers Based on Ease of Overcoming

Barriers influencing worker productivity	E(x)	√V(x)	COV	Rank
Keeping needed items in the right places	3.6444	0.871	0.239	1
Buildable designs	3.5556	0.934	0.263	2
Participative management style for workforce	2.6222	0.695	0.265	3
Management leadership	3.6222	0.968	0.267	4
Use of standard components	2.5778	0.704	0.273	5
Steady work engagement	2.4318	0.670	0.276	6
Communication within teams	3.1778	0.877	0.276	7
Understanding of needs of customers, i.e., internal and external	3.6222	1.059	0.292	8
Project team skills	3.2000	0.936	0.293	9
Well-defined focus of teams	2.6889	0.810	0.301	10
Documenting agreements and procedures	2.7111	0.937	0.346	11
Quality materials	3.5556	1.253	0.352	12
Ability to measure performance of the team to gauge the team’s progress	3.5778	1.295	0.362	13
Capability of teams to maintain alignment with other teams	2.4222	0.886	0.366	14
Continuous improvement	3.0222	1.113	0.368	15
Parallel execution of different development tasks in multidisciplinary teams	2.5556	1.025	0.401	16
Client and supplier involvement	3.2444	1.325	0.408	17
Group culture, shared vision and shared consensus	2.3333	0.955	0.409	18
Multi-functional layout on jobsite	2.5111	1.028	0.409	19
Reward systems based on teams goals	2.3778	1.013	0.426	20
Defect prevention	2.5111	1.074	0.428	21
Provision of benchmarks	2.6444	1.143	0.432	22
Certainty in the production process, i.e., workflow reliability	2.3778	1.104	0.464	23
Provision of inputs just when required, i.e., pull driven scheduling	2.2667	1.064	0.469	24
Accurate pre-planning	2.2222	1.131	0.509	25
Knowledge and skills of workers	2.6000	1.336	0.514	26
Prefabrication	2.5111	1.301	0.518	27
Certainty in the supply chain	2.1556	1.180	0.547	28
Infrastructure in transportation and communication	2.0444	1.225	0.599	29
Organisational culture supporting teamwork	2.6222	1.604	0.612	30
Steady prices of commodities	1.5778	1.068	0.677	31



1 Provision of inputs just when required, i.e., pull driven scheduling
2 Infrastructure in transportation and communication
3 Capability of teams to maintain alignment with other teams
4 Certainty in the supply chain
5 Steady prices of commodities
6 Reward systems based on teams goals
7 Buildable designs
8 Participative management style for workforce
9 Parallel execution of different development tasks in multidisciplinary teams
10 Accurate pre-planning
11 Defect prevention
12 Project team skills
13 Communication within teams
14 Certainty in the production process, i.e., workflow reliability
15 Provision of benchmarks
16 Use of standard components
17 Multi-functional layout on jobsite
18 Steady work engagement
19 Well-defined focus of teams
20 Knowledge and skills of workers
21 Group culture, shared vision and shared consensus
22 Client and supplier involvement
23 Understanding of needs of customers, i.e., internal and external
24 Organisational culture supporting teamwork
25 Prefabrication
26 Ability to measure performance of the team to gauge the team's progress
27 Quality materials
28 Continuous improvement
29 Keeping needed items in the right places
30 Documenting agreements and procedures
31 Management leadership

Figure 3. Prioritising Lean Construction Barriers According to Strength in Influencing Worker Productivity and Ease of Overcoming

CONCLUSION

To the building firms operating in Uganda, this study presents the strength and ease of overcoming lean production barriers. This study can be useful to the practitioners in different ways. First, by identifying and evaluating the effects of lean production barriers, firms can focus their attention and resources on the real issues. Second, by assessing the difficulty associated with overcoming the various barriers, firms can tackle the easiest first. Additionally, they can use the priority list that includes the strongest barriers as well as the easiest barriers to enhance their chances of minimising waste. Moreover, the study sets the foundation for further analysis of each barrier. This will enable building firms to gain more insight into the barriers and improve their chances of overcoming the barriers in order to minimise waste on building sites.

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