



Journal of Construction Project management and Innovation

Volume 7 Number 1 June, 2017

ISSN 2223-7852



ABOUT JCPMI

The **Journal of Construction Project Management and Innovation** is published bi-annually (twice per year) through the Sustainable Human Settlement and Construction Research Centre (SHSCRC) of the University of Johannesburg, by Sabinet Online - SA ePublications.

Journal of Construction Project Management and Innovation is an open access journal that publish all sorts of researches on Construction project management; Project management; Design and construction management processes; Housing and infrastructure development; Stakeholder management; Project planning and project impact assessments; Design and implementation of labour-intensive projects; Procurement management; Management of construction companies; Industry development; Knowledge management in construction; Empowerment of women; Innovation; Project financing; Current and emerging infrastructure issues in developing countries etc. as well as other issues. The goal of JCPMI is to broaden the knowledge of construction professionals and academicians by promoting free access and providing valuable insight to construction-related information, research and ideas. JCPMI is a bi-annual publication and all articles are peer-reviewed.

Submission of Manuscript

Submit manuscripts as e-mail attachment to the Editorial Office at: caigbavboa@uj.ac.za, didibhukut@uj.ac.za. A manuscript number will be mailed to the corresponding author shortly after submission.

For all other correspondence that cannot be sent by e-mail, please contact the editorial office (caigbavboa@uj.ac.za, didibhukut@uj.ac.za).

The Journal of Construction Project Management and Innovation will only accept manuscripts submitted as e-mail attachments. Please read the Instructions for Authors before submitting your manuscript. The manuscript files should be given the last name of the first author.

Editor-in-Chief

Prof. Wellington Didibhuku Thwala

Professor of Construction Management
Department of Construction Management and Quantity Surveying
Faculty of Engineering and the Built Environment
University of Johannesburg
South Africa.

Editor

Prof. Clinton Ohis Aigbavboa

Associate Professor
Department of Construction Management and Quantity Surveying,
Faculty of Engineering and the Built Environment
University of Johannesburg
South Africa.

Guest Editor - Lean Construction in Africa (LCiA)

Prof. Fidelis Emuze

Associate Professor and Head: Built Environment
Head: Unit for Lean Construction and Sustainability
Faculty of Engineering and Information Technology
Central University of Technology, Free State
South Africa.

ARTICLES

Research Articles

- A discourse on lean construction in Africa using a supply chain example
Fidelis EMUZE 1664
- A theoretical review of lean implementation within construction SMEs
Emmanuel Nsiah ANKOMAH, Joshua AYARKWA, and Kofi AGYEKUM 1675
- The state of adoption of lean construction in the Tanzanian construction industry
Nyamagere Gladys SOSPETER and Geraldine John KIKWASI 1689
- An investigation into the usage of lean construction techniques in Nigeria
Olatunji J OLADIRAN 1712
- Traces of lean construction practices in the indigenous building culture of the Talensi of northern Ghana projects
Zoya Evans KPAMMA, Eric Kwaku ASARE and Emmanuel Nsiah ANKOMAH 1726
- The prospect of minimising production flow waste on construction sites in Nigeria through the last planner® system
Emmanuel Itodo DANIEL, Christine PASQUIRE and Oko John AMEH 1739
- A Gemba kaizen model based on BPMN for small- and medium-scale construction businesses in Nigeria
Temitope OMOTAYO and Udayangani KULATUNGA 1760
- Nigerian construction-related professional services firms to adopt lean construction practices
Olajide OLAMILOKUN, Umar Datti YUSUF, and Emmanuel Dele OMOPARIOLA 1780
- The influence of culture, beliefs and experience on the sustainable end-of-life management of buildings in Nigeria
Aminu Lawan ABDULLAHI and Angela LEE 1793
- A Continuous improvement framework using IDEFO for post-contract cost control
Temitope OMOTAYO and Udayangani KULATUNGA 1807
- Modelling a conceptual framework of technology transfer process in construction projects: an empirical approach
De-Graft OWUSU-MANU, Erika PÄRN, Maxwell ANTWI-AFARI, and David EDWARDS 1824

A THEORETICAL REVIEW OF LEAN IMPLEMENTATION WITHIN CONSTRUCTION SMEs

Emmanuel Nsiah ANKOMAH¹, Joshua AYARKWA², and Kofi AGYEKUM³

¹Department of Building Technology, Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana, Email: bd310nsiah@gmail.com

²Department of Building Technology, KNUST, Kumasi, Ghana, Email: jayarkwa.cap@knust.edu.gh

³Department of Building Technology, KNUST, Kumasi, Ghana, Email: agyekum.kofi1@gmail.com

ABSTRACT

Small- and medium-sized enterprises (SMEs) are considered the backbone of many economies. SMEs constitute over 90% of global enterprises and account for about 60% of employment. However, SMEs still suffer from many problems, such as low product quality and working efficiency, budget overruns, and substantial construction waste. Lean construction has increasingly been implemented as a potential solution for organisations to deal with waste of all types. The aim of this article is to suggest lean tools that can be implemented within the construction SME set-up. A systematic review of empirical and theoretical studies obtained from ResearchGate, International Group for Lean Construction (IGLC) conference proceedings, ScienceDirect (Elsevier), Emerald Insight, Taylor & Francis Group, Google Scholar, and other Internet sources was conducted in this study. This paper was based on four hypotheses, which are related to construction SMEs' capacity to implement lean as efficiently as large enterprises do. The study found that lean was applicable in construction SMEs, but that it has to be contextualised within the peculiar characteristics of the SME, such as its size, financial capabilities, organisational culture, and human resource capacity. The paper concluded by recommending lean tools such as 5S, A3 problem solving, and 5 Whys, which require less monetary investment to be implemented by construction SMEs. A change of mindset is needed for lean implementation, as there is still a low rate of lean adoption among SMEs.

Keywords: SMEs, lean construction, process improvement, value, innovation

INTRODUCTION

The performance of the construction industry in Ghana is poor, and it experiences several problems, ranging from contract administration difficulties to complex and lengthy payment procedures, from delayed payments to project execution challenges

(Anvuur et al., 2006). The construction industry in Ghana is dominated by small- and medium-sized enterprises (SMEs), which are characterised by high attrition rates. These are the least organised of enterprises, and their performance is usually below expectations. In essence, there is not much difference between the problems militating against the construction industry in Ghana regarding project execution and performance and the problems experienced in the construction industry in other developing countries. The main difference, however, is that Ghana is yet to take the necessary steps to address the problems (Gyadu-Asiedu, 2009).

Small- and medium-sized enterprises (SMEs) are one of the most significant forces for economic growth. SMEs are recognised worldwide as vital in the stimulation of innovation, economic growth, job opportunities, and poverty reduction, and they support large-scale enterprises. SMEs account for approximately 90% of businesses and more than 50% of employment worldwide. In developing countries, SMEs account for 45% of formal employment (Bauchet and Morduch, 2013). SMEs are also believed to contribute about 70% to Ghana's GDP, and to account for about 92% of businesses in Ghana (Ackah and Vuvor, 2011). Therefore, the contribution of this sector to the economy of Ghana cannot be overemphasised.

Notwithstanding these contributions, SMEs still suffer from many fundamental problems, such as low product quality, low working efficiency and projects being completed over budget, and huge construction waste, among other things. Lean construction is a potential solution to the many problems faced within the industry, and it results in exceptional performance improvement (Bhamu and Sangwan, 2014). Yet there is still a low rate of lean adoption by construction SMEs, both in Ghana and in other countries. This problem has always been attributed to the fact that SMEs lack the capacity to implement such a management philosophy. In some earlier studies, it was revealed that SMEs do not have the capacity to implement lean construction (Shang, 2013; Ayarkwa et al., 2012). Construction SMEs, and the industry as a whole, have been criticised by many for limited collaborative working ethos, their slow uptake of new technologies and processes, and issues associated with organisational management (Miller et al., 2002). Considering the investment levels of the construction industry, and the development needs of most developing countries, attention to these matters is long overdue. Construction SMEs constitute the largest group in the construction industry, and their performance impacts greatly on the performance of the industry as a whole (Gyadu-Asiedu, 2009). Therefore, any improvement efforts to SMEs will impact greatly on the performance of the industry as a whole.

Any method that seeks to make an enterprise lean always reduces waste and maximises value in the company, enhancing core resources and establishing a corporate culture dedicated to identifying and continuously promoting customer satisfaction (Arroyo and Gonzalez, 2016). The principles in making an enterprise lean can be categorised as identifying value, eliminating waste, and generating smooth flow (Azharul and Arif-Uz-Zaman, 2013). It appears, however, that there is a significantly lower rate of adoption of lean principles in SMEs than in large enterprises (LEs) (Shah and Ward, 2003), and that many SMEs are still unfamiliar with lean implementation (Achanga et al., 2006).

RESEARCH METHODOLOGY

The article was developed based on a review of empirical and theoretical studies already published. Past research on lean construction and SMEs was obtained primarily from research databases, including ResearchGate, IGLC conference proceedings, ScienceDirect (Elsevier), Emerald Insight, Taylor & Francis Group, Google Scholar, and other Internet sources. The initial descriptors used for the search were “lean construction tools”, “construction SMEs”, and “lean and construction SMEs”. The initial descriptors were used to search the databases. A total of 75 articles were reviewed for the research. This work is based on four research questions, which are related to construction SMEs’ capacity to implement lean as efficiently as large enterprises do. The questions are: “Does the size of the firm matter in lean adoption and implementation?”; “Can SMEs benefit from lean if they apply the lean package only partially?”; “Can SMEs benefit from lean, considering their organisational structure and culture, and their financial and human resource capacities?”; and “Is the organisational culture of construction SMEs in Ghana supportive of lean construction?” The article seeks to answer these questions, and it goes on to recommend lean tools that can be implemented by construction SMEs in Ghana.

THE NEED FOR LEAN IMPLEMENTATION IN CONSTRUCTION SMEs

Construction is one of the world’s major industries, and it is normally recognised as having high levels of waste (Bølviken and Koskela, 2016). There is a need for construction SMEs to be aware of lean and to be able to motivate their employees, clients, and partners to attain greater joint performance (Ofori and Toor, 2012).

This, the authors believe, can be achieved through implementation of lean construction principles in construction SMEs in Ghana. There have been a number of reviews of literature on lean. For example, Moyano-Fuentes and Sacristán-Díaz (2012) developed a general framework for lean, and, most recently, Shang (2013), in his PhD thesis, proposed a lean implementation framework for large construction companies in China. These reviews have largely focused on lean in general, or they have focused on larger enterprises, neglecting smaller ones. There is thus a gap in the literature on lean that is pertinent to SMEs. Given the nature of the contingency management approach, it follows, then, that a management philosophy such as lean construction is contingent upon the characteristics of each unique organisation. The fact that such management practices have worked well for large enterprises does not necessarily mean that they will work well in SMEs. It is more important to adjust where necessary to better suit the peculiar characteristics of SMEs. Studies conducted within the construction industry in Ghana suggest a low level of familiarity and application of lean construction among practitioners within the industry (Ankomah et al., 2015; Ayarkwa et al., 2012).

Rose et al. (2011) pointed out that there is currently no standard measure for lean implementation that SMEs can adopt. Although different researchers have different perspectives on the issue, they stress that SMEs should opt for the least costly practices, such as 5S, visual management (VM), etc. SMEs face challenges in their processes of production, and this makes the implementation of lean in construction

worth exploring.

LEAN APPLICABILITY WITHIN CONSTRUCTION SMEs

This paper is based on four hypotheses, which are related to construction SMEs' capacity to implement lean as efficiently as large enterprises do.

Does size of the firm matter in lean adoption and implementation?

There is still considerable interest as to whether there is a difference in the applicability of lean between large enterprises (LEs) and SMEs (Rose et al., 2013). It is the subject of continued debate whether the size of a firm is a critical factor in lean implementation. Many authors have suggested that lean is more suitable for large enterprises than for SMEs (e.g. Shah and Ward, 2003; Achanga et al., 2006). The researchers argue that implementation of lean by SMEs is a challenge, due to their lack of required resources and capabilities. However, other researchers disagree, asserting that size does not affect a firm's ability to implement lean, and that SMEs can implement these systems as effectively as large organisations do (Rose et al., 2011). They go on to assert that SMEs can implement lean, but that they should opt for the least costly practices. The authors' provisional proposition is that the size of the firm does not really matter. Small firms, by virtue of their size, can implement some lean tools for their own benefit, but they need to opt for tools that require less investment.

Can SMEs benefit from lean if they apply the lean package only partially?

Although some researchers (e.g. Liker, 2004; Anand and Kodali, 2009) have suggested that lean practices should be implemented as a full package, Golicic and Medland (2007) have argued otherwise. The researchers believe that lean can be applied partially. Application of some lean tools will lead to gradual performance improvements in SMEs, which can then lead to more advanced practices (Rose et al., 2011).

Can SMEs benefit from lean, considering their organisational structure and culture, and their financial and human resource capacities?

At the financial level, SMEs lack the funding (Mazanai, 2012) and infrastructure/facilities (Panizzolo et al., 2012) needed to implement lean. Ongoing implementation of the full version of lean can require substantial investment before benefits are realised, and SMEs may be more restricted in this regard in terms of available financial resources or ability to invest upfront in sufficient time to support training and knowledge development (Mazanai, 2012).

SMEs can implement some of the tools, such as the Last Planner, 5S, etc., to enhance their performance and productivity. SMEs can do this without having to invest huge sums of money. As the SMEs grow, they can implement other tools that require substantial investment, such as building information modelling (BIM).

Is the organisational culture of construction SMEs in Ghana supportive of lean construction?

The construction industry differs culturally from one country to another, and

therefore practices and procedures that are well suited to the culture of one country may not be suitable in other countries (Kheni, 2008). Evidence from the literature suggests that an organisation cannot succeed in lean unless it has a healthy culture. In the UK, only 10% of firms succeed in their lean implementation efforts. The reason behind the low success rate is culture and management (Taleghani, 2010). Culture is a vital factor for successful lean implementation (Al-Swidi and Mahmood, 2011). Dahlgaard and Dahlgaard-Park (2006) have argued that appropriate culture cannot be compromised if a company wants to adopt lean successfully. A discussion of organisational culture is appropriate, as lean initiatives are normally undertaken at the organisation level, where changes occur away from the traditional management approaches to construction (Shang, 2013). According to Atuahene (2016), small firms in Ghana have a dominance hierarchy culture focused on internal structures. The relationship between contractors and suppliers within the industry is also short-term, and only based on the needs of current projects (Ankomah et al., 2015).

Lean construction requires a culture of employee empowerment, teamwork, and enhanced relations with employees and suppliers (Womack et al., 1990). Companies that have successfully implemented lean have argued that it would not have been possible without sustained employee and supplier engagement and support at all levels of the organisation (Korb, 2016). Hierarchical structure, along with a top-down leadership style, is one of the many cultural barriers that cause lean initiatives to fail (Shang, 2013). The organisational culture in the construction industry in Ghana will need to change if the industry is to accommodate lean initiatives.

LEAN PRACTICES

Table 1 identifies lean practices applicable to construction, with a brief description of the tools, and the literature sources consulted. The categorisation was mostly informed by an analysis of IGLC conference proceedings, although other studies published elsewhere were also consulted.

Table 1A. Identified lean practices applicable to construction, description of the tools and references

Lean tools	Brief description	References
Last Planner System	The Last Planner™ System (LPST™) provides a regimented process of achieving reliable workflow on simple and complex construction projects. This system was created in order to improve the predictability and reliability of construction production.	Toledo et al., (2016); Habchi et al., (2016); Salem et al., (2005)
Increased Visualisation	It is about communicating key information effectively to the workforce through posting various signs and labels around the construction site. This includes signs related to safety, schedule, and quality.	AlNimr and Mohammed (2010); Salem et al., (2005)
Daily Huddle	Daily huddles are for communication, not only for managers to talk to employees, but also for employees to	Salem et al., (2005)

Meetings	express themselves and learn from each other.	
5S Process	5S is a basic method for clean-up and organisation of the workplace. It works by asking once why an effect happened, and to the response of that question, ask again, why it happened.	Tezel et al., (2016); Berrior et al., (2015)
5 Why's	Same procedure is repeated until asking five times why it happened and by the end of the process, the answer is the root cause.	Fuenzalida et al., (2016); Kemmer et al., (2006)
Concurrent Engineering	A simultaneous engineering that attempts to optimise the design of a project and its construction process by the integration of design, fabrication, construction and erection activities.	Knotten et al., (2014)
Choosing by Advantages (CBA)	CBA is a value-based Multi-Criteria Decision- Analysis system that supports sound decision-making based on the comparisons among the advantages of alternatives.	Kpamma et al., (2014)
Building Information Modelling (BIM)	A virtual process that encompasses all aspects, disciplines, and systems of a facility within a single, virtual model. Some new concepts and BIM applications have been developed for different purposes in the construction industry, such as 4D, 5D, 6D and 7D dimensions	Abou-Ibrahim and Hamzeh (2016); Harris and Alves (2016)
Kaizen	Kaizen is a Japanese word for improvement. This Lean construction tool involves looking at some task in the field and finding out how to do it better, more efficiently, safer and quicker.	Rossiti et al., (2016); Liker and Meier (2006)
Poka-Yoke	In building a culture of stopping to fix problems, poka-yoke is one of the lean tools that help the employees to detect the defects and halt the process. It is synonymous with fail safe for quality and safety.	Shang (2013); Tommelein (2008)
A3 Report	An A3 is an orderly document that aids thinking. A3 reports are so named because they fit on one side of an A3 size paper. The A3 report is a way of representing an action course, in which goals, methodology, agents involved and others are included. The document is for problem solving, proposing action or project status reporting.	Fuenzalida et al., (2016); Rybkowski et al., (2016); Koskela (2015)

Table 1B. Identified lean practices applicable to construction, description of the tools and references

Lean tools	Brief description	References
The Ishikawa	The Ishikawa diagram is a representation of a	Fuenzalida et al., (2016)

diagram	cause-effect analysis that is carried out for any type of result.	
Location Based Management System (LBMS)	The Location Based Management System (LBMS) provides a much needed spatial element to planning and has strong optimization and forecasting capability that can help plan and steer the project towards its goals.	Dave et al., (2016); Frandsen et al., (2015)
Andon	A visual control tool which shows the operation status and signalize the occurrence of abnormalities.	Biotto et al., (2014); Kemmer et al., (2006)
Heijunka	Leveling the work flow of a production system and balancing or distributing load and capacity	Alves et al., (2009); Barbosa et al.,(2013)
Value Stream Mapping	Systemic view of the production process (of the value flow), identification of real problems and wastes and proposition of improvements.	Murguia et al.,(2016); Covarrubias et al., (2016)
Material Kanban Cards	It is used as a material process flow technique for the pull replenishment logic system.	Jang and Kim (2007)
Six Minute Exchange Die (SMED)	SMED practices in project management can be seen as a method for fast tracking the project schedule.	Antunes et al.,(2016)
Action Learning	The core idea behind Action Learning is to create small, mutually supportive groups (known as SETs) of people who band together to solve real problems or difficulties which are not solved in current best practice.	Hirota and Formoso (2001)

Based on the lean construction tools identified within the literature cited in Table 1, the authors categorised these tools into three groups, namely

- A. Tools that require less monetary investment to implement,
- B. Tools that can be fully implemented by construction SMEs, and
- C. Tools that can be partially implemented by SMEs.

The categorisation has been done for the purposes of suggesting lean construction tools for use by SMEs based on their peculiar characteristics. The contents of Table 2 are based on the categorisation as indicated above.

Table 2. Three groups of lean tools

Lean tool	Group		
	A	B	C
Last Planner System	×	×	
Increased visualisation	×	×	

Daily huddle meetings	×	×	
First-run studies	×	×	
5S process	×	×	
5 Whys	×	×	
Concurrent engineering	×	×	
Choosing by Advantages (CBA)	×	×	
Building Information Modelling (BIM)			×
Kaizen	×	×	
Poka-yoke	×	×	
A3 report	×	×	
The Ishikawa diagram	×	×	
Location-Based Management System (LBMS)	×	×	
Andon	×	×	
Heijunka	×	×	
Value stream mapping (VSM)	×	×	
Material kanban cards	×	×	
Single-minute exchange of dies (SMED)	×	×	
Action learning	×	×	

Researchers such as Rose et al. (2011) and Salem et al. (2005) have confirmed that tools such as 5S, kanban cards, SMED, kaizen, increased visualisation, Last Planner, daily huddle meetings, first-run studies, poka-yoke, and andon are the least costly, and can be implemented by SMEs. A review of the literature on the other lean construction tools (5 Whys, concurrent engineering, Choosing by Advantages, A3 report, the Ishikawa diagram, LBMS, heijunka, VSM, and action learning) shows these tools as not being capital-intensive, and therefore not within the reach of SMEs. The authors will subsequently validate these other lean construction tools. Considering the poverty levels in Ghana, the authors recommend that lean tools that require less monetary investment be implemented by construction SMEs, as can be seen in Table 2. SMEs can implement these tools without having to invest that much, and as the SME grows, it can implement tools such as BIM, which requires some investment in software and hardware. SMEs can implement some aspects of BIM, such as 3D, which does not require substantial investment.

ADOPTING LEAN PRACTICES BY CONSTRUCTION SMEs IN GHANA

A change in mindset is required before embarking on lean implementation (Herrala et al., 2012; Emuze and Ungerer, 2014). This is because a fundamental part of implementing any lean strategy is a change of mindset, and a change of organisational culture (Liker and Meier, 2006). Top management must intervene, and this requires that people behave differently, starting with changing their conventional mindsets. As this process is repeated, a different set of beliefs and values – a new organisational culture – will ultimately evolve. This, however, requires a long-term

commitment to continuous improvement. Professional bodies, such as the Ghana Institute of Architects (GIA), the Ghana Institution of Surveyors (GhIS), and the Ghana Institution of Engineers (GhIE), should expose their members to the concept of lean thinking, through their continuing professional development programmes. There could also be collaboration with leading institutional proponents of lean construction, such as the Lean Construction Institute (LCI), to offer special training for contractors in Ghana on strategies for applying the lean thinking concept within the industry. Furthermore, there should be deliberate government policy to implement lean, particularly within public-sector construction works. There is also a need for research and teaching to be strengthened in the academic and professional training of students pursuing construction-related disciplines.

CONCLUSIONS

The global economy is changing, and is becoming much more competitive. The benefits of implementing lean are substantial, while the cost of not being able to meet project goals may be significant. The primary objective of this paper was to propose lean construction tools that can be implemented within the construction SME set-up. This is against the backdrop of SMEs' lack of the needed resources to implement lean construction. Through a review of the literature, this paper has proposed lean construction tools that can be implemented within the construction SME set-up. The study found that SMEs can implement some lean tools, such as the Last Planner, 5S, etc., which will not require having to invest huge sums of money. This is an important finding, as some authors have argued that SMEs do not have the capacity to implement lean construction. This is preliminary research from an ongoing PhD, which aims to develop a lean implementation framework to enhance the performance of construction SMEs. The findings in this study will be validated through a nationwide survey, case studies, and interviews in Ghana.

ACKNOWLEDGEMENT

This article was language-edited by a freelance language editor, Anthony Sparg. He has edited several academic journal articles and master's theses in the field of construction management. He has an MA *cum laude* in African Languages (isiXhosa), an MA *cum laude* in Linguistics, and a Higher Diploma in Education.

REFERENCES

- Abou-Ibrahim, H. and Hamzeh, F. (2016). BIM: A TFV perspective to manage design using the LOD concept. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 4. pp. 3–12. Available at: www.iglc.net
- Achanga, P., Shehab, E., Roy, R. and Nelder, G. (2006). Critical success factors for lean implementation within SMEs. *Journal of Manufacturing Technology Management*, 17(4), 460–471.

- Ackah, J. and Vuvor, S. (2011). *The challenges faced by small & medium enterprises (SMEs) in obtaining credit in Ghana*. A dissertation submitted to Blekinge Institute of Technology, Karlskrona, Sweden, for the award of master's degree.
- AlNimr, A. and Mohammed, Y. (2010). Application of gaming engines in simulation driven visualization of construction operations. *ITcon*, 16, 23–38.
- Al-Swidi, A. K. and Mahmood, R. (2011). How does organizational culture shape the relationship between entrepreneurial orientation and the organizational performance of banks? *European Journal of Social Sciences*, 20(1), 28–46.
- Anand, G. and Kodali, R. (2009). Development of a framework for lean manufacturing systems. *International Journal of Services and Operations Management*, 5(5), 687–716.
- Ankomah, E. N., Baiden, B. K. and Ofori-Kuragu J. K. (2015). Lean techniques approaches to managing Ghanaian contractor supply chains. *International Journal of Construction Engineering and Management*, 4(3), 87–94.
- Antunes, R., Gonzalez, V. A. and Walsh, K. (2016). Quicker reaction, lower variability: The effect of transient time in flow variability of project-driven production. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. 21–23 July. Boston, MA. Section 1. pp. 73–82. Available at: www.iglc.net
- Anvuur, A., Kumaraswamy, M. and Male, S. (2006). Taking forward public procurement reforms in Ghana. *CIB W107 Construction in Developing Economies International Symposium*. “Construction in Developing Economies: New Issues and Challenges”. 18–20 January. Santiago, Chile.
- Arroyo, P. and Gonzalez, V. (2016). Rethinking waste definition to account for environmental and social impacts. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. 20–22 July. Boston, MA. Section 10. pp. 13–22.
- Atuahene, B. T. (2016). *Organizational culture in the Ghanaian construction industry*. A thesis submitted to the Department of Building Technology, College of Art and Built Environment, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, in partial fulfilment of the requirements for the degree of Master of Philosophy.
- Ayarkwa, J., Agyekum, K., Adinyira, E. and Osei-Asibey, D. (2012). Perspectives for the implementation of lean construction in the Ghanaian construction industry. *Journal of Construction Project Management and Innovation*, 2(2), 345–359.
- Azharul, K. and Arif-Uz-Zaman, K. (2013). A methodology for effective implementation of lean strategies and its performance evaluation in manufacturing organizations. *Business Process Management Journal*, 19(1), 169–196.
- Barbosa, G., Andrade, F., Biotto, C. and Mota, B. (2013). Heijunka system to level telescopic forklift activities using tablets in construction site. *Proceedings of the*

- 21st Annual Conference of the International Group for Lean Construction (IGLC)*. Fortaleza, Brazil.
- Bauchet, J. and Morduch, J. (2013). Is micro too small? Microcredit vs. SME finance. *World Development*, 43, 288–297.
- Bhamu, J. and Sangwan, K. S. (2014). Lean manufacturing: Literature review and research issues. *International Journal of Operations & Production Management*, 34(7), 876–940.
- Biotto, C., Mota, B., Araújo, L., Barbosa, G. and Andrade, F. (2014). Adapted use of andon in a horizontal residential construction project. *Proceedings of the 22nd Annual Conference of the International Group for Lean Construction (IGLC)*. Oslo, Norway.
- Bølviken, T. and Koskela, L. (2016). Why hasn't waste reduction conquered construction? *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 1. pp. 3–12.
- Covarrubias, A., Mourgues, C. and Arroyo, P. (2016). VSM for improving the certificate of occupancy process in real estate projects – A Chilean case study. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 4. pp. 123–132. Available at: www.iglc.net
- Dahlgaard, J. J. and Dahlgaard-Park, S. M. (2006). Lean production, six sigma quality, TQM and company culture. *The TQM Magazine*, 18(3), 263–281.
- Dave, B., Seppänen, O. and Modrich, R.-U. (2016). Modeling information flows between Last Planner and Location Based Management System. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 6. pp. 63–72. Available at: www.iglc.net
- Emuze, F. and Ungerer, H. (2014). Change in South Africa construction: Lessons from lean thinking. In: Kalsaas, B.T., Koskela, L. and Saurin, T.A. *22nd Annual Conference of the International Group for Lean Construction*. Oslo, Norway. 25–27 June. pp. 1121–1131.
- Fransson, A. G., Seppänen, O. and Tommelein, I. D. (2015). Comparison between Location Based Management and Takt Time Planning. *Proceedings of the 23rd Annual Conference of the International Group for Lean Construction*. 28–31 July. Perth, Australia. pp. 3–12. Available at: www.iglc.net
- Fuenzalida, C., Fischer, B., Arroyo, P. and Salvarierra, J. L. (2016). Evaluating environmental impacts of construction operation before and after the implementation of lean tools. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 10. pp. 3–12.
- Golicic, S. L. and Medland, S. S. (2007). Size might matter: A case study of lean implementation in an SME. *Proceedings of the Society for Marketing Advances*. Kuala Lumpur, Malaysia: Society for Marketing Advances. pp. 261–264.
- Gyadu-Asiedu, W. (2009). *Assessing construction project performance in Ghana: Modelling practitioners' and clients' perspectives*. A thesis submitted to the

- Eindhoven University of Technology, Eindhoven, The Netherlands, for the award of doctorate degree.
- Harris, B. N. and Alves, T. C. L. (2016). Building information modeling: A report from the field. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 5. pp. 13–22. Available at: www.iglc.net
- Herrala, M. E., Pekuri, A. and Aapaoja, A. (2012). How Do You Understand Lean? In: Tommelein, I. D. and Pasquire, C. L. *20th Annual Conference of the International Group for Lean Construction*. San Diego, CA. 18–20 July.
- Hicham, H., Taoufiq, C. and Aziz, S. (2016). Last Planner® System: Implementation in a Moroccan construction project. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 6. pp. 193–202. Available at: www.iglc.net
- Hirota, E. H. and Formoso, C. T. (2001). Barriers to management innovations: Communicating meanings. *Proceedings of the 9th Annual Conference of the International Group for Lean Construction*. Singapore, Singapore.
- Jang, J. W. and Kim, Y.-W. (2007). Using the kanban for construction production and safety control. *Proceedings of the 15th Annual Conference of the International Group for Lean Construction (IGLC)*. East Lansing, MI.
- Kemmer, S. L., Saraiva, M. A., Heineck, L. F. M., Pacheco, A. V. L., Novaes, M. de V., Mourão, C. A. M. A. and Moreira, L. C. R. (2006). The use of andon in high rise building. *Proceedings of the 14th Annual Conference of the International Group for Lean Construction*. Santiago, Chile.
- Kheni, N. A. (2008). *Impact of health and safety management on safety performance of small and medium-sized construction businesses in Ghana*. A thesis submitted to Loughborough University, Loughborough, UK, in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy.
- Knotten, V., Svalestuen, F., Aslesen, S. and Dammerud, H. (2014). Integrated methodology for design management – A research project to improve design management for the AEC industry in Norway. *Proceedings of the 22nd Annual Conference of the International Group for Lean Construction*. Oslo, Norway.
- Korb, S. (2016). “Respect for people” and lean construction: Has the boat been missed? *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 1. pp. 43–52. Available at: www.iglc.net
- Koskela, L. (2015). Where rhetoric and lean meet. *Proceedings of the 23rd Annual Conference of the International Group for Lean Construction*. Perth, Australia. 29–31 July. pp. 527–535. Available at: www.iglc.net
- Kpamma, Z. E., Adjei-Kumi, T., Ayarkwa, J. and Adinyira, E. (2014). Enhancing user-involvement through a multi-criteria decision aid: A lean design research agenda. *Proceedings of the 22nd Annual Conference of the International Group for Lean Construction*. Oslo, Norway.

- Liker, J. (2004). *The Toyota Way: 14 management principles from the world's greatest manufacturer*. New York: McGraw-Hill.
- Liker, J. K. and Meier, D. (2006). *The Toyota Way fieldbook: A practical guide for implementing Toyota's 4Ps*. New York: McGraw-Hill.
- Mazanai, M. (2012). Impact of just-in-time (JIT) inventory system on efficiency, quality and flexibility among manufacturing sector, small and medium enterprise (SMEs) in South Africa. *African Journal of Business Management*, 6(17), 5786–5791.
- Miller, C. J. M., Packham, G. A. and Thomas, B. C. (2002). Harmonization between main contractors and subcontractors: A prerequisite for lean construction? *Journal of Construction Research*, 3(1), 67–82.
- Moyano-Fuentes, J. and Sacristán-Díaz, M. (2012). Learning on lean: A review of thinking and research. *International Journal of Operations & Production Management*, 32(5), 551–582.
- Murguía, D., Brioso, X. and Pimentel, A. (2016). Applying lean techniques to improve performance in the finishing phase of a residential building. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 2. pp. 43–52. Available at: www.iglc.net
- Ofori, G. and Toor, S. R. (2012). Leadership development for construction SMEs. *Working paper proceedings of the Engineering Project Organizations Conference*. Rheden, The Netherlands. 10–12 July.
- Panizzolo, R., Garengo, P., Sharma, M. K. and Gore, A. (2012). Lean manufacturing in developing countries: Evidence from Indian SMEs. *Production Planning & Control: The Management of Operations*, 23(10-11), 769–788.
- Rose, A. N. M., Deros, B. Md. and Rahman, M. N. Ab. (2013). Lean manufacturing perceptions and actual practice among Malaysian SMEs in automotive industry. *International Journal of Automotive and Mechanical Engineering*, 7, 820–829.
- Rose, A. N. M., Deros, B. Md, Rahman, M. N. Ab. and Nordin, N. (2011). Lean manufacturing best practices in SMEs. *Proceedings of the International Conference on Industrial Engineering and Operations Management (IEOM)*. Kuala Lumpur, Malaysia: IEOM Research Solutions. pp. 22–24.
- Rossiti, I. S. M., Serra, S. M. B. and Lorenzon, I. A. (2016). Impacts of lean office applications in the supply sector of a construction company. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 8. pp. 63–72. Available at: www.iglc.net
- Rybkowski, Z. K., Munankami, M., Shepley, M. M. and Fernández-Solis, J. L. (2016). Development and testing of a lean simulation to illustrate key principles of Target Value Design: A first run study. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 4. pp. 133–142. Available at: www.iglc.net

- Salem, O., Solomon, J., Genaidy, A. and Luegring, M. (2005). Site implementation and assessment of lean construction techniques. *Lean Construction Journal*, 2(2), 1–21.
- Shah, R. and Ward, P. T. (2003). Lean manufacturing: Context, practice bundles, and performance. *Journal of Operations Management*, 21(2), 129–149.
- Shang, G. (2013). *The Toyota Way model: An implementation framework for large Chinese construction firms*. A thesis submitted to the Department of Building, National University of Singapore, for the degree of Doctor of Philosophy.
- Taleghani, M. (2010). Success and failure issues to lead lean manufacturing implementation. *World Academy of Science, Engineering and Technology*, 6, 615–618.
- Tezel, A., Aziz, Z., Koskela, L. and Tzortzopoulos, P. (2016). Benefits of visual management in the transportation sector. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 6. pp. 123–132. Available at: www.iglc.net
- Toledo, M., Olivares, K. and González, V. (2016). Exploration of a Lean-BIM planning framework: A Last Planner System and BIM-based case study. *Proceedings of the 24th Annual Conference of the International Group for Lean Construction*. Boston, MA. Section 5. pp. 3–12. Available at: www.iglc.net
- Tommelein I. D. (2008). “Poka yoke” or quality by mistake proofing design and construction systems. *Proceedings of the 16th Annual Conference of the International Group for Lean Construction*. Manchester, UK.
- Womack, J. P., Jones, D. T. and Roos, D. (1990). *The machine that changed the world: The story of lean production*. New York: Harper Perennial.