

# THE INTEGRATION OF HEALTH AND SAFETY (H&S), LEAN AND SUSTAINABILITY IN CONSTRUCTION: A LITERATURE REVIEW

Fidelis Emuze<sup>1</sup> and John Smallwood<sup>2</sup>

## ABSTRACT

In most cases, the motivation for health and safety (H&S) has been legislation instead of enhanced business and project performance. The emphasis on legislation may be attributable to a lack of appreciation of the dynamics and synergy that exist between H&S and other project performance criteria and the role of H&S in reducing waste while realising sustainability.

The purpose of this paper is to examine the relationship between H&S, lean construction and sustainability. The effort is a precursor to the development of a research agenda to guide theoretically based future research that would inform managerial decisions in the domain. An extensive literature review was conducted to examine research and practice with respect to the concurrent use of H&S, lean and sustainability initiatives in construction. Corroboratory views related to the three strategic options were deduced from an in-depth review of the literature.

Findings suggest that optimum H&S contributes to enhanced cost, environment, quality, and time performance, and overall reduction of waste and the realisation of sustainability in its broadest sense. Preliminary concluding remarks include: that H&S could be the catalyst for overall project performance in terms of lean construction and sustainability; and H&S should be promoted on the basis of its role in overall project performance, as opposed to the need to comply with legislation.

## KEYWORDS

Health and Safety, Lean Construction, Sustainability, Waste.

## BACKGROUND

A survey that was designed to establish the extent that the construction industry has been affected by the global financial crisis (GFC) and the Euro crisis observe that the GFC has had a major impact in Europe and other developed countries, and the impact is expected to continue to affect the industry in the near future; while in developing countries, population growth, urbanisation and infrastructure development that are now and will, over the conceivable future, be the anchor behind the demand for construction (de Valence & Runeson, 2011). The findings of the survey also noted

---

<sup>1</sup> Senior Lecturer, Department of Built Environment, Central University of Technology, Free State Private Bag X20539, Bloemfontein, 9300, South Africa Tel: (051) 507 3648 Fax: (051) 507 3254 E-mail: femuze@cut.ac.za

<sup>2</sup> Professor, Department of Construction Management, Nelson Mandela Metropolitan University, PO Box 77000, Port Elizabeth, 6031, South Africa Tel: (041) 504 2790 Fax: (041) 504 2345 E-mail: John.Smallwood@nmmu.ac.za

that the nature of construction will have to change in response to the dynamics of the global economy. Whether it is the approach to technology, to new business models, to sustainability, there appears to be a near undivided assumption that ‘we need to do things differently if we are to adapt to trends’ in the long term (de Valence & Runeson, 2011). Relating this assumption to the construction process suggests that change is now mandatory, especially at the project execution level. There is a need to go beyond the traditional project parameters in order to assure success in any given undertaking. For a project to be adjudged successful, cost, environment, H&S, quality and time targets should be the minimum expected standards. In other words, making sense of construction improvement through lean construction and other philosophies cannot be overlooked (Green, 2011).

While there are separate streams of established research on H&S, lean and sustainability in construction, limited publications have addressed the intersection of these strategic initiatives. This is a crucial oversight since contractors may be missing synergies available through improved concurrent implementation, on the one hand; and they may also be failing to address important trade-offs that may arise when there are mismatches between the initiatives, on the other hand. As an illustration, the literature has shown that lean and sustainability strategies are often seen as compatible initiatives because of their common focus on waste reduction (Ma, 2011; Mollenkopf *et al.*, 2010). When lean construction initiatives enable only value added activities and / or conversion activities to flow through the supply chain, a reduced amount of inventory needs to be sourced, transported, packaged and handled, which also minimizes the negative environmental impact of the attendant construction method / procedure. However, lean strategies that employ just-in-time (JIT) delivery of construction materials can require increased transportation, packaging, and handling that may contradict a sustainable construction / development approach. Increased transportation could also lead to motor vehicle accidents that are fast becoming an issue in South African construction, for instance (Emuze & Smallwood, 2012). By identifying this conflict, contractors may be able to recognize trade-offs so as to come up with solutions that would mitigate undesirable consequences.

Although this illustration may appear simple, it is meant to show the potential for synergies and inconsistencies that may arise when implementing any combination of lean and sustainability. Thus, the purpose of this paper is to examine the relationship between H&S, lean and sustainability as found in the literature, with emphasis on the concomitant application of these three strategic initiatives in order to optimize performance in the construction industry. The effort is a precursor to the development of a research agenda to guide industry focused future research that would inform managerial decisions in practice. As a guide for the literature review, a research question was proposed. The question asked: “*what plan of action can promote lean and sustainable construction through a focus on H&S that improves project value.*”

## **RESEARCH STRATEGY**

A review of the literature in each of the three interfaces of H&S, lean and sustainability was conducted with Google Scholar and other databases. Google Scholar allows the search of many sources, including peer-reviewed papers, theses, books, abstracts and articles, from academic and professional publishers. Google Scholar (2013) works to discover the most relevant research across multiple

disciplines and sources. Although Google Scholar does not provide all full-text articles, it encompasses information pooled from different databases. However, articles that are specific to the subject were not immediately available after scanning four pages of the Google Scholar download results. Thus, a university research library that directly links researchers to databases through one search engine was accessed. The databases that were accessed include EBSCO Co-Host, Emerald, Science Direct, and Wiley Interscience.

The keywords used for the search were developed through an iterative process. To supplement the keyword search, the '*Lean Construction Journal*' and the '*IGLC proceedings*' were accessed for emergent themes. When examining the IGLC proceedings, themes pertaining to H&S, sustainability and theory were critically reviewed. The literature review focused on the broad scope of each article that was accessed.

## **LEAN AND SUSTAINABILITY IN THE CONSTRUCTION CONTEXT**

In '*Making Sense of Construction Improvement*', Green (2011) undertook a critical look at lean thinking in the construction context, and concluded that in practice, lean construction continues to be conceptualised and enacted differently in different contexts, often taking on different manifestations from those envisaged. Green (2011) went on to present three models of lean: waste elimination, partnering and structuring the context. The first model in the form of waste elimination recognised that waste elimination is paramount while focusing on construction operations.

The espoused aim of the model is to ensure smooth uninterrupted flow of activities. The model assumed that cost savings made at the project level will aggregate to the corporate level and all parties should benefit equally from improved performance. Green (2011) further noted that the model discourse is dominated by the machine metaphor and the underlying unitary perspective on organisations. However, a plethora of articles have attested to the gains of this model in the industry (Forbes and Ahmed, 2011). Meiling *et al.* (2012) illustrated the benefits, in terms of enhanced performance alignment with organisational vision and goals, of introducing the lean concept through the experience of two off-site manufacturing firms in Sweden. Therefore, as the diffusion of lean principles and technique continues, lean construction may act as a catalyst for change in the workplace (Green, 2011).

Sustainability in the construction context began with the Brundtland report of 1987. Sustainable development that meets the needs of the present without compromising the needs of the future became the centre of industrial and academic discourse as a result of the impact of human societies on the environment (Kibert, 2009). Through the use of environmental sustainability assessment methods such as the Building Research Establishment Assessment Method (BREAM) in the UK, developed countries are setting standards for best practice (Abiding, 2010).

However, the extent of sustainable construction practices in developing countries is not at par with that of developed countries. In the developing country context, notable barriers identified include unclear cost / benefit analysis, lack of necessary knowledge; perceived economic / financial constraint; ignorance about effects of unsustainable practices; lack of enforcement of existing legislation; lack of appropriate government interventions; lack of urban and construction policy; existing

construction procedures / standards; lack of skilled manpower; and poor knowledge relative to construction materials (Abiding, 2010; Miranda & Marulanda, 2001).

Du Plessis (2001) further notes that the lack of capacity in both the construction sector and in government, an uncertain economic environment, lack of accurate data on which to base decisions, poverty and the subsequent low urban investment, the lack of interest by stakeholders in the issue of sustainability, and technological inertia and dependency due to entrenched colonial codes and standards were identified as the main barriers to the realisation of sustainable construction in developing countries. In spite of these barriers, prevailing climate change realities indicate that sustainable construction practices should be driven to an appreciable level in developing countries. Further, sustainable construction may however be driven from the technical point of view through (Warnock, 2007; Shen, 2008; Matar *et al.*, 2008):

- Management: Overall management policy, commissioning site management, and procedural issues;
- Energy use: Operational energy and carbon dioxide issues;
- Health and well-being: Indoor and external issues affecting health and well-being;
- Pollution: Air and water pollution issues;
- Transport: Transport-related CO<sup>2</sup> and location-related factors;
- Land-Use: Greenfield and brown-field sites;
- Ecology: Ecological value of conservation and enhancement of the site;
- Materials: Environmental implication of building materials, including life-cycle impacts, and
- Water: Consumption and water efficiency.

To be succinct, the principles of sustainability and lean construction can be found in the mainstream construction management corpus. Popular journals in the discipline, such as *Construction Management & Economics*, have featured both concepts extensively, either as special issues and general issues of a number of volumes. It can thus be argued that these concepts will form key aspects of change drivers in the industry for the foreseeable future and they will play important role in the realisation of expected project performance criteria in the form of cost, quality, environment, satisfaction on the part of clients, end-users, and workers, and H&S.

## **INTERFACE BETWEEN H&S, LEAN & SUSTAINABILITY IN**

### **CONSTRUCTION**

This section relies on publications that were disseminated through the *Lean Construction Journal* (LCJ) and the IGLC conferences since Google Scholar failed to yield significant results that were specific to the research theme. Table 1 shows that limited diffusion of H&S and sustainability in the lean construction context, has occurred through the LCJ. From 2004 to 2012, only 4 papers have focused exclusively on the initiatives. It is important to note that with the exception of 2005

and 2011, the LCJ only have an issue per annual. In 2005, 2 issues were published and in 2011 a special issue was published apart from the year issue. As indicated in the table, 2 papers each addressed H&S and sustainability in different issues of LCJ. Although none of the papers addressed the interface and / or synergy between the two strategic initiatives, insightful nuances were highlighted through case studies.

An empirical examination of the relationship between lean construction and H&S in the industrialized housing industry in the USA by Nahmens and Ikuma (2009) shows that a better understanding of the applicability and potential benefits of Lean in the housing industry in terms of employee safety outcomes is possible. The authors observed that specific Lean strategies appear to have some positive effects on H&S incidence rates, which suggest that Lean may be beneficial not only for process improvement and waste reduction, but also for improving H&S in the construction industry.

The results of the study provide empirical support for the prediction that accident rates will be reduced with the implementation of Lean because the analysed data indicate continuous improvement programmes are associated with significantly lower incidence rates regardless of plant production volumes. The observations of Court *et al.* (2009) were not dissimilar from the argument that lean can reduce / eliminate H&S related injuries and accidents. A comparison between the system in a case project and the traditional method shows that construction workers were exposed to lower H&S risks from site operations, a situation that led to zero reportable accidents (Court *et al.*, 2009). Even on the case project appropriate ergonomics was achieved through a focus on workplace designs that improves the wellbeing of workers.

Two LCJ articles focus on the applicability of lean construction with respect to the realisation of sustainability goals. Peng and Pheng (2011) used a case study in Singapore to explore the contribution of the lean concept to the achievement of sustainability objectives in a precast concrete factory setting. They suggest that the lean production philosophy has practical contributions to sustainable development, which can be adopted by the industry to achieve improved performance in terms of some sustainability factors that includes energy consumption, carbon emissions and production efficiency.

The second sustainability paper outlines a detailed modelling protocol for evaluating the delivery processes of green projects by blending existing protocols and the specific needs of green building projects. Klotz *et al.* (2007) thus proposed a protocol that is intended to help define the data collection and analysis procedures as well as the instruments (metrics) of analysis required to reduce hidden waste in green projects. Therefore, these papers have informed practice related to H&S and sustainability from the lean construction perspective.

Table 1: Approximate number of H&S and sustainability articles in LCJ

Year	2004	2005	2007	2008	2009	2010	2011	2012	Total
H&S	0	0	0	0	2	0	0	0	2
Sustainability	0	0	1	0	0	0	1	0	2
<b>Total</b>	0	0	1	0	2	0	1	0	<b>4</b>

However, given the limited numbers of papers that was identified in the LCJ, another content analysis was undertaken through the IGLC conference proceedings. The IGLC H&S and sustainability related conference papers are indicated in Table 2.

Most of the papers were grouped under two main themes. They were grouped either under theory or Safety, Quality and Environment. It is notable that theme sections in the IGLC conference proceedings began with the 1998 conference due to increased accepted papers. The sustainability related paper of 1998 conference was however grouped under site management.

In brief, H&S papers have been delivered more than sustainability papers at the IGLC annual conferences. And the sustainability related papers mostly address the environmental aspects of sustainable development in construction. None of the papers explicitly addressed the social and economic aspect of sustainable development and majority of the sustainability papers were presented at the 2012 conference. Some of H&S papers focused on behavior-based safety (BBS) and how lean principles and other continuous improvement tools can be used to achieve zero accident statistics in construction.

Table 2: IGLC H&S and sustainability related conference papers (1993-2012)

Year	H&S	Sustainability
1993	0	0
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	1
1999	0	0
2000	0	0
2001	0	0
2002	2	1
2003	2	1
2004	2	0
2005	2	1
2006	2	0
2007	3	4
2008	1	2
2009	1	2
2010	2	0
2011	4	1
2012	5	7
Total	26	20

A concise description of the papers will show that lean construction has indeed addressed and will continue to, H&S management and sustainability initiatives. For instance, in order to understand how lean construction practices affect project H&S performance, an interactive matrix between lean construction and H&S management practices was developed by Antillon *et al.* (2011). They conducted a research synthesis and validated the synthesis with structured interviews. Antillon *et al.* (2011) observe that there is an important evidence of synergy between lean and H&S practices when their interface was evaluated. As an illustration, they suggest that a project-specific H&S objective can be incorporated in the lookahead planning process, and the automation could be extended to worker involvement in a way that workers can stop production whenever they felt unsafe.

In other words, they argued that construction production and H&S management models can be integrated. Brioso (2011) further argues that the integration of loss control, a key feature in H&S management and lean construction strategies, could

contribute to the decline of waste / NVAAs in construction. Another empirical study that was based on both qualitative and quantitative research methods in the form of meetings, discussions and personnel surveys reinforced the synergy between lean and H&S initiatives (Leino & Elfving, 2011). The findings of the study show that shared value exists between lean and H&S via, inter alia, respecting people, zero waste and prevention policies. In essence, many lean construction researchers have evaluated the interface between H&S and lean and come to the conclusion that the dynamics of the industry demand a synergistic approach to the issues.

Similarly, the interface between lean construction and sustainability has been examined to a significant extent in IGLC conferences, especially at the 2012 edition. A recent study demonstrates why ‘choosing by advantages’ (CBA) is in line with lean thinking in the context of sustainable alternative material selection in the construction industry (Arroyo *et al.*, 2012). The authors argue that for reasons related to fewer questions and value based methods, CBA should be considered when deciding on a sustainable alternative material or method in construction.

Novak (2012) took a step further by exploring the synergy between lean construction and sustainability as expressed in the context of value. Using data, both quality and quantitative, derived from exemplary lean projects, Novak (2012) contends that a strong correlation exist between the cohesiveness of lean thinking and the level of collaboration on the delivery of sustainability values. The import of the study by Novak (2012) was that there is an opportunity for the construct of value to serve as a catalyst that shifts construction management from restrictive overtones to a paradigm of positive sustainability prosperity as evident in the 3 case studies that were presented. The study findings show a relationship between lean and sustainability mainly because the stakeholders focused on the concept of value.

Using these arguments, especially the focus on value, it can be argued that the preposition shown in Figure 1 should be explored in construction. The qualitative data analysis that was conducted shows that although lean, H&S and sustainability have continued to receive the attention of researchers, the synergy between the three initiatives have not been extensively explored. Mainstream construction management literature has indicated various H&S management models that can enhance project value through the prevention of loss and the achievement of zero cost of accidents (CoA). Surely the concept of the construct of value should be able to drive the holistic synergy between H&S, lean construction and sustainability, despite divergent views in the construction management domain.

These prepositions corroborate the assertion that there is a need to dismantle dated management paradigms such as management-by-results and management-by-means, so that new methodologies that can advance the performance of delivered projects can be engendered (Ballard & Howell, 2004). The issue illustrated in Figure 1 is not far from the notion that accidents constitute a source of NVAAs in construction (Forbes & Ahmed, 2011) and construction processes that limit environmental impact improves H&S (Ofori, 1992) and value (Smallwood & Haupt, 2005). Environmental concerns are often interrelated with construction H&S issues - unhealthy and unsafe practices, such as concrete run - off or spillage, fires, and uncontrolled sanitation impact negatively on the environment (Coble and Kibert, 1994). In addition, the generation of dust, hazardous materials and the release of non-biodegradable material into the environment have H&S implications for construction workers and the general

public. While sustainability is been driven by legislation and business needs, strategic options are the main reason for the adoption of lean construction as is the case in Sri Lanka (Senaratne & Wijesiri, 2008). Because construction workers, mostly in developing nations, are often ignorant of flow activities that create waste and their causes; core principles in lean construction and sustainability, in addition to H&S management can be used to engender continuous improvement in the sector. The abstraction suggested in Figure 1 however requires a plan of actions in order to operationalize the illustration. The future empirical study to follow this initial literature review should be able to show how a focus on H&S will improve project value and promote sustainable development. The notable gap in the literature that should be bridged would pertain to the methodology that would allow the integration of H&S, lean and sustainability for the delivery of project value in construction.

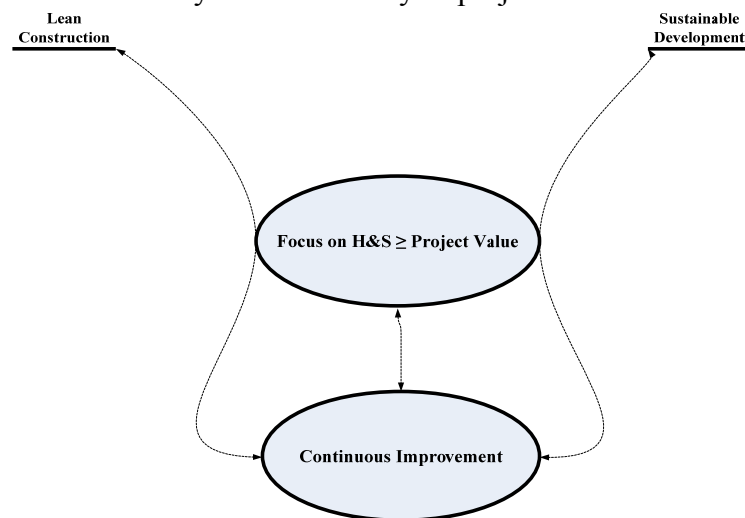


Figure 1: Holistic role of H&S relative to lean construction and sustainability

## CONCLUDING REMARKS

As opposed to competition, construction management strategy can be used in a complimentary manner. Given the documented need to change the ‘*way and speed*’ of project delivery in the industry, especially in developing countries, a holistic view of strategic options is now an imperative in the sector. In terms of suitability and acceptability for reasons not limited to legislation and business competitiveness, lean construction and sustainability have emerged as key drivers of change in the industry. In the same manner, the statistics related to injuries and accidents as well as the corresponding fatalities and CoA in the industry have to be continually addressed.

Thus, the conceptual framework presented in this paper have argued for the exploitation of the interface between H&S and key strategic options available for the management of projects in the industry. It has been argued that a focus on H&S has implications for the realisation of lean construction and sustainability objectives. The exploitation of this synergy, inter alia, could lead to enhanced value achieved on projects when H&S issues are mitigated. A focus on H&S should improve the sequence of conversion activities and also ensure that minimal pollution occurs due to construction activities. It should also ensure that optimum decisions that take a long term view of project life cycle is adopted in favour of alternative construction



materials. However, this concept is limited in that it is yet to be empirically examined. This limitation would therefore form the basis of a multiple case study research project that shall be embarked upon in the near future. The application of the concepts depicted in Figure 1 to a case project should provide insights about how a focus on H&S would lead to improved project value and sustainable development. Thus, the research agenda that has been established through the reviewed literature relate to the methods / ways that lean and sustainability can be promoted through a focus on H&S that improves project value.

## REFERENCES

- Abiding, N.Z. (2010) Sustainable construction in Malaysia-developers' awareness. *International Journal of Social Sciences*, Vol. 5(2), pp.122-129.
- Antillon, E.I., Alarcon, L.F., Hallowell, M.R. & Molenaar, K.R. (2011). A research synthesis on the interface between lean construction and safety management. In: *Proceedings of the 19th Conference of the International Group for Lean Construction (IGLC)*, 13-15 July, Lima, Peru, pp. 644-655.
- Arroyo, P., Tommelein, I.D. & Ballard, G. (2012). Deciding a sustainability alternative by 'choosing by advantages' in the AEC industry. In: *Proceedings of the 20th Conference of the International Group for Lean Construction (IGLC)*, 18-20 July, San Diego, USA, pp. 41-50.
- Ballard, G. & Howell, G.A. (2004). Competing construction management paradigms. *Lean Construction Journal* 2004, pp. 38-45.
- Brioso, X. (2011). Applying lean construction to loss control. In: *Proceedings of the 19th Conference of the International Group for Lean Construction (IGLC)*, 13-15 July, Lima, Peru, pp. 656-666.
- Coble, R.J. and Kibert, C.J. 1994. The environment as a construction safety concern. In: *Proceedings of the 5th Annual Rinker International Conference focusing on Construction Safety and Loss Control*, Gainesville, Florida, 535-542.
- Court, P.F., Pasquire, C. & Gibb, A. (2009). A lean and agile construction system as a set of countermeasures to improve health, safety and productivity in mechanical and electrical construction. *Lean Construction Journal* 2009, pp. 61-76.
- de Valence, G. & Runeson, G. (2011). On the state of the building industry after the GFC and the Euro crisis. *Australasian Journal of Construction Economics & Building*, Vol. 11(4), pp. 102-113.
- Du Plessis, C. (2001) Agenda 21 for Sustainable Construction in Developing Countries: final discussion document. In: *Proceedings of Agenda 21 for Sustainable Construction in Developing Countries*, Pretoria, CIB-CSIR.
- Emuze, F.A. & Smallwood, J.J. (2012). Construction Motor Vehicle Accidents in South Africa: Preliminary Findings. In: *Proceedings of CIB W099 International Conference 2012: Modelling and Building Health and Safety*, 10-11 September 2012, Singapore, pp. 203-208.
- Forbes, L.H. & Ahmed, S.M. (2011) *Modern Construction: lean project delivery and integrated practices*. Boca Raton: CRC Press.
- Google Scholar (2013). About Google Scholar [online]. Available at: <http://scholar.google.co.za/intl/en/scholar/about.html> [Accessed March 5, 2013].
- Green, S.D. (2011) *Making sense of construction improvement*. Chichester: Wiley-Blackwell.

- Kibert, C.J. (2009). *Sustainable construction: green building design and delivery*. 2<sup>nd</sup> edition. New Jersey: John Wiley & Sons.
- Klotz, L., Horman, M. & Bodenschatz, M. (2007). A lean modelling protocol for evaluating green project delivery. *Lean Construction Journal* 2007, pp. 1-18.
- Leino, A. & Elfving, J. (2011). Last planner and zero accidents program integration - workforce involvement perspective. In: *Proceedings of the 19th Conference of the International Group for Lean Construction (IGLC)*, 13-15 July, Lima, Peru, pp. 622-632.
- Ma, U. (2011). *No Waste: Managing Sustainability in Construction*. Surrey: Gower publishing Ltd.
- Matar, M.M., Georgy, M.E. & Ibrahim, M.E. (2008). Sustainable construction management: introduction of the operational content space (OCS). *Construction Management and Economics*, Vol. 26(2), pp. 261-275.
- Meiling, J., Backlund, F. & Johnson, H. (2012). Managing for continuous improvement in off-site construction: evaluation of lean management principles. *Engineering, Construction and Architectural Management*, Vol. 19(2), pp. 141-158.
- Miranda, L & Marulanda, L. (2001) Sustainable construction in developing countries- a Peruvian perspective. In: *Proceedings of Agenda 21 for Sustainable Construction in Developing Countries*, Pretoria, CIB-CSIR.
- Mollenkopt, D., Stolze, H., Tate, W.L & Ueltschy, M. (2010). Green, lean, and global supply chains. *International Journal of Physical Distribution & Logistics Management*, Vol. 40(1/2), pp. 14-41.
- Nahmens, I. & Ikuma, L.H. (2009). An empirical examination of the relationship between lean construction and safety in the industrialized industry. *Lean Construction Journal* 2009, pp. 1-12.
- Novak, V.M. (2012). Value paradigm: revealing synergy between lean and sustainability. In: *Proceedings of the 20th Conference of the International Group for Lean Construction (IGLC)*, 18-20 July, San Diego, USA, pp. 51-60.
- Ofori, G. (1992). The environment: the fourth construction project objective? *Construction Management & Economics*, Vol. 10(5), pp. 369-395.
- Peng, W. & Pheng, L.W. (2011) Lean production, value chain and sustainability in precast concrete factory – a case study in Singapore. *Lean Construction Journal* 2010, pp. 92-109.
- Senaratne, S. & Wijesiri, D. (2008). Lean construction as a strategic option: testing its suitability and acceptability in Sri Lanka. *Lean Construction Journal* 2008, pp. 34-48.
- Smallwood, J. & Haupt, T. (2005). The need for construction health and safety (H&S) and the Construction Regulations: engineers' perceptions. *Journal of the South African Institution of Civil Engineering*, Vol. 47(2), pp. 2-8.
- Shen, L.Y., Song, S.C., Hao, J.L. & Tam, V.W.Y. (2008). Collaboration among project participants towards sustainable construction- a Hong Kong study. *The Open Construction and Building Technology Journal*, Vol. 2(1), pp.59-68.
- Warnock, A.C. (2007). An overview of integrating instruments to achieve sustainable construction and building. *Management of Environmental Quality: An International Journal*, Vol. 18(4), pp.427-441.