Leadership in Sustainable Infrastructure
Leadership en Infrastructures Durables

Case Study

Vancouver, Canada
May 31 – June 3, 2017/ *Mai 31 – Juin 3, 2017*

INTEGRATING CONCEPTS AND PRINCIPLES FROM LEAN THINKING AND THE DESIGN FOR X TO BIM

Fokwa Soh, Mathieu[1, 4], Forgues, Daniel[2] and Doré, Sylvie[3]
[1, 2, 3] École de technologie supérieure, Canada
[4] mathieu.fokwa-soh.1@ens.etsmtl.ca

A short executive summary: The U.S. Environmental Protection Agency (EPA) (2002) stated that approximately 138 million tons of building-related construction and demolition waste was generated in 1996 (Wang et al. 2010). Furthermore, 1-10% by weight of the purchased construction materials become waste at the end of the projects (Bossink and Brouwers 1996). Even worse, according to the bureau of labour statistics (BLS) (2006), only in 2006, 21% of deaths and 11% of disabling accidents at work-sites came from the construction industry. To these wastes are added the losses of time related to the work to be redone and the conflicts between companies involved in the project (Eastman et al. 2011). For some authors (Forbes and Ahmed 2010; Osmani, Glass, and Price 2008; Crotty 2013), these problems stem from the fragmentation between the design and the construction phases. More precisely, they are caused by the lack of information about construction, during the design phases (Bossink and Brouwers 1996).

For some authors (Koskela 2000), a virtual design and construction technologies such as Building Information Modelling (BIM) is seen as a means to reduce fragmentation in the construction industry. For others, BIM is presented as the most appropriate way to reduce waste in the construction industry (Crotty 2013; Deutsch 2011; Eastman et al. 2011). However, the construction industry is gradually integrating BIM, without taking full advantage of the benefits that it can bring to the collaboration between the different stages and actors of a project, more precisely between the design and construction stages (Nawi, Baluch, and Bahauddin 2014).

Also, Koskela, a pioneer of Lean construction, introduced the TFV theory (Transformation-Flow-Value theory) as a relevant approach to waste elimination in the construction industry (Koskela 2000). This theory proposes the reduction of waste and the generation of customer's value as objects to be associated with the management of production within construction industry, while stimulating the integration of BIM and sustainable development in the Architecture, Engineering and Construction (AEC) industry (Koskela, Owen, and Dave 2010). However, none of the concepts introduced in the AEC industry formally establishes how construction and design teams involved in construction projects should communicate. Thus, poor collaboration between design and construction phases in US construction projects costs US $ 7-36 billion annually (Forbes and Ahmed 2010).

In the manufacturing industry, the collaboration between design and production teams is well established and formalized through different methods and design rules, such as Design for Manufacturing and Assembly(Boothroyd 1994) or Design for Environment (Kuoa, Huangb, and Zhangc 2001). These rules guide the work of the designers who act upstream of the manufacturing of parts and of their assembly, in

order to guide design decisions that promote a reduction of time and cost, while increasing the quality of products.

The main objective of this presentation is to highlight the links between BIM, Lean construction and design rules, through a new concept that we will call design for TFV. This concept will promote the simultaneous integration of the benefits of BIM and Lean construction in reducing waste. This concept may also become a major step in the integration of design rules in the construction industry, which will enable decision-making in favour of saving time and money, while promoting sustainable infrastructures.

Key Words: Design rules, Building information modelling, Transformation-Flux-Value, project lifecycle, sustainable infrastructures.

References

Boothroyd, Geoffrey. 1994. 'Product design for manufacture and assembly', *Computer-Aided Design*, 26: 505-20.

Bossink, BAG, and HJH Brouwers. 1996. 'Construction waste: quantification and source evaluation', *Journal of Construction Engineering and Management*, 122: 55-60.

Crotty, Ray. 2013. *The Impact of Building Information Modelling : Transforming Construction* (Routledge: Abingdon, Oxon, US).

Deutsch, Randy. 2011. *BIM and integrated design: strategies for architectural practice* (John Wiley & Sons).

Eastman, Chuck, Charles M Eastman, Paul Teicholz, Rafael Sacks, and Kathleen Liston. 2011. *BIM handbook: A guide to building information modelling for owners, managers, designers, engineers and contractors* (John Wiley & Sons).

Forbes, Lincoln H, and Syed M Ahmed. 2010. *Modern construction: lean project delivery and integrated practices* (CRC Press).

Koskela, Lauri. 2000. "We need a theory of construction." In *Berkeley-Stanford Construction Engineering and Management Workshop: Defining a Research Agenda for AEC Process/Product Development in*.

Koskela, Lauri J, Robert L Owen, and Bhargav Dave. 2010. 'Lean construction, building information modelling and sustainability'.

Kuoa, Tsai-C, Samuel H Huangb, and Hong-C Zhangc. 2001. 'Design for manufacture and design for X': concepts, applications, and perspectives', *Computers & Industrial Engineering*, 41: 260.

Nawi, Mohd Nasrun Mohd, Nazim Baluch, and Ahmad Yusni Bahauddin. 2014. "Impact of fragmentation issue in construction industry: An overview." In *MATEC Web of Conferences*, 01009. EDP Sciences.

Osmani, Mohamed, Jacqueline Glass, and Andrew DF Price. 2008. 'Architects' perspectives on construction waste reduction by design', *Waste Management*, 28: 1147-58.

Wang, Jiayuan, Hongping Yuan, Xiangping Kang, and Weisheng Lu. 2010. 'Critical success factors for on-site sorting of construction waste: a China study', *Resources, Conservation and Recycling*, 54: 931-36.