AIN SHAMS UNIVERSITY

FACULTY OF ENGINEERING

AN INTEGRATED APPROACH FOR USING BIM AND LEAN THINKING IN CONSTRUCTION MANAGEMENT

A Thesis submitted in partial fulfillment of the requirements of the Degree of Doctor of Philosophy (PhD) in Structural Engineering
By

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Master of Science in Civil Engineering (Structural Engineering)
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DECLARATION STATEMENT

I, **Mohammed Ahmed El Deeb,** having read, understood and accepted to be bound by Ain Shams University guidelines and regulations related to plagiarism and authenticity; do hereby declare that this thesis is founded on my own individual and independent work and that no statements contained herein that may be works of other authors have gone unacknowledged. I further confirm as part of this declaration that this thesis in part or entirety has not been submitted in fulfillment of the requirements of any degree or qualification in any other scientific entity.

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ABSTRACT

The construction industry in Egypt is in rapid expansion, witnessing a steady growth rate in recent years. That notwithstanding, the Egyptian construction industry is still suffering from many problems, including low product quality, low working efficiency, projects exceeding projected budgets, huge construction wastes and an unsustainable Construction Project Footprint. Generally, the process of construction is carried out in several smaller processes whereby success is contingent upon achievement of harmonious continuity between these smaller processes. Amid the execution of the processes, waste is generated as in any other process and there is a growing need to manage the generation of waste and mitigate non-value adding activities in order to reduce waste and save costs. LEAN and BIM have been two major developments that shifted the management of construction projects and provided hope for the reduction of waste and augmentation of value in construction projects. Lean thinking is defined as a conceptual approach aimed at producing the right product at the right time in the right quantity for the customer. On the other hand, BIM is defined as "transformative information technology" involving computer aided and digital machine-readable tools and processes that visually document and simulate a building's plan, construction, performance and operation. Construction management is defined as a systematic and coordinated set of activities and practices through which an organization optimally and sustainably manages its constructions and construction systems, their associated performance, risks and expenditures over the lifecycles of projects for the purpose of achieving organizational strategic plan.

This thesis, through the study of a real construction project case scenario, sought to model the application of BIM and Lean construction methods and use Arena simulation software to simulate the current state as well as the projected future state of the project. This was in an effort to provide an in-depth practical justification for the interaction between BIM-Lean functions and principles and the importance of the interaction to the construction industry in Egypt. The research in pursuit of precision, focused on the design phase submittals process of the project and relied on accurate on-site data from authoritative on-site personnel of the project under study. Based on real on-site data for planned and actual activity execution timelines, the research value stream mapped the current state of the construction project's submittals processes and simulated the current state to determine the issues apparent. The research then projected a future state of the project's submittals processes based on the application of integrated BIM-Lean functions and principles to the project. The research found that, the application of BIM-Lean interaction in the future state of the project would afford the project significant reduction in the time taken for submissions in the design phase. Pursuant to the need for veracity, the research featured an actual case of the implementation of BIM-Lean Common Data Environment in an ongoing project to verify the percentages of time savings for submissions in the design phase of an actual project as well as the advantages of the same to the construction phase of an ongoing project.

Centering on the results of this project's case study and experience, the research came up with a new matrix for the BIM-8 Lean wastes interactions as the primary new contribution of the research.

The study also revisited the conventional BIM-Lean matrix and revised the interaction to achieve potential positive interactions between previously negative BIM functionalities and Lean principles. The results provide justification for the interaction between BIM-Lean functions and principles and their joint applicability in construction projects to provide more efficiency, reduce wastes, cost savings, improve product quality and customer satisfaction among others. This is in agreement with countless evidences of research on the interaction of the two approaches and their potential synergy and positive output in the construction industry.

Keywords: BIM; LEAN; Simulation; Common Data Environment; Construction management; BIM-8 Lean wastes interactions

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LIST OF ABBREVIATIONS

Abbreviation	Full
BCG	Boston consulting group
BIM	Building information modeling
BTS	Bureau of transportation statistics
CAD	Computer aided design
CDE	Common data environment
CII	Construction industry institute
CIRIA	Construction industry research and information association
DES	Discreet event simulation
EEC	Egyptian electricity company
EGP	Egyptian pound
E&Os	Errors & Omissions
GCs	General Contractors
GIS	Gas insulated substation
IGLS	International group for Lean construction
IPD	Integrated project delivery
JIT	Just in time production
LPDS	Lean project delivery system
OBG	Oxford business group
RFI	Request for information
ROI	Return on investment
SDS	System dynamic simulation
SMED	Single minute exchange dies
TOC	Taking over certificate
TPM	Total production maintenance
VDC	Virtual design construction
VSM	Value stream mapping