AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
ARCHITECTURE ENGINEERING

# Sustainable Management Processes:
## Integrating Sustainability and Lean Principles in Architectural Projects

A Thesis submitted in partial fulfillment of the requirements of the degree of Master of Science in Architecture Engineering

By

**Reem Ahmed Mohamed Othman**

Bachelor of Science In Architectural Engineering

Faculty of Engineering, Ain Shams University, 2011

Supervised By

**Professor Dr.** Ahmed Atef Faggal

**Associated Professor Dr.** Laila Khodier

Cairo - (2016)

# STATEMENT

This thesis is submitted as a partial fulfillment of Master of Science in Architectural Engineering, Faculty of Engineering, Ain Shams University.

The author carried out the work included in this thesis, and no part of it has been submitted for a degree or a qualification at any other scientific entity.

**Reem Ahmed Mohamed Othman**

Signature

……...…….

Date:15 November 2016

# RESEARCHER DATA

| | |
|---|---|
| Name | : Reem Ahmed Mohamed Othman |
| Date of birth | : 24th of June 1989 |
| Place of birth | : Jeddah- Saudi Arabia |
| Last academic degree | : Bachelor degree |
| Field of specialization | : Architectural Engineering |
| University issued the degree | : ……. |
| Date of issued degree | : ……. |
| Current job | : Teaching Assistant, Ain shams University. |

# DEDICATION

This thesis is dedicated to:

My parents,

**Ahmed Othman & Wafaa Mostafa**

"As a sign of love and Gratitude"

My beloved daughter,

**Rojeen Elkhatib**

# ABSTRACT

Architecture, Engineering, and Construction (AEC) industry faces abundant chronic problems; either as source of wastes and environmental pollutant through its whole life cycle from the Design till demolition, or the efficiency problem like delays, overruns, etc. Countries worldwide is trying to overcome those problems in their development visions. On the other hand, Researchers suggested that the AEC should depend on a new green management process that care about the effect of AEC industry on environment, society, and solve its efficiency problem as well.

Sustainability becomes a prime concern in most of countries development vision in the AEC industry and all industrial sectors. However, Most of the researches about AEC focus on the sustainability of the operational phase "Building" and give less attention to the sustainability of the processes. In addition, it was found in many studies about lean management technique that it has great contributions in most of industrial sectors including AEC sector because of its potentials in waste reduction, customer satisfaction, and process improvement. This research highlights that lean as a management technique can be an effective solution to most of the AEC problems.

The research begins by reviewing the background of lean from its beginning till it has been introduced in the AEC industry. It also presents some lean tools, and the different between lean and other management techniques (i.e. Value engineering and BIM). Afterwards, a review that studies the relation between lean and sustainability is presented to conclude whether lean achieves sustainability or not. A correlation matrix

between some sustainability indicators and the lean construction principles was considered in this study.

The research also evaluates the current implementation degree of lean principles and sustainability indicators in the management process for AEC firms in Egypt through questionnaires, semi structure interviews, and documentary analysis. It was found that although 97% claimed by not using lean, lean principles is partially implemented without naming it a lean process. Finally, a framework has been proposed to help AEC firms implementing lean in the management of the design phase process. On the other hand, the research studied the barriers that hinder the implementation of lean in AEC firms in Egypt in order to conclude some recommendations for Egyptian government, companies, and developer/client.

## KEY WORDS

Architecture, Engineering, and Construction Industry; Lean Construction; Lean Principles; Sustainability Process; Design Process.

# ACKNOWLEDGMENT

This piece of work has been accomplished first and foremost by "ALLAH" blessing and guidance. I have learnt a lot through working in this research, and I hope it will be useful and helpful for others as it was for me.

I would like to express my sincere gratitude to the dissertation supervisor Prof. Ahmed Atef for his patience, immense knowledge and guiding comments, and many special thanks for Dr. Laila Khodier for her continuous support through my studies and related research, as well as for her motivation and guidance that helped me to finish this research in such quality.

In addition, I sincerely appreciate the help of Prof. Dr. Ayman Othman (The British University in Egypt) and Dr. Hisham Said (Santa Clara University in the United States of America) for providing me with data and their insightful comments and encouragement.

My sincere thanks also go to my colleagues Arch. Hadeer Arab (Assisting lecture, Ain Shams University), and Arch. Kholoud Salah (Senior Architect, Talent Construction) for introducing me to some consultancy firms to collect the survey questionnaire data. Furthermore, many sincere thanks for Eng. Miguel Adam (General project manager, Turner construction) for conducting an interview with me and support me with some survey data. Also, I appreciate all the consultancy offices that held interviews in spite of their tight schedule, and everyone that helped or responded to the survey questionnaire.

Last but not least, this research could not have been finished without the personal support and understanding of my mother (Wafaa), brother (Mohamed), and sister (Radwa); as well as the patience, support, guiding comments, and reviewing the research writing by my beloved husband (Tamer Elkhatib).

# TABLE OF CONTENTS

ABSTRACT ..... I
ACKNOWLEDGMENT ..... III
TABLE OF CONTENTS ……..……V
LIST OF FIGURES…….….IX
LIST OF TABLES ……XII
LIST OF ABBRIVIATION.....XIII
**INTRODUTION** ..... 1
Architecture, Engineering, and Construction Industry Problems ..... 2
The Challenges Facing AEC Industry Efficiency ..... 3
The Negative Impact of AEC Industry on Environment and Society . 4
Research Motivation ..... 5
Why Sustainability? ..... 5
Research Objectives ..... 9
Research Question ..... 11
Research Scope ..... 11
Research Methodology ..... 12
Research Structure ..... 17
**CHAPTER ONE: LEAN AND ARCHITECTURE, ENGINEERING, AND CONSTRUCTION INDUSTRY** ..... 19
1.1 Introduction ..... 19
1.2 The Definition of Construction Industry ..... 20
1.2.1 The Life Cycle of Construction Industry ..... 21
1.2.1.1 Design Phase ..... 22
1.3 The Background of Lean ..... 23
1.3.1 The Origin of Lean Production ..... 23

1.3.2 Toyota Production System (TPS) ..... 24
1.3.3 TPS to Lean Philosophy ..... 26
1.3.4 Lean from Manufacturing into AEC Industry ..... 27
1.4 Lean Construction ..... 29
1.4.1 Lean Construction Principles ..... 31
1.5 The Implementation of Lean in AEC industry ..... 34
1.6 Lean Tools and Techniques ..... 35
1.6.1 Benchmarking ..... 35
1.6.2 Kaizen ..... 36
1.6.3 5S Technique ..... 36
1.6.4 Last Planner System ..... 37
1.7 The contribution of lean in AEC industry ..... 39
1.7.1 Contribution in Construction Phase ..... 39
1.7.2 Contribution in Design Phase ..... 41
1.8 Guidelines to Implement Lean in Design Phase ..... 42
1.9 The Challenges and Barriers Facing the Implementation of Lean ..... 45
1.10 Lean versus Traditional Management Approach ..... 48
1.11 Lean Management and Other Management Techniques ..... 51
1.11.1 Lean Concept and Value Engineering ..... 52
1.11.2 Lean and Building Information Modeling (BIM) ..... 54
1.12 Summary ..... 56
**CHAPTER TWO: LEAN AND SUSTAINABILITY PRINCIPLES** ... 59
2.1 Introduction ..... 59
2.2 The Background of Sustainability ..... 60
2.2.1 Sustainability in Construction Industry ..... 61
2.2.2 The Sustainability Development in the Management of Organizations ..... 63

2.3 Lean Construction and Sustainability Agenda ..... 64
2.4 The Integration of Lean and Sustainability Principles ..... 71
2.5 Lean Construction Principles and Sustainability Indicators..... 72
2.5.1 Sustainability of Management process ..... 73
2.5.1.1 Social Indicators ..... 73
2.5.1.2 Environmental Indicators ..... 74
2.5.1.3 Economic Indicators ..... 75
2.5.2 Discussion of the Area of Interaction between Lean Principles and Sustainability Indicators ..... 78
2.6 Summary ..... 80
**CHAPTER THREE: DATA ANALYSIS** ..... 85
3.1 Introduction ..... 85
3.2 Questionnaire Analysis ..... 85
3.3 Lean Implementation in AEC Firms in Egypt ..... 89
3.3.1 Value Principle ..... 89
3.3.2 Value Stream Principle ..... 90
3.3.3 Flow Principle ..... 93
3.3.4 Pull Principle ..... 94
3.3.5 Perfection Principle ..... 95
3.3.6 The Barriers of Implementing Lean in AEC firm in Egypt. 99
3.4 Sustainability in AEC Firms in Egypt ..... 101
3.4.1 Environmental Sustainability ..... 102
3.4.2 Social Sustainability ..... 104
3.4.3 Economic Sustainability ..... 106
3.4.4 The Motivation of Appling Sustainability in the Organization 108
3.5 The Stages of Lean and Sustainability Trends in AEC Firm in Egypt ..... 109
3.6 Summary ..... 111