



**Ain Shams University**  
Faculty of Engineering  
**Architecture Department**

# Integrating Value Engineering in the Design of Intelligent Buildings

**A Thesis submitted to the Faculty of Engineering in the partial fulfillment of the  
requirements for the degree of Master of Science in Architecture.**

Prepared By:

**Arch. Armia Ellia Noshy**

B.Sc in Architecture – Ain Shams University, 2004

Under the supervision of:

**Prof. Dr. Hanan Mostafa Kamal Sabry**

Professor of Architecture  
Faculty of Engineering – Ain Shams University

**Ass. Prof. Akram Farouk Mohamed**

Associate Prof. of Architecture  
Faculty of Engineering  
Ain Shams University

**Ass. Prof. Ahmed Atef Eldesouky**

Associate Prof. of Architecture  
Faculty of Engineering  
Ain Shams University

Cairo, Egypt  
2012



Name: **Armia Ellia Noshy Hanna**

Title: **Integrating Value Engineering in the Design of Intelligent Buildings.**

Degree: **Master of Science Degree in Architecture**

### **The Jury Committee**

**Prof. Dr. Yasser Mansour**

Prof. and Head of Architecture Department

Ain Shams University- Faculty of Engineering (Examiner)

**Prof. Dr. Ahmed Samer Ezz El-Deen**

Prof. of Architecture

American University in Cairo - Faculty of Engineering (Examiner)

---

**Prof. Dr. Hanan Mostafa Kamal Sabry**

Prof. of Architecture

Ain Shams University - Faculty of Engineering (Supervisor)

**Ass. Prof. Akram Farouk Mohamed**

Associate Prof. of Architecture

Ain Shams University - Faculty of Engineering (Supervisor)

### **Post Graduate Studies**

Approval Stamp

/ /

The Research was approved on:

/ /

**Faculty Council Approval**

/ /

**University Council Approval**

/ /

## ***Dedication...***

***I dedicate this thesis to my Family, especially...***

*My dear Father, Mother and Brothers,*

*And*

*My supporting Wife and lovely Sons...*

Every one of you had set an example in a way that brought along this success, without your continuous support, patience, love and sacrifice; it would have been a lot harder for me to be who I am.

## ***The Research Identification***

**Name:**

Armia Ellia Noshy Hanna

**Date of Birth:**

24<sup>th</sup> of July 1982

**Graduation:**

B.SC. degree in Architecture, V. Good with honors

**Graduation Date:**

July 2004

**Present Position:**

Teaching Assistant at Departure of Architecture – Faculty of Engineering – Ain Shams University

## ***Statement***

This Thesis is submitted to Ain Shams University, Faculty of Engineering in partial fulfillment of the requirements of Master of Science Degree in Architecture.

The work included in this thesis was accomplished by the researcher at the Department of Architecture – Faculty of Engineering – Ain Shams University, in the period between “2006 – 2012”. No part of this thesis has been submitted for a degree or a qualification at any other University or Institute.

**Name: Armia Ellia Noshy**

**Signature:**

**Date:    /    / 2012**

## ***ACKNOWLEDGEMENTS***

Firstly, I sincerely thank God for being able to complete my thesis. I would never have been able to finish my dissertation without the guidance of my committee members, help from friends, and support from my family and wife.

I would like to express my deepest gratitude to my advisor, ***Prof. Dr. Hanan Mostafa Sabry***, for her excellent guidance, caring, patience, and providing me with an excellent atmosphere for doing research, and how patiently corrected my writing. Thanks for giving me the chance to experience professionally and academically the concepts of research and providing continuous support and encouragement.

I would like also to thank ***Dr. Akram Farouk & Dr. Ahmed Atef***, for their attention, support and for guiding my research. Special thanks to all the staff members from Architecture Departement who help and advise me along my research trip, and to all who participate in my final defense committee.

I would like to thank Mina Ragheb, who as a good friend, was always willing to help and give his best suggestions. I share the credit of this research with Doaa Soliman the technical engineer in Saint Gobain for her support in the most important part of this thesis, and the workers in the Egyptian Consultant Group for helping me collect data from the field. My research would not have been possible without their helps.

It gives me great pleasure in acknowledgement the support of my parents, two elder brothers, and younger sister. They were always supporting me and encouraging me with their best wishes. Finally, I would like to thank my wife, Rasha Gamil. She was always there cheering me up and stood by me through the good times and bad.

***God gives success***  
***The Researcher***

## ***Abstract***

There is undefined relation between the value engineering concepts and the intelligent building in optimizing the value and cost of the building during its life cycle time. The research aims at defining the architectural parameters that achieve the integration of value engineering in the design of intelligent buildings.

The research study the value engineering methodology application and techniques and focuses on the life cycle costing technique defining and explaining the methodology of calculations of this technique as it is used in the analytical application.

The research discuss the intelligent buildings from an economic perspective illustrating the design criteria of these buildings and the market demand for the intelligent building demonstrating the reasons for extra initial cost and the reduced life cycle cost.

The research presents a value engineering study for two traditional buildings, illustrating the step of application of the value engineering methodology and the techniques used. The analytical study aims at highlighting the architectural value engineering proposed ideas that affect the life cycle cost of the building.

The research also analyzes local case studies buildings applying value engineering study for the façade elements of the building and studies the consequences of using the proposed intelligent alternatives suggested by the value engineering on the life cycle cost of the building.

Finally, the research introduced a set of conclusions and recommendation to motive the design of intelligent buildings under the scope of value engineering and the research suggests a “value engineering check list for intelligent buildings”

## ***Keywords***

Value engineering (VE) – Life cycle Cost (LCC) - Intelligent Building (IB)  
– Intelligent buildings in Egypt .

## *List of Abbreviations*

<b>Abbreviation</b>	<b>Word</b>
VA	Value Analysis
VE	Value Engineering
LCC	Life Cycle cost
LCCA	Life Cycle Cost Analysis
IB	Intelligent Building
PW	Present worth
PWA	Present worth of annuity
CTP	Capital Tower Project
NEH	National Eye Hospital
ECG	Engineering Consultant Group



## **List of Contents**

Abstract .....	i
List of Contents .....	ii
List of Figures .....	v
List of Tables .....	vii

## **Introduction**

Problem statement .....	<u>xi</u>
Research Goal .....	<u>xi</u>
Research Scope and Limitations .....	<u>xii</u>
Research Hypothesis .....	<u>xiii</u>
Research Methodology .....	<u>xiii</u>
Research Structure .....	<u>xiv</u>
Literature Review .....	<u>xiv</u>

## **Chapter 1**

### **Value Engineering and Life Cycle Cost Analysis**

1.1- Introduction .....	1
1.2 Value Engineering Terminology and Definition .....	1
1.3 VE History and Development .....	2
1.4 VE objectives .....	3
1.4.1 Value .....	3
1.4.2 Function .....	4
1.4.3 Cost .....	4
1.5 VE and Traditional Cost Reduction .....	6
1.6 Interacting Concepts with VE .....	8
1.7 Applying VE .....	9
1.8 VE Methodology .....	13
1.8.1 VE Records .....	14
1.8.2 VE Workshop .....	14
1.8.2.1 VE Execution Process (VE Job Plan) .....	15
1.8.3 Reporting .....	21
1.9 VE Check List .....	22
1.10 VE Special Techniques .....	24
1.11 Overview on Life Cycle Cost Analysis .....	25
1.11.1 Life Cycle Cost Definition .....	25

1.11.2 LCC Applications .....	26
1.11.3 LCC Application in the Design Process .....	26
1.11.4 LCC Considerations.....	28
1.11.5 LCC Procedures .....	31
1.12 LCC and VE.....	31
1.12.1 Comparison of LCCA and VE.....	33
1.12.2 Combined Use of LCCA and VE.....	33
1.13 LCC Methodology .....	34
1.14 LCC Fundamentals .....	35
1.14.1 Time Value of Money .....	37
1.14.1.1 Present worth method .....	37
1.14.1.2 Annualized method .....	37
1.14.2 Analysis Period .....	38
1.14.3 Present Time .....	38
1.14.4 Discount Rate.....	39
1.14.5 Costs.....	40
1.15 Life cycle Cost Calculation.....	42
1.15.1 LCC general Formula .....	42
1.15.2 LCC for Building Related Projects .....	42
1.16 Application of LCC to Buildings <sup>(1)</sup> .....	43
1.17 Summary .....	46

## **Chapter 2**

### **Intelligent Building in Economic Perspective**

2.1 Introduction.....	49
2.2 IB Definition .....	49
2.3 Historical Models of IB .....	49
2.3.1 Automated buildings .....	49
2.3.2 Responsive buildings .....	50
2.3.3 Effective buildings .....	52
2.4 Building life Cycle.....	54
2.5 IB Design Issues .....	55
2.5.1 Site Issues.....	58
2.5.1.1 Aspects and landscape .....	58
2.5.1.2 Access .....	58
2.5.1.3 Car parking.....	58
2.5.2 Architectural Elements.....	58
2.5.2.1 Shell Issues.....	58
2.5.2.2 Skin Issues .....	61

2.4.3 Building Systems .....	63
2.4.3.1 Mechanical systems .....	63
2.5.3.2 Electrical systems.....	64
2.5.3.3 Security and access control system .....	64
2.5.4 Information Technology services .....	65
2.5.4.1 Building Services .....	65
2.5.4.2 Building Management.....	66
2.6 Economic Vision of IB .....	69
2.6.1 The Market's Demand to IB .....	69
2.6.2 Reasons of extra cost in IB .....	69
2.6.2.1 Initial costs .....	69
2.6.3 Savings in IB .....	70
2.6.3.1 Operating cost savings .....	<b>Error! Bookmark not defined.</b>
2.6.3.2 Churn cost savings .....	71
2.7 IB Example: Ruffino Pacific Tower .....	71
2.8 Summary .....	76

<p style="text-align: center;"><b>Chapter 3</b> <b>Value Engineering Analytical Examples</b></p>
--

3.1 Introduction.....	77
3.2 Case studies.....	77
3.2.1 Capital Tower Project “CTP” .....	77
3.2.1.1 Project Description.....	78
3.2.1.2 Cost Estimate .....	79
3.2.2.3 VE Objectives .....	80
3.2.1.4 VE Job Plan.....	80
3.2.2.5 VE Proposed Ideas .....	83
3.2.2.6 VE Checklist .....	89
3.2.2.7 VE Recommendation .....	90
3.2.2 National Eye Hospital (NEH) .....	99
3.2.2.1 Project Description.....	99
3.2.2.2 Cost Estimate .....	99
3.2.2.3 VE Objectives .....	100
3.2.2.3 VE Job Plan.....	100
3.2.2.4 Cost Model.....	100
3.2.2.5 VE Proposed Ideas .....	101
3.2.2.6 VE Checklist .....	106
3.2.2.7 VE Recommendations .....	107

3.3 Data Analysis of Case Studies .....	109
3.4 Summary .....	110

## **Chapter 4**

### **VE Case Studies for IB**

4.1 Introduction.....	111
4.2 Objective of the Case Study.....	111
4.3 Selection Criteria of buildings in the case study.....	111
4.4 Methodology used in analyzing the building.....	112
4.5 VE Proposed Ideas .....	113
4.6 Engineering Consultant Group (ECG) Building.....	114
4.6.1 Building Information .....	115
4.6.2 IB Features .....	116
4.6.2.1 Site Issues.....	116
4.6.2.2 Architecture elements .....	116
4.6.2.3 Building Systems .....	118
4.6.2.4 IT Services .....	120
4.6.3 Initial and Running Cost .....	122
4.6.4 VE application .....	122
4.7 Beltone Building .....	128
4.7.1 Building Information .....	128
4.7.2 IB Features .....	129
4.7.2.1 Site Issues.....	129
4.7.2.2 Architecture elements .....	130
4.7.2.3 Building Systems .....	132
4.7.2.4 IT Services .....	133
4.7.3 Initial and Running Cost .....	136
4.7.4 VE Application .....	136
4.8 Results and Discussion .....	142
4.9 Summary .....	142

## **Chapter 5**

### **Conclusions and Recommendations**

5.1 Conclusions.....	143
5.1.1 VE Checklist for IB .....	145
5.3 Recommendations.....	147

<b>List of Figures</b>
------------------------

**Chapter 1**

Figure 1.1: VE milestone .....	3
Figure 1.2: WLC and LCC.....	9
Figure 1.3: Potential saving for VE applications .....	10
Figure 1.4: Effect of VE team approach .....	11
Figure 1.5: VE Team members applying the Job Plan .....	11
Figure 1.6: Major decision makers' influence on facility cost .....	12
Figure 1.7: VE Job Plan .....	21
Figure 1.8: VE Techniques in the job plan steps .....	24
Figure 1.9: Phase Cost Reduction, Facilities Construction.....	27
Figure 1.10: Decision Makers' impact on total building cost.....	28
Figure 1.11: Cost Considerations .....	29
Figure 1.12: LCC Elements .....	31
Figure 1.13: Interrelationship of VE and LCC .....	32
Figure 1.14: LCC Logical Methodology .....	35
Figure 1.15: LCCA Fundamentals .....	36
Figure 1.16: Present Time Diagram.....	39
Figure 1.17: Cost of Ownership using PW concept for a typical office building .....	44

**Chapter 2**

Figure 2.1: Building supply life cycles .....	51
Figure 2.2: Life Time of Building Components .....	54
Figure 2.3: IB Design Issues.....	57
Figure 2.4: Reference case LCC .....	73
Figure 2.5: Ruffino Pacific Tower .....	73
Figure 2.6: LCC of Ruffino Tower and Non-IB .....	74

**Chapter 3**

Figure 3.1: Capital Tower Project.....	78
Figure 3.2: Plot 1A master plan .....	78
Figure 3.3: CTP Cost break down.....	79
Figure 3.4: CTP VE document.....	80
Figure 3.5: Capital Tower Project FAST Diagram .....	82
Figure 3.6: Cost Model Pareto Chart .....	83
Figure 3.7: CTP Savings .....	84
Figure 3.8-a1: CTP VE Recommendation Sheet .....	91
Figure 3.8-a2: CTP VE Recommendation Sheet .....	92

Figure 3.8-b1: CTP VE Recommendation Sheet .....	93
Figure 3.8-b2: CTP VE Recommendation Sheet .....	94
Figure 3.8-b3: CTP VE Recommendation Sheet .....	95
Figure 3.8-c1: CTP VE Recommendation Sheet .....	96
Figure 3.8-c2: CTP VE Recommendation Sheet .....	97
Figure 3.8-c2: CTP VE Recommendation Sheet .....	98
Figure 3.9: NEH in Cairo .....	99
Figure 3.10: NEH Cost break down .....	100
Figure 3.11: NEH Cost Model Pareto Chart .....	101
Figure 3.12: NEH Cost Model Pareto Chart .....	102
Figure 3.13: Autoclaved Aerated Concrete Blocks .....	107
Figure 3.14: NEH VE Recommendation Sheet .....	108

## **Chapter 4**

Figure 4.1: Smart Village Map .....	112
Figure 4.13: Electro-chrome Glass .....	114
Figure 4.3: ECG Building Smart Village .....	115
Figure 4.4: ECG Landscape .....	116
Figure 4.5: ECG Layout .....	116
Figure 4.6: ECG 1st Basement Plan .....	116
Figure 4.7: ECG Typical Floor .....	117
Figure 4.8: ECG Ground Floor Plan .....	117
Figure 4.9: ECG Typical Floor .....	117
Figure 4.10: ECG Northern Elevation .....	118
Figure 4.11: Louvers on South, East and West Elevations .....	118
Figure 4.12: Building Western Core .....	119
Figure 4.13: Building Eastern Core .....	119
Figure 4.14: Lighting system in Office space .....	119
Figure 4.15: CCTV Security system .....	120
Figure 4.16: Cables Distribution system .....	120
Figure 4.18: Glazing & HVAC Initial and running cost .....	125
Figure 4.19: ECG Building LCC Calculations for Alternatives .....	126
Figure 4.20: ECG Building VE Recommendation Sheet .....	127
Figure 4.21: Beltone Building Smart Villag .....	128
Figure 4.22: ECG Layout .....	129
Figure 4.23: ECG 3rd Basement Plan .....	129
Figure 4.24: Beltone Typical Floor .....	130
Figure 4.25: Beltone Atrium .....	131
Figure 4.26: Beltone Ground Floor Plan .....	131
Figure 4.27: Beltone Elevation .....	132
Figure 4.28: Lighting system in Office space .....	133
Figure 4.29: Beltone Core .....	134

Figure 4.30: Glazing& HVAC Initial and running cost .....	139
Figure 4.31: Beltone Building LCC Calculations for Alternatives.....	140
Figure 4.32: Beltone Building VE Recommendation Sheet .....	141

## **List of Tables**

### **Chapter 1**

Table 1.1: VE Objective, approach and result .....	5
Table 1.2: VE Objective .....	6
Table 1.3: A comparison between VE and CR .....	8
Table 1.4: VE job Plan steps according to pioneers point of view .....	16
Table 1.5: VE Team applying the job Plan .....	17
Table 1.6: VE Job Plan Methodology .....	20
Table 1.7: VE checklist.....	23
Table 1.7: VE Checklist.....	23
Table 1.8: Comparison of VE and LCC.....	34
Table 1.9: Fundamental Questions and LCCA Key elements .....	36
Table 1.10: Discount Factors for LCC calculations	40

**Error! Bookmark not defined.**

### **Chapter 2**

Table 2.1: The IB model of building intelligence .....	53
Table 2.2: Models of IB .....	53
Table 2.3: IB Design Criteria.....	68
Table 2.4: Ruffino Tower IB Criteria .....	75
Table 2.5: Savings in Ruffino Tower.....	76

### **Chapter 3**

Table 3.1a: VE Recommendation Items .....	85
Table 3.1b: CTP VE Recommendation Items.....	86
Table 3.1c: CTP VE Recommendation Items .....	87
Table 3.1d: CTP VE Recommendation Items.....	88
Table 3.2: CTP VE Checklist.....	89
Table 3.3a: NEH VE Recommendation Items .....	103
Table 3.3 b: NEH VE Recommendation Items .....	103
Table 3.3 c: NEH VE Recommendation Items .....	105
Table 3.4: NEH VE Checklist.....	106
Table 3.5: Comparison of VE items of case studies .....	110

### **Chapter 4**

Table 4.1: ECG IB Features.....	121
Table 4.2: Running Costs of ECG Building .....	122
Table 4.3a: Building facades' specifications .....	123