



Ain Shams University
Faculty of Engineering
Architecture Department

Impact of Value Engineering on the Selection of Finishing Materials of Sustainable Interiors in Egypt

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

By:

Arch. Mark Victor George

Bachelor of Science – Architectural Engineering - 2016

Teacher Assistant

Faculty of Engineering – Ain Shams University

Supervised By:

Prof. Dr. Ahmed Atef Al-Desouky

Assoc. Prof. Dr. Laila Mohamed Khodeir

Cairo – (2020)



Ain Shams University
Faculty of Engineering
Architecture Department

Impact of Value Engineering on the Selection of Finishing Materials of Sustainable Interiors in Egypt

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

By:

Arch. Mark Victor George

Bachelor of Science – Architectural Engineering - 2016

Teacher Assistant

Faculty of Engineering – Ain Shams University

Examiners' Committee

Name and Affiliation

Prof. Dr. Ahmed Samer Ezz-Eldin

Construction Engineering, American University in Cairo

Prof. Dr. Akram Farouk Mohamed

Architectural Engineering, Ain Shams University

Prof. Dr. Ahmed Atef Al-Desouky

Architectural Engineering, Ain Shams University

Assoc. Prof. Dr. Laila Mohamed Khodeir

Architectural Engineering, Ain Shams University

Signature

.....

.....

.....

.....

Date:/...../2020

Statement

This thesis is submitted as a partial fulfilment 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.

Student name

Mark Victor George

Signature

.....

Date: ___/___/2020

Research Data

Name :Mark Victor George
Date of birth :19th of November 1993
Place of birth :Cairo, Egypt
Last academic degree :Bachelor of Science
Field of specialization :Architectural Engineering
University issued the degree :Ain Shams University
Date of issued degree :2016
Current job :Teacher Assistant, Ain Shams University

Abstract

With increasing the number of new construction large-scale and mega projects in Egypt, it becomes an obligation rather than a need to develop economic studies in order to control and direct the assigned budgets properly. This is in addition to the urgent need to adopt sustainability in line with Egypt's vision 2030 for sustainable development. Barriers are found towards the usage of sustainable interior materials such as its high initial costs and lack of awareness about it. One of the powerful studies concerning these issues is value engineering studies which help in the selection of materials especially interior finishing materials where it has an impact on project's overall quality and budget to select a material and reject another. Value engineering studies are concerned with cost and function studies to develop alternatives and select optimum choices for interior finishes.

The main aim of the study is to provide general prerequisites and proposed selection criteria for the finishing materials of sustainable interiors through value engineering studies and sustainability concepts to be used by key stakeholders or decision makers in the materials' selection process of new large scale and mega projects in Egypt. In addition to proposing an action plan for real adoption of both value engineering studies and sustainable interior materials in Egypt. In order to achieve this aim, the researcher went through a literature review for a set of previous studies and research about sustainable interiors and value engineering in addition to studying the relation and mutual impact between them.

The researcher also analyzes foreign, Arabian and Egyptian projects that apply value engineering studies or use sustainable interior materials or both in order to highlight application benefits, problems and update the preliminary selection criteria developed from literature review chapters. For a comprehensive vision for the current situation in Egypt, the researcher made an online survey questionnaire with a sample size of 50 engineers in different fields like architecture, interior design, BOQ and specifications, management, technical office and site engineers working in 17 leading architecture and consulting firms in Egypt. In addition to 36 personal interviews directed towards key stakeholders and decision makers in any new large scale project who are: clients, designers, owners, consultants and suppliers with an objective to develop a final updated version of the selection criteria of sustainable interior materials beside general prerequisites.

Finally, for the objective of making a preliminary validation for the criteria, the researcher analyzes 4 case studies from the educational sector in order to assess the

usage of sustainable materials as interior finishes concerning their value, cost and specifications, the project with the highest application costs is then selected to apply value engineering studies on the selection of one item to check the benefits of value engineering application. Value engineering studies extracted different materials as alternatives, the researcher select one of them to be set in comparison with the already used material in the project by the help of the proposed criteria developed from the study. The research at the end propose an action plan that help in the adoption of value engineering studies and sustainable interior materials selection in Egypt.

Keywords:

Value Engineering, Materials Selection, Interior Finishing Materials, Sustainable Interiors and Sustainable Interior Materials

Acknowledgment

It is a pleasure to thank those who made this thesis possible, before all, without Allah's blessings and grace, this academic work would not have come to light.

I am sincerely thankful and indebted to my thesis instructors Prof. Dr. Ahmed Atef for his guidance and valuable comments throughout my work on the thesis, and would like to express my sincere gratitude to Assoc. Prof. Dr. Laila Khodeir for her great efforts and helpful comments in each and every step that guide me to produce this academic work in such an organized form.

A sincere thanks goes to my parents – my firmest supporters – and the reason of every success in my life because of their endless sacrifice, May Allah reward them for all their efforts.

A heartfelt sense of gratitude is expressed to my beloved fiancé Arch. Mariam Adel for her love, patience and support.

February 2020

List of Contents

Abstract	A
Keywords	B
Acknowledgment	C
List of Contents	D
List of Figures	J
List of Charts	K
List of Tables	L
List of Acronyms	N
Introduction	P
A. Problem Statement.....	Q
B. Research Hypothesis.....	R
C. Research Aim.....	R
D. Research Objectives.....	S
E. Research Questions.....	S
F. Research Methodology.....	T
G. Research Content.....	T
H. Research Structure.....	U
I. Literature Map.....	W
1. Chapter One: The Nature of Sustainable Interiors	1
1.1 Introduction.....	1
1.2 Introduction to Sustainable Interiors.....	3
1.2.1 Concept of Sustainable Interior Design.....	3
1.2.2 The Role of Interior Design in Sustainable Design.....	5
1.2.3 Environmental Impacts for Indoor Spaces.....	5
1.2.4 Environmental Assessment Tools and Aspects of Sustainable Interiors.....	6
1.2.5 Sustainability in Interior Design Elements.....	8
1.2.5.1 Interior Design Element: Materials.....	8
1.2.5.2 Interior Design Element: Furnishing.....	9
1.2.5.3 Interior Design Element: Lighting.....	9
1.2.6 Attitude Towards Sustainable Interior Design Practices.....	9
1.2.7 Barriers Towards Sustainable Interior Design Practices.....	9
1.3 Sustainable Criteria and Materials Selection.....	10
1.3.1 Conventional Criteria for Selecting Finishing Materials.....	11
1.3.1.1 Aesthetic Criteria.....	11
1.3.1.2 Functional Criteria.....	11
1.3.1.3 Economic Criteria.....	11

1.3.1.4 Sustainability Criteria.....	11
1.3.2 Sustainable and Green Finishing Materials.....	11
1.3.3 Application of “Materials and Resources” Category in LEED.....	12
1.3.4 Selection Criteria for Sustainable Interior Design Solutions.....	13
1.3.4.1 Producers’ Criteria.....	13
1.3.4.2 Health Criteria.....	14
1.3.4.3 Reduction of Consumption.....	14
1.3.4.4 Sustainable Design Components.....	14
1.3.4.5 Efficient Design Resource Management.....	15
1.3.5 Certifications and Labels for Sustainable Interior Materials.....	15
1.3.6 Barriers to Sustainable Materials Selection.....	17
1.4 Findings.....	18
1.4.1 Focus on Interiors and Finishing Materials.....	18
1.4.2 Role of Interior Designers towards Sustainable Adoption.....	19
1.4.3 Preliminary Selection Criteria for Sustainable Interior Materials.....	20
1.5 Guiding Remarks.....	21
2. Chapter Two: The Relation between Value Engineering and Sustainability.....	23
2.1 Introduction.....	23
2.2 Nature of Value Engineering.....	24
2.2.1 Value Engineering Terminology and Definition.....	25
2.2.2 Value Engineering History and Development.....	25
2.2.3 Value Engineering Application Phases.....	26
2.2.4 Value Engineering Objectives.....	27
2.2.4.1 Value.....	27
2.2.4.2 Function.....	28
2.2.4.3 Cost.....	28
2.2.5 Value Engineering Methodology.....	28
2.2.5.1 Records.....	28
2.2.5.2 Workshop and Job Plan.....	28
2.2.5.3 Reporting.....	28
2.2.6 Value Engineering Checklist and Special Techniques.....	28
2.2.7 Barriers towards Value Engineering Application.....	29
2.3 Value Engineering and Sustainability.....	29
2.3.1 Value Engineering in Sustainable Building Construction.....	29
2.3.2 Importance of Integrating Value Engineering with Sustainability.....	30
2.3.2.1 The Strengths of Value Engineering for Supporting Sustainability.....	30
2.3.2.2 Establishing Link Between Value Engineering and Sustainability.....	31

2.3.3 The Context of Sustainability Within Value Engineering	32
2.3.3.1 Integration Concept between Value Engineering and Sustainability.....	33
2.3.3.2 The Effects of Sustainability Integration to the Value Engineering Process.....	33
2.3.3.3 The Success Factors for Integration.....	33
2.3.4 Efforts Relating Sustainability to Value Engineering.....	34
2.4 Findings.....	36
2.4.1 Potentials of Integrating Value Engineering and Sustainability.....	37
2.4.2 Role of Value Engineering in Sustainable Interior Finishes.....	38
2.4.3 Updated Selection Criteria for Sustainable Interior Materials.....	38
2.5 Guiding Remarks.....	40
3.Chapter Three: Analysis of National and International Examples.	41
3.1 Introduction.....	41
3.2 Examples on the Selection of Sustainable Interior Finishing Materials.....	41
3.2.1 Sustainable Materials Selection.....	41
3.2.1.1 Adam Joseph Lewis Center for Environmental Studies.....	42
3.2.1.2 University of British Columbia CK Choi Building.....	43
3.2.2 Alternatives of Interior Finishing Materials.....	44
3.2.2.1 Hilton Hotel in Vancouver Canada.....	44
3.2.2.1.1 Materials Selection Criteria in Hilton Hotel.....	46
3.2.3 Points of Conclusion.....	46
3.3 Examples on the Application of Value Engineering in Different Arab Countries Projects.....	47
3.3.1 Capital Tower Project in Jordan.....	47
3.3.1.1 Value Engineering Objectives and Methodology in Capital Tower Project.....	49
3.3.1.2 Value Engineering Checklist and Recommendations in Capital Tower Project.....	50
3.3.2 National Eye Hospital in Egypt.....	51
3.3.2.1 Value Engineering Objectives and Methodology in National Eye Hospital Project.....	52
3.3.2.2 Value Engineering Checklist and Recommendations in National Eye Hospital Project.....	53
3.3.3 Points of Conclusion.....	53
3.4 Examples on Delivering Sustainability Through Value Engineering.....	54
3.4.1 University of Florida in Gainesville, United States.....	54
3.4.2 Points of Conclusion.....	56

3.5 Findings.....	57
3.5.1 Selection of Sustainable Interior Finishing Materials.....	57
3.5.2 Additional Benefits due to Value Engineering Application on Sustainable Projects.....	59
3.5.3 Updated Selection Criteria for Sustainable Interior Materials Based on Analyzed Examples.....	59
3.6 Guiding Remarks.....	61
4.Chapter Four: Application Study: Interviews and Survey	
Questionnaire.....	62
4.1 Introduction.....	62
4.2 Target Groups and Expected Outcome.....	62
4.3 Process of Survey Questionnaire.....	64
4.3.1 Descriptive Approach and Adopted Survey Typology.....	64
4.3.2 Sample Population and Selection Criteria.....	64
4.3.3 Survey Main Aim and Secondary Objectives.....	65
4.3.4 Survey Methodology.....	65
4.4 Participants Basic Information.....	66
4.5 Survey Findings: Value Engineering Application.....	67
4.5.1 Awareness and Practice of Value Engineering.....	67
4.5.2 Evaluation of Value Engineering Impact on New Projects.....	69
4.5.3 Barriers Facing Value Engineering Application.....	70
4.5.4 Suggestions for Value Engineering Application in New Projects.....	71
4.6 Survey Findings: Interior Finishes and Sustainable Materials.....	72
4.6.1 Factors Affecting the Achievement of Sustainability Objectives.....	72
4.6.2 Factors Affecting Sustainable Materials Selection.....	73
4.6.3 Influencing Stakeholders on Materials Selection Process.....	74
4.6.4 Barriers Facing Sustainable Materials Selection.....	75
4.6.5 Suggestions for Finishing Materials of Sustainable Interiors.....	75
4.7 Survey Findings: Selection Criteria for Interior Finishing Materials.....	76
4.7.1 Priorities in Selection Criteria.....	76
4.7.2 Impact of Comprehensive Selection Criteria.....	77
4.8 Process of Personal Interviews.....	78
4.8.1 Validity and Reliability of Personal Interviews.....	78
4.8.2 Personal Interviews Methodology.....	79
4.8.3 List of Interviewees.....	79
4.8.4 Personal Interviews Objectives.....	82
4.9 Interviews Findings: Value Engineering Application.....	82
4.9.1 Awareness about Value Engineering Studies and its Impact.....	82

4.9.2	Barriers towards the Application of Value Engineering Studies.....	83
4.10	Interviews Findings: Interior Finishes and Sustainable Materials.....	83
4.10.1	Priorities in the Selection of Interior Finishes.....	83
4.10.2	Awareness about the Sustainable Materials.....	83
4.10.3	Availability of Sustainable Interior Materials in Suppliers' Market.....	84
4.10.4	Barriers Facing Sustainable Materials Adoption.....	84
4.10.5	Projects and Products Related to Sustainable Interiors.....	85
4.11	Interviews Findings: Current Situation, Recommendations and Responsibilities.....	85
4.11.1	Current Situation and Market Trends in New Projects.....	85
4.11.2	Recommendations, Additions and Suggested Solutions.....	85
4.11.3	Responsibilities towards Sustainability	86
4.12	Findings.....	86
4.12.1	General Prerequisites for Criteria Application.....	88
4.12.2	Limitations for the Application of the Proposed Selection Criteria.....	89
4.12.3	Final Version for the Preliminary Selection Criteria for Sustainable Interior Materials.....	89
4.13	Guiding Remarks.....	92
5.	Chapter Five: Preliminary Validation of the Selection Criteria on Case Studies.....	93
5.1	Introduction.....	93
5.2	Case Studies Overview.....	93
5.2.1	Objectives of Case Studies.....	93
5.2.2	Selection Criteria for Case Studies.....	93
5.2.3	Methodology of Analyzing Case studies.....	94
5.3	Project (1): Egypt-Japan University of Science and Technology.....	95
5.3.1	Project Description.....	95
5.3.2	Application of Sustainable Interior Materials.....	96
5.3.2.1	Specifications of the used materials.....	97
5.3.2.2	Costs Data.....	98
5.3.2.3	Application Pros and Cons.....	98
5.4	Project (2): The Knowledge Hub.....	99
5.4.1	Project Description.....	100
5.4.2	Application of Sustainable Interior Materials.....	101
5.4.2.1	Specifications of the used materials.....	101
5.4.2.2	Costs Data.....	103
5.4.2.3	Application Pros and Cons.....	104
5.5	Project (3): Al-Galala University.....	104

5.5.1 Project Description.....	105
5.5.2 Application of Sustainable Interior Materials.....	105
5.5.2.1 Specifications of the used materials.....	106
5.5.2.2 Costs Data.....	106
5.5.2.3 Application Pros and Cons.....	106
5.6 Project (4): Upper Egypt Schools Development.....	107
5.6.1 Project Description.....	107
5.6.2 Application of Sustainable Interior Materials.....	107
5.6.2.1 Specifications of the used materials.....	108
5.6.2.2 Costs Data.....	109
5.6.2.3 Application Pros and Cons.....	109
5.7 Findings of Case Studies Analysis.....	110
5.8 Application of Value Engineering Studies on Project (3).....	110
5.8.1 Application of Value Engineering on the selection of Item (1).....	111
5.9 Preliminary Validation of the Proposed Selection Criteria on Item (1) and its Alternative.....	114
5.10 Findings.....	119
5.10.1 Benefits of Value Engineering Application on the Selection of Sustainable Interior Materials.....	119
5.10.2 Action Plan towards Value Engineering and Sustainable Materials Adoption.....	120
5.11 General Remarks.....	122
Conclusions	123
Recommendations	126
Research Limitations	127
References	128
Appendices	139

List of Figures

Figure (1): Theoretical Integration between Sustainability and Value Engineering (<i>Author</i>).....	R
Figure (2): Research Structure.....	V
Figure (1.1): The Three Intersected Aspects of Sustainability (<i>Ahmed E. Suliman,2013</i>).....	4
Figure (2.1): Value Engineering History and Evolution Timeline (<i>Author after Ellia, A.,2012</i>).....	26
Figure (2.2): Value Engineering Phases of Application on Sustainable Materials Selection (<i>Author</i>).....	27
Figure (2.3): Proposed Conceptual Model for Integrating Sustainability Aspects into Value Engineering Studies (<i>Zainul Abiding, N.,2005</i>).....	35
Figure (2.4): Potentials of Integrating Value Engineering and Sustainability.....	38
Figure (2.5): Selection of Sustainable Interior Finishes based on Value Engineering Strategy.....	38
Figure (3.1): Hilton Vancouver Hotel Study Phases (<i>Author</i>).....	45
Figure (3.2): Elements of Capital Tower Project (<i>Author after Ellia, A.,2012</i>).....	48
Figure (3.3): Value Engineering Objectives for Capital Tower Project.....	49
Figure (3.4): Value Engineering Techniques & Output for each Job Plan for Capital Tower Project (<i>Ellia, A.,2012</i>).....	49
Figure (3.5): Value Engineering Objectives for National Eye Hospital.....	52
Figure (3.6): Project Items Affecting LEED Categories (<i>Author</i>).....	53
Figure (3.7): Materials Selection for Sustainable Projects: Criteria, Problems and Lessons Learned.....	58
Figure (3.8): Additional Benefits due to Value Engineering Application on Sustainable Projects.....	59
Figure (4.1): Main Stages of Application Approach.....	62
Figure (4.2): Sequence of Developing the Selection Criteria for Sustainable Interior Materials (<i>Author</i>).....	90
Figure (5.1): Main Stages of Preliminary Validation Approach.....	93
Figure (5.2): Methodology of Analyzing the Case Studies.....	94
Figure (5.3): E-JUST Main Campus Building (https://ejust.edu.eg , last accessed December 2019).....	95
Figure (5.4): E-JUST Main Campus and the Residential Buildings (<i>Google Maps-Satellite View</i>).....	96
Figure (5.5): The Knowledge Hub Universities Campus (https://tkh.edu.eg , last accessed December 2019).....	100
Figure (5.6): The Knowledge Hub Universities Planning (https://tkh.edu.eg , last accessed December 2019).....	101
Figure (5.7): Al-Galala University (https://gu.edu.eg , last accessed December 2019).....	104
Figure (5.8): Al-Galala University Planning (<i>Ministry of Higher Education Achievements 2018 and Future Plans in 2019 report</i>).....	105

List of Charts

Chart (1.1): Literature Sources Discussing Sustainable Interiors (1995-2018).....	18
Chart (1.2): Literature Sources Discussing Sustainable Criteria and Materials Selection (1995-2018).....	18
Chart (1.3): Scorecard of LEED-New Construction Version (4).....	19
Chart (2.1): Literature Sources Discussing Value Engineering (1995-2018).....	36
Chart (2.2): Literature Sources Discussing Value Engineering and its Relationship with Sustainability (1995-2018).....	36
Chart (3.1): Cost Breakdown of Capital Tower Project (<i>Ellia,A.,2012</i>).....	48
Chart (3.2): Potential Savings in Capital Tower Project (<i>Ellia,A.,2012</i>).....	50
Chart (3.3): Cost Breakdown of National Eye Hospital (<i>VE Reports of the NEH, EGYCAN office,January 2012</i>).....	51
Chart (3.4): Potential Savings in National Eye Hospital (<i>Pareto Chart</i>).....	52
Chart (4.1): Participants Specialized Work Fields.....	66
Chart (4.2): Participants Years of Experience.....	67
Chart (4.3): Time of Value Engineering Application in New Projects.....	68
Chart (4.4): Awareness and Practice of Value Engineering.....	68
Chart (4.5): Reasons Why Companies Don't Apply Value Engineering.....	68
Chart (4.6): The Interest in Value Engineering Application for Participants Who Don't Know Value Engineering.....	69
Chart (4.7): Impact of Value Engineering on New Projects.....	69
Chart (4.8): Detailed Results of Barriers Facing Value Engineering Application.....	70
Chart (4.9): Detailed Results of Factors Affecting the Achievement of Sustainability Objectives.....	72
Chart (4.10): Participants Evaluation of Different Factors Impact on Achieving Sustainability.....	73
Chart (4.11): Detailed Results of Factors Affecting Sustainable Materials Selection.....	73
Chart (4.12): Detailed Results of Influencing Stakeholders on Materials Selection Process.....	74
Chart (4.13): Participants Choices for the Finishing Materials of a Sustainable Interior.....	76
Chart (4.14): Participants Rank for the Selection Criteria for Interior Finishing Materials.....	77
Chart (4.15): Impact of Comprehensive Selection Criteria for Finishing Materials of Sustainable Interiors.....	77
Chart (4.16): Awareness about Value Engineering According to Interviews.....	82
Chart (5.1): Weights for each Criterion in Project (3) (<i>Based on one of the Key Stakeholders</i>).....	114
Chart (5.2): Material (C) and Material (D) Scores in the Selection Criteria.....	119