



بسم الله الرحمن الرحيم

∞∞∞∞

تم رفع هذه الرسالة بواسطة / سامية زكى يوسف

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى

مسئولية عن محتوى هذه الرسالة.

ملاحظات: لا يوجد





AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
DEPARTMENT OF ARCHITECTURE

**COST EFFICIENT SUSTAINABLE STRATEGY FOR
RETROFITTING SIGNIFICANT BUILDINGS IN EGYPT**

A Thesis submitted in partial fulfilment of the requirements of the degree of
"Doctor of philosophy in Architecture"

Submitted by

Ayman Ahmed Ramadan Abdelaziz

B.Sc. Architecture - Ain Shams University- 2007

M.Sc. Architecture - Ain Shams University- 2013

Under the supervision of

Prof. Dr. Yasser Mohamed Mansour

Professor of Theories of Architecture

Faculty of Engineering, Ain Shams University

Prof. Dr. Hanan Mostafa Kamal Sabry

Professor of Architecture and Environmental control

Faculty of Engineering, Ain Shams University

Cairo - (2022)



AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
DEPARTMENT OF ARCHITECTURE

**COST EFFICIENT SUSTAINABLE STRATEGY FOR
RETROFITTING SIGNIFICANT BUILDINGS IN EGYPT**

Submitted by: Ayman Ahmed Ramadan Abdelaziz
M.Sc. in Architecture Engineering, Assistant Lecturer- Department of
Architecture, Faculty of Engineering, Ain Shams University- 2013
Degree: Doctor of Philosophy in Architecture

Examiners' Committee

Signature

Prof. Dr. Ahmed Fared Gamal Hamza

.....

Prof. of Professor of Theories of Architecture,
Faculty of Engineering, Banha University

Prof. Dr. Morad Abd- Elkader Abd- Elmohsen

.....

Prof. of Architecture and Environmental Control,
Faculty of Engineering, Ain Shams University

Prof. Dr. Yasser Mohamed Mansour

.....

Professor of Theories of Architecture, Faculty of
Engineering, Ain Shams University.

Prof. Dr. Hanan Mostafa Kamal Sabry

.....

Professor of Architecture and Environmental control,
Faculty of Engineering, Ain Shams University.

Date of Thesis Defence:/...../2022

Postgraduate studies

Approval Stamp

Thesis was approved on/...../2022

Faculty Council Approval/...../2022

University Council Approval/...../2022

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ
"وَقُلْ رَبِّ زِدْنِي عِلْمًا"

(طه: ١١٤)

صدق الله العظيم

To the soul of my father

To my family & my brothers

To my loving wife Marwa and her family

To my little sons Zeyad & Dana

For all your support and unconditional love

STATEMENT

This dissertation is submitted to Ain Shams University - Faculty of Engineering - Department of Architecture for the degree of Doctor of Philosophy in Architecture.

The work included in this thesis was accomplished by the author at the Department of Architecture, Faculty of Engineering, Ain Shams University, during the period from 2013 to 2022. No part of this thesis has been submitted for a degree or a qualification at any other university or institute.

Date/...../2022

Signature

Name Ayman Ahmed Ramadan Abdelaziz

Assistant Lecturer - Department of Architecture,

Faculty of Engineering - Ain Shams University

ACKNOWLEDGEMENTS

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

By the name of ALLAH, the Most Gracious, the Most Merciful

Now that I have to come to the end of this journey, I realize that several professors, collaborators, friends, institutions, and family members have helped me reach my final destination. However, acknowledging everyone who has helped me along the way would be an impossible task. **I would like to first** thank *ALLAH*, for his blessings and for completing my academic thesis. I would also like to thank both of my supervisors, **Professor Yasser Mansour and Professor Hanan Sabry**, for sharing their life of experience and for inspiring intellectual leadership. They have exceeded every positive expectation I had for my advisors. They contributed important guidance to help me pursue my own research path. I learned how to tackle unstructured problems and not to fear the unknown but to seek them.

A special thanks to Professor Hanan for all her efforts and, above all, for being a second mother to me.

My deepest gratitude and thanks go to my **examining committee, Professor Ahmed Fareed Hamza and Professor Morad Abdelkader**, for their time, effort, and feedback in spite of their busy commitments. In addition, I would like to thank my sincere friend, **Dr. Mohamed Abdelmohsen Dardir**, for guiding me and helping with the simulation issues that, while they were not an accomplishment, wouldn't have made this research work succeed.

This work is dedicated to my parents, especially my mother, **Hoda Kotb**, and both of my brothers, **Tamer Ahmed** and **Yasser Ahmed**, for their unwavering support throughout my academic journey. I want to thank my dear wife, **Marwa Fouad**, for sharing this journey with me. Although burdened by a lot in her daily life, she managed to find time to support me through all my ups and downs.

To my dear sons **Zeyad & Dana**, I ask your forgiveness, for you have been suffered the most from it. I know I cannot recreate the moments we lost, but I will try my best to make up for them. Thank you for being part of my life.

In addition, to the soul of my father, **Eng. Ahmed Ramadan Abdel-Aziz**, who always believed in me, I hope one day I will be able to see again the proud look in your eye, as always.

Also, to the soul of my role model, **Professor Ahmed Mito**, who encouraged and inspired me on my practical design journey.

In addition, a special thanks to the following persons for their helpful support:

Dr. Akram farouk	Professor and head of architecture department- Ain Shams University
Dr. Shaimaa kamel	Professor and former head of architecture department- Ain Shams University
Dr. Diaa Eldin Ibrahim	Professor- Ain Shams University
Dr. Ayman Ahmed Farid	Lecturer- Ain Shams University
Dr. Hussein Ahmed Farid	Lecturer- Ain Shams University
Eng. Abdelrahman Ayman	Assistant Lecturer- Ain Shams University
Eng. Nada Emad Hamdy	Senior Architect- Artline Consultants

Ayman Ahmed Ramadan Abdelaziz
August. 2022
Cairo, Egypt

ABSTRACT

Retrofitting approach is seeking to improve the building performance to extend the life span period of the building. Moreover, it saves the building capital and value compared to demolishing that building to build a new one. Hence, retrofitting is considered an effective means that works to preserve buildings.

This research is conducted for existing buildings in Egypt by choosing the high-rise building construction in Cairo, dated from 1980 s to 1990 s, which was the time of economic growth in Egypt. These buildings are considered as significant national treasures with their culture, use, or even age values, but with low and outdated insulation levels. Some of these buildings are still used today, while other buildings suffer from degradation problem. At the age of 30 to 40 years, facades reached the end of their technical life span and these buildings have been recognized as an inefficient consumer of costs. Particularly in high-rise buildings, façades are unfortified to face the climate change due to their exposure and unfavorable volume in terms of their surface facades. Consequently, energy consumption proportionately increases with high running costs of mechanical systems and it needs an improvement through facade retrofitting without compromising its value.

Despite there are many studies that discussed the façade retrofitting in practicability, there are no rigor results that investigated or proceeded in aspects related to a synthetic strategy configuration as creative way that contributes the scientific methods in evaluating the façade retrofitting efficiency.

This research focuses on understanding the synthetic strategy configuration's dimensions and their measurements indicator variables, as any change in these variables directly affects the level of façade retrofitting's efficiency. Seeking to fill the gaps of retrofitting practicability knowledge.

This research aims at developing a decision- making process modeling for the evaluation of the retrofitting techniques implemented at the façade of a

significant building in Egypt, without compromising its value. The evaluation is taking into consideration the requirements of sustainability and the cost efficiency along the building's life span period.

In order to achieve the decision- making process modeling, the facade retrofitting techniques that are commonly used in the building construction industry concerning the façade retrofitting concepts for the significant building's situation with their components will be evaluated through a multi-disciplinary evaluation approach, which is based on a scientific measurement method and is derived on two complementary approaches: the qualitative and the quantitative approach.

Where the qualitative evaluation approach is reflected the relativity and it is related to a multi criteria decision- making (MCDM) in the construction industry, in which the qualitative values is translated to easy negotiable quantitative numerical values. It attempts to evaluate the facade retrofitting techniques against the measuring indicator variables for the sustainable characteristics of façade retrofitting based on applying the weighted evaluation matrix method (WEMM) in order to assess the sustainable efficiency percentage for each technique. Its results are considered as independent results since they will be determined from the research study and related to existing variables and reliable processes making these results to be generic.

On the other hand, the quantitative evaluation approach is related to value management approach in the construction industry. It attempts to evaluate the facade retrofitting techniques against the measuring indicator variables for the lifecycle costs of façade retrofitting based on applying the present value evaluation method (PVEM) in order to assess the cost efficiency percentage for each technique over the façade building life span period. Its results are considered as dependent results since they will be determined from the application study and related to changeable previous variables from building to another, even they could change with time.

The proposed framework was applied for its validity and reliability through the practically investigation application for the verification process description on an existing case study to evaluate the possibility for its application and Ramses Hilton hotel building was chosen.

The results provide the conclusion that support research hypothesis which assumes that: “The evaluation of the façade retrofitting techniques through a multi- disciplinary approach: qualitative and quantitative evaluation approaches, based on linking their results and studying their measuring indicator variables; affects the level of sustainable and cost efficiency value percentage for the façade retrofitting techniques”, through a decision-making process modeling regarding scientific methods.

Finally, this process modeling offers significant potential to optimize the selection of façade retrofitting techniques alternatives for significant building without compromising its value, at the same time achieving sustainability and cost efficiency. Accordingly, it facilitates the decision- making for the architects and stockholders to judge which technique in practicability is the most suitable choice to the owner demand for solving the building problems regarding the budgetary.

KEYWORDS

Decision-making, Sustainable efficiency, Cost efficiency, Façades retrofitting techniques type, Qualitative evaluation approach, and Quantitative evaluation approach.

TABLE OF CONTENTS

STATEMENT	i
ACKNOWLEDGEMENTS	ii
ABSTRACT.....	iv
TABLE OF CONTENTS	vii
LIST OF FIGURES.....	xii
LIST OF TABLES	xiv
INTRODUCTION.....	xix
I. Preface.....	xix
II. The Research Problem	xxi
III. The Research Hypothesis.....	xxii
IV. The Research Main Goal and Objectives.....	xxii
V. Research Scope and Limitations	xxiii
VI. The Research Methodology	xxiv
VII. The Research Significancy.....	xxv
VIII. The Research Structure	xxvi
Chapter 01: FACADE RETROFITNG IN PRACTICE FOR SIGNIFICANT EXISTING BUILDINGS: TECHNIQUES AND COMPONENTS	2
1.1 Introduction	2
1.2 Terms and definitions	2
1.2.1 Retrofitting.....	2
1.2.2 Sustainability in construction.....	5

1.2.3	Cost efficiency.....	6
1.2.4	Significant value for the existing buildings	6
1.3	Motivation for studying façade retrofitting.....	7
1.4	The fundamentals of façade retrofitting in practice.....	9
1.4.1	Façade retrofitting concepts for the building’s situation ..	9
1.4.2	Façade retrofitting techniques description	10
1.4.3	Façade retrofitting components in practice.....	17
1.5	Systemizing review for the façade retrofitting techniques types	23
1.6	Conclusion.....	26
Chapter 02: QUALITATIVE EVALUATION APPORACH FOR THE FACADE RETROFITTING TECHNIQUES.....		30
2.1	Introduction	30
2.2	Variables for the sustainable characteristics of façade retrofitting	31
2.2.1	Building architecture and function variables	35
2.2.2	Building performance variables	36
2.2.3	Building economics variables	37
2.3	Qualitative evaluation approach’s applicability and phases ...	38
2.3.1	Point system analysis phase	39
2.4	Applying the weighted evaluation matrix method	55
2.5	Conclusion.....	57
Chapter 03: QUANTITATIVE EVALUATION APPROACH FOR THE FACADE RETROFITTING TECHNIQUES.....		60
3.1	Introduction	60

3.2	Variables for the lifecycle costs analysis of façade retrofitting	61
3.2.1	The components' variables for the façade retrofitting techniques	63
3.2.2	The building's variables for the case study	66
3.3	Quantitative evaluation approach's applicability and phases	67
3.3.1	Simulation phase	68
3.3.2	Computational phase	71
3.3.3	Assessment phase	75
3.4	Applying the present value evaluation method	78
3.5	Conclusion	81
Chapter 04: PROPOSED METHODOLOGY FRAMEWORK		84
4.1	Introduction	84
4.2	Research methodology framework	84
4.2.1	Methodology Framework General Outline	85
4.2.2	Development of the methodology structure	87
4.2.3	The proposed methodology frame work	95
4.3	Conclusion	97
Chapter 05: METHODOLOGY FRAMEWORK VERIFICATION APPLICATION		100
5.1	Introduction	100
5.2	The selection for application of the case study - Ramses Hilton hotel	102
5.2.1	Building characteristics Ramses Hilton	102
5.2.2	Significant value for Ramses Hilton	102

5.2.3	Reasons for Ramses Hilton to be retrofitted	103
5.3	The application for the quantitative evaluation approach on Ramses Hilton hotel.....	106
5.3.1	Identifying the measuring indicators variables for the lifecycle costs of façade retrofitting.....	106
5.3.2	Applying the quantitative approach’s phases.....	125
5.4	The application for the correlation study	129
5.4.1	Analyzing the obtained results from the qualitative approach	129
5.4.2	Analyzing the obtained results from the qualitative approach	133
5.4.3	Generating a coded alternatives for the decision-maker	136
5.4.4	Evaluating the coded alternatives for the decision-making	137
5.5	Conclusion.....	150
6.	CONCLUSIONS AND RECOMMENDATIONS.....	152
6.1	Findings and contributions.....	152
6.1.1	How to judge how to retrofit?	152
6.1.2	The expected practical benefits of using this research .	161
6.2	Limitations and recommendations.....	162
6.3	Future work	163
	APPENDICES	165