



بسم الله الرحمن الرحيم

∞∞∞∞

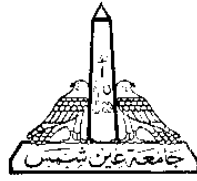
تم رفع هذه الرسالة بواسطة / سامية زكى يوسف

بقسم التوثيق الإلكتروني بمركز الشبكات وتكنولوجيا المعلومات دون أدنى

مسئولية عن محتوى هذه الرسالة.

ملاحظات: لا يوجد





AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
ARCHITECTURAL DEPARTMENT

Use of vertical greenery systems to conserve energy in administrative buildings in Egypt

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

Supervised By

Professor Dr. Ahmed Atef Faggal

Professor of Architecture and
Environmental Control
Ain Shams University

A. Professor Ashraf Ali Nessim

Associate Professor - Department of
Architecture
Ain Shams University

by

Mahmoud Ibrahim Beder

Bachelor of Science in Architectural Engineering
Faculty of Engineering, Architecture Department. Misr International University ,2017

Cairo - (2022)



Ain Shams University
Faculty of Engineering
Architectural Engineering Department

Use of vertical greenery systems to conserve energy in administrative buildings in Egypt

A Thesis submitted in partial fulfillment of the requirements of the degree of

Master of Science in Architectural Engineering

(Architecture Engineering)

by

Mahmoud Ibrahim Beder

Bachelor of Science in Architectural Engineering

Examiners' Committee

Signature

Prof.Dr Mohamed Khairy

Professor of Architecture

Faculty of engineering at shoubra Benha University

Prof.Dr Laila Mohamed

Professor of Architecture

Faculty of engineering, Ain Shams University

Prof.Dr Ahmed Atef Faggal

Professor of Architecture

Faculty of engineering, Ain Shams University

Dr. Ashraf Nessim

Associate Professor of Architecture

Faculty of engineering, Ain Shams University

Statement

This thesis is submitted as a partial fulfilment of Master of Science in Architectural Engineering 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.

Mahmoud Ibrahim Beder

Signature

.....

Date:29 June 2022

Researcher Data

Name : Mahmoud Ibrahim Beder
Date of birth : 21/ 4/ 1994
Place of birth : Cairo
Last academic degree : Bachelor of Architectural Engineering
University issued the degree: Misr International University
Date of issued degree : 2017

Disclaimer

This thesis is submitted as partial fulfillment of M.Sc. degree in Architecture, Faculty of Engineering, Ain Shams University. The work included in this thesis was carried out by the author and no part of it has been submitted for a degree or qualification at any other scientific entity. The candidate confirms that the work submitted is her own and that appropriate credit has been given where reference has been made to the work of others.

Name : Mahmoud Ibrahim Beder

Signature:

Date :

Acknowledgment

First and foremost, I feel always indebted to Allah, the most kind and most merciful.

I'd like to express my respectful thanks and profound gratitude to Prof.Dr Ahmed Atef Faggal and A. Prof Ashraf Ali Nessim for their keen guidance, kind supervision, valuable advice and continuous encouragement, which made possible the completion of this work.

I would like to express my hearty thanks to all my family for their support till this work was completed.

Abstract

Expansion and urban development in Egypt have led to the main problem which is increased energy consumption and it sometime comes at the expense of green areas. For example, it is possible to dispense with large green areas and trees in order to develop the road network.

Administrative buildings are one of the main energy consuming entities in Egypt. so the aim of thesis is to rationalize energy consumption in administrative buildings, and also to increase green spaces in Egypt.

Therefore, the thesis examines the types of Vertical greenery systems (VGS) in detail, their use, structure and technological systems for it. The main goal is to demonstrate the effectiveness of vertical green systems in Egypt through a simulation of an administrative building using the Design Builder program.

The thesis will discuss the issue through two main parts.

Firstly, theoretical and analytical study, based on a comprehensive literature review of vertical green systems and explain their importance, their construction systems, how they work, drainage and irrigation, etc.

As well as analyzing energy consumption data within the administrative buildings in Egypt. And explain to what extent those buildings consume energy. And how it can be extensively reduced through vertical green systems.

Secondly practical study, based on DesignBuilder simulation. A three-story administrative building is simulated with different scenarios. A Base scenario with zero greenery which will be compared to two different scenarios that applied a vertical green system.

The first scenario will use VGS on 100 percent of the southern façade of the building while the second scenario, will use 70 percent of the southern façade to be covered with VGS.

Finally, a comparison was made between the three scenarios, and the results show that the first scenario had the lowest energy consumption and saved about 9 percent annually of the annual administrative building's energy consumption compared to the base scenario.

While the second scenario saved almost 7 percent of the energy consumption annually. So, it was clear that vertical green systems have a significant and effective role in rationalizing energy consumption in administrative buildings.

Keywords:

Vertical Green systems, Greenwall, Administrative building, Energy consumption, living wall

Abbreviations

VGS	Vertical green system
LWS	Living wall system
GF	Green facade
GW	Green wall
DSF	Double skin façade
Ktoe	Kilotonne of Oil Equivalent

Disclaimer	i
Acknowledgement	ii
Abstract.....	iii
Abbreviations	v
Table Of Content.....	vi
List Of Figures.....	ix
List Of Tables	xii
Introduction	2
Problem Statement	7
Research Objectives	8
Research Hypothesis	8
Research Methodology	8
Research Structure	9
Research Process Flowchart	11
Chapter 1: Administrative Buildings & Energy Consumption	13
1.1 Introduction.....	13
1.2 Definition of administrative buildings.....	14
1.3 Types of administrative buildings.....	14
1.4 Energy consumption in administrative buildings & Thermal Comfort	15
1.4.1 thermal loads.....	16
1.4.2 Occupancy rate in administrative buildings	17
1.4.3 Administrative building envelope and its impact on energy consumption.....	18
1.5 Solutions to conserve energy and achieve thermal comfort	21
1.5.1 Double skin facade	21
1.5.2 Thermal insulation material	23
1.5.3 Vertical green systems.....	24
1.6 Chapter summary and conclusion	25
Chapter 2: Vertical Green System Technology (VGS)	27
2.1 Introduction	27
2.2 Definition of Vertical green systems	28
2.3 History of vertical green systems	28
2.4 Benefits of Vertical green systems	30
2.4.1 Public benefits	30

2.4.2 Private benefits	32
2.5 Types of Vertical green systems	33
2.5.1 Green facades (GF)	34
2.5.2 Living wall.....	35
2.6 Technology of Vertical green systems	39
2.6.1 Vegetation.....	39
2.6.2 Irrigation	40
2.6.3 Drainage.....	41
2.6.4 installation and maintenance	42
2.7 Chapter summary and conclusion	45
 Chapter 3: Analysis of Previous Vertical Green System Case Studies	47
3.1 Introduction	47
3.2 Case study 1 : Consorcio Santiago Building	48
3.2.1 Overview.....	49
3.2.2 Climate condition	50
3.2.3 Green wall strategy	51
3.2.4 Plant Species	52
3.2.5 Green wall performance	52
3.2.6 Conclusion	54
3.3 Case study 2: Council House 2 Building	55
3.3.1 Overview.....	56
3.3.2 Climate condition	57
3.3.3 Green wall Strategy	58
3.3.4 Plant Species	60
3.3.5 Conclusion	61
3.4 Case study 3: Acros Fkuoka Prefectural International Hall	62
3.4.1 Overview.....	63
3.4.2 Climate Condition.....	65
3.4.3 Green Wall Strategy	66
3.4.4 Plant Species	67
3.4.5 Irrigation	67
3.4.6 Conclusion	68
3.5 Chapter summary and conclusion	69

Chapter 4: Analysis and results of Simulation process	72
4.1 Introduction	72
4.2 Simulation program usage	73
4.3 Preparation of simulation model.....	76
4.3.1 ASHRAE Standard 90.1	76
4.3.2 Types of ASHRAE Standard 90.1 prototype office building model....	77
4.3.3 Preparing base scenario of administrative building on DesignBuilder	80
4.3.4 Methodology	80
4.4 Analysis of different scenarios.....	84
4.4.1 Analysis and results of base scenario	84
4.4.2 Analysis and results of first scenario	87
4.4.3 Analysis and results of second scenario	91
4.5 Results and discussion of the study	95
4.6 Chapter summary and conclusion	98
 Conclusion.....	 99
Recommendations /future research	101
 References	 102

List Of Figures

Introduction

Figure 0-1: Map of Egypt in 1990 and 2019 - Expansion of urbanization-	2
Figure 0-2 Heliopolis map	3
Figure 0-3 Total area of greenery in Triumph Square	4
Figure 0-4: Total area of greenery in El Marghany Street	5
Figure 0-5: Total area of greenery in Abo bakr Elsedek Street.....	5
Figure 0-6: Total area of greenery in Othman Ibn Affaan Street	5
Figure 0-7: Total area of greenery in El Hegaz Street	5
Figure 0-8: Total energy consumption in Egypt from 1990 to 2020	6
Figure 0-9 : Total Electrical Energy Consumption from 2000 to 2019 (MKwh)	6
Figure 0-10 : Thesis structure chart	11

Chapter 1: Administrative Buildings & Energy Consumption

Figure 1-1 Average Office building Electricity Consumption	15
Figure 1-2 : Occupancy intensity in public offices.....	17
Figure 1-3: The National Planning Institute building.....	19
Figure 1-4: Degla View office building	20
Figure 1-5: Audi Bank New Cairo	20
Figure 1-6: Double skin façade section	22

Chapter 2: Vertical green system technology (VGS)

Figure 2-1: LOS CABOS INTERNATIONAL CONVENTION CENTER (ICC)	27
Figure 2.2 hand-colored engraving for hanging gardens of Babylon	28
Figure 2-3: MFO-Park green wall in Zürich.....	29
Figure 2-4: National Grid car park, Warwick	31
Figure 2-5: Classification of VGS, according to their construction characteristics	33
Figure 2-6: Direct green facade, private house, Golegã, Portug	34
Figure 2-7: Indirect green facade	34
Figure 2-8: Vertical Garden (Halles, Avignon (2005) at the date of creation	35
Figure 2-9: Museum of Contemporary Art, Busan Vertical Garden Patrick Blanc	36
Figure 2-10: Modular living wall (Trays)	37

Figure 2-11: Modular living wall (Vessels).....	37
Figure 2-12: Modular living wall (Planter tiles)	38
Figure 2-13: Modular living wall (Flexible bags)	38
Figure 2-14: Recirculating irrigation system	41
Figure 2-15: Direct irrigation system	41

Chapter 3: Analysis of previous vertical green system case studies

Figure 3-1: Consorcio Santiago Building	48
Figure 3-2: Typical floor plan of Consorcio Santiago building	49
Figure 3-3: Section of Consorcio Santiago Building.....	49
Figure 3-4: Detailed of green wall Consorcio Santiago Building	49
Figure 3-5: Average Annual Temperature Profile in Santiago (°C)	50
Figure 3-6: Average Relative Humidity (%) and Average Annual Rainfall in Santiago.....	50
Figure 3-7: conceptual analysis diagram of greenery	51
Figure 3-8: Detail of green wall section of Santiago office building	52
Figure 3-9: Section of green wall of Santiago office building	52
Figure 3-10: Consorcio building vs average of 10 tall buildings in Santiago	53
Figure 3-11: Energy analysis of floors (with vegetated wall and without in Consorcio building.	53
Figure 3-12: sketch of the final concept of Santiago office building with green elements	54
Figure 3-13: Council House 2 Building.....	55
Figure 3-14: plan of CH2 building	56
Figure 3-15: Average annual temperature of Melbourne, Australia	57
Figure 3-16: Average relative humidity % and average annual Rainfall of Melbourne, Australia	57
Figure 3-17: Conceptual plan diagram describe green façade function of CH2 building	58
figure 3-18: conceptual section diagram of northern façade of CH2 building	59
Figure 3-19: view of top roof view of CH2	59
Figure 3-20: Section of CH2 building with plant selection	60
Figure 3-21: Acros Fukuoka prefectural international hall (Top view)	62
Figure 3-22: Acros Fukuoka prefectural international hall	63
Figure 3-23: Site plan of Acros building	64
Figure 3-24: Cross section of ACROS building	64