

**PASSIVE ENERGY DESIGN STRATEGIES AND WORKERS PRODUCTIVITY IN  
THE DESIGN OF A HIGH-RISE LETTABLE OFFICE BUILDING FOR LAGOS,  
NIGERIA**

**PIRISOLA OYINDAMOLA HERITAGE**

**(12CA014082)**

**SEPTEMBER 2020**

**PASSIVE ENERGY DESIGN STRATEGIES AND WORKERS PRODUCTIVITY IN  
THE DESIGN OF A HIGH-RISE LETTABLE OFFICE BUILDING FOR LAGOS,  
NIGERIA**

**BY**

**PIRISOLA OYINDAMOLA HERITAGE  
12CA014082  
B.Sc Architecture, Covenant University, Ota.**

**A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES  
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF  
MASTER OF SCIENCE (M.Sc.) DEGREE IN ARCHITECTURE IN THE  
DEPARTMENT OF ARCHITECTURE, COLLEGE OF SCIENCE AND  
TECHNOLOGY, COVENANT UNIVERSITY.**

**SEPTEMBER 2020**

## **ACCEPTANCE**

This is to attest that this dissertation is accepted in partial fulfilment of the requirements for the award of the degree of Masters of Science (M.Sc.) Degree in Architecture in the department of Architecture, School of Post-Graduate Studies, College of Science and Technology, Covenant University, Ota, Nigeria

**Mr. Taiwo B. Erewunmi**  
(Secretary, School of Postgraduate Studies)

**Signature and Date**

**Prof. Akan B. Williams**  
(Dean, School of Postgraduate Studies)

**Signature and Date**

## **DECLARATION**

**I, PIRISOLA OYINDAMOLA HERITAGE** declare that this research was carried out by me under the supervision of Dr. A.A. Oluwatayo of the Department of Architecture, College of Science and Technology, Covenant University, Ota, Nigeria. I attest that the dissertation has not been presented either wholly or partially for the award of any degree elsewhere. All sources of data and scholarly information used in this dissertation are duly acknowledged.

**PIRISOLA OYINDAMOLA HERITAGE**

**Signature and Date**

## **CERTIFICATION**

We certify that this dissertation titled **“PASSIVE ENERGY DESIGN STRATEGIES AND WORKERS PRODUCTIVITY IN THE DESIGN OF A HIGH-RISE LETTABLE OFFICE BUILDING FOR LAGOS, NIGERIA”** is an original research work carried out by **PIRISOLA OYINDAMOLA HERITAGE** in the Department of Architecture, College of Science and Technology, Covenant University, Ota, Ogun State, Nigeria under the supervision of Dr. A.A. Oluwatayo. We have examined and found this work acceptable as part of the requirements for the award of Master of Science in Architecture.

**Dr. Adedapo A. Oluwatayo**  
(Supervisor)

**Signature and Date**

**Dr. Adedapo A. Oluwatayo**  
(Head of Department)

**Signature and Date**

**Prof. Emmanuel B. Jaiyeoba**  
(External Examiner)

**Signature and D**

]

]]]ate

**Prof. Akan B. Williams**  
Dean, School of Postgraduate Studies

**Signature and Date**



## **DEDICATION**

This design thesis is dedicated to God almighty, the one who has given the strength and grace to write it.

## **ACKNOWLEDGEMENT**

The inspiration and guidance from God has been key to writing this dissertation. I would like to acknowledge the crucial role of my parents, Pst. and Dcns. Bayo Pirisola, whose efforts have kept me this far through their moral and financial support

I want to thank my supervisor, Dr. A.A. Oluwatayo for all the time, advice, help and support, and

I want to extend my gratitude to all my friends and colleagues in the department of architecture, especially to those whose work came in handy in writing this dissertation.



# TABLE OF CONTENTS

<b>ACCEPTANCE.....</b>	<b>i</b>
<b>DECLARATION.....</b>	<b>ii</b>
<b>CERTIFICATION.....</b>	<b>iii</b>
<b>DEDICATION.....</b>	<b>v</b>
<b>ACKNOWLEDGEMENT.....</b>	<b>vi</b>
<b>TABLE OF CONTENTS.....</b>	<b>vi</b>
<b>LIST OF PLATES .....</b>	<b>xii</b>
<b>LIST OF FIGURES .....</b>	<b>xiv</b>
<b>LIST OF TABLES .....</b>	<b>xv</b>
<b>ABSTRACT.....</b>	<b>1</b>
<b>CHAPTER 1:INTRODUCTION.....</b>	<b>2</b>
1.1 Background to the Study .....	2
1.2 Statement of the Research Problem .....	4
1.3 Aim of the Research.....	7
1.4 Objectives of the Research.....	7
1.5 Justification of the Research .....	8
1.6 Clients/Users .....	9
1.7 Scope of Study .....	9
1.8 Location.....	10
1.9 Definition of Key Terms .....	10
<b>CHAPTER TWO: LITERATURE REVIEW .....</b>	<b>12</b>
2.1 Introduction .....	12
2.2 Office Buildings and Energy Use.....	12
2.3 Energy Design Strategies For Office Buildings .....	13
2.4 Passive Energy Design Strategies .....	16
2.5 Principles of Passive Design .....	18
2.5 Office Building Passive Energy Strategies and Workers Productivity.....	46
2.5.1 Factors of Workers Productivity.....	50
2.5.1.1 Job Satisfaction.....	50
2.5.1.2 Worker Engagement .....	51
2.5.1.3 Motivation to Work .....	52

2.5.1.4 Satisfaction With Work Environment .....	52
2.6 High Rise Office Buildings .....	53
2.6.2 Classification of High Rise Office Buildings.....	55
2.6.3 Types of Structures in High Rise Buildings.....	57
2.6.4 Energy Efficiency in High Rise Buildings.....	66
<b>CHAPTER 3: RESEARCH METHODOLOGY .....</b>	<b>68</b>
3.0 Chapter Overview .....	68
3.1 Research Philosophy .....	68
3.2 Research Approach .....	69
3.3 Study Population .....	70
3.3.1 Sampling Method.....	73
3.3.2 Sample Size.....	73
3.4 Data Collection Instruments.....	74
3.4.2 Fieldwork .....	75
3.5 Methodology By Objective .....	75
3.6 Ethical Consideration .....	78
<b>CHAPTER 4: RESULTS AND DISCUSSIONS .....</b>	<b>79</b>
4.0 Chapter Overview .....	79
4.1 Demographic Characteristics of Respondents.....	79
4.1.1 The Extent to Which Passive Energy Strategies Are Adopted in High-Rise Office Buildings.....	82
4.2 Case Study Analysis.....	85
4.2.1. Case Study 1: Heritage Place.....	85
4.2.1.4 Assessment of Passive Energy Strategies in Heritage Place .....	88
4.2.1.5 Form and Space Adequacy .....	90
4.2.1.6 Exterior Walling System/Material.....	92
4.2.1.7 Finishes .....	93
4.2.1.8 Services.....	94
4.2.1.9 Vertical Circulation Systems .....	95
4.2.2 Case Study 2: The Civic Tower.....	95

4.2.2.4	Assessment of Passive Energy Strategies in Civic Towers .....	97
4.2.2.5	Form and Space Adequacy .....	100
4.2.2.6	Exterior Walling System/Material .....	100
4.2.2.7	Finishes .....	101
4.2.2.8	Services .....	102
4.2.2.9	Vertical Circulation Systems .....	102
4.2.3	Case Study 3: Nestoil Tower .....	102
4.2.3.4	Assessment of Passive Energy Strategies in Nestoil Tower.....	105
4.2.3.5	Form and Space Adequacy.....	107
4.2.3.6	Exterior Walling System/Material .....	109
4.2.3.7	Finishes.....	110
4.2.3.8	Services .....	111
4.2.3.9	Vertical Circulation Systems.....	111
4.2.4	Case Study 4: The Wings Towers .....	111
4.2.4.4	Assessment of Passive Energy Strategies in Wings Towers .....	113
4.2.4.5	Form and Space Adequacy.....	116
4.2.4.6	Exterior Walling System/Material .....	120
4.2.4.7	Finishes.....	121
4.2.1.8	Services .....	122
4.2.4.9	Vertical Circulation Systems.....	123
4.3.	The Level of Workers’ Productivity in High-Rise Office Buildings and the Influence of the Adoption of Passive Energy Strategies On Workers’ Productivity .....	123
4.4.	Site And Environmental Analysis .....	134
4.4.1	Background Knowledge of Eko Atlantic City.....	134
4.4.2.	Site Selection Criteria .....	137
4.4.3.	Accessibility of the Site.....	139
4.4.4.	Potentials of Eko-Atlantic .....	139
4.4.5.	The Choice of Site, Location, Visibility.....	141
4.4.6.	Features of The Site.....	141
4.4.6.	Physical Features on The Site.....	141
4.4.7.	Impact of The Physical Features of The Site on the Design of the Building .....	143
4.4.8.	Climatic Condition of the Site .....	143

<b>CHAPTER 5: DESIGN CRITERIA AND APPROACH .....</b>	<b>149</b>
5.0 Chapter Overview .....	149
5.1 Design Challenge .....	149
5.2 Project Goals And Objectives .....	149
5.3 Design Considerations.....	150
Landscape Considerations .....	150
Building Mass.....	150
Energy Efficiency .....	150
Sustainability And L.E.E.D Rating .....	151
Site Location.....	151
Site Conditons.....	151
Building Orientation .....	151
Solar Shading.....	152
5.4 Functional And Space Criteria .....	152
5.4.1 Administrative Unit .....	152
5.4.2 Business Units.....	153
5.4.4 Service And Support Spaces .....	154
5.5 Performance Requirement.....	157
5.5.1 Fire Safety And Security .....	157
5.5.3 Ventilation .....	157
5.6 Technological And Environment Criteria .....	158
5.6.1 Materials And Finishes .....	158
5.6.2 Services.....	158
5.7 Legal/Planning Regulations .....	159
5.8. Behavioural And Aesthetic Criteria .....	160
<b>CHAPTER SIX:DESIGN PHILOSOPHY,CONCEPTUALISATION AND PROPOSAL</b>	<b>161</b>
6.1 Concept and Its Justification .....	161
6.2 Design Development Process.....	161
6.2.1 Site Zoning .....	162
6.2.2 Bubble Diagram.....	163
6.2.3 Flow Chart .....	165
6.3 Design Proposal.....	165

<b>REFERENCES.....</b>	<b>166</b>
<b>APPENDICES.....</b>	<b>176</b>

## LIST OF PLATES

Plate 2.1.: Seasonal Sun Path with respect to Building Orientation. ....	33
Plate 2.2.: Effect of Envelope to Volume Ratio on Energy Efficiency. ....	34
Plate 2.3.: Landscape Strategies for Passive Solar Heating and Daylighting Control Envelope to Volume Ratio on Energy Efficiency. ....	36
Plate 2.4: Example of Strategic Space Planning for Energy Efficiency. ....	37
Plate 2.5: Example of Double Facade as Buffer Space (Daytime Performance). ....	38
Plate 2.6.: Example of Double Facade as Buffer Space (Nighttime Performance). ....	39
Plate 2.7.: Thermal Bridging in Window Framing. ....	41
Plate 2.8.: Effects of Internal and External Shading. ....	43
Plate 2.9.: Effects of Thermal Mass Internal and External Shading. ....	44
Plate 2.10.: Effects of Air- and Moisture-tight Envelope. ....	46
Plate 2.11: IEQ factors and Occupant Productivity. ....	50
Plate 2.12: China Tower of 1990 (left) and View on Buildings Structure from Interior of the Building (right) ....	60
Plate 2.13: Hotel de las Artes, Exo – Structure at Main Structural System (left) and View on Detail of Elevation, Structure Connection to the Buildings Volume (right) ....	62
Plate 4.1: Location map of Heritage Place. ....	86
Plate 4.2: Exterior view of Heritage place. ....	87
Plate 4.3: Ground floor plan for Heritage Place. ....	91
Plate 4.4: Typical car park for Heritage Place. ....	91
Plate 4.5: Typical office layout of the building. ....	92
Plate 4.6: Typical open floor plan of the building. ....	92
Plate 4.7: View showing exterior materials of the building. ....	93
Plate 4.8: View showing interior finishes in the building. ....	94
Plate 4.9: A 3-dimensional section cut through the building showing services. ....	94
Plate 4.10: Location map of Civic Towers. ....	95
Plate 4.11: Exterior view of The Civic Tower. ....	96
Plate 4.12: Civic tower floor plans. ....	100
Plate 4.13: View showing exterior materials used in The Civic tower. ....	101
Plate 4.14: Interior view of civic towers showing the finishes in the building. ....	101
Plate 4.15: Location map showing Nestoil Tower. ....	103
Plate 4.16: Exterior view of Nestoil Tower. ....	104
Plate 4.17: Ground floor plan of the building. ....	107
Plate 4.18: First floor plan of the building. ....	108
Plate 4.19: Third to sixth floor of the building. ....	108
Plate 4.20: Seventh to tenth floor of the building. ....	109
Plate 4.21: Exterior view showing exterior materials. ....	110
Plate 4.22: Interior view showing finishes in the building. ....	110
Plate 4.23: Location map showing the wings Towers. ....	111
Plate 4.24: Exterior view showing Wings Towers. ....	112
Plate 4.25: Ground floor plan of the building. ....	116

Plate 4.26: Basement parking in the building .....	117
Plate 4.27: Typical podium parking in the building .....	117
Plate 4.28: Typical corporate cellular floor in the building .....	118
Plate 4.29: Typical open floor plan of the office building.....	118
Plate 4.30: Typical mixed floor plan in the building .....	119
Plate 4.31: Multi-tenant option and escape route in Wings Towers .....	119
Plate 4.32: View showing exterior materials in Wings towers.....	121
Plate 4.33: Interior view showing finishes in Wings Towers .....	122
Plate 4.34: Section view of building showing services.....	123
Plate 4.35.: Aerial View, showing Eko Atlantic’s Expansive Road Network.....	139
Plate 4.36.: 3D image, showing Eko Atlantic’s Marina District. ....	140
Plate 4.37.: 3D image, showing Eko Atlantic’s Marina District. ....	141
Plate 4.38.: Aerial View of Eko Atlantic. ....	142
Plate 6.1.: Main Conceptual Bubble Diagram for the Site. ....	162
Plate 6.2: Site Zoning based on noise .....	162
Plate 6.3: Bubble diagram ground floor.....	163
Plate 6.4: Bubble diagram first floor.....	163
Plate 6.5: Bubble diagram second floor.....	163
Plate 6.6: Bubble diagram third floor .....	164
Plate 6.7: Bubble diagram sub-sixth floor .....	164
Plate 6.8: Bubble diagram fourth to fifth floor .....	164
Plate 6.9: Bubble diagram sixth to fourteenth floor.....	164
Plate 6.10: Vertical flow chart .....	165

## LIST OF FIGURES

Figure 2.1: Rigid Frames of High-Rises .....	58
Figure 2.2: Variations of Tubular structures.....	59
Figure 4.1.: The Southwestern Coast of Nigeria, Showing Eko Atlantic. ....	136
Figure 4.2.: The Selected Site located in the Marina District. ....	137
Figure 4.3.: Rendered Site Layout of the Marina District. ....	138
Figure 4.4: Average Monthly Temperature and Precipitation of Eko Atlantic. ....	144
Figure 4.5.: Precipitation Diagram for Eko Atlantic.....	145
Figure 4.6.: Graph showing the monthly number of sunny, partly cloudy, overcast and precipitation .....	146



## LIST OF TABLES

Table 3.1 The list of all high-rise commercial buildings in Lagos State .....	71
Table 3.2 Sampled High-rise office buildings .....	74
Table 4.1: Gender of respondents .....	80
Table 4.2: Age Group of respondents .....	81
Table 4.3: Religion of respondents .....	81
Table 4.4: Marital Status of respondents .....	81
Table 4.5: Highest level of education of respondents.....	81
Table 4.6: Name of office .....	82
Table 4.7: How long respondents have worked in the office .....	82
Table 4.8: Mean score for passive energy strategies that influence workers’ productivity.....	83
Table 4.9: Table showing assessment of passive energy strategies employed in Heritage Place	88
Table 4.10: Assessment of passive energy strategies employed in Civic Towers.....	97
Table 4.11: Table showing assessment of passive energy strategies employed in Nestoil tower .....	105
Table 4.12: Table showing assessment of passive energy strategies employed in Wings towers .....	113
Table 4.13: Respondents’ Job satisfaction.....	124
Table 4.14: Respondents’ motivation .....	124
Table 4.15: Respondents’ work environment .....	124
Table 4.16: Respondents’ engagement .....	125
Table 4.17: Respondents’ total productivity.....	125
Table 4.18: Coefficients for dependent variable.....	127
Table 5.1.: Spatial Program for the Administrative unit.....	152
Table 5.2.: Spatial program for the business unit .....	153
Table 5.3.: Spatial program for the facility management unit .....	154
Table 5.4.: Spatial program for the service and support spaces.....	154
Table 5.5.:The summary of spaces within the centre.....	155
Table 5.6: Plumbing fixture requirements .....	159
Table 5.7: Parking requirements .....	160

## **ABSTRACT**

The nature of office work has undergone transformation over the last century from that which entails activities that are static and passive, to that which connotes flexible and dynamic activities. This changing nature of work in offices has created tensions and critical thinking in office design, thus creating a challenge for modern office designers to create environments that support the manner in which people work. It is therefore becoming increasingly important to understand the office environment in general and how it affects the productivity of users. Passive design is a veritable panacea, with large potential gains in the short and long-term. The aim of this research is to propose a high-rise office building located in Eko Atlantic, Lagos State, Nigeria that is designed based on the principles of passive design. The concept of passive energy design is investigated in this research in order to see how productivity of workers in these offices can be enhanced, the consumption of energy reduced and the impact on the environment minimised. The methodology employed in this study was based on different research objectives, it therefore utilised a combination of both quantitative and qualitative methods. An in-depth review of relevant literature was carried out to identify the specific strategies that enhance productivity in office buildings. In addition, case studies of existing high-rise office buildings were carried out to determine the extent to which they adopt the identified passive design strategies. A survey was carried out as well on users of the centres to examine their perception of said strategies and establish a relationship between the adoption of the strategies and the productivity of the users. The findings of this study suggest that a number of the identified strategies have a significant effect on the productivity of the workers. The proposed design therefore applies the strategies of passive design identified in the research, to help enhance the comfort of the users which in turn enhances productivity.