THE IMPACT OF WINDOW GLAZING SPECTRAL SELECTIVITY ON ENERGY-USE FOR COOLING IN ADMINISTRATIVE BUILDINGS

(Applied Study: Building (B-19), Smart Village, 6th October-Giza)

By

Eslam Mohamed Naguib Ali Taha

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
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Under the Supervision of

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Title of Thesis:

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Key Words:
Window glazing; spectral selectivity; energy efficiency; cooling loads; economics and energy costs.

Summary:
Windows are the least insulating element of the building assembly and the excessive use of the large glazed area can lead to greater energy consumption for cooling load demands, occupant discomfort and discomfort glare.
Therefore, windows must be carefully designed to control over the solar gains to achieve thermal comfort in different climatic regions and different orientations. Accordingly, this thesis deals with energy-efficient windows in Egyptian administrative office buildings and the impact of the glass selectivity on energy consumption in administrative office buildings, the study follows a scientific approach consists two main study areas; the theoretical study and the applied study including building model thermal simulation, down to results and recommendations.

Acknowledgments

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- **Prof. Dr. Ayman Hassan Ahmed,** Professor of Architecture and Landscape, Faculty of Engineering, Cairo University.

Special thanks to Saint-Gobain Glass co. for providing me with information and glass guide, as well as providing an opportunity to visit the float glass product line at the factory in Al-Ain El-Sukhna.

Dedication

I dedicate this work to my beloved parents and brothers for always encouraging and supporting me, because they are the pushing force in my life. Without their interest, none of this would finish.

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Nomenclature

Sympol	Unit	Description
ASHRAE		The American Society of Heating, Refrigeration and Air Conditioning Engineers
BTO		Building Technologies Office
DOE		U.S Department of Energy
GHG		Greenhouse gases
g-value		Total energy transmittance at spectrum range 300-2500nm
HVAC		Heating, ventilation and air-condition systems
IPCC		Intergovernmental panel on climate change
IGU		Insulating glass unit
K-value	W/m-k	The thermal conductivity
LSGR		Glazing selectivity/light-to-solar gain ratio
LBNL		Lawrence Berkeley National Laboratory
R-value	m^2.k/W	The glass resistance to thermal conductivity
SHGC		Solar heat gain coefficient
(Sc)or(b)		Glass shading coefficient=g/0.87
$S= \tau_{vis} /g$		Selectivity index
SBCI		Sustainable Buildings & Climate Initiative
TR		Ton of refrigeration describes the cooling capacity for A/C
V_T%,LT,τ_{vis}	%	Visible light transmittance
U-cg	W/m^2.k	Center of glass U-value
U-factor or U-value	W/m^2.k	The overall heat transfer coefficient
UNEP		United Nations Environment Program
WWR%	%	The window-to-wall ratio
λ	nm=10^{-9} m	Spectrum wave length
ε	%	Glass emittance=84% for standard single clear glass
f#		Coating face

Abstract

The improvement of energy efficiency of buildings needs to raise the performance level of the building envelope which has become necessary.

One key element which affects the overall energy performance of the building is the window; which has an effective role in determining the energy performance of the building through allowing or preventing sunlight and heat from entering the room. Energy efficient windows can control over this free solar energy to lower the energy consumption for cooling loads.

However, windows are the least insulating element of the building assemblies and the excessive use of the large glazed area can lead to more energy consumption for cooling load demands, occupant discomfort, and discomfort glare. Therefore, windows must be carefully designed to control over the solar gains to achieve thermal comfort in different climatic regions and different orientations.

Accordingly, this thesis deals with energy-efficient windows in administrative office buildings located within Cairo-delta region through studying the impact of glazing wavelength spectral selectivity and inert gas fill within the insulating glass unit (IGU) on energy consumption for cooling in administrative office buildings and take the benefit through the ability to maximize the (WWR%).

The study follows a scientific approach consists two main study areas; theoretical study and applied study, down to results and recommendations, the theoretical study based on these main topics:

- Review of window performance requirements and the conventional window technologies such as; spectrally selective window coatings and films, super windows and evacuated windows followed by the advanced window technologies and the impact of modern techniques used in different window types such as; photo-chromic, thermo-chromic, liquid crystal device(LCD) and suspended particle device(SPD) and the technology of electro-chromic windows which have a significant effect on light transmission and heat flow through window glazing by the ability to alter their properties for a wide range of (SHGC) and (VT) by applying low-voltage electric current.
- Understand the basic of energy flow through commercial buildings, window thermal performance indices that affect the heat flow, the steady state heat transfer through double pane and single pane windows, finally, the solar gains and ways to control for efficient energy use as well as the physical and radiative properties of the window.
- The performance characteristics of high performance insulating glass units (IGUs), specifically its insulating value (U_{cg}), solar heat gain Coefficient (SHGC) and its visual transmittance (VT %) through one-dimensional heat transfer and solar-optical modeling. The (IGU) can achieve a significant effect on improving its performance characteristics by understanding the effect of combining different glazing materials, inert fill gases, thin solar films, and solar coatings.

The theoretical study is followed by an applied study and thermal simulation process to identify the energy performance of a perimeter space due to glazing types alternatives graded in their wavelength spectral selectivity and the effect of glazing thermal properties on the energy used for cooling. In addition, the thermal comfort and the economic aspects can be achieved through a running cost analysis calculation. The