Ain Shams University
Faculty of Engineering
Department of Architecture

High Performance Facades: Designing Office Building Facades to Enhance Indoor Daylighting Performance.

A Thesis Presented in Partial Fulfillment of the Requirements for
Master of Science Degree in Architecture Engineering

by

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STATEMENT

This thesis is submitted to Ain Shams University for the M.Sc. degree in Architecture.

The work included in this thesis was carried out by the researcher at the Department of Architecture, Faculty of Engineering, Ain Shams University, and During the Period from September 2009 to May 2013.

No Part of this thesis has been submitted for a degree of a qualification at any other university or institute.

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Abstract

While architects aim to design better spaces and achieve a better user experience in their designs, which includes visual and thermal comfort, only few consider the daylighting performance through the design process. That reflects on the quality of the designed spaces. The building skin plays the main role in delivering the natural daylighting inside the building; therefore building skins shouldn't be just designed for its aesthetic aspects but also as a functioning element in the building. This thesis aims at identifying the daylighting systems and strategies that can be used in office building facades to create high performance facades. The research investigates the use of several types of widely used daylighting systems and their effect on providing good daylit office space around the year. This includes shading systems such as: horizontal and vertical sun breakers, and solar screens; as well as redirecting systems such as light shelves and louvers. The research addresses these factors in the desert climate of the city of Cairo, Egypt that is characterized by sunny clear-skies. The research also proposes and investigates an alternative method in designing performative buildings, by integrating performance simulation techniques and computational methods. This method aims at reaching optimal and high performance solutions from a wide range of designs in the early design stages.

The thesis consists of three parts and ends with the conclusions and recommendations. The first part (chapter 1) investigates the development of high performance facade and studies the strategies and systems used for enhancing the daylighting performance. In the second part (chapter 2) the available daylighting metrics and performance indicators were analyzed. An office space in Cairo was selected as a case study and its daylighting performance was analyzed. In the third part (chapters 3, 4, and 5) the effect of using shading and redirecting systems on daylighting performance was studied. Moreover, an investigation was conducted on the ability of optimization techniques such as Genetic Algorithms (GA) to be used for reaching optimal design by combining two or more systems together.

The studied cases were parametrically modeled using Grasshopper and Rhinoceros 3D modeling software. Diva-for-Rhino a daylighting simulation plug-in was used to interface Radiance and Daysim for annual daylighting simulation and illuminance calculation. The daylighting level adequacy was evaluated annually using Dynamic Daylighting Performance Metrics (DDPM), while Daylight Glare Probability was calculated for visual comfort assessment.

The results provide a daylight performance-based comparison of the different techniques and parameters along with guidelines for using each of them. Moreover, for each orientation, the thesis presents a matrix of different possible solution that can aid designers in creating a well-daylit office spaces.

Abbreviations

CBDM	Climate based daylighting metrics
CGI	CIE Glare Index
CIE	Commission Internationale de l´Eclairage
DA	Daylight Autonomy
DDPM	Dynamic Daylight Performance Metrics
DF	Daylight Factor
DGI	Daylight Glare Index
DGP	Daylight Glare Probability
GA	Genetic Algorithms
HSA	Horizontal Shading Angle
SPT	Single Point in Time
UDI	Useful Daylight Index
UGR	Unified Glare Index
VSA	Vertical Shading Angle
WWR	Window Wall Ratio

Keywords

Daylighting Systems; High Performance Facade; Daylighting Simulation; Daylight Availability; Daylight Glare Probability; Optimization; Form Finding; Genetic Algorithm

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