Cairo University

# DAYLIGHTING DESIGN OPTIMIZATION OF HOSPITAL PATIENTS' ROOM USING LIGHT REDIRECTING SYSTEM FOR VISUAL COMFORT UNDER DESERT CLEAR SKY

By

**Aya Mohamed Hisham Ahmed Essa**

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

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

**Dr. Ayman Hassan Mahmoud**

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FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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**Title of Thesis:**
Daylighting Design Optimization Of Hospital Patients' Room Using Light Redirecting System For Visual Comfort Under Desert Clear Sky

**Key Words:**
Daylighting, Visual comfort, Light selves, shading devices, Hospital, optimization

**Summary:**
Daylighting has a positive effect on users' health, physical and psychological. Hence, daylighting use should be maximized to benefit users from its advantages, especially in health care facilities, where visual indoor comfort is more crucial than other building types due to the vulnerability of its users. In patients' rooms specifically, indoor environment quality affects the healing process in terms of time interval and pain reduction. Since reaching visual comfort cannot be achieved by openings design alone, light-redirecting systems are essential. Light redirecting systems, namely light shelves and shading devices, are proved to have an impact on indoor daylight quality and quantity which shows as better distribution, increased quantity in space depth, and reduced glare probability. Accordingly, the aim of this study is to arrive at a range of optimally configured light-redirecting systems for one of most common patient room prototype while gaining a better understating of the effect of each of the independent variables understudy. This study first investigates the various visual comfort assessment metrics as well as how daylighting and visual comfort is evaluated in a number of building performance assessment systems. Followed by daylighting simulation engines and tools overview, the types and effect of light-redirecting systems, including light shelves and shading devices, are investigated. The theoretical section is concluded by a synopsis of similar studies. Succeeding, to explore the effectiveness of the studied systems this study includes a comparative analysis of LEED certified healthcare buildings that have achieved visual comfort. Finally, in an attempt to optimize daylighting in a patient room prototype, an application of a light-redirecting system is carried out using varying rotation angles, horizontal projection, mounting height, WWR and reflectance. The near optimal solutions are determined by LEED v.4 criteria.

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Aya Essa

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# Nomenclature

| | |
|---|---|
| ASE- | Annual Sunlight Exposure |
| BREEAM- | Building Research Establishment Environmental Assessment Methodology |
| CASBEE- | Comprehensive Assessment System for Built Environment Efficiency |
| CBDM- | Climate-based daylight metrics |
| CGI- | CIE Glare Index |
| DA- | Daylight Autonomy |
| DACON- | Continuous Daylight Autonomy |
| DF- | Daylight Factor |
| DGI- | Discomfort Glare Index |
| DGP- | Discomfort Glare Probability |
| ERC- | External Reflected Component |
| GUI- | Graphical user interface |
| IEA- | International Energy Agency |
| IRC- | Internal Reflected Component |
| L- | Luminance |
| LEED- | Leadership in Energy and Environmental Design |
| PGSV- | Predicted Glare Sensation Vote |
| SBTool- | Sustainable Building Tool |
| SC- | Sky Component |
| sDA- | Spatial Daylight Autonomy |
| sUDI- | Spatial useful daylight illuminance |
| UDI- | Useful Daylight Illuminance |
| UGI- | Unified glare index |
| WWR- | Window-to-wall ratio |