SYNOPSIS

KEY POINT SUMMARY

OBJECTIVES

To evaluate the changes in visual comfort levels within a digitally modeled standard hospital patient room simulating four different types of responsive building facades.

Visual comfort assessment of hospital patient rooms with climate responsive facades

Toodekharman, H., Abravesh, M., Heidari, S. 2023 | Journal of Daylighting, Volume 10, Issue 1, Page(s) 17-30

Key Concepts/Context

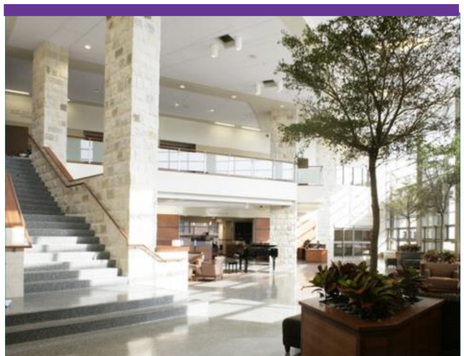
Responsive building facades are a cutting-edge technology that comprise part of a building's envelope. These facades automatically adapt to and algorithmically learn the surrounding environment, in turn reducing energy consumption, adjusting daylighting and ventilation, and influencing thermal and visual comfort. This study uses various simulations to investigate visual comfort within a patient room built with responsive facades, concluding that a façade with a 60% window to wall ratio (WWR) showed the best overall performance.

Methods

The 3D modeling program Rhinoceros was used to recreate a standard patient room in a hospital located in Tehran, Iran; this room was used as the baseline model throughout the study. The modeled room was a two-bed, south-facing room measuring 3.5 meters high, 4.2 meters wide, and 7.5 meters long, with an area of 31 square meters. The room featured a window with a variable WWR; the higher the WWR percentage, the larger the window in relation to the wall.

To simulate daylighting and climate, the authors used the parametric design tool Grasshopper, augmented with the programs Honeybee and Ladybug to visualize the results of daylight using backward ray-tracing. Data concerning the surrounding environmental conditions of Tehran were factored into the simulation process; climate-based metrics were gathered from the online database EnergyPlus.

The four responsive building facades were algorithmically coded in Grasshopper. The patterns utilized by the simulated facades were modeled after existing buildings and other conventional patterns. Each façade was modeled to open and close along different horizontal and vertical axes throughout the day.



The Center for Health Design: Moving Healthcare Forward

The Center for Health Design advances best practices and empowers healthcare leaders with quality research that demonstrates the value of design to improve health outcomes, patient experience of care, and provider/staff satisfaction and performance.

Learn more at www.healthdesign.org

To capture and measure various parameters within the simulated room, a simulation grid was set at the height of the patient beds, which was 90 centimeters above the floor. The dimensions of this grid network were defined as 10x10 centimeters for high accuracy. To account for glare, which is dependent on a given observer's location, a simulated patient's head was introduced as a critical focal point.

Overall outcomes accounted for in this process included spatial Daylight Autonomy (sDA), Annual Sunlight Exposure (ASE), Daylight Glare Index (DGI), and Daylight Glare Probability (DGP).

Findings

A baseline goal for façade functionality is provided by the LEEDv4 certification requirements, which stipulate that ASE should not exceed 10% and sDA should not exceed 75% in healthcare facilities. Two facades (numbered two and four) exceeded the proposed ASE values under all circumstances; however, when façade one was given WWRs of 50% and 60% and façade three was given a WWR of 50%, LEEDv4 requirements were met. Baseline sDA requirements were met by all four facades. These results suggest that façade one was the top performer due to its ability to meet LEEDv4 requirements for ASE and sDA with an WWR of both 50% and 60%, while façade four was the poorest performer overall.

When considering variables and outcomes related to indoor glare, including DGP, façade one remained the top performer. Due to ASE reports, LEEDc4 compliance, and the fact that sDA with a larger window is generally more desirable, the authors investigated further results for façade one with a WWR of 60%. Whereas the baseline model room was found to have glare around both patient beds during different times of the year, the introduction of responsive façade one eliminated the glare in the majority of cases for bed one (which was situated closer to the window) and in all cases for bed two.

Limitations

All results from this study were derived from digital simulations; any adjustments to any of the methodological variables, including (but not limited to) the baseline model of the patient room, the simulation grid used for data capture, weather modeling data, or the types of responsive facades could significantly affect the results.

Design Implications

To control glare in patient rooms with WWRs of 50% and no response facades installed, suggestions include paying special attention to indoor furniture arrangement, increasing the length of the room, and converting all rooms to singlebed rooms where possible. When none of these options are feasible, protective elements such as responsive facades may be helpful tools for improving indoor visual comfort.

And Also...

To better understand the simulated models and different façade types described in this study, helpful color-coded figures are provided.