Contribution ID: **12** Type: **not specified**

IndiLight Module: A control system for combined operation of façade and artificial lighting systems to optimize human comfort and overall building energy consumption

Friday 25 August 2023 13:15 (15 minutes)

Optimizing the thermal and lighting conditions in office rooms for each worker individually tends to be an expensive task in terms of both planning and operation. An workplace-individual lighting module (IndiLight module –ILM) facilitating this task has been developed and will be introduced in this work and compared to state of the art façade control strategies. To minimize the installation effort, the quantification of the lighting situation at each working place is performed by simulation, based on measured values from only outdoor sensors. For keeping the planning effort low, model data of the standard planning phase is used in the process of setting up the control module, which can therefore be easily integrated into a BIM workflow. To keep the indoor lighting and thermal condition close to optimal, the module is executed in defined intervals (e.g., every 15 min). Since the module is planned to run on embedded hardware of the building control system, performing a full daylight simulation in every time step is not affordable. To overcome this problem, the major part of the daylight simulation is done in a pre-calculation step, comprising the generation of the matrices for the radiance three phase method. During operation, the module has only to perform the multiplication of those matrices in every time step to retrieve the daylight illuminance on each working desk, which is further used to calculate the artificial lighting demand, and the luminance values observed from each working position to estimate the individual glare situation. For the thermal situation, the solar heat gain coefficient is taken as an input in a thermal model, based on the (outdated) standard EN 13790. In the optimization routine first some of the possible façade states are excluded due to glare issues or potential overheating risk and for all remaining states a target function is calculates, which depends on the estimated heating or cooling and artificial lighting energy demand and on the degree of façade opening. The façade state with the best target function value is then chosen. In this work the ILM is applied to office rooms in a thermal and in a lighting simulation environment. In the annual dynamic building simulation in TRNSYS, the heating, cooling and artificial lighting energy demand is calculated. The daylight glare situation is verified by calculation of the daylight glare probability for each working place throughout the year applying the raytraverse simulation workflow. The same process is also applied to state of the art reference control strategies and the results are compared. The main benefit of this study is to investigate the influence of façade control algorithms on the thermal and lighting comfort for office workers and on the total building energy demand.

Keyword 1

Daylighting

Keyword 2

control strategy

Keyword 3

simulation study

Keyword 4

visual comfort

Keyword 5

thermal comfort

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Session Classification: Presentations

Track Classification: Assessing daylight and cross-domain effects