Comparison of Daylighting in Different Climatic Conditions

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This article compares daylighting in administrative building located in different climatic zones. Depending on the simultaneous identical changes in window geometry and wall reflectance, the changes of distribution and values of daylight factor were monitored and compared in each case of localization of the building.

Keywords: daylighting, daylight factor, administrative building, Czech Republic, Sweden, Greece

Daylight has been used as the main source of light in interiors for centuries and has always been an integral part of architecture since buildings have existed. Not only does it replace electric lighting during the day, reducing electricity consumption, but it also affects heating and cooling, making it an important parameter in energy efficient design. Research has shown that daylighting is of great benefit to the health and comfort of occupants [1]. Nowadays, in the context of a significant increase in energy prices, the contribution of daylight to the interior of buildings is becoming increasingly important. Many studies have shown that the right daylighting space can improve occupant productivity, reduce electricity consumption, and thus contribute to sustainable design. The dynamic nature of daylighting presents many challenges when considering the metrics that define good and efficient daylighting design [2,3]. In the following work, the evaluation of daylighting in different climatic conditions of the Czech Republic, Sweden and Greece is investigated. The research focuses on the calculation and evaluation of daylighting in a residence room (spaces that may be regularly occupied by people) in a multi-storey building located in Ostrava (Czech Republic), as well as in Stockholm (Sweden) and Athens (Greece). The choice of countries is characterized by different latitudes and thus different median diffuse horizontal skylight illuminance. A static simulation method in Building Design was used to determine the daylight illuminance in the room under evaluation.

Considered input values

The considered input values, which were used for modelling in the Building Design simulation program, were taken from ČSN EN 17037 [4], Table A3. These are the median diffuse skylight horizontal illuminance, and the requirements for the value of the daylight factor in the residence room in each case.

Data about the compared room

The assessment room is located in a multi-storey building. Residence room number 104 on the first floor of the building under evaluation was selected. The room is oriented southeast and located in the corner of the building. It is a children's playroom. The dimensions of the room are 4,000 × 5,000 mm and its clear height is 2,600 mm. A regular set of points with a spacing of 571 × 600 mm has been placed in the room, which is set back a minimum of 500 mm

Table 1. *Considered input values and requirements of daylighting.*

	Czech Rep.	Sweden	Greece
City	Ostrava	Stockholm	Athens
Latitude	50.10°	59.65°	37.90°
Median diffuse horizontal skylight illuminance	14,900 lx	12,100 lx	19,400 lx
D over 100 lx	0.7%	0.8%	0.5%
D over 300 lx	2.0%	2.5%	1.5%

from the walls of the room. The point array was placed at a height of 800 mm above the floor of the room under assessment. The simulation was carried out for 2 model situations in which simultaneous changes in window geometry and wall reflectance of the room took place. The changes were considered the same in all cases (Czech Republic, Greece, Sweden).

Description of model situations

In the model situation No.1 the following windows dimensions were considered: width – 1,750 mm, height – 1,500 mm, sill height – 900 mm. Clear, double glazing with a transmission coefficient of 0.92 (for each glazing) was considered. Both windows in the room have identical dimensions and glazing properties. The simulation was performed with the considered reflectivity of the walls surrounding the room – 0.5. The floor reflectivity was chosen to be 0.3 and the ceiling reflectivity 0.7.

In the model situation No.2 the following windows dimensions were considered:

Window 1: width – 1,750 mm, height – 1,500 mm, sill height – 900 mm. Clear glazing with double glazing with a transmission coefficient of 0.92 (for each glazing) was considered.

Window No. 2: width – 2,500 mm, height – 1,500 mm, sill height – 900 mm. Clear, double glazing with a transmission coefficient of 0.92 was considered. The simulation was carried out with the considered reflectivity of the walls surrounding the room – 0.77. The floor reflectance was chosen to be 0.3 and the ceiling reflectance 0.7.

The ISO-line were then used to show the levels where the daylighting requirements of ČSN EN 17037 [4] are met. The isolines show the level at which the value of the daylight factor is constant.

Simulations and results

Czech Republic

The minimum value of the daylight factor (0.7%) must be met on at least 95% of the room area according to the legislative requirement. The required value of the daylight factor (2.0%) shall be met by a minimum of 50% of the room area as required by legislation.

By simulation in the Building Design software and subsequent calculation for model situation 1 was found, that the minimum value of the daylight factor (0.7%) is met in 100% of the room area. The required daylight factor value (2.0%) is met for 54% of the room area. The boundary where the required value is met is shown in ISO-line green.

By simulation in Building Design and subsequent calculation for model situation 2 was found, that the minimum value of the daylight factor. (0.7%) is met in 100% of the room area. The required daylight factor value (2.0%) is met for 83% of the room area. The boundary where the required value is met is shown in ISO-line green.

Sweden

The minimum value of the daylight factor (0.8%) must be met in at least 95% of the room area according to the legislative requirement. The required value of the daylight factor (2.5%) shall be met by a minimum of 50% of the room area as required by legislation.

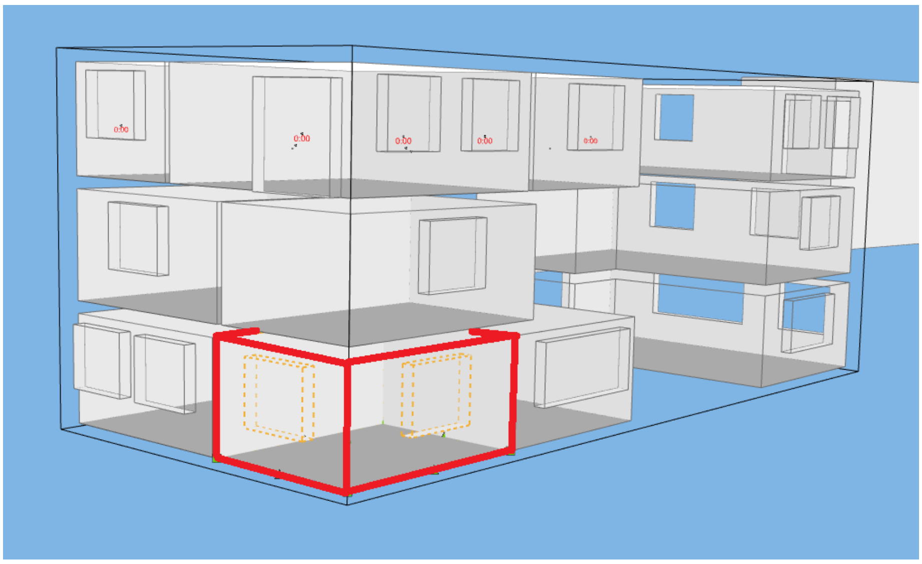

Figure 1. The location of the rated room in the building.

Table 2. Data considered for the calculation of daylighting in Czech Republic.

	Czech Rep.
City	Ostrava
Latitude	50.10°
Median diffuse horizontal skylight illuminance	14,900 lx
D over 100 lx	0.7%
D over 300 lx	2.0%

Table 3. Data considered for the calculation of daylighting in Sweden.

	Sweden
City	Stockholm
Latitude	59.65°
Median diffuse horizontal skylight illuminance	12,100 lx
D over 100 lx	0.8%
D over 300 lx	2.5%

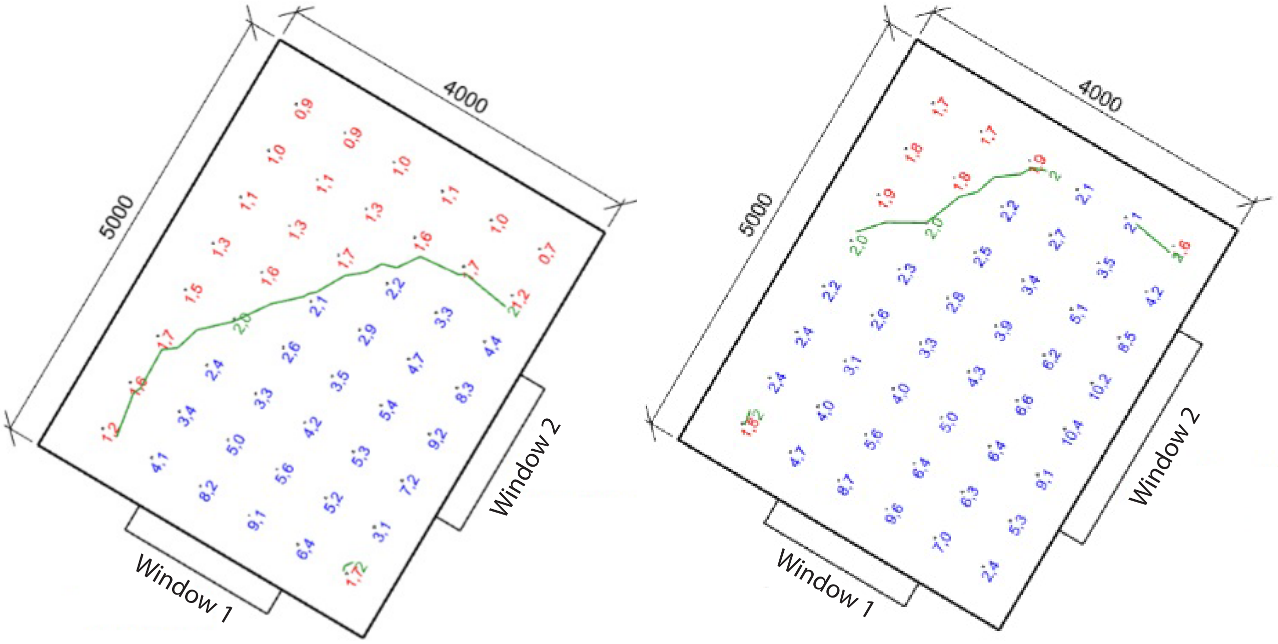

Figure 2. Distribution of the daylight factor in the treatment room for the first and second model situation in Czech Republic.

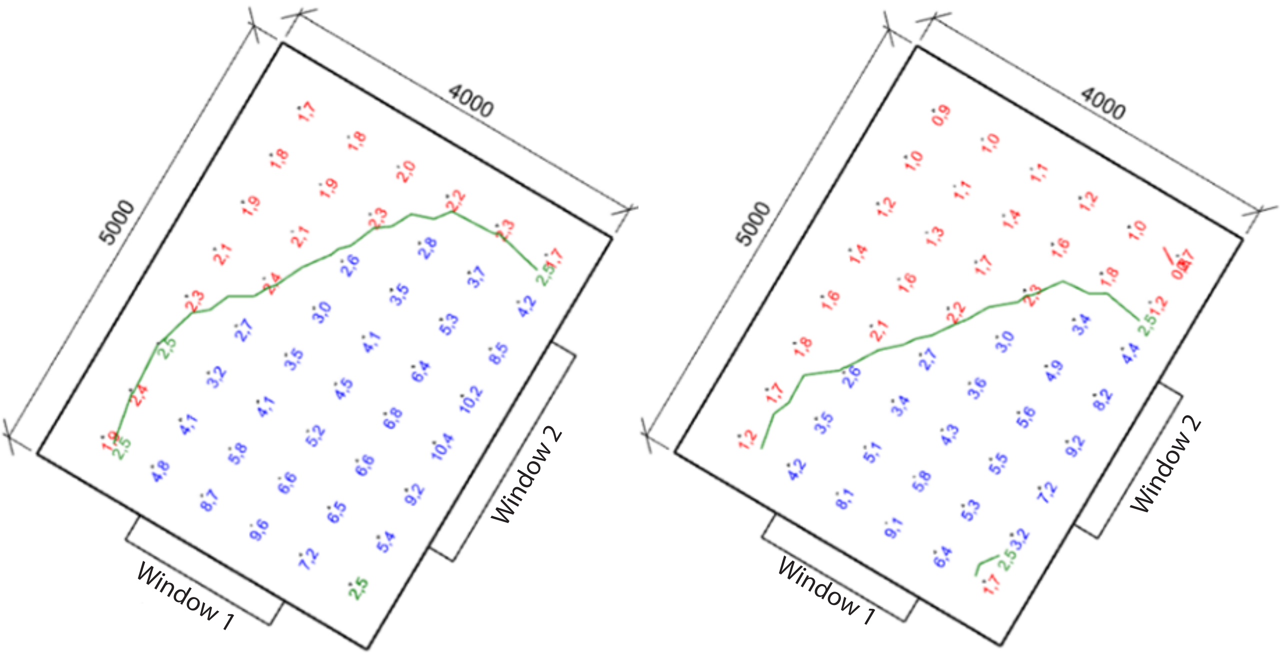

Figure 3. Distribution of the daylight factor in the treatment room for the first and second model situation in Sweden.

By simulation in the Building Design software and subsequent calculation for model situation 1 was found, that the minimum value of the daylight factor (0.8%) is met in 98% of the room area. The required value of the daylight factor (2.5%) is met in 48% of the room area. The boundary where the required value is met is shown in ISO-line green.

By simulation in Building Design and subsequent calculation for model situation 2 was found, that the minimum value of the daylight factor (0.8%) is met in 100% of the room area. The required value of the daylight factor (2.5%) is met on 67% of the room area. The boundary where the required value is met is shown in ISO-line green.

Greece

The minimum value of the daylight factor (0.5%) must be met in at least 95% of the room area according to the legislative requirement. The required value of the daylight factor (1.5%) shall, according to the legislative requirement, be met at least for 50% of the room area.

Table 4. *Data considered for the calculation of daylighting in Greece.*

	Greece
City	Athens
Latitude	37.90°
Median diffuse horizontal skylight illuminance	19,400 lx
D over 100 lx	0.5%
D over 300 lx	1.5%

By simulation in the Building Design software and subsequent calculation for model situation 1 was found, that the minimum value of the daylight factor (0.5%) is met in 100% of the room area. The required value of the daylight factor (1.5%) is met in 71% of the room area. The boundary where the required value is met is shown in ISO-line green.

By simulation in Building Design and subsequent calculation for model situation 2 was found, that the minimum value of the daylight factor (0.5%) is met in 100% of the room area. The required value of the daylight factor (1.5%) is met for 100% of the room area. The boundary where the required value is met is shown in ISO-line green.

Conclusion

Based on the modelling, simulation and subsequent calculation for each model situation, the following was evaluated: In the baseline model situation, the daylighting requirements were met in the case of the Czech Republic and in the case of Greece. In the case of Sweden, the minimum target daylight factor requirement was not met, which was only met for 48% of the assessment room area (the standard requirement is 50% of the assessment room area). The requirement for the target daylight factor was met. After the changes made to the window geometry and wall reflectance in the assessment room, the daylighting requirements

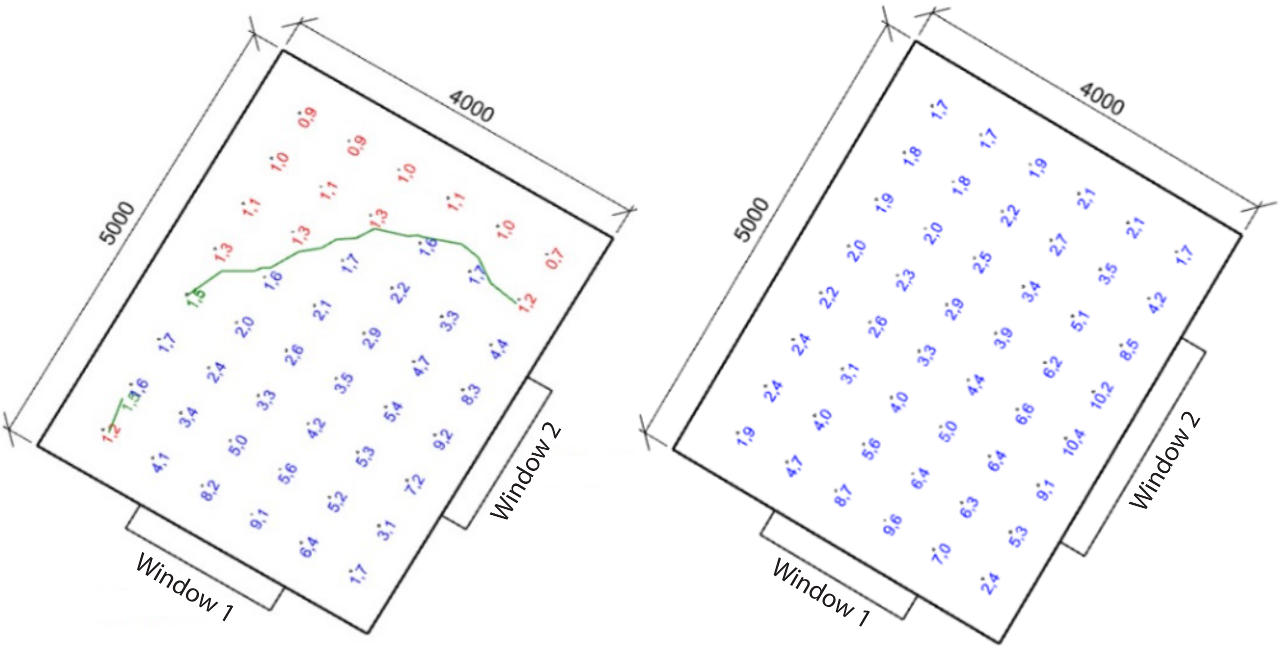

Figure 4. Distribution of the daylight factor in the treatment room for the first and second model situation in Greece.

have already been met, even for the building location in Sweden.

As can be seen from the simulations and calculations carried out, the change in window geometry and wall reflectance will be the most significant in terms of daylighting in the case of Greece. This is due to both the requirement for a target daylight factor of 1.5% (lowest) and the median horizontal sky illuminance, which is highest in Greece (19,400 lx). On the other hand, in the case of Sweden, the change in the geometry of the lining and the reflectivity of the walls is the least affected, given that the median horizontal sky illuminance is the lowest in the case of Sweden (12,100 lx).

It has been found that in the case of the Swedish building location, larger window openings or higher wall reflectance than in Greece or the Czech Republic have to be considered in order to meet the daylighting requirements. This is due to the fact that the median horizontal sky illuminance decreases with increasing latitude, while at the same time the minimum and required daylight factor in the living room increases. ■

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References

[1] NOVÁKOVÁ, Petra, VAJKAY, František. Factors influencing the value of daylight factor. In MATEC Web of Conferences. MATEC Web of Conferences. 10th International Scientific Conference Building Defects (Building Defects 2018). CEDEX A, France: E D P SCIENCES, 2019. ISSN: 2261-236X.

[2] ABU-DAKKA, Moana Ghazi. The Use of Useful Daylight Illuminance (UDI) to Test New Designs for Improving Daylight Performance of Office Buildings in Dubai-UAE. Dubai, 2009. Master Thesis. Faculty of Engineering, The British University in Dubai. Prof. Bassam Abu-Hijleh.

[3] BHAVANI, R. G. and KHAN, M. A., (2006) Present Trends and Future Direction of Lighting Control in Dubai. Middle East Economic Survey (MEES) 2007, vol. 50, no. 30, pp 23-24.

[4] ČSN EN 17037+A1, Daylight in buildings (EN 17037:2018+A1:2021).