Evaluating of daylighting in selected office room: Case of Study

Dolnikova Erika

Technical University of Košice, Slovakia
Civil Engineering Faculty, Institute of Architectural Engineering
e-mail: erika.dolnikova@tuke.sk

Abstract

On average, we spend 90% of our time indoor particularly at work and a healthy work space is essential to that feeling of wellbeing. In a typical building, lighting accounts for up to 40% of energy consumption. Allowing more natural light to penetrate the building and controlling both the light and heat components of power consumption, will result in significant reductions. However, using natural light doesn't come without some issues. Glare, overheating, variability and privacy issues can all cause problems. Daylight is a basic human need, which is highlighted by the provision of transparent and translucent surfaces to all occupied spaces that we see around us. In many cases, the drive to create healthier, more occupant-conscious buildings works hand in hand with the requirement for greater energy efficiency. This article presents illumination of indoor workspace using daylight lighting. Measured values were compared with values calculated by simulation program Velux Daylight Visualizer 3.

Key words: daylighting, glare, daylight factor, workspaces, illuminance, simulation

1 Introduction

Daylighting means simply to introduce natural light into a building. To maximize the positive benefits natural light can provide, it is vital that we expand the interpretation of what daylighting is. Rather than being a question of weather to include daylighting measure or not, it should always be considered as part of a buildings holistic energy strategy to produce interiors that truly work for owners and occupiers. If unmanaged direct sunlight can cause disruptive or disabling glare or may lead to an overreliance on air cooling systems. Increasing energy use and running costs as well as causing low humidity and uncomfortable air quality. Quality of daylighting and the correct selection of daylighting materials to provide controlled natural daylighting is therefore essential [1].

Daylighting is the practice of allowing a controlled amount of natural light into a building to reduce electric lighting costs. A daylighting system includes skylights and windows along with a daylight-responsive lighting control system. Such a system can reduce energy costs by

as a much as 33%. Through the passage of light through the atmosphere, some wavelengths are absorbed by oxygen, ozone, water vapor and carbon dioxide [9].

Figure 1: Spectrum of solar radiation [9].

2 Daylight requirements in internal spaces

The quantitative aspect of daylight illumination is enough daylight for securing the visual activity. The quantitative level of daylight is expressed by the daylight factor. Daylight factor is the ratio of the internal light level to the external light level

$$DF = (E_i / E_o) \times 100 \quad (\%) \quad (1)$$

where

E_i - illuminance due to daylight at a point on the indoors working plane

E_o - simultaneous outdoor illuminance on a horizontal plane from an unobstructed hemisphere of overcast sky

Figure 2: Room – Daylight factor [4].

Lighting technical requirements for daylight are specified by the standard STN 73 0580-1 Daylighting of buildings. Part 1: Essential requirements. The daylight-light requirements required for different occupational activity are determined using daylight-light values based on the inclusion of work activity in the room in the visual activity class [6, 7].

3 Experimental Setting

Measurements were realized in a typical office room in Košice. The selected room was facing south and located on the third floor. Interior dimensions of room are 3.5m x 5 m x 2.7 m. In the room there is sidelighting. Sidelighting is created by the window with dimensions 1200 mm x 2100 mm. The height of parapet is 900 mm. The fenestration systems are created by double plastic glass. In the calculation the following coefficients were considered (transmittance coefficient 0.8, maintenance factor of glazing on exterior surface 0.9, maintenance factor of glazing on interior surface 0.85, reflectance factor of ground 0.15 - dark ground). The surface of walls is white color with reflectance factor 0.7, white ceiling by reflectance factor 0.7. The floor has reflectance factor 0.2. Light loss coefficient due to window construction was $\tau = 0,63$. The height of the assessed point, where the daylight was measured was 0.75 m. The room is used for medium-precision production with work of various kinds and therefore the room is classified in III. - IV. light – technical class. With the given lighting system in the critical point of functional place on horizontal plane these values are required: minimum standard value of daylight factor $D_{\min} = 1.5 - 2 \%$, average daylight factor $D_{\text{average}} = 5 - 6 \%$ [5]. We recommend levels of minimum 300 lx for most of the room area by meeting of target climate-based daylight factor and 500 lx for areas where productive work is performed. In the calculation exterior horizontal illumination of 5000 lx was considered. On the selected days, the value of the outside light ranged from 6.500-7.000 lx in the first day, 6.500-8.000 lx on the second day and 6.500-8.500 lx on the third day.

Figure 3: Plan of the test office room

4 Results

The article presents the results of measurements for control point for three days in January (shown in Figure 4-6). Illuminance levels of work-surface ranged between 100 and 600 lux averaging 350 lux. The results of the measurement values can be seen in Table 1. Temperature of room varied about 24°C and humidity varied about 40%. The results of DF lighting and illumination and luminance calculated can be seen in Figure 7-11.

Table 1. The calculated DF values from the measured values.

1 st day		
D_{min}	D_{max}	$D_{average}$
0.37	3,35	1.08
2 nd day		
D_{min}	D_{max}	$D_{average}$
0.36	4.65	1.38
3 rd day		
D_{min}	D_{max}	$D_{average}$
0.81	6.02	1.42

Figure 4: Measured values-1st day

Figure 5: Measured values-2nd day

Figure 6: Measured values-3rd day

Figure 7: Results of illumination (lx) - overcast sky

Figure 8: Results of illumination (lx) - overcast sky

Figure 9: Results of daylight factor DF (%) - overcast sky

Figure 10: Results of daylight factor DF (%) - overcast sky

Figure 11: Results of luminance (cd.m⁻²) – overcast sky

5 Conclusion

The provision of natural daylight within the built environment can deliver genuine, positive benefits to the finished construction; benefits that can enhance the financial and environmental performance of the building in service, benefits that can improve the internal environment and make it a better, more pleasant place to be. When our mind needs to be stimulated and concentrated, it's important to have the area or office brightly lit. Unfortunately offices tend to turn to fluorescent light, but even the slightest bit of natural light can make a big difference in productivity [11].

The zone with sufficient daylight is only about 1/3 of the room depth where work is located. In the test room window is about 15% floor area. The pictures (Figure 4-6) show that the most light is around lunch. Then there is also glare. Morning is not enough light levels, so you need to use artificial lighting. Then, after about 15.00 p.m., the level of illumination decreases again. From the calculated values by simulation program it shows that in the middle of the room is a daylight factor 1% (Figure 9-10). Daylight factor at a point on the indoors working plane is 2% (Figure 9-10). Minimum standard value of daylight factor $D_{min} = 1.5 - 2 \%$ is met. However, protection against glare is required, especially in the afternoon (Figure 11).

From the calculated value from measured values it shows that minimum standard value of daylight factor (requested value $D_{min} = 1.5 - 2 \%$) is not fulfilled in several hours. The requirement is met between 12 am and 13 pm on each day and also on the third day when the sky was less cloudy.

The difference between the measured values and the calculated values by simulation program is that the external horizontal illumination has changed and in simulation is constant (5.000 lx-requirement by standard).

Acknowledgements

This paper was elaborated with the financial support of the research project VEGA 1/0674/18 of the Scientific Grant Agency, the Ministry of Education, Science, Research, and Sport of the Slovak Republic and the Slovak Academy of Sciences.

References

- [1] Konis, K. 2013. Evaluating daylighting effectiveness and occupant visual comfort in a side-lit open-plan office building in San Francisco, California. *Build. Environ.* 59, 662–677.
- [2] Bellia, L.; Bisegna, F.; Spada, G. 2011. Lighting indoor environment: Visual and non-visual light sources with different spectral power distribution. *Build. Environ.* 46, 1984–1992.
- [3] Gonzalez, J.; Fiorito, F. 2015. Daylight design of office buildings: Optimisation of external solar shadings by using combined simulation methods. *Buildings* 5, 560–580.
- [4] Lee, J.H.; Moon, J.W.; Kim, S. 2014. Analysis of occupants' visual perception to refine indoor lighting environment for office tasks. *Energies* 7, 4116–4139.
- [5] Integral Lighting. 2015. ČSN 360020; Czech Office of Standards, Metrology and Testing: Prague, Czech Republic.
- [6] EN 12464-1:2012. 2012. Light and Lighting-Lighting of Work Places-Part 1: Indoor Work Places; Slovak Republic Office of Standards, Metrology and Testing: Bratislava, Slovakia.
- [7] STN 730580; Daylighting in buildings, – 1 Basic requirements, 1986 – 2; Daylighting of residential buildings, 2000, Slovak Republic Office of Standards, Metrology and Testing: Bratislava, Slovakia; 2000
- [8] CEN/TC 169 07/2017 2017. Daylight in buildings (TC 169 WI 00169068) CEN/TC 169.
- [9] Gou, Z.; Lau, S.S.; Qian, F. 2015. Comparison of mood and task performance in naturally-lit and artificially-lit environments. *Indoor Built Environ.* 24, 27–36.
- [10] Shishegar, N.; Boubekri, M. 2016. Natural light and productivity: Analyzing the impacts of daylighting on students' and workers' health and alertness. In Proceedings of the International Conference on “*Health, Biological and Life Science*” (HBLS-16), Istanbul, Turkey.
- [11] Ferencikova, M.; Darula, S. 2017. Availability of daylighting in school operating time, *Light and Engineering*. 25 (2), 71-78.