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Influence of colour of shading obstacles on indoor daylighting

Abstract. *Daylighting is one of major requirements for indoor climate. Quality of light is a factor which influences habitants comfort and health. Proper indoor visual climate depends on many factors. One of the influencing factors might be external shading obstacles which could reduce access of daylight significantly and their colours might also play negative role for spectral range of light. The main results of an evaluation of daylighting in a residential building influenced by a neighbouring building with brightly coloured façades are presented in the article.*

Streszczenie. *Oświetlenie pomieszczeń światłem dziennym jest jednym z wymogów mających wpływ na klimat wewnętrzny. Jakość światła jest czynnikiem wpływającym na wygodę i zdrowie mieszkańców. Właściwe wewnętrzne środowisko wizualne zależy od wielu czynników. Jednym z nich mogą być zewnętrzne przeszkody zacieniające, którą mogą wyraźnie ograniczyć dostęp światła dziennego a swoimi kolorami mogą mieć negatywny wpływ na dostępny zakres widma światła. Wyniki pomiarów oświetlenia dziennego w budynkach mieszkalnych podlegają wpływom sąsiednich obiektów o kolorowych fasadach, o czym jest mowa w artykule.* ***(Wpływ kolorowych filtrów na wewnętrzne oświetlenie światłem dziennym).***

Keywords: daylight, visual comfort, illuminance.
Słowa kluczowe: światło dzienne, komfort wzrokowy, oświetlenie.

Introduction

Daylighting plays positive role in building indoor climate. Natural light represents healthy and energy saving alternative to artificial lighting. Modern energy efficient buildings are based on solar energy utilisation for solar gains and proper daylighting. Sufficiently large windows are only one of many design requirements. It means sufficient light transmittance of daylight in its natural spectrum is necessary for indoor visual comfort [1]. The visual conditions in buildings are determined mainly by a type of façade glazing and its framing and shading system, dimensions of windows and their positions with respect to the room dimensions and geometry, interior furniture and surfaces finishing – their shape and colours and surface properties - smooth, rough, polished surfaces or mirrors [2].

External shading obstacles as neighbouring buildings, trees, special constructions, billboards etc. can reduce and interior daylighting significantly. It is know fact which must be considered during the building design process. It is necessary to take into account positions and dimensions of the external obstacles and their distances from the designed building and its windows. Surface reflectance and colours of the shading obstacle can also highly influence indoor daylight quality in near buildings. The article presents results of evaluation of influence of large building with brightly coloured façade on indoor climate in a neighbouring building.

Fig.1. Aerial photograph of the investigated building and the coloured neighbouring obstacle

Investigated building and its shadings

An indoor daylighting of a residential building which opposes to the new big shopping store with large red coloured façade panels was investigated. Figure 1 shows an aerial photograph of the locality with the investigated residential building and the newly constructed building of the department store with red façade panels [3].

The following photographs present a part of the red coloured façade of the neighbouring building (Fig. 2) and its influence on the opposite residential building (Fig. 3) [3].

Fig.2. Red coloured façade of the department store

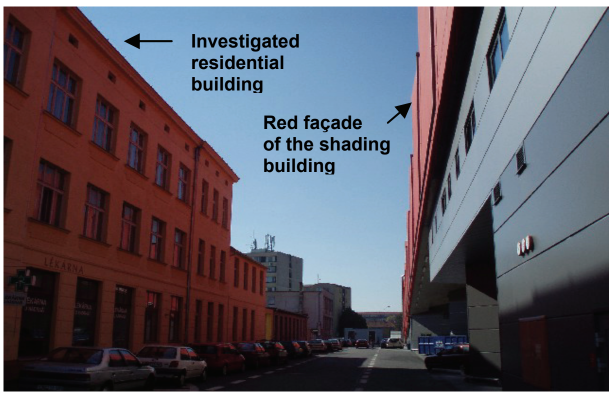


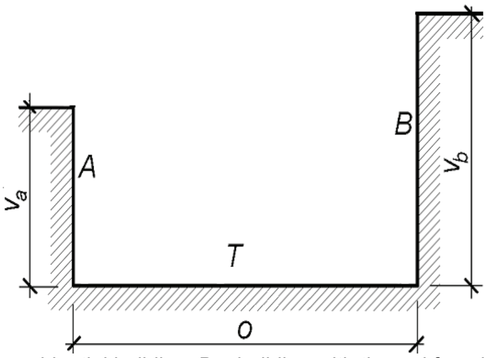
Fig.3. Influence of the red façade on the shaded opposite residential building façade

There is obvious high influence of the red façade on the colour of the residential building in photograph. The original yellow colour of the residential building façade seems to be orange in the shade of the opposite red panels Fig.3.

The brightly coloured neighbouring façade influences not only the residential building façade appearance but also internal visual comfort. The quality of internal daylighting is not proper which affects health of the building inhabitants.

Daylighting in the residential building

The influence of the façade bright colour on the indoor climate of the residential building was investigated. Geometrical relations between the two buildings are presented in Fig. 4.



A – residential building, B – building with the red façade
v_a - height of the centre of the window of the residential building on the 2nd floor v_a=7.0 m, on the 3rd floor v_a=11.3 m
v_b - height of the opposing red façade building, 19.20 m
T – road with two pavements
0 – horizontal distance between the building A and B, O=12 m

Fig.4. Geometrical relations between the residential building windows and the opposite shading building with the red façade

The internal illuminance on the working plane 0.85 m over the floor level on the 2nd floor was monitored for the daylight factor evaluation. The daylight factor DF [%] is a ration between internal illuminance and illuminance on the non shaded horizontal plane in exterior [4]. It consists of three components as DF = SC + ERC + IRC [%], where SC-sky component, ERC-externally reflected component, IRC-internally reflected component (Fig. 5).

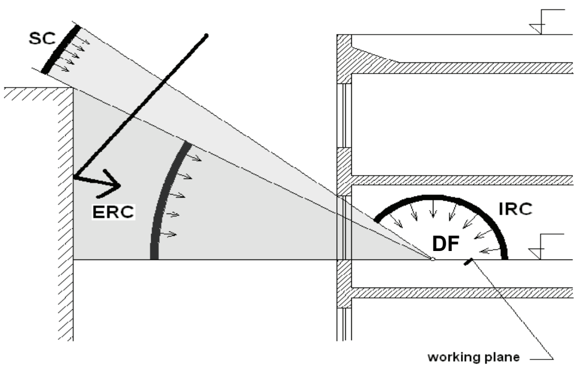


Fig. 5. Daylight factor DF [%] components (SC, ERC and IRC)

Data of the illuminance measurements (luminance meter Minolta T10) were compared to daylight simulations in daylight simulation computer program WDLS [5]. The simulations were carried out for two design variations. Variation I was completed for the residential building without shading obstacles and Variation II compares the same residential building influenced by the shading of the opposite red façade building. The main results of maximal (DF_{max}), minimal (DF_{min}), and average (DF_{aver}) values as well as daylight uniformity DF_{min}/ DF_{max} are summarised in Table 1.

Table 1. Results of the daylight factor DF evaluation

Evaluation	DF_{max} [%]	DF_{min} [%]	DF_{aver} [%]	DF_{min}/DF_{max} [-]
Variation I	7,29	1,23	3,18	0,436
Variation II	1,61	0,24	0,71	0,440

The daylight factor reduction in case of the shading obstacle is high. It means the opposite building decreases indoor illuminance level. But it is not the main problem of the residential building. The opposite building red façade causes deformation of the natural spectrum of the indoor light which is very negative and disturbing factor for the places with permanent inhabitancy.

Spectral radiance measurements

Spectral radiance measurements were carried out by the spectrometer Jeti Specobos. The following two figures compare spectral radiance of external places under clear blue and overcast sky (Fig. 6) and the space between the investigated residential building and the opposite building with the red façade (Fig. 7).

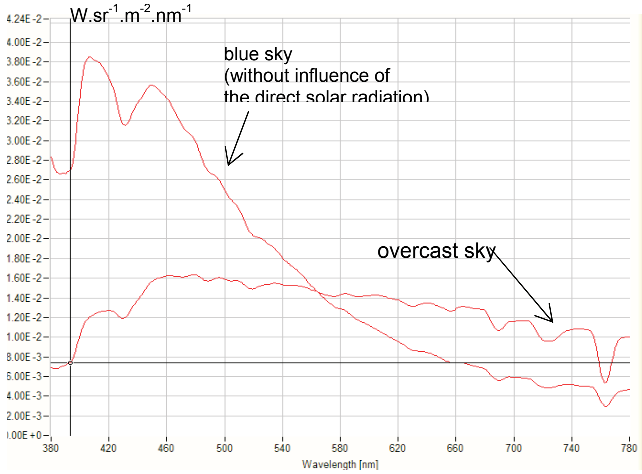


Fig. 6. Spectral radiance of the blue and overcast sky

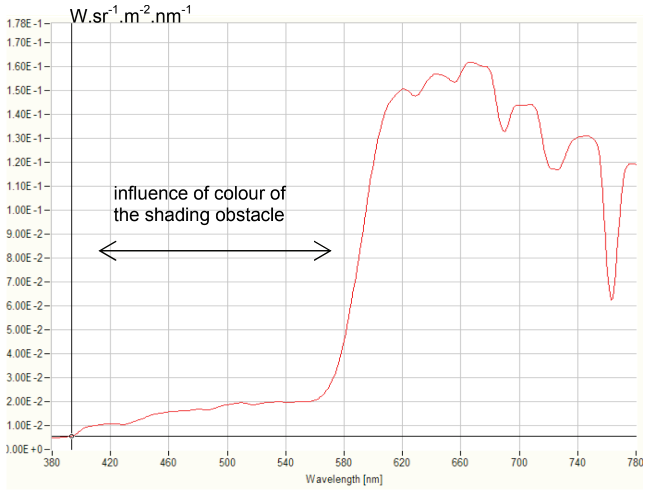


Fig. 7. Spectral radiance [$W.sr^{-1}.m^{-2}.nm^{-1}$] of light reflected from the red façade

The externally reflected component of the daylight in the rooms of the residential building is highly influenced by the light reflected from the opposite red façade. It is obvious from Fig. 7 that the spectral radiance of the half of visible range (380-550 nm) is very low and it is highly increased from wavelength 600 nm. Maximal radiance was monitored in the spectral range between 670 and 690 nm.

Chromaticity diagram and circadian factor

The CIE chromaticity diagram [6] uses XYZ imaginary primaries to describe colour space. Chromaticity co-ordinates x, y and z represent the relative contribution of the three primaries, the sum of the coordinates is $x + y + z = 1$.

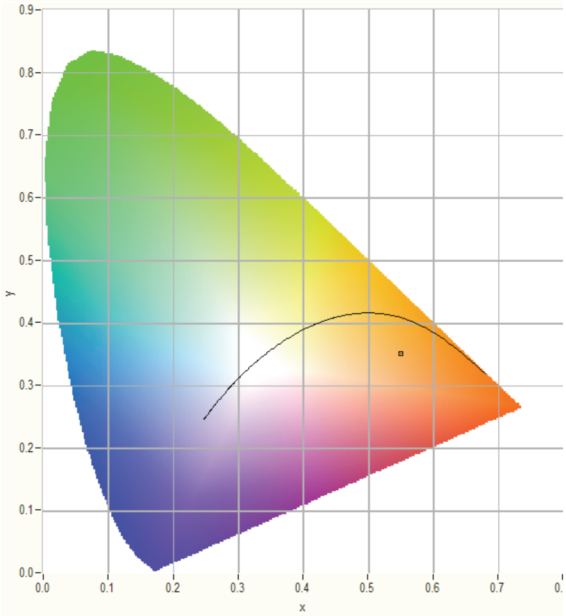


Fig.8. Chromaticity diagram of colour of the light reflected from the red façade

The evaluation of influence of light on health requires a *circadian factor* determination. The *circadian factor* is defined [7] as $a_{cv} = y/z = 1 - (x + y)/y$.
It is recommended to specify so call *biological index of light* $Ra_{cv}=100a_{cv}$ as an equivalent to the *colour rendering index* Ra. Estimated values of the *biological index of light* and *circadian factor* for the reflected daylight from the monitored red façade in the comparison with different light sources are presented in Table 2.

Table 2. Biological index of light and its circadian factor

Light source	*Biological index of light* Ra_{cv}	Circadian factor a_{cv}
Direct solar radiation	83	0.83
Cloudy sky light	173	1.73
Northern blue sky light	200	2.00
Moonlight	62	0.62
Reflected daylight from the monitored red façade	29-43	0.29 – 0.43

Conclusion

The evaluation of the brightly coloured shading obstacle and its influence on interior daylighting in the residential building presented in the article give unambiguous results. It is possible to summarise that the large red façade has a negative impact on the visual comfort in the opposite investigated building.

The improper visual indoor comfort due to the colour of the neighbouring building façade refers problems which might have serious unwanted impacts for indoor climate mainly in densely inhabited municipal areas with high rise buildings. The solution of these problems is in the integrated solar-daylight urban concept and optimised architectural design.

There are two major design tasks in this case which have to be considered in the building design process as light transmittance for sufficient internal illuminance without glare for the required visual activity and the quality of light in its natural spectral range and colour. The optimised design which respects the above mentioned requirements is very important for generation of proper indoor climate in buildings as well as comfort and health of their inhabitants.

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