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Effect of externally and internally reflective components on interior daylighting

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ABSTRACT

Daylighting in a building residential area was simulated for different external ground reflectances and for various internal surfaces and window to wall areas. The simulations were run in software Velux Daylight Visualizer. Variations in internally and externally reflected components were studied for days of summer and winter solstice under clear and overcast sky conditions. These conditions were selected for two extreme cases for maximal and minimal daylight levels in the internal space during the annual evaluation. The purpose of the simulation study is to find differences in the room daylighting for different conditions than the traditional model of the overcast sky conditions and dark ground. It was found that the room illuminance levels for various interior and exterior reflectances can vary significantly for different sky models. This finding points on the importance of the climate based daylight evaluations.

1. Introduction

Design of buildings for indoor comfort and daylighting depends on many parameters as climatic locality and sky conditions, building surroundings, internal room geometry, window size and orientation, window glazing and shadings, and geometry and interior finishings [1].

Total amount of the natural light is distributed into buildings in three ways as the light transmitted directly from the sky and externally and internally reflected components [1,2]. The externally reflected component is influenced due to surface reflectance of the surroundings as the ground and external obstructions. The internally reflected component depends on interior surfaces as wall and floor and ceiling finishes and furnishing.

Shading obstructions as neighbouring buildings, walls, billboards, trees and bushes and ground surfaces etc. at a building site influence indoor visual environment [3,4], They limit sky component but effect externally reflected component of rooms daylighting. Analyses of daylight evaluation show importance of ground reflection for the internal daylight performance [5,6].

Daylighting in building interiors is also influenced due to internally reflected component of daylighting [7,8]. Room geometry and interior colour design [9] and surface patterns are important for inter-reflections and scattering of daylight in the interiors [10].

Indoor daylighting should be optimised with respect of the above mentioned factors of the external and internal reflections [11,12]. Daylight simulations are useful for the design optimisation. The simulations are in many cases carried out for the most unfavourable daylight conditions. It means for the dark ground and overcast sky [13]. In real sky conditions external illuminance variations influences indoor daylighting [13,14]. Also different surfaces of ground as asphalt or concrete pavement, grass, sand or gravel fillings have effect on the external reflective component of indoor daylighting [15].

A snow cover has importance for the ground reflection in annual daylight evaluations, in snowy regions. Values of light reflectance for common exterior and interior surfaces are available for lighting evaluation purposes [16,17]. They can be used as input data for computer daylight simulation. The simulation of daylighting [18,19] in buildings gives possibility of design studies for the best practice of daylighting for indoor visual comfort.

The article is focused on an analysis of daylighting in a residential area influences by different externally and internally reflected components for clear and also overcast sky conditions. Computer daylight simulations were run for the evaluation. The simulation outputs give data for design requirements for daylighting in the side-lit residential areas.

2. Daylight simulations

An influence of externally and internally reflective components on daylighting in a reference room was studied. The study is completed as an analysis of computer simulations of several

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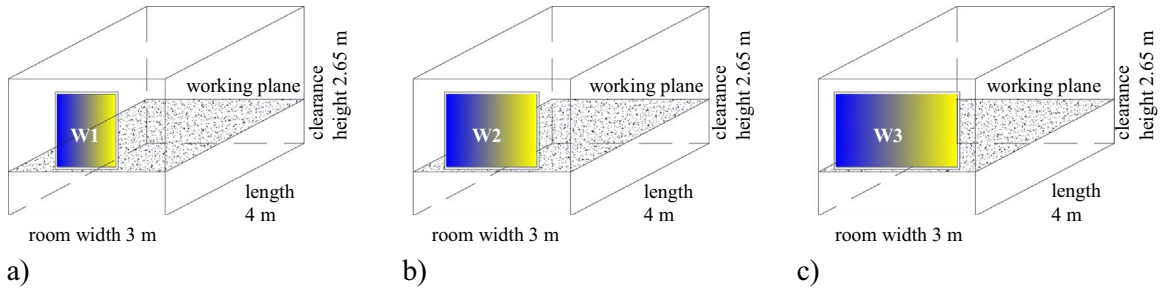

Fig. 1. The reference room with window selected for daylight simulations. a) W1 – window of dimensions 1.2 m × 1.5 m (window sill 0.9 m), b) W2 – window of dimensions 1.8 m × 1.5 m (window sill 0.9 m) and c) W3 – window of dimensions 2.4 m × 1.5 m (window sill 0.9 m).

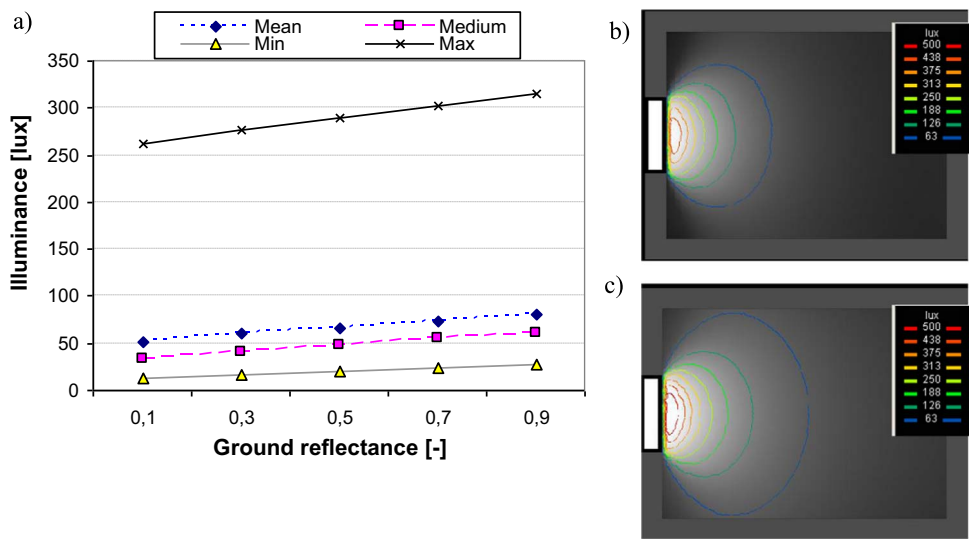

Fig. 2. Illuminance in the room with window 1.2 m × 1.5 m, simulated for different ground reflectance, 21st December, the CIE overcast sky, 12:00. a) Min, Max, Mean and Median values of illuminance for ground reflectance from 0.1 to 0.9, b) working plane illuminance distribution for ground reflectance 0.1, and c) working plane illuminance distribution for ground reflectance 0.9.

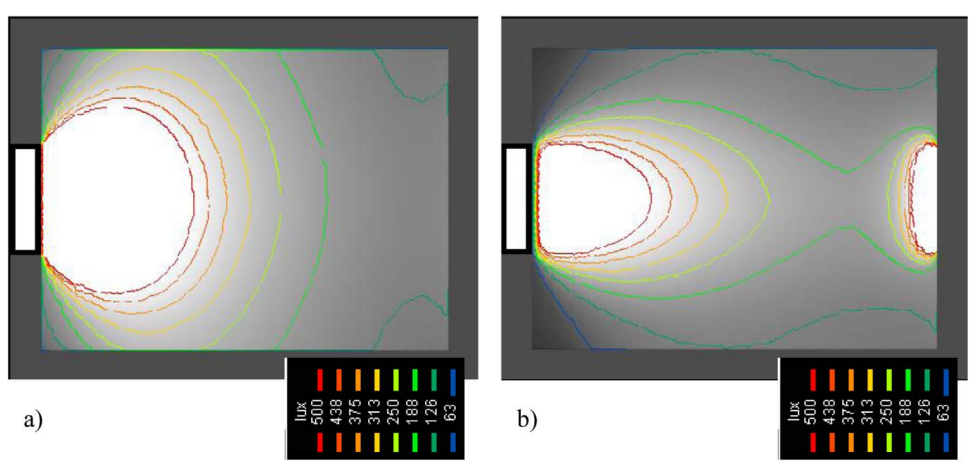

Fig. 3. The room daylighting – illuminance [lx] on the working plane – simulated for the CIE clear sky, South orientation, comparison for the 21st June and 21st December. a) window width 1.2 m, ground reflectance 0.1, 21st June, time 12:00 and b) window width 1.2 m, ground reflectance 0.1, 21st December, time 12:00.

design variations.

The software Velux Daylight Visualizer was used for the daylight simulations [20]. The visualizer is recommended for prediction of daylight levels and appearance of a space lit with natural light in the building design. It offers daylight simulations for a set of fifteen sky conditions. The sky conditions are in compliance with standard general sky models [21]. Velux Daylight Visualizer calculations has been validated against the CIE 171:2006 [22–24]. The software validation was carried out under the CIE TC 3-33 "Test Cases for Assessment of Accuracy of Lighting Computer Programs" that took part in the preparation of the report about assessment of the accuracy of lighting computer programs [22].

The Velux Daylight Visualizer outputs are in compliance with other daylight simulation tools as Radiance, Daysim, Desktop Radiance, IESve, DIALux, Relux, Ecotect, LightCalc [25].

The effects of light reflectance on daylighting were simulated for two extreme cases of external sky conditions overcast sky and clear sky models [26]. The sky models were selected from fifteen