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Assessing and predicting average daylight factors of adjoining spaces in atrium buildings under overcast sky

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ABSTRACT

Daylight use in an atrium is particularly beneficial as the natural light can illuminate potentially dark core areas and decrease energy consumption from electric lighting. This study has investigated, for overcast sky conditions, the horizontal daylight levels in spaces adjoining atria and the vertical daylight levels on atrium well walls in atria. The daylight levels in the rooms and on the walls were derived from scale model measurements, theoretical calculations and predictions from the lighting simulation package Radiance. A comparison of measured data and modelling has validated Radiance simulations of atrium daylighting. The simulations show generally good agreement with theory while some limitations in the calculations used in determining the daylight factors in rooms with large widow area to total wall area ratios were observed. The average daylight levels in rooms displayed a linear relationship with the vertical daylight levels on the well wall. In terms of the well geometry and well façades (decided by the ratio of window area to solid wall area) and well surface reflectance, the variations of daylight level in the adjoining rooms have been analysed and some conclusions and design strategies for supporting preliminary design decisions are presented.

1. Introduction

Daylighting is one of the most significant environmental advantages an atrium can bring to a building. The natural light from the atrium well can not only decrease artificial lighting use but also improve the interior on psychological and ergonomic grounds [1]. According to two reviews [1,2], the daylight levels in the adjoining rooms are significantly influenced by the vertical daylight levels on the well wall and the room properties (size and surface reflectances). The well geometries and surface reflectances are very important atrium characteristics which have a direct effect on the vertical daylight levels at the atrium wall [3,4]. The reviews [3,5] indicated that much of the research investigating daylight in atria has tended to focus upon illuminance levels on the atrium well floor. Studies relating to daylight levels in adjoining rooms and at well walls are less common. Based on a scale-model experiment, Szerman [6] developed a nomogram for calculating the mean daylight factor in an adjoining room. In order to use the nomogram the information required were the room position, atrium width, section-to-aspect ratio SAR (height/depth), atrium wall and floor reflectance and glazing type. Although this nomogram was relatively simple and easy to use, it still lacked some validation and flexibility and it was hard to extend it to general applications [7]. Baker et al. [8] introduced some measured data concerning horizontal illuminances in the adjacent rooms of a square atrium. The results indicated that the rooms near the ground were mainly illuminated by light reflected from the wall and floor whilst the top rooms received most light directly from the sky. Simulation using the lighting software package Radiance [9] studied the daylight factor at one point in the adjoining room of a ground floor in atria with various wall reflectances and well index WI values. The window areas at each floor were proportionally increased from the top to the base, which was an idea suggested by two other studies [10,11]. It was found that increasing the wall reflectance could not significantly increase the daylight level of rooms on the ground floor. This is because the fully glazed wall surface on the ground floor could not reflect more light into opposite or neighbouring rooms. Measurement [12], nevertheless, proved that increasing floor reflectance at the edges of the well did improve light levels in adjacent rooms. For deep atria, the surface reflectance of the well was more crucial for rooms on the lower floors than the higher floors. Most previous studies have tended to focus only on one

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