Daylighting in adjacent rooms connected to an atrium by artificial sky measurements

NOMOGRAPH DERIVED FROM ARTIFICIAL DIFFUSED SKY MEASUREMENT PREDICTS MEAN DAYLIGHT FACTOR IN OFFICE ROOMS CONNECTED TO LINEAR ATRIUM

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Michael Szerman discusses in his CIB Montréal Conference paper an artificial diffused sky for conducting model measurements, all within the framework of the IEA Task XI Project.

Keywords: daylight, atrium, artificial sky

Preface

Within the framework of the German activities in the IEA TASK XI project [1], an artificial diffuse sky for conducting model measurements was designed and built at the Fraunhofer-Institute of Building Physics in Stuttgart [2]. The measurement campaign dealt with the question of how the performance of atria influences the amount of daylight available in adjacent rooms. This chapter explains the artificial skydome, the measurement techniques and the sensitivity study.

Artificial sky

The artificial diffuse sky that has been set up at the Fraunhofer-Institute of Building Physics is presented in Fig. 1. It consists of 85 halogen lamps with diffuse radiation characteristics. Each light source is independently dimmable by a PC, so that different sky luminance distributions can be modelled. The models of rooms or of whole buildings can be placed on a table under the sky. The models may have no floors, as the floor is in a movable connection with the table. On this operable floor, different measuring instruments can be installed. During measurements, the floor is moved inside the model by a computer-controlled robot unit. The robot drives the measurement instrument to defined coordinates inside the room. Thus, it is possible by comparative tests to obtain measured data at the same geometrical position. This is useful for comparing different systems or boundary conditions under the same sky conditions. A schematic drawing of the sky is presented in Fig. 2.

Measurement technique

A miniature photometer can be installed on the movable floor to record the illuminance distribution on any plane in the room. In practice, the measurement is carried out

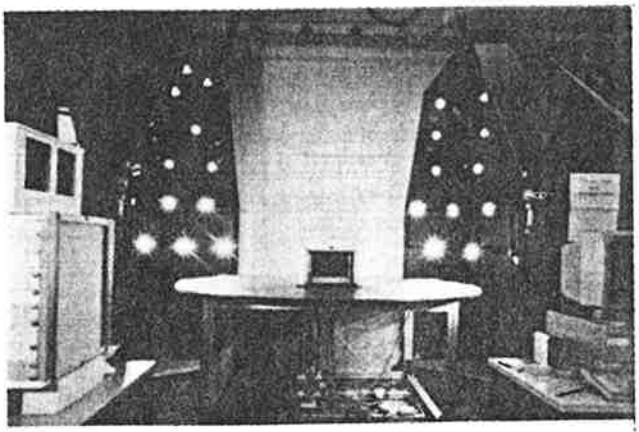

Fig. 1. Photograph of the open artificial sky. Under the table the robot unit, which drives the floor, the photometerhead and the endoscope video camera unit are visible.

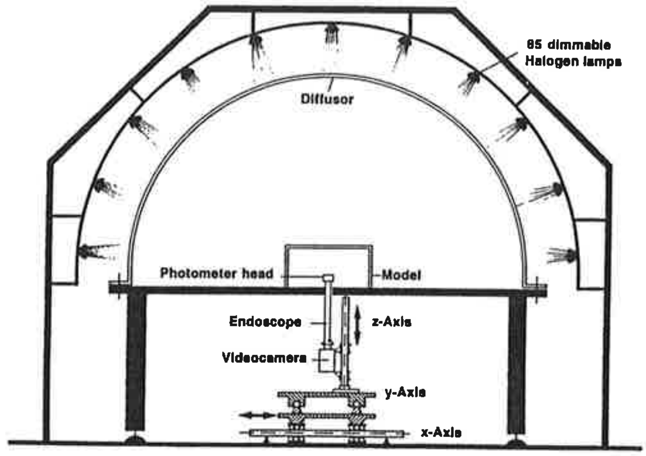

Fig. 2. Schematic drawing of the artificial sky. Each halogen lamp is individually dimmable by a PC. Luminance and illuminance measurements within the models are carried out automatically.

for a horizontal plane at the height of a working place. The miniature photometer head is connected to the robot unit which moves it across the room. The measurement data is recorded when the defined geometrical position is reached. It is possible to execute measurements on a very fine grid (>0.005mm). For a plane in a normal room, the whole procedure only takes a few minutes and is carried out completely automatically.

Besides measuring the illuminance distribution with photometer heads it is possible to record it on the surfaces by means of an endoscope connected to a black/white video camera. The endoscope-camera unit is mounted on the robot and moveable along three axes. The video signal is analysed by a video processing image computer system installed on a PC. By means of a calibration function the luminance of the surrounding surfaces can be measured. The total of 256 grey steps of an image can be processed with a wrong-colour routine, so that different areas with the same luminance with respect to the endoscope lens have the same colour. Areas with a different luminance have different colours.

Table 1. Parameter variations of glazing type reflectivities

Glazing type	
Office	Atria
IR coated/gasfilled	double
IR coated/gasfilled	IR-coated-gasfilled
double	IR-coated/gasfilled

Table 2. Parameter variations of reflectivities

	Reflectance (%)	
Surface	Atria	Office room
Floor	20–70	15
Walls	20–70	50
Ceiling	—	70

Parametric study

The sensitivity study performed within the IEA-TASK XI project [1] is aimed at investigating the influence of the performance of atria on daylighting conditions in adjacent office rooms. The linear type of atrium is commonly used. For this reason, investigations on the impact of different atria variations concerning the daylighting performance of office rooms were carried out with this type of atrium. The measurements were performed in the artificial sky of the Fraunhofer-Institute of Building Physics, Stuttgart, under CIE standard overcast conditions.

In the present sensitivity study the ratio of atrium height (h) to width (w) is varied. In addition, the distance (d)

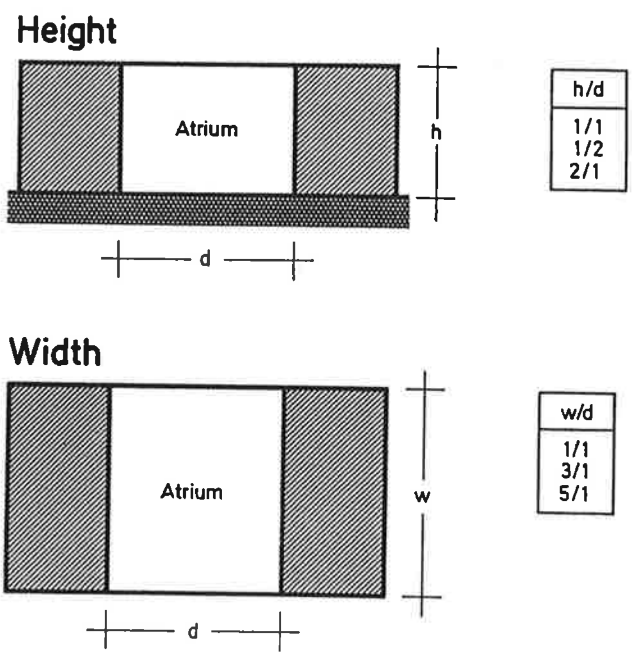

Fig. 3. Parameter variations of atrium height, width and depth.

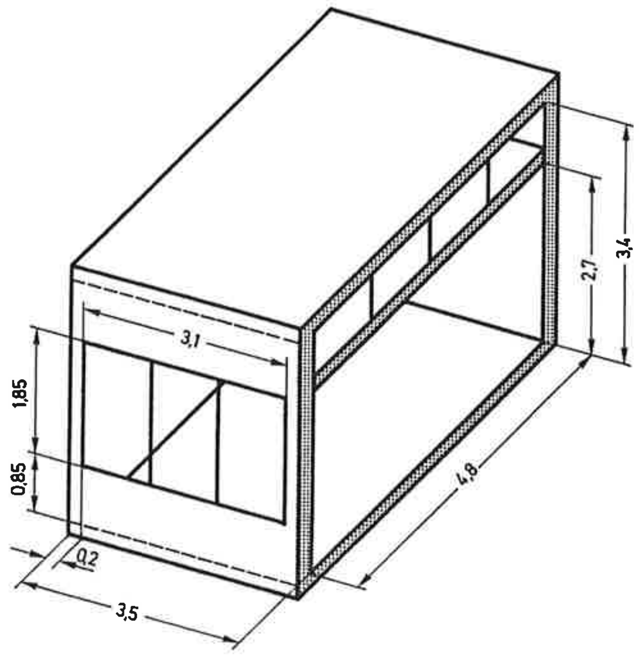

Fig. 4. Geometry of the measured office connected to the atrium.

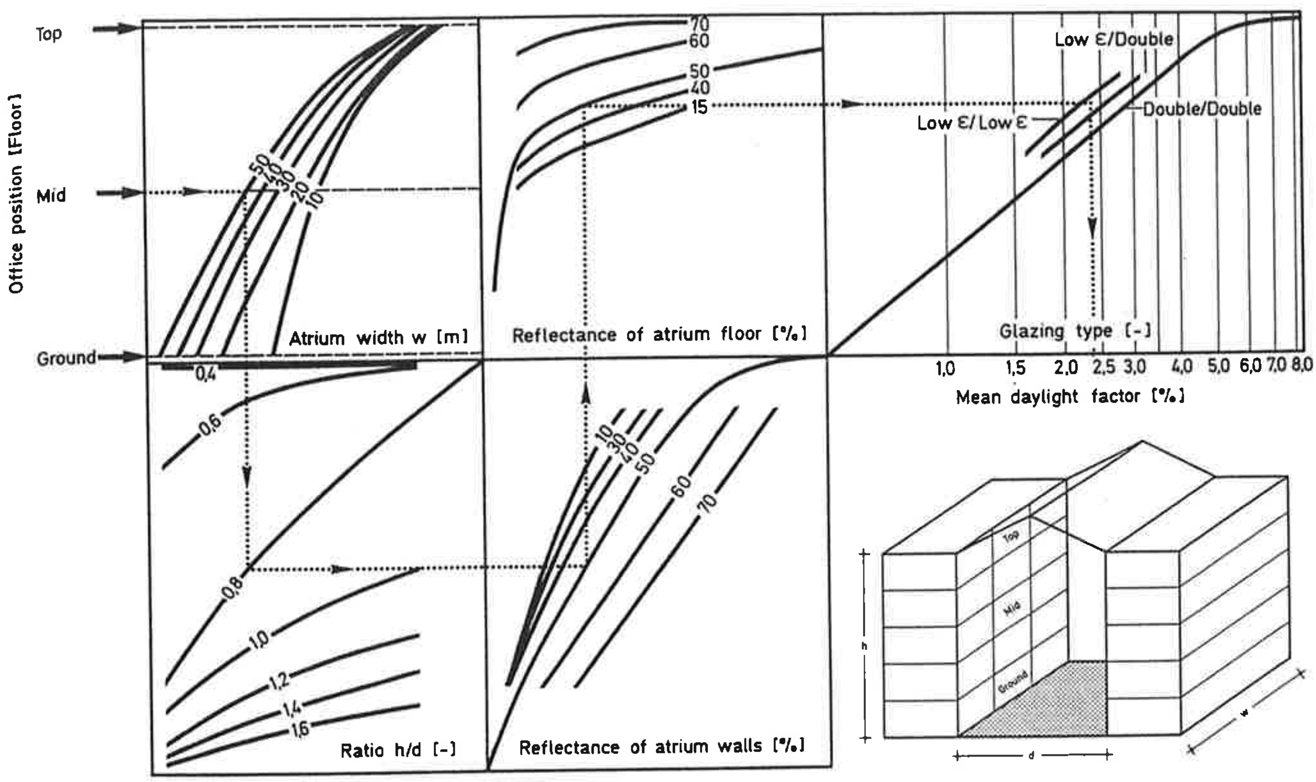

Fig. 5. Nomograph for deriving mean daylight factors of rooms connected to atria. The graph has been constructed from a set of measurements carried out for a wide range of variations in the artificial sky at the Fraunhofer-Institute of Building Physics.

between the two linear office buildings is also varied. These variations can be seen in Fig. 3.

Another parameter under investigation is the glazing type of the atrium roof and the office room windows. Here, normal double glazings (Double) and IR coated/gas-filled glazings (Low-E) are considered variations. Moreover, the reflectivities of the floor and the walls inside the atrium are modified. The different variations are compiled in Tables 1 and 2.

The adjacent room connected to the atrium is a common office with a window/facade ratio of 60%. The dimensions of the room are presented in Fig. 4. The geometry of the adjacent office is fixed for the sensitivity study. The reflectivities of all surfaces inside the room are fixed (15% floor; 50% walls; 70% ceiling). For each variation, the illuminance distribution was measured on the working plane at 0.85cm above the floor.

Results

The daylight factor distribution on a horizontal plane inside an office connected to an atrium is derived from these measurements. For the sake of easy handling, the data have been compiled to give mean daylight factors to describe the result for one single set of variations for a room. All values are condensed into a nomograph (Fig. 5). Even though this nomograph has been derived from a limited number of measurements, it is possible to read the mean daylight factor of a room connected to an atrium for a wide range of variations.

An example of how to use the nomograph

The mean daylight factor of an office connected to an atrium can be read from the nomograph for the following boundary conditions:

- office at centre level of atrium
- atrium depth, 15m
- atrium width, 50m
- atrium height, 12m
- Reflectivity of opaque atrium wall, 50%
- Reflectivity of atrium floor, 50%
- glazing type:

  office–atrium, double
  atrium–outside, low-E

Resulting mean daylight factor, 2.30%

Summary

A nomograph derived from artificial sky measurement data has been developed to predict the mean daylight factor in office rooms connected to a linear atrium. This nomograph can easily be used by architects and designers to obtain information about the impact of different design parameters on the usable daylight in office rooms which are daylit through an atrium.

References

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2. Szerman M. (1989) *Künstlicher Himmel–Quantifizierbare Tageslichteplanung im Entwurfsstadium*, Fraunhofer-Institut für Bauphysik, Kurzmitteilung 174, 16.