*Proc. Conf. on Indoor Climate of Buildings, Štrbské Pleso, Bratislava: SSTP, 1998, p. 79 - 82.*

# ARTIFICIAL SKY: POSSIBILITIES TO EVALUATE DAYLIGHT IN MODELS

Dr. D a r u l a Stanislav
Institute of Construction and Architecture Slovak, Academy of Sciences
9th. Dúbravska, SK - 842 20 Bratislava, Slovak Republic

One of the way to evaluate daylighting in building interiors is to measure it in their models an under artificial sky. At ICA SAS was built the artificial sky with an eight meter diameter. There can be simulated exterior illuminance conditions after the CIE Overcast Sky and the CIE Clear Sky. The moveable artificial sun gives also possibilities to study insolation problems in the buildings.

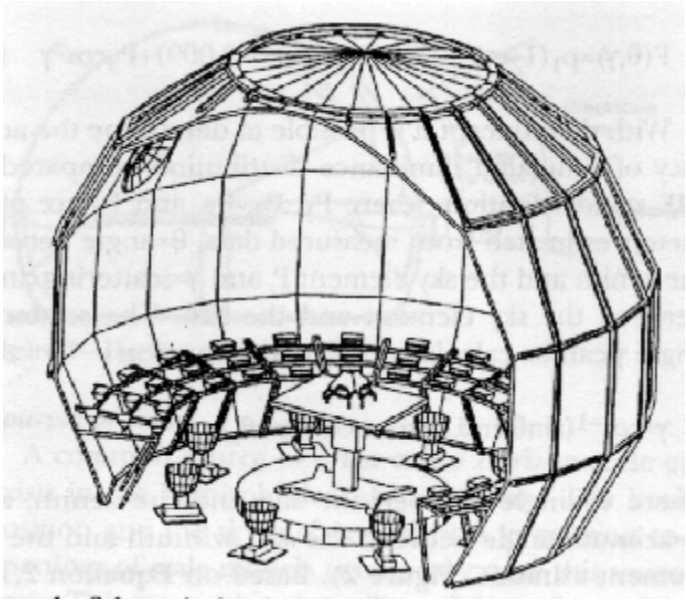

Fig. 1 Schematic drawing of the artificial sky at Ann Arbor, Michigan, USA

Fig. 2 New Japanese artificial sky with sun illuminated by dimmable 853 sky elements

## Introduction

In the past in the daylighting studies of buildings were investigated several ways to define more exactly the description of interior illuminance. The illuminance measurements in real rooms are expensive and can be done only after the designed building is in performance. Daylight in nature changes very often in real time after different cloudiness conditions and therefore its evaluating can be done or compared only under standard conditions. At the same time also measurements under different exterior conditions can give discussable results. The daylight checks are based on the daylight factor after the Slovak standard code STN 73 0580. Daylight factors depend on the luminance distribution on the sky, i.e. under stable and comparable conditions. Researchers in theory of daylight have already formulated several algorithms for daylight calculations in regular rooms and for rectangular windows.
Nowadays architects are designing more and more buildings with different complex plans and different rooms sizes, slope and geometry of windows. In complicated cases the only possibility to check the daylight design is the model measurement under an artificial sky.

In some countries artificial skies were built in experimental laboratories, for example in TU Eindhoven, NISF Moscow, The University of Michigan in Ann Arbor, USA on Fig. 1, Sekisui Housing Research and Development Institute near Kyoto, Japan on Fig. 2, and ICA SAS Bratislava.

## Description of the artificial sky in ICA SAS Bratislava

The artificial sky at ICA SAS is in use for daylight research and model studies for architectural design studies since 1970. Under the ICA SAS artificial sky can be simulated following exterior sky/diffuse illuminance and direct sunlight conditions:
- a CIE Overcast Sky with dark ground characterised by the ratio horizon to zenith luminance of 1:3,
- an overcast sky with snow covered ground defined by the ratio of 1:2,
- the sky with uniform luminance distribution,
- a CIE Clear Sky.

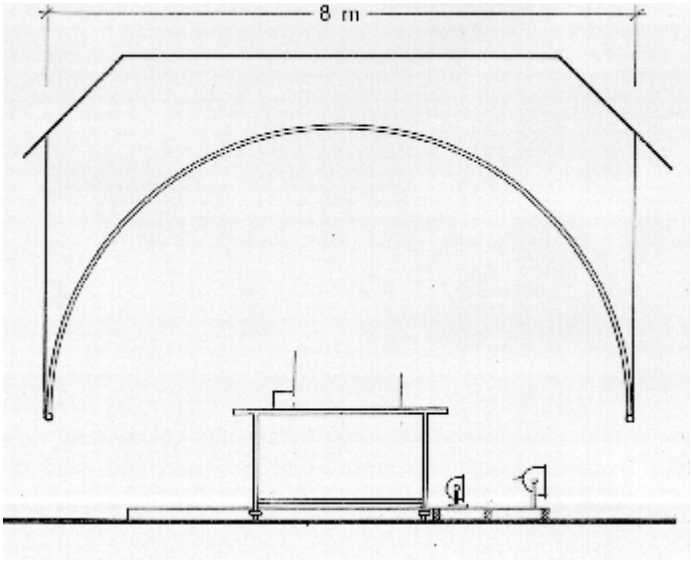


Fig. 3 Scheme of the artificial sky at ICA SAS Bratislava

Fig. 4 Example of the model classroom with an interior photocell, scale 1 : 10

The device consists of the hemispherical dome, 8 m in diameter, artificial sun, i.e. a parabolic mirror with a 1.2 m diameter and a halogen lamp in its focus, under which is a rotating table (size 2.35 x 2.35 m, about 1,45 m above the floor) for placing models and which is illuminated by a set of the lamps, as shown in Fig. 3. The inner reflective surface has ideal reflectance and diffusion properties. Due to the parabolic mirror the artificial sun is simulated by parallel beams. On the measuring table there can be located models of rooms with model obstructions respectively. Inner illuminance is measured by photocells located exactly in checked points of the model, then daylight factors can be calculated. Simultaneously exterior Illuminance is checked separately by a photocell during the measurement session.

## Measurements under the artificial sky

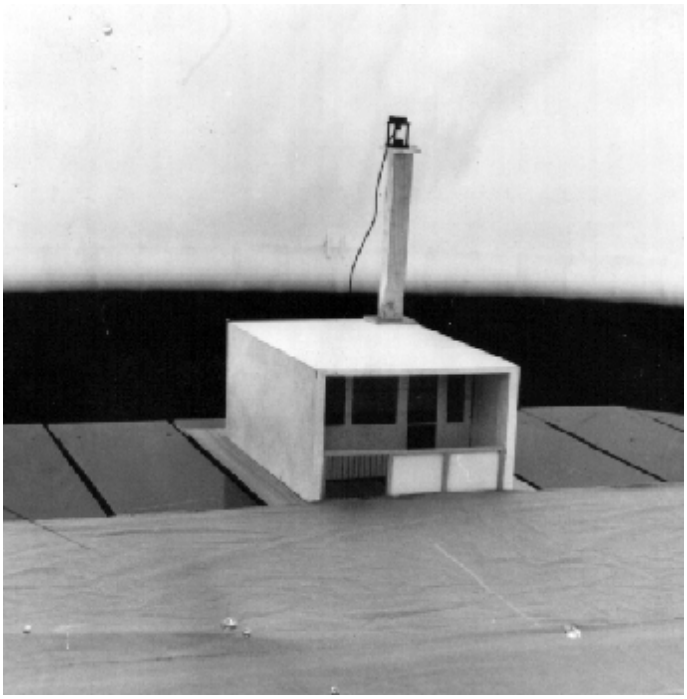

Fig. 5 Living room behind a loggia space in scale 1:10 under the ICA SAS artificial sky dome with exterior photocell

To justify the correctness of measurement results, it is important to determine the model scale, the reflectances of inner and exterior surfaces and the transmitance of windows. The scale model for evaluating daylight can be produced from different materials, usually the walls, floors and ceilings as well as obstructions are made of cardboard, wood or plastic. The surfaces should be covered by paper or painted and their reflectance measured. The model has to be sealed and any penetration of exterior light has to be hindered except the windows. It is useful to prepare prefabricated changeable coverings of the walls and floors for daylighting design studies when several alternatives have to be tested. The model should not be too small, optimal scale is from 1:10 to 1:12, Fig.4 and Fig.5. In many real situations when the new building is placed in the city centre or industrial zone with complicated obstructions the scale has to be modified in accordance with the obstruction situation, Fig. 6. Note that windows of obstructing buildings have to be modelled with their elements and low reflectance.

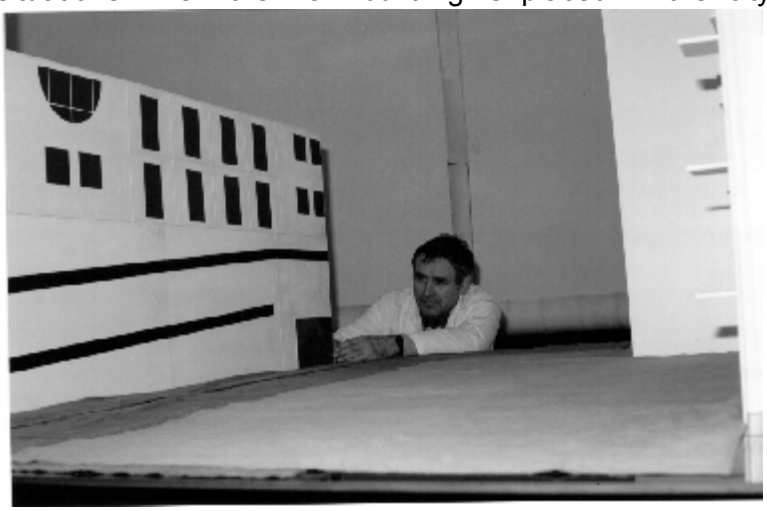

Fig. 6 An installation of the model exterior obstruction in an experiment under the ICA SAS sky

When miniature photocells are used models with scale to 1:20 are acceptable. Glazing or other window transparent material has to be modelled in original width to simulate its transmittance properties.

## Conclusions

The use of small scale models during the designing process is one of the oldest method in daylight design. Scale models provide cheap means of testing alternative solutions changing one variable at a time, e.g. window size, geometry, its placement, orientation, skylight shapes, shading systems or surface properties in interior spaces or obstructions. The measurements under an artificial sky enable to compare measured results with standard code conditions and can represent the only means to evaluate daylight in

buildings of irregular window shape and size, under complicated obstructions and complex properties of window shading.

**Acknowledgement**

The Author is grateful for the support of the Slovak grant VEGA 95/5305/013.

**References**

1. Kittler R.: *New artificial overcast and clear sky with artificial sun for daylight research*. Light. Res. Technol. 4, p. 227-229 (1974).
2. Navaab M.: *Scale model photometry techniques under simulated sky conditions*. Journ. of IES, 1, p. 57-68 (1996).
3. Kittler R., Kittlerová L.: *Návrh a hodnotenie denného osvetlenia*. Alfa Bratislava (1968).
4. STN 73 0580 *Denné osvetlenie budov* (1987).
5. STN 36 0014 *Meranie denného osvetlenia* (1966).
6. Okado M., Goto K., Nakamura H., Koga Y., Fujii S. : Development of a new artificial sky. Proc. Lux Pacifica, E63 - 66, (1997).