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RESEARCH BRIEF 2001/002

Study of Daylight Attenuation through Windows in Urban Environments

The tropical region of the earth presents a unique opportunity of harnessing the abundant natural resources that prevail in these geographical areas, in the form of light and radiation. In the absence of adequate knowledge and the technology of taming this tremendous energy, these resources are being looked upon as a bane rather than a blessing and people in these regions live uncomfortably and unproductively, blaming the sun for the heat and humidity.

Knowing the availability of daylight in quantifiable models is absolutely necessary for the creative use of its potential.

This project successfully developed the sky luminance and total horizontal illuminance models for Singapore, a country with a warm and humid climate, typical of the tropical regions of earth. Also, for its application in building designs, the realistic estimation of the transmission of daylight, which undergoes attenuation as it passes through the deposited dust and the glazing material, is important for the interior design and energy conservation (with daylight integration with the artificial lighting).

INTRODUCTION

Daylight passing through the glazing material of buildings is affected by the deposition of atmospheric pollutants on the glass surface. The airborne pollutants scatter and reduce the sunlight as it passes through the atmosphere. These pollutants, brought by the wind, may stick to any material that comes into contact with them. The deposition of these pollutants on the window glass causes the attenuation of daylight as it enters the indoor environment.

The transmission of daylight through the glazing can enhance the quality of the indoor environment greatly and if the daylight is integrated with the indoor artificial lighting system, substantial energy expenses can be saved. The glazing transmittance is the main property that determines the daylight transmission. All major cities experience a certain amount of air-borne pollution, which will reduce the daylight transmittance of glass. Glass is also used in solar photo-voltaic panels and solar hot water panels, which also

suffer from the attenuation of daylight transmission due to the dirt deposition on the glass surface.

The International Daylight Measurement Programme (IDMP) initiated the collection of daylight solar radiation and relevant weather data in the nineties leading to the development of databases, whereas for design purposes, empirical relations are found to be more useful for optimisation and applications. Thus, in this study, attempts were made to enhance and establish the daylight models for Singapore, which were earlier tried with limited data.

Thus, the research study aimed to:

- Enhance and establish daylight models for Singapore, in view of the proposed 15 standard daylight models for all locations of the world and availability of more comprehensive data.
- Identify the spectral characteristics of daylight transmittance of window glass, when exposed to the outdoor.
- Identify the effects of various weather factors such as the wind speed, direction and frequency, and rain on the daylight transmittance of glass.

METHODOLOGY

The scanned data of sky patch illuminances were analysed to develop improved sky luminance and horizontal illuminance models.

A model room with glass on its four sides and on the horizontal floor was exposed to the outdoor environment and studied for 41 weeks, where the outdoor and indoor illuminances were recorded. During this period, various weather factors such as the wind speed and frequencies, the rainfall and the dust contents of the air were also recorded.

The data recorded were analysed to identify the effects of various weather parameters on the dust deposition on the glass and the effective transmittance of the glass with the dust on it.

MAJOR FINDINGS

Improved sky luminance and horizontal illuminance models for the three prevalent sky conditions, namely, clear, mixed and overcast sky conditions of Singapore and a one-year database of hourly sky conditions from 8.00 am to 6.00 pm were prepared for daylight simulations. Zenith sky models for Singapore for the three prevalent sky conditions have been developed for use with the sky models.

The transmissions of the direct component of daylight were estimated from the spectral transmittance of the energies, obtained with the use of the spectrophotometer and converted into light flux using the photopic visual efficiency function. The dirt components of the transmittances for the studied orientations and the horizontal glass were separated and their variations over the time period of the study were explained with regard to the wind velocity and frequency on a particular orientation and rainfall. The critical velocities at which a dust particle will bounce from the surface were also considered, reviewing the size distribution of dust monitored.

The transmissions of the diffuse component of the daylight were studied by considering the solar geometry. The corrections due to the placing of the light sensor inside the model box were developed. The variations of the diffuse daylight transmissions were again explained with regard to the weather parameters of the wind speed and frequency of a particular orientation and rainfall. The bouncing of monitored dust particles of various sizes were also considered again in the explanation of the variation of transmittances over the orientations.

FUTURE WORKS

The sky models took into account the prevalent condition, but it is still not possible to predict the occurrence of the particular condition. A long-term database of the cloud cover of the sky may be analysed to obtain the probability of a particular sky condition occurring at an hour.

The distribution of the cloud on the sky vault is another factor which has to be understood for the daylight availability on the various orientations of the window glass. There is no data available in Singapore in this regard. It is recommended that a sky mapping system using a digital camera be installed for obtaining data in this regard. The digital data can also be further developed for the control of the glare, probably through online assessment of the sky luminance distribution and digital control of glazing properties.

For the application of the daylight data, it is also important to incorporate the latest sky models in the building energy analysis computer programs, such as DOE2.

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