ABSTRACT

Determining the Daylighting Performances of Atria by the Monte Carlo Method and Ray-tracing Technique

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It is obvious that given many examples, atrium is of great advantage to a building. However, designers should take various factors into consideration with the introduction of an atrium. Designers need to grasp how the indoor lighting condition will be created when daylight and diffuse light are penetrated into an atrium through a canopy system. Predicting the indoor lighting condition in design process, they can deal with the problem of a building and meet the requirements of a building. Accordingly, they need a design tool which forecasts the indoor lighting condition in advance.

Daylighting performance of atrium space is mainly affected by the geometric configurations of atrium itself and canopy system together with the photometric characteristics of canopy glazing. Especially the impact of canopy system on the atrium daylighting is very difficult to evaluate because of the complex geometry and photometric properties. This study was performed to develop a computer model which can accurately estimate the illuminances inside the atrium space. The computer model was developed based upon the Monte Carlo method and Ray-tracing technique. The accuracy of the computer model was validated through measurements with physical scale models under real clear sky conditions.

This study consists of a total of six chapters, and each chapter can be summarized as follows:

In Chapter 1, the background, the purpose, the scope and the method of the study were described.

In Chapter 2, theories related to atrium daylighting were studied. The theories included

Monte Carlo method, ray-tracing technique, and Perez sky model.

In Chapter 3, a computer model for predicting the illuminance values within an atrtum were described. The computer madel was developed based upon the Monte Carlo method and ray-tracing technique.

In Chapter 4, The accuracy of the computer model was validated through measuments with scale models under real skies.

In Chapter 5, a series of computer simulations was performed for various atrium geometries, atrium canopy systems and different dates and hours.The simulation results were summarized into the forms of graphs and tables, which can be easily used by the designers.

In Chapter 6, the conclution of the study were stated.

The study results are summarized as follows :

[1] Determining the illuminance values within atrium spaces with complex-shape canopy systems were almost impossible by the conventional Daylight Factor Method, Lumen Method and Luminous Flux Transfer Method. Especially, determining the illuminance due to the direct sunlight was the most difficult task. However, the ray-tracing technique coupled with the Monte Carlo method effectively addressed the problem.

[2] The accuray of the model developed in the study was verified through physical scale model measurement. The average error of the computer model was less than 5%.

[3] A series of atrium daylighting design tools, such as graphs and tables was developed through computer simulations with various atrium aspects.