ABSTRACT

Developing a Numerical Model to Predict the Performance of Light Collectors in Sunlight Illumination Systems

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A sunlight illumination system is one of the active daylighting systems which can introduce the beam sunlight to spaces where daylight may not be reached naturally. The sunlight system consists of light collectors and light distributors and the performance of the sunlight illumination system mainly depends on the performance of the light collectors.

In this study, a numerical model was developed to predict the performance of the light collectors with different combinations of optic devices, such as concave mirrors, convex lenses and plane mirrors. The numerical model was based on the Monte Carlo method and ray-tracing technique. Then, the accuracy of the numerical model was validated through measurements with a physical model. In addition, major variables related to the performance of light collectors were identified and design tools of sunlight illumination systems were developed from the results of computer simulations for the major variables.

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

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

In Chapter 2, to develop the numerical model for the light collectors, literatures on various daylighting systems were reviewed. The Monte Carlo method and ray-tracing technique were studied in relation with the light theories such as reflection, refraction, and interference. Finally, Perez's sky model was also studied in order to determine the outdoor illuminance levels and sky luminance distributions.

In Chapter 3, the structure of the numerical model was described.

In Chapter 4, the developed numerical model was validated through the measurements with a physical scale model. The result showed that the numerical model had an accuracy higher than 97% for the light collectors with two convex lenses.

In Chapter 5, design tools were developed for light collectors with six different configurations through a series of computer simulation based on the numerical model.

In Chapter 6, the conclusion of the study was stated.

The results of the study can be summarized as follows:

1. The need of the study of mechanical daylighting systems was presented.
2. The photon theory as well as the wave theory were applied to the numerical model.
3. External illuminances on normal surfaces were calculated by the Perez's sky model whose major input variables include measured solar radiation and dew point temperature data.
4. Using Monte Carlo method and ray-tracing technique, light movement in sunlight illumination systems was analyzed.
5. A numerical model to predict the performance of light collectors in sunlight illumination systems was developed as a design tool.
6. The numerical model was verified by a physical-scale model.
7. Sunlight collectors with various configurations were simulated by the developed

computer program. Then, the performances of each light collector were tabulated which can be used as a design tool.

8. Further required research topics were stated.