ABSTRACT

The Development of Design Tools and Guidelines of Daylight Duct Systems for Underground Spaces

Seo, Kwang-Bum
Directed by Prof. Sohn, Jang-Yeul
Department of Architectural Engineering
Master of Science of Graduate School
Hanyang University

Recently, the utilization of underground spaces for various purposes to enhance the land use in urban areas became an important issue. The underground spaces have several advantages over conventional building spaces in terms of physical environment. The underground spaces provide thermally stable environment throughout the year and they are mostly free from exterior airborne noises. However, the underground spaces have difficulties in utilizing daylight for interior illumination. Consequently, without a proper daylighting aperture system, the underground spaces must depend upon artificial electric energy for most of the occupied hours throughout the year. This disadvantage will result in not only a large amount of electric energy for the lighting system, but also significantly increased air-conditioning load due to the heat generated by the lighting fixtures.

In developed countries, research on light admitting and guiding systems such as light duct and fiber-optic systems have been being lively conducted in order to create more energy-efficient and visually comfortable underground spaces. In Korea, research on environmental control systems for underground spaces is still in its initial stage and proper design guidelines have not been fully developed. Therefore, this research focuses on developing design tools of daylight duct systems for the creation of energy-efficient and visually comfortable underground spaces. To achieve this goal,

this research depends upon computer simulation and physical scale model experiments in order to identify key parameters that affect the daylighting performance of daylight duct systems and the interrelationships between the parameters. The products of this research will include computer models and a group of tables and graphs which can be used by building designers at the initial design stages.

The main contents of this study are as follows;

In chapter 1, the background, purpose, scope and method of this study are described.

In chapter 2, the basic theories about daylighting systems, methods of daylighting analysis and luminous efficacy are described.

In chapter 3, the algorithm, which based on luminous flux transfer rates and Geometry of solar angles and size of daylight ducts, to predict luminous flux transfer rates of vertical rectangular daylight ducts is described considering not only diffuse sky conditions, but direct sunlit conditions as well.

In chapter 4, the numerical model is validated through scale model measurements under various skies with different solar angles are described.

In chapter 5, method and results of scale model measurements which were performed to predict illuminance levels on work plane in underground space with various vertical rectangular daylight duct systems were described. This graphs are made through scale model measurements.

In chapter 6, the computer simulation for various vertical rectangular daylight duct systems and underground spaces was performed with exterior illuminance data which were converted by luminous efficacy and direct and diffuse solar radiation data.

In chapter 7, the results of this study are described.

Through these procedures, following results have been obtained.

[1] The numerical model was developed to predict luminous flux transfer ratios,

which is the ratio of output flux to input flux, of vertical rectangular daylight wells with diffuse inside surfaces under not only diffuse sky conditions, but direct sunlit conditions as well.

[2] The accuracy of the numerical model was examined through scale model measurements under various skies with different solar angles. Results showed that the percent errors between calculated values and field measured values were less than ±5% .

[3] The optimum number of grid elements, which can quarantee 95% of accuracy, were suggested for different sky and sunlight conditions as shown table 4.5, 4.6 in chapter 4.

[4] As a result of scale model measurements for various underground space with various daylight duct systems, graphs were made to calculate illuminance level by direct and indirect components in underground spaces with daylight duct systems.

[5] As design tools to predict and evaluate daylight effects in underground space with daylight duct systems, graphs that predict the luminous flux transfer ratios of vertical rectangular daylight duct were made by computer simulation(chaper 6 and index 1).

.