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A Study of Applicability of a-Si PV Window System to Apartments Considering Daylighting Performances

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Abstract. This study evaluated the applicability of the transparent thin-film PV window system to apartments. Considering daylighting, the optimum ratio of installation area (500-2500lx of indoor illuminance secured) was 50% of the maximum installable area for window systems, accounting for about 7.3% of power consumption per apartment unit (based on 84m^2 in floor area). Therefore, it appears that the transparent thin-film PV window system would be applicable to apartments.

Keywords: Building Integrated Photovoltaic, illumination, Daylighting, Daylight-Factor, Generating efficiency, Apartment house

1 Introduction

To evaluate the applicability of the transparent thin-film PV module-based window system to apartments, this study attempted to quantitatively assess the daylighting performance and power-generating efficiency of the PV window system through simulation analysis and Mock-up test.

2 Analysis methods

The overview of the analysis on this study which evaluated the daylighting performance of the PV window system with a goal of applying the transparent thin-film PV window system to apartments is as follows:

(1) For the selection of PV module and Mock-up configuration, the following simulation was conducted: (Ecotect 2011, SQU1)

First, the maximum window area for the installation of the PV window system was calculated, and annual mean insolation was estimated against a total of 206 apartment units in Korea.

Second, to estimate the optimum application ratio for the PV module which is applied to the transparent thin-film PV window system, housing performance (indoor

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illuminance) and power-generation efficiency according to the standard scope (UDI-a(500-2,500Lx)[1)] were estimated.

(2) After configurating a Mock-up which reflected the simulation results, insolation and power generation output by the time zone and indoor and outdoor illuminance were collected and analyzed. Based on the Mock-up test results, annual mean insolation of apartments estimated in the clause (1) above and power consumption[2)] acquired through a literature survey, the applicability of the transparent thin-film window system to apartments was evaluated. (for the data on power generation output used in this analysis, the inverter efficiency (96%) was applied to the collected DC power generation output.)

3 Analysis results

3.1 Design of the PV module area for window system through simulation analysis

(1) Simulation results

According to simulation on a total of 206 apartment units, the maximum installable area for the PV window per apartment unit (based on 84m^2 in floor area) was 18m^2, and annual mean insolation was 446.5Wh/m^2.

In addition, illuminance simulation on 58 different types was conducted by increasing the PV module application ratio for the living room window (based on 84m^2 in floor area) by 10% from the top and bottom of the window each.

The analysis found that the maximum application ratio for the PV module enough to secure at least UDI-a(500-2,500lx) within a 2m space was 50% (bottom).

(2) Window configuration based on simulation results

The size of the transparent thin-film PV window system was set to 1,300x1,100mm in consideration of the size of living room and balcony windows in Korean apartments (206 units) within the scope of the maximum production for the PV module.

The application ratio for the PV module applied to the test was divided into three types: Type 'A' (100% PV module) which considered power generation performance only, Type 'B' (50% PV module) in which at least UDI-a(500-2,500lx) of indoor illuminance was secured considering both daylighting and power-generation performances and PV module-less Type 'C' (100% transparent glass). All three types were fitted with low-e triple glass.

3.2 Verification and applicability assesment through Mock-up

(1) Results of illuminance analysis on PV window system

The height of the illuminance surface was measured at 450mm (living room) and 850mm (bedroom) in accordance with the apartment work plane standards (KS A 300:

Illuminance Standards). The measurements by the depth (distance from the inner glass surface to the indoor measuring point) are shown in Figure 1 below:

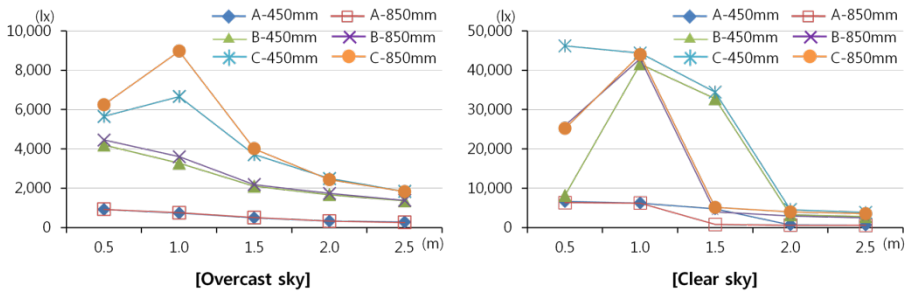

Fig 1. Results of Indoor Illuminance Measurements

According to the measurement of indoor illuminance, 500lx or higher was observed in all measuring points under clear sky conditions. In overcast sky, UDI-a(500-2,500lx) or lower was found at the measuring point of 1.5m or above in Type 'A' (PV 100% window).

(2) Analysis on the power generation output of PV window system

According to analysis on power generation efficiency according to insolation and power generation, the maximum power generation under clear sky conditions was 137.5W so that the power generation efficiency to insolation intensity ratio has been analyzed as 6.7%. On the other hand, the maximum power generation under overcast sky conditions was shown as 2.7W so that the power generation efficiency to insolation intensity ratio has been analyzed as 0.1%.

When simulation was conducted considering this fact, 14.6% was observed in Type 'A'. In Type 'B' in which indoor illuminance was considered, 7.3% was found.

4 Conclusion

This study can be concluded as follows:

(1) According to the selection of optimum ratio for PV modules based on simulation, the percentage in which UDI-a(500-2,500lx) or higher of illuminance can be secured within a 2m space was up to 50% (bottom).

(2) According to a Mock-up test, the power-generation efficiency of the PV module was 6.7% at maximum compared to insolation intensity. In Type 'A' in which power generation performance was only considered, a maximum of 14.6% of power consumption per apartment unit (based on 84m^2 in floor area) was observed. According to analysis on daylighting performance, UDI-a(500-2,500lx) or lower at

1.5m or deeper. Therefore, it was disadvantageous in terms of daylighting performance.

In case of Type 'B' in which daylighting performance was considered, UDI-a(500-2,500lx) or higher of indoor illuminance was secured in overcast sky conditions through a Mock-up test, accounting for about 7.3% of power consumption per apartment unit (based on 84m^2 in floor area). Therefore, it would be applicable to apartments.

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