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UNCERTAINTY AND SENSITIVITY ANALYSES ON SOLAR HEAT GAIN COEFFICIENT OF A GLAZING SYSTEM WITH EXTERNAL VENETIAN BLIND

Jeong-Yun Lee
Young-Sub Kim
Cheol-Soo Park

Department of Architecture and Architectural Engineering,
College of Engineering, Seoul National University
1 Gwanak-ro, Gwankak-gu
Seoul, 08826, SOUTH KOREA

ABSTRACT

This study compares the static vs. dynamic solar heat gain coefficient (SHGC) of a glazing system with an external venetian blind. For many engineering applications, static SHGC has been still widely used. The authors aimed to investigate the difference between the two SHGCs (static vs. dynamic). For this purpose, “pyWinCalc”, developed by US LBNL was employed to simulate the dynamic thermal behavior of the system. The Sobol sampling was conducted for uncertainty and sensitivity analyses of the SHGC. It was found that the variation in SHGC depending on the slat angles as well as uncertainty in SHGC is significant.

1 INTRODUCTION

The solar heat gain through transparent building envelopes has a significant impact on building energy consumption. External venetian blinds have been widely used as one of the most effective shading devices to reduce transmitted solar radiation into indoor spaces. The shading effect of a venetian blind is usually expressed as solar heat gain coefficient(SHGC), defined as the ratio of the solar heat gain through the window and the solar radiation incident on the window. It is known that SHGC is influenced by many factors such as slat angles, material properties (reflectance and absorbance) of slats, and environmental boundary conditions (direct and diffuse irradiance, and wind velocity). However, existing calculation methods and standards of SHGC are based on a steady-state boundary condition with the direct irradiance value at a normal angle. This static SHGC approach could cause the performance gap between predicted vs. measured energy use because it cannot take into account the aforementioned dynamic environmental changes. In this study, the authors aim to investigate the uncertainty and sensitivity of SHGC calculation of the blind system (Figure 1).

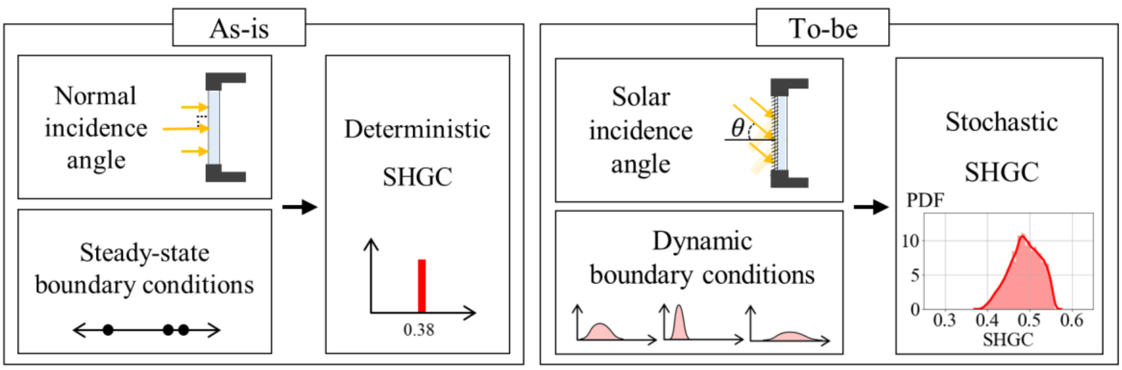

Figure 1: deterministic (as-is) vs. stochastic (to-be) SHGC calculations.

2 METHODOLOGY

For a case study, the authors selected a south-facing window system located in Seoul at 1:00 pm on June 21st. The system consists of two layers of interior and exterior clear glazing (6mm) with a 12mm air gap with external venetian blinds (slat width: 50mm, spacing: 50mm, thickness: 0.02mm, tilt range: -90˚ to +90˚(0˚: horizontal, the angle decreasing when rotating toward the sky). "pyWinCalc" developed from WINDOW Calc Engine by LBNL was used. For uncertainty and sensitivity analyses, 14,400 samples were generated using Sobol method, one of the global sensitivity analysis methods. The Sobol method provides the sensitivity indices of input parameters using the conditional variance of the output (Saltelli et. al, 2008). The following parameters were used for the Sobol sampling: outdoor air temperature, indoor air temperature, direct and diffuse solar radiation, outdoor wind velocity, and direction.

3 RESULTS AND CONCLUSION

The results are summarized as follows:

- Variation in SHGC: *The degree of variation in SHGC* according to slat angles is significant (Figure 2). In most building energy certification processes, there is no *set-in-stone slat angle* of external blinds. This could be one of the reasons for the performance gap. Figure 2 will be also beneficially used for optimal control of motorized external blinds.
- Uncertainty in SHGC: The uncertainty of SHGC is expressed as the ratio between the standard deviation and the mean SHGC denoted by υ in Figure 2. Figure 2 shows that dynamic SHGC must be introduced in building simulation tools, instead of using static SHGC.
- Sensitivity of SHGC: When slat angles are positioned toward the ground (60 ˚, 80 ˚), the wind velocity becomes more influential than the others (Table 1).

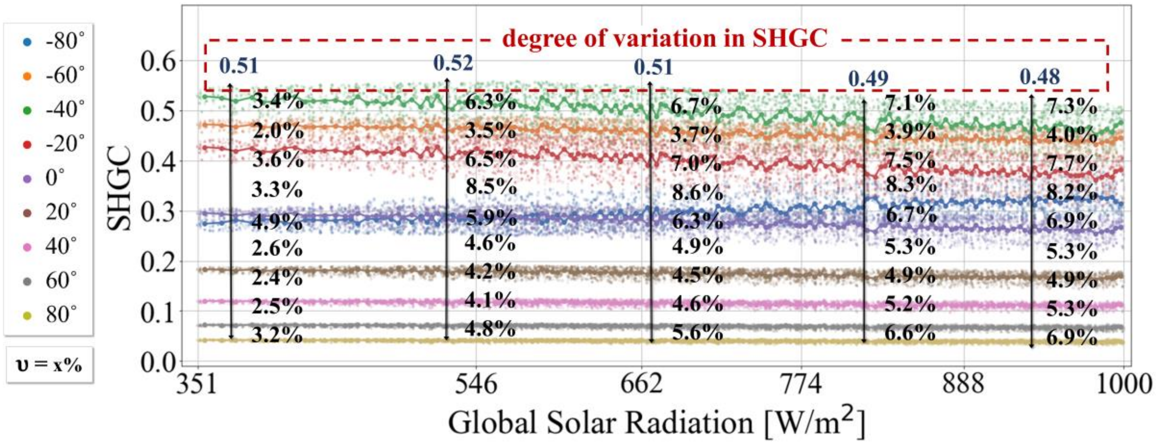

Figure 2: Global solar radiation and SHGC at nine slat angles.

Table 1: First order sensitivity index from Sobol.

Slat Angle	-80 ˚	-60 ˚	-40 ˚	-20 ˚	0 ˚	20 ˚	40 ˚	60 ˚	80 ˚
Direct Solar Radiation	0.69	0.68	0.68	0.68	0.67	0.65	0.60	0.48	0.32
Diffuse Solar Radiation	0.30	0.30	0.30	0.30	0.29	0.28	0.26	0.22	0.15
Wind Velocity	0.00	0.01	0.01	0.01	0.01	0.04	0.11	0.25	0.44

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