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A Fundamental Study about Development of the Guideline of Shading Design by Energy Simulation in Office Building in Korea

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Abstract

The area of window is increasing by the design trend and prefer of exterior of buildings. So the heat gain and heat loss through the window were increased. For theses reason, the researcher studied the methods about improvement of window performance. But the performance of window has property of glazing, so the performance of window has limited to envelop of buildings. Because of window is transmission body, the effect of solar radiation is very important. The shading installation in office buildings has attention for blocking solar radiation. Actually the designer hard to design of shading to energy saving. So the designer need to the guideline of the shading device design. Also these guideline should contain the regulation and existing guideline of windows in Korea. The guideline of shading design needs utility and easily understanding. Also this guideline should have quantitative reliability.

In this study, the authors proposed the shading design guideline of easily understanding. That is contained the energy simulation results. By the energy simulation, the authors confirmed the variation of energy consumption by various window performance and design plan. As a results, the authors developed the shading design guideline through the energy simulation analysis of design and various performance factor.

Keywords - Window; Shading device; Guideline; Office building; Window performance factor

1. Introduction

The area of window in building is increasing by various reason and the effort for energy saving is increasing too. In the ratio of window area increasing, the heat gain and heat loss through windows was increased because the difference of property between window and wall in buildings. In this situation, the energy consumption of heating and cooling for the comfortable indoor environment was much affected to outdoor environment. Especially, the influence of the heating and cooling energy consumption was affected the performance of window.[1]

The performance of window was classified to thermal insulation, air-tightness and solar heat gain. Generally the thermal insulation performance and air-tightness performance lead to energy saving by isolation indoor and outdoor. So these performance should be enhanced. But the window performance of solar heat gain has some different influence of the indoor environment by season. So the designer must be careful about choice of the SHGC of windows.

However the energy saving through the improvement of window performance is not easy. Because energy saving by window, the remodeling of windows need the expensive cost and long period of remodeling. So the shading or sunlight control devices for reducing solar heat gain on summer daylight have attracted attention. The property of shading has many different by the installation location, shape and material of shading device. Therefore the prediction of energy saving by use of shading device is difficult. Figure 1 shows the horizontal shading devices on windows.

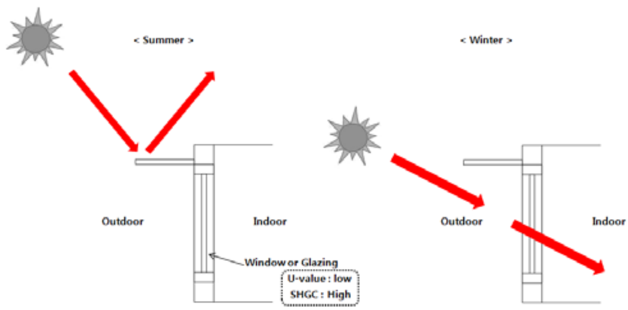

Fig. 1 Ideal concept of Shading & Window role

It shows the need of shading devices through the different angle of sunlight in seasonal. These shading device blocked direct sunlight on cooling season. Besides this horizontal shading, other shading device could be controlled the quantity of solar radiation through windows too.[2]

In this study, for development of guideline of shading installation or design, the authors confirmed the performance factor and the regulation in Korea. Also authors determined a range of guideline and regulation by preliminary considerations. An authors proposed the understandable guideline form for designer and builder of shading devices through referenced existing windows design guideline. For the shading device design guideline, authors simulated the heating and cooling energy consumption by variation of performance factor and shading devices installation. Also they confirmed the variation of energy consumption by simulation results. Finally they developed the guideline and proposed the guideline.

2. Regulation and consideration for the development of guideline

In this chapter, authors confirmed the range of guideline and the factor of guideline through an review about regulation of the shading devices installation in Korea.

'Building Energy Conservation Design Standard' was published by Ministry of Land, Transport and Maritime Affairs and was enacted on January 11, 2008. The purpose of this standard was to determine about energy savings of buildings. Recently, the limitation of the shading devices installation has been added by revision. This standard proposed the solar heat gain coefficient(SHGC) through the ratio of the incident solar radiation at windows per incoming solar radiation at indoor. And this standard considers the cooling load reduce by shading devices. In this standard, for reduce the incoming solar radiation at indoor, shading devices separated exterior shading, interior shading and the between glazing shading by the position of shading installation. Also shading devices distinguished the fixed and movable by operation weather. Movable shading devices mean manual type, electric type and the sensing operative type. For advantage of new building, this standard accepts the ratio of the shading installation that shading devices have the value of 0.6 of SHGC. Then this standard proposed the minimum level of thermal insulation performance at envelope of buildings. In case of window, this standard proposed the minimum U-value by region differences. Table show the U-value level of window by region differences[3].

'Green Building Certification Criteria' is the certification system of KOREA government for reduces greenhouse gases in buildings. The object of this certification system is a new building. In this certification system, the shading device installation was evaluated to the methods of reducing glare. In case of horizontal shading installation, this system proposed minimum length(P) of horizontal shading devices. Where, P is the length of horizontal shading. H is the horizontal length to shading from the bottom of the window and A is the meridian altitude in summer(90-latitude+23.5)[4].

In the building design phase, these guidelines can be used to reference but it is hard to confirm to quantity of the energy saving by use shading devices. Also because some contents of guideline are out of range of standard and certification system, the guideline is hard to applying to real.

3. Energy consumption analysis through energy simulation

In case of the shading devices installation at buildings, the effect of shading could be change by the window performance and the design plan. Therefore before development of guideline, the author confirmed the variation of energy consumption by changing the various factor through energy simulation.

In this study, authors performed to energy simulation through referenced 'The Window Design Guideline for Energy-saving of Buildings'[5]. The simulation tool was used COMFEN. COMFEN is façade design tool. Also COMFEN could be confirmed the annual heating and cooling energy consumption by changing the window performance, window component and shading devices installation through the unit space modeling. The object space selected the unit space by 'The Window Design Guideline for Energy-saving of Buildings' and precedent study. So the number of window, position and size was selected too. The size of unit space is 6 m(W) × 4.5 m(D) × 2.7 m(H). Table shows HVAC system, temperature set point, indoor load, U-value of façade wall and simulation period. Also the orientation of object space is cardinal point north, south, east and west. The area of windows at façade wall is 20% ~ 80% than façade wall. The weather data was provided from the Korean Solar Energy Society. Finally, the results show the sum of heating and cooling energy consumption.

In case of constant the window performance, author confirmed the variation of the energy consumption by changing the design plan like a orientation and window to wall ratio(WWR). Also the case of constant design plan, author confirmed the variation of the energy consumption by changing the window performance.

The window performance are 2.1 W/㎡•K of U-value and 0.6 of SHGC. These value are satisfied the minimum window performance of Seoul from 'Building Energy Conservation Design Standard'. By the result of energy simulation, based on 40% of WWR, the energy consumption was decreased 11.2~24.5% in WWR decreasing 20%, the energy consumption was increased 26~52.8% in WWR increasing 80%. By these result, authors confirmed that the energy consumption has increased by WWW increasing in constant the window performance.

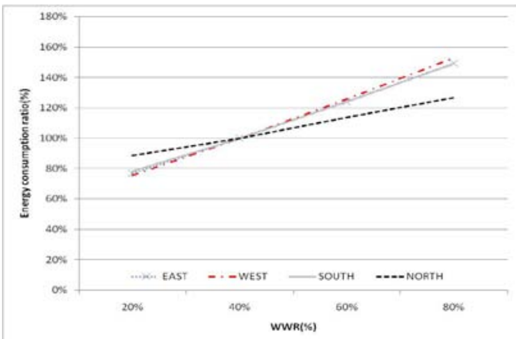

Fig. 2 Simulation Results by WWR and Orientation

The U-value of window could be critical to heat gain and heat loss through envelope of buildings. So the low value of U-value could be helped to the reducing energy consumption. For confirm to the variation of energy consumption of heating and cooling by decreasing the U-value of windows, author confirmed that the case of minimum U-value of window in standard(CASE 1) changed to the case of decreasing U-value of window. Table shows the cases.

By the simulation result, case of decrease 2.1 W/㎡•K to 1.8 W/㎡•K of U-value, authors confirmed the drop of consumption 2.2% of minimum to 3.2% of maximum by

East, West and South. But the case of North, author confirmed the energy consumption decrease 2.6% ~ 8.1% by WWR. That reason is high quantity of solar heat gain through window than heat loss of the window of the thermal performance in summer season. So the case of North has the low energy consumption because the low effect of solar radiation.

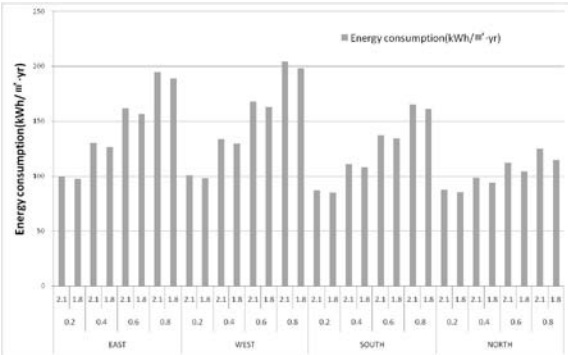

Fig. 3 Energy consumption by various performance factor and orientation

In case of the SHGC change 0.6 to 0.4, the energy consumption decreased 35% ~ 18.7% by various WWR in East, West and South facade. But the case of North facade slightly decreased 0.6% ~ 2.8% of energy consumption. By these results, the case of North has slightly effect about the control of SHGC on windows than other orientation.

In case of the shading device installation, authors was analyzed the energy consumption in buildings. The simulation case has used the horizontal shading device as a shading device on window. So the installed the shading devices, the energy consumption was decreased 2.8% ~ 21.7% by WWR in the East, West and South facade. The energy consumption has reduced 0.3% ~ 1.4% in North facade. Therefore the case of north facade has not enough effect of the shading device installation like the case of changing U-value of the windows.

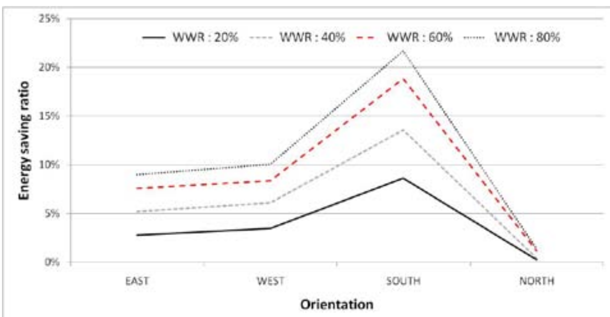

Fig. 4 Energy saving ratio by orientation and WWR

4. Propose to guideline of shading design

By the preceding simulation results, the authors developed the guideline of shading device design that is suitable intention of designer. So this chapter has explanation of that guideline. Because the design of facade in building needs to abide by regulation in Korea, the guideline should contain the regulation details. Therefore authors show the quantity of energy saving and various index of various case about energy saving in guideline. Also authors expressed the standard case of 40% WWR and minimum performance of window in the Korea regulation. The figure showed guideline by the energy simulation results.

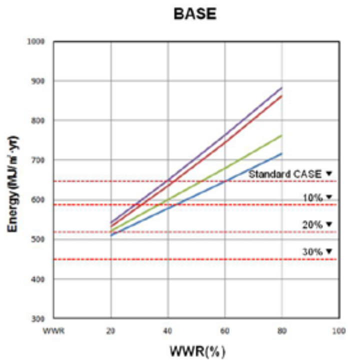

Fig. 5 Guideline by energy simulation results

5. Conclusion

In this study, authors confirmed the variation of energy consumption by various performance factor through energy simulation. For the practical guideline, authors developed the shading device design guideline for the energy saving design. This guideline could help the design of shading design in Korea.

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