First International Conference on Sustainability and the Future
FISC2010

Paper's No. BUE-FISC2010-152

Evaluation of daylighting performance of window glazing in office buildings

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ABSTRACT:
The lighting energy load generally accounts for about 30% of the entire electric energy consumption in common buildings. The lighting energy can be dramatically decreased by using sunlighting system in commercial buildings depending upon sky conditions. Daylighting can improve the luminous quality of indoor environment. For designing good daylighting, light should be placed where it is desired and avoid excessive contrasts, glare and high quality light. This study aims to evaluate window performance different with different glazing materials. For the purpose, applied with 4 different types of glazing materials; clear glass, clear coated low-e glass, blue coloured glass and blue low-e glass. An identical configuration of unit space has been same sized and had same size windows but glazing material was differently arranged. The models were simulated during 12pm to 4pm at 1hour interval. In the conclusion part, lighting performance analyzed difference from glazing material, based on simulation result as expected not surprisingly. The results indicate that indoor illuminance and uniformity were influenced by photometric characteristics of glazing material.

Conference Topic: The Earth/Desert/Green and Sustainable Buildings
Keywords: Daylighting, Window, Glazing, Office building, RADIANCE

1. INTRODUCTION:

Energy saving is an important issue in nowadays. In an entire industry has been practicing energy conservation. Buildings are major driver for energy consumption. Office buildings produce 30% of energy consumption. And the lighting energy load generally accounts for about 30% of the entire electric energy consumption in common buildings. In Korea the most of modern office buildings had glass façade. The glass façade is transmitting much sun light than any other finishing material. However, glass façade cause energy loss in buildings because the heat transmission of the glass is high. In Korea, the subject of ongoing research is mainly on the thermal performance of glass and windows. Previous studies focused on thermal performance to reduce energy loss. Finding glazing material effects to indoor visual environment has not studied. This study aims to evaluate window performing of difference from glazing material using RADIANCE software.

2. RESEARCH METHOD:

The unit size was 12.0m × 8.0m × 3.24m. It was determined according to a paper which described present architectural planning considerations from 115 tall office buildings in the world(Cho. 2006). The window size was 9000×2490, 22.41m^2 (22.8 percent of floor area) and the orientation was south. The interior reflectance of floor, wall, and ceiling are set as 85.5%, 59.5%, 36.7%. All variable were same except the window glazing material because evaluate daylighting performance defends on window glazing.

In this paper, to predict the difference from season in daylighting performance, a set of simulation was carried out based on various seasons, 3/21(spring equinox day), 6/21(summer solstice), 12/22(winter solstice). Between spring equinox day and autumnal equinox day (9/21) were in error by less than 5.7%. From the result this paper use only spring equinox day data. Table1 shows the daylighting analysis options.

The Optic5 is a support program for analyzing optical properties of glazing systems. In this study, 12 types of window (all of the available windows and glasses from Energy-Plus data set and OPTIC5 library) were chosen. Window setting was based on doublepane glazing developed to triple-pane glazing and quadruple-pane glazing. Clear glass, clear coated low-e glass, blue colour glass and blue low-e glass were used.

Table.1 Daylighting analysis options

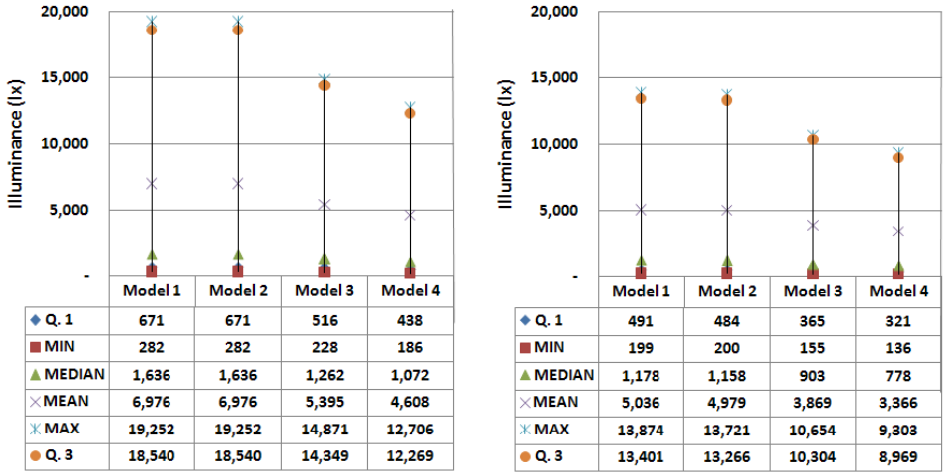
Option	Details	
Size	12.0m×8.0m ×3.24m	
Time	GMT+9 Japan, Korea 12:00 to 16:00	
Month/ Day	3/21, 6/21, 12/22	
Orientation	South	
Location	Seoul, Latitude 37, Longitude -127	
Sky Condition	Clear, Overcast	
Surface Reflectance	Floor	85.5%
	Wall	59.5%
	Ceiling	36.7%
Window type	Double glazed window, Triple glazed window, Quadruple glazed window	
Pane type	Clear (4mm, 6mm), Low-e (4mm, 6mm), Blue (6mm), Blue low-e (6mm)	

3. RESULT AND DISCUSSION:

3.1 Lighting performance in winter solstice Site:

Figure 1 shows the light performance within windows under clear sky conditions. The model1 and model2 have the highest illuminance value (19252lx) at 12:00 pm. It also has a very high average illuminance value (6976lx).

The triple-pane glazing, model1 has the highest illuminance value (5036lx) between them. The average illuminance value was 4313lx with triple-pane glazing.



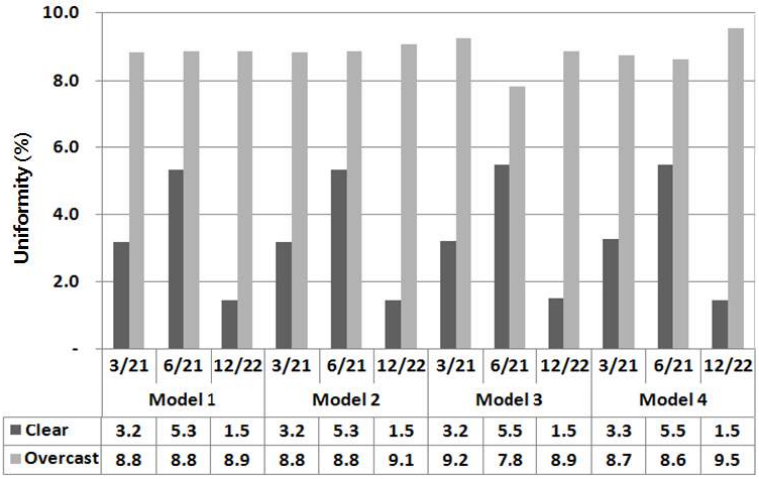
	Model 1	Model 2	Model 3	Model 4
Q. 1	671	671	516	438
MIN	282	282	228	186
MEDIAN	1,636	1,636	1,262	1,072
MEAN	6,976	6,976	5,395	4,608
MAX	19,252	19,252	14,871	12,706
Q. 3	18,540	18,540	14,349	12,269

	Model 1	Model 2	Model 3	Model 4
Q. 1	491	484	365	321
MIN	199	200	155	136
MEDIAN	1,178	1,158	903	778
MEAN	5,036	4,979	3,869	3,366
MAX	13,874	13,721	10,654	9,303
Q. 3	13,401	13,266	10,304	8,969

Fig.1 Indoor illuminance (Clear sky conditions)
Left: Double-pane glazing, Right: Triple-pane glazing.

3.2 Uniformity:

Figure 2 shows the uniformity double glazed window under clear and overcast sky conditions. The uniformity did not change significantly under overcast sky condition. Also, uniformity of all models under clear sky condition was changed by solar altitude.



	3/21	6/21	12/22	3/21	6/21	12/22	3/21	6/21	12/22	3/21	6/21	12/22
	Model 1			Model 2			Model 3			Model 4		
Clear	3.2	5.3	1.5	3.2	5.3	1.5	3.2	5.5	1.5	3.3	5.5	1.5
Overcast	8.8	8.8	8.9	8.8	8.8	9.1	9.2	7.8	8.9	8.7	8.6	9.5

Fig.2 Uniformity (Double glazed window)

3.3 The relation between visible transmittance and indoor illuminance:

Figure 3 shows the relation between visible transmittance and indoor illuminance. The graph means visible transmittance (Tvis) has effect on average indoor illuminance. Generally Tvis is proportion to average illuminance.

The model 4 is an exception. In this case, window glazing changes double-pane glazing to triplepane glazing, indoor illuminance decreased proportionally. But triple-pane glazing to quadruplepane glazing is different. The illuminance has been decreased not much as double to triple.

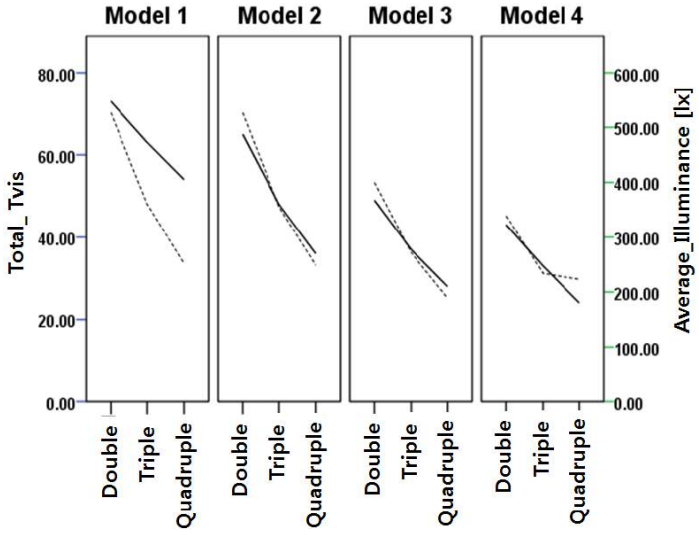


Fig.3 The relation between Tvis and average indoor illuminance (clear sky)

4. CONCLUSION

The purpose of this study was to evaluate window performing of difference from glazing material. The conclusion of this paper is as follow.

1. All quadruple glazing did not satisfy KS-A3011: the office space illuminance criteria under overcast sky it has a problem to use sunlighting in office. Also all three type window did not satisfy IESNA criteria.
2. Uniformity of all glazing combination was not different under clear sky condition.
3. The simulation result of triple glazing and quadruple glazing (model 4), average illuminance difference was spring equinox day: 4lx, summer solstice: 7lx, winter solstice: 8lx. So that triple pane glazing and quadruple-pane glazing has lighting performance. So when chose the glazing material for energy saving, the thermal performance needs to considered.

Furthermore, evaluating energy performance and visual environment of difference from glazing material will be discussed in further study.

Acknowledgement

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (No. 2010-0001860)

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