

Luminance Characteristics of an Interior Space with Three Different Sized Model

Seung heon Baik¹, Jeong Tai Kim²

¹Kyung Hee University, Yongin, Korea, paint1999@naver.com

²Kyung Hee University, Yongin, Korea, jtkim@khu.ac.kr

ABSTRACT:

Mock-up model can be applied to measure accurate performance data but difficult to apply the variables in experiment. There can be a slight experiment errors in Scale model, but various parameters can be applied for a objective experiment. This paper aims to compare the daylighting performance in 1, 1/5, 1/10 scale model of offices and analyze the experiment errors to certificate the influence of model experiment. To analyse daylighting performance, a comparison of a Mock-up model, sized 12.0m(w)x7.2m(l)x3.7m(h), designed for experimentation of day lighting systems and its 1:5, 1:10 scale model. Measurement was conducted at a point viewing the window part from the rear end of outdoor center-line so that window part, ceiling plane, left and right wall plane and floor plane could be measured. And luminance of window, rare of the room was measured under clear sky. It is to be monitored by the Radiant Imaging ProMetric 1400.

Keywords: Mock-up model, Scale model, Daylighting system, Luminance

1. INTRODUCTION

IEA SHC Task21 has suggested an international monitoring protocol which tests the performance of lighting by comparing the result of tests conducted at a laboratory equipped with a mock-up model identical with the lighting system under the sky with the result of tests at the standard room not equipped with such a mock-up model. As a weak point of such mock-up models, it is difficult to apply diverse variables to the tests using mock-up models, as indoor conditions, such as the shape, materials and reflexivity of the building, as well as exterior conditions, such as direction, prospect and location, are fixed from the stage of design. Unlike a model to observe

such conditions as thermal environment, dynamic structure, sound and ventilation, to test performance of natural lighting, a scale model does not require a reduced scale like an actual object.

On the other hand, scale model tests allow us to obtain quantitative data of lighting and evaluate inner space through visual observation. In addition, it is easy for scale model test to compare alternatives, as it allows us to apply many variables to test.

For such reasons, this study is purposed to compare indoor luminance of office space for different model scales (1, 1/5, 1/10) and analyze experimental errors to find the effect that model scales have on the precise estimation of lighting performance and their utility.

2. EXPERIMENTAL METHODOLOGY

2.1 CONFIGURATION OF MODELS



Figure 1. Configuration of Models

The mock-up model was installed on the rooftop of the Technology Building, K University in compliance to the international standard. The room was made in the size of 4900x7200x2580mm. The interior was finished with materials with relatively light color.

Two scale models were made in scales of 1/5 and 1/10, and in the same shape and material as the mock-up model. However indoor walls made of plywood instead of sandwich panel were finished with the same color and reflectivity.

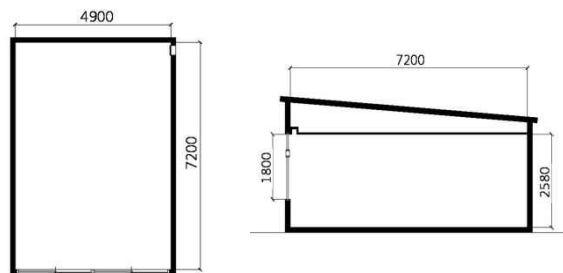


Figure 2. Plan and Section of Mock-up

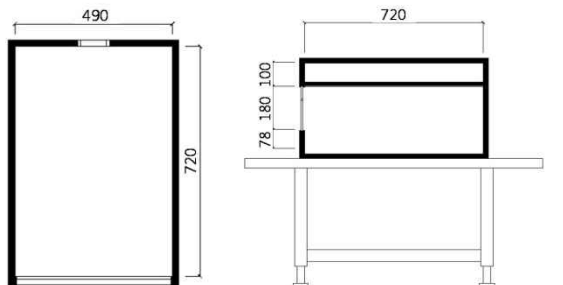


Figure 3. Plan and Section of scale model

Windows were configured to a double window (4800×1800mm) of a view window and a lighting window. Low-E glass, which is generally used for office windows, was used for the lighting window and the view windows of the room.

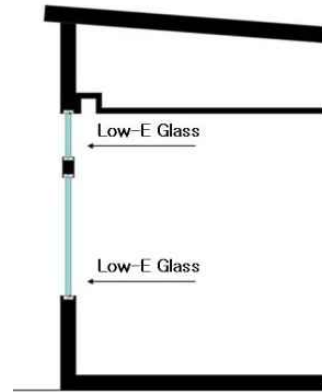


Figure 4. Window system

2.2 EXPERIMENTAL ARRANGEMENT

The three models were installed on the rooftop clear of obstacles of the Technology Building, K University in a row to the same direction so that the same conditions could be ensured to all of them.

Indoor luminance was measured at the state of clear sky with an outdoor daylight illuminance of over 50,000[lux]. Sky luminance of the outdoor horizontal plane was also measured. Interior surface luminance of reference room and test room of mock-up model, 1/5 scale model and 1/10 scale model was measured from 11:50 to 13:00, December 4.

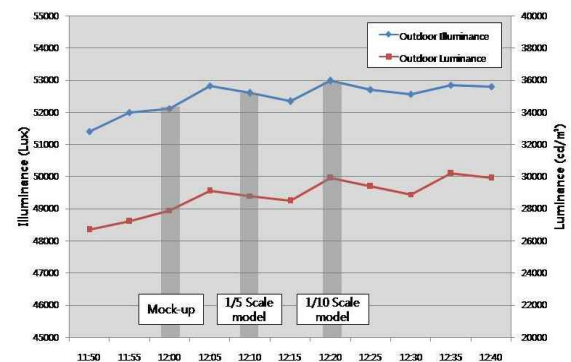
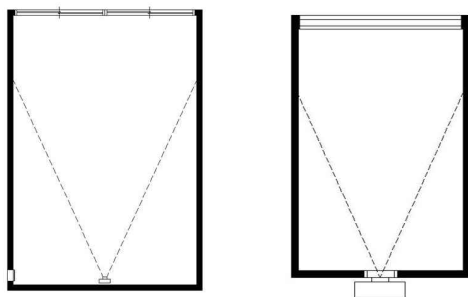


Figure 5. Sky Condition and period of measurement

Measurement was conducted at a point viewing the window part from the rear end of outdoor center-line so that window part, ceiling plane, left and right wall plane and floor plane could be measured. Radiant Imaging ProMetric developed by US-based Radiant Imaging Inc was used in the measurement of luminance and images obtained from the measurement were analyzed using an analysis program.



(a) Mock-up (b) 1/10 Scale model

Figure 6. Luminance Measurement

3. RESULTS

3.1 COMPARISON LUMINANCE OF THREE DIFFERENT SIZED MODEL

The analysis of indoor lighting performance subject to model scale began from reference room. Figure 8 is the graph showing analysis of indoor surface luminance for various parts of reference room of the three models. Luminance values measured from three models show slight difference, with the biggest difference in the window part.

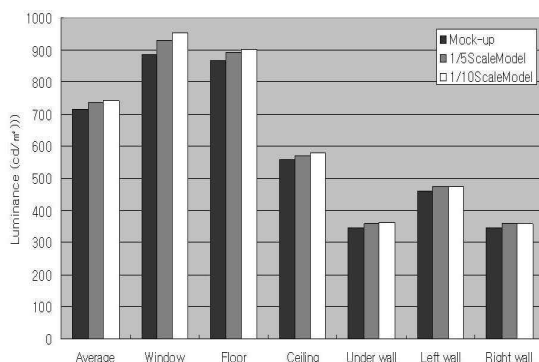


Figure 7. Luminance of Interior spaces

Comparison of indoor surface luminance of the mock-up model with that of 1/5 scale model showed an average difference of 3.2%, 1/5 scale model showing higher luminance value than mock-up model. In the comparison of luminance values for parts, the window part showed the highest difference (4.7%) and the ceiling plane the lowest difference (2.7%). Comparison of luminance of the mock-up model with that of 1/10 scale model showed an average difference of 4.1% and on the whole, showed higher luminance values.

Luminance difference at the window part was the highest, with 7.4%, that of the floor plane 4.2%, the wall part under the window 4.0% and that of the right and left wall planes was the lowest, with 3.0%.

Indoor surface luminance for the mock-up model was measured against the window part in the room, while that for scale models was impossible to measure in the room as the measuring instrument was too big to use indoor. For the reason, there may be slight error in the range of measurement and it seems that variance in azimuth of sun and exterior sky luminance at measurement have caused difference in luminance values between models. It also seems that the window part showed the highest difference because the sky view, ground reflexivity and object of view vary depending on the location of models.

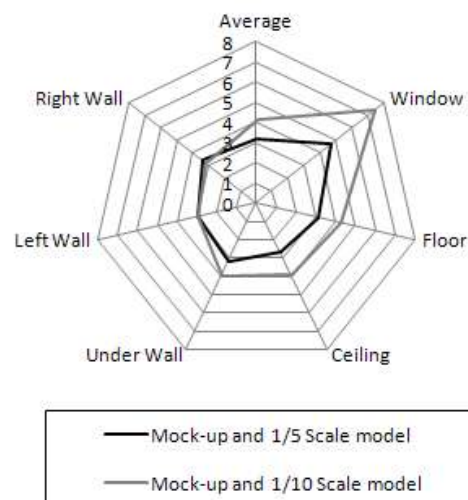
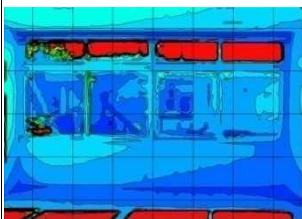
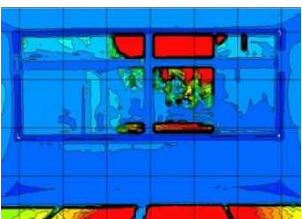
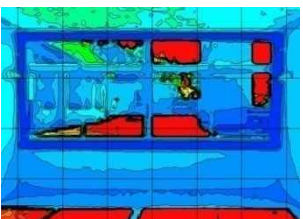


Figure 8. Luminance Difference of Interior Spaces in Scale Model With Mock-up(%)

	Mock-up Model	1/5 Scale Model	1/10 Scale Model
Photo			
Outdoor Illuminance (lux)	52,110	52,340	52,560
Outdoor Luminance (cd/m ²)	27,900	28,500	28,900
Indoor Luminance (cd/m ²)			
Average	714	737	743
Window	888	930	954
Floor	867	894	903
Ceiling	557	572	579
Left Wall	461	475	475
Right wall	348	360	359
Wall under window	348	359	362

4. CONCLUSION

To obtain more precise measuring values, it is required to make scale models and lighting systems in identical shapes with the same materials and reflexivity, and express details. To reduce margin of error, it is also required to consider changes of the sky view viewed from the window plane, ground reflexivity and direction angle of the sun.

To find more precise margin of error in daylighting performance in future field measurement and model tests, it is required studies about how to compensate indoor surface luminance depending on the changes of outdoor horizontal daylight luminance as well as experiments about diverse variables, including sizes varying depending on location, height of scale models, prospect element, state of the sky and model proportion of luminance sensors, and analysis of error factors generated from natural lighting tests using such data.

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