

Luminance Characteristics of Interior Space with Lightshelf in Scale Models and Mock-up Model

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ABSTRACT:

This study is purposed to compare interior luminance of office space equipped with lightshelf 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. A comparison of a Mock-up model, sized 12.0m(w)x 7.2m(l)x3.7m(h), designed for experimentation of daylighting systems and its 1:5, 1:10 scale model. The sloped type lightshelf system was designed as 10mm transparency sheet glass, tilt angle degree 29°, and total sized 1.28m (interior length 0.88m, exterior length 0.49m). 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. It is to be monitored by the Radiant Imaging ProMetric 1400 under clear sky.

Keywords: Mock-up model, Scale model, Lightshelf, Luminance

1. INTRODUCTION

Daylighting system effectively applied to architecture can save energy as well as improve visual conditions and efficiency of work, while if improperly applied, it could cause waste of energy and visually unpleasant feeling. It is necessary to carry out research on advanced daylighting systems designed to enhance the high effectiveness daylighting system. However, It is very hard to test the performance of the daylighting system under the sky, as the state of the sky, the height and azimuth of the sun change incessantly. According to the IEA SHC Task21 suggestion, developed countries, such as the US, the UK and Switzerland, have made mock-up models of international

standard and have been testing performance of diverse lighting systems.

Mock-up model can be applied to measure accurate performance data but difficult to apply diverse variables to the tests using mock-up models. On the other hand, There can be a slight experiment errors in Scale model, but it allows us to obtain quantitative data of lighting and evaluate inner space through visual observation.

Therefore, this study is purposed to compare luminance characteristic of office space equipped with lightshelf for different model scales 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

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. 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 interior walls made of plywood instead of sandwich panel were finished with the same color and reflectivity.

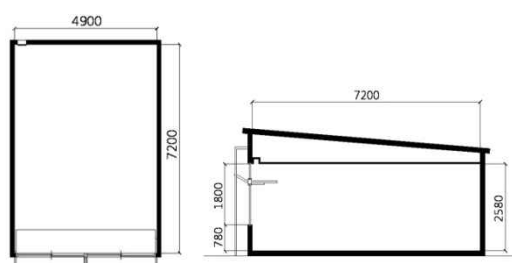


Figure 1. Plan and Section of Mock-up

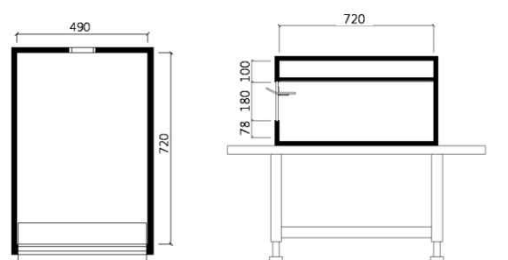


Figure 2. Plan and Section of scale model

2.2 LIGHTSHELF SYSTEM

A lightshelf system was installed at the bottom of the lighting window of the room. Lighting system of the lightshelf in the laboratory of the mock-up model was set at 29 degrees at the exterior considering the southing altitude of the sun at the winter solstice and horizontally at the interior. The system had a length of 810mm at the interior and 390mm at the exterior. For light

reflection to the interior of room, MIRO-4 reflecting film with a reflexivity of 97% made by Germany-based Alanod was attached to galvanized sheet iron and the lighting window was made of plain glass with a good transmittance and for the view window of the room was Low-E glass which is generally used for office windows. Lighting systems for scale models were reduced in proportion of the system in the mock-up model and reflecting film of the same materials was attached to have the same light reflexivity.



Figure 3. Lightshelf system

2.3 EXPERIMENTAL ARRANGEMENT

Interior 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. 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.

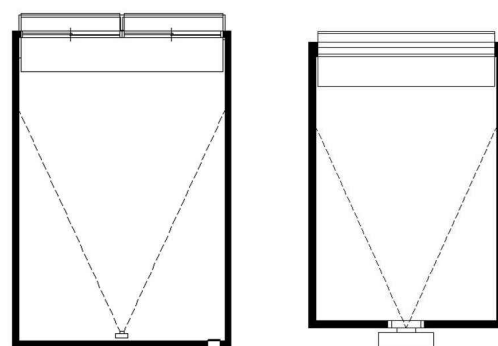


Figure 4. Luminance Measurement

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.



Figure 5. Measurement Instrument

3. RESULTS

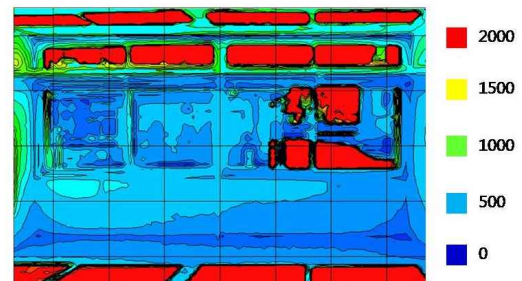
3.1 COMPARISON LUMINANCE OF THREE DIFFERENT SIZED MODELS

To analyze differences of variation rates of interior surface luminance resulted from the installation of lightshelf, variance rate of interior surface luminance measured at the interior space of the mock-up model was compared with that measured at spaces of 1/5 scale model and 1/10 scale model.

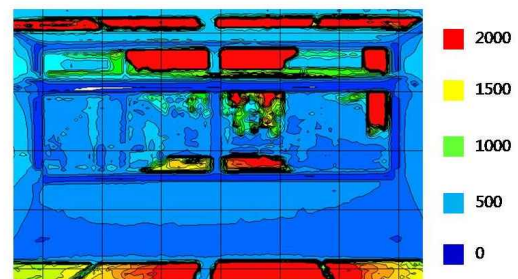
Table 1. Interior Luminance at Three Different Sized Models (cd/m²)

	Mock-up Model	1/5 Scale Model	1/10 Scale Model
Outdoor Luminance	29,100	29,900	30,200
Average	940	975	988
Window	1,054	1,110	1,138
Floor	998	1,032	1,040
Ceiling	1,626	1,716	1,695
Left Wall	503	518	519
Right Wall	441	455	457
Wall under Window	422	437	440

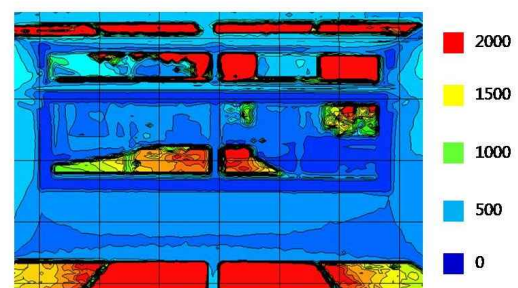
Figure 6 is the diagram of analyzed interior surface luminance of the interior space in respective cases equipped with lightshelf at the three models.



(a) Mock-up Model (cd/m²)



(b) 1/5 Scale Model (cd/m²)



(C) 1/10 Scale Model (cd/m²)

Figure 6. Interior Luminance of Three Different Sized models

Comparison of variance rate of interior surface luminance at the mock-up model and the 1/5 scale model owing to the install of lightshelf showed a difference of 5.3% on average and the 1/5 scale model showed higher variance rates than the mock-up model on the whole. Especially the window plane showed the highest variance rate (8.4%) and the ceiling plane, to which the direct rays of the sun is reflected from the lightshelf system, relatively high variance

(7.0%). Wall planes on the right and left side showed the lowest variance of 2.2%. Comparison of the mock-up model and the 1/10 scale model showed an average variance as high as 7.5%, higher 2.2% than 1/5 scale model. In variance rates for parts, the window part showed the highest variance of 10.8%, and the wall planes and floor planes showed variances ranging from 4.4 to 5.4%.

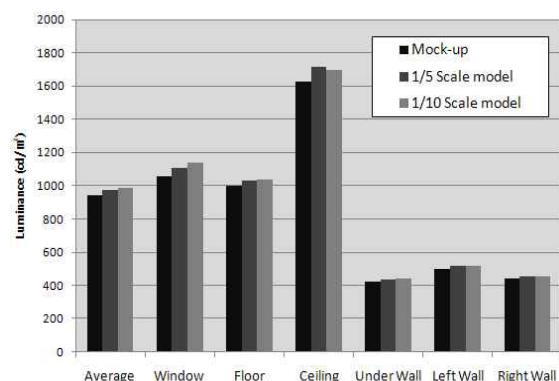
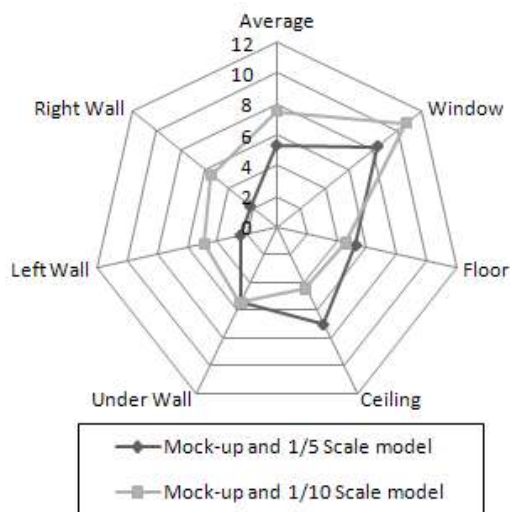


Figure 7. Interior Surface Luminance of Parts at Three Different Sized Models

Figure 8. Luminance of Scale Model



comparing with Mock-up by Lightshelf(%)

4. CONCLUSION

Such variances in interior surface luminance are deemed to have originated from an error in measuring range due to the size of equipment, and difference in

materials, color and detail shape of the lighting system.

Variances in luminance values for parts seems to have originated from the change of direction of the direct rays of the sun due to the changed altitude and angle of direction of the sun at different measuring times. Like the comparison of surface luminance in the room, the window planes are deemed to have shown variances more than any other parts due to variances of sky view and ground reflexivity depending on the location of models.

Finding of precise margin of errors between mock-up model and scale models through tests of daylighting performance would contribute to enhancing the efficiency of lighting system for buildings and improvement of visual environment and working efficiency.

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