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A Preliminary Study on Daylighting Performance of Light Shelf according to the Depth of Space

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Abstract. The existing researches relating to light shelf did not play the role of basic data when designing light shelves for various sizes of indoor spaces as they have mostly dealt with factors of simple light shelves. Thus, this study aims to draw optimal solution for light shelf and correlation with depths of spaces by conducting performance evaluation in consideration of factors of depth of space and light shelf and to establish basic data for designing light shelves based on the result. As the result, it has been drawn that the standard of the optimal light shelf for depth of space is a light shelf with 0.3m width and adjustable angle, and this is meaningful in the aspect that it is the result through the factor which is the depth of indoor space where the occupant is located.

Keywords: Light-Shelf, Depth, Performance Evaluation

1 Introduction

The amount of energy consumed in buildings is in increasing trend, and the ratio of energy consumed for lighting among energy consumption of buildings has been pretty high. This leads to the highlighted necessity of a variety of researches and technology development for reducing lighting energy. Among such various systems, light shelves have been suggested as the solution for reducing lighting energy as its efficiency has been recognized for the system allowing exterior natural lights deeply into indoors through reflection. However, the previous researches have been carried out focusing on performance evaluation for the factors relating to the performance of light shelves with fixed size of space. Recently, due to introduction of the concept of flexibility of interior space together with various types of spaces resulting from the needs of residents, the size of interior space is not fixed but rather flexible in various forms, which requires changes in the existing researches focusing on factors of light shelves. Thus, this research aims to draw optimal solution for light shelf(light shelf:L.S) through performance of light shelves for the various sizes of spaces and, based on such result, to be utilized as the basic data for designing light shelves.

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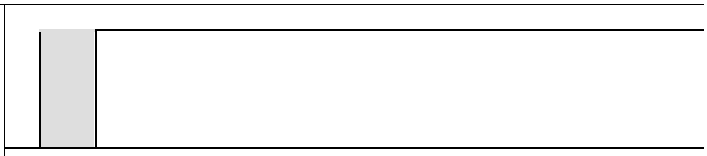
2 Set up of Performance Evaluation of L.S for Depth of Space

2.1 Setup of Depth of Space and L.S

Table 1 conveys the setup of depth of space and L.S

Table 1. Setup of Depth of Space and L.S

Minimum unit space / Changes of spatial depth			
Reflectivity	Ceiling:74.99%, Wall:55%, Floor:25.1%		
Window Area Ratio / Glass Material	2.0m x 1.8m / Pair-glass with 12mm thickness, penetration ratio:80.82, clear colors		
Height	Angle	Width	Reflectivity
1.8m	0˚, 10˚, 20˚, 30˚,	0.3m, 0.6m, 0.9m,	85.77%

2.2 Position for Measurement of Illuminance for Performance Evaluation

Figure 1 conveys the position for measurement of illuminance for performance evaluation. Also, each time the depth of space was increased by 1m, I added 24 measurement spots. For the outside environment, due south, the summer solstice were applied to the performance evaluation.

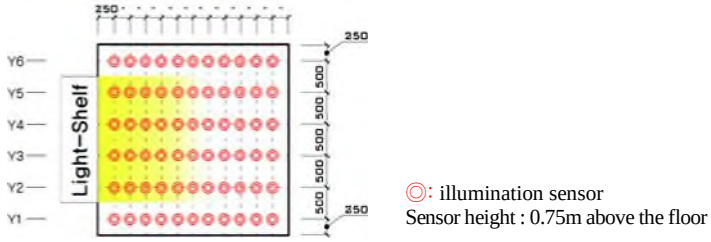


Fig. 1. Illuminance measurement for evaluating daylighting performance of the L.S

3 Result of Performance Evaluation of L.S for Depth of Space

The result of performance evaluation for the angle and width of L.S for the depth of space on the summer solstice is as follows: Firstly, as shown in Table 3, in the case of not installing any L.S on the summer solstice, the standard illuminance 400lux is

satisfied in overall for the depth of space up to 3m, and in the case of installing L.S, the depth of space that satisfies in overall the standard illuminance 400lux depending on the width and angle of the L.S is equally shown as 3m. Also, there is a tendency that, as the width of L.S increases, the depth of space satisfying the standard illuminance 400lux gets shorter, and as the angle of L.S increases, the depth of space satisfying the standard illuminance 400lux gets longer. Secondly, Table 4 describes the shape that lights for the angle of the outdoor-type L.S with 0.9m width are brought into indoors and reflected on the summer solstice, and as the angle of L.S increases, it gets more advantageous as the depth of space into which lights are brought increases. From the above result, if the performance of L.S and evenness for the depth of space on the summer solstice are considered, the outdoor type L.S with 30° angle is more efficient, and as the width of the outdoor type increases, the performance of the L.S relating to the depth of space and evenness improves and reaches the highest when the width is 0.9m.

Table 3. L.S performance evaluation based on the depth of space during summer solstice

Standard illuminance satisfaction degree (m) / ratio(%)							Average illuminance (lux) / Uniformity			
Category	Depth		3m	4m	5m	6m	3m	4m	5m	6m
L.S not installed			3.00	3.00	2.75	2.75	2514/0.185	1906/0.136	1535/0.096	1282/0.075
L.S installed	width(m)	angle								
	0.3	0°	3.00/100	3.00/75	2.75/55	2.75/45.8	1214/0.384	956/0.268	787/0.194	659/0.144
		10°	3.00/100	3.00/75	3.00/60	2.75/45.8	1251/0.378	981/0.269	806/0.195	672/0.141
		20°	3.00/100	3.00/75	3.00/60	3.00/50	1267/0.387	998/0.285	813/0.206	686/0.139
		30°	3.00/100	3.25/81.2	3.00/60	3.00/50	1258/0.399	995/0.286	812/0.212	689/0.158
	0.6	0°	3.00/100	3.00/75	3.00/60	2.75/45.8	1332/0.373	1040/0.250	851/0.178	713/0.139
		10°	3.00/100	3.00/75	3.00/60	3.00/50	1375/0.356	1085/0.257	885/0.176	740/0.137
		20°	3.00/100	3.25/81.2	3.00/60	3.00/50	1396/0.370	1094/0.272	896/0.200	750/0.145
		30°	3.00/100	3.25/81.2	3.25/65	3.00/50	1382/0.400	1082/0.271	900/0.186	754/0.155
	0.9	0°	3.00/100	3.00/75	3.00/60	3.00m/50	1394/0.360	1090/0.242	893/0.175	758/0.126
		10°	3.00/100	3.25/81.2	3.00/60	3.00/50	1438/0.366	1144/0.251	917/0.174	780/0.133
		20°	3.00/100	3.25/81.2	3.00/60	3.00/50	1459/0.375	1133/0.255	931/0.198	785/0.154
		30°	3.00/100	3.50/87.5	3.25/65	3.25/54.1	1426/0.413	1120/0.294	925/0.217	776/0.172

: 100% : 99%～80% : 79%～60% : 9%～0% : This indicates lower score than the value estimated with no Light shelf installed

Table 4. Reflection of the nature light by the angle of L.S during summer solstice

Width 0.9m, Angle 0°	Width 0.9m, Angle 10°	Width 0.9m, Angle 20°	Width 0.9m, Angle 30°

: Illuminance sensor measurement (height)

4 Conclusion

This research has conducted performance evaluation for the depth of space and factors of L.S, and the conclusion therefrom is as follows:
Firstly, while the depths of space satisfying in overall the standard illuminance 400lux when any L.S is not installed for the summer solstice are analyzed as 3m respectively, they are shown as 3m respectively when the L.S with the width and angle set up in this research, and thus there is no lighting efficiency for any change in the depth of space when any L.S is installed. However, for the depth of space for which the rate of satisfying the standard illuminance is not 100%, it is possible to improve indoor lighting performance with the width and angle L.S. Secondly, as the width and angle of L.S increase, the reflection area has tendency to increase, and as the reflection area increases, the evenness gets improved. The shaded area decreases as the angle of L.S increases, and in the case of the winter solstice, lower angle that makes a bigger shaded area is shown to be more advantageous due to the lower sunlight angle. Also, in the case of the summer solstice, the shaded area is not proportional to the increase in width and angle of L.S set up in this study, and it is judged that, if the width and angle of L.S are above any specific values, the shaded area does not show any change and thus they are not significant in performance improvement of L.S. Fourthly, in consideration of the depth of space, inflow of lights and type of reflection by the L.S, and evenness set up in this study, it has been drawn that the respective optimal solution for the summer solstice are the outdoor type L.S with 30° angle and 1.2m width.
This study is meaningful in the aspect that it provides the basic data that considers physical characteristics of space in designing light shelves as a research for performance of light shelves for the depth of space, provided that the fact that this study has been carried on by fixing the height and reflectance of L.S, and he height of ceiling of the indoor space is the limitation of this study, and it shall be applied in the subsequent researches

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