

A Preliminary Study on the appropriate specifications of Light-Shelf based on the Curve ceiling during winter solstice

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Abstract. Studies on the light-shelf as a solution for the problem of lighting energy consumption increase in buildings have been carried out continuously, but there is lack of studies on light-shelf according to the form of space. The purpose of this study is to evaluate the performance of light-shelf in form of cover ceiling and draw the appropriate specifications. The result of this study is as follows. 1) When applying light-shelf to the curve ceiling with 3 m of spatial depth, there is no lighting performance improvement. 2) In case the light-shelf is installed, the average illumination of indoor space is lower in comparison to the case of non-installation of light-shelf. And, as the height of ceiling increases, the average illumination of indoor space becomes lower. 3) The uniformity ratio of illumination tends to increase the width and angle of light-shelf due to the diffusion of light. 4) In the viewpoint of improving the spatial depth satisfying the standard illumination and uniformity ratio of illumination according to the installation of light-shelf, it is considered that the light-shelf with the width 0.6m and angle over 20° is appropriate specifications for curve ceiling.

Keywords: Light-Shelf, Curve ceiling, Performance Evaluation, Appropriate specifications

1 Introduction

The light-shelf is recognized as a solution for the issue of increased lighting energy consumption in buildings, but the previous studies on the light-shelf only focused on the performance evaluation according to simple light-shelf factors, so the result of those studies are used limitedly as primary data for actual light-shelf design. Also, recently the indoor space appears in various shapes according to the demand of occupants as well as the intention of designers, and this requires studies on light-shelf to present the preliminary design data for the various shapes of space.

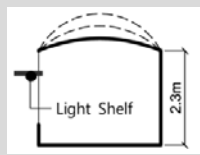
Therefore, the purpose of this study is to present appropriate specifications by carrying out the performance evaluation of light-shelf in indoor space with curve ceiling which is a special form of space.

2 Setup of Performance Evaluation of Light-shelf for Curve ceiling

2.1 Setup of Curve ceiling and Light-shelf

Table 1 includes contents regarding the Setup of Curve ceiling and Light-Shelf.[1]

Table 1. Setup of Curve ceiling and Light-Shelf

Curve ceiling				
	1) The minimum height of curve ceiling in this study was fixed to 2.3 m, and the evaluation of lighting performance was carried out by increasing the maximum height of curve ceiling to 2.6m, 2.9m and 3.2m. 2) 6m were set for the spatial depth for the performance evaluation. 3) The window was placed at 0.5 m above from the floor.			
	Window Area Ratio / Glass Material	2.0m x 1.8m / Pair-glass with 12mm thickness, penetration ratio:80.82, clear colors		
	Light-Shelf			
Reflectivity	Ceiling:74.99%, Wall:55%, Floor:25.1%			
Height	1.8m	Angle	0°, 10°, 20°, 30°	
Width	0.3m, 0.6m	Reflectivity	85.77%	

2.2 Position for Measurement of Illuminance for Performance Evaluation

Figure 1 includes contents regarding the illumination photometry for performance evaluation of light-shelf.[2]

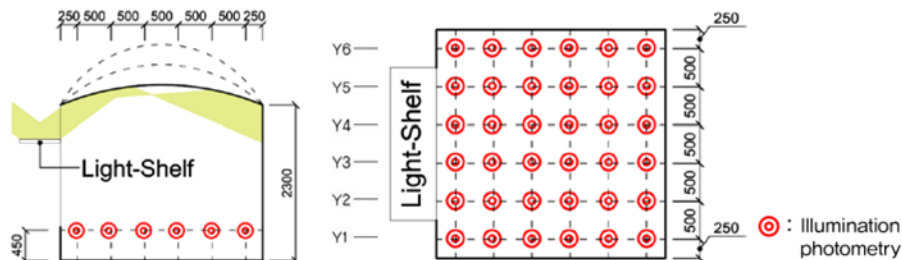


Fig. 1. Illumination photometry for performance evaluation of Light-shelf

3 Performance Evaluation of Light-shelf for Curve ceiling

In the summer solstice, the result of performance evaluation by the shape of curve ceiling and the light-shelf factor is as follows.

First, in the summer solstice, the spatial depth satisfying the standard illumination according to the installation and non-installation of light-shelf in case of curve ceiling with 3 m of spatial depth is 3 m, showing no improvement of depth satisfying the standard illumination according to the application of light-shelf.

Second, In case the light-shelf is installed, the average illumination of indoor space is lower in comparison to the case of non-installation of light-shelf. And, as the height of ceiling increases, the average illumination of indoor space becomes lower. On the other hand, decrease in the width of light-shelf reduces the awning area, raising the average illumination of indoor space, and increase in the angle of light-shelf increases the reflection area and the amount of light brought into indoor, raising the average illumination. However, The angle of light-shelf at 30° brings natural light into indoor spatial depth, improving the spatial depth satisfying the standard illumination, but the average illumination becomes lower due to the form of reflection.


Third, the uniformity ratio of illumination tends to increase the width and angle of light-shelf due to the diffusion of light, so it is an element to be considered for design.

Fourth, in the viewpoint of improving the spatial depth satisfying the standard illumination and uniformity ratio of illumination according to the installation of light-shelf, it is considered that the light-shelf with the width 0.6 m and angle over 20° is appropriate specifications for curve ceiling.

Table 2. Light-shelf performance evaluation based on the Curve ceiling during winter solstice(Depth : 3m)

Depth : 3m										
Light Shelf		Ceiling height 2450mm			Ceiling height 2600mm			Ceiling height 2750mm		
		S.I. (m)	A.I. (lx)	U.F.	S.I. (m)	A.I. (lx)	U.F.	S.I. (m)	A.I. (lx)	U.F.
not installed		3.00	3694	0.134	3.00	3619	0.137	3.00	3564	0.127
Width	Angle									
0.3	0	3.00	1195	0.446	3.00	1084	0.480	3.00	999	0.493
	10	3.00	1211	0.455	3.00	1117	0.492	3.00	1024	0.501
	20	3.00	1229	0.460	3.00	1120	0.485	3.00	1041	0.505
	30	3.00	1238	0.478	3.00	1119	0.495	3.00	1038	0.505
0.6	0	3.00	1308	0.442	3.00	1179	0.473	3.00	1085	0.494
	10	3.00	1352	0.441	3.00	1203	0.488	3.00	1102	0.494
	20	3.00	1366	0.467	3.00	1223	0.498	3.00	1126	0.507
	30	3.00	1347	0.486	3.00	1207	0.521	3.00	1121	0.549

S.I.: Standard illuminance satisfaction degree(m), A.I.: Average illuminance, U.F.: Uniformity factor,

 : This indicates lower score than the value estimated with no Light shelf installed

4 Conclusion

As the study related to the performance evaluation of light-shelf for the form of curve ceiling and the appropriate specifications of light-shelf, the following result was drawn.

First, in the summer solstice, the spatial depth satisfying the standard illumination according to the installation and non-installation of light-shelf in case of curve ceiling with 3m of spatial depth is 3m which is same with the curve ceiling.

Second, in case the light-shelf is installed, the average illumination of indoor space is lower in comparison to the case of non-installation of light-shelf. And, as the height of ceiling increases, the average illumination of indoor space becomes lower. Also, decrease in the width of light-shelf reduces the awning area, raising the average illumination of indoor space.

Third, the uniformity ratio of illumination tends to increase the width and angle of light-shelf due to the diffusion of light.

Fourth, in the viewpoint of improving the spatial depth satisfying the standard illumination and uniformity ratio of illumination according to the installation of light-shelf, it is considered that the light-shelf with the width 0.6 m and angle over 20° is appropriate specifications for curve ceiling.

As the study for evaluating the performance of light-shelf on the cover ceiling which is a special form in indoor space and drawing the appropriate specifications, this study has its significance as the preliminary data for the light-shelf design, and follow-up studies regarding the performance evaluation according to the physical form of space and each season would be necessary for establishing preliminary data for light-shelf design.

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