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A Performance Evaluation According to the Distance of an Internal Double Light-Shelf

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Abstract

The light-shelf has been presented as a solution to address the increased consumption of lighting energy, and is classified by type into the single-plate light-shelf and double light-shelf. Previous studies on the double light-shelf are mostly simulation studies. In such studies, the evaluation of lighting performance was carried out by limiting the solar altitude at meridian passage to summer solstice [3]. Therefore, the purpose of this study is to verify the validity of an experimental study according to the distance of the internal double light-shelf. The double light-shelf is more efficient through the use of two reflecting plates, but there has been a lack of related research. Therefore, an evaluation of performance according to the distance of the internal double light-shelf was carried out in this study, and the findings are as follows. 1) When a double light-shelf is applied, the average illumination increases in comparison to a single light-shelf. 2) When an internal double light-shelf is applied, the uniformity ratio of illumination decreases in comparison to single light-shelf, and this should be considered when installing the light-shelf. 3) Appropriate distance of double light-shelf varies according to solar term, and the double light-shelf which enables the control of distance is suggested.

Keywords: Light-Shelf, Ceiling Height, Performance Evaluation

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1 Introduction

Today, lighting energy has come to represent an increasing proportion of building energy usage. The natural lighting system using natural light from the outside is a very effective solution, and various studies have recently been carried out in this area [1][2]. Light-shelves can be classified into single plate light-shelves or double light-shelves according to the number of reflecting plates, and as previous studies related to the light-shelf have only focused on the single plate light-shelf, there is a lack of studies regarding the double light-shelf.

Therefore, the purpose of this study is to verify the effectiveness of the double light-shelf through an analysis of performance according to the distance between the reflecting plates in the internal double light-shelf.

2 Concept of Double Light-Shelf and performance evaluation of an internal-type Light-Shelf

2.1 Concept of Double Light-Shelf

The method of evaluating performance according to the distance between the reflecting plates in the internal double light-shelf is as follows. First, the performance evaluation was carried out according to the solar altitude at meridian passage. Second, the width of 600 mm for single plate light-shelf and of 300 mm for both top and bottom light-shelves in the case of double light-shelf are prepared for the evaluation. Third, the height of the bottom light-shelf is gradually increased in 100 mm increments, from 1800 mm to 2300 mm.[3]

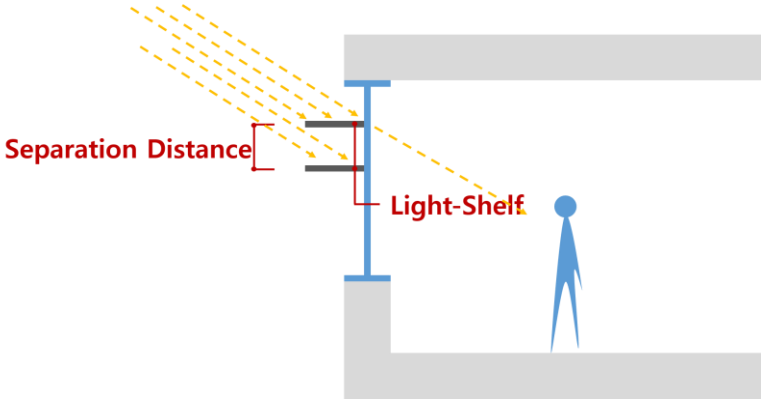

Fig. 1. Concept of Double Light-Shelf[3]

2.2 Position for Measurement of Illuminance for Performance Evaluation

Table 1 shows the setting of the width, height, separation distance and angle of single and double light shelves. Table 2 reveals the setting of the size, quality of material, reflectivity, window size and the quality of material of test-bed[3].

Table 1. Setup of Light-shelf[3]

Light-Shelf	Single Light-Shelf Width	600mm
	Double Light-Shelf Width	lower: 300mm, upper: 300mm
	Height	1800mm
	Separation distance	By 100mm at 2300mm
	reflectance	Reflective film (85%)
	angle	Fixed-type (0°)
Meridian transit altitude		Summer (29.5˚), Winter (76.5˚), Spring& Autumn(53˚)

Table 2. Installation of Internal Double Light-Shelf and Location of Illuminance Sensor within Test-bed[3]

Room Size	4.9m(W)×6.6m(D)×2.5m(H)	
reflectance	Wall: reflectance 46%, Ceiling: reflectance 86%	
Windows Size	1.76m(W) × 1.76m(H)	

2.3 Position for Measurement of Illuminance for Performance Evaluation

An internal double light shelf is shown on the left of Fig. 2, and the plane of test-bed is shown on the right, and the location of an illuminance sensor is indicated. In consideration of working surface, the illuminance sensor was located at 750mm above the working surface.[3]

Fig 2. Performance evaluation result according to the separation distance of internal double light- shelf's reflector on the summer solstice[2][3]

3 Performance Evaluation Method and Result of double Light- Shelf

The method of performance evaluation according to the distance between the reflecting plates in the internal double light-shelf is as follows. First, the performance evaluation was carried out according to the solar altitude at meridian passage. Second, the width of 600 mm for single plate light-shelf and 300 mm for both top and bottom light-shelves in case of double light-shelf are prepared for the evaluation. Third, the height of bottom light-shelf is increased by 100 mm gradually from 1800 mm to 2300 mm.[3]

Table 3. Performance evaluation result according to the separation distance of internal double light- shelf's reflector on the summer solstice[3]

		Sensor 1	Sensor 2	Sensor 3	Sensor 4	Average Illumination	Uniformity Illumination
Single Light Shelf		183.44	179.98	56.94	99.86	130.06	0.44
Separation distance	100mm	207.4	272.08	85.36	492.72	264.39	0.32
	200mm	202.08	247.38	69.56	454.54	243.39	0.29
	300mm	201.02	248.30	69.18	440.22	239.68	0.29
	400mm	205.02	255.32	61.22	503.12	256.17	0.24
	500mm	198.52	268.90	55.46	573.44	274.08	0.20

Table 4. Results of performance evaluation according to the distance of the reflecting plates in the internal double light-shelf on the winter solstice

		Sensor 1	Sensor 2	Sensor 3	Sensor 4	Average Illumination	Uniformity Illumination
Single Light Shelf		781.74	898.34	879.83	1902.44	1115.59	0.70
Separation distance	100mm	835.75	1001.54	897.10	7978.89	2678.32	0.31
	200mm	816.19	950.22	830.81	7455.44	2513.16	0.32
	300mm	896.59	909.82	943.22	7090.73	2460.09	0.36
	400mm	873.97	970.42	879.53	8193.18	2729.27	0.32
	500mm	821.60	1000.76	827.93	8962.10	2903.10	0.28

Table 5. Results of performance evaluation according to the distance of the reflecting plates in the internal double light-shelf on the spring and autumnal equinox

		Sensor 1	Sensor 2	Sensor 3	Sensor 4	Average Illumination	Uniformity Illumination
Single Light Shelf		351.61	484.82	214.49	187.32	309.56	0.61
Separation distance	100mm	410.85	650.25	268.05	2207.75	884.23	0.30
	200mm	396.56	543.58	234.70	1246.60	605.36	0.39
	300mm	422.92	534.99	255.42	1084.22	574.39	0.44
	400mm	395.42	547.60	218.79	1219.08	595.22	0.37
	500mm	418.74	582.01	237.02	1399.50	659.32	0.36

The results of performance evaluation according to the distance of the reflecting plates in the internal double light-shelf are as follows. 1) When a double light-shelf is applied, the average illumination increases in comparison to single light-shelf, resulting in an increase in the amount of incoming light brought from the light-shelf. 2) When an internal double light-shelf is applied, the uniformity ratio of illumination decreases in comparison to the single light-shelf, and this should be considered when installing the light-shelf. 3) The appropriate distance for internal double light-shelf is 100 mm on the summer solstice, 500 mm on the winter solstice and 200 mm on the spring and autumnal equinox.

5 Conclusion

This study is a performance evaluation of double light-shelf according to the distance of reflecting plates, and is carried out in order to provide preliminary data for designing the double light-shelf. The results of this study are as follows. 1) When a double light-shelf is applied, the average illumination increases in comparison to single light-shelf. 2) When an internal double light-shelf is applied, the uniformity ratio of illumination decreases in comparison to the single light-shelf, and this should

be considered when installing the light-shelf. 3) The proper distance for an internal double light-shelf is 100 mm on the summer solstice, 500 mm on the winter solstice and 200 mm on the spring and autumnal equinox. Therefore, it is found that designing the double light-shelf in which the distance of the reflecting plates can be controlled is the optimal plan, and that an experiment utilizing internal, external and mixed-type double light-shelves will be necessary in future studies.

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