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A Study on the Appropriate Position for an Illumination Sensor for Lighting Control Based on Actual Residence Environments

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Abstract

Today, a range of technologies to reduce energy consumption are being developed to address various environmental issues. In particular, advanced “smart” technologies related to lighting control are being developed, and various related studies have been carried out. The purpose of this study is to identify the appropriate position for an illumination sensor and establish preliminary data to verify its performance for lighting control based on actual residence environments through experiments. The position of an illumination sensor for lighting control which represented the average illumination at 700 mm and 1,500 mm above the working surface was determined according to the solar term, and the result is as follows. 1) The positions that showed approximate value with the average illumination at 700 mm and 1,500 mm above the working surface on the summer solstice, the spring and autumnal equinox and the winter solstice were 2.5 m, 2~3 m, 2.5~3.5 m and 2.5 m from the window, respectively. 2) This was determined based on the result drawn above that the position of 2.5 m from the lighting window was an appropriate measurement position of illumination for lighting control during the summer solstice, spring and autumnal equinox and winter solstice. This study intended to determine an appropriate position for an illumination sensor for lighting control based on actual residence environments, and was limited to the summer solstice, spring and autumnal equinox and winter solstice. Given this limitation, a study using diverse variables should be carried out in the future to supplement the findings of this study.

Keywords: Light Control, Illumination sensor, Optimum Position

1 Introduction

Various technologies to reduce energy consumption, including insulation technology, eco-friendly technology and energy generation technology, are being developed to solve recent global environmental issues. In particular, as various technologies related to lighting control are incorporating information technologies, related studies such as phased lighting control and real time monitoring of lighting energy consumption according to the user's work and usage are being carried out. Therefore, this study was conducted with a view to establishing preliminary data for proper position of lighting control and lighting control technology in real life.

2 Consideration of Sensor Function for Lighting Control system

Lighting control refers to adjusting and controlling brightness of the installed lightings to save the indoor working environment and user required environment, as well as lighting energy. While lighting control simply meant and designed as the lighting control simply with on/off switch in the past, the lighting control technologies with various technologies have been applied to living and office areas. In particular, the factors to consider for energy saving include the use of buildings and spaces, use of daylight and maintenance of illuminance of the area. The types of the lighting control devices can be categorized as in Table 1[2][3][7].

Table 1. Types of Lighting Control Devices[7]

Type		Key Attributes
Switch Control		Organize the simple circuit for lighting
Time Control		Control lighting by use time (manual operation available by changing the schedule)
Sensor Control	Light Sensor	Control the indoor artificial lighting using the daylight
	Detection Sensor	Control the lighting based on the occupants and motions

3. Analysis of Location of Illuminance Sensor for Basic Research on Lighting Control

3.1 Overview of the Test-Bed

The summary of the test bed is shown in Table 2 below, and the method to draw the position of sensor for lighting control in this study is as follows. First, the lighting was controlled by drawing the scope and point that can represent the average illuminance of the area, and the error range was set to be ±5% to identify the range to measure the illuminance close to the average illuminance value. The setting of ±5% of error range is based on the accuracy of lighting sensor used in this research. Second, this research limited the season to the winter solstice, the summer solstice and vernal/autumnal equinox to conduct the test, and the intersection between each average illuminance value and the scope close to the values was decided to be the final lighting control point[7].

Table 2. Overview of Test-bed[7]

Category	Key Attributes	Category	Key Attributes	
Area Size	W : 4.9m, D : 6.6m, H : 2.5	Window Size	W : 2.2m, H : 1.8m	
Reflectivity	wall : 46%, ceiling : 86%	Window Material	Pair glass 12mm	

3.2 Setting the Location of Illuminance Sensor for Measuring Illuminance

The height of the illumination sensor was set based on the height of working surface and the eye level of people [7].

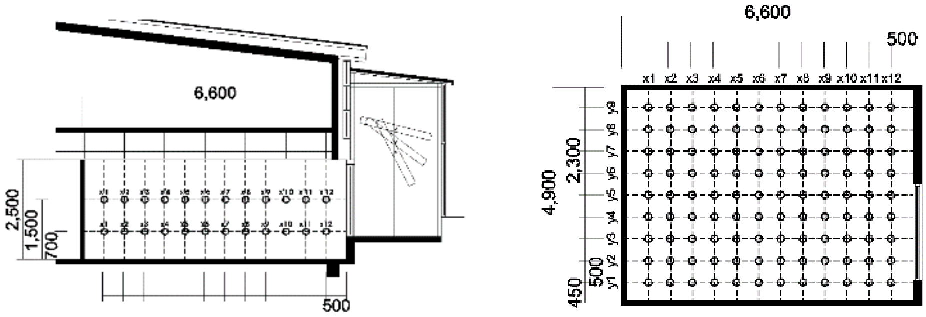

Fig 1. Location of Lighting Sensor on 700mm, 1,500mm of Working Surface Lighting Control [7]

4 The Result of Indoor Illuminance Analysis Depending on the Location of Illuminance Measurement Sensor for Lighting Control

At the summer solstice, the average illuminance drawn from the environment set in this research was 166.6lx and the location that had ±5% of the average illuminance value was 2.5m away from the window, calculated as the scope of Y2-Y5. At the vernal/autumnal equinox, the average illuminance calculated in the environment set in this research was 830.2lx and the location that had ±5% of the average illuminance value was 2~3m away from the window, calculated as the scope of Y3~Y6. At the winter solstice, the average illuminance calculated by the set environment in this research was 1852.2lx, and the location that had ±5% of the average illuminance value was 2.5~3.5m away from the window, calculated as the scope of Y4~Y5. Based on the results, the location to measure the illuminance through lighting control is calculated to 2.5m from the lighting window[7].

Table 3. Analysis of illumination distribution at 700mm above the working surface on the summer solstice, spring and autumnal equinox and winter solstice [7]

Summer Solstice(Average Illuminance : 166.6lx)												
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12
y9	33.3	36.6	39.8	44.9	51.6	59.1	65.7	73.2	83.2	87.5	77.4	71.6
y8	34.9	38.3	41.6	46.6	56.6	63.2	74.9	87.4	99.0	117.3	115.6	89.9
y7	37.4	81.25	44.1	49.9	60.7	70.7	76.5	108.2	132.3	185.0	208.7	154.8
y6	38.3	41.6	45.	53.2	65.7	79.0	99.8	156.4	181.4	256.3	385.9	410.2
y5	39.1	42.4	47.4	54.9	67.2	85.7	109.0	160.6	217.2	332.8	545.8	929.3
y4	39.1	43.3	48.3	55.9	69.9	87.4	111.5	165.6	238.8	359.4	614.8	1116.4
y3	38.4	42.4	45.8	54.9	66.6	85.7	109.8	160.6	242.1	364.4	628.2	1198.9
y2	36.6	40.8	42.4	50.6	60.7	72.1	107.3	156.4	226.3	346.9	559.9	1045.0
y1	34.9	36.6	40.8	43.3	56.6	67.4	94.8	121.4	195.5	285.4	453.4	588.6
Vernal/Autumnal Equinox(Average Illuminance : 830.2lx)												
y9	109.8	119.7	130.6	138.1	148.9	161.4	173.9	168.9	183.0	168.1	147.3	134.1
y8	121.5	131.5	143.9	150.6	165.6	188.0	208.0	210.5	239.1	229.5	182.2	157.2
y7	134.0	143.6	162.2	173.1	198.0	242.1	276.2	282.0	369.4	387.7	317.3	198.0
y6	143.9	182.1	188.9	198.8	235.5	349.4	456.8	569.1	838.7	986.8	1024.4	631.5
y5	151.6	166.4	198.0	213.0	264.4	416.0	788.8	832.2	891.7	2521.0	3032.6	3937.9
y4	158.1	179.5	207.2	223.3	272.1	480.0	795.7	911.2	2318.8	3764.8	4305.6	5147.9
y3	158.9	153.5	200.3	224.6	273.7	494.2	830.2	915.7	2698.2	4269.7	4729.9	5301.5
y2	156.4	177.4	188.9	205.7	237.0	434.5	767.9	1843.6	2090.0	3278.9	3445.5	3814.1
y1	147.3	159.7	170.6	181.4	223.1	367.7	513.3	703.0	1115.7	1327.0	1234.7	837.5
Winter Solstice(Average Illuminance : 1852.2lx)												
y9	378.1	34.5	391.5	397.8	406.6	416.6	426.1	427.4	625.3	620.2	604.6	595.1
y8	389.5	396.2	404	409.9	422.4	136.9	452.7	676.6	695.7	701.5	646.5	651.2
y7	390.2	396.4	407.6	416	433	460.9	480.8	739.9	795.6	827.6	807.8	721.3
y6	412.4	433.1	438.2	447.3	1471.9	1435.5	1399.6	1454.7	1611.3	2722.9	2806.4	2622.2
y5	439.2	448.2	466.5	477.8	1509.6	1774.7	1902.8	1944.8	2683.2	3147.5	3509.6	4154.0
y4	434.7	447.5	436.	475.7	1507.1	1889.8	2050.7	5989.8	6638.7	6422.0	6820.1	7492.1
y3	409.5	508.8	433.9	450.6	1681.1	2000.8	2031.3	5944.1	6776.2	6626.1	6985.1	7556.3
y2	501.6	514.2	520.7	533.2	1553.9	1978.4	2011.7	3392.9	4041.2	4695.8	4885.6	5312.5
y1	498.2	505.2	512.8	519.4	1546.9	1694.6	1948.1	2353.9	2570.3	2737.9	2775.8	2644.8
: ±05% Scope : ±10% Scope												

At the summer solstice, the average illuminance drawn from the environment set in this research was 144.2lx and the location that had ±5% of the average illuminance value was 2.5m away from the window, calculated as the scope of Y4. At the vernal/autumnal equinox, the average illuminance calculated in the environment set in this research was 299.1lx and the location that had ±5% of the average illuminance value was 2.5m away from the window, calculated as the scope of Y4. At the winter solstice, the average illuminance calculated by the set environment in this research was 580.1lx, and the location that had ±5% of the average illuminance value was 2.5m away from the window, calculated as the scope of Y4~Y5. Based on the results, the location to measure the illuminance through lighting control is calculated to 2.5m from the lighting window.

Table 4. Analysis of illumination distribution at 1,500mm above the working surface on the summer solstice, spring and autumnal equinox and winter solstice [7]

Summer Solstice(Average Illuminance : 144.2lx)												
	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12
y9	38.2	39.1	46.5	51.5	59.0	66.5	73.2	85.7	101.5	103.6	83.2	84.1
y8	40.7	41.6	49.7	55.7	63.2	69.8	81.5	92.9	113.1	127.6	128.1	110.8
y7	41.6	42.3	52.4	57.4	68.2	47.0	86.7	107.3	137.2	173.8	187.0	209.6
y6	40.7	43.2	51.5	58.8	69.8	77.2	94.8	129.7	161.9	237.1	312.3	493.7
y5	42.4	43.5	49.9	58.2	71.2	79.8	99.2	131.1	183.3	283.1	435.9	772.2
y4	39.	43.2	46.9	57.4	73.1	82.6	102.3	144.7	195.5	312.8	524.1	940.9
y3	30.7	43.2	47.4	54.9	66.5	84.0	104.2	136.3	193.2	271.1	470.9	892.7
y2	36.6	39.1	40.7	45.7	53.2	65.7	84.1	111.4	155.5	249.2	366.1	701.3
y1	34.1	35.7	39.1	40.7	47.4	60.7	74.8	98.1	138.9	225.4	357.7	480.1
Vernal/Autumnal Equinox(Average Illuminance : 299.1lx)												
y9	72.2	84.9	93.2	99.8	114.2	126.5	140.6	165.6	178.9	187.4	182.2	153.7
y8	78.7	87.5	98.5	113.3	125.6	143.9	159.9	184.7	215.5	234.6	247.1	157.2
y7	86.8	92.5	104.8	120.6	138.9	158.1	184.7	216.3	266.2	318.7	308.5	298.6
y6	88.1	94.1	107.9	127.1	145.7	171.4	203.8	250.4	326.1	434.5	630.7	1070.8
y5	89.2	96.5	109.8	131.5	152.3	179.7	221.3	271.1	368.6	512.5	803.2	1895.6
y4	87.8	97.9	108.2	130.9	151.1	182.1	232.7	299.7	388.5	550.8	835.4	2367.2
y3	86.5	98.2	107.3	129.8	149.7	185.5	228.2	291.4	367.7	530.8	852.2	2486.7
y2	82.9	78.2	93.5	109.6	125.6	165.2	194.7	153.6	320.3	480.1	659.8	1819.6
y1	79.6	74.2	86.9	93.7	103.2	131.5	158.1	196.4	259.6	399.4	535.8	733.3
Winter Solstice(Average Illuminance : 580.1lx)												
y9	155.6	161.7	171.3	173.1	175.9	179.7	188.2	194.7	197.2	198.1	173.1	156.4
y8	166.4	169.1	175.7	178.4	181.7	201.9	216.3	234.6	238.7	245.2	221.3	170.6
y7	173.9	196.1	209.4	210.5	215.9	228.1	260.7	284.5	302.5	357.8	334.5	268.2
y6	207.2	213.5	212.7	237.6	245.7	256.3	317.5	491.7	494.2	954.1	1268.8	1340.7
y5	217.8	222.4	228.3	239.8	252.1	271.2	339.5	577.9	626.5	1369.5	2425.3	3367.1
y4	230.5	232.7	235.4	242.5	280.4	307.1	368.1	581.6	749.6	1732.2	3134.1	4802.4
y3	219.2	223.8	239.2	252.2	273.9	300.4	374.4	574.4	758.5	1753.9	3014.9	3907.4
y2	207.1	210.5	211.7	212.3	258.9	266.2	319.5	495.7	638.2	1422.7	2293.7	2687.5
y1	187.9	189.1	193.4	196.4	203.2	233.8	275.5	337.5	379.4	630.7	875.5	993.1
: ±05% Scope : ±10% Scope												

5. Conclusion

This study was a preliminary study to determine the position of illumination measurement sensor for efficient lighting control, and the performance evaluation was carried out by establishing the test bed space. The average illumination drawn at 700 mm and 1,500 mm above the working surface on the summer solstice, spring and autumnal equinox and winter solstice was calculated in order to find the position of illumination measurement for lighting control, and each average illumination drawn was compared and analyzed with the position where the approximate value with the average illumination was measured to drawn the correlation. The result is as follows. First, the position which showed approximate value with the average illumination at 700 mm above the working surface on the summer solstice, the spring and autumnal equinox and the winter solstice was 2.5 m, 2~3 m, 2.5~3.5m from the window, respectively, and the position which showed approximate value with the average illumination at 1,500 mm above the working surface on the summer solstice, the spring and autumnal equinox and the winter solstice was 2.5 m from the window for each. Second, it is determined based on the result drawn above that the position of 2.5 m from the lighting window was an appropriate position for the measurement of illumination for lighting control from 700 mm and 1,500 mm above the working surface during the summer solstice, spring and autumnal equinox and winter solstice.

This study intended to derive a proper position for an illumination sensor for lighting control based on actual residence environments, and was limited to the summer solstice, spring and autumnal equinox and winter solstice. Given this limitation, a study using diverse variables should be carried out in the future to supplement these findings.

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