Analysis on the Efficiency of Interconnection System between the LED Daylight Responsive Dimming System and Shading Device According to the Types of Shading Device and Control Methods

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ABSTRACT

As people become more interested in environment-friendly and renewable energy as well as reduction of energy, there have been a lot of studies on how to reduce energy consumption in architecture. In architectural lighting sector, the energy-saving LED daylight responsive dimming system has been examined. The amount of energy saved through the LED daylight responsive dimming system varies depending on the type and control method of a shading device. Therefore, this study has measured the distribution of indoor illuminance after classifying it into three categories depending on the type and control methods of the shading device. It also analyzed the amount of lighting energy saved through the LED daylight responsive dimming system.

Keywords: roller shade, venetian blind, LED daylight responsive dimming system, energy saving, control methods

1. INTRODUCTION

As energy deletion and environmental pollution become more serious along with the rapid industrial development in a modern society, reduction of energy consumption has drawn great attention in the architecture industry. In architectural lighting sector, there have been many studies on the LED daylight responsive dimming system which saves energy by controlling the brightness of artificial lighting depending on the amount of daylight entering a room[1]. The amount of energy saved through the LED daylight responsive dimming system differs depending on the type and control method of a shading device. Therefore, this study has measured indoor illuminance after classifying it into three categories depending on the type and control methods of the shading device. Also, it analyzed the amount of lighting energy saved through the LED daylight responsive dimming system.

2. BODY

2.1 Measurement Overview

As stated in Table 1, a test was performed in a lecture room of ‘S’ University which had symmetric structure. The lecture room was divided into Room ‘A’ and Room ‘B’ by installing a blackout blind. A venetian blind was installed in Room ‘A’ while a roller shade was installed in Room ‘B’. As described in Table 1, each space was divided into five points (P1 to P5), and measurement spots were estimated.
Direct sunlight was blocked by adjusting the height of fabric in the case of the roller shade or controlling blind height and slat angle in the case of the venetian blind. Slat angle can be controlled with the cut off angle or 90 degree of profile angle. The profile angle refers to the solar altitude on the surface which is right-angled to the building facade. The cut-off angle means the angle from which the direct sunlight starts to be blocked considering the slat width and interval of the blind. Therefore, it is more advantageous to secure an external view to use the cut-off angle than the 90 degree of profile angle[2].

Thus, in this study, the illuminance of work plane was measured every hour from 10:00 to 17:00 on April 20, 23 and 27, 2012 in the following three cases: Case 1 – direct sunlight is blocked by fully rolling down the roller shade, Case 2 – the venetian blind is fully rolled down, and the slat angle is controlled with the 90 degree of profile angle, Case 3 – the venetian blind is fully rolled down, and the slat angle is controlled with the cut-off angle. Taking the levelness as ‘0,’ when slat was adjusted upward to the indoor, a positive (+) angle was perceived. Table 1 above reveals sky conditions on the day of measurement and test overview.

2.2 Results

Table 2 below reveals the result of the measurement of illuminance of work plane in Cases 1, 2 and 3 and uniformity ratio of illumination. The illuminance of work plane was the highest in Case 3 n Day 1 Day 2and Day 3 In Cases 1 and 2 illuminance was higher in Case 2 until 13:00. After 14:00, on the contrary, it was higher in Case 1 It appears that this kind of result was obtained because of a large amount of reflected daylight entering the room instead of the daylight which is blocked by the blind due to the little changes in slat control angle in Case 2 until 13:00.

According to the uniformity ratio of the natural illumination standards of BREEAM in the U.K, uniformity ratio 'A' (the minimum illuminance ratio against the average illuminance of work plane) should be at least 0.4. According to the recommended uniformity ratio defined in the lighting handbook of the illuminating engineering institute of Japan, the uniformity ratio 'B' (the minimum illuminance ratio against the maximum illuminance of work plane) should be at least 0.1 [3, 4]. In all these cases (Cases 1, 2 and 3), both uniformity ratio standards A and B met in all measurement time and spots. Therefore, the use of a shading device distributes the distribution of the indoor illuminance equally. In general, the uniformity ratio was high in order of Case 2, Case 3 and Case 1. Venetian blind would also be more advantageous than a roller shade in terms of the uniformity ratio because in the case of the venetian blind, daylight is reflected on the slat and penetrates deep into the room. In case of the control angle of venetian blind, 90 degree of profile angle is more advantageous than the cut-off angle in terms of uniformity ratio. In other words, the cut-off angle is greater than the 90 degree of profile angle in terms of the amount of daylight penetrating into the building because of bigger window area.

Table. 2 The illumination measuring result of case 1, 2, 3

<table>
<thead>
<tr>
<th></th>
<th>2012.4.20</th>
<th>2012.4.23</th>
</tr>
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<tbody>
<tr>
<td>time</td>
<td>P1 (lx)</td>
<td>P2 (lx)</td>
</tr>
<tr>
<td>10</td>
<td>348</td>
<td>191</td>
</tr>
<tr>
<td>11</td>
<td>417</td>
<td>230</td>
</tr>
<tr>
<td>12</td>
<td>511</td>
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<td>16</td>
<td>465</td>
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<tr>
<td>17</td>
<td>678</td>
<td>241</td>
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<tr>
<td></td>
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<td>119</td>
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shaded area : blow 500lx
2.3 Analysis of the amount of energy saved through LED daylight responsive dimming system

According to the results of the measurement as shown in Table 2 above, the amount of daylight entering the building varies by case (Cases 1, 2 and 3). Therefore, the amount of energy saved through the LED daylight responsive dimming system differs. In this section, this kind of result will be comparatively analyzed.

In general, the LED daylight responsive dimming system dims artificial lighting by receiving signals through a photo sensor. In this study, however, the amount of lighting energy saved has been analyzed by assuming that the measurement of the illuminance of work plane was dimming control variables. It has been assumed that the dimming control group was classified into two groups, and the luminaire 'A' was influenced by the measurement points P1, P2 and P3 while the luminaire 'B' was influenced by the measurement points P3, P4 and P5. The target illuminance of dimming control was set to 500lx, the recommended illuminance of work plane in the office. After estimating average illuminance by dimming control group, it has been assumed that average illuminance satisfied target illuminance(500lx). The amount of lighting energy saved was estimated through the Equation (1) below:

\[
\text{Lighting energy savings} = \left( \frac{\text{average lux of dimming control group}}{500} \right) \times 100(\%) \leq 100
\]

![Fig. 1 Lighting energy savings of cases 1, 2 and 3]
According to Figure 1 above, the amount of lighting energy saved was the highest in Case 3 and the lowest in Case 1 in all measurement days (Days 1, 2 and 3). Therefore, if a shading device is connected with the LED daylight responsive dimming system, a venetian blind would be more advantageous than a roller shade in terms of energy efficiency. In terms of the control angle of a venetian blind, it is likely that the cut-off angle is more efficient than the 90 degree of profile angle.

3. CONCLUSION

In order to analyze the efficiency of the LED daylight responsive dimming system by the type and control methods of blind, this study has classified it into three cases depending on the type and the control methods of a shading device and the measured illuminance of work plane. Subsequently, energy efficiency that was connected with the LED daylight responsive dimming system has been analyzed. According to the analysis, the illuminance of work plane was the highest in Case 3 in all measurement days (Days 1, 2 and 3). In terms of the uniformity ratio, Case 2 was the highest, followed by Case 3 and Case 1. In terms of the amount of energy saved through the LED daylight responsive dimming system, Case 3 was the highest, followed by Case 2 and Case 1.

In Case 1 in which a roller shade was used, both the uniformity ratio and the amount of energy saved through the LED daylight responsive dimming system were the lowest. In Cases 2 and 3 in which a venetian blind was used, the uniformity ratio was pretty similar. Therefore, it’s been confirmed that a venetian blind is more advantageous than a roller shade for the even distribution of indoor daylight. In terms of the amount of energy saved through the LED daylight responsive dimming system, Case 3 was higher than Cases 1 and 2 by about 28%. Therefore, it appears that controlling the slat angle of a venetian blind with the cut-off angle would be more advantageous in terms of energy efficiency once connected with the LED daylight responsive dimming system. The result of this study would be available as a basic data for development of an energy-saving system which integrates both the automatic shading system and LED daylight responsive dimming system. However, the tests were performed only in spring among four seasons. In addition, the target space was mostly situated in the southwest. Therefore, it would be necessary to consider diverse seasons and directions in future studies.

REFERENCES


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