Advanced Science and Technology Letters
Vol.47 (Architecture and Civil Engineering 2014), pp.50-53
http://dx.doi.org/10.14257/astl.2014.47.12

A Research on Basic Data for the Design of Combined Light Shelves Depending on Internal Angle

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Abstract. One of the natural lighting systems, Light Shelf, has advantages of higher constructability and economic feasibility compared to other passive natural lighting systems. Active light shelves can control the amount of indoor light according to the preference of the occupants. Light shelves can also control glare from direct sunlight as a shade against the strong light levels on the window side. This research aims to identify the relevance of the impacts of changing angles of combined light shelves on natural lighting in residential spaces, and to draw the values of efficient lighting performance of light shelves using a real-scale test bed. The research was conducted in the following order: 1) To analyze the definition, application cases and problems of light shelves and find out experimental elements and variable factors of light shelves by contemplating the advanced researches; 2) to apply the meridian transit altitude in each solar term and the light levels based on the advanced researches, and conduct experiments by setting the height, angle, size and external variable factors of light shelves; and 3) to conduct the performance evaluation to verify the validity of light shelves. Performance evaluation is conducted in each solar term depending on the solar altitude of combined light shelves, and verifies the relevance and utility of variable factors by analyzing the indoor lighting levels based on the daylight inflow according to the angles of combined light shelves.

Keywords: Light Shelf, Daylighting Performance, illumination

1 Introduction

1.1 Research Background and Purpose

People have enjoyed abundant lives thanks to the development of lighting technology and supply of cheap electronic energy since the Industrial Revolution. In this consumerist society, such a cheap energy supply led us to squander energy, which resulted in the oil shock in the 1970s. It raised the need for energy conservation. As environmentally friendly alternative energy technologies started to be developed, the natural lighting technology using daylight also has advanced from the perspectives of energy conservation. Light shelves, one of the natural lighting systems, can save

ISSN: 2287-1233 ASTL

energy from daylighting as they bring daylight into the building by reflecting light against the indoor ceiling. Light shelves have advantages of higher feasibility with excellent constructability and economics compared to other active natural lighting technologies. Current researches on light shelves are limited to simulations or scale models while there is a lack of research regarding the relevance of the angles of combined light shelves. In this regard, this study intends to identify the relevance of the impacts of angle changes of the combined light shelves on the natural lighting in residential spaces, and to find the values of efficient lighting performance of light shelves using a real-scale test bed.

1.2 Research Method and Procedure

This research conducts a performance evaluation on the angles of combined light shelves at summer solstice, winter solstice and vernal/autumnal equinox using artificial sunlight that can change the settings of external light level values per solar terms for a real-scale test bed and analyzes light level values of daylight that entered the building. It also draws appropriate methods for combined light shelves by calculating average light levels and uniformity ratio of illuminance. The research proceeds in the following procedures:

1) Contemplation on Light Shelf
By investigating the advanced researches, this study analyzes the definition, application cases and problems of light shelves and discovers experimental elements and variable factors of light shelves.

2) Variable Factors of Experiment Setting of Light Shelf
Based on the advanced researches, this research conducts experiments by applying the meridian transit altitude per solar terms and light level values under clear sky conditions, and by setting the height, angle, size and external variable factors of light shelves.

3) Performance Evaluation of Light Shelf
The study conducts a performance evaluation to verify the validity of light shelves. The evaluation is conducted in each solar term according to the solar altitude of combined light shelves, and verifies the relevance and utility of variable factors by analyzing the indoor lighting levels based on the daylight inflow according to the angles of combined light shelves.

2 Concept of Light Shelf

2.1 Light Shelf

A light shelf is a light control device that saves energy from daylighting and improves the visual environment as it brings daylight into the building by reflecting light onto the indoor ceiling. Light shelves commonly use materials with higher reflectivity such as aluminums or silver plated metals for the exterior and interior of side windows and have advantages of higher constructability and economic feasibility than other active natural lighting technologies.

2.2 Angle Control of Light Shelf

Moveable light shelves that can control the angles are often more expensive than fixed light shelves, but they are more flexible in usage. Reducing the angles of light shelves hides the area around the windows and decreases the amount of light reflected against the ceiling. Increasing the angles of light shelves improves penetration of reflected sunlight but reduces the light shielding effect of the windows. Exterior fixed light shelves can reduce the indoor cooling load because they can prevent more amount of direct sunlight from the fenestra below the light shelves.

3 Overview of Performance Evaluation of Combined Light Shelves

3.1 Light Level Sensor

To analyze daylight inflow depending on the variable factors of light shelves, six light level sensors were arranged on the area with a length of 1550mm at intervals of 1650mm width from the window. The light level sensors were installed at 450mm height from the floor based on the height of working surface in accordance with the advanced researches

3.2 Overview of Test Bed

This study analyzed the luminance value of the inflow of daylight indoors and calculated the average luminance and evenness through six indoor luminance sensors by conducting a performance evaluation for the angle and size of the indoor type light shelf system on the summer solstice, spring and autumnal equinoxes, and winter solstice by using artificial sunlight, the factors of which can be set according to the

outdoor luminance of each solar term on the actual size test bed. The test bed is, as shown in <Table 1>, designed as 4.9m in width, 6.6m in depth, and 2.5m in height of the ceiling, and the size of the opening is 2.2m in width by 1.8m in height, and 12T pair glass was used for the glass of the opening.

Table 1. Test Bed

Summary of the Test Bed Model		Summary of the Chamber Model	
Room Size and Material	4.9m(W) x 6.6m(D) x 2.5m(Height of the Ceiling) Wall : reflectance 46%; Ceiling : reflectance 86%	Chamber Size	4.5m(W) x 2.7m(D) * 4.6m(H)
Window Size and Material	2.2m(W) x 1.8m(H) Pair Glass 12mm(3mm+6mm+3mm)	Artificial Sunlight Irradiation Equipment	2.08m(W) x 2.8m(H)

4 Conclusion

This research created a real-scale test bed to build basic data for the design of combined light shelves to address a rapidly growing issue of lighting energy and identified lighting performance depending on the angle control of external and internal reflection boards, which is one of the variable factors. The research on establishment of basic data for the design of combined light shelves not only improves the performance of combined light shelves but also holds significance in building the basic data for the design of interior and exterior light shelves. Basic researches to design such light shelves should continue to be conducted from the perspective of addressing the energy issues.

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