

Preliminary Experiment on Daylighting Performance of Lightpipe under Different Sky Conditions

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ABSTRACT: In order to ensure that daylight buildings will become the preferred option in this millennium, it is necessary to optimise energy savings by taking into account the integration of daylighting. Lightpipe systems are considered to save lighting energy and improve visual comfort. Accordingly, the purpose of this study is daylight performance of Lightpipe under overcast sky and clear sky. For the purpose, lightpipe system was designed as 650 diameter, with and aspect ratio of 2. Agilent data logger and photometric sensor were used. Lightfactor and illuminance were used to analyse daylight performance under different sky condition.

Keywords: lightpipe, illuminance, Lightfactor

1. INTRODUCTION

For centuries, daylight was the only effective source of light available. Daylight provides high illuminance and permits excellent colour discrimination and colour rendering. Especially, Lightpipe systems are considered to save lighting energy and improve visual comfort compare to other daylighting systems. However, lightpipe systems have not been widely applied to buildings under varying clear and overcast sky conditions in Korea.

Accordingly, the purpose of this study is daylight performance of lightpipe under overcast sky and clear sky. For the purpose, lightpipe system was designed as 650 diameter, with and aspect ratio of 2. Agilent data logger and photometric sensor were used. Light factor and illuminance were used to analyse daylight performance under different sky condition.

2. EXPERIMENTAL METHODOLOGY

2.1 DESCRIPTION OF THE LIGHTPIPE

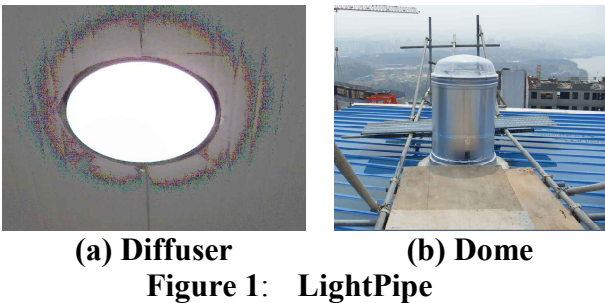
The lightpipe system is made up of a skylight dome, a reflective tube and a diffuser assembly.

The reflective tube with highly reflective material leads the light rays through a building, starting from an entrance-point located on its roof or one of its outer walls.

The entrance point comprises a dome, which has the function of collecting and reflecting as much sunlight as possible in to the tube. At the end point, a diffuser spreads the light into the room.

The lightpipe dome and diffuser are made in acrylic. Lightpipe acrylic material is High Impact HI950, 92% transparent and UV protected.

The lightpipe was straight SIT system and 65cm long giving an aspect ratio of 2.0.



2.2 DESCRIPTION OF THE MOCK-UP MODEL

The overall experimentation was carried out on the Shinan construction site, located near Seoul, Korea (latitude 37.30 N, longitude 127.01 E). The mock-up model, placed on a roof of the Shinan apartment, is surrounded by an open plain.

The room dimensions are 6×6m and 4m floor-to-ceiling height, as can be seen in Fig 3. The reflectance values are listed in Table 1 A mock-up model of the test module was constructed using sandwich panel.

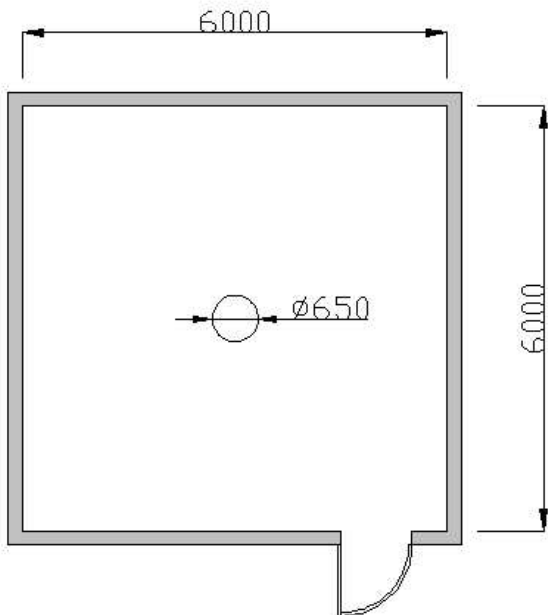


Figure 2: plan of test room configuration

Table 1: Reflectance of surfaces

Surface Type	Reflectance
Walls	68%
Ceiling	68%
Floor	53%



Figure 3: External view of the model

2.3 MONITORING METHOD

LI-210SA of sensors was used to monitor the floor illuminances and external illuminance. The floor illuminances in the module were monitored every 1 second by means of a HP34970A data logger (figure 4). The daily monitoring periods were from 11:00 to 14:00. The sensitivity of the photometric sensor was typically 20mA/100klx, and the maximum deviation of linearity was 1% up to 100klx.

7 Sensors were inside the mock-up model in a grid arrangement representing the floor plane (figure 5). An exterior sensor was used to measure the horizontal illuminance under unobstructed sky.

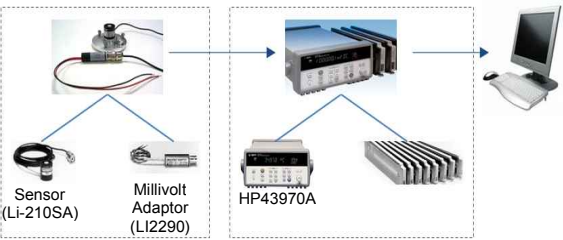


Figure 4: Monitoring System

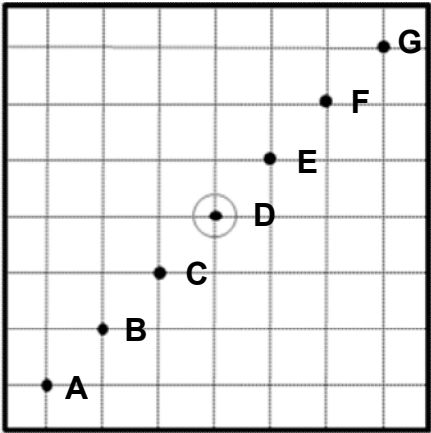


Figure 5: Measurement Point

3. RESULTS AND DISCUSSION

The measurements were carried out on Wednesday the 16 April and on Tuesday the 22 April 2008. Figure 6 shows the external illuminance. The highest external horizontal illuminance was 86,642lx on 16 April 2008. The lowest was 32,442lx on 22 April 2008.

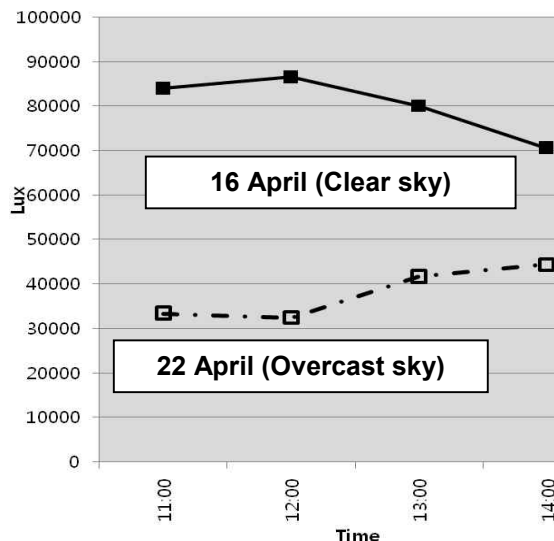


Figure 6: External Horizontal Illuminance

Figure 7,8,9 and 10 show the performance of the lightpipe under clear and overcastsky conditions.

The measurements were carried out on Tuesday the 22 April 2008. The highest illuminance was 482lx at sensor D point at 14:00h. The lowest was 159lx in the darkest cornerof the G point at 11:00h. The highest light factor was 1.08% at sensor D point at 14:00h. The lowest was 0.49% at seonsor G point at 11:00h.

The measurements were carried out on Thursday the 16 April 2008. The highest illuminance was 953[lx], 1.1% of the light factor at sensor E point at 12:00h. The lowest illuminance was 281[lx], 0.4% of the light factor at sensor A point at 14:00h.

The internal illuminance under clear sky had higher readings than the internal illuminance under overcast sky from 11:00h to 14:00h. However, the lightfactor under overcast sky had higher readings than the internal lightfactor under overcast sky from 11:00h and 14:00h.

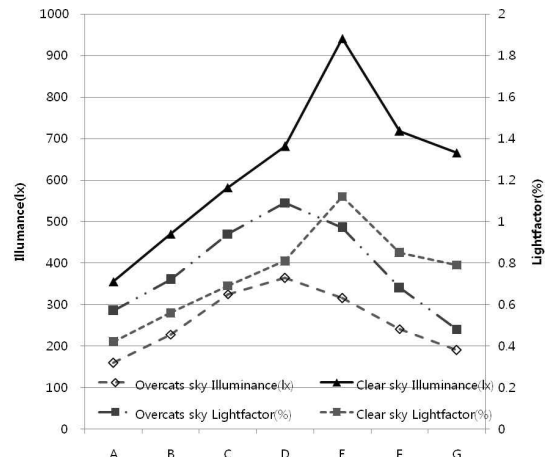


Figure 7: Lightpipe system, 11:00

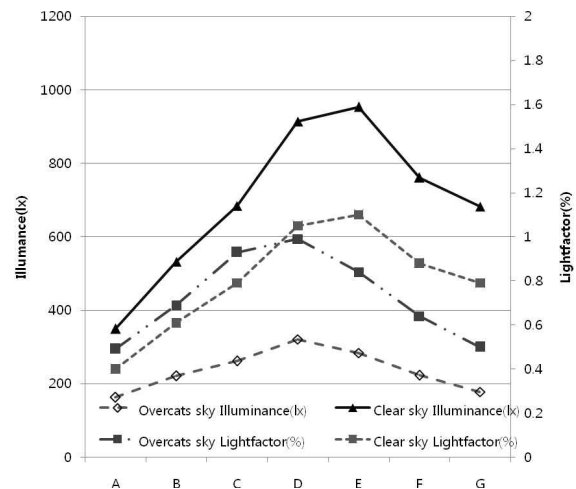


Figure 8: Lightpipe system, 12:00

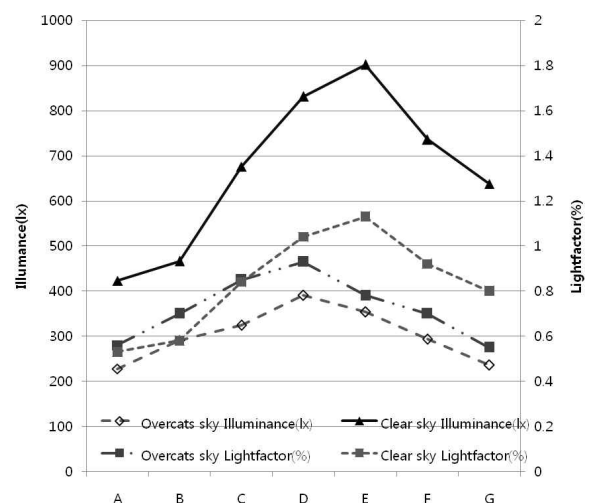


Figure 9: Lightpipe system, 13:00

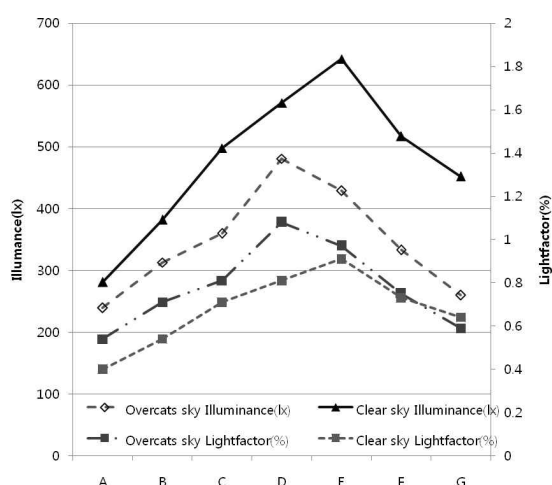


Figure 10: Lightpipe system, 14:00

For example, the average illuminance under overcast sky was 286lx. The average illuminance under clear sky was 618lx. However, the average lightfactor under overcast sky was 0.75%. The average lightfactor under clear sky was 0.77%. As a result, the average illuminance under overcast sky was more than 3 times lower than clear sky condition. However, The average lightfactor under overcast sky was similar to under clear sky.

This effect is probably due to the lens inside the dome that improves the light capturing efficiency when the under overcast sky.

The lightpipe at position A, B, C, D was similar to E, F, G when the under overcast sky. However, The lightpipe at position E, F, G had higher readings than the lightpipe at position A, B, C, D when the under clear sky. In other words, Lightpipe systems have limited applications in climates dominated by overcast sky conditions. For clear sky climates, the lightpipe can direct sunlight into a room when the high altitude.

The lightpipe systems may perform well in all climates.

4. CONCLUSION

The performance of lightpipe was tested in April for overcast and clear sky conditions. Both the ratio of interior illuminance to outdoor illuminance and the absolute illuminance inside the mock-up

were measured. A characteristic value of light factor was 0.75% under overcast sky and 0.77% under clear sky. It would also have very high light factor from direct sun penetration and large potential glare problems.

Under clear sky conditions, the illuminance levels were often above 500lx throughout most of a typical 2.4-m-deep room, allowing electric lighting to be dimmed or turned off.

Under overcast sky conditions, the lightpipe do not change daylighting level or light distribution dramatically compared to clear glazing.

The lightpipe system opening provides better glare control and improved visual comfort than skylights.

ACKNOWLEDGEMENT

REFERENCES

- [1] D. Jenkis, T. Munner, "Modelling light-pipe performance - a natural daylighting solution", *Building and Environment*, Vol. 38, pp. 965-972, 2003
- [2] G. Oakley, S. B. Riffat and L. Shao, "Daylighting Performance of Lightpipes", *Solar Energy*, Vol. 69, No. 2, pp. 89-98, 2000
- [3] IEA SHC Task 21, "Daylighting in Buildings", ECBCS Annex 29, 2000.06
- [4] M. Paroncini, B. Calcagni, F. Corvaro, "Monitoring of a light-pipe system", *Solar Energy*, Vol. 81 pp. 1180-1186, 2007
- [5] S. Szokolay, "Environmental Science Handbook for Architects and Buildings", pp. 91, 1979
- [6] William M. C. Lam, *Sunlighting as Formgiver for Architecture*, Van Nostrand Reinhold, New York, 1986, pp. 146-156
- [7] <http://www.solarspot.it/it/>
- [8] <http://www.whilkor.com/>
- [9] http://en.wikipedia.org/wiki/Light_tube