Light Pipe - A Sustainable Daylightining System for Building

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Abstract-*In present scenario, many countries in the world are facing huge power crisis for domestic and industry needs. Fossil fuels are no longer going to support the present demand and renewable energy is the only alternative to meet the crisis. Solar energy has highest potential for utilization as alternative energy source. This paper reviews the current daylighting strategies incorporated to a building. The development of a highly efficient reflective and refractive materials have made the redirection of daylighting into areas of buildings far away from the façade. Cities are consuming more power in day time as cities set backs are not maintained properly for buildings as per municipal norms . To address these problems, an innovative sustainable technology named as Light Pipe is proposed and explained in order to resolve these issues very effectively and economically for better building lighting services. Light pipe system is one invention that transports daylight efficiently from outdoor into rear part of a room. It does not only provide sufficient luminance into the room but also improve the internal environment without generating excessive heat.*

Keywords - *Daylighting, energy consumption, luminance, light pipe system, sustainable.*

1. INTRODUCTION

Day lighting is a method to illuminate building interiors with natural light without artificial lighting in daytime. Side lighthing from windows is commonly used to allow daylight to enter into the buildings. Besides that, daylighting also can enter into building from top lighting such as skylight or clerestory window especially for buildings with limited façade.Nowadays, there are technology in harnessing daylight and transporting it into building interior by using highly reflective materials known as light pipe system. It is the simplest daylight system which allows daylight to enter into the interior spaces where windows restricted. With proper introducing of daylighting system, it will help in reducing energy consumption and has positive physiological effects on building occupants. Morever, this approach is one of the aspects in green building certification due to its potential that can improve energy effiency and the quality indoor environment.

2. DAYLIGHTING OPTIMIZATION

In recent years, with an increasing awareness of sustainable development, daylight has been seen as an effective means of saving energy and reducing the environmental impact. Previous studies have confirmed the benefits to users satisfaction and well-being.

2.1 Benefits of daylighting

The overall objective of daylighting is to minimize the amount of artificial light and reduce electricity costs, but it can also lower HVAC costs as well. Electrical lighting produces a lot of heat, whereas, if properly controlled, natural lighting generates hardly any heat at all.

For most buildings incorporating daylighting, the overall energy savings range from 15 to 40 percent. Although energy savings and sustainability may be the reasons companies initially opt for daylighting, it can also have an impact on the productivity and satisfaction of employees, students and even clients and retail customers.

People have a natural attraction and need for daylight. Studies suggest that daylighting has a direct impact on well-being, productivity and overall sense of satisfaction. Even retail stores like Wal-Mart have seen the environmental and monetary benefits of daylighting for both employees and consumers. In an experiment, stores that included skylights over certain departments found that overall sales per square foot were higher in the departments lit by natural light.

2.2 Daylighting strategies for building

Daylight illumination can come directly from the sun, light diffused through the atmosphere and light reflected from external surfaces.

Side and top lighting are conventional methods in illuminating building. Side lighting from windows is the prominent architectural aspect in building design. In addition to lighting purposes, windows offer ventilation, view and fresh air. These may provide relaxation and inspiration to occupants. However, the illuminance levels from windows decrease rapidly with distance from the window as shown in Figure1.

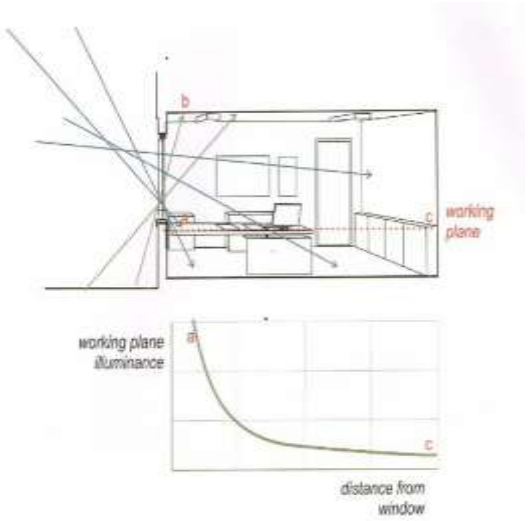

Figure 1 - Sidelighting Strategies

By introducing large window areas to allow more daylight into a space is not a good idea, because these strategies may allow excessive heat gains or losses which increases the air-conditioning cooling or heating load and consequently the energy consumption Even though window offer good view, its also increases the level of noise,glare or contributes to the distraction of the occupants. Previous studies of showed that the students learning progress is reduced with the distraction from outside activity. Thus, people tend to use window blinds, curtain and artificial lighting in controlling the glare, distraction and privacy. Thus, this behaviour indirectly increased the energy consumption, when people switch on lighting during daytime. Therefore the peak demands for electrical lighting occurs at the same time as peak availability of daylight

3. LIGHT PIPE SYSTEM

Light pipe systems are linear devices that channel daylight into the core of a building. This system brings daylight into deep of a building without producing extreme warmth .Figure 2 shows the typical of light pipe system. The light pipe systems comprise of a collector, a light tube and a diffuser. A collector is usually located at roof level and is made of clear domed light to accept sunlight from the whole sky hemisphere. Light tube acts as a light transport that will guide the light into the room to be daylighted. The tube with highly reflective internal surfaces, like aluminium sheet with reflectance of about 95–99%, increases the efficiency

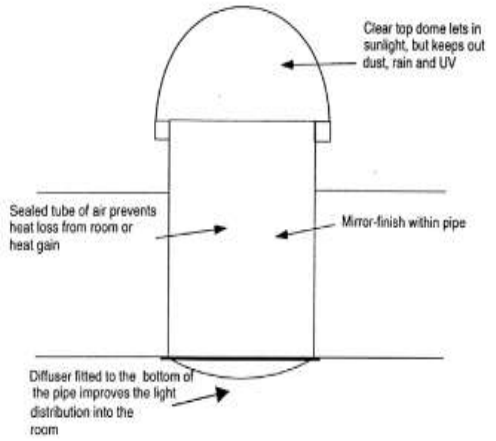

Figure 2 - Schematic of Typical Light Pipe

High efficiency reflection is the principle in light pipe system. Hence, the use of elbow or bend will result in light loss. In a review done by mentioned that, each elbow may loss 8% of light. Studies by on 330mm diameter on elbows and straight pipe showed that straight pipe performed better than elbows due to light loss. The light loss in straight pipe with elbows will be higher than the straight pipe without elbows. With a simpler installation, this system is suitable to install in new buildings or retrofitted to buildings.

3.1 PERFORMANCE OF LIGHT PIPE SYSTEM

The performance of light pipe system as natural daylighting system has been reported in a number of studies. These studies have verified the efficiency of light pipe system as a light source in a building. An experimental study carried out by Oakley, G.,Riffat, S.and Shao, L. 2000, Daylight Performance of Lightpipes, Solar Energy. 69:89–98. reported that light pipes are proficient devices for introducing daylight into buildings. Surveys conducted by Al-Marwaee, M.and Carter,D. J. 2006. Tubular Guidance Systems for Daylight: Achieved and Predicted Installation Performance, Applied Energy on 13 buildings have found that light-pipe systems could provide 25% –50% of the work plane illuminance and tend to reduce lighting energy consumption. In another study revealed that interior illuminance on the working plane could vary depends on sky condition. Figure 3 shows the inter correlations between indoor illuminance and sky condition. This study was supported by Evaluation of Daylighting Effectiveness and Energy Saving Potentials of Light-Pipe Systems in Buildings Indoor and Built Environment through the prediction model, where there are strong associations between the

daylighting performance of the light-pipe and local climate conditions (i.e.,solar altitude, sky clearness index, and external illuminance)

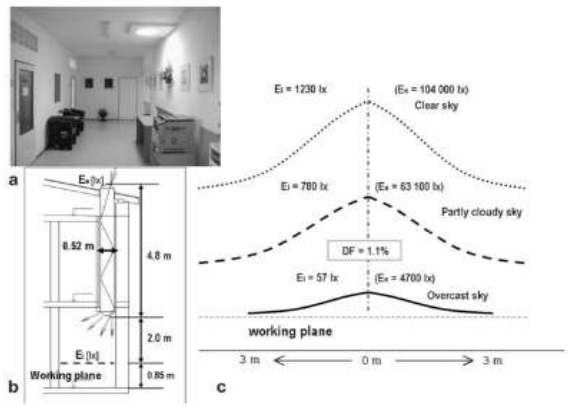

Figure 3 - Illuminance Measurements in the Windowless Corridor

3.2 CHALLENGES OF LIGHT PIPE SYSTEM UTILIZATION

Although previous studies show positive performance of light pipe system, but there are several challenges that caused it are not popular. The challenges can come in terms of cost, maintenance and the awareness of users.

(a) High initial cost

There are cost association in maximising daylight illumination in building. The installation of light pipe systems were substantially cost higher compared to the electric systems and conventional window. The initial cost will be increased due to implementation of advanced technology in order to collect more amount of daylight. However, light pipe system is an inexpensive method compared to other innovative daylighting system. Moreover, the light pipe system provides sufficient daylight in the clear sky condition and provides a significant amount of light.

(b) Maintenance

To ensure the quality of illuminance, maintenance program should be applied to the system. Dirt and dust can reduce the efficiency of the systems, hence it require regular cleaning. The replacement of affected component due to optical distortions or possibility of broken or degraded components.
the maintenance of light pipe system may a problem and more inaccessible than the conventional lighting.

(c) User awareness

Users' awareness on the use of daylight is essential for widespread its use. Studies conducted by Carter,D. J. 2004. Developments in Tubular Daylight Guidance Systems, Building Research & Information 32: 220–234 , recognizing that the human factor as a key determinant of delaying implementation of the technology to be more widely. Reducing electricity bill is not enough to convince the user due to light pipe system with high initial cost. By providing information about the benefits in term of visual environment, well-being impact and productivity improvements can increase user awareness of this system.

4. CONCLUSION

This paper presents an overview of light pipe system as an effective daylighting system to building. The overview emphasized not only the studies of theory and performance of light pipe, but also some overview of Indian climate in optimizing day lighting using light pipe system. In addition, this paper also discusses the common challenges in using light pipe as a daylighting system. With the advantages offered by light pipe system, it has the potential to be widely used in Indian buildings.

REFERENCES

1. Liberman J. Light—Medicine of the future (Bear & Co.) (1991)

2. Oakley G., Riffat S. and Shao L. Daylight performance of light pipes CIBSE Annual Conference Proceedings pp 158-174 (Oct. 1999)

3. Smith SJ, Riffat S., Shao L. and Mualim AA Evaluation of dichroic material for enhancing natural ventilation and daylighting in an integrated system Applied Energy 62(4) 253-266 (1999)

4. Edmonds IR, Moore GI, Smith G. and Swift PD Daylighting enhancement with light pipes coupled to laser-cut light-deflecting panels Lighting Res. Technol. 27(1) 27-35 (1995)

5. Shao L., Sharples S. and Ward IC Tracer-gas mixing with air Building Serv. Eng. Res. Technol. 14(2) 43-50 (1993)

6. Shao L., El-Mualim and Yohannes I. Mirror light pipes: daylighting performance in real buildings Int. J. Building Res. Technol. CIBSE series B 30(1) 37-44 (1998)

7. Etheridge D.W. and Sandberg M. Building ventilation: theory and measurement 2006