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Technology Interventions of Daylight for Deep Plan Building

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Abstract: Daylight is important for buildings because it provides numerous benefits to the occupants and the building. Firstly, natural light is essential for visual comfort and productivity. Secondly, daylight is a source of energy and reduces the reliance on artificial lighting, which can lower energy costs and carbon emissions. Moreover, daylighting has been shown to positively impact human health and wellbeing by reducing stress and improving mood. However, deep plan buildings fail to receive natural light which hinders the productivity as well as the aesthetics of the building. This paper explores the importance of daylight in deep plan buildings, where spaces are located further from the perimeter walls and rely heavily on artificial lighting. Daylight has a significant impact on the quality of indoor environments, including visual comfort, energy efficiency, and occupant health and wellbeing. However, designing for daylight in deep plan buildings requires a specific set of considerations and strategies. The paper discusses these strategies, including the use of different technologies for introducing daylight in such buildings and presents case studies of successful daylighting in the same. The paper concludes that incorporating daylighting strategies in deep plan buildings is crucial to creating healthy and sustainable indoor environments.
Keywords: Insufficient Daylight, Parameters, Light Pipe, Installation, lux.

I. INTRODUCTION

Insufficient natural light is a common problem in deep plan buildings. Such buildings have large floor areas and limited exposure to natural light, making it difficult to provide adequate light to interior spaces. Lack of natural light can have negative effects on the well-being and productivity of occupants. In addition, it can also increase the demand for artificial lighting, leading to higher energy consumption and costs. Deep planned buildings pose complex light penetration and ventilation problems, which are relatively easy to solve for single-story buildings, but often require artificial lighting and air conditioning. or ventilation if they are on stage.

These buildings have a high ratio of interior floor area to exterior wall area, resulting in a large floor area more than 4m from the outer wall. As a result, the deep central parts of these structures cannot be naturally lit by auxiliary lights and must rely entirely on electricity for illumination.

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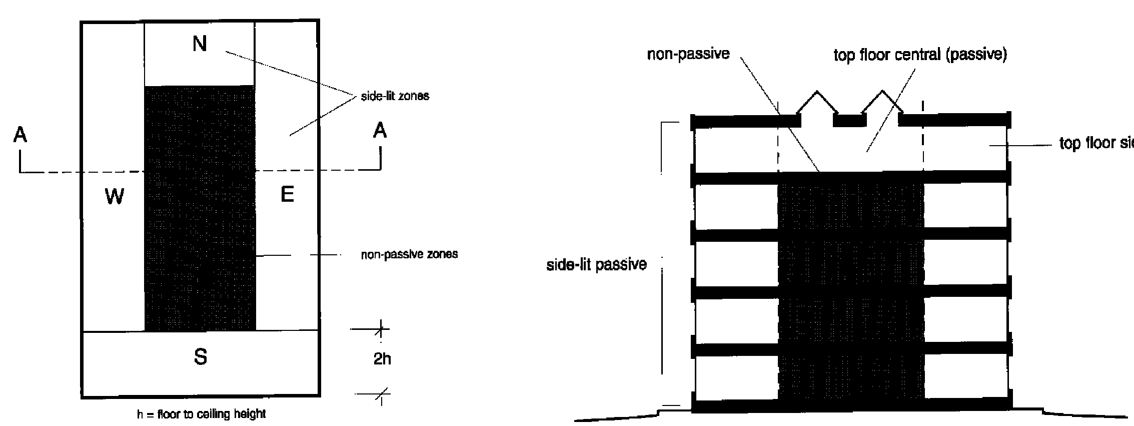

Fig 1: Building passive zones (Baker and Steemers, 2000).

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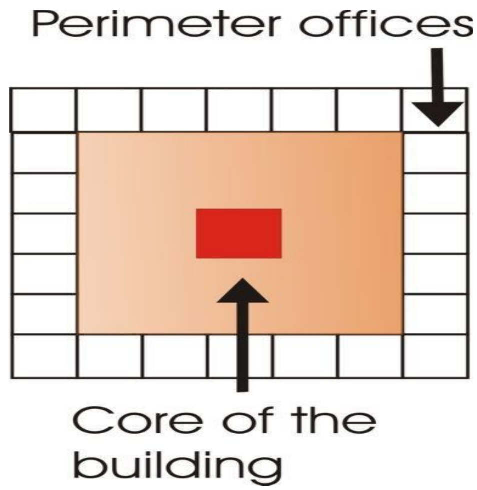

Fig 2: Perimeter offices and their walls reduce the quantity of natural light that reaches a building's core

To address this problem, designers can incorporate various strategies, such as designing buildings with open floor plans, using reflective surfaces to increase natural light penetration, and incorporating light wells or atria to bring natural light deep into the building. Overall, ensuring adequate natural light in deep plan buildings is crucial for creating healthy, sustainable, and comfortable indoor environments. Another innovative concept is to introduce an integrated daylighting system (IDS) in a deep plan building.
The goal of integrated daylighting systems (IDS) is to provide appropriate illumination in buildings when the quantity of available daylight from standard daylighting systems is insufficient. These optical daylighting technologies may extend the reach of natural light within a high-rise structure beyond what is possible with traditional daylighting methods like windows and sky wells. There are primarily two categories of novel outside lighting technology:

1) Light Guiding Systems
2) Light Transporting Systems.

II. LITERATURE SURVEY

A. Light Guiding System

The light guide system guides and disperses the sun into the room, blocking light and heating. There are colorful and different systems, all with similarities in their overall performance, their position within the structure, or their light-guiding systems.

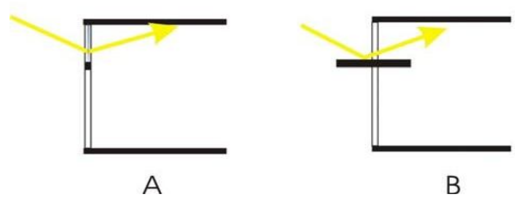

Fig 3: A) Vertical Source, B) Horizontal Source

B. Vertical Elements

This category includes gadgets that are commonly found near windows (vertically or diagonally). These elements use reflection and refraction to direct light deep into space. Acrylic sheets (e.g. laser cut sheets or prism sheets), acrylic components are stacked vertically on double glazing (e.g. solar control glass), or polymer films sandwiched between two pieces of glass (e.g. holographic optics) element). The ease of implementation into building plans is a major plus. These tools are effective to a depth of 10 meters.

C. Horizontal Elements

A daylight baffle takes the incoming direct sunlight and directs it, usually toward the ceiling of the room. These devices perform her two functions: Anti-glare to deflect direct sunlight away from occupants' eyes and daylight transmission to diffuse sunlight deeper into spaces where it would otherwise not be allowed.

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Daylight redirection devices typically take one of two forms: Large horizontal elements or slat systems. Devices that redirect daylight horizontally are often called light shelves.

D. Light Transport System

A transport device used to distribute natural or artificial light over a remote space. In daylight applications, they are also called solar tubes, solar tubes, lights or daylight tubes, depending on their position in the building.

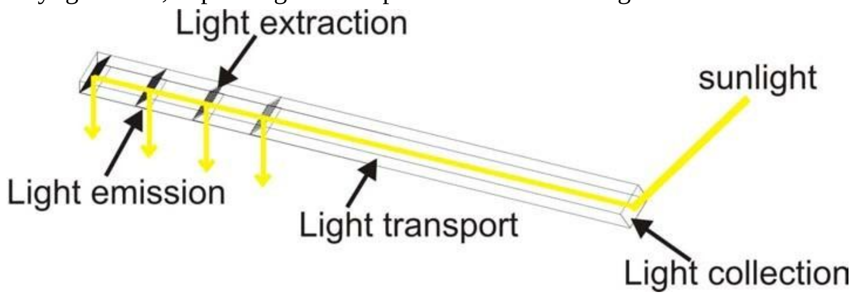

Figure 4: Pipe Lighting System Diagram

The following are some of the advantages of light piping systems:

Solar light guides provide better insulation than skylights and traditional windows. Their flexibility allows them to be used in interior spaces that do not share walls with the outer walls of the building. Natural light exposure is amplified by light guides and is of great benefit to people with seasonal affective disorder.

Moreover, the use of light guides also avoids over-illumination due to direct sunlight. Saving energy by reducing the use of artificial lighting is a clear advantage.

Light guides and daylights are also available in hybrid arrangements using both forms of light, and automation can be installed to keep lighting levels constant.

Design Intervention Of Light Transport System

	System	L (m)	H (m)	W (m)	Orientation	p	Collector	Extraction	Performance	Methods of analysis
A	Anidolic Ceiling	5 device 6.6 room	0.43	3.02	South (NH)	90	CPC passive	Anidolic element	Efficiency of the system 32%	Full scale model Radiance software
B	CPC Light Pipes	9.1	0.6	1.8 to 0.9	South (NH)	95	CPC passive	The inclination of the pipe's ceiling and the diffusing substance. The first section of the pipe has been covered. The pipe's last segment (4.5m) has an aperture covered with diffusing material.	Throughout the year, from 8:30 to 3:30, the average light level is 200lux.	IDC (Integration of Directional coefficients) (Integration of Directional coefficients) The technique is a hybrid methodology that combines scale model photometry with computer-based simulation.
C	Light Pipes with glazed collectors	6	1	2	West or East Tropics.	80	Glazing with spectrally selective coating.	Inclination of the ceiling of the pipe.	Increase in brightness at the room's far end from 0.9% to 16.1% 25% efficiency.	Ray tracing technique Lumen method.
D	Light Pipe with active collection.	12	0.5 to 0.45	2 to 1	South (NH)	95	Electric motor with active reflector (simple movement).	Radiance Opticad.A2:I5A5	Average monthly values 300lux.	Radiance Opticad.

Table 1 : . Comparison Table for Different Pipes layout

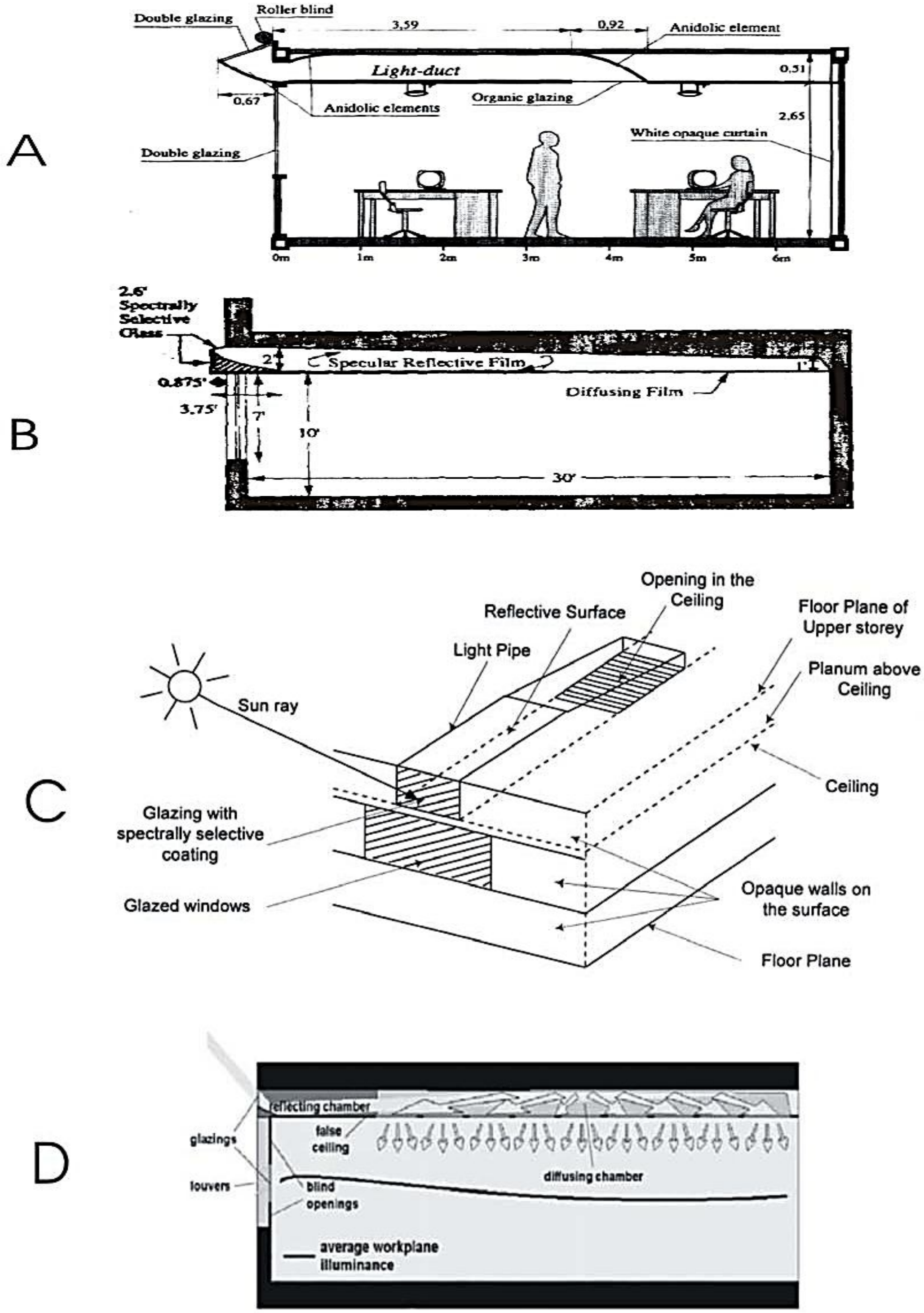

Fig 5 : Design intervention with different design ceiling parameters

E. Light Distribution

Sunlight entering a window is divided into three parts- diffuse light, direct transmitted light, and polarized transmitted light.

Surfaces in space are divided into small rectangular elements and the radiosity method is applied to compute the illumination of each element based on the initial light output. The direct and polarized transmitted light is distributed from the direct and polarized light to the rectangular elements following the path of the sun.

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Elements hit by direct or redirected light are treated as emitting light sources based on the amount of direct and redirected light on the element. The purpose of this method is to allow combined assessment of daylight, artificial light, heating and cooling energy consumption in the early stages of design, based on a limited amount of information about building design.

F. Light Extraction

The system was able to gather the same quantity of light via each of the holes. This is made possible by the first extraction plate being highly reflective—enough to deflect around 25% of the light.

The second panel redirects one-third of the residual light, the third redirects half, and the last extractor redirects everything.

PMMC light diffusion tubes of 2 m in length and 0.1 m and 0.2 m in diameter are set up on the second and third levels.

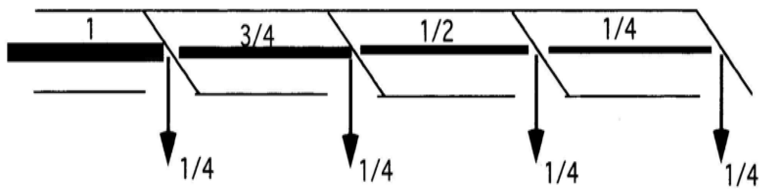

Fig 6 : Light extraction in the light pipes

G. Light Emission

Light emitters are devices used to disperse the light produced by a light transport system.

In 1995, Ayer and Cater distinguished between two distinct kinds of emitters: those that do double duty as a transport and emission system, continually pulling light from a distant source system and emitting it, and a separate device that may be used to redirect the light from a transit system in the same way as traditional lamps do.

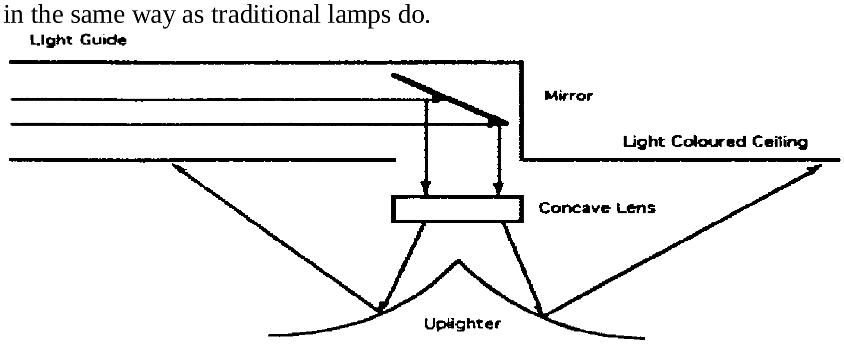

Fig 7 : Solar Light Flux Emitter

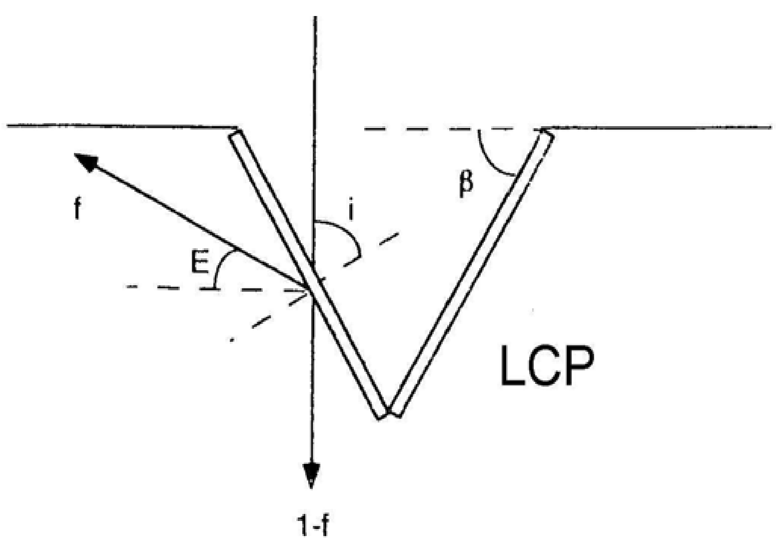

Fig 8 : Laser cut panel as an emitter.

III. CASE STUDY SELECTION

A case study conducted on a Waterfront deep plan building with horizontal pipes showed the following result-

A. *Building Details*

4.6 m floor to floor height
Core that faces west (as a thermal buffer)
300 lux backdrop, 600 lux for working
A 2,000 square meter deep floor plan
shading in the direction of light to direct sunlight toward the plate's edge
light tunnels to bring natural light to the middle of the floor plate

B. *Result*

The research concluded that deep plan structures benefit from the combination of light pipes and laser cut panels, with illuminance values of 200 to 300 lux being achieved between the hours of 12 and 4 p.m., helping to meet the minimum requirement of 300 lux for the Water Front House Building.
At higher sun angles, more of the incoming light is deflected, so it travels through the pipes with fewer reflections and produces better results. The number of reflections experienced by the off-axis beam increased and the amount of light deflected decreased while viewing at a lower angle.
The analysis shows that using light pipes will increase the passive zone in the building and thus save energy by using daylight.
Another case study conducted on a Millennium Library deep plan building with vertical pipes showed the following result –

C. *Building Details*

North-East Orientation,
6000 m2 deep plan floor plate,
The building has five storey,
3.8m from floor to floor.

D. *Result*

For the building design, daylighting was achieved by the use of vertically acquainted light pipes for a five-level building with a 100m by 60m layout. Pipes were 18.5 m in length and 2 m in diameter. The collectors were constructed from mixtures panels that were ray-cut.
A total of 144 m2 were flooded with light, with some coming from either bottom. In order to break up the hectic middle portion of the building's architecture, eighteen light pipes were considered.
The goal was to determine the potential and limitations of the technology in terms of perpendicular lighting in a variety of settings inside a building. The LCP collector's effectiveness was not constant throughout the day.
For higher and lower sun elevation angles (50lux to 150lux), LCP with steeper inclination angles (e.g. 45 degrees) showed lower performance but lesser uniformity, while LCP with shallower inclination angles showed higher performance but a broader range of illuminance values (50 lux to 300lux).

IV. COMPARITIVE ANALYSIS

A. *Difference Between Vertical And Horizontal Pipes*

In contrast to a vertical light pipe, which may collect light from the whole sky vault (provided that no girding buildings cast obscuration over the system's collector), a vertical light pipe can only gather light from half of the sky vault.
Vertical light pipes are simpler to prize and distribute in space due to light peregrination over within the pipe to the ceiling through a listed interdicting face (i.e. cone extractors), whereas vertical light pipes, especially those located inside the service fake ceiling, are more difficult to prize and distribute in space due to their position above the ceiling

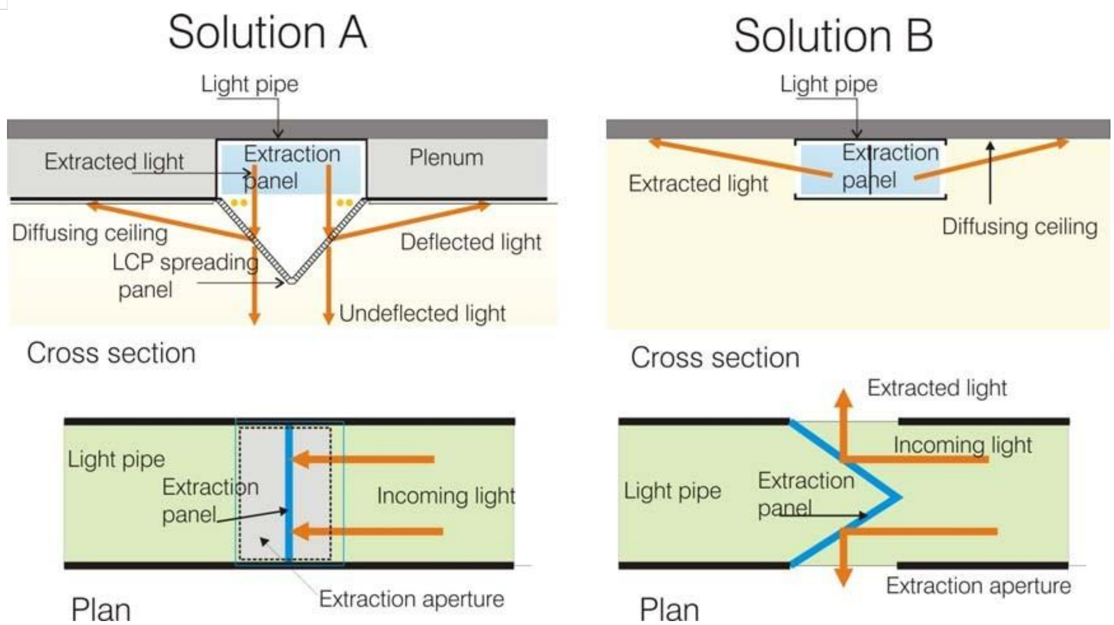

Fig 9: Section A Represents Vertical Light Pipe and Section B Represents Horizontal Light Pipe

V. CONCLUSION

Natural light in deep plan constructions can be provided and improved through the use of light pipes. This paper has shown that light pipes can expand the building's "unresistant zone," which might lead to a decrease in the amount of power needed for things like lighting and ventilation systems.

Natural lighting in deep plan constructions can be improved with the use of passive vertical and perpendicular light pipes.

Ambient illumination (up to 300 lux) can be provided with the light levels reached in this study without the use of artificial lighting; however, artificial lighting is required for task illumination and to maintain appropriate lighting levels when daylighting alone is insufficient.

REFERENCES

[1] Bean, R. (2004) Lighting: Interior and Exterior, Architectural Press. Elsevier,Amsterdam.
[2] Edmonds, I. (1995) Applied Optics, 34, 6522-6526.
[3] Edmonds, I. R., Moore, G. I. and Smith, G. B. (1995) Lighting Res. Technol.
[4] Baker, N. and Steemers, K. (2002) Daylight Design of Buildings, James & James,London.
[5] Littlefair, P. J. (1985) The Luminous Efficacy of Daylight. Lighting Res. & Tech..
[6] Littlefair, P. J. (1990) Innovative daylighting: Review of systems and evaluationmethods. Lighting Res. Technol..
[7] Daylighting Technologies In Non-domestic Buildings- 2010
[8] Materials and systems for efficient lighting and delivery of daylight.-2014
[9] Daylight and energy performances of a new type of light pipe- 2008
[10] Smart Technology used for active daylighting techniques mainly based on smart windows, artificial lighting and daylight harvesting.-2019
[11] Solar Optical Fiber Daylighting System With An IR Filter: Experimental And Modeling Studies-2020
[12] Advanced Daylighting Technologies for Sustainable Architecture Design-2008
[13] Windows in the workplace: examining issues of environmental sustainability and occupant comfort in the selection of multi-glazed windows-2014
[14] Integration Issues For Using Innovative Daylighting Strategies In Light Wells -2017
[15] Improving The Day Lighting Of Deep plan Buildings By Means Of Light Piping Technique.-2019
[16] The use of light pipes for deep plan office buildings : a case study of Ken Yeang's bioclimatic skyscraper proposal for KLCC, Malaysia-2005