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Analysis of Light Shelf Design

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***Abstract*—This paper is an experimental analysis of the optimum design of a light shelf for better daylight illumination of the space. This provides data that can be referred when considering light shelf as a passive method for introducing natural light deeper and evenly in the space. This paper can form a base for other researches on the topic, as to deeply evaluate the technique.**

***Index Terms*—Day lighting, Glare, Light Shelf, Sunlight penetration.**

I. Introduction

Day lighting is an extremely important factor in any building space. Apart from influencing an occupant visually as well as psychologically, the optimum use of daylight in a building can drop down the cost of artificial lighting to a significant extent, thus making the building more energy efficient. The allowance of daylight is done through conventional techniques such as windows, skylights etc. But it is important that it is allowed in controlled manner. If not, it can cause discomfort, due to uneven illumination, causing glare and leading to increased cooling charges.

Visual comfort is important consideration in illumination of any area. It is important to control the variations and intensity of light entering a space. This is because too little or too much of light can cause strain on our eyes, constantly adjusting to it. And this can even lead to fatigue. Thus space should be designed for the visual comfort, or adaptations be done to existing lighting conditions so as to making the space more visually comfortable.

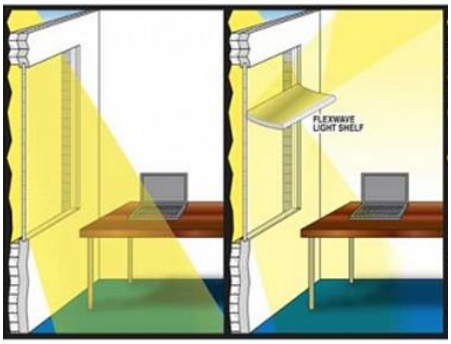


Fig. 1. Window with no treatment and with light shelf

A light shelf is an adaptive method for providing natural light into the building space more effectively and evenly. It works by 'reflecting' the day light entering through the window, deeper into the space, and that too more evenly.

II. Light Shelf

Light shelf is a passive device to introduce natural light deeper into the space. Through this device, daylight can be used more effectively by the occupants. The amount of light entering through the window cannot be controlled normally. Large amount of light can enter the room, concentrated on a single area, causing glare. This can cause discomfort to the occupants. Also, illumination being maximum near the window, the inside area of deeper floor plan remains dark. Thus light shelf can be preferred in such case, so as to increase the penetration of natural light.

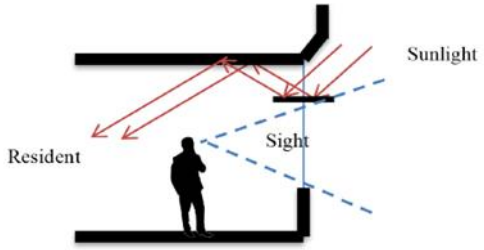


Fig. 2. Principle of light shelf

A. Internal or External Light Shelf

Light shelf can be used either fixed internally in the room, or externally.

- External light shelf can be preferred due to the reason that they prevent heat gain into the space to great extent.
- Internal light shelf can be preferred owning to the minimized maintenance as it's easily accessible.

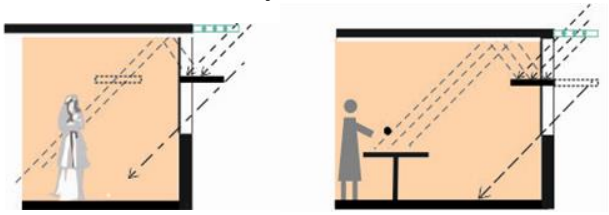


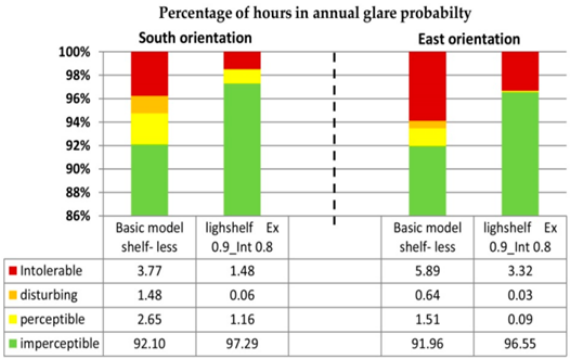
Fig. 3. External and internal light shelf

B. Impact of Sun's Direction

Performance of light shelf may vary according to the sun's direction.

- *North/South direction:* Light shelf when used in these directions, allow deeper penetration of sunlight into the space. And also would be shading the space near the window.

- East/West direction- Light shelf when used in these directions, lower the heat gain, but do not allow deeper penetration.



	Basic model shelf- less	lighshelf Ex 0.9_Int 0.8		Basic model shelf- less	lighshelf Ex 0.9_Int 0.8
Intolerable	3.77	1.48		5.89	3.32
disturbing	1.48	0.06		0.64	0.03
perceptible	2.65	1.16		1.51	0.09
imperceptible	92.10	97.29		91.96	96.55

Fig. 4. Percentage of hours and glare

C. *Advantages of Light Shelf*

- *Reduced glare:* Through this passive technique, glare through the window is significantly reduced with the help of the light shelf.
- *Increased sunlight penetration:* Since light falling on the surface of light shelf is reflected into the space, this property allows deeper sunlight penetration.
- *Decreased heat gain:* Through reduction of glare near the window, the heating of space is reduced through the light shelf.
- *Decreased cooling charges:* Since heating is reduced, the amount of money spent on cooling the space through artificial means, is reduced.

D. *Performance Parameters of a Light Shelf*

- Height from floor
- Size
- Angle
- Reflecting surfaces
- Sky Condition

Here in this paper, the performance of a light shelf was tested, based on its width, surface type and sun angle.

III. Method of Experimental Analysis

The optimum design for a light shelf is discussed in this paper. Parameters like the width and surface for the performance of a light shelf are tested through experiment.

The window in concern being south east facing. The experiment performed in Indore, latitude 22.72 (22°43'12"N) and longitude +75.86 (75°51'36"E). The selected month was October, times 9am, 12 pm. The light shelf heighted at 1.7m from floor level.

A model of light shelf was used for this experiment, running along the window (1.5m). Two surfaces were tested upon, plain white surface and aluminium reflective surface. The light shelf was placed internally in the room.

The variables for this test were three different widths of 0.3, 0.6 and 0.9m. Two different surfaces of plain white surface and reflective aluminium surface.

For the experiment, a sheet (super white drawing sheet) was used on a board and the same board with aluminium foil coating. White sheet used because, a surface built from fibers reflects light diffusely to great efficiency.

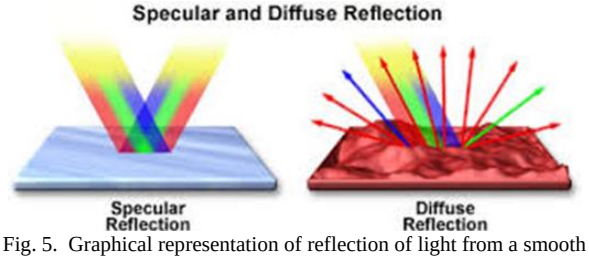


Fig. 5. Graphical representation of reflection of light from a smooth finished surface such as a mirror, and a rough textured surface like the paper sheet

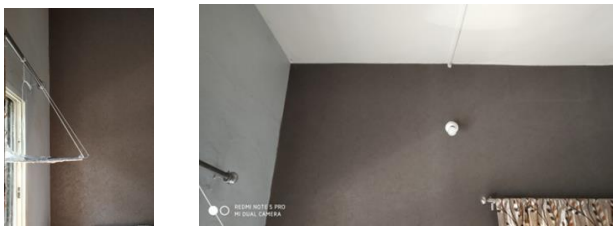
TABLE I
SETTING UP LIGHT SHELF

Height from floor	1.8m
Width	0.3,0.6,0.9
Surface type	Plain white, Aluminium
Angle	0

TABLE II
ROOM DATA

Length	7m
Width	3m
Ceiling	White plastered

When you open trans_jour.docx, select “Page Layout” from the “View” menu in the menu bar (View | Page Layout), (these instructions assume MS 6.0. Some versions may have alternate ways to access the same functionalities noted here). Then, type over sections of trans_jour.docx or cut and paste from another document and use markup styles. The pull-down style menu is at the left of the Formatting Toolbar at the top of your *Word* window (for example, the style at this point in the document is “Text”). Highlight a section that you want to designate with a certain style, and then select the appropriate name on the style menu. The style will adjust your fonts and line spacing. Do not change the font sizes or line spacing to squeeze more text into a limited number of pages. Use italics for emphasis; do not underline.



(a) (b)

Fig. 6. (a) Experimental model of light shelf suspended and held in horizontal position through strings (b) Sun light reflected through shelf onto ceiling and wall

IV. Results

A. Variations in Morning and Noon

Morning (9 am):

- It was observed that more light enters the space due to lower angle of sunlight. But this sunlight was not as harsh as the noon sunlight.
- Penetration of sunlight is deeper in the room.
- Amount of glare was more near the window.

Noon (12 pm):

- Less but comparatively intense sunlight enters the space.
- Penetration of sunlight is not as deep.
- The glare was less near the window.

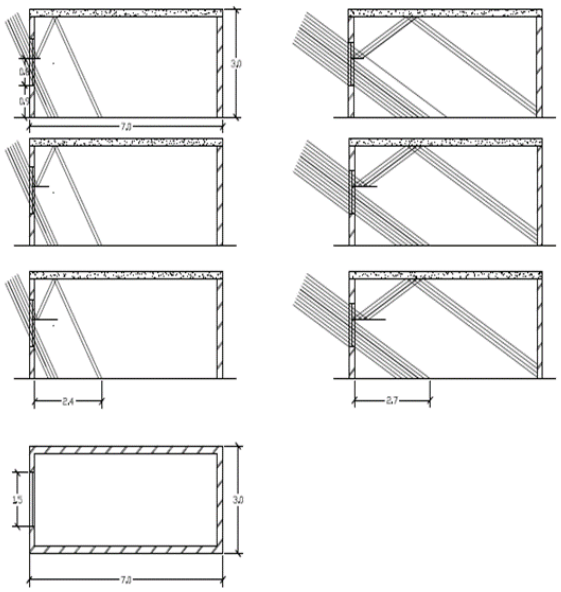


Fig. 7. Altitude angle of sun and light penetration at 12pm, altitude angle 60° (a, b, c) And 9 am altitude angle 30° (d, e, f)

B. Variations According to Width

- Shelf with 0.3 m width: The performance in case of higher space above the shelf up to top of the window would still allow glare to enter beyond the width. In this case too, small amount of sunlight was entering through window beyond the surface of light shelf.
- Shelf with 0.6 m width: The performance was better, and ideal as all of rays entering, reflected through the shelf and were penetrated into space
- Shelf with 0.9 m width: The performance was similar to that of 0.6m light shelf, but it was observed that the utilization of entire length was not there in 3m height room. It may be possible in rooms with higher ceiling and higher window.

Also this light shelf may cause undue obstruction in the room.

C. Variations According to Surface Type

- Plain white surface: It was observed that the reflection of sunlight was not as strong as that from light shelf with aluminium as surface. The average day light illumination, for 0.6m light shelf through smooth white surface was about 210 lux.
- Aluminium surface: It was observed that the reflection of sun light was much better through this light shelf. The light reflected deeper into the space through this type. The average day light illumination, for 0.6 light shelf was aout 280 lux.

D. Other Considerations Apart from this Experiment

Following are the considerations, not discussed in the above experiment that can further enhance the light shelf performance-

Geometry:

- It was noted that light shelf at an angle of 30° can allow more light to enter and also provide shading from summer sun.

Material:

- Providing textured surface rather than smooth surface, can provide more scattered light into the space and various particles reflect light at same time.
- The surface should be matte finish, a glossy finish would not be ideal for reflection of light.
- Transparency in the material can be beneficial rather than opaque surface, as it can result in more even illumination.

V. Conclusion

Thus light shelf can be an optimum solution to uneven day lighting, and can improve the functioning of the occupants and would even lead to elimination of artificial lighting to great extent. But this can only be done through proper designing of a light shelf. Taking note from this paper, such parameters like the width, surface type, sun direction, altitude angle could be useful in determining the optimum design for a light shelf. Thus careful considerations should be done to ensure maximum utilization of the day light.

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