The potentiality of reflected sunlight through Rawshan screens

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ABSTRACT

Rawshans has been one of the traditional architectural devices that are still being used in recent buildings as an environmental controlling device. Beside their use as an architectural component, they have been used to control natural ventilation and light. The most critical portion of the Rawshan, as light control concern, is the front screen. A systematic analysis of this portion has not yet been taken care of. However, pervious work of this component was investigated by the author for the effect of direct sunlight transmission. The attention of this paper is to check the effect of the reflected lighting component for the screen cells. The typologies of the screen cells were reviewed; and selected types of screen geometry were tested using laboratory experimentations.

1. WHAT IS A RAWSHAN?

Rawshan is an architectural device made of a combination of wood strips and screens, which is commonly used, for large external openings. It is also defined as a projected bay window with decorative wooden screens as an enclosure. (Saini, 1991). The word Rawshan originated in India where it is known as" rushandan" which means to give light, (Ashraf, 1983). There is no difference between the types of Rawshans in different countries as far as their functional principles are concerned. They are generally considered to fulfill their common functions such as cross ventilation, light control, humidity control, cooling of water in clay jars, and ensure social privacy for occupants, (Spencer, 1990). However, there are various kinds of Rawshans, which vary in appearance that arose from the taste of the client and the skills of the craftsmen.

Their sizes also depend on the size of the opening, which is mainly influenced by the type of climate. The Rawshans can be classified in to three kinds: cantilevered, screen panels, louvered timber walls and louvered windows, (Aljofi, 1995).

2. THE ENVIRONMENTAL ISSUES

It is common to read information in articles and architectural magazines about Rawshans and their contribution as ventilators or light controllers. However, it is almost lacking in any critical evaluation of performance. There are a few researchers who have dealt scientifically with the thermal performance of the Rawshan, particularly, the potentials of its natural ventilation. An investigation of air movement through different areas of the traditional house in Jeddah city centre indicated that air velocity is about 0.3 to 1.3 m/s due to the room location and wind speed (Allyali, 1990). Humidity may also be reduced in internal spaces as saturated air passing through the screen loses some of its humidity molecules as the wooden screen absorbs them (Hassan, 1988).

Because of the high intensity of the atmosphere, screens act as a light filter to reduce the glare effect (Spencer, 1990). Saini stated that screens not only diffuse sunlight but also distribute it uniformly through the internal space (Saini, 1991). These comments about the use of screens as a glare controller are found in many other articles. However, there is no further explanation of their physical behavior.

3. TYPOLOGY OF SCREEN GEOMETRY

The most effective components of the Rawshan as far as daylighting is concerned are the screen panels. They contain various forms of gaps and strips, which function differently, to avoid direct beam penetration and to reduce glare effect.

Few researchers have mentioned the size of the screen gaps in their works Spencer stated the names of some of the various design pattern of the screens such as Sahrigi (square grid) and Musadass (Hexagon), (Spencer, 1990). Depending on the craftsmen's skills, there are screens of very complicated shapes composed of up to 2000 pieces to one square yard (Spencer, 1990). The most common patterns of the screen strips are the cress crossed; diagonal crossed and rounded strips (Ashraf, 1983). Figure 1 shows some of these types (Jean, 1976).

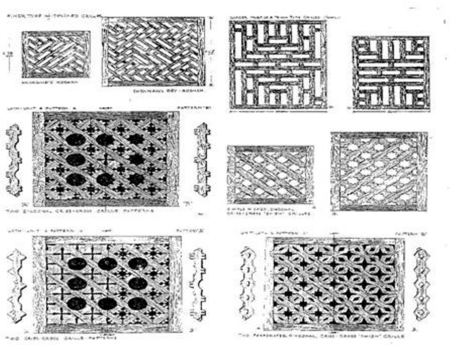

Figure 1: Some types of screen cells.

4. THE LIGHT CHARACTERISTICS OF SCREEN

As light passes through the screen device, its quantity is reduced. This filtering takes place in two ways: blocking by the screen unit as whole and obstruction due to the geometry of the single cell.

A screen is generally composed of organized groups of cells, which are separated by opaque strips of a certain thickness. Depending on the geometry of the single cell and the thickness of the opaque, the screen device filters around 51% of the direct sunlight falling on its surface, (Aljofi, 1995).

The single cell is the void part of the screen. Its contribution to the reduction of light transmission depends on its geometrical characteristics. The sunlight falling on the single cell comprise of two components, the direct sunlight penetrating through the cell and the reflected sunlight off the base of the cell frame. In addition, the reflectivity of the screen materials also contributes to light transmission. In the case of the common screen material, wood, the reflectance ranges from 10-50%, depending on its color and type (CIBSE, 1994).

5. LIGHT TRANSMISSION THROUGH SCREEN CELL

In the pervious section, it was stated that 51% of the incident light is reflected back due to the solid strips of the screen unit. The proportion of light, which is not reflected back by the outer face of the screen, is either transmitted directly through the screen device without being interrupted by its surfaces; or falls onto the internal surfaces of its cells and reflected inside the space. The proportions of light reflected off the single cell internal surfaces are illustrated here (Figure 2).

It is to be expected that sunlight transmitted directly through the single cell would represent the major contribution of the transmitted percentage and that reflected sunlight of the cell frame might be much smaller. An investigation of the feasibility of measuring the transmitted light due to direct beam was explored previously by the author (Aljofi, 1995). Furthermore, a predictive tool to enable further study of the contribution of this light component for specific

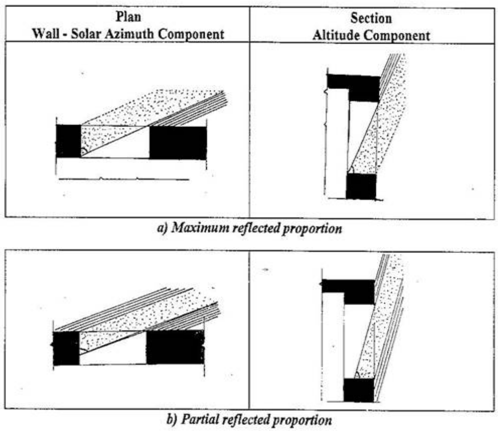

Figure 2: The proportion of reflected light off single cell.

site location was published using computer analytical program (Aljofi, 2003). Depending on orientation and times of the day, reflected sunlight can play an important role in the light level penetration through Rawshan screens Therefore, it's the purpose of this paper to investigate the feasibility of measuring the levels of transmitted light due to the reflected beam from the internal surface of the screen cell in addition to the reflected light from the sky.

6. METHOD OF INVESTIGATION

To explore the feasibility of transmitted light contribution due to reflected beam from the internal sides of the single cell, an experimental process was made for some types of the single cell geometry like rounded and complicated shapes. This experiment was carried out using different screen panels of various shapes of cells fitted at one face of a cube wooden box. The tested face was oriented towards south orientation to ensure the maximum exposure to sun path with no penetration of direct beam of light. For this purpose, afternoon hours where the sun position is high were chosen. The light values were recorded using group of photocells that were placed on various positions inside the cube.

The cube was made of five opaque hard wooden surfaces of 40 cm x 40 cm each; and five mm of thickness to ensure no light transmission through them. The cube was internally painted black matt to ensure that the photocells' readings did not embody the effect of the internal reflectance. One of the surfaces is opened to fix the tested panels on it. Six panels of different compositions of cell geometries were selected for this investigation (Figure 3).

A rotator tool was made to hold the photocells in position and to allow for rotation at different angles and record their values light at horizontal and vertical positions. The tool consists of a semi circular metal bar, with narrow slits for fixing the photocells (Figure 4). These slits were positioned at a distance corresponding to the angular distribution of 15 intervals from the centre of the semi circle. The metal bar was welded to a simple straight bar at the centre of the curved bar to hold the semi circular bar in position as it crosses through the back of the cube. A small knob was screwed at the other

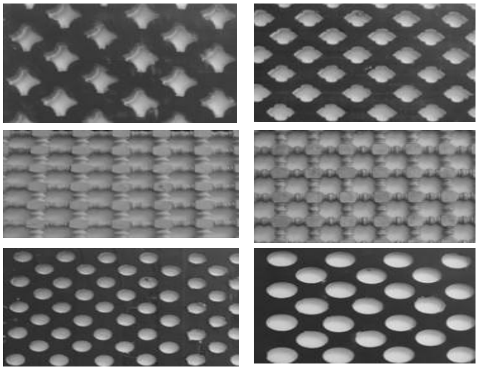

Figure 3: Six screen panels of different shapes.

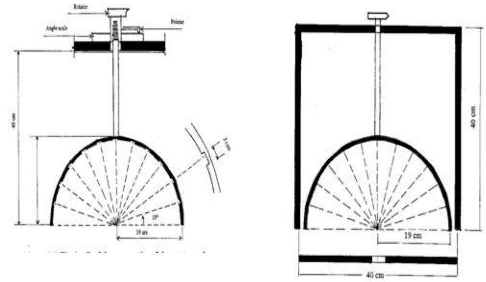

Figure 4: The rotator tool & the tested box.

end of the straight bar to facilitate its rotation from the outside of the cube. Another hole was made on the back face of the cube to insert the photocells and their connecting wires. All the wires were bound together with black adhesive tape to avoid the effect of any internal reflections.

7. IINSTRUMENTATION

Digital light meter was used as a recorded instrument for the reflected light values to enable researcher to record and store data at specific periods of the day. Megatron light meter model 234 was used (Megatron). It consists of seven light cell, additional one to read external light level and data logger connected to eight 2m covered copper wires of 2mm in diameter. The other end of the wires were connected to light cells of 2 cm in diameters. Falling light on these sine corrected cells is transferred to an electromagnetic signal. Then these signals are Transferred to digital readable numbers that been stored in the data logger. The external light photocell reads external horizontal illiminance in

Klux (one Klux = 1000 lux). The data logger contains a plug adapter to enable its connection to a personal computer to transfer the stored data via an attached software program called " Darka". The data logger is able to read and store light data at time increments that can be preprogrammed up to a minute A dry battery is usually used to operate the system up to 130 days to facilitate the use of the instruments for long period without personal observation.

8. EXPERIMENTAL SET-UP & ANALYSIS

The purpose of the analysis of the experimental results aimed to determine the effect of screens on light distribution upon various internal zones of the tested cube. The following procedures of sitting up this experiment can be conducted as:

1. The experimental cube was located on top of a table and placed on roof of a building to enable reading unobstructed light beam.
2. For each screen panel, at each photocell, one hour of reading was recorded at each five minutes and the average at each photocell was taken into consideration for the analysis.

The reflected light contribution through the screen cells was investigated in term of their shape, size and reflectance on the following paragraphs.

8.1 The effect screen cell shape

Various screen shape have a great influence on direct sunlight contribution (Aljofi, 1995), because different geometry effect the physical manner of direct beam transmission inside the space. This part of the experiment aimed to find out the importance of the geometry of the single screen cell on contribution of reflected light inside the space. Three different screen panels of different shapes were tested. These are rounded cells of 2 cm in diameter, a composed irregular geometry cell of 3 cm in, and an internally curved cell of 2 by 3.5 cm.. As daylight factor is the ratio between the global horizontal light outside and light level at the reference point inside the space (CIBSE, 1994), it is considered as a parameter of comparison.

According to the graph (Figure 5), the results can be summarized as follows:

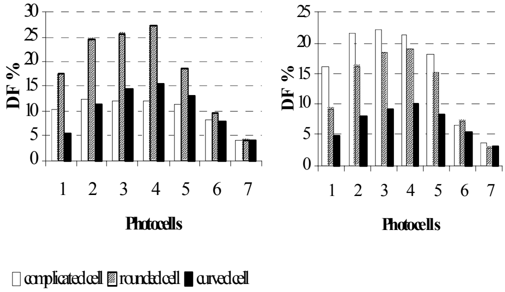

Figure 5: The effect of cell shape on horizontal & vertical light distribution.

1. For all shapes, the highest value of reflected light contribution was experienced at the central zone of the photocell holder as the daylight factor was of 10 -23%, while it was less than 12% on both ends of it. This is within the recommended standards of more than 5% for a well-lit appearance (CIBSE, 1994). However, the two ends are not quite equal for both positions. This expresses the high-reflected beam off the bottom base of the screen cells while it is little from their sides. The higher quantity of light falling on the bottom the screen base is due to the high solar position on the tested orientation.
2. The graph (Figure 5) also illustrates the great variety in the contributed reflected light due to the different shape. In addition, light increased on one end of the photocell holder on vertical position and reduced gradually up to the other end of the holder. However, light was more in the case of complicated shape of the screen cell while it was lower in the case of the rounded screen cell. Although the results indicated the influence of the shape on reflected light contribution, it is not yet a solid proof as the different shapes are not of equal size. Therefore, it is required to investigate the effect of size of screen cells on reflected light contribution on the second part of this experiment.

8.2 The effect of size of the screen cells

The opening size has a great effect on direct beam contribution through the screen cell (Aljofi, 1995). Therefore, this experiment aimed to investigate the effect of size of screen cells on reflected light inside the space. Two screens of different size of cells were tested. The first one is of 2 cm in diameter, while the other is of 5 cm

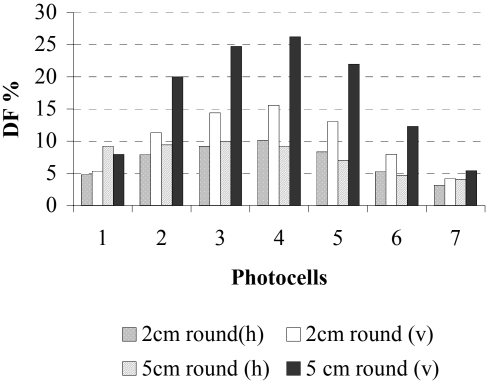

Figure 6: The effect of size on reflected light.

in diameters. The first one composed of 113 cells representing 22% of the total panel area while the other one is composed of 25 cells representing 31%. The results indicate (Figure 6) the following:

1. In both screens, light distribution on vertical position is more than on the horizontal one because more external reflected light falls on the bottom part of the circle cell due to the high position of sun on the tested orientation during afternoon period.
2. In both horizontal and vertical positions of the photocells, contributed reflected light is more in the screen of large cell diameter than the screen of the smaller diameter. This is due to the ratio of openings to solid parts of the screen panels as an increase of the single cell diameter. Consequently, the exposed area to external reflected light is increased.

8.3 The effect of surface reflectance of the screen

The reflectance of external surfaces represents a major component of reflected light contribution in building interior. Yet this might be decreased in the case of screen opening as the screen bars block around 51% of the light (Aljofi, 1995). Therefore, these experiment intents to clarify whether the reflected light of the inner faces of the screen cells represent a reasonable contribution of light or not. However, this investigation took into consideration the sky component contribution into account. Two typical screen cells of the same size and shape were investigated. The first one is made of light oak wood of 27 % of reflectance, while the other one was dark oak of 15 % of reflectance.

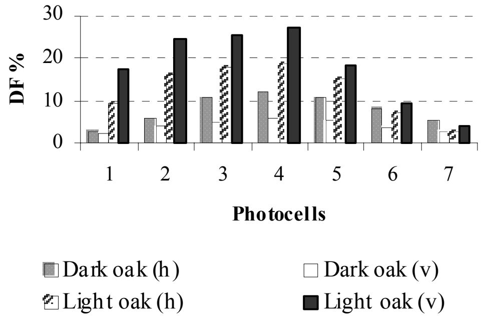

Figure 7: The effect of reflectance off cells.

The results clarify (Figure 7) that:

1. At the horizontal position, light contribution was increased at the central zone facing the screen cells and reduced at the two end zones. However, it is more at one end than the other because falling light beam covered the bottom base of each of the screen cells and part of one of their sides. This is due to the high altitude of sun position on south orientation at the tested period (afternoon).
2. Light contribution at the vertical photocells behaves in the same way of the horizontal ones. However, light level in the vertical photocells read more than in the horizontal for both types of tested screens.
3. Due to the high reflectance of the of the light oak wood screen as compared to the dark one, the light contribution of the light oak wood screen is more than the other one by an average DF of 17%.

9. CONCLUSION

Six panels of different compositions of cell geometries were selected for the investigation of the feasibility of the reflected light from the cell, four of them were of irregular, complicated shapes: the other two were composed of rows of rounded cells. The results indicate that for all shapes, the highest value of reflected light contribution was experienced at the central zone of the photocell holder as the daylight factor of 10 -23%, while it was less than 12% on both ends of it, and this is within the recommended standards. In addition light is lower in the case of rounded shape than in the other shapes. In both horizontal and vertical positions of the photocells, contributed reflected light is more in the screen of large cell diameter than the screen of the smaller diameter. This is due to the ratio of openings to solid parts of the screen panels. Due to the high reflectance of the of the light oak wood screen as compared to the dark one, the light contribution of the light oak wood screen is more than at the other one by an average DF of 17%. All of the stages of these experiments identified that there is no great difference in light distribution between horizontal and vertical photocells inside the space, and the only change is due to the solar position and the patch of light falling on the side faces of the screen cell.

REFERENCES

Aljofi, E., 1995. Effect of the Rawshan on the provision of daylight for shopping precincts, PhD thesis, University of Wales, Cardiff.

Aljofi, E., 2003. Theory of direct sunlight transmission through orthogonal screens cells, proceedings of the international symposium on renewable energy, Malysia.

Allyaly, S., 1990. The Traditional House of Jeddah: a study of the interaction between climate, form and living patterns. Ph.D. Thesis, Department of Architecture, University of Edinburgh.

Ashraf, S., 1983. Elrawashin of Jeddah, Saudi Arabia, cit. Jannas, S. Passive and low energy architecture, Oxford, Pergaman press.

Saini, 1991. Building in hot dry climates. John Wiley & Sons.

CIBSE Guide, 1994. Code for interior lighting, (London chartered institution of building services engineers).

Spencer, J., 1990. Mashrabeya, an architectural language. Art & The Islamic worl.

Hassan, F., 1998. Natural energy and vernacular architecture, The united nations University.

Jean, P., 1976. Green law, The coral buildings of Suakin, Stock field: oriel press.

Megatron, model234, Megatron, Limited, l65 Marlbrough Road, London, N16 4NE.