ISSN: 0975-833X

Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 12, Issue, 03, pp.10484-10490, March, 2020

DOI: https://doi.org/10.24941/ijcr.38256.03.2020

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

RESEARCH ARTICLE

RAWĀSHĪN OF TRADITIONAL DWELLINGS IN MADINAH, SAUDI ARABIA: INTEGRATING AESTHETIC DESIRE WITH FUNCTIONAL ASPECTS

*Randah Ashour and Robert Chen

Faculty of Art, Design, and Humanities, De Montfort University, Leicester, UK

ARTICLE INFO

Article History:
Received 24th December, 2019
Received in revised form
20th January, 2020
Accepted 28th February, 2020
Published online 28th March, 2020

Key Words:
Daylight, Rowshan, Madinah, Saudi Arabia.

ABSTRACT

Background: Rowshan (pl. Rawāshīn) is the projected latticework window, commonly found in façades of traditional dwellings in Madinah. Due to functions that Rowshan provides, such as overlooking the surroundings with complete privacy and controlling natural ventilation and lighting in the dwelling, it achieved a widespread popularity in the traditional architecture of Madinah, which gave the city its unique architectural identity. **Aim:** We attempt to explore that the Madinah's Rawāshīn carving units are not only esthetic, but also functional for daylight filtering. Our goal is to perform a computer simulation experiment using Velux Daylight Visualizer software and analyze the daylight performance filtered through the front (top) carving units of the Rawāshīn of Madinah. **Method:** Thirty carving panels of Madinah's Rawāshīn were studied to calculate the solid: void ratios using Image J software. A total of 12 carving units was selected with different solid to void ratios ranged from 0.8:1 to 11.5:1. Our experiment identified the background data such as material specifications, climate input and lighting conditions before the simulation process sets about. The experiment applied a basic geometry model of the standard living room found in Madinah's traditional houses, measuring 4 m (Length) x 3 m (Width) x 3 m (Height) with Rowshan window's (Forehead part of Rowshan) dimensions of 3 m (Width) x 1 m (Height) and window projection of 50 cm out of the wall. The Rowshan window is located 2 m from the floor. The daylight level of 100-300 lux was selected as a target lux level for these experiments. The lux levels were measured three times a day, three seasons a year and over four directions. **Results:** The average illuminance levels decreased dramatically with the use of Rowshan screens with all ratios compared with base cases with no screen in all orientations and seasons and at three different times of the day. The Rowshan screens with the ratios of (S:V 3.8:1) and (S:V 4.3:1) can provide the recommended levels of daylight (100-300 lux) in the studied room in all orientations and seasons and at three different times of the day. **Conclusion:** The findings of the present study alter the perception that the interior of the traditional house of Madinah has always been dark and subdued and suggest that the Rawāshīn of Madinah can be presented as potential daylight filters.

Citation: ***Randah Ashour and Robert Chen.*** **2020.** "Rawāshīn of traditional dwellings in madinah, saudi arabia: integrating aesthetic desire with functional aspects", *International Journal of Current Research*, 12, (03), 10484-10490.

INTRODUCTION

Rowshan (pl. Rawāshīn) is the projected latticework window, commonly found in façades of traditional dwellings in Madinah. It is created in wood as it is a natural insulator prevents the burning rays of the sun reaching the building and it is a material that resists natural conditions (Abu Al Haija, A. and Abu Al Haija, J., 2016). The unit of Rowshan is created by a front and two side boards, with a ceiling and a floor. It contains both mixed moving and fixed parts. Structurally, a single Rowshan can be divided into three separately made parts: from the bottom to the top, the "Base" is the lower part, the "Body" is the middle part, and the "Head" is the upper part; each part has a different function. The base is the lowest part of Rowshan, responsible for bearing the weight of Rowshan by shifting its vertical load to the wall underneath. The body is divided into three main parts: from the bottom to the top, the "Lodge", the "Openings" and the "Forehead". The ledge is the part of Rowshan's body designed for seating. It is typically has no openings and very plain on the inner surface, because it is always covered with the cushions, and more ornamented with carved decorations on the outer surface as it is exposed to the exterior (Alitany, 2014) (Figure 1). The opening section consists of two identical sections; the upper and the lower section. Each section contains an upward adjustable sliding shutter (Al-Hussayen, 2002). The inner side of each sliding shutter is made of plain, non-perforated wood, while the outer side consists of laths of wood fit into one another at right angles (crisscrossed) called "Shish".

Corresponding author: **Randah Ashour,**
Faculty of Art, Design, and Humanities, De Montfort University, Leicester, UK.

The Shish lath is about 1-2 cm thick; each Shish opening is 2 cm x 2 cm in dimensions (Al-Hussayen, 2002). (Figure 1). From a cultural point of view, the Shish, with its small size openings, provides a veil which permits the residents, particularly women, inside the house to look outside without being seen (Al-Murahhem, 2010). The forehead is the upper part of Rowshan's body, usually embellished with geometrical and floral designs incorporating perforations, that can be up to 10 cm x 10 cm in dimensions, in order to admit light to the house interior (Figure 1). This part is the only fixed source of light that enter to the house's interior and contains most of the aesthetic geometric designs found in Rowshan, therefore, it receives a great attention by Madani people (Al-Ban, 2014, Hariri, 1991). The head is located at the top of Rowshan and protrudes an additional 37 to 60 cm from the three sides of Rowshan (Taha, 2008). It shades Rowshan's body and diverts rainwater away from it (Alitany, 2014).

Unfortunately, Rowshan has disappeared from the architectural landscape of Madinah since the middle of the 20th century, as a result of the massive demolishing processes of many traditional dwellings around the Prophet Mosque, and replaced by aluminium frames with glass panels, as a step to confer the modern appearance to the building's façade, which many people were keen to express (Abu Al Haija, A. and Abu Al Haija, J., 2016, Al-Hussayen, 2002, Al-Mahdy, 2013). Giving that glass is a transparent material that does not prevent vision or block the sunlight, a new element was introduced in the shape of a curtain made of cloth, in addition to a blackout curtain or even thermal insulation at times. With the passage of time, this type of windows could not meet the needs of the community for privacy, leading owners to keep their outside-looking windows shut all the time. This approach does not only have a negative impact on the well-being of the house occupants, as it deprives them of sun light exposure, but it also increases the energy demand for electrical lighting, thereby increasing energy consumption and cost (Al-Hussayen, 2002). Research on the daylight performance of traditional shading devices has been published in several simulation studies (Batterjee, 2010, Al-Jawder, 2014, Batool, 2014,Kotbi and Ampatzi, 2016,Sherif *et al*., 2010,Zurainiet *al*., 2015). However, no such study has been done in the Madinah region of Saudi Arabia. To the best of our knowledge, the present research study is the first study on daylighting measurement in the traditional dwellings in the Madinah region of Saudi Arabia. We attempt to explore that the Madinah's Rowshan carving units are not only aesthetic, but also functional for daylight filtering.

METHODS

The investigation started with inventory surveys of the existing traditional houses in Madinah. The data consists of results of the field survey of the surviving traditional houses in old neighbourhoods in Madinah such as Assih and Almughaisilahneighbourhoods as well as of visits of the local museums such as Dar Al Madinah Museum and Museum of Madinah Summit to examine the remaining pieces of Rowshan closely. The researcher used AutoCAD software to build up a basic geometry model of the standard living room found in Madinah's traditional houses, measuring 4 m (Length) x 3 m (Width) x 3 m (Height) with Rowshan window's (Forehead part of Rowshan) dimensions of 3 m (Width) x 1 m (Height) and window projection of 50 cm out of the wall. The Rowshan window is located 2 m from the floor.

The openings of the window are divided into two horizontal panels. Each panel has four cells, and each cell is 50 cm high and 50 cm wide. The sides of the window contain one vertical panel that has two cells, and each cell is 50 cm high and 50 cm wide. The living room is selected to be modelled in this study as it is the most used room by the family members during the morning and afternoon. The study focuses on the top part of Rowshan (forehead or Rowshan window), as it is the main and fixed source of admitting daylight into the house's interiors. Therefore, thirty carving panels of Madinah's Rawāshīn were drawn in 3D drawings using AutoCAD software and were studied to calculate the solid: void ratios using the Fiji Image J program. It is open access, easy to use tool for quantitative image analysis. It helped the researcher to calculate the percentage of both simple and complex-shaped openings easily. A total of twelve carving units was selected with different solid (S) to void (V) ratios ranged from 0.8:1 to 11.5:1, as illustrated in Table 1. In this study, twelve Rowshan screens (cases), each with different S:V ratios (from 0.8:1 to 11.5:1), were modelled (Figure 2, 3). A base case without a Rowshan screen was also modelled to compare the daylight quality between a window with Rowshan and another without it in order to evaluate the impact of Rowshan on filtering daylight that admitted in the interior spaces. The models were then exported to Velux Daylight Visualizer software to measure the daylight lux level in the studied living room. Velux Daylight Visualizer is a professional lighting-analysis tool that allows designers and architects to test, predict and document daylight levels and appearance of space prior to realization of the building design. The software permits importing of 3D models, identifying the locations (latitude and longitude) and orientation of the models, specifying the date and the time the simulation, as well as the sky type (from clear to overcast), choosing the materials of the models and displaying the analysis grid at the height and dimensions needed (Labayrade *et al*., 2009). In addition to photorealistic rendering, the simulation output includes luminance, illuminance and daylight factor maps (Velux, 2014). Figure 4 shows the flow chart of stages of computer-based daylight experiments.

The location of analysis is Madinah, which lies on latitude 24º N and longitude 39º E. The weather in Madinah is very hot; the average daily temperature is 44°C in summer and can reach 50°C in extreme cases. In winter, the average daily temperature is twelve °C, and the minimum temperature can reach -3°C in extreme cases. The maximum mean daily hours of sunshine (daylight hours) is 13 hours in June and the minimum is 10 hours in January (Kaki (17)). The simulated sky condition was set as a 'clear sky' as this is the typical sky in such a climate. The daylight level of 100-300 lux is considered adequate to illuminate the interior spaces in residential buildings as shown in previous studies. Thus, this was selected as a target lux level for these experiments. The lux levels were measured three times a day, three seasons a year and over four directions. Ceiling, interior walls and floor reflections were set at 80%, 60% and 40% respectively since interior surfaces of traditional houses in Madinah are usually painted with white colour to intensify reflected solar radiation. The lighter the colour and more reflective the surface, the less heat will pass through the roof. Table 2 presents the assumed parameters for the modelled living room and the reflectance values of indoor surfaces. The reference plane on which daylighting performance was simulated was set above 80 cm from the room floor as people who occupied traditional houses in

Madinah used to sit on the floor. The selected house is surrounded by four streets at least 10 m wide; hence, external obstructions were ignored in these experiments. No artificial light or interior furniture reflections were used in the calculations.

RESULTS

The results of simulating average illuminance levels are presented in Table 3. In all cases, the average illuminance levels decreased dramatically with the use of Rowshan screens compared with base cases with no screen in all orientations and seasons and at three different times of the day. Concerning the average illuminance with the use of Rowshan, it can be seen that Rowshan screens with the ratios of (S:V 3.8:1) and (S:V 4.3:1) in the studied room can provide the recommended levels of daylight (100-300 lux) in all orientations and seasons and at three different times of the day. For the same room without Rowshan using, the results for average illuminance exceeded the recommended levels all year round in the North and South orientations as well as in the East and West orientations with the exception of late afternoon and early morning in the East and West orientations, in all seasons, respectively (Table 3).

East orientation simulation results: Results of this study demonstrated that in the East orientation, the Rowshan screens with the ratios of (S:V 3.2:1) and (S:V 4.9:1) proved to be successful in providing the recommended levels of daylight at most of times of the year, apart from early morning in summer and late afternoon in winter for the ratios of (S:V 3.2:1) and (S:V 4.9:1) respectively, where they provided daylight levels close to the recommended levels. Similarly, the ratios of (S:V 2.6:1) and (S:V 5.7:1) had good performance in providing the recommended levels of daylight all year round with the exception of spring and summer at 09:00 am for the ratio of (S:V 2.6:1) and autumn and winter at 15:00 pm for the ratio of (S:V 5.7:1). In contrast, the Rowshan screens with the ratios of (S:V 0.8:1), (S:V 1:1), (S:V 1.5:1) and (S:V 2.1:1) did not prove successful in providing satisfying levels of daylight as they provided the recommended levels of daylight in half of the readings only. The ratio of (S:V 11.5:1) was even worse as it failed to provide an adequate level of daylight in interior spaces all year round (Table 3).

North orientation simulation results: Table 3 shows that in addition to the ratios of (S:V 3.8:1) and (S:V 4.3:1), the ratio of (S:V 3.2:1) proved to be successful in providing the recommended levels of daylight in the studied room in all seasons and at three different times of the day, indicating that Rowshan influence on daylighting was found to be very much dependent on the orientation of the building (three ratios provided the recommended levels of daylight in the North orientation compared with two ratios in the East orientation). The ratios of (S:V 2.1:1) and (S:V 2.6:1) were also proved to be more successful in the North orientation as they provided the recommended levels of daylight all year round and at three different times of the day, apart from summer at noon. The ratios of (S:V 1.5:1), (S:V 4.9:1) and (S:V 5.7:1) also had good performance in providing the recommended levels of daylight all year round with the exception of spring and summer at noon for the ratio of (S:V 1.5:1) and autumn and winter at 09:00 am and 15:00 pm for the ratios of (S:V 4.9:1) and (S:V 5.7:1). In contrast, the Rowshan screens with the ratios of (S:V 0.8:1), (S:V 1:1) and (S:V 6.1:1) proved to be less successful in providing satisfying levels of daylight as they provided the recommended levels of daylight in the majority of the readings, while in some readings the results for average illuminance exceeded the recommended levels. Similar to its performance in the East orientation, the ratio of (S:V 11.5:1) in the North orientation was failed to provide an adequate level of daylight in interior spaces. The daylight level in the studied room was less than 100 lux in all seasons and at three different times of the day (Table 3).

West orientation simulation results: Since the sun path is symmetrical, east and west results were almost similar. The ratios of (S:V 2.6:1), (S:V 3.2:1), (S:V 4.9:1) and (S:V 5.7:1) proved to be successful in providing the recommended levels of daylight at most of times of the year with the exception of late afternoon in spring and summer for the ratios of (S:V 2.6:1) and (S:V 3.2:1) and early morning in winter for the ratios of (S:V 4.9:1) and (S:V 5.7:1). In contrast, the Rowshan screens with the ratios of (S:V 0.8:1), (S:V 1:1) and (S:V 1.5:1) did not prove successful in providing satisfying levels of daylight as they provided the recommended levels of daylight in half of the readings only. The ratio of (S:V 11.5:1) was even more worse as it failed to provide an adequate level of daylight in interior spaces all year round (Table 3).

South orientation simulation results: Table 3 shows that nearly half of the Roshan screen cases in the South orientation can provide the recommended levels of daylight in the studied room in all seasons and at three different times of the day. These are the ratios of (S:V 3.8:1), (S:V 4.3:1) (S:V 4.9:1), (S:V 5.7:1) and (S:V 6.1:1). Change in daylighting performance of other ratios was considerably affected by the time of the day. For instance, the ratios of (S:V 1.5:1), (S:V 2.1:1) and (S:V 2.6:1) proved to be successful in providing the recommended levels of daylight in the studied room in all seasons and at three different times of the day except mid-day (12.00 pm) in all seasons. Likewise, the ratio of (S:V 3.2:1) proved to be successful in providing the recommended levels of daylight in all seasons and at three different times of the day except mid-day (12.00 pm) in all seasons apart from summer. Similar to its performance in other orientations, the ratio of (S:V 11.5:1) in the South orientation was failed to provide an adequate level of daylight in interior spaces. The daylight level in the studied room was less than 100 lux in all seasons and at three different times of the day.

DISCUSSION

In this paper, the effect of Rowshan's ornamentations on the quantity of the daylight that is admitted into the space has been analyzed in order to explore the effectiveness of using Rowshan screen in residential buildings in Madinah for reasons of aesthetical and functional. The daylight analysis performed using the Velux Daylight Visualizer simulation tool to get information on illuminance distribution in a typical living room found in residential buildings in Madinah. In the present study, the average illuminance levels decreased dramatically with the use of Rowshan screens with all ratios compared with base cases with no screen in all orientations and seasons and at three different times of the day. This indicates the ability of Rowshan to minimize the amount of direct sunlight entering the space. In her PhD thesis, (Al-Jawder, 2014) conducted a field study in one of the traditional houses in Bahrain to evaluate the performance of Rowshan in providing daylight in the space.

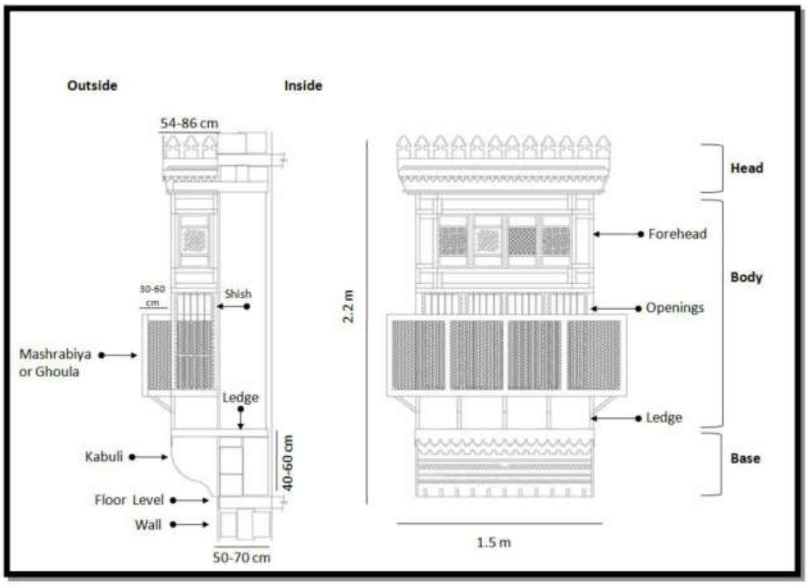


Figure 1. Rowshan's different structural parts.

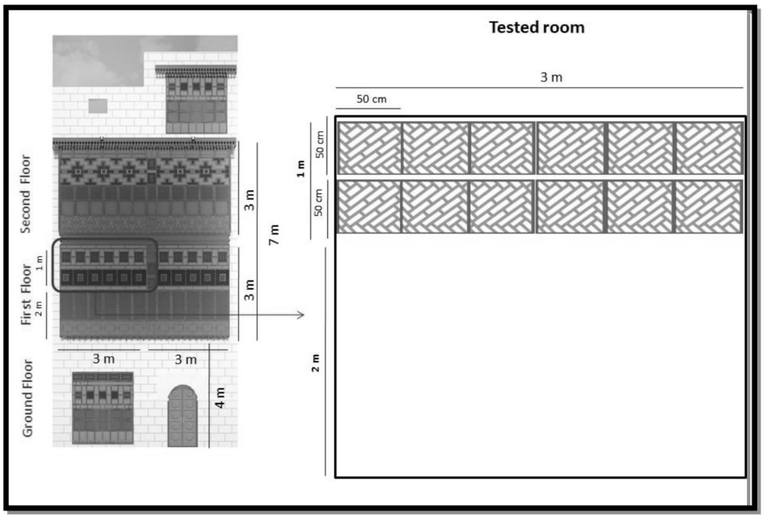


Figure 2: Example of a Rowshan screen with a S:V ratio of 0.8:1 (case 1) used in the daylight analysis experiment.

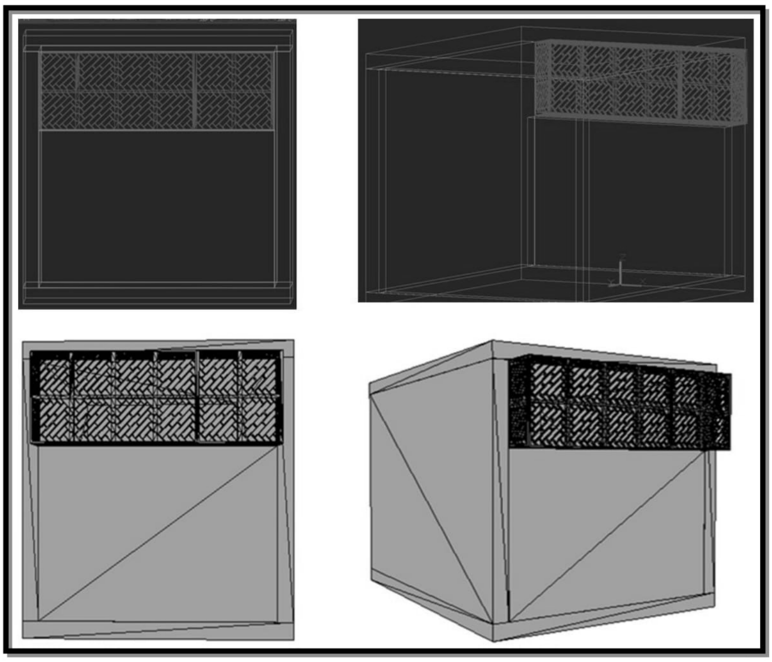


Figure 3: An example of Rowshan screen with S:V ratios (0.8:1) drawn in AutoCAD software (top) and then imported to Velux Daylight Visualizer software (bottom)

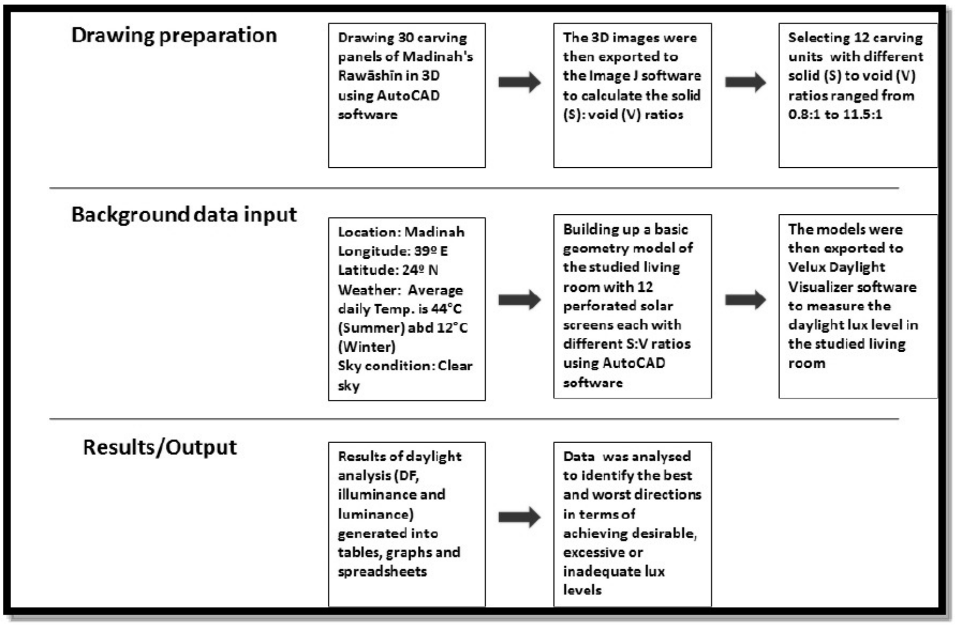


Figure 4: The flow chart of stages of computer-based daylight experiments

Table 1. Samples from the selected carving units.

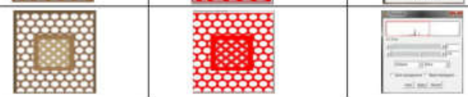
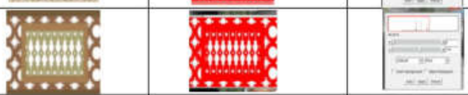
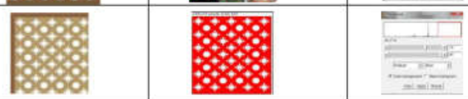
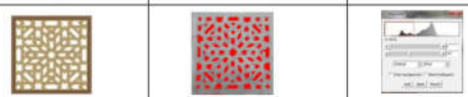
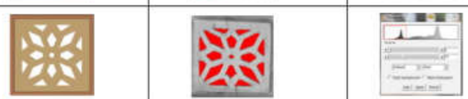
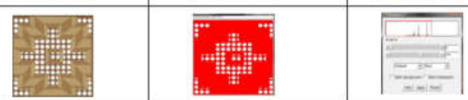
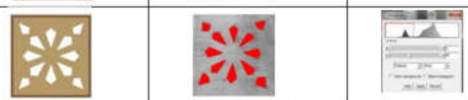
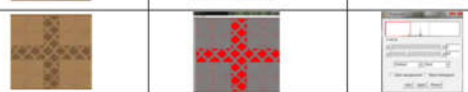
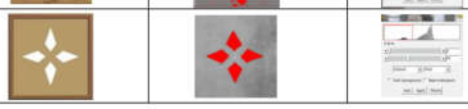
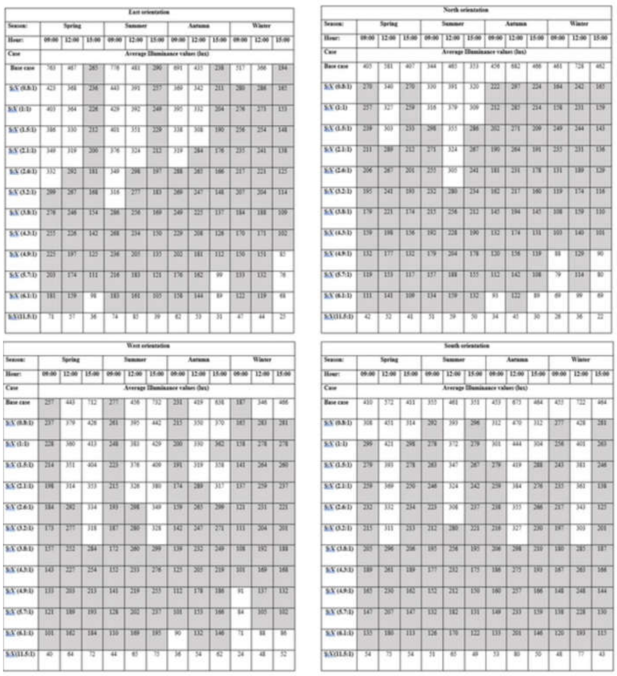
Case No.	Carved ornamental unit	Solid to void ratio
1		0.8:1
2		1:1
3		1.5:1
4		2.1:1
5		2.6:1
6		3.2:1
7		3.8:1
8		4.3:1
9		4.9:1
10		5.7:1
11		6.1:1
12		11.5:1

Table 2: Detailed dimensions and parameters of the living room space, Rowshan window and Rowshan screen cell.

Variables	Specification
Room parameters	
Floor level	First Floor
Dimensions	4 m (Length) x 3 m (Width) x 3 m (Height)
Working level	80 cm above the floor
Internal surfaces	
Ceiling	
Material	White coloured ceiling
Reflectance	80%
Walls	
Material	Medium coloured internal-walls (off-white)
Reflectance	60%
Floor	
Material	Wooden floor
Reflectance	20%
Rowshan window parameters	
Window to wall ratio	33%
Number of windows	1
Dimensions	3 m (Length) x 1 m (Height)
Height from the floor	2 m
Projection	50 cm
Orientation	East/ North/ West/ South
Rowshan cell parameters	
Cell size	50 cm (Length) x 50 cm (Height)
Solid to void ratios	0.8:1 to 11.5:1
Material reflectance	Wood (35%)

Table 3: Illuminance values of East, West, North and South orientations. The highlighted cells represent the cases that achieved recommended levels of daylight (100-300 lux).



In addition, a simulation of same room was performed to compare the behavior of the daylight in the space without any screen. According to her, the performance of daylight throughout Rowshan was better than without any screen. Her results showed that Rowshan blocked 88.6% of the daylight in summer and 85% of the daylight in winter compared with base cases with no screen. However, (Batterjee, 2010) from Jeddah, Saudi Arabia, conducted a simulation study using Ecotect and Radiance software programmes to investigate the daylighting performance of the traditional Rowshan and found that the average illuminance lux levels were exceeded the recommended levels in most readings in all orientations and seasons and at three different times of the day, except in the North orientation.

We also noticed that the illuminance values were directly proportional to the perforation percentages of the Rowshan screens; the higher solid (S) to void (V) ratios increased, the lower day lighting performance of Rowshan. This is in line with the results of (Batool, 2014), who measured the daylight filtered through traditional Jali screens in Lahore, Pakistan to determine the most efficient Jali screen in energy conservation and daylight performance of office buildings. Three cases for Jali screens with different perforation ratios (30%, 40% and 50%) were selected for the experiment. She found that 50% and 40% Jali screens in windows facing south and west seemed to provide the maximum level of Useful Daylight Illuminance (100-300 lux) respectively. (Kotbi and Ampatzi, 2016), investigated how different perforation ratios affect the daylight level in school classrooms in Riyadh, Saudi Arabia. Ten screens with different perforation ratios from 10-90% and a base case without a screen were simulated. The authors found that for the East orientation, 80% perforation ratio provided more daylit area than other rates, while 90% perforation ratio achieved better daylight availability than other rates in the South orientation. For the North and West orientations, all cases failed to achieve an acceptable daylight level.

The daylight performance of Rowshan screens was considerably affected by the orientation of the building; the Rowshan performance was better in the South orientation than in the North, East and West orientations.Most ratios proved to be successful in providing the recommended levels of daylight in the studied room in all seasons and at three different times of the day except mid-day (12.00 pm) in all seasons. (Sherif *et al*., 2010) from Egypt reported a similar finding. The authors conducted a computer simulation experiment using Radiance simulation software to investigate the influence of perforation percentages of Rowshan (10-90%) on the daylighting performance of a typical residential living room. They found that, for southern orientation, the daylighting performance was found to be adequate (≥ 200 lux) for most of the perforation percentages in almost all seasons and at all three tested zones, except for summer at the far zone at 9:00 a.m. and 3:00 p.m. Concerning the average illuminance with the use of Rowshan, it can be seen that Rowshan screens with the ratios of (S:V 3.8:1) and (S:V 4.3:1) in the studied room can provide the recommended levels of daylight (100-300 lux) in all orientations and seasons and at three different times of the day. For the same room without Rowshan using, the results for average illuminance exceeded the recommended levels all year round in the North and South orientations as well as in the East and West orientations with the exception of late afternoon and early morning in the East and West orientations, in all seasons, respectively. This is consistent with the results of (Al-Jawder, 2014), who found that Rowshan in the studied room can provide illuminance values, at most of times of the year, close to the recommended levels with the exception of winter at 3:00 pm. For the same room without Rowshan using the simulation software, the results for average illuminance exceeded the recommended levels all year round. In addition, (Zuraini *et al*., 2015) from Malaysia conducted a computer simulation experiment, using Autodesk Ecotect software and analyzed the daylight performance filtered through the carvings on the top of the windows of the traditional Malay houses. A total of ten carving units were selected for the experiment, each representing each ratio of solid and void opening category. The ratio of solid to void ranged from 1:1 to 99:1. The light filtered through carvings in the tested living room was at satisfactory levels and ranged from 337 lux to 391 lux.

Conclusion

In conclusion, our results showed that the daylight levels filter through the carvings ornamental units of the Madinah's Rawāshīn were at satisfactory levels, which indicates that these carving units were not only aesthetic, but also functional for daylight filtering.

Conflicts of interest: The authors have no conflict of interests and the work was not supported or funded by any drug company.

Source of support: Nil

REFERENCES

Abu Al Haija, A. & Abu Al Haija, J. 2016. Medina Traditional Roshan– the Effected. In: XIV International Conference on World Heritage And Degradation: Smart Design, Planning and Technologies Role, June 10-12 2016;Naples and Capri: Italy.

Al-Ban, A. 2016. Architecture and cultural identity in the traditional homes of Jeddah. (dissertation). USA: University of Colorado.

Al-Hussayen, M. 2002. Al-Rowshan Onsur Wazefiwa Jamali feWajehat MasakenAl-Madinah Al-Munawarah Altaqlediyah: Alwsolela Taqyees Wehdatoh Waajzaaoh. (Arabic Source). Journal of King Saud University, 12:19-51

Alitany, A. 2014. A new strategy of ICT integrated methodologies of 3D documentation. (dissertation). Spain: UniversitatPolitècnica de Catalunya.

Al-Jawder, H.2014. Residential windows: daylight Vs. visual privacy. (dissertation). Australia: University of Sydney.

Al-Mahdy, O. 2013. Madinah: Reviving Place Identity through Public Space. (dissertation). USA: University of Waterloo.

Al-Murahhem, F. 2010. The mechanism of the rawāshīn: the case study of Makkah. WIT Transactions on Ecology and the Environment, 128: 561-573.

Batool, A. 2014. Quantifying environmental performance of Jali screen façades for contemporary buildings in Lahore, Pakistan. (dissertation). USA: University of Oregon.

Batterjee, S. 2010. Performance of shading device inspired by traditional Hejazi houses in Jeddah Saudi Arabia. (dissertation). UAE: The British University in Dubai.

Hariri, M. 1991. Tasamim Al-RowshanwaAhamiyatahu Li Almaskan. (Arabic Source). Journal of Umm Al-Qura University, 5:175-237.

Kaki, A.A. 2001. Reconstructing the historical development of Al-Madinah Al- Munawarah. (dissertation). USA: Heriot-Watt University.

Kotbi, A. &Ampatzi, E. 2016. Using solar screens in school classrooms in hot arid areas: the effect of different perforation rates on daylighting levels. In: 32nd International Conference on Passive and Low Energy Architecture. Cities, Buildings, People: Towards Regenerative Environments, Dec. 18-20; United State of America.

Labayrade, R., Jensen, H.W., Jensen, C. 2006. Validation of Velux Daylight Visualizer 2 against CIE 171: test cases. In: 11th International IBPSA Conference, 2009, Nov. 17-19; UK.

Sherif, A., Sabry, H., Rakha, T. 2010. Daylighting for privacy: evaluating external perforated solar screens in desert clear sky conditions. In Renewable Energy Conference, 2010, Oct. 11-13;Japan.

Taha, H. Taibah waFannaha Al-rafee.(Arabic Source). 3nd rev Madinah: Al-Halabi Library,2008.

Velux 2014. Daylight, Energy and Indoor Climate Basic Book. 3nd rev Hørsholm: VELUX Knowledge Centre for Daylight, Energy and Indoor Climate (DEIC), 2014.

Zuraini, D., Noor, H.A., Arifin, N. 2015. Ingenious Malay wood carving as daylight filtering devices. In: Asian Conference on Environment-Behaviour Studies, Nov. 22-24; Iran.

****