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Analysis of the Performance of the Shanashir according to its Role in Shading*

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ABSTRACT

Bushehr has a valuable historical texture which provides many instructive points in the field of climatic architecture, in terms of both the general characteristics of the texture and the architectural details. However, there are ambiguities about the efficiency and performance of some of its elements one of which is the Shanashir. This element is widely used in the facades of the buildings in Bushehr, making it important to determine its effect on the building performance. Among the considerable number of scientific and experimental solutions, one of the most practical solutions is to review and study the climatic and contextual elements of a specific urban area and compare them with the traditional constructions in it. Reviewing previous studies on Shanashir indicates that most studies have described and analyzed the reasons for the use of the Shanashir in the building and just a few studies have addressed the effect of the Shanashir on the natural ventilation in the building. In the present study, it is attempted to examine another dimension of the function of the Shanashir to find new things about its function. To this end, the simulation software of Radiance and Honeybee are applied to analyze, and explain findings, and provide solutions. By analyzing the investigations performed, the right pattern of the exterior Shanashir in Bushehr in terms of shading is presented, which can be used by designer architects. To this end, after identifying and examining various types of Shanashir (4 types), the effect of the Shanashir on interior lighting is assessed through computer simulation. The results show that the Shanasir attached to the roof, which extends one meter from the roof, acts much like a horizontal canopy. On the other hand, this type of Shanashir, in terms of shading, has a much better performance compared to the Shanasir (with a height of 1 to 1.5 meters) attached to the floor.

Keywords: Vernacular Architecture, Bushehr, Shading, Shanashir, Daylight Simulation.

* This article is derived from the first author's master's thesis entitled "Study of the role of shanashir in optimizing the building shell in the hot-humid climate of Bushehr" under the supervision of second and third authors at the University of Tehran in 2019.

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1. INTRODUCTION

The building shell acts as a shield between the interior spaces in the building and the exterior space. Nowadays, due to the increase in the building height, the building shell is more affected by external conditions than the low-rise buildings of the past. For this reason, in addition to aesthetic and structural issues, the energy performance of the building shell is also considered in the design of the building shell. Today, the removal of the courtyard from residential architecture has led to the use of the balcony in modern buildings. While in the old houses of Bushehr with the hot-humid climate, the balcony acts as a living space, and also as a semi-open space used to ventilate the rooms in front of it. As a result, the sustainable design of some of the symbols of old buildings, such as Shanashir, as part of the building shell and the balcony, requires more accurate investigations.

Shanashirs are divided into two types based on their locations in the building: interior Shanashir and exterior Shanashir. Due to the importance of balconies in modern architecture, the present study addresses the role of the exterior Shanashir.

The present study seeks to answer the following question: How was the performance of the old Shanashir in shading? First, the importance of the Shanashir as a horizontal canopy was identified, and then, its performance in shading was investigated using the simulation software.

2. RESEARCH BACKGROUND

The Shanashir is a narrow balcony made of wood. It is installed on the upper floors, it faces the alley or courtyard, and creates a shady and cool atmosphere (Hamidi, 2011, p. 65).

Since Bushehr was the residence of consulates and companies of different countries during the Qajar period, it is assumed that Shanashir, as an imported element, was able to adapt to the culture and climate of this region. Considering that the term Shanashir is not described in Persian dictionaries such as Dehkhoda, Amid, and Amin, it is concluded that it is not a Persian word (Hedayat & Eshrati, 2017, p. 42).

The Shanashir is called by different names in different countries. For example, one can mention "Mashrabiya" in Egypt and Saudi Arabia, "Rawshan" in India, and "Shanashil" in Iraq, which, generally had similar functions despite their different appearances (Ibid).

It should be noted that in the vernacular architecture of Bushehr, there is another element called "Tarmeh", which differs from Shanashir in structure and function. The "Tarmeh" is a recess within the walls of houses, that is used as a place to rest during the warmer times of the year. So, the different functions of the two elements must be considered. In fact, Tarmeh is open on one side, it is surrounded by wooden shutters (Shanashir) and a wicker sunshade, and it is roofed or without a roof (Hedayat & Tabaian, 2013).

Previous studies have mentioned different climatic functions for Shanashir. Shanashir, as a semi-open space, prevents the dazzling sunlight enter the interior (Fathy, 1986) by creating shadows on the openings and bodies (Hedayat & Eshrati, 2017, p. 47; Mohammadi, 2012, p. 54). Also, as a shadow-creating element in the building, it minimizes the possibility of absorbing heat from the surfaces, due to being made of materials with low heat capacity such as wood (Takapoomanesh & Shahin, 2003, p. 23; Haghighat, 2013) and it is also mentioned as a heat transfer-reducing element to save energy and create thermal comfort (Zangouei & Torkamon, 2014, p. 170).

In this regard, comparing the physical-climatic pattern of Shanashir in houses Ahvaz and Bushehr indicates that the protrusion of Shanashir on the southern façade is 20 to 30 cm greater than it on the northern façade. Also, the compaction of the Shanashir on the southern façade is more than it on the northern façade. The direction of shading is due to the increase of sunlight from the south (Masoudinejad et al., 2016, p. 22).

Another climatic function of the Shanashir in the hot-humid climate is to reduce humidity[1] by controlling and directing airflow into the interior space, which has been discussed in many articles, and in his book entitled "Natural Energy and Vernacular Architecture", Hassan Fathy also refers to it (Hedayat & Eshrati, 2017, p. 47; Fathy, 1986; Shaeri e al., 2017).

According to Ranjbar et al. (2010), special elements such as Shanashir and Tarmeh have been formed to take advantage of the wind in the structure of urban spaces. Due to the protrusions of the exterior wall, these elements improve the quality of ventilation in the house, increase the wind speed in the passages, and reduce humidity. Therefore, many studies have pointed out the importance of the role of the Shanasir as a factor for directing the wind and benefiting from the wind flow (towards the interior space where humans are present) and increasing the wind speed (since it acts as a nozzle[2]) (Hedayat & Ziaei, 2012; Hedayat & Tabaian, 2013; Bahrani et al., 2018; Ranjbar et al., 2010).

Considering the climatic functions of the Shanashir obtained from the studies on it, the present study aims to discuss its role as a climatic element in shading. Many studies have mentioned the Shanashir as a climatic solution for shading, which requires more investigation. In this study, using simulation software and based on climatic conditions, it is attempted to investigate the importance of the Shanashir as a horizontal canopy to answer the following question: What was the role of the Shanashir in shading? And what is its optimal design in terms of shading?

3. RESEARCH PROCESS

In the present study, Rhino software and Grasshopper plugin were used to define the structure and geometry of the Shanashir in 3D space. Moreover, Radiance[3] and Dysim[4] software was applied to analyze the lighting performance in different modes provided by the generating algorithm. Since the analyses and outputs of Radiance and Dysim software were defined as objective functions, connecting these analyses was made possible in Grasshopper using the Honeybee[5] plugin. The south room with the dimensions of 5 (width)* 5 (depth)* 3 (height) meters, and 50% of its south wall area as a window, was considered the study space (Fig. 1)[6]. After defining the generating algorithm in the Grasshopper plugin, lighting materials are given to them according to each surface. The reflection coefficient of the interior walls, floor, and ceiling[7] on the studied room was considered to be 50%, 20%, and 80%, respectively, and the visible light transmittance for the window glass was considered to be 65%.

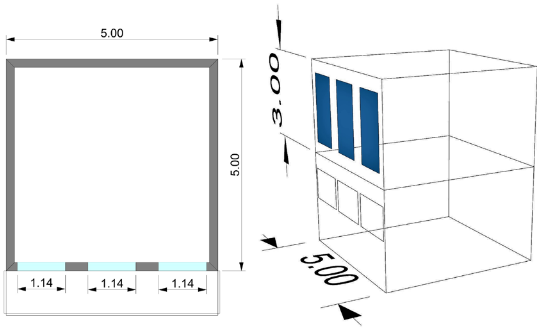

Fig. 1. Specifications of the Simulated Sample

The Sanashires used in Bushehr are divided into two types of exterior Shanashir and interior Shanashir based on their locations, and the two types of semi-open Shanashir and closed Shanashir based on the degree of enclosure, semi-open and closed. In the present study, the exterior Shanashir is investigated. According to the field studies and the review of historical images, semi-open Shanashirs have existed as wooden shelters in various forms (Fig. 2-4). Also, closed Shanashirs have a body in the form of wooden walls that are completely covered with wood (Fig. 5). In this study, by modeling the existing Shanashirs, 4 different types of Shanashirs that can be used in today's balconies have been designed and the required simulations have been performed on them.

Fig. 2. Semi-open Shanashir (Department of Rural Cooperatives)
(Study and survey of the old texture of Bushehr, Technical Office for Conservation and Rehabilitation)

Fig. 3. Semi-open Shanashir (Iranian Commercial Firm) (Ibid)

Fig. 4. Semi-open Shanashir (Shahpour Street) (Ibid)

Fig. 5. Closed Shanashir
(Study and survey of the old texture of Bushehr, Technical Office for Conservation and Rehabilitation)

4. DISCUSSION AND ANALYSIS

In this section, the importance of the Shanashir and its role in shading are examined by simulating the existing Shanashirs. Finally, the right locations of the Shanashirs are determined according to the desired span of the canopy.

4.1. Investigating the Importance of Shanashir as a Horizontal Canopy for the South Window

Using the information obtained from the Meteorological Department, the climate of the region was investigated. To this end, the following three steps must be carried out carefully to find the cooling and warming periods (cycles) of the region:

1. Assess the weather information of a place with one of the comfort indices (in this research, the universal thermal climate index (UTCI) is used).
2. Prepare a calendar showing the needs for shadow and sunlight
3. Project the abovementioned calendar on the sun path diagram

The abovementioned calendar was developed to show the distribution of the identical heat points throughout the year or to identify times when humans have a similar feeling of warmth. Identifying these situations helps know the humans' climatic need to achieve comfort conditions in the study area. Since the need for shadow is practically related to the annual thermal comfort, it is not adequate to design the window canopy and the skylight for a particular time and it is required to meet the need for canopies and skylights for all warm seasons of the year. For this purpose, the UTCI was used to determine the times of the year when we feel the warmth and need to create shadows (Fig. 6). In this approach, the positive effects of the thermal mass of the walls and the resulting time delay in heat transfer are ignored.

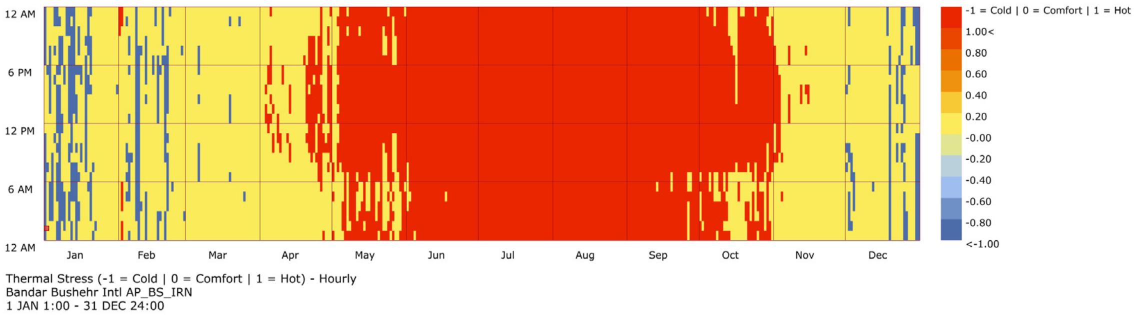

Fig. 6. UTCI Calendar of Bushehr

Red areas indicate warm times of the year, which are often in summer (Hot = 1), blue areas indicate cool times of the year (Cold = -1), and yellow dots indicate times when temperatures are in the thermal comfort range (Comfort = 0). We are looking for times of the day at which we want to block the sunlight. For this purpose, this information is projected on the sun path diagram (Fig. 7). In this diagram, the concentric circles show the height of the sun, the curved lines show the months of the year, and the lines perpendicular to the curved lined indicates the hours of the day.

We are looking for times of the day to block the sun. For this reason, the times of the year when there is a feeling of warmth are kept on the sun path diagram.

Then, a horizontal canopy with the ability to block the sunlight at all the identified times is drawn for the south window (Figure 8).

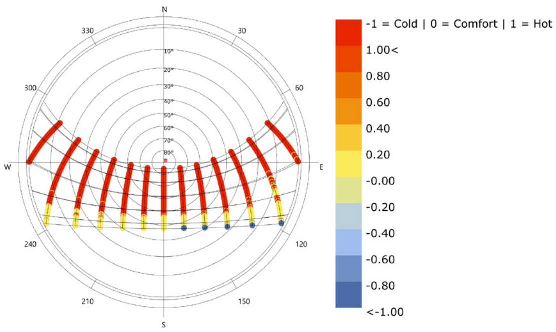

Fig. 7. UTCI on the Sun Path Diagram

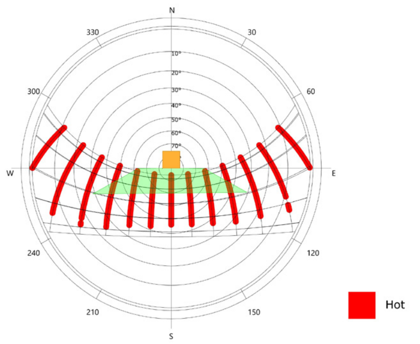

Fig. 8. Design of a Horizontal Canopy for the South Window

To evaluate the performance of the canopy, its shading mask was drawn. As seen in Figure 9, it covers the whole sunlight (Fig. 9).

In this case, one can see that if the software is asked to use only one horizontal canopy, it will provide a canopy of large dimensions (Fig. 10).

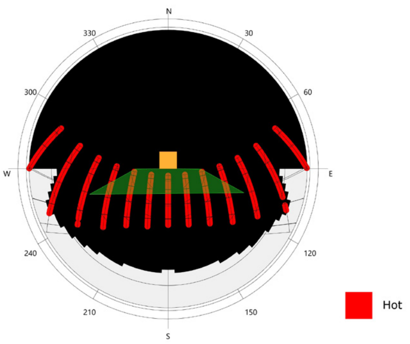

Fig. 9. Drawing a Shading Mask for a Horizontal Canopy

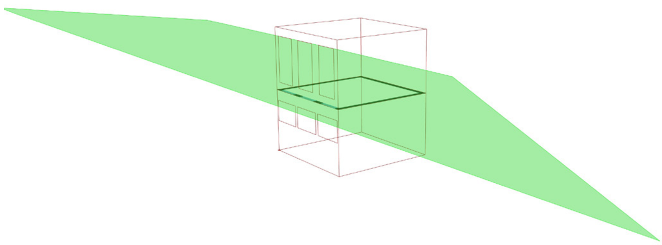

Fig. 10. A Horizontal Canopy for the South Window

While if it is asked to use several smaller canopies (such as Shanashir louvers) instead of one canopy (Fig. 11), the same surface will be covered by the shading mask despite the reduced space occupied by the canopies (Fig. 12), indicating that the Sshanashir can create a good shading on the south window on all warm days of the year.

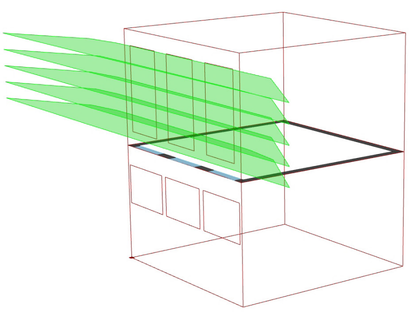

Fig. 11. Several Horizontal Canopies (Such as Shanashir) for the South Window

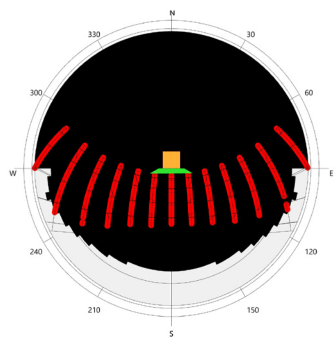

Fig. 12. Several Horizontal Canopies (Such as Shanashir) and the Shading Mask for the South Window

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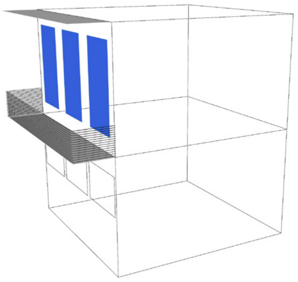
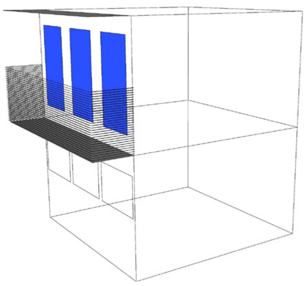
4.2. Investigating the Shading of the Shanashir

The Shanashir has been generally defined as a shelter with a wooden fence or a shutter wall with an angle of 30 to 45 degrees, and also the degree of projection (cantilever) of the roof beams to create a balcony has been mentioned to be 1 meter (Hedayat & Eshrati, 2016, p. 48; Dehdashti & Roasaei, 2014, p. 6).
In this study, to evaluate the effect of the Shanashir on the interior lighting and its role in shading, 4 different types of Shanashirs (Fig. 13) were simulated with the Shanashir angles of -30, and -40 degrees[8] (slope towards the room is considered negative), a 5-cm distance between the Shanashir blades, and the balcony depth of 1 meter (Figs. 14-18).

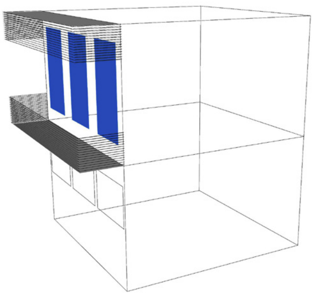
Shanashir Type I: The Shanashir extends from the floor to a height of 1 meter.



Shanashir Type II: The Shanashir extends from the floor to a height of 1.5 meters.



Shanashir Type III: Unlike Shanashir Type I, this type extends downward 1 meter from the ceiling.



Shanashir Type IV: Wide Shanashir

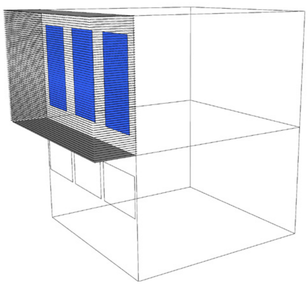


Fig. 13. Different types of Shanashirs

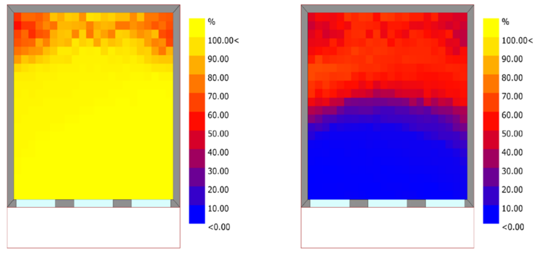


Fig. 14. The Distribution of Light in the Room in the Mode with no Shanashir

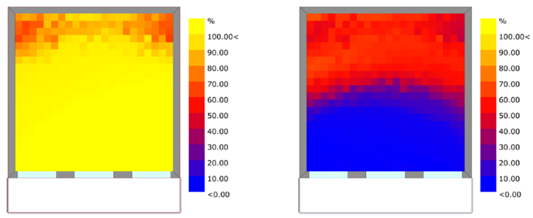


Fig. 15. The Distribution of Light in the Room with a Shanashir Type I at an Angle of -40 Degrees

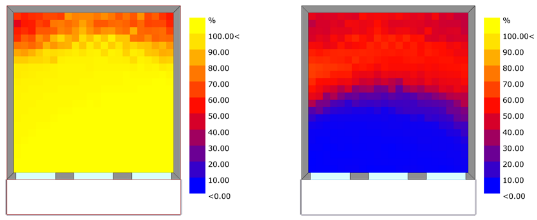


Fig. 16. The Distribution of Light in the Room with a Shanashir Type II at an Angle of -40 Degrees

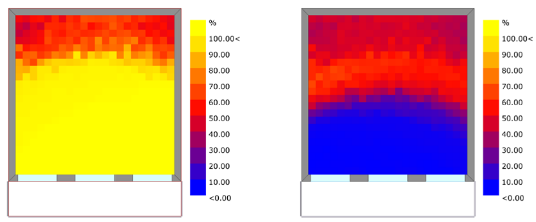


Fig. 17. The Distribution of Light in the Room with a Shanashir Type III at an Angle of -40 Degrees

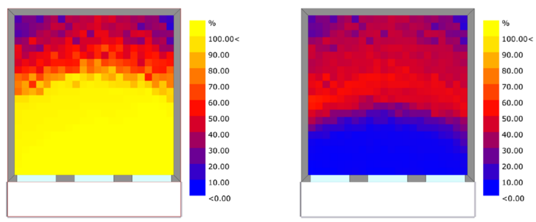


Fig. 18. The Distribution of Light in the Room with a Shanashir Type IV at an Angle of -40 Degrees

In general, there are two static (depending on the choice of only one type of sky, for example, overcast sky) and dynamic (extracting data from the climate file of the study area) methods for assessing daylight in the building. Since the quantity and quality of daylight vary momentarily, static evaluation faces some limitations. Dynamic simulation is increasingly used by users today. In the dynamic simulation method, after selecting a specific period of the year or the whole year, the manner and amount of space lighting in that period (based on changes in daylight depending on climate change during the period) is measured (Reinhart, Mardaljevic, & Rogers, 2006, p. 7).

After selecting the dynamic simulation to select the appropriate index to evaluate daylight, the daylight assessment indices were examined.

Daylight Autonomy (DLA) is a dynamic daylight metric that is represented as the percentage of occupied times in the year during which the threshold illuminance level (300 lux) can be met by daylight alone (Reinhart & Weissman, 2012, p. 156).

Useful Daylight Illuminance (UDLI), like Daylight Autonomy, is one of the dynamic daylight metric, and indicates how effective and efficient the daylight illuminance in the building (between 100 and 2000 lux) and how much is it very dark (less than 100 lux) or very light (more than 2000 lux) (Nabil & Mardaljevic, 2006, p. 906).

Since these metrics represent a specific value for each point in the space, the UDLI100_2000 and DLA300 averages were used to assess the average daylight distribution throughout the room. On the other hand, this average value also has a drawback. The drawback is that it is not specified how daylight is distributed in space[9].

To this end, spatial Daylight Autonomy (sDA) was used to assess the daylight distribution on room surface. Spatial Daylight Autonomy describes the percentage of floor area that receives at least 300 lux for at least 50% of the annual occupied hours (8am-6pm) (Andersen, Ashmore, & Beltran, 2012, p. 2). After calculating the sDA metric, the samples (including a Shanashir) and the mood with no Shanashir were compared in performance (Table 1). The results show that in Shanashir Types I and II, for both -30 and -40 angles, the presence of the Shanashir has no significant effect on the space lighting and no difference in the sDA value is observed between them and the mood with no Shanashir. In all three cases, sDA = 100. In Shanashir Type III (i.e. a case where the Shanashir extends downward 1 meter from the ceiling), the effect of the shading produced by the Shanashir on the space lighting is greater compared to Shanashir Types I and II. In Type IV, considering the wide Shanashir, the effect of the shading produced by the Shanashir was increased at the same angles and balcony depth (Fig. 19). According to these analyses, it is concluded that in cases where the Shanashir extends only from the floor to a height of 1 or 1.5 meters, the Shanashir produces no effective shadows and for shading, in addition to Types I and II, it is necessary to apply the Shanashir extending downward from the ceiling, and the wide Shanashir provides the best option.

Table 1. Annual Daylight Distribution for Different Types of Shanashirs

	Depth Balcony	Angle	Average (300-600)	Percent (300-600)	Average DLA	Average UDLI (100-2000)	sDA (Depth Balcony=1m)
Type 1	1m	-40	27.09	29.96	94.25	77	100
		-30	26.94	27.89	94.28	76.89	100
Type 2	1m	-40	26.38	16.94	91.76	78.09	99.79
		-30	26.15	17.56	92.92	77.4	100
Type 3	1m	-40	25.81	14.05	86.96	78.98	94.83
		-30	26.1	17.98	89.91	80.02	98.55
Type 4	1m	-40	24.82	1.03	76.23	80.95	73.97
		-30	25.08	3.1	84.27	81.58	88.43
Without Shanashir	1m		27.13	28.31	93.61	77.12	100

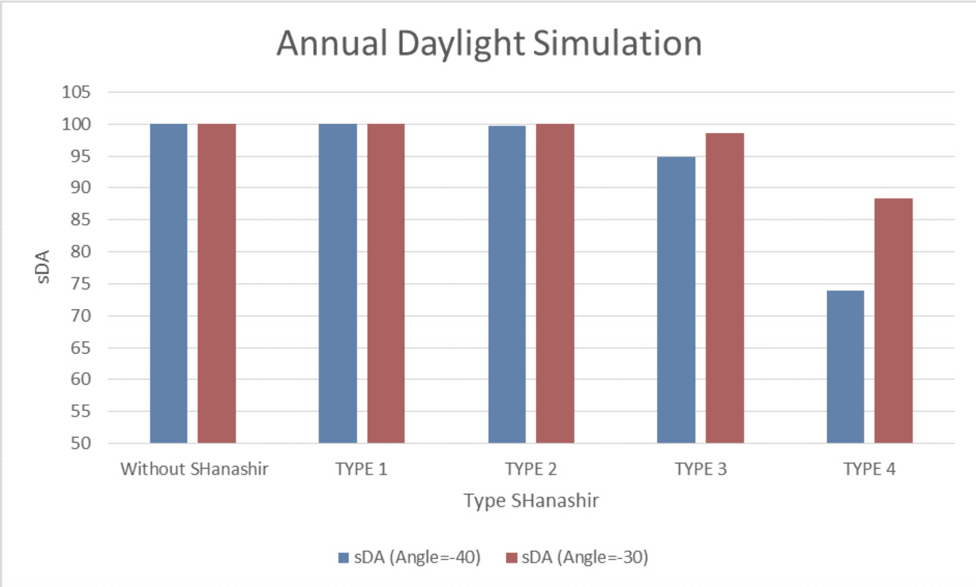


Fig. 19. Annual Daylight Distribution for Different Shanashirs

To determine the right locations of the Shanashirs, a hypothetical screen is first placed in front of the window at a distance of one meter. By meshing this screen, knowing the outdoor air temperature throughout the year and the sun position, the desired locations of this screen to create shadows are determined. To this end, first, the difference between the air temperature and the comfort temperature is determined for all times of the year, and those points on the screen that block the sunlight are considered desired points. Naturally, a negative sign is assigned to the times when the air temperature is lower than the comfort temperature, and a positive sign is assigned to those times when the air temperature is higher than the comfort temperature (Fig. 20). As a result, a value is assigned to each part of the screen.

By multiplying the utility value (positive and negative values obtained from the difference between air temperature and comfort temperature) of each meshed part of the screen by its area, a set of values with positive and negative points is obtained. Finally, by selecting the most effective parts in shading (meshes receiving the most daylight), the desired span of the canopy on this screen is determined as shown below (Fig. 21).

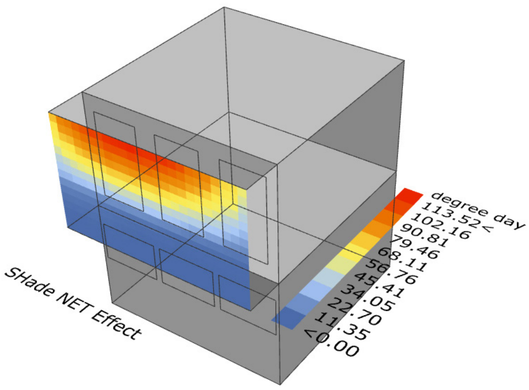


Fig. 20. Determining the Proper Location of the Canopy

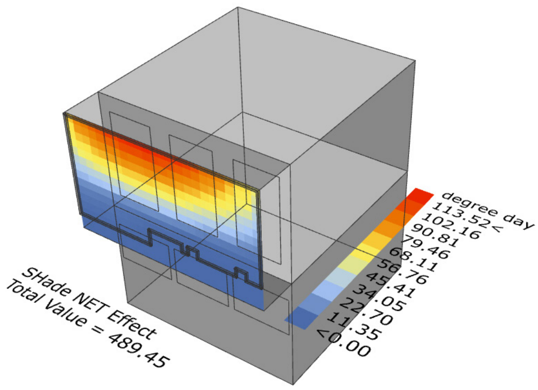


Fig. 21. The Desired Span of the Canopy

Next, according to the utility analysis of the hypothetical canopy screen, the parts with the most impact on the production of shadows on the window were selected as places with denser Shanashirs (Fig. 22).

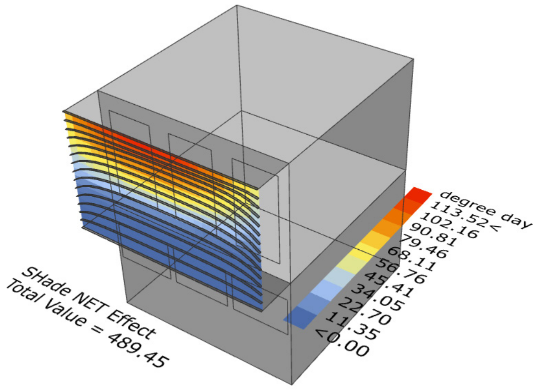


Fig. 22. Design of the Shanashir according to the Desired Span of the Canopy

According to the information obtained from this analysis, it is concluded that due to the increase in the amount of daylight entering through the upper part of the window, it is necessary to extend the Shanashir from the ceiling as well to make it act as a suitable shading element. For this reason, Shanashir Type I outperform Shanashir Types I and II in shading. On the other hand, the simulation indicates that for the provision of better shading, more compaction is required in the upper part of the Shanashir.

5. CONCLUSION

Many studies have introduced the Shanashir as a climatic solution for shading. Shanashir is considered a semi-open space placed in front of the closed space on one side and protects the closed space behind itself from direct sunlight (Dehdashti & Roasaei, 2014). In the present study, based on quantitative analyses, it was attempted to find a new thing on the performance of the Shanashir. The results indicated the usefulness of Shanashirs. It should be noted that the Shanashir has the same function as a horizontal canopy with the difference that it covers the shadow mask on a smaller scale. This allows us to use several small canopies called Shanashir, instead of a large horizontal canopy. The results of simulations and studies on the right location of the canopy, indicate that due to the increase in the amount of daylight entering through the upper part of the canopy, it is necessary to extend the Shanashir downward from the ceiling to increase its effectiveness. In addition, the obtained results completely reject the shading effect of the Shenashirs extending 1.0 to 1.5 meters from the floor and reinforce the hypothesis stating such Shanashirs were formed solely for cultural reasons, and therefore, it was only considered a shield to meet the expectations of residents in the field of confidentiality and privacy. To improve the effectiveness of the Shanashir with an angle of -30 or -40 degrees, in terms of shading, it is better to have a higher density of blades in the upper part. The results of numerical simulations are completely consistent with the common pattern, because in many semi-open Shanashirs in Bushehr (similar to Type 3), the upper part is usually designed more densely (Fig. 23).

Fig. 23. Shanashir in the Iranian Commercial Firm (Center of Cultural Heritage)

It should be noted that in the present study, the thermal performance of the Shanashir has not been investigated and it is recommended to investigate the effects of different types of Shanashirs on energy consumption and comfort conditions at various times, especially in the seasonal transition periods, considering the solutions presented in the study by evaluating the effect of natural ventilation under different conditions. In addition, it is suggested to perform deductive field measurements to evaluate the effect of all influential phenomena (including natural ventilation and time lag of the Shanashir, etc.) under actual conditions.

END NOTES

1. The shape and direction of the Shanashir blades direct more airflow. So, the Shanashir greatly reduces surface moisture.
2. Ranjbar et al., in their study entitled "An Analysis of the Function of External Senasir Types and Their Effects on the Wind Flow in the Historical Part of Bushehr" have mentioned Shanashir as a factor directing and increasing the wind. In this study, it was stated that in general, when the cross-sectional area of the compressible fluid flow decreases with the subsonic velocity in the flow direction, the velocity of the fluid increases, and the fluid pressure decreases (according to the law of nozzles). This also happens in the Shanashir and the wind speed increases by passing through the Shanashir. In addition, its direction is changed. In fact, the Shanashir directs the wind towards the room floor where the individuals are present. In short, it can be said that the Shanashir increases the wind speed and changes its direction to the part of space in which man is present. In other words, the Shanashir provides a place for achieving thermal comfort.
3. Radiance software is used for lighting simulations.
4. Dysim software is used to analyze daylight based on the Radiance algorithm. It calculates the annual illuminance and brightness of interior spaces based on weather data.
5. It is an energy-related plugin for Grasshopper software.
6. According to field observations in Bushehr architecture, rooms with these dimensions have been observed, but no detailed statistical study has been performed to determine the common dimensions of the sample. On the other hand, we have been looking to use the Shanashir in contemporary buildings, so the width and depth of the room were considered 5 meters to measure the effect of the Shanashir parameters in the depth of the room. Considering the room size, it is common to consider 50% of the window for the room and many samples with this percentage of light transmission have been observed.
7. The reflection coefficient varies according to the angle at which a ray of light hits the surface and the surface coating. Since the ceiling has no coating, it reflects more light than the floor and walls. These values are assumed as default values based on research conducted at the research center and there is no written source for them.
8. Because in most samples, the angle of the Shanashir was between 30 and 45 degrees. Averagely, we performed studies for these two angles.
9. In fact, Daylight Autonomy (DLA) is a standard that defines the minimum for lighting and assigns a value to any point in space. Since we were looking for the optimal conditions, we did not use this parameter. On the other hand, Useful Daylight Illuminance (UDLI) gives a value for each point of the space. As a result, the average of these two indices is used to measure the average light distribution in the whole room, which is the criterion for measuring the lighting for our desired angle. However, the average value also has a drawback. The drawback is that it is not specified how daylight is distributed in space. For this reason, spatial Daylight Autonomy (sDA) has been used to determine how light is distributed throughout the room.

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