



## Window Design in Ardabil Traditional Houses for Conservation of Energy

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**ABSTRACT:** Windows have a major role on absorbing solar energy, reducing heat losses, and adding their values in traditional houses in Ardabil. The main aim of this research is to study windows as elements of beautification and production of clean and free energy. We discern that windows can be designed to respond to the regional climates. To explore that, we review four samples of the windows in the famous traditional houses of the Ardabil such as: Rezazadeh's, Ebrahimi's, Ershadi's and Sadeghi's that are related to the Qajar and Zand architecture periods in Iran. Research method for this study is the comparative and interpretative–history review. Moreover, the information is collected from documents and libraries. We focused in sash window design in southern front of traditional houses. Results showed that the physical dimensions of these windows are compatible in cold climates of Ardabil which are different from the other front of architectures. Also, this research showed that light loss in the Rezazadeh House is 17% and in Ebrahimi is 7%, Ershadi's and Sadeghi's were respectively 8.5% because there is a canopy above the window at Rezazadeh House. The last three houses are close to the average. So, it showed that windows can be designed to respond to the regional climates. The placements of windows in front wall without any indentations in the south walls indicate the need for more light on this front. But in the east and west side windows, the windows are associated with a slight indentation. Also, using large dimension windows in southern side of the case studies shows that light in these fronts was very important.

**Keywords:** Sunlight- Traditional Houses, Ardabil, Window, Architecture.

### INTRODUCTION

Ardabil is an old city in Iran which its historical urban core is still alive. The remained traditional houses from historical periods (including Post-Islamic era) in this city are few in number and all of them were designed by local architects for upper-class or upper-middle-class residents. Since the city is located in a mountainous region with a cold climate, domestic architecture and buildings forms have significantly influenced by the climate (en.wikipedia, 2014). The remained traditional houses from historical periods (including Post-Islamic era) in this city are few in number and all of them were designed by local architects for upper-class or upper-middle-class residents. Since the city is located in a mountainous region with a cold climate, domestic architecture and buildings forms have

significantly influenced by the climate. (Kharazminezhad & Hajizadeh Bastani, 2012).

### TRADITIONAL HOUSES IN ARDABIL

#### *Ebrahimi House*

This building which has been constructed during the Zand dynasty era in Iran situated in Ardabil. The city has cold climate and is located between latitudes 37° 45' N and 39° 42' N. Its average level of precipitation is 300 mm, with 15 mm as the maximum daily level of raining. The maximum and minimum levels of temperature in the area have been reported 35 and -27 degree of centigrade, respectively. Hence, it can be seen that the construction is built in a climate with bitterly cold winter and temperate summers. The construction including a yard and its mass space are situated in the north direction. It has a side

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entrance in Masoomi alley, Sarcheshmeh Sq. which is connected to the yard through a vestibule-like corridor. In the northern front of the yard there is a hall with one and half storey height. The hall has several tall and colorful openings to the yard called sash windows in its one side, and it is surrounded by some wooden doors decorated with Muqarnas' architectural elements in its other three

sides (Fig. 1). A space has been predicted for summer use on the left side of Shahneshin hall (Fig. 2). The space enjoys bigger windows in southern front which opens up to yard. But on the left side of Shahneshin, another space has been specified for wintertime, in which windows are located in the western front to absorb more light (Fig. 3). (Jame'e, 2000).



Fig. 1. Muqarnas, Architecture Elements in the Ebrahimi House

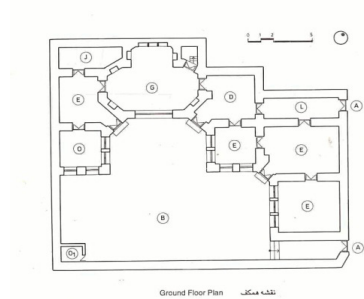


Fig. 2. Plan of the Ebrahimi House

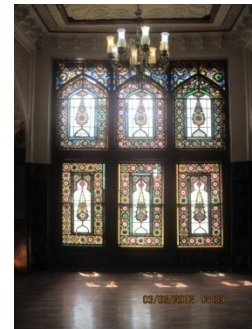


Fig. 3. Internal View the Sash Window in the Ebrahimi House

### Rezazadeh House

This house is located in Uch Dukan<sup>2</sup>-one of the six historical neighborhoods in Ardabil. Its history refers to late Qajar period. The transom over the house's entrance is located in the south eastern front of the building which is across from a square. The entrance connects to the space of yard via a vestibule and indirect lobby. The Rezazadeh House is a two -storey building and covers an area of 640

m<sup>2</sup> and has a u-shape and horseshoe plan. The first floor of this house includes two side rooms and a side corridor between them which is perpendicular to another lobby with two staircases at its both sides. These stairs make it possible to have access to the second floor which involves two side rooms with a hall or Shahneshin between them. The geometry of the yard and the stone-made pond at the center of it recall the traditional Geometry of gardens in Iran (Jame'e, 2000). (Fig. 4, 5, 6)



Fig. 4. Internal View the Sash Window in Rezazadeh House

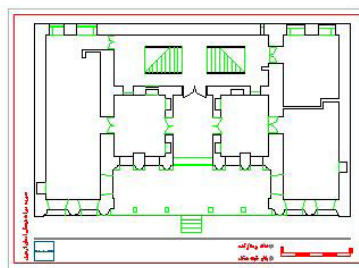


Fig. 5. Plan of the Rezazadeh House



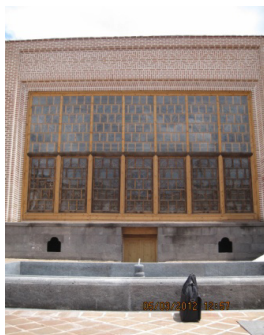
Fig. 6. Exterior View the Sash Window in the Rezazadeh House



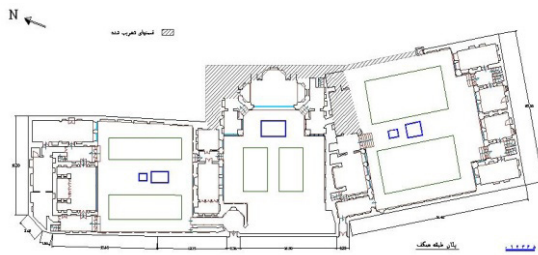
**Sadegi House**

The magnificent and luxurious house of Sadegi House is located at the heart of historical texture of Ardabil city, i.e., in Uch Dukan neighborhood, Sartip Abad alley. The building dates back to 1863 AD and is one of great monuments constructed during Qajar dynasty in the field of housing. This historic house has such unique features that a foreign ancient building seldom can include altogether. This construction includes “Hosseinieh”,

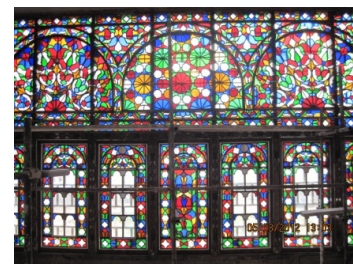
intended for social interactions; “Shahneshin” section, considered for formal interactions and relationships with Iranian or foreign businessmen; the inner part of the house, specified for family members’ living, the “Khademshin” section devoted for servants’ living, and a stable, regarded for service purpose. The techniques applied in this building such as materials used in its foundation, walls and ceilings indicate that this house is one of the tradition of the early Qajar dynasty’s historical houses. (Jame’e, 2000) (Fig. 7, 8, 9).



**Fig. 7. Exterior View of the Sadegi House**



**Fig. 8. Plan of the Sadegi House**



**Fig. 9. Internal View the Sash Window in the Sadegi House**

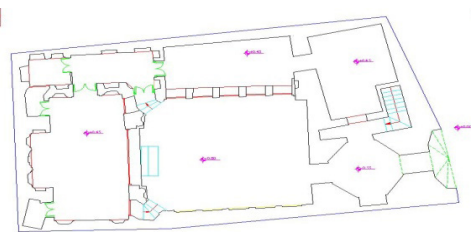
**Ershadi House**

This building situated in the Uch Dukan neighborhood, since beginning of its construction, has had housing function. In terms of architectural decoration and style of construction, it is one of the impressive buildings in Ardabil which was erected in the late Qajar dynasty’s era. This house includes 277m<sup>2</sup> as court and 366 m<sup>2</sup> as mass space. In order to have direct access from outside to

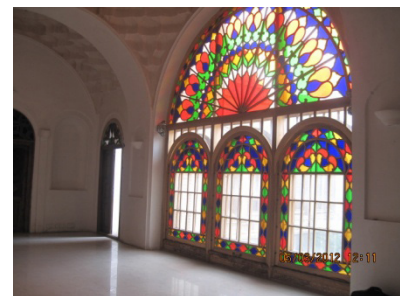
the inner parts of the house (avoided parts), the exterior space is separated from the yard and the two parts of the construction via vestibules from four directions are perpendicular to each other. Shahneshin is decorated with arch skullcap and plaster muqarnas coverings in its four corners and has big windows (sash windows) which have been double-glazed in the past. In the present time its inner layer includes Arabesque designs and colorful glasses (Jame’e, 2000) (Fig. 10, 11, 12).



**Fig. 10. Exterior View of the Ershadi House**



**Fig. 11. Plan of the Ershadi House**



**Fig. 12. Interior View the Sash Window in Ershadi House**



## METHODOLOGY

Since the window in Iranian architecture had high standing, it causes the diversity of climate. There are divers use dimensions of window regarding to its frontage and materials which is caused many windows in cold climates. Accordingly, the research method of the present paper is interpretation in the historical study. This study is based on Traditional windows in 4 samples traditional houses of Ardabil, which is located in cold climate (Table1). All 4 traditional houses as samples have sash windows with special decoration in southern front of buildings.

- This research in its process studies library documents of relevant literature and field observations. Finally, the measured data is presented as follows:
- First the results of physical dimensions of the windows, elevations the cases building and materials of windows were analyzed (Table 1).
- Second, use the beautiful wood ornaments in such windows, the percent of glass surface to window surface was calculated. (Table 2)
- Third, the effect of window position in the wall and on the loss light were calculated. (Table 3)

Finally, Exposure and loss light of sash windows were calculated and Discussion and conclusions were presented.

## GENERAL CHARACTERISTICS IN WINDOWS OF TRADITIONAL HOUESES

Traditional windows are an intrinsic part of the character of our historical and vernacular buildings (Ireland Government Printing Office, 2010). In general, people of Iran have benefited from a positive point of the regional to prevent excessive heat in summer and cold in winter (Memarian, 2005). Meanwhile, the climatic solutions have been the main feature of the Iranian architecture (Gobadian, 2008). In other word, windows have been attended as one of the cases in climatic solutions by Iranians. The windows in these houses are limited to several types that depending on the climatic conditions and the direction of the building. Regarding to the function of each type, they are used in different fronts of the construction and required certain parts of the walls to be installed on (Hui, 2000). The factors which are necessitate for employing windows are: light, heat, compatibility of window in terms of architecture (Zomarshidi, 2006) as well as creating a condition for watching landscape or the artificial sceneries outside the enclosed space (Soltanzadeh, 2003).

In these constructions, the stained-glass windows, colored or clear, acted as a shield against hot and very bright sunshine, while reflected the sunshine in different colors. These types of windows were used in those spaces which were considered more important than other places, and were designated as shahneshin (the place that a king sits) in Persian. These windows provided a calm and pleasant atmosphere for relaxing and working in Shahneshin, as well as it could control the sun's rays and preserve the privacy of the place and block the sight of strangers (Amraei & Rahnavard, 2005). It is worth mentioning that windows did not only serve as a simple element for meeting the basic needs, but also like many of architectural elements they fulfilled important role in decoration and aesthetics of the buildings. That is why its shape, size, position, and organization have attracted a lot of attention (Soltanzadeh, 2003).




**Table 1. Physical's Characteristic of Windows in the Traditional Houses of Ardabil.**

	View	Window Type	Windows Surface (m <sup>2</sup> )	Percent Surface of Window to Facade Surface	The Height of the Window to Room Deep (m)	Additional Elements to Create Shade	Windows Material
Rezazadeh House	South View	Sash Window	9 m <sup>2</sup>	66 to 160= 0.41	3.40 to 4.20	With Canopy (3 m*3 m)	Wood & Clear Glass
		Double Door & Window	57 m <sup>2</sup>		2 to 10	Doors of Canopy	Wood & Clear Glass
	East View	Double Door & Window	3 m <sup>2</sup>	3 to 18.9= 0.31	2 to 4	Doors of Canopy	Wood & Clear Glass
	West View	Double door & Window	3 m <sup>2</sup>	3 to 18.9= 0.31	2 to 4	Doors of Canopy	Wood & Clear Glass
Ebrahimi House	South View	Sash Window	24.8 m <sup>2</sup>	24.8 to 107.5= 0.23	2 to 6	No Canopy	Wood and Colored Glass
	East View	Double Door & Window	2.2 m <sup>2</sup>	2.2 to 20= 0.11	1.5 to 3.2	Doors of Canopy	Wood & Clear Glass
	West View	Double Door & Window	8.8 m <sup>2</sup>	8.8 to 47.5= 0.18	2 to 4	Doors of Canopy	Wood & Clear Glass
Ershadi House	South View	Sash Window	16.28 m <sup>2</sup>	20 to 52.25= 0.38	3.8 to 5	No Canopy	Wood and Colored Glass
		Double Door & Window	4 m <sup>2</sup>		2.3 to 3	Doors of Canopy	Wood & Clear Glass
	East View	-	-	-	-	-	-
	West View	Double Door & Window	11 m <sup>2</sup>	11 to 38.25= 0.28	2.3 to 3	Doors of Canopy	Wood & Clear Glass
Sadegi's House	South View	Sash Window	61.6 m <sup>2</sup>	61.6 to 160= 0.47	4 to 5.75	No Canopy	Wood and Colored Glass
	East View	Double Door & Window	13.4 m <sup>2</sup>	13.4 to 91.25= 0.14	2 to 4	Doors of Canopy	Wood & Cear Glass
	West View	-	-	-	-	-	-

### EXAMINATION OF WINDOWS FROM ENERGY CONSUMPTION POINT OF VIEW

Window is a key element in buildings that lets the air currents pass through it, it brings about mental peace and is a natural attractor to inside the construction. This element yields several benefits, but if it is carelessly designed, it will be found as an intrusive element inside the construction. Solar radiation exerts a lot of influence on the temperature inside the rooms. Particularly, when the sun directly shines, the thermal effects of window are more than that of walls. And the temperature of

interior space of the house, immediately after receiving direct sunshine, rises (Kasmaei, 2003). So far, many environmental engineers in their studies have made attempt to determine the thermal range in different regions of the country (Sharples & Heidari, 2002) and (Melukov, 2007). Window can be studied from two respects, as an element with aesthetic and identity enhancing features from inside or outside of the construction, and also as a component that provides thermal, visual, and aural comfort. Although the above-mentioned two cases have mutual effect on each other, the present paper addresses the second one concerning the energy consumption (Heidari, 2009).



### NATURAL LIGHT SOURCE UTILIZATION FOR GENERATING HEAT AND LIGHT

Since internal spaces in the houses in question were enclosed, producing light was of high significance. The most reasonable way of exploiting the natural light source for producing light and heat, adhering to some principles, was the use of windows. Concerning the cold climate of Ardabil, concentration on absorbing the sun's heat through windows to inside the place was the focus of designers (Ebnalshahidi, 2011). Accordingly, no blinds were placed on windows, additionally, many windows were designed double glazed to retain the warmth of the inside. Amount of solar energy that automatically penetrates through windows or glass walls rests upon the type of blinds and, to a lesser degree, to the kind of glasses (Kasmaei, 2003). For exploring the effectiveness of the mentioned windows in lighting and heating, it is required to investigate light loss factor, lighting coefficient, window function, glare, direct absorption through the window and also some effective factors to obtain some results in this field. Mahdaveinejad and others (2008) found that the illumination on the south facing vertical surface was estimated using the "Illuminating Engineering Society of North America"IESNA method in order to obtain a developed regression model and

daylight availability in Tehran. This model, showed a good linear correlation between measured and calculated values ( $r^2=0.9535$ ) (Mahdaveinejad et al., 2008).

### EXAMINING GLASS SURFACE AND DAYLIGHT AVAILABILITY

In order to obtain the coefficients of light loss, performance and etc., the proportion of glass to the area of window, as well as the windows' daylight availability must be measured (Heidari, 2009). Glass passes the light from the outside to the inside, thus higher the proportion of glass is to the window's area, the more light would penetrate inside the building. Shekari and others (2008), found that the frequency of clear days in a working year through a given outdoor vertical illumination is exceeded. Also, maximum value of measured illumination for south facing in Iran (79.6 KLx) is presented in compare to Saudi Arabia (3), Thailand (5), India (6) Hong Kong (7), San Francisco (8) and France (9) at corresponding measuring time (Shekari et al., 2008). So, Air quality for the case studies in this research is considered clear sky without clouds. Moreover, in the investigated houses, sash windows had intricate wooden adorning, which made it difficult to obtain its glass area. Thence, quintuple scale is employed for estimating the pane area. (Heidari, 2009) Table2.

**Table 2. Percent of Glass Surface to Window Surface in Sash Window of Research Houses**

Amount of Network Window	Very High	High	Average	Low	Very Small
Percent Glass Surface to Window Surface	60	68	75	82	90

(Heidari, Shahin, 2009, p. 57)

With regard to the above-mentioned table, the proportion of glass to window area in south-front sash windows is 82%, and in east-front and west-front windows is 68%. This result indicates that in southern fronts, more need for light and heat was considered, and in eastern and western fronts where there was a poor light, the glass percentage was less. Furthermore, on these fronts, shutters, behind the windows, blocking out the light, considerably reduced the amount of light pass, and was controllable for the occupants. It is worth noting that, the proportion of window area to the whole facade in southern fronts is the highest of other fronts in all four samples (statistical population), and the western front, holds the second position, with respect to the proportion

of window area to the whole facade; the third position belongs to eastern front on which it has been avoided to install windows in the houses of Ershadi and Sadegi (Table 1). The glasses used in various fronts were two types: clear and colored. The percentage of light pass through clear glasses is 82%, and through colored ones is 30% (Heidari, 2009). It is noteworthy that only colored glasses were utilized in "Shahneshin". These colorful glasses let the ray of white light penetrate into "Shahneshin" in colors and create a pleasant atmosphere. This function of colored glasses in Shahneshin can imply its centrality in traditional houses. As a matter of fact, opaque glasses can refract the light more than clear glasses. "Sharples Steve" and colleagues demonstrated that opaque glasses



reduce the light Transmittance to the inside, up to 70%. On the other hand, since the windows under study in this research in all four samples were viewed as the same, the

glasses were considered as clear (Sharples & Heidari, 2002).

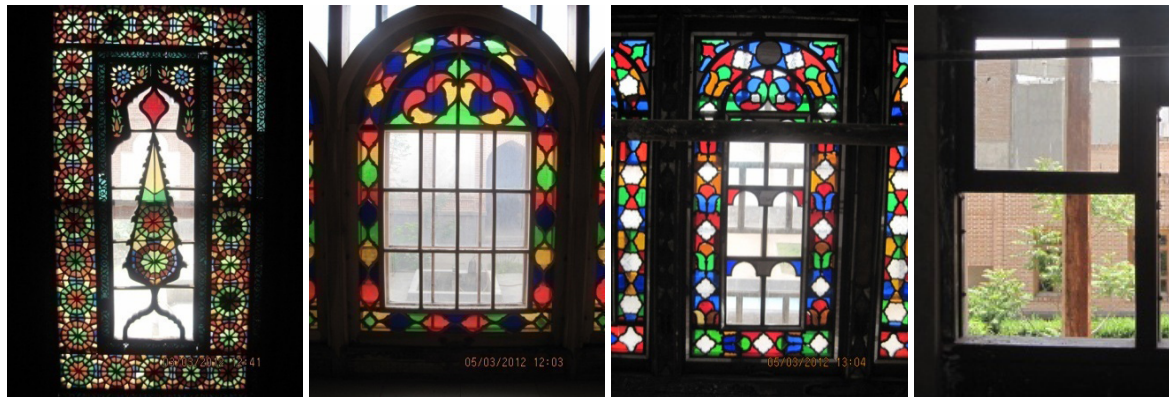


Fig. 13, 14, 15, 16. Left to Right. Ebrahimi’s Sash Window, Ershadi’s Sash Window, Sadeghi’s Sash Window and Rezazadeh’s Sash Window

***The Relationship between Light Amount of Space and Thickness of the Wall***

In this section, the light loss factor based on wall thickness and location of window in it is investigated. It must be mentioned that, just for the eastern and western fronts, where window width was less than the distance of the exterior wall, this factor is computable. In southern fronts, that the proportion was higher, it is not possible to calculate it, because the exterior walls do not exert any effect on decreasing the lighting of these fronts’ windows (Heidari, 2009). Concerning the high number of windows

in eastern and western fronts, just one of them as a sample is examined. This window with the area of 2.20 m<sup>2</sup>, in a wall with thickness of 50 cm was in the Ebrahimi House and was located in front of the wall. The amount of its loss is about 7% according to the calculations below. This indicates that in these two fronts, it was attempted to prevent the light penetration due to its unsuitability. On the contrary, the windows of Shahneshtin, because of being located in the south, and transmitting the southern light, were installed without any indentation from walls (Table 3).

**Table 3. Affects the Position of the Window in the Wall Regarding to the Light Loss.**

Wall thickness Location Window in the Wall	0 to 10 cm	10 to 20 cm	20 to 30 cm	30 to 40 cm	40 to 50 cm	50 to 60 cm
Forward	%1	%2.5	%4	%5.5	%7	%8.5
Middle	%2	%5	%8	%11	%14	%17
Back	%4	%10	%16	%22	%28	%34

(Heidari, Shahin, 2009)

\*used the table number for calculation the lighting loss in window at after step



**LIGHTING COEFFICIENT**

The lighting area of window depends on a number of conditions comprising window frame, glass, and thickness of the wall containing the window, blind, added components, and the window's color (Heidari, 2009). This calculation has been performed for the south-front windows of the houses in question, due to the prominence of light in southern fronts of Ardabil's cold climate. In the table 4, window area in all four houses has been examined. As mentioned before, the proportion of glass to south-front sash windows is considered 82% (Table 2). Thus by multiplying the obtained area to its coefficient,

total size of glass can be attained. This amount is 7.38 m<sup>2</sup> in Rezazadeh House. Since colored glasses were used in these windows, the proportion of loss light is determined as 100%, but in other samples are 55%. Additionally, no blinds were placed over the window, except for Rezazadeh House where there was one over the entrance porch. As a consequence, in Rezazadeh's house where a blind with 3m length and 3m width was placed over the window of Shahneshin, we add the two quantities' coefficient to the window' circumference; the calculated number is for the sash window of Rezazadeh House 17% and for other three houses are %5 that explains the following.

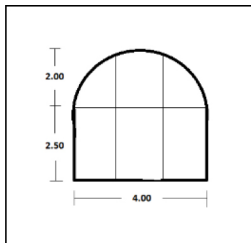
**Table 4. Analysis Lighting the Sash Windows in the Houses Studied**

	Shahneshin Window Surface (m <sup>2</sup> )	Percentage Glass to Window	Glass Surface (m <sup>2</sup> )	Glass Type	Percentage of Lighting Coefficient (Glass type)	Canopy	Loss of Lighting (λ)
Ershadi House	16.28	82	13.34	Transparent & Colored	%55	No canopy	%8.5
Ebrahimi House	16	82	13.12	Transparent & Colored	%55	No canopy	%7
Sadeghi House	35	82	28.70	Transparent & Colored	%55	No canopy	%8.5
Rezazadeh House	9	82	7.38	Transparent	%100	Ok(3×3 m)	%17

**IN THIS SECTION, THE AMOUNT OF LIGHT LOSS CAN BE CALCULATED IN THE SASH WINDOWS**

With reference to the above table (Table 3) the sixth column and the first row, (SL=%14), Can be found that amount of lighting loss in the houses for the sash windows is: λ=%8.5

**Amount of Light Loss in Ershadi House**



$$S = P_w \times T_w / 4$$

$$S = \left\{ (2 \times 2.5) + 4 + \left( \frac{2\pi R}{2} \right) \right\} \times 0.6 / 4 \quad [1]$$

$$S = 2.3 \text{ m}^2$$

$$SL = \frac{S}{S_w} = \frac{2.292}{16.28} = 0.14 \rightarrow \%14 \quad [2]$$

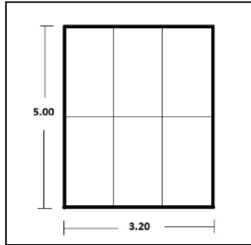
Surface loss from this window

- π = 3.14
- R = Radius
- S = Shadow
- SL = Surface Loss Light
- P<sub>w</sub> = Window Perimeter
- T<sub>w</sub> = Wall thickness
- S<sub>w</sub> = Surface Window
- λ = Light loss factor





### Amount of Lighting Loss in Ebrahimi House



$$S = P_w \times T_w / 4$$

$$S = \{2 \times (5 + 3.2)\} \times 0.5 / 4$$

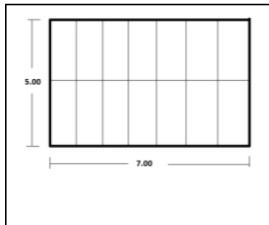
$$S = 1.97 \text{ m}^2$$

$$SL = \frac{S}{S_w} = \frac{1.97}{16} = 0.12 \rightarrow \%12$$

Surface loss from this window

Too, with reference to the table in before page (table3), the fifth column and the first row, (SL=%12), Can be found that amount of lighting loss in the sash windows is:  $\lambda = \%7$

### Amount of Lighting Loss in Sadegi House



$$S = P_w \times T_w / 4$$

$$S = \{2 \times (5 + 7)\} \times 0.6 / 4$$

$$S = 3.60 \text{ m}^2$$

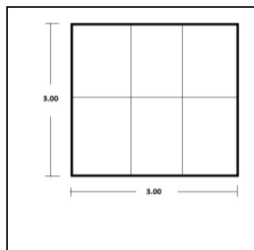
$$SL = \frac{S}{S_w} = \frac{3.60}{35} = 0.10 \rightarrow \%10$$

Surface loss from this window

Too, with reference to the table in before page (Table. 3), the sixth column and the first row, (SL=%10), Can be found that amount of lighting loss on the houses for the sash windows is:  $\lambda = \%8.5$

### Amount of Lighting Loss in Rezazadeh House

To calculate the amount of lighting loss in the Rezazadeh House with the windows have canopy is used same procedure. However, be added the canopy surface to the wall thickness and too, instead dividig of 4, divided by to 3, to obtain. (In this house, the sash window has a canopy with distance 3 m×3 m in upper the window), (Fig. 4).



$$S = \frac{\{P_w \times T_w\} + C_s}{3}$$

$$S = \frac{\{2(3 + 3) \times 0.6\} + (3 \times 3)}{3}$$

$$S = \frac{\{2(3 + 3) \times 0.6\} + (3 \times 3)}{3}$$

$$S = \frac{16.2}{3} = 5.40 \text{ m}^2$$

$$SL = \frac{S}{S_w} = \frac{5.40}{9} = 0.6 \rightarrow \%60$$

Surface loss from this window

With reference to Table 3 (in the previous page), sixth column and second row, which shows that SL = 60%, can be found that the rate of light loss for sash windows in Rezazadeh House equals 17%.

The computed light loss rate is 8.5% in Ershadi House, 7% in Ebrahimi House, 8.5% in Sadegi's house, and 17% in Rezazadeh House. This result reveals that area of lighting is equal and above average in the first three houses. In Rezazadeh House, however, an owing to the blind over the window of this house is very lower. Since the type of glass used for the window of this house is clear glass, the rate of light pass through this window is 100% (Table 4).

### EFFECTS OF WINDOW HIGHT IN RELATIONSHIP WITH ROOM'S DEPTH ON THE UNIFORMITY OF LIGHTING AND PREVENTION FROM GLARING

In a room which receives light from a single side, the light area is so wide near the window. However, its amount sharply reduces by becoming distant from the wall containing the window. With regard to the fig.5, in Rezazadeh House, in the southern front, the depth of the east-facing and west-facing rooms equals 10m, which is an appropriate depth for this section with the purpose of lighting uniformity and maximum use of desirable light.

### Other Effects of the Window on Lighting

#### Double Door

Open parts of exterior walls is embedded the daily lighting of the sun, is similar to gateway that in the winter season should be possible to prevent the building from heat loss. The house windows is used the method of double doors in the back windows.

#### Canopy

Important cases see in the traditional houses in Isfahan, Kashan, Yazd and Kerman, have used the canopy at the top of the window. The intense radiation of the sun is on the south side. Building located at the south side of sunshine in Ardabil cold climate design is one of the important ideas. So, with study of the window of traditional houses in the Ardabil city understand that the southern front of this house is no used canopy. Buildings which were located in East and West sun exposure in a specific case is problematic. However, with study traditional houses in front of the head to prevent the penetration depth of the sun room is used the door in the back window. (Sheikhzadeh et al., 2006)



## CONCLUSION

The windows employed in traditional houses of Ardabil served a substantial role in absorbing solar energy, lowering the heat loss, as well as aesthetics.

Noticing the dimensions of the east-facing and west-facing windows of the under-study houses in Ardabil as a cold climate, and comparing them with south-facing ones, it may be a part of a paradigm which concludes that the design of traditional houses in Iran was in close harmony with nature. Regarding the studies undertaken in this research, the obtained results can be stated as follows:

1. Location of the windows in front of the walls in southern fronts of the under-study houses indicated that, due to the need for more light in the southern fronts, there was no tendency to design blinds as it opposes to the houses of warm climates. For instance, the light loss rate is 17%~7% in all of the houses.
2. The use of appropriate glass area in different fronts was in accord with the amount of required natural light in those fronts, which was conducted intelligently.
3. The use of colored glasses in sash windows of historic houses seems to be an attempt to break up the sun's white ray of light into spectrums with an assortment of colors inside the place (which has its root in Iranians' religious beliefs about bringing the colors of heaven into the house), and is effective in balancing the amount of lighting of the space. It was demonstrated that the amount of lighting is 0.39 in the houses of Rezazadeh's and Ebrahimi, 0.43 in Ershadi House, and 0.45 in Sadegi's house; it is evident that in the two latter houses the lighting amount is near average.
4. Windows' double-glazing technique has been utilized in order for heat loss to be reduced inside the architectural space in these houses. On the other hand, in eastern and western fronts, this technique was implemented by the use of shutters behind the window, which served the role of double-glazing, as well as lowering the harsh sunlight in those fronts.

According to the above-mentioned points, it can be claimed that the windows of Ardabil's traditional houses, besides meeting the aesthetic criterion and adding variety, have a sophisticated design, and take a significant part in optimizing energy consumption. Furthermore, striving for adding a feeling of holiness to the design of the windows seems to be suggestive of religious beliefs of the occupants. Consequently, by modeling the

contemporary architecture on the present paper's results, we can succeed to design windows with higher quality and more meaning. Results of this research can be used in new design process of the windows and the relationship between the dimension, color and other factors of the window and their effects on the lighting of architecture in the contemporary period.



## ENDNOTES

1. Is a type of corbel employed as a decorative device in traditional Islamic and Persian architecture. The related mocárabe refers only to projecting elements that resembles the stalactites.
2. Is a historical neighborhood in Ardabil city that in the local language called three shops

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