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An Analysis of Natural Ventilation Function in Vakil Bazaar

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ABSTRACT:

Despite the similar performance of Bazaar[1] in different cities of Iran, there are some the skeletal differences between markets in different climates. The Bazaar roof protects customers against natural events in any climate. The ceiling height and the sitting down of the Bazaar`s floor are determined based on the need for air circulation and movement in various climates. Hence, combination of all the factors would shape the market. Natural ventilation and cooling air are one of the major factors determining the market shape in hot and dry areas. This study aims to analyze the function of natural ventilation concerning direct and indirect effective elements and their impacts on market shape in hot and dry city-Shiraz. For this purpose, Vakil Bazaar is chosen. In this research, a combination of descriptive and case methods are applied analytically, a field which determines the wind and air function based on the dominant wind and other elements affecting the natural ventilation of Shiraz` Vakil Bazaar that in the end achieve factors to providing favorable comfort in this place.

Keywords: *Natural ventilation, Wind, Ventilator, Thermal comfort, Vakil Bazaar*

INTRODUCTION

Wind as an indicator of climate has a significant impact on human life and his surrounding environment. Wind energy was used in many ways especially to control the temperature. Dwellers in cities have been always considering the climatic conditions of the area and particularly dominant winds. And depending on local circumstances, they not only have taken advantage of the wind in indoor thermal comfort through the use of ventilator, but also the city's main thoroughfares and public transits are chosen regarding the implications of this climatic event (Consulting Engineers of Betel Mccarthy, 2002).The link between climate and architecture is more likely to the relation between an infant and embrace, any herb and the soil or safe privacy and a bed growing. The dependency pauses evolutional, aspired but not causes limits. Architecture is born in environment and is shared in some conditions. The climate as far as is concerned to man, it is the result of the interplay of elements such as sunlight, temperature, humidity, wind and rain falls (Hatami & Eghtesadi, 2014) In addition to influencing the overall structure of the city and the shape of neighborhoods, markets in historical and cultural cities are considered as one of the most important and valuable aspects of architecture and public identity and during history, it has always been one of the main areas of common interactions in civil life (Jahad Daneshgahi, 2009).Wind catcher is known as a traditional conditioning element with the function of "Catching the Wind", as the name suggests (Bloorchi & Eghtesadi, 2014). Air conditioning (Curran) has been significant not only in markets but also in all important ancient architectural monuments of Iran to use in a best way. In Iranian markets, the width of Raste[2] of Bazaars is made based on the magnitude of the city, and in the construction of its height, the area climate should be considered carefully. So, high ceilings are appropriate for hot and arid climates and lower height is suitable for colder climates.

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Lighting and ventilation are provided by the roof openings and sometimes by Khishkhan[3] in Timcheh[4] and Charsuq[5] of Bazar In fact, Khishkhan is defined as a kind of central dust ventilator which is built on top of dome, its wooden openings can control the temperature and the air conditioning through opening and closing in different seasons (Jahad Daneshgahi, 2009). As the urban market forms the main part of a city, it has a major role in climate and natural ventilation to achieve comfort condition. Regarding the prevailing wind direction and desirable climatic conditions of the city, the other effective elements in natural ventilation, the role of ventilators in natural ventilation and comfort condition at Vakil Bazaar of Shiraz, wind is considered as a variable in this study and is investigated computationally and analytically. The researchers hope this study would offer some good solutions to achieve using natural ventilation in urban environments.

The Study Area

Shiraz is located in the geographic area of 52 degrees and 1 minute to 53 degrees and 34 minutes to east longitude and 28 and 58 to 29 and 54 in north latitude. Shiraz elevation above sea level is 5,000 feet that means more than 1500 meters. Shiraz beautiful plain is approximately 40 km long and 15 km wide and forms an east - west rectangle (Golshani, 2009). During Zand period, a collection of buildings were constructed in the city including government citadel, a mosque and a bazaar, marinas and city squares (drill field and artillery) (Golshani, 2009). Zand building complex was connected to the city by the Raste of Bazaar (Nasr, 2008). The natural ventilation function of Vakil Bazaar in Shiraz is analyzed here. This market was chosen to study since it is one of the functional urban places that after many years its function still persists (Fig.1).

Natural Ventilation

According to Watson and Labz (1997), natural ventilation contains an airflow which is caused by pressure and thermal loads resulting from atmospheric interactions. These include the blind natural air and flue system. "Natural movement", in the terms of engineering heat transfer, is defined as the heat transferred by air movement which is affected by the thermal energy, if the "natural ventilation" is created by wind or thermal power. Consulting Engineers of Betel Mccarthy (2002) believed that if the building is located in the direction of airflow, it would cause a normal pressure difference. It means that if air molecules are compressed, they lead to higher pressure. On the other hand, the pressure would decrease if the molecules are not compressed. By using the pressure difference around the building, through the inlets in the areas with positive pressure, and via putting a wind-driven in the area of negative pressure, natural ventilation is done. Pressure difference between the inlet and outlet areas would provide the force required to flow the air in the building. Any increase in speed reduces the static pressure. If we consider the atmospheric pressure as the reference (zero), it will be negative. Due to obstacles in the way it is in the air, the air molecules are compressed more. So the air will condense. Clashing to a barrier in the way, air molecules became more compressed and dense. Then the air molecules pass through the barrier and accelerate. As a result, their density decreases, which causes a negative pressure or suction (Fig. 2).

Therefore, the natural ventilation system can utilize some valves windward (interlude) and some other behind the wind (wind reading) in order to provide air flow. Natural ventilation function can be analyzed in two ways, firstly, by using wind as the main power system with speed, power and flow. Secondly,

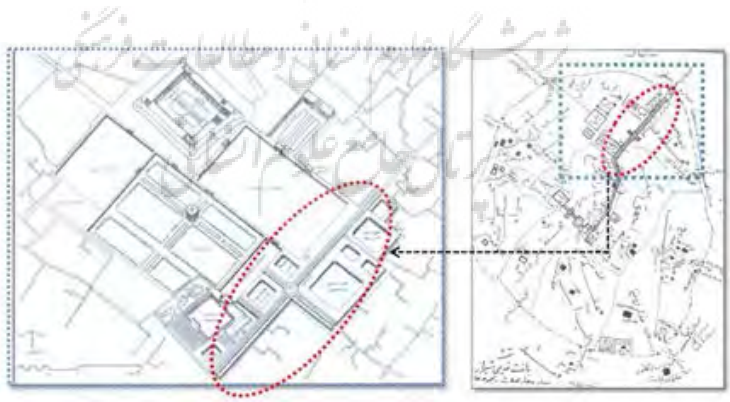

Fig. 1: Location of the study area, Vakil Bazaar

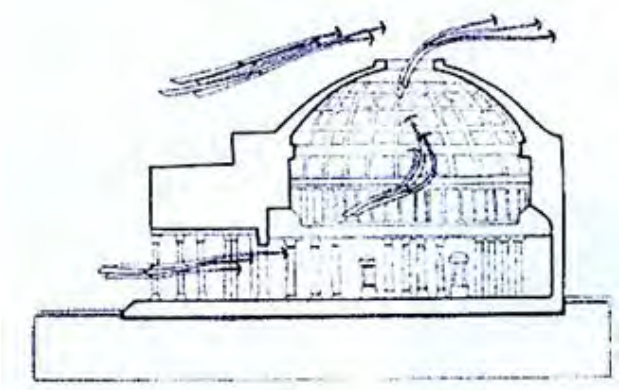

Fig. 2: The Pantheon Building in Rome, where air conditioner is used (Consulting Engineers of Betel Mccarthy, 2002).

the use of thermal power and thermal load that causes the pressure difference and air moving thorough McCarthy (2002) thought that understanding the behavior of the wind and the wind pressure on the building is inevitable for architects and designers who are going to use the available wind energy. Kasmaee (1999) indicated that generally in each hemisphere, there are three wind systems: the trade winds, western and polar winds, and seasonal winds. Moreover, there three more wind systems and also the blowing sea breeze during day and night. Ghiabkolu (2011) stated that the wind is a vector quantity that has two properties: one is direction and the other is speed that can be estimated by observation or be measured by using special tools. According to Ghobadian (2011), a large number of towns and villages in the desert and desert areas in Iran mostly are located depending on the position of wind. Thus, the entire city, the buildings, the wind deflector openings and ventilators are designed towards favorable wind direction and behind hot and dusty winds. In this way, the desirable wind is taken into the city and buildings and decreases the dryness and hotness of the air. It also hinders the entrance of extreme dust and hot air. He also mentions that assessment of the prevailing wind direction and intensity are of great importance in distribution of functions and urban design.

Wind Direction and Speed

Consulting Engineers of Betel Mccarthy in 2002 showed that the wind direction is the most important factor in determining how air passes through a building. Wind causes a variable positive or negative pressure field when it moves over the buildings. Then the air moves from the areas with positive pressure to the areas with negative pressure. He stated that the wind direction and its speed over the building cause a pressure field around the building. Then, it is important to note that wind-driven and wind ages are provided to increase the pressure difference between the inlet and output. This would increase the efficiency of the ventilation plan, since it may decrease the openings levels. But this difference is based on wind speed. If the pressure be lower than a certain limit, only chimney effect (float) affects the air ventilation badly. The air ventilation only when the wind speed exceeds 2/5 meters per second is effective. The wind direction is the direction from which the wind is blowing, so a wind screen named as Wind rose is used to determine the wind direction (Consulting Engineers of Betel Mccarthy, 2002). If the main directions of north, south, east and west of the screen drawn on paper are connected to each other and the distance between them is divided into two, four or eight equal parts, thus the resulting Wind rose would be eight, sixteen or thirty-two directions (Ghiabkolu, 2011).

The Air Temperature and the Temperature Difference

As mentioned by Hashemi (2011), temperature is defined as a quantitative comparison which determines the degree of warmth and coldness of an object and depends on the particles of the material. He also stated that the amount of solar energy that reaches the earth's surface at any point during the year depends on the intensity and duration of sunshine on that point and the degree of surface warmth and coldness of earth determines its temperature. As the temperature increases, air density decreases, so the air moves up (Kasmaee, 1999). The temperature difference between inside and outside of the building, and between various regions cause pressure difference, and subsequently displacement of the air. This phenomenon is called "the chimney effect". Therefore, natural ventilation systems must be designed in a way that can reinforce the floating air. And the wind tends to act the buoyancy force in the same direction to prevent the elimination of the two forces (Consulting Engineers of Betel Mccarthy, 2002).

Humidity

The humidity is the amount of water that changes into vapor in the air. This vapor is transferred by airstreams and wind to

the rest of the land surface. The warmer the air is the more vapor holds in itself (Kasmaee, 1999). The amount of moisture in the air is measured by a variety of scales such as specific humidity, vapor pressure and relative humidity. In areas with low humidity, there is no humidity during the day due to dry air that resists against sun light, so the temperature during day is very high. There is no humidity during night that prevents radiation, so the temperature in this area comes down quickly. Therefore, the temperature difference between day and night in warm and dry regions is higher than other regions (Ghiabkolu, 2011). The vapor pressure reduced faster due to height increases than the vapor pressure of the air pressure. Hence, the density of vapor in the air increases as the height decreases. The vapor pressure of the air layers near the ground is always higher. Due to this reason any vertical air mixing results in reduction in the vapor pressure of the air layer near the ground. Relative humidity less than 25% may cause extreme stiffness and relative humidity more than 75% leads to excessive moisture (Kasmaee, 1999). Overall, 25% RH to 60% RH is optimum for human environment (Ghiabkolu, 2011).

Elements of Natural Ventilation in Shiraz

The natural ventilation with the air exchange rate inside a building is one of the primary factors in determining the health and comfort of human. Natural ventilation affects human in two forms, one direct and the other indirect effects. On one hand, purity and velocity of airstream in the building influence human being directly, on the other hand ventilation condition affecting air temperature and humidity and indoor surfaces of building can indirectly impact human (Kasmaee, 1999). Direct effect of some factors like wind, the orientation of the building, location and size of inlets and outlet air valves, the function of air conditioning system on the users (humans) is more efficient and factors such as temperature, humidity, type of building materials affect natural ventilation system and finally human indirectly.

Direction and Wind Speed in Shiraz

Fig. 3and the diagram in Fig.4 illustrate the direction and wind speed in Shiraz that can be utilized to check Vakil Bazaar. In Fig.5 Shiraz prevailing winds are blowing from the northwest to the southeast. According to data from Fig.4, the prevailing wind blows with the speed of approximately 5.4-7.1 m/s. The winds with speeds more than 2.5 m/s in natural air cooling function efficiently, so the prevailing winds over Shiraz have the needed speed for desirable ventilation. The winds with the mentioned features have the ability to create suction and air circulation in this case (Vakil Bazaar of Shiraz).

Air Temperature and Humidity in Shiraz

In the Fig.6, the data about the relative humidity (RH) indicates that RH during all months in Shiraz roughly defined in the optimum range of the human environment. So, in contrary to other hot and dry areas, there is no need to provide moisture for comfort in this city.

In Fig. 7, the absolute maximum temperature in Shiraz illustrates highest and lowest degree (22.4 to 43.2° C). And the statistical information in the first six months of the year shows

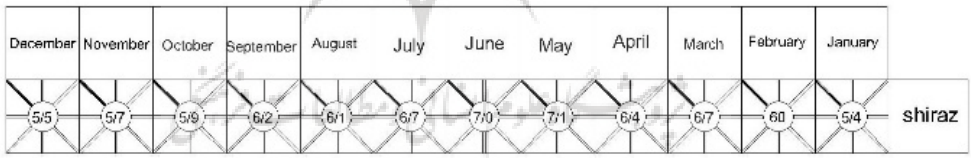

Fig. 3: Chart of the prevailing winds and the maximum wind speed in Shiraz (Kasmaee, 1999)

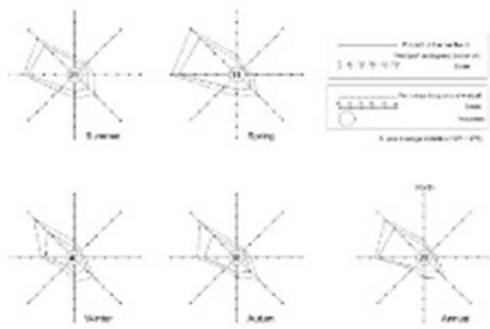

Fig.4: Diagram of wind direction and speed (Kasmaee, 1999)

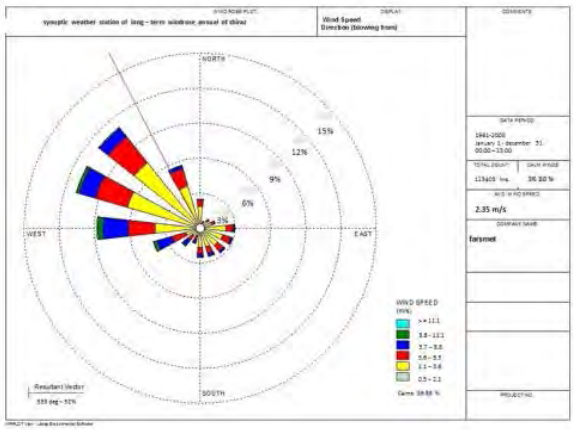

Fig. 5: Annual long synoptic weather station (Fars Meteorological Organization,(1961)

Average relative humidity %			Average temperature ℃			Months of the year
Average daily	Time 12:30	Time 6:15	Average daily	Average minimum	Average maximum	
63/5	49	78	5/8	-0/4	12	January
59/75	43/5	76	8	1/2	14/8	February
53	37	69	11/8	4/5	19	March
48/5	32	65	15/7	7/9	23/5	April
37	23	51	21/4	12/7	30/1	May
25/5	15	36	26/1	16/6	35/5	June
24/5	15	34	28/5	19/6	37/3	July
25/75	15/5	36	27/4	18/3	36/4	August
28	16	40	23/8	1412	33/4	September
35	19	51	18/1	8/5	27/7	October
48/5	32	65	11/9	3/5	20/2	November
62	45	79	7/2	0/4	13/9	December
						Annual

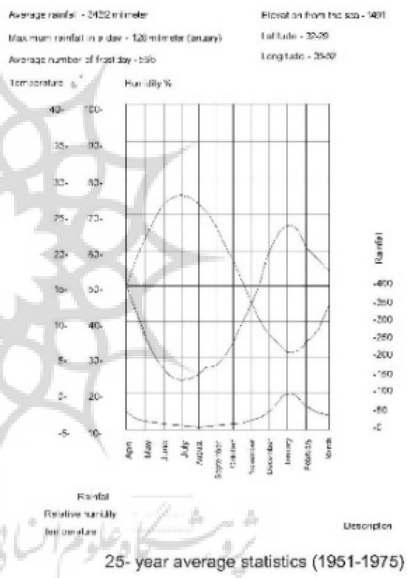

Fig. 6 : Average temperature, relative humidity, rainfall in Shiraz during last 25-years (1971-1996) (Kasmaee, 1999)

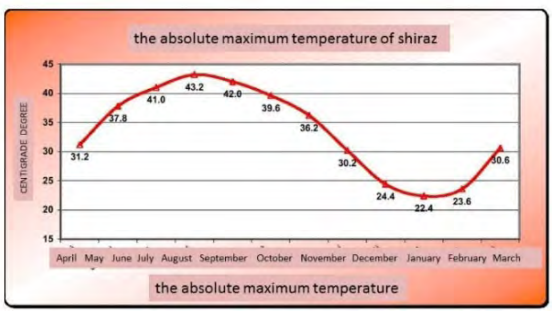

Fig. 7 :Shiraz absolute maximum temperature (Fars Meteorological Organization,1971-1996)

higher temperatures than the second half of the year. Hence, the need for cooling air is felt more in this period of the year.

Vakil Bazaar

It is a street market almost a quarter mile long, built entirely of brick with an arch that is more or less similar to the" Pyatzas" in "Covent Garden". The design of this building with an area equal to 31,840 square meters and an infrastructure equal to 22,960 square meters (including inns), is taken from the Caesarea market of Lar and the Long Bazaar of Isfahan built by Shah Abbas the Great. Comparing to these markets, Vakil Bazaar is wider. It has also 74 beat arch spans with a height of over 11 meters which are higher than other markets, today due to embankment of market floor, the arches height have been reduced to 10 meters. This bazaar has three passage spaces, (transits space for clients), shop frontage (with a height of approximately 2 steps above ground level), the shop space (selling place). It also has five large doors located on its four corners. It includes two major north - south and east - west passages that cross each other. The intersection of these two categories, Chaharsooghi is located on a porch. It has a strong arch and there are some brickwork bergamots on the foot of the arches. There are some rectangular two-floor shops in the vestibule. Houses and other buildings associated with the market are located in its margins around the main way and find ways to the market via some doorways and corridors. After the establishment of Zand street, the north and south Raste of Bazar were cut at a point near Chaharsooghi and now there are a few rooms and arches in this section (Fig. 8 and 9) (Nasr, s2008).

This architectural masterpiece in Iran`s history is still strong and alive. In the market plan, controlled lighting and temperature are driven through skylights and networking, so that it is cool in summer and warm in winter (Golshani, 2009). This bazaar included forty-one arches to reach the Chaharsooghi. In the middle of the market, there was another market with eleven arches called Shamshirgiran market, another with a forty-six arches called Kolahdoozan market and another with nineteen arches called Yraqbndan, and finally another market with ten arches named Sarajan (Ghobadian, 2011). On the top of each chamber, some windows were embedded providing the lighting of the central part of the market. The air conditioning system due to high ceilings of arches and Tavizeh of the market is complete. This is done by simple ventilators. In the past, some outlet valves and openings named as Jamkhaneh or Hurnur was embedded under the ceiling that provide the needed air and light for market. But now, after restoration, these openings and valves are closed, instead there are some openings above the stores for lighting and air conditioning (Nasr, 2008).

Fig.8:Vakil Bazaar during the Naseredin Qajar Shah (Ghobadiyan, 2011)

An Analysis of the Natural Ventilation Function of Vakil Bazaar in Shiraz

The Role of Structural Elements in the Function of natural ventilation in buildings

Energy conservation in building arena is essential issue for achieving sustainable environment. However, buildings experienced significant amount of heat gain or loss through window and this will affect the thermal comfort of buildings' occupants. Building without window is able to save energy, but it is not recommended due to the benefits of natural light on visual comfort and the biological effect of natural light on humans(Hee et al., 2015)Referring to the discussion on natural ventilation, climate effects on the building and the role of each of the physical elements in the natural ventilation function, data taken from the book called climate and architecture, (Kasmaee, 1999), role of building orientation, locating the windows horizontally and vertically, dimensions of openings, and for the study of factors affecting the function of natural ventilation in Vakil Bazaar are analyzed in detail here.

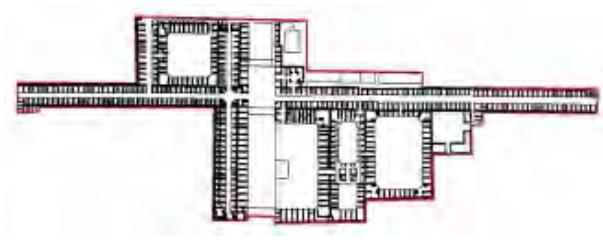

Fig. 9:The Vakil Bazaar plan (Fars Department of Cultural Heritage, Handicrafts and Tourism,2010)

Building Orientation andthe Deployment of Valves (Plan)

The optimum natural ventilation occurs if the opposite openings are put windward and the other behind the wind, so the air flow all over the room. The most efficient ventilation is done when the wind direction is inclined toward the window (Fig.10). vertical temperature difference in the occupied zone and indoor thermal comfort, while the vent shape and the horizontal position of heat source on the floor seem to have marginal influence on the transient natural ventilation(Yang et al. ,2015).Based on the experiments in past research if a room has some windward and behind the wind windows, the vertical wind will enter through the windward window and exit directly and without any change through the one behind the wind. Consequently, in this case, the points in the room that are not located in the airflow path are not effectively influenced by the wind. But when the wind direction is inclined to window, almost all parts of the room will be affected by the airflow andwith a circular motion of the wind, the air flows through the space. In this way, optimum ventilation would occur and the airstream in the room can change. As a result, orientation of a building is very effective in air conditioning. Fig. 12 shows the proper location to take advantage of the winds of the northwest, southwest, northeast and southeast (Hashemi, 2011).

The orientation of Vakil Bazaar is in line with the rest of the pattern in Figure 12 from north-east to south-west which is very effective. Figure 11 corresponds to the direction of the prevailing wind over Shiraz. It can be assumed thatthe range of the prevailing winds blows in the angle between the axis of the wind in northwestern and the west of Iran. And this direction of the wind is inclined to the surface of the market. The windows and openings located on the wall of the longitudinal axis

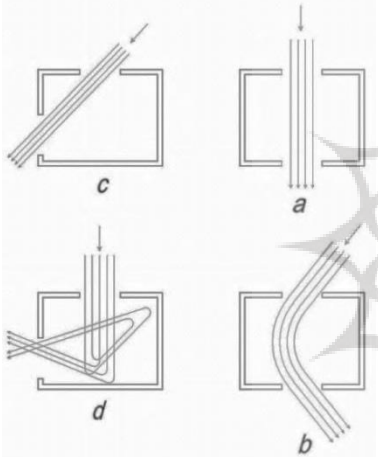

Fig.10:The effect of the window position on the natural ventilation function (Kasmaee,1999)

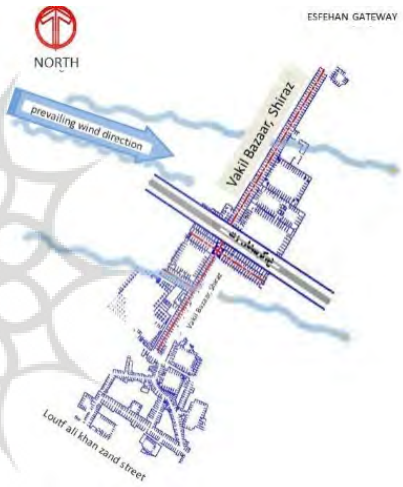

Fig. 11:The effect of window position on the air conditioning function

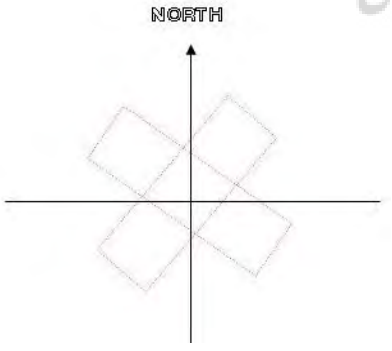

Fig.12 : The desirable orientation for better use of the wind (Hashemi, 2011)

Fig. 13: The location of windward windows inclined to the wind direction

functions well in the windows towards the wind (windward) and back to the wind (wind-driven) since they were inclined to the wind direction and establishment of circular airflow which is shown in Fig. 13.

The Height of the Market and the Proper Location of the Windows

Air velocity at different heights in a room regarding the position of windows to the horizontal distribution is fixed. So we can control the air velocity on vertical surfaces in a room by careful planning the height of the windows. The height of window bottom and the type of windward window opening are more important in determining the wind direction and wind speed inside the chamber than the wind-driven window. For this reason, the height of the wind-driven window has little impact on the shape and speed of air movement inside. But the wind speed suddenly decreases to 25% of the main wind in the lower part of the window bottom when it enters. Hence, the height change of the bottom of the window may also change air velocity in different heights. However, this change will have little effect in the mean air velocity inside the room (Fig. 14) (Kasmaee, 1999). As mentioned before, the indoor height of the market is about 11 meters which is higher than the surrounding buildings because of shell and dome thickness. There are some valves in the longitudinal wall on two sides under the dome and Hurnurs that play the role of windward and wind-driven windows. It can be inferred that the market height as a barrier creates a high pressure area in the windward part which can provide good conditions for the windward windows. So, there would be more air movement inside the market. Fig. 15 illustrates the circulation of wind at high-altitude of human scale and the wind movement in the higher areas in the inlet and outlet valves (under the dome) and finally suction.

The Window Sizes

The effect of window sizes on indoor ventilation greatly depends on the existence or non-existence of air circulation in the room (this air circulation is created by wind in a room when each one of the front and back wall has an opening). If windows are just located on a wall, the size effect is very low. While increasing windward and wind-driven window sizes can lead to high air velocity inside the room because of air circulation. It is noted that a combination of a small windward window and a big wind-driven window results in the maximum air speed in a limited area of the room whereas the air velocity will increase in other parts of the room. The sizes and dimensions of windward and wind-driven windows of natural ventilation system in Vakil Bazaar are the same which are not elaborated here (Hashemi, 2011)

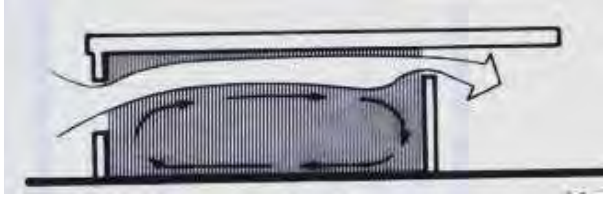

Fig. 14 :The effect of window height on the room air (Kasmaee,1999)

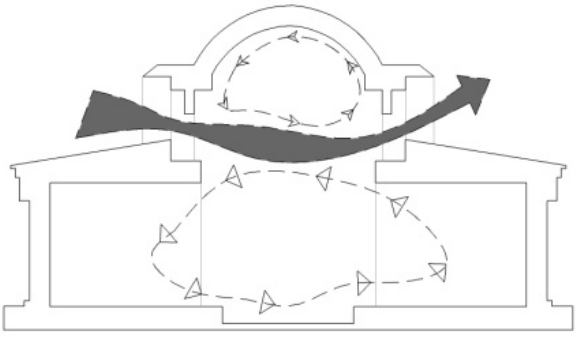

Fig. 15 :Wind circulation at high-altitude of human scale

The Role of Non-structural Elements Affecting the Natural Ventilation Function

Natural Ventilation by Wind Power and Chimney Effect

Natural ventilation takes place by using the pressure difference around the building, by means of the wind and chimney phenomenon. Natural ventilation is based on three climatic events: wind speed, wind direction and temperature difference (Consulting Engineers of Betel Mccarthy, 2002). The function of ventilation in this method as shown in figure 16 indicates that during natural ventilation, the height of domes causes wind circulation with a speed of over 2.5 m/s and high pressure in a windward direction. This high pressure airflow enters through the windward openings under the domes. After the establishment of air circulation, it is transferred to wind-driven openings with lower pressure. This action is just like a ventilator, a combination of wind-driven and windward elements.

Natural Ventilation by Thermal Buoyancy Force and Effect Stack

The air will move due to density or pressure differences. When a mass of air is heated, the air expands, and its density decreases, and then moves upward. In fact, a cool mass of air replaces the hot air and pushes it to move upward. It can be inferred that the thermal power runs the air mass. The phenomenon is called air buoyancy. When the thermal power sends out the air from a building, this action is known as "chimney effect" (Kasmaee, 1999). The natural ventilation in Vakil Bazaar of Shiraz when the wind speed is not high enough to generate suction and air circulation creates a pressure difference shown in figure 17 and then a high-pressure area is made under the domes. Thermal

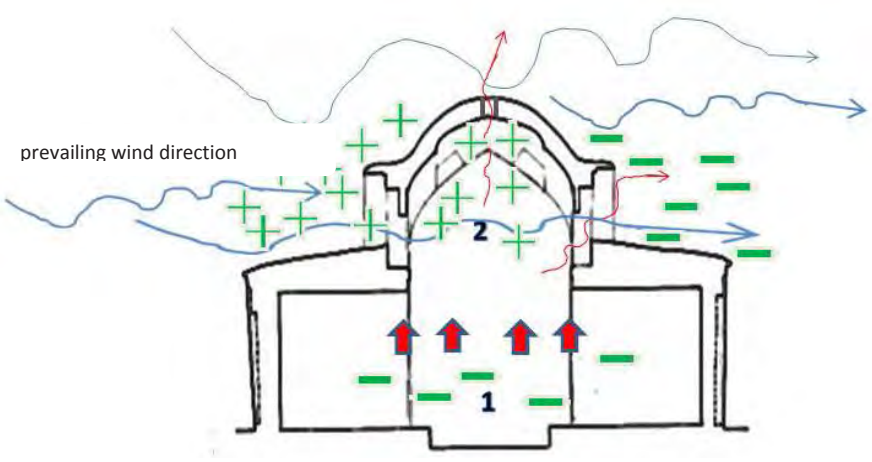

Fig. 16: Natural ventilation by wind and chimney effect

power caused by the activities in the market and the hot environment will generate the air buoyancy system. Warm air having less density is run to higher levels, and is replaced by the cool air. After air movement caused by pressure difference, the chimney effect phenomenon takes place and the warmer air is sent out through the above openings. So, it can provide natural ventilation in hot hours of a day for human when wind does not blow.

The Shell (Thermal Coefficient and Type of Materials, Color and Thickness)

Natural ventilation function is expressed in three different ventilation modes: for human health, for comfort and for cooling. In ventilation for cooling the building, many elements such as inside and outside temperature of the building, color of the shell, and temperature coefficient plays significant roles in providing comfort temperature.

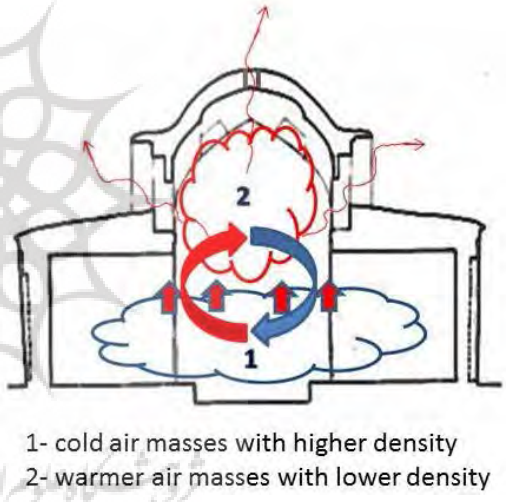

Fig. 17: Natural ventilation by thermal buoyancy force and chimney effect(authors)

The Effect of the Color of the Shell on Internal Temperature Change

Generally, the ratio of the average temperature inside and outside the room depends on the color of outer surfaces of walls. If the color of the outer walls is darker, the air in the room gets warmer. But the fluctuation of indoor temperature depends on the thermal capacity and resistance of materials and the fluctuation of outer surface temperature (Hashemi, 2011). The dominant construction material in hot and dry climate is clay and brick. And this is true about this market
because of the surrounding nature. The building shell is constructed entirely of brick. The assumption is that the color of the external shell absorbs radiation of sun more, and for this problem an alternative should be found.

The Effect of Thermal Coefficient and the Shell Thickness on the Internal Temperature

The rate of internal temperature variation depends on the thermal capacity and resistance of wall materials and the fluctuation of external surfaces of the walls. When a building is ventilated, the air exchanged between the inside and outside of the room (Kasmaee, 1999). The thermal capacity of a wall is the result of especial weight, thickness, and its heat. Generally, the thermal capacity is almost based on material weight. But any increase of the thermal capacity is accompanied by the augmentation of especial weight-making materials more dense through increasing the thermal conductivity coefficient. So, it reduces the heat resistance substantially in one hand, and replaces the heavier

materials with lightweight materials and the heat resistance without changing the wall thickness decreases the heat capacity (Hashemi, 2011). The heat from the radiation in hot summer and high temperature around the building because of the walls with approximately 70 cm thickness made of brick materials with high thermal storage are utilized in the building. These have been used to undermine the possibility of heat exchange. This also occurs in the ceiling that its dome shape can decrease the thermal radiation via its shadow.

CONCLUSION

The function of natural ventilation system in Vakil Bazaar is affected by the following factors which can act as well even after many years and provide desirable conditions. These factors are:

- Having proper orientation and placed in line with the model shown in Fig.(11-12) for better utilization of climatic factors;
- Being higher than the adjacent buildings since it generates a barrier against wind and creates a high pressure area;
- Locating the windward window (at the level of the dome roof) in a good height for wind direction caused by the high-pressure region into the indoor;
- Establishing windward and wind-driven windows appropriately (at the level of the dome roof) in order to rotate the valve to inflate the area under the dome;
- Placing the windward valves inclined to the wind direction and using the wind circulation in all parts;
- Building Hurnur on dome ceiling to create a vertical suction (chimney effect and air buoyancy) when the wind speed is absent;
- Using high shell thickness due to the weakness in the heat capacity of materials (mud and bricks) and the minimum temperature exchange inside and outside the building;
- Covering by domes on the roof to minimize the level of exposure to create a shadow on the roof;
- Being suitable for natural ventilation and comfort condition, blowing wind with the needed speed (2.5m/s) by using two side openings on the walls that play the role of windward and wind-driven windows (wind power and chimney effect), without blowing wind by using Hurnur ceiling windows (chimney effect and air buoyancy).

The current analysis was about natural ventilation of Vakil Bazaar. It is clear that our ancestors had created such a masterpiece creatively and professionally and taken advantage of climatic conditions for a desirable and sustainable function. It is necessary to pay more attention to these rich resources, extract the positive points and apply them in the urban designs.

NOTES

1. Bazaar: A place for buying and selling goods
2. Raste of Bazaar: a long way between two sides of the shop.
3. Khishkhan: Khishkhan is defined as a kind of central dust ventilator which is built on top of dome, its wooden openings can control the temperature and the air conditioning through opening and closing in different seasons.
4. Timcheh: Small closed spaces in Bazaar that include a few shops or chambers, which their merchants trade and deal a particular type of goods in there.
5. Charsuq: The intersection of two major Raste, and each side has a market and shops.

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