The Study of the Airflow in Wind Towers for the Old Buildings Air Conditioning

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Abstract: - Wind towers are small towers with square, rectangular or triangle sectional shapes. They have been used for the building air conditioning in different regions of Iran since very old times. Due to the blowing effect of wind, air comes down from channels that are at the top of wind tower to its column. It finally transfers the heat to the internal surfaces of its walls as it comes into the building. Various perfect wind tower types can be found in some cities of Iran e.g. Yazd, Kashan, Tabas, etc. Design of wind towers depends on the shape of building, speed and direction of wind, height of wind tower, air passing section and wind tower location. The most important advantage of wind towers is the air conditioning and air cooling without any use of electrical energy. In this paper two patterns of wind tower are studied experimentally. The temperature of connecting space and air speed in the internal space of channel are measured and the direction of airflow in the wind tower is evaluated. The results show that the wind tower plays the role of blowing and sucking at different air speeds. Therefore, in both cases, they cause the air conditioning of internal spaces of building. In this paper the operation of each wind tower is studied at the different air speeds for the various hours of day.

Key-Words: - Wind tower; Cistern; Air Conditioning; Passive Cooling

1 Introduction

The cities and regions that are located in deserts have their own individual constructions. There is ablaze sunshine and cool weather at night. Lack of raining and snowing, existence of sand storms and strong winds and the temperature difference between sunshine and shadow are dominated in those areas. The people who live in deserts have found out many ways to confront against this unpleasant climate[1-5]. One may refer to centralization of buildings, cistern building, digging long ducts, houses with tall walls houses and domed roof and narrow alleys with archways [6, 7]. If we compare the structure of old houses with modern ones, we find that old houses are made of adobe and mud tall and thick walls. However, modern buildings are made of thin and short walls i.e. They have less material and are accordingly lighter. Therefore the old structures usually have high costs for their building, maintenance and ventilation. Moreover, cheap ventilation and air conditioning are important issues in the selection and construction of buildings. There is not exist accurate information about history and antiquity of wind towers but base on inspections and studies which have been accomplished by Dehghani [8], these wind towers have a history around 1000 years which had been invented by Persians and these wind towers have reached to others countries of Middle East.

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2 Wind tower Performance

2.1 Introducing Measuring Devices

For measuring temperature and air flow velocity were used orderly thermometer model TM-915A and anemometer model AM-4206M made by LUTRON ELECTRONIC company.

2.2 Experimental Results

Wind towers could be divided according to their applications. The first type transfers the flow into the basement. In this type the flow may be transferred into the basement directly from the channels of wind tower or by the rooms located under the wind tower with wooden or metallic grid that is installed in the floor.

When the flow reaches the basement, it contacts the damp walls and its humidity ratio increases while its temperature decreases. The room which is located under wind tower has valves, which can be used when the flow should be directed into or out of hall and adjacent rooms. Moreover, the basement has windows to discharge the flow. We will explain about our study and experiments about this type of wind tower as the following. The tested wind tower transfers the flow into the basement through the room under the wind tower with the wooden grid floor. The wind tower has 12m height, 4m length and a square cross section. The room under the wind tower has 4m length, 3m height and 3 windows and 2 doors in order to transfer the flow into the adjacent rooms or vice versa. A basement with 4m length, 3.6m width and 4.5m height is located under the room. It is connected to another larger basement through a corridor. The larger basement has 5 windows and 2 exit doors. The windows are opened into the building yard. All of the entrance and exit flow gates are opened with favorable or unfavorable direction to the wind flow. The two other sides of wind tower only have one open entry. This wind tower has nine flow entrance and exit channels. Six of them are connected to the entrance and exit flow gates with favorable or unfavorable direction to the wind flow. Two other channels are joined to other sides which have one way entrance and exit and the middle channel is connected to the one of which has one entrance and exit flow gates.

The flow enters the room under the wind tower through four entrance gates at wind speeds lower than 3m/s, and through five entrance gates at wind speeds higher than 3m/s. It circulates through the room and some part of it enters the basement through the wooden grids in the floor. Based on our measurements (Table 1) the flow enters the basement at the half of entrance speed. The other part of the airflow enters and exits through the other symmetrical sucker channels. Sucking function occurs when the pressure difference between two opposite side of wind tower causes a vacuum area around the side which is unfavorable to the flow direction. This pressure difference makes the air suction. When the flow enters the basement, its humidity increases and its temperature decreases due to touching the damp walls. Moreover, when the flow goes through the corridor between basements, its relative humidity rises and the temperature decreases also (Fig.1).

One can conclude that using this type of wind tower, the minimum and maximum temperature differences between the basement and outside from 8 a.m. to 8 p.m. are from 4 to 5°C and from 12 to 15°C respectively. It is also interesting to note that the basement temperature remains almost constant (Fig.1). This figure shows the important role of wind towers for adjustment of the inside temperature and keeping it constant. Based on those diagrams, the average ambient temperature during the day is 32°C and the average basement temperature is about 23°C that is very suitable for desert regions. Fig.2 shows the operation of this type of wind tower.

The second type of wind towers is built on the cellars and cisterns. This type is the first and the most primary ones. As the other types of wind towers have been improved, this type has been gradually developed.

The third type of wind towers has tall height. They are used in one floor buildings with many rooms. There was a hall with domed roof near the room under the wind tower that has important role in ventilation of the building. Dolat-Abad garden wind tower, which is shown at Fig.3, is the third type wind tower. Its performance has been tested by some actual measurements. This wind tower, with 33.8m height and an octagon shape, is one of the highest and the most beautiful wind towers in the world. The flow from each direction and speed may enter its entry channel which is located at 10m height.

The channel cross section is isosceles (Fig.4). Each channel flank is 2.4m and its cross section is 1.6m. The room under wind tower has 6m length, 4m width and 2.5m height. An eight-sided basin with 1.75m length and 0.75m depth is located under the wind tower. Table 3 shows the results of the measurements for Dolat-Abad wind tower (Fig.3) during a day. When the wind average speed is less than 5m/s, the wind tower acts as a chimney. Sucking or blowing function in wind tower depends on the wind tower height, number of rooms and halls, wind speed and number of windows. When the wind speed is less than 5m/s, the air flows over the nearby trees and bushes, humidifies and its temperature reduces at the same time. There are some pools in front of the building doors and windows, which will cause its humidity to be increased and its temperature to be reduced further. The temperature reduction during a day, as Fig.5 shows, is from 3 to 5 °C. Airflow finally enters into the room under the wind tower after passing through the rooms, halls and corridor.

Some part of the airflow is transferred outside by the domed roof and the rest goes outside through the sucking action of the wind tower. Moreover, we should mention that there are some pools in the rooms and halls in order to make the airflow damp and cold. Also the airflow enters through the wind tower's four channels, goes through the room under wind tower mixes with the flow coming from doors and windows and finally discharges by another four channels. It is important to mention that windows and doors, which are in the direction of the wind flow, are opened and the other ones are closed. When the wind speed is above 5m/s, the flow which enters through the wind tower dominates the other one. The wind speeds at the bottom of the wind tower and through the inlet channels are equal. This inlet flow touches the pool water which makes the air to cool down and to absorb the dust. In this case, the dust gathered by the pools outside the building is less than pools under the wind tower because the flow which enters by wind tower hits the water pool vertically and with higher speeds. The flow which enters through the wind tower discharges via the open gates, windows or domed roof and the channels which are symmetrical to the inlet channel.

3 Conclusion

In this study, the wind towers structure, their function and types, regarding to their application, are reviewed. Two types of them are tested. The first case, the flow goes to the basement and the second case, which has tall height, is used in the buildings with one floor and multi rooms (Dolat-Abad wind tower). The experiments show that at the different wind speeds, the wind towers can ventilate the building, naturally and without extra expenses. Those types can decrease the input airflow temperature and acts as a classical ventilator. Especially, the first type makes high temperature difference between ventilated environment and outside which is suitable for the warm days in the summer.

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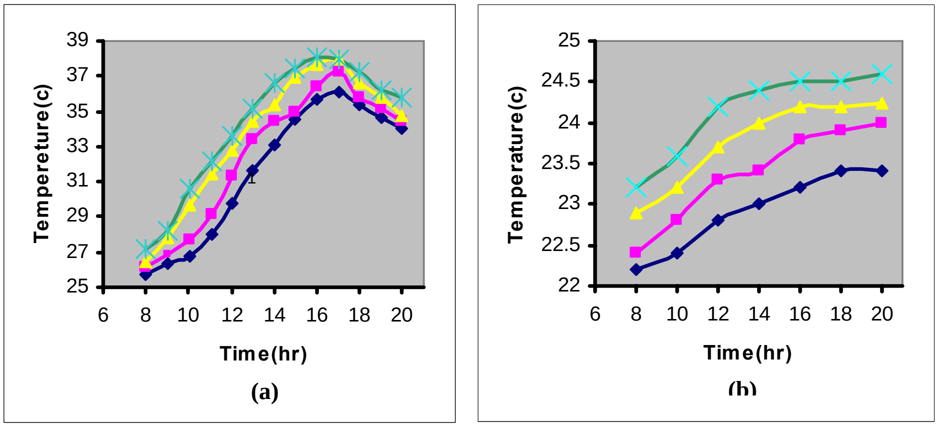

Fig.1. Temperature distribution for four consecutive days in August 2002.
(a) Ambient Temperature changes, (b) Temperature changes at larger basement

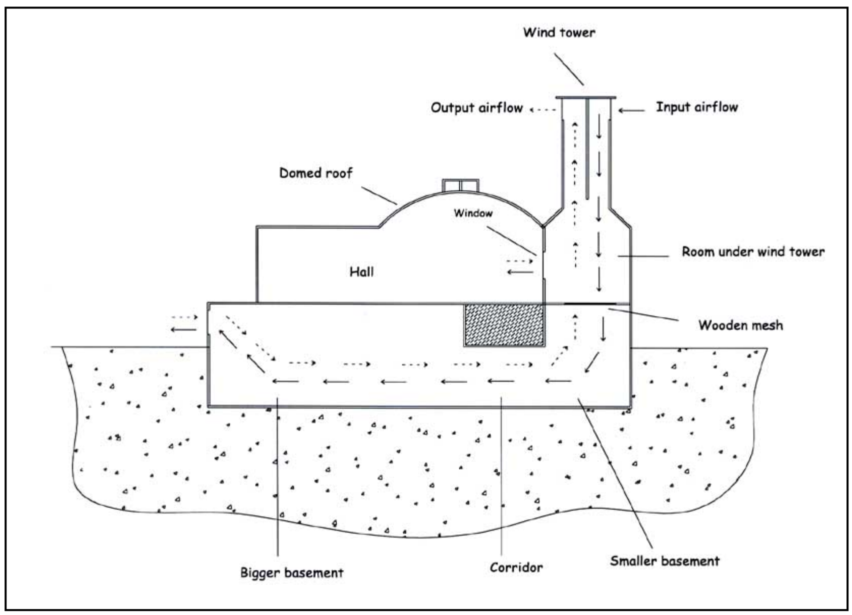

Fig.2. The airflow path through the tested wind tower (Type 1). Note: Suction -------- Blowing ———

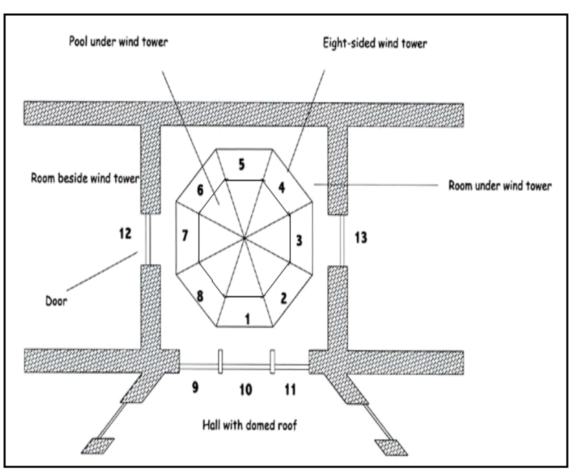

Fig.4. Inside view of Dolat-Abad wind tower.

Fig.3. Dolat- Abad wind tower – yazd

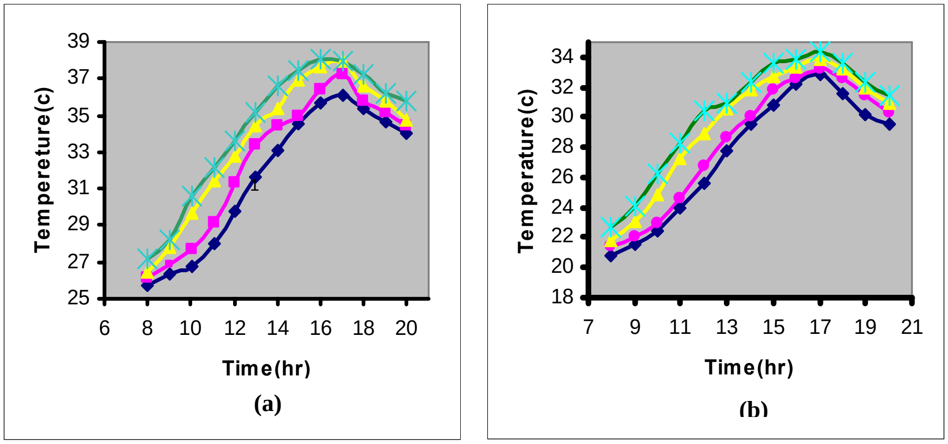

Fig5. Temperature graph for four sequential days in August 2002.
(a) Temperature changes outside the room (b) Temperature changes in the room under wind tower

Table 1. The wind tower inlet airflow speed at the basement entrance and through the corridor between the basements.

Date & Time	Inlet airflow speed to wind tower (m/s)	Inlet airflow speed to smaller basement (m/s)	Inlet airflow speed into the corridor (m/s)
Aug.14, 09:45	0.80	0.45	0.22
Aug.14, 19:30	1.32	0.64	0.34
Aug.15, 10:00	1.53	0.71	0.39
Aug.15, 14:30	3.56	1.60	0.65
Aug.16, 10:30	1.21	0.77	0.30
Aug.16, 6:45	2.81	1.39	0.69
Aug.17, 12:00	6.20	0.34	0.89
Aug.17, 6:30	4.72	2.71	0.78

Table 2. The airflow speed in Dolat-Abad wind tower channels and room doors under wind tower, Please notice to doors and channels Number in Fig.7 (Door number 13 was closed during the experiment)

The airflow speed at door **12**	The airflow speed at door **11**	The airflow speed at door **10**	The airflow speed at door **9**	The airflow speed at the end of channel **8**	The airflow speed at the end of channel **7**	The airflow speed at the end of channel **6**	The airflow speed at the end of channel **5**	The airflow speed at the end of channel **4**	The airflow speed at the end of channel **3**	The airflow speed at the end of channel **2**	The airflow speed at the end of channel **1**	The airflow speed outside	
1.0(m/s) into the room	1.1(m/s) into the room	0.9(m/s) into the room	1.3(m/s) into the room	1.4(m/s) blowing	1.0(m/s) suction	1.4(m/s) suction	1.7(m/s) suction	1.3(m/s) suction	0.8(m/s) blowing	1.7(m/s) blowing	2.3(m/s) blowing	2.5(m/s)	Aug.18 9:30
2.6(m/s) out doors	1.1(m/s) out doors	1.5(m/s) out doors	1.4(m/s) out doors	4.9(m/s) blowing	5.8(m/s) blowing	5.0(m/s) blowing	2.1(m/s) suction	2.4(m/s) suction	2.5(m/s) suction	2.8(m/s) suction	2.9(m/s) blowing	5.7(m/s)	Aug.18 18:20
1.7(m/s) into the room	1.9(m/s) into the room	2.1(m/s) into the room	2.1(m/s) into the room	2.4(m/s) blowing	2.8(m/s) blowing	1.2(m/s) suction	1.9(m/s) suction	1.7(m/s) suction	1.1(m/s) suction	2.4(m/s) blowing	2.8(m/s) blowing	3.0(m/s)	Aug.19 9:30
3.0(m/s) out doors	2.1(m/s) out doors	2.4(m/s) out doors	2.2(m/s) out doors	5.7(m/s) blowing	3.2(m/s) blowing	3.1(m/s) suction	3.0(m/s) suction	3.5(m/s) suction	2.9(m/s) suction	3.1(m/s) blowing	7.0(m/s) blowing	6.2(m/s)	Aug.19 18:15
0.9(m/s) into the room	0.8(m/s) into the room	0.7(m/s) into the room	0.6(m/s) into the room	2.8(m/s) blowing	0.8(m/s) blowing	1.3(m/s) suction	1.4(m/s) suction	1.3(m/s) suction	1.1(m/s) suction	2.5(m/s) blowing	3.0(m/s) blowing	3.1(m/s)	Aug.20 9:20
0.6(m/s) into the room	0.7(m/s) into the room	0.8(m/s) into the room	0.8(m/s) into the room	2.8(m/s) blowing	1.6(m/s) blowing	1.2(m/s) blowing	1.1(m/s) suction	1.4(m/s) suction	0.8(m/s) suction	0.7(m/s) suction	0.8(m/s) blowing	2.9(m/s)	Aug.20 18:35
0.3(m/s) into the room	0.3(m/s) into the room	0.3(m/s) into the room	0.4(m/s) into the room	0.7(m/s) blowing	1.0(m/s) blowing	0.7(m/s) suction	1.0(m/s) suction	0.7(m/s) suction	0.5(m/s) suction	0.8(m/s) blowing	0.9(m/s) blowing	0.8(m/s)	Aug.21 10:30
0.6(m/s) into the room	0.7(m/s) into the room	0.7(m/s) into the room	0.8(m/s) into the room	1.8(m/s) blowing	1.1(m/s) suction	1.6(m/s) suction	1.2(m/s) suction	0.9(m/s) suction	1.1(m/s) blowing	2.3(m/s) blowing	2.8(m/s) blowing	2.6(m/s)	Aug.21 18:20