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Research Article

Employment Minarets Wind-catcher Natural Ventilation and Passive Cooling in the Mosques of Baghdad

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Abstract

Earth-air- tunnel heat exchanger (EATHE) systems are inadequate to meet the requirements of thermal comfort in summer and winter in a country like Iraq. The presence inlet air to enter at the top of minaret and different column of air pressure increases the natural air movement in the lining of the minaret built of bricks drill (wet) equipped with water spraying system, and minaret continues within the earth deeply 4m. Air moves to spend pottery pipes that are wetted in view of ground water into the earth. The heat exchangers are air-cooled and moistened and access to the prayer hall through four outlets, the removal of the accumulation of warm air to the outside through the windows at the base of the dome. The heat exchanger model based on the development of computational fluid dynamics (CFD) and validation of the simulation results and experimental data obtained. The results showed that the use of natural ventilation through the minaret can reduce the temperature of the air temperature 19 ˚C when she was abroad 47.3 ˚C and improvement in the relative humidity to 22%. Summer high temperature 9 ˚C when I was abroad 10 ˚C winters. To increase the air column and section Wind-catcher (minaret) makes the heat exchanger system (MEAHE) a means of self-sustainable cooling to reduce energy consumption.

Keywords: *Wind catchers, Heat exchanger, Dome, Minarets, Environmental design, Ventilation, Hot day.*

1. Introduction

The lacks of buildings to approach the limits of thermal comfort were offset by an increase in electric power consumption. At the same time there is a crisis in the electric power supply as well as higher prices. Which made us think about the alternatives depends on the self-cooling. Many studies have touched on the reduction of energy consumption. It remains a need to find less expensive alternatives. Wind catcher used as a system of passive cooling and natural ventilation to reduce non-renewable energy consumption and reduce harmful emissions. Is a high structure on the roof of the building contains an opening to face the wind and other air to evacuate because of the negative pressure variation (Fathy *et al*, 1986). However, this element has disappeared in contemporary architectural practice with the advent of evaporative chillers and air conditioners that work pressure cooling vapour to achieve the conditions of comfort, Because the amount of air provided by a few that do not meet the requirements of thermal comfort for the time being. The increase in energy consumption in summer and rising energy prices and motivated to reduce dependence on fossil fuels and emission of pollutants affecting sustainability. Many alternative energy technologies, including heat exchangers earth techniques with the air have been explored (V. Bansal *et al*, 2009, V. Bansal *et al*, 2010). ETHE system which depends on the air in the pump inlet pipe for summer cooling and vice in the winter (Darkwa *et al*, 2011). And there was an attempt for the researcher to explore the effectiveness of Wind catcher heat exchange for Earth - air concept WEAHE system (Jamal A.J, 2015). Most previous studies of natural ventilation and heat exchange earth to air experiments carried out on the basis of chewing through the air pipe small spaces (Ramfrez. L *et al*, 2014, Sirwan A, 2014, Bisnoiya T *et al*, 2015).

There are fewer in the use of advanced *Wind-catcher* and a low height depends on the energy in their work. This study is based on the employment of minarets *Wind-catcher* for the purpose of finding the importance of rising air column and achieving heat exchange with the walls of the minaret and pipes made of pottery buried material into the soil to achieve natural ventilation within the thermal conditions in closed places. The present paper is a new design of heat exchanger from Earth to the air by using the minarets Wind catcher Natural air and move from the top of the minaret holes through the bottom of the walls that are lined with clay bricks pride provider

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spraying water through pipes buried in the soil moistened because of groundwater and then to the prayer hall. Advantage of air movement to generate electrical power to the water pump and fan through the air turbine, which is placed in the outlet air entry into the minaret. The research aims to design minarets Wind catcher heat exchange from Earth to the air depending on the natural air movement and achieve self-passive cooling and natural ventilation to reduce consumption non-renewable energy and reduce the emission of environmentally harmful. And it can take advantage of the system in the design of the new towers in residential complexes to regulate the natural movement of air in enclosed places to achieve thermal comfort. Structure search as the first part of the introductory section includes the proposed system and the second section analyses the performance of the new design put forward the research.

2. Climate Characteristics

The study region is situated in Baghdad, Iraq, at a latitude 33°30'N and longitude 44°40'E. And it rises 34.1 m above sea level, Classified as warm regions and as containing two main chapters hot summer and cold winter. Climate advantage being a desert climate or semi-desert and strongly solar radiation resulting from the drought and the high rate of vaporization, Vary the temperature between summer and winter and day and night. Air temperature reaches about 50°C in late July. Relative humidity (RH) between 22% in June and 71% in December, Most of the wind may carry with them a local dust and sand. That the length of the period and warm temperate eight months either cold is four months, These give a picture of the type of air conditioning required in the region. Summer cooling is desirable while heating in the winter is not embarrassing. For this when there is a great need for electrical energy required to find energy alternatives, including the achievement of natural ventilation and take advantage of the soil and groundwater heat.

3. Description of minarets conditioning system Wind catcher

Wind catcher is a traditional tower rises above the building provider outlets wind in front of the prevailing winds. Where cold air Pick up and moving to the interior spaces of the building. Pick up the cold air and moving the internal spaces of the building. The rise of the towering minarets of mosques and contain an internal cavity and an area of a large section Wind catcher compared with traditional can be used to move air, Fig.1. For a sustainable design depends the designed concept:

Design of openings at the top of the minaret natural air to enter is toward the northwest, where the prevailing winds in the study area. There Serbs air in the region is linked to the entry of air dynamo to generate power for the batteries running on water plunger and rotate the bottom of the water tank to the base of the minaret in the roof of the mosque.

Lining minaret of the internal thickness of 12 cm clay bricks burn 750-1150 degree heat because it contains an integrated capillary action up 7m of the base of the minaret. With three layers of cold asphalt paint to rise 3.5 m from the ground level to ensure the prevention of the brick lining of water leakage to the outside wall of the minaret.

Put water sprinkler system of perforated tubes (for moistening)To the upper side of the lining.

There is a ventilation fan inside the minaret level of the earth's surface to increase air movement when periods of silence protected by air cover.

Horizontal tracks underground depth of 4m in the form of two lengths 52.50 m and 31.60 m and a diameter of 50 cm and a thickness of 3cm is manufactured tubes of pottery material or of polyethylene high density processor chemicals weatherproof composition of microbes bear high pressures to ensure the quality of heat exchange.

Four ports for air to enter the hall Musalla high 1.5 m from the ground level can be conquest or control with a locking clip protection.

There is in the roof of Musalla dome at its base contains slots conquest or control lock, provide ventilation fan to increase the hot air withdrawn from the upper layers of the Musalla space.

The study was conducted on the assumption of homogeneity of the characteristics of the soil where the degree of soil temperature and low of 10-15 °C depends on the soil type and depth. It is heat exchange between the air and the process of lining the walls of the minaret and with the wet cold wet pipes that move according to the principle of air pressure between the air entry slot of the minaret and the air out of the slot through the holes in the base of the dome. The quantity received for the air space of Musalla of the minaret would be great and the largest movement of air and cool fresh air and relatively free of dust compared with traditional air Wind catcher section area does not exceed 0.2m^2. Which made us think about the importance of the adoption of natural ventilation and to develop a model Wind catcher -sectional area to increase heat exchange from the earth to the air.

Fig.1 Models of the minarets of mosques

Fig.2 The study case design of a mosque in the city of Baghdad

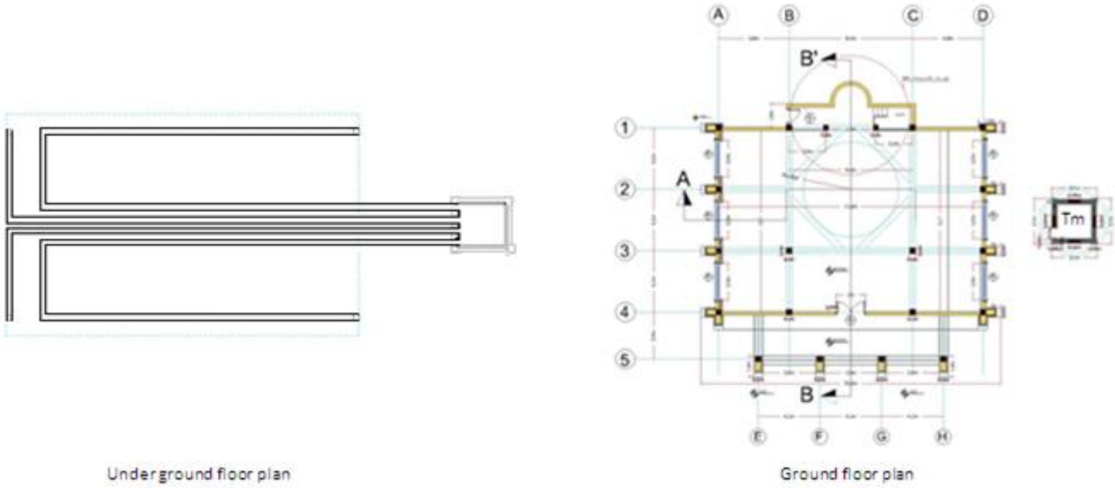

Fig.3 The study model contains a mosque minaret in the city of Baghdad

4. Research Methodology

For the purpose of verifying the performance of the heat exchanger from the earth into the air and the impact of natural air movement the adoption of minarets Wind-catcher posed Search with a domed ceiling in Musalla. The study was conducted in 2014 for the summer months, July, August. And the 2014 winter months November and December for three days in the climatic conditions of the city of Baghdad as part of the hot dry climate.

- Conducted experimental measurements of the model of a mosque in the city of Baghdad has a minaret was designed Wind-catcher and using a device testo testo 417 Set-2 Anemometer
- A computer simulation using Computational fluid dynamics program (CFD).

4.1 The Study Model

The building, which was used for the study of a mosque in the city of Baghdad Musalla interior space dimensions 17.90 m length, 12.70 m width and 4.50 m height ,Fig. 2. The walls are built of bricks 25 cm. wrapping from the outside stone Alcino, The inside of the white plaster. Windows are made of polyvinyl chloride PVC double glazing, Concrete ceiling. Moving away from the minaret chapel 4 m form a polygon with eight ribs along area of 4.66 m^2 height 24.00m. It contains a vertical staircase of aluminium. Put outlets in the minaret air to enter at a height of 19.75 m. Fig.3

4.2 Description of the Heat Exchange

The heat exchange between the air inside of the slot with lining of the minaret which rise 7m (wetted) water spray as a first stage are air-cooled. In the second stage of air moving through the pipe pottery diameter of 60cm and a thickness of 3cm That are hydrating because of underground water and the soil in which the temperature is low. And are heat exchange between the air and the walls of the pipes hydrating process. System consists of four tracks, two of which pipes 52.5 m length of each tube and two 31.6 m length. Placed at a depth 4m under the soil surface and tends to a small minaret base to prevent condensation of water inside the tubes. The system is equipped with a fan placed in the minaret base level of earth (buckle iron level ground) to move the air in a period of no wind. That the pressure difference between the inlet and the exit port of the base of the dome because of the air column difference. Use the remote testo testo 417 Set-2 Anemometer to measure the temperature and wind speed. Table 1. Fig.4.

Table 1 Physical and Thermal Parameters used in Simulation

Material	Density (kg/m3)	Specific heat Capacity (J/kg K)	Thermal conductivity (W/mK)
Air	1.225	1006	0.0242
Soil	2050	1840	0.52
Pottery therapist	1600	1436	0.405
PVC	1380	900	1.16

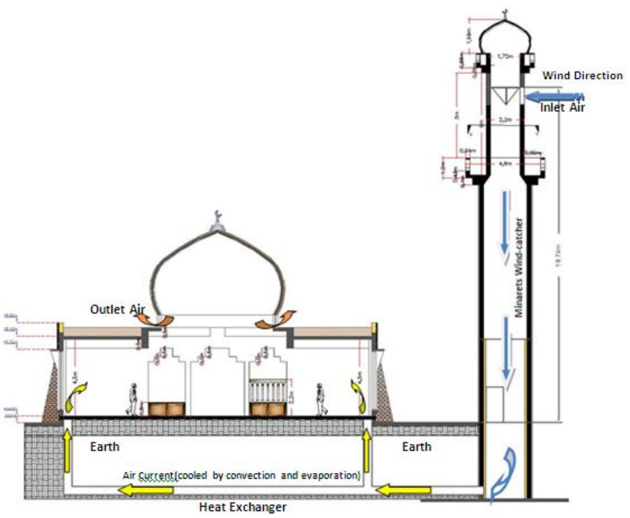

Fig.4 The study model contains a mosque minaret in the city of Baghdad

4.3 Hourly Analysis

Evaporative cooling system (MATHE) integrated to provide thermal comfort conditions, carried out using the minarets of mosques Wind-catcher to the city of Baghdad. The proposed system has been done to determine the suitability of thermal comfort. It is validated CFD modeling MEAHE Conducting experimental accounts separately for testing 15-16-17 days of summer months of July and August 2014 for the months November and December Winter 2014 by three hours from 12:00 to 15:00 every day. The notes are transferred to speed airflow 1.5-3.0-5.0 m/s. The coefficient of performance (COP) was calculated according to the formula proposed by (ASHRAE ,1980) and calculating the total cooling air flow for hours following equation:

$$Q = \dot{m}\, c_p\, (T_{inlet} - T_{outlet}) \qquad (1)$$

Where $\dot{m} = (\pi/4)\, d^2 pv.$

Cp =specific heat capacity at constant pressure (kJ/ Kg ℃).

T_{inlet} = inlet temperature (℃)

T_{outlet} = outlet temperature (℃)

$$COP = Q_{out} / Win \qquad (2)$$

Where

Q_{out} = The heat added by the air (w)

Win = Energy input (w)

$$m = V / v \qquad (3)$$

V = volumetric flow rate ($m^3\, s^{-1}$)

v = air specific volume ($m^3\, kg^{-1}$)

5. Results and Discussion

5.1 Soil Temperature System

Depends Soil temperature system on the homogeneity of the soil and the characteristics of fixed physicist and the level of groundwater in the study area was found 2.5 m depth. The temperature in depth 2-3m stable system of temperature, the temperature depth 2.5-3.0 m ranging from 22.50 ℃ to 24.40 ℃ during the test period. These results support the Sharan and Jadhav (Sharan, G. and R. Jadhav, 2004) in the tropics. These depths can be used as a source of cooling in the summer.

5.2 Experimental Readings of Minarets Wind-catcher

Readings conducted experimental system MEAHE model study. Table 2 shows the temperature in the open air and temperatures in the chapel during the test period in summer 2014 for the months July August, The winter months of 2014 in November and December and during 15-16-17 three days of each month the time from 12:00 to 15:00, respectively. Rate readings were taken for testing hours and four exits rate readings. The results indicated that the temperature indoor higher volatility during the month of August in summer and winter month of December compared with other months. Although the difference between ocean temperatures and grades within the indoor space. Teams recorded 19 ℃ summer and 9 ℃ winters.

Table 2 Experimental Temperature during the Summer Month and winter 2014

Month	Average air temperature for the day 15		Average air temperature for the day 16		Average air temperature for the day 17	
	External Temperature	Internal Temperature	External Temperature	Internal Temperature	External Temperature	Internal Temperature
July	47.3	28.3	47.1	28.1	46.8	27.6
August	48.1	28.6	47.6	28.2	47.7	27.5
January	10.0	18.6	10.3	18.3	10.7	19.1
February	9.0	18.3	9.5	18.1	10.6	19.0

5.3 Readings Experimental Simulation of Heat Exchange

Table 3 shows temperatures in the open air and the average internal temperatures of space chapel during the probationary period for three days 15-16-17 from the summer months of July and August 2014 and for the months November and December Winter 2014 by three hours from 12:00 to 15:00 every day. The results indicated that there is a clear difference between external and internal degrees of heat. Decreased in the month of July 19-20 ℃ when the outside temperature of 47.3 and 48.1. And an increase in the internal temperature 8.6 ℃ when the outside temperature 10 ℃ for the month of November 9.3 ℃ and 9.0 ℃ when it was the winter of 2014.

The table 3 shows average experimental readings and computer simulations to temperatures in the outdoor temperatures in the base of the minaret lining bricks (moistened) The temperatures at the air exit port in the chapel hall at different wind speed 1.5-3.0-5.0 m / s during the months of the study.

M system indicated the existence of a clear difference when the air speed of 1.5 m / s in the summer during the month of July to 19 ℃ to 20 ℃ and the month of August 19.2 ℃ to 19.9 ℃ . The difference when the air speed is 5 m /s from 19.4 ℃ to 20.2 ℃. The increase in air speed increase of the difference in temperature in summer and approaching the limits of thermal comfort within the space. In the winter there is convergence with the limits of thermal comfort and it can be concluded that the system alone is enough to provide the limits of thermal comfort in the summer with no need for artificial aid, in the winter, there are few limits aid to the rest died. This system can be applied easily in the tropics .Table 3. Fig.5.

Table 3 Experimental and Simulation Temperature and Relative Humidity in the summer and winter for Day15-2014

	Month	Location	Air flow velocity = 1.5 m/s			Air flow velocity = 3 m/s			Air flow velocity = 5 m/s		
			Exp. temp.	Sim. temp.	RH	Exp. temp.	Sim. temp.	RH	Exp. temp.	Sim. temp.	RH
Summer	July	T inlet	47.3	47.3	20%	47.3	47.3	20%	47.3	47.3	20%
		T m	33.6	32.6	24%	33.1	32.6	25%	32.2	31.6	26%
		T outlet	28.3	27.6	32%	28.0	27.6	34%	27.1	27.9	34%
	August	T inlet	48.1	48.1	19%	48.1	48.1	19%	48.1	48.1	19%
		T m	33.9	33.1	23%	32.2	32.7	24%	32.6	32.1	24%
		T outlet	28.9	28.2	31%	28.1	27.6	32%	27.7	27.2	33%
Winter	November	T inlet	10.0	10.0	65%	10.0	10.0	65%	10.0	10.0	65%
		T m	13.4	14.2	65%	14.9	14.6	67%	15.2	14.9	68%
		T outlet	18.0	18.2	69%	19.1	19.0	71%	19.4	19.0	71%
	December	T inlet	9.0	9.0	66%	9.0	9.0	66%	9.0	9.0	66%
		T m	13.9	14.5	66%	14.9	14.6	69%	15.3	14.8	68%
		T outlet	17.8	18.3	70%	18.8	19.1	72%	19.5	19.2	72%

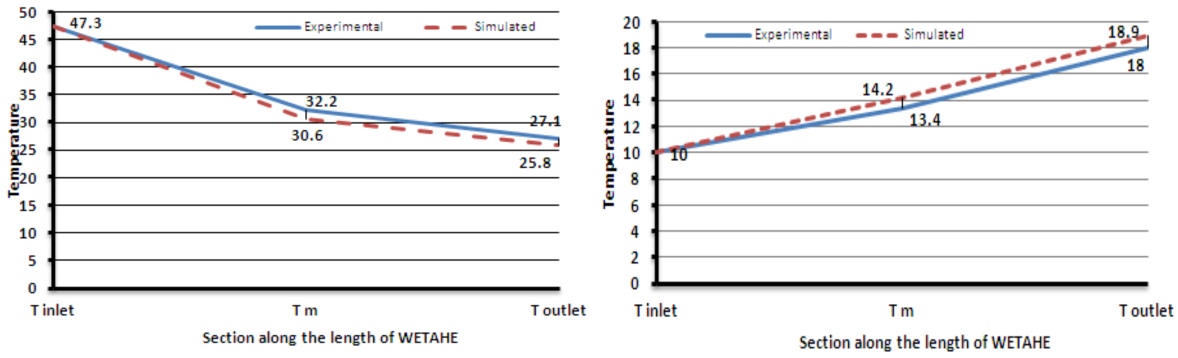

Fig.5 Temperature distribution along the length of the Wind-catcher and pipe and out speeds 1.5 m / s during the summer and winter 2014

5.4 Results and limits of thermal comfort

Average air temperature measured by dry air bulb thermometer inside the Musalla hall in the summer, August 15.08.2014, Air temperature and found to wet bulb thermometer was 17.1(Roland. S, 2011). The air movement inside Musalla room rate of about 1.5 m/s.

Therefore, the temperature felt by the human wearing ordinary clothes (1 Clo.) as shown in Fig. 6, it will be as 22°C, which is within the limits of thermal comfort(Ogunsote, O and Prucnal, 2002), Fig.6.

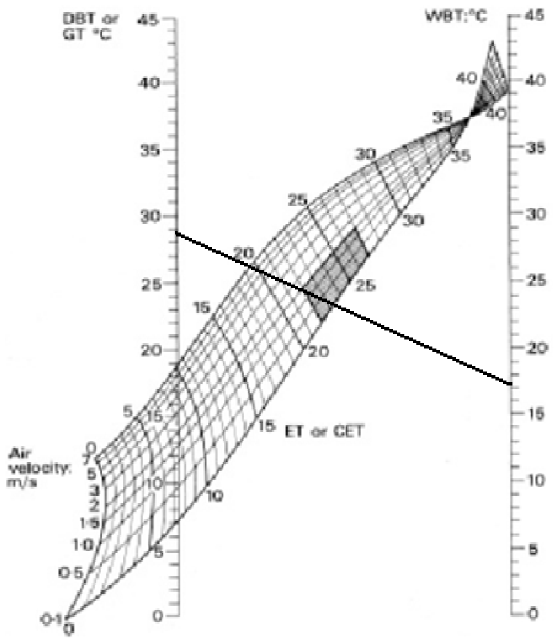

Fig.6 Effective temperature nomogram for thermal comfort limits for people wearing normal clothes, represented by relationship between air temperature, humidity and air velocity

6. Conclusions

Employment minarets Wind-catcher mean an increase in Wind-catcher space and an increase in the height of the air inlet comparative with traditional Wind-catcher, leading to an increase in the speed and the amount of air moving because of the air pressure difference column. The heat exchanger system proposed Search MEAHE adoption of earth source heat because the soil temperature within a depth of 4m be fixed and low and the use of the lining of the minaret built of bricks (moistened) Spraying water system and pottery pipes buried Wet because of groundwater contribute to increased evaporative cooling and reduction of air temperature and relative humidity improve. That there is a direct correlation between air flow speed and the length of the pipeline is buried the inverse relationship between relative humidity and the length of the tube, which confirms the use of material pottery pipes due to capillary. Temperature has dropped summer 19 ℃ when she was outside temperature 47.3℃. And an increase in temperature in winter 8℃ when the temperature 10 ℃. It has achieved a coefficient of performance (COP) difference 4.60-3.20 with the increase in air speed of 1.5-5 m / s. When the equation of thermal comfort between effective and the temperature at which it is achieved at the limits of the required comfort when air speed is 1.5 m / s for reach the 22 ℃.

Advantage of air to move the air turbines located in the slot entry of air in the minaret to generate electric energy to perpetuate the operation of the compressor and water fan to increase air movement in the air dormancy. These make the new design and a means of self-sustainable cooling and reduce the consumption of energy in the hot dry countries such as Iraq.

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