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Solar Passive Techniques: Earth Air Tunnel

Vishal Yardi[1], Utkarsh Jain[2], M. Islamuddin Faraz[3]
[1]DOA, SDPS, INDIA [2]CED, IIST, INDIA [3]CE&AMD, SGSITS, INDIA

Abstract: *Solar passive technique is basically based on the principle of taking the maximum advantage of the local climatic conditions for desired surrounding conditions. In the present paper different methods namely: wind towers and earth air tunnel have been discussed and an experimental setup for earth air tunnel has been performed to study the effect of the same on the surroundings. Heating and cooling tests were performed for three consecutive days and for 7 hours each day.*

Keywords: *earth air tunnel, wind towers.*

I. INTRODUCTION

1.1 Wind Towers

In this system a wind is invited in a building through a shaft or tower. Temperature of thus air is modified by evaporation. This air is circulated throughout the building. This is very old technique, & installed successfully in many old buildings.

1.1.1 Principle

The cardinal principal behind its operation lies in changing the temperature & thereby density of the air in & around the tower. The difference in density creates a draft, pulling air either upwards or downwards through the tower.

1.1.2 Working

A) Night-The tower area is so designed that the top part provides large heat storage capacity, & the same time has a large surface area for heat transfer. The walls of the tower & internal walls of the air flow passages absorb heat during the day time & release heat at night thus warming the cool night air in the tower. An upward draft is created as the warm air moves up which is finally exhausted from the openings. The cold night air is pulled through the doors and windows of the building due to the pressure difference created. In the absence of the wind the tower acts as chimney. The nocturnal radiation through the roof & external walls brings about further cooling. In the presence of the wind, the cool night time air enters the tower & forces itself down into the structure

B) Day-The hot ambient air coming in contact with the cool top part of the tower is cooled and becomes cold & dense. It sinks through the tower & into the living spaces, replacing the hot air. In the presence of wind, the air is cooled more effectively & flows faster down the tower & into the living area. The temperature of the tower soon reaches that of the ambient air & hence in the absence of wind downward flow ceases. The tower then begins to act like chimney. Operation of the tower depends greatly on the ambient fluctuations like the air temperature changes, wind velocity etc. The reduction in the temperature of the air can be as much as 10 to 15 degrees.

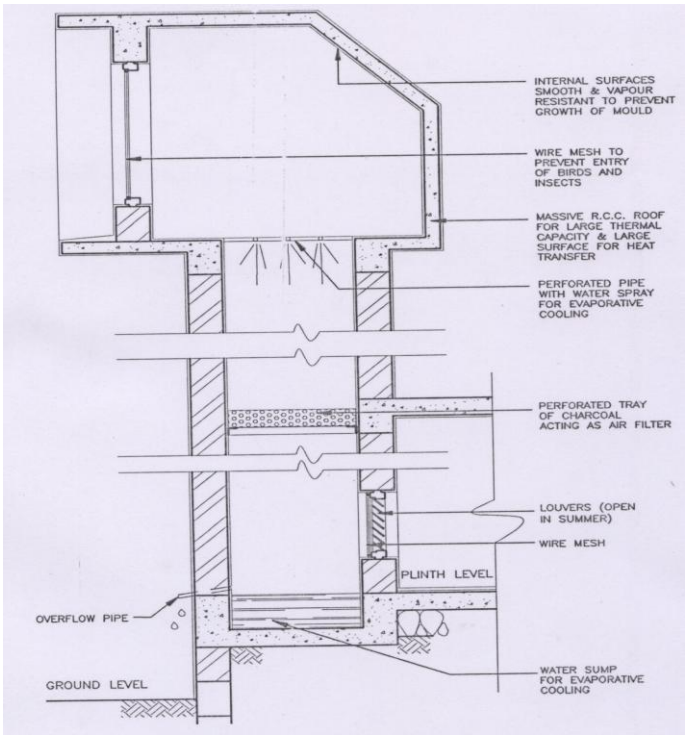

Fig.1 A typical diagram of wind tower

1.1.3 Points to be considered

A) A prerequisite for using a wind tower is that the site should experience the winds with fairly good & consistent velocity.
B) Wind towers are for use only in summer & must be closed properly in winter.
C) Due consideration must be given to prevent the entry of dust, birds & insects.

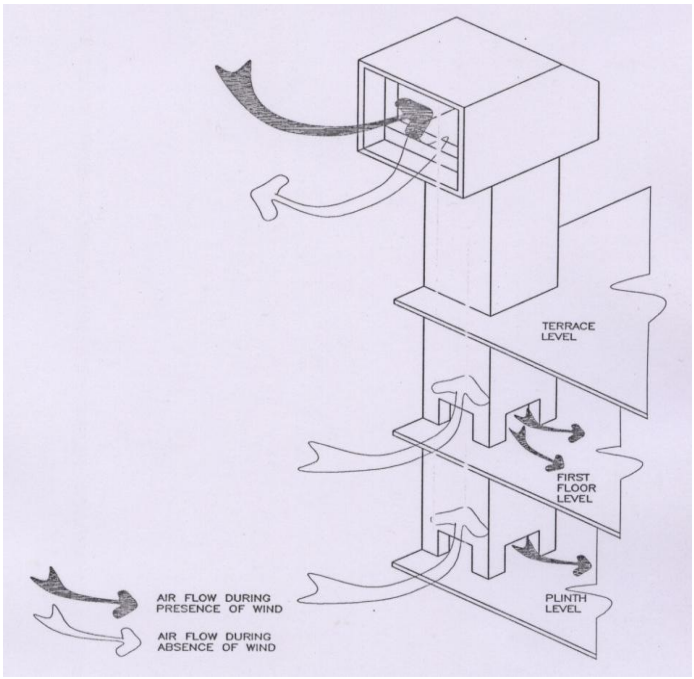

Fig.2 Air flow in wind towers

1.2 Earth Air Tunnel

This technique is invented by Romans long back ago.

1.2.1 Principals-

a) Daily & annual temperature fluctuations decrease with the increase in the depth below the ground surface.
b) At a depth of about 4m below ground, the temperature inside the earth remains nearly constant round the year & it is nearly equal to the annual average temperature of the place.
c) A tunnel in the form of a pipe embedded at a depth of about 4 meters below the ground will acquire the same temperature as the surrounding earth at its surface & therefore the ambient air ventilated through this tunnel will get cooled in summer & warmed in winter & this air can be used for cooling in summer & heating in winter.
d) Thus the earth can be used as heat source or sink for heating or cooling air in underground pipes as the earth-air heat exchanger system utilizes the stable temperature & large thermal capacity of the earth.
e) The key concept to remember is that heat always flows from a warmer system to a cooler system (the surrounding air and walls). So if we are "warmer" than the surrounding air, the heat of our body will escape to the surrounding air until temperature equilibrium is reached.
f) Likewise, if the air inside the room is warmer than the surrounding walls, heat will be drawn out of the air into the walls, thus cooling the air (and warming the walls).
g) Conversely, if the air inside the room is cooler that the surrounding walls, heat will be drawn out of the walls into the air thus warming the air (and cooling the walls)., uses this thermodynamic principal in conjunction with bare earth to help control the climate within a man-made structure. For example, an earth sheltered dwelling will use the surrounding earth to regulate its temperature throughout the year.

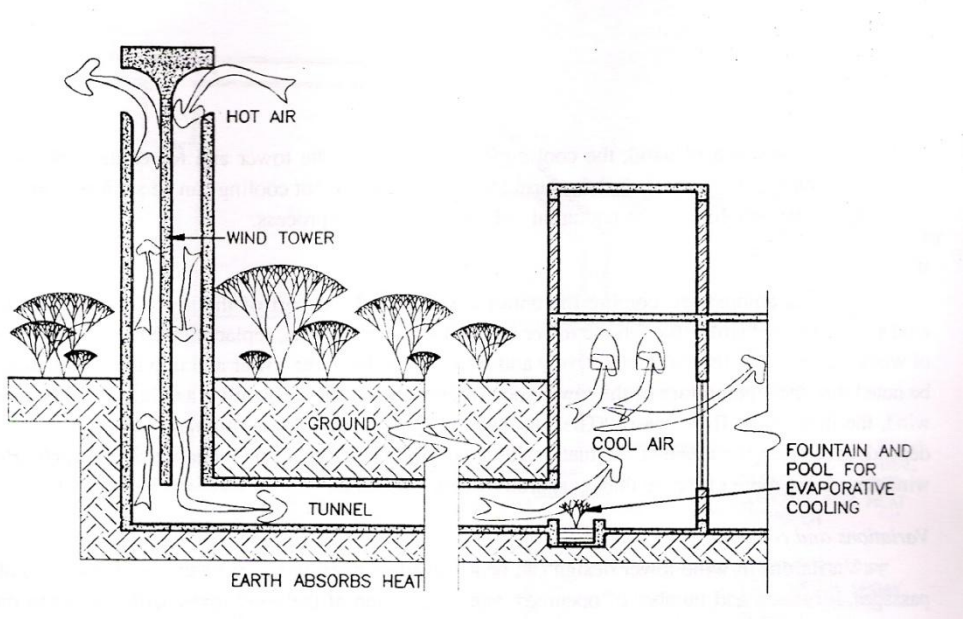

Fig.3 Earth air tunnel section

II. STUDY AREA

The present work has been performed on a retreat building at Gurgaon with the following salient features:

- Underground structures are not exposed to the sun and thus do not heat up as much.
- Secondly, the surrounding earth insulates them, which helps in maintaining a more or less constant temperature.
- Temperatures recorded at roughly 4 meters below the surface show that they are stable and reflect the average annual temperature of a place.
- The amount of heat exchanged between the air & surrounding soil depends on various parameters as

A. surface area
B. The length of pipes
C. Velocity of air
D. Size & capacity of fans.

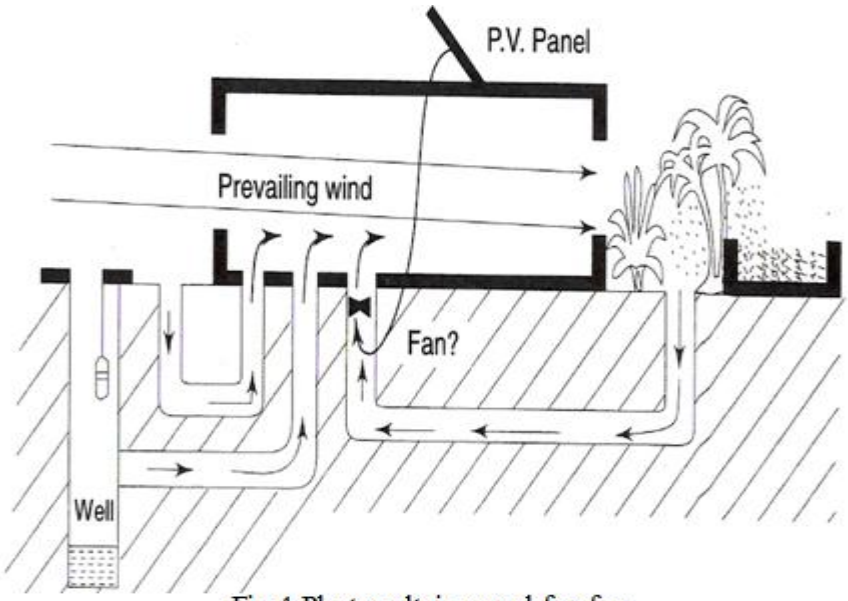

Fig.4 Photovoltaic panel for fan

Followings points must be considered to have effective system.

- ✓ Use of wire mesh to prevent entry of birds, insects, rats etc.
- ✓ Location of wind tower at windward side.
- ✓ Sufficient free space near fan for air movement.
- ✓ Provision of louvers in front of fan
- ✓ Proper fixing of fan to minimize vibrations &noise
- ✓ Protection of wind tower from rain
- ✓ Proper joining of pipes to chambers & waterproofing of joint
- ✓ Inspection chambers at proper intervals for maintenance.

III. METHODOLOGY

The following methodology has been adopted:

- Cooling tests were carried out three consecutive days in each month. On each day system was operated for 7 hours during the day and shut down for the night.
- Heating tests were carried out at night in January.
- Test results are presented in summary form for each month. Detailed analysis is presented for two months only May for cooling and January for heating.
- ETHE cools the ambient air in May by as much as 14^{o}C. It heats the ambient air in January nights also by similar amount.

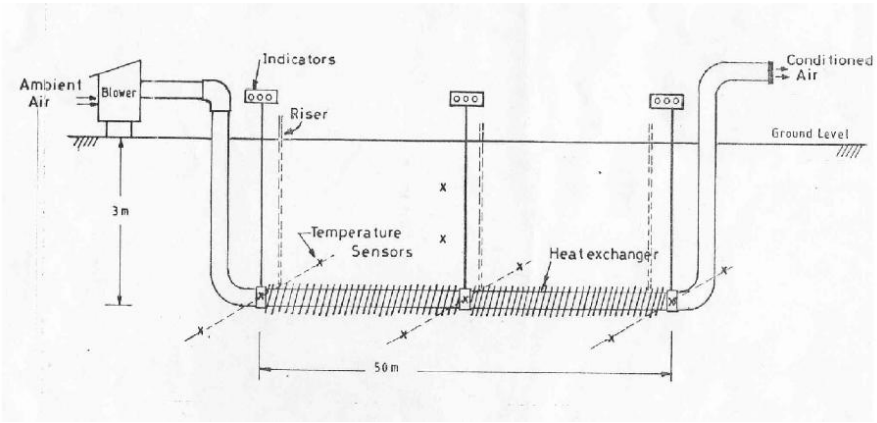

Fig.5 Earth tube heat exchanger

IV. RESULTS

The results obtained are tabulated below:

Table 1. Summary of cooling test result

Month	**Ambient temperature at 14 hours (°C)**	**Basic soil temperature (°C)**	**Outlet temperature at 14 hours (°C)**	**% reduction in outlet temperature at 14 hours**
January	Heating Test			
February	37.9	25.2	26.4	30
March	39.4	35.8	26.4	33
April	41.4	26.6	28.0	32
May	40.8	26.6	27.2	33
June	37.5	29.8	31.9	15
July	No test due to rain			
August	No test due to rain			
September	39.1	28.9	30.0	23
October	34.8	25.6	26.2	25
November	30.6	24.2	24.2	21
December	30.7	24.4	24.4	21
Values are mean of 3 consecutive days of test in each month				

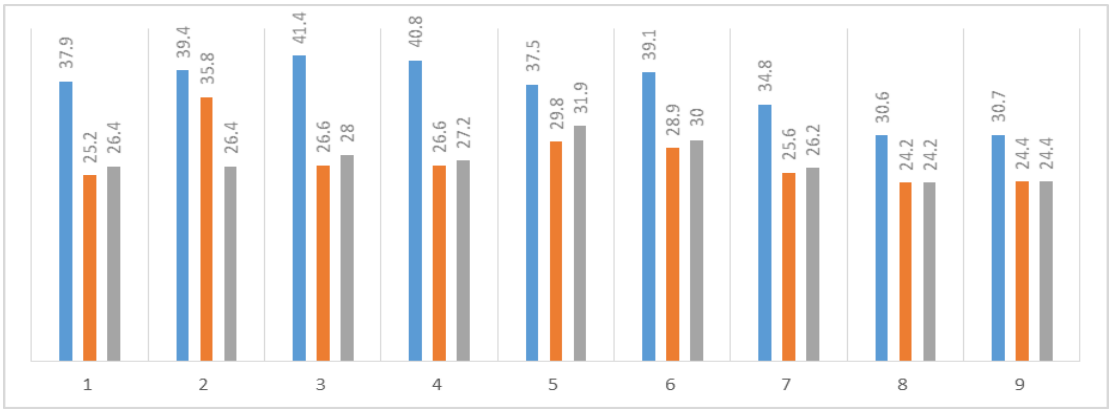

Fig.6 Bar Chart for cooling test results

V. CONCLUSION

The following conclusions may be drawn from the present study:

A. The earth air tunnel method is an effective way to reduce the ambient temperature.

B. The maximum percentage of reduction of ambient temperature has been found in the months March and May i.e. 33%. The minimum percentage of reduction of ambient temperature has been found in the month of June i.e. 15%.

C. The maximum reduction of ambient temperature is found in the month of May i.e. 14 °C.

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