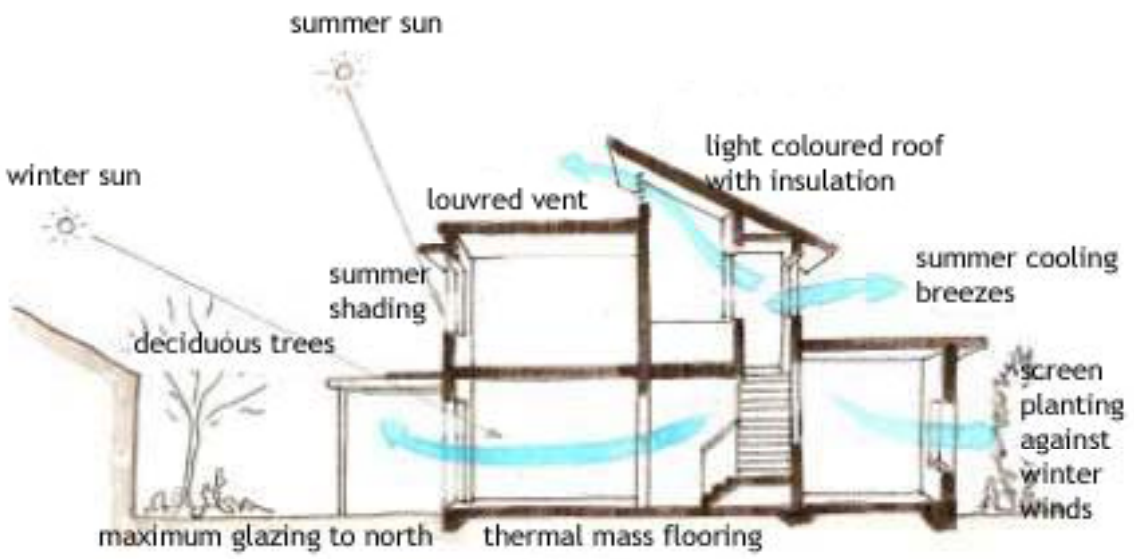
Passive Cooling Techniques



PASSIVE COOLING

- Passive cooling systems are least expensive means of cooling a home which maximizes the efficiency of the building envelope without any use of mechanical devices.

- It rely on natural heat-sinks to remove heat from the building. They derive cooling directly from evaporation, convection, and radiation without using any intermediate electrical devices.

- All passive cooling strategies rely on daily changes in temperature and relative humidity.

- The applicability of each system depends on the climatic conditions.
- These design strategies reduce heat gains to internal spaces.

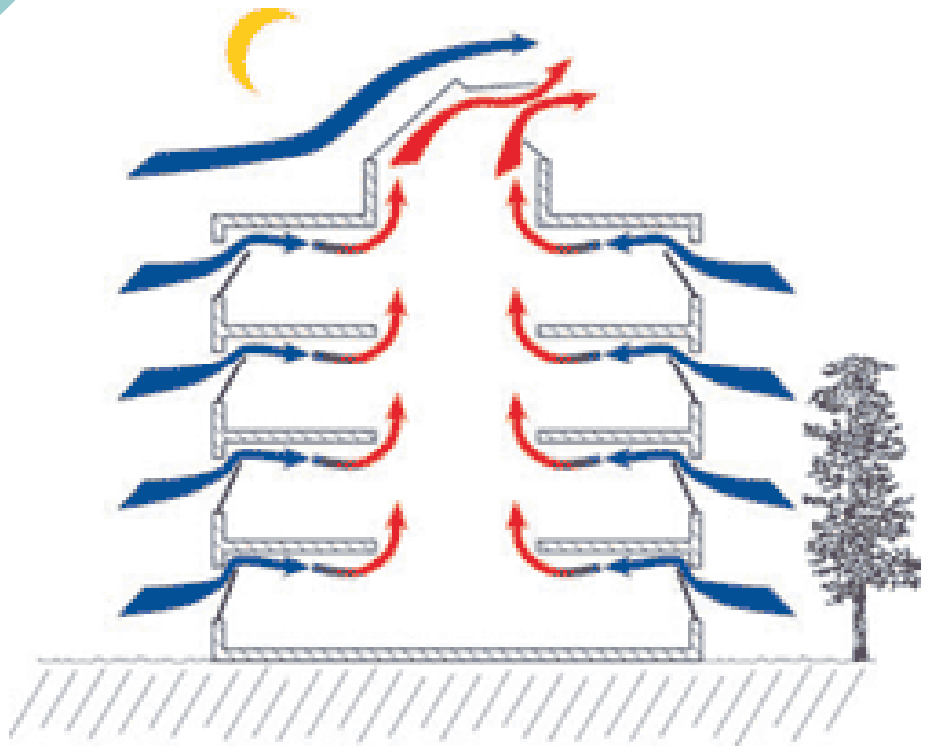
- Natural Ventilation
- Shading
- Wind Towers
- Courtyard Effect
- Earth Air Tunnels
- Evaporative Cooling
- Passive Down Draught Cooling
- Roof Sprays

NATURAL VENTILATION

• Outdoor breezes create air movement through the house interior by the 'push-pull' effect of positive air pressure on the windward side and negative pressure (suction) on the leeward side.

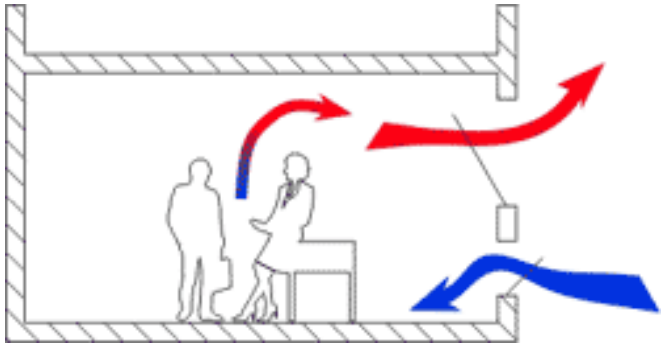
• In order to have a good natural ventilation, openings must be placed at opposite pressure zones.

• Also, designers often choose to enhance natural ventilation using tall spaces called stacks in buildings.



•With openings near the top of stacks, warm air can escape whereas cooler air enters the building from openings near the ground.

•The windows, play a dominant role in inducing indoor ventilation due to wind forces.



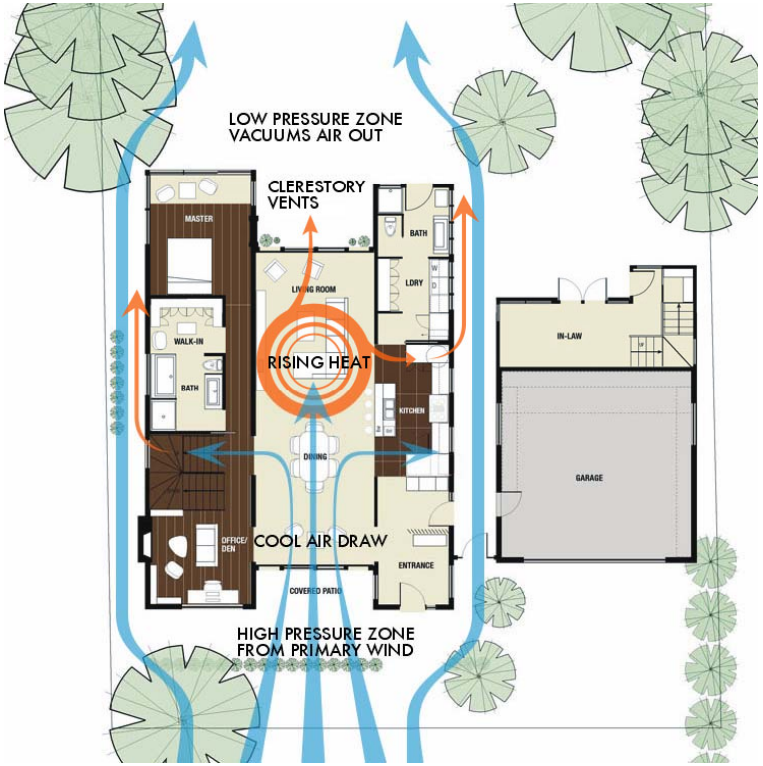
•In most homes, exhausting the warm air quickly can be a problem.

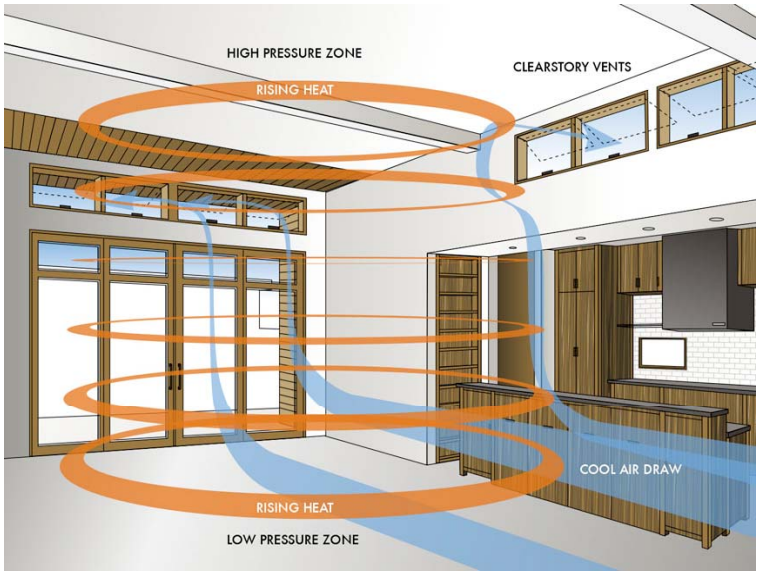
•With the design of high ceilings throughout the breeze zone combined with clerestory windows at the 14’ ceiling height on three walls, the rising hot air is allowed to escape which in turn does two things.

•Firstly the rising air creates a low pressure zone on the cool mass floor, pulling air along the floor from other areas of the house as well as any open doors.

•Secondly the rising and escaping air creates an interior low pressure that should pull in large volumes or exterior air from the patio doors.

•Depending on the primary wind direction and which doors are opened relative to time of day and shade, we can create a breeze of cooler incoming air.





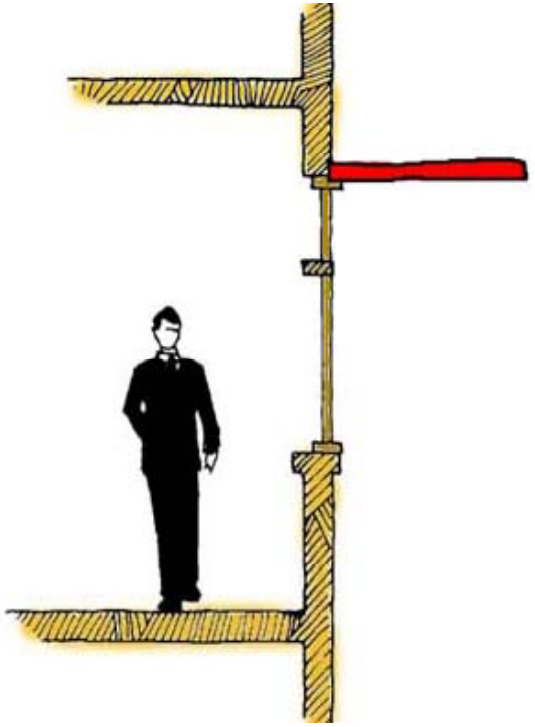
SHADING

•Solar control is a critical requirement for both cooling-load dominated and passively solar-heated buildings.

•The most effective method of cooling a building is to shade windows, walls and roof of building from direct solar radiation.

•Heavily insulated walls and roofs need less shading.

•Can use overhangs on outside facade of the building.



Each project should be evaluated depending on its relative cooling needs:

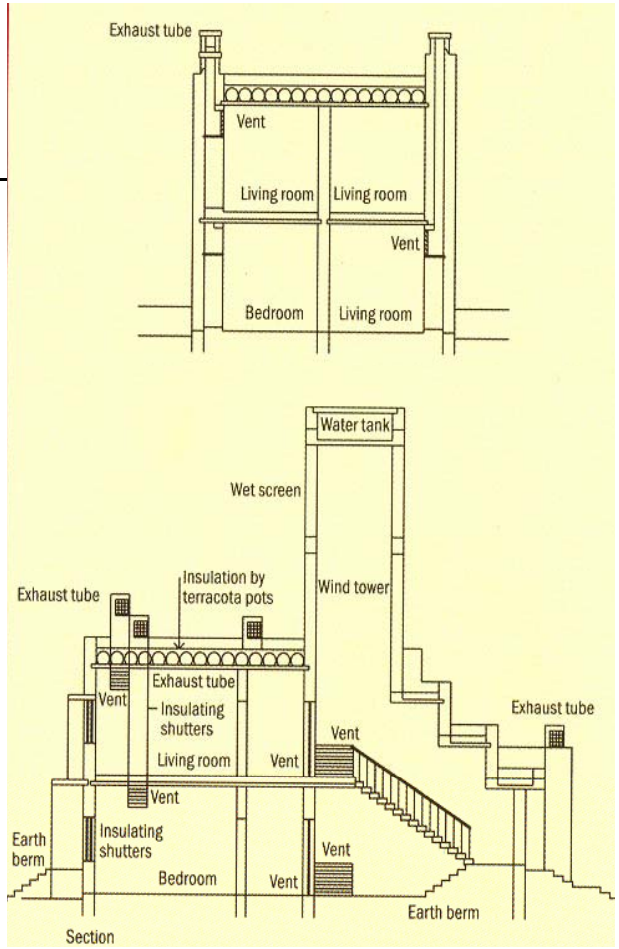
•Extend the overhang beyond the sides of the window to prevent solar gain from the side.

•Use slatted or louvered shades to allow more daylight to enter, while shading windows from direct sunlight.

•Reduce solar heat gain by recessing windows into the wall.

WIND TOWER

- In a wind tower, the hot air enters the tower through the openings in the tower, gets cooled, and thus becomes heavier and sinks down.
- The inlet and outlet of rooms induce cool air movement.
- In the presence of wind, air is cooled more effectively and flows faster down the tower and into the living area.
- After a whole day of air exchanges, the tower becomes warm in the evenings.
- During the night, cooler ambient air comes in contact with the bottom of the tower through the rooms.



Wind tower in **Jodhpur Hostel** to catch favorable cool wind from south-west for passive cooling

Building-integrated chimney in **Sudha and Atam Kumar's residence** in New Delhi from effective ventillation especially during humid season.

•The tower walls absorb heat during daytime and release it at night, warming the cool night air in the tower.

• Warm air moves up, creating an upward draft, and draws cool night air through the doors and windows into the building.

•The system works effectively in hot and dry climates where fluctuations are high.

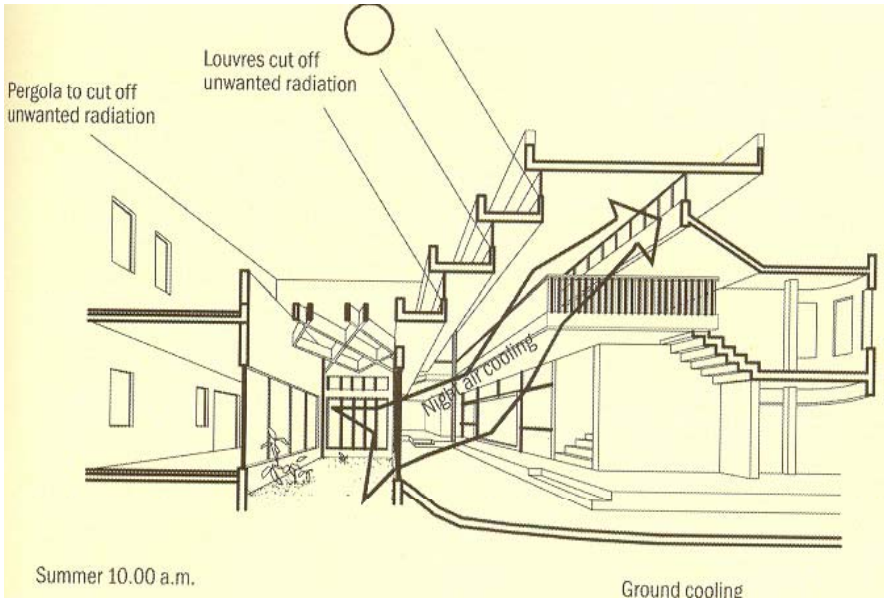
•A wind tower works well for individual units not for multi-storeyed apartments.

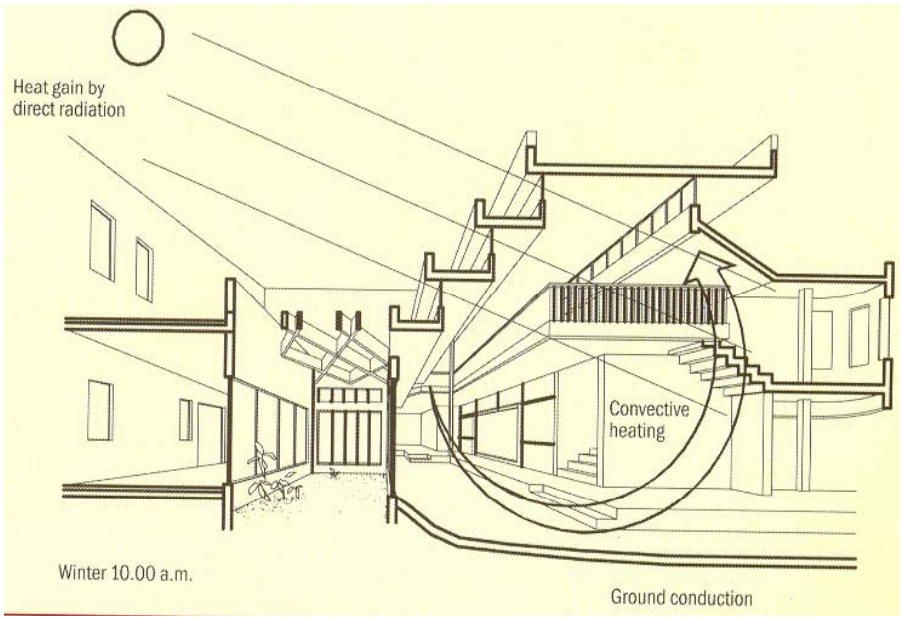
•In dense urban areas, the wind tower has to be long enough to be able to catch enough air.

• Also protection from driving rain is difficult.

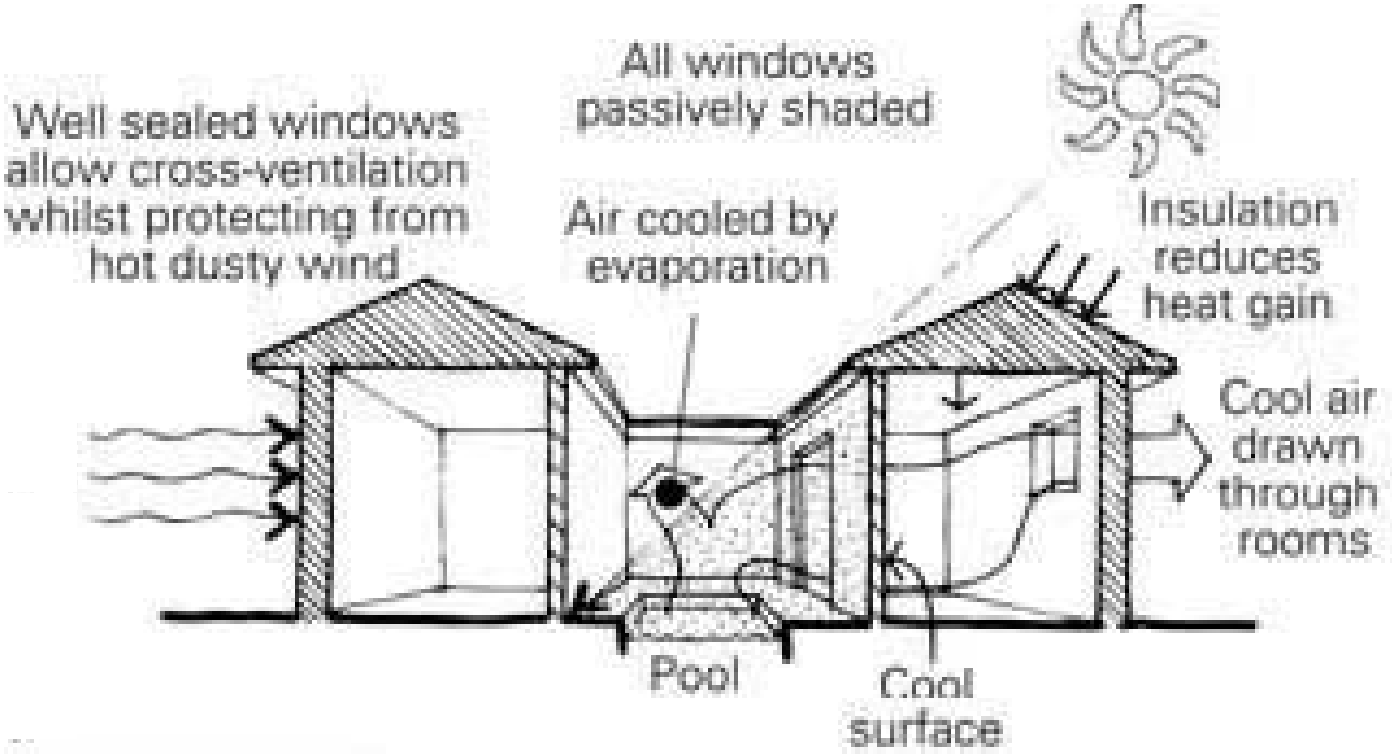
COURTYARD EFFECT

- Due to incident solar radiation in a courtyard, the air gets warmer and rises.
- Cool air from the ground level flows through the louvered openings of rooms surrounding a courtyard, thus producing air flow.
- At night, the warm roof surfaces get cooled by convection and radiation.
- If this heat exchange reduces roof surface temperature to wet bulb temperature of air, condensation of atmospheric moisture occurs on the roof and the gain due to condensation limits further cooling.





Courtyard as a moderator of internal climate



• If the roof surfaces are sloped towards the internal courtyard, the cooled air sinks into the court and enters the living space through low-level openings, gets warmed up, and leaves the room through higher-level openings.

• However, care should be taken that the courtyard does not receive intense solar radiation, which would lead to conduction and radiation heat gains into the building.

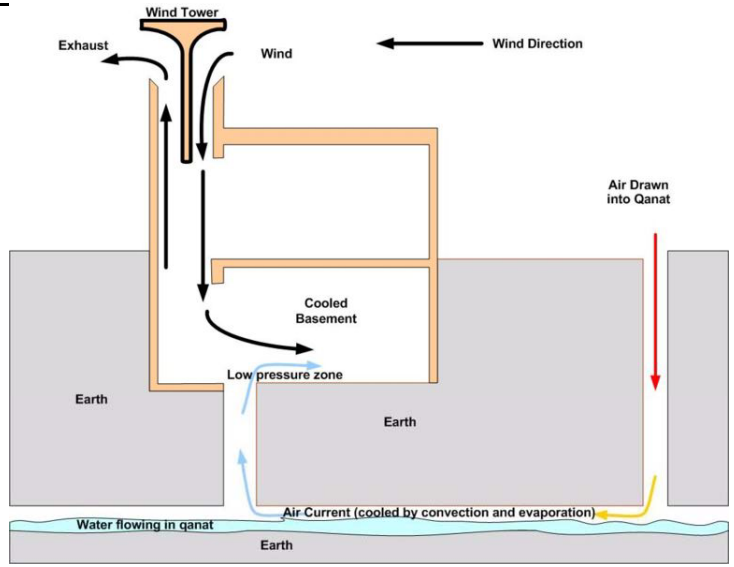
EARTH AIR TUNNELS

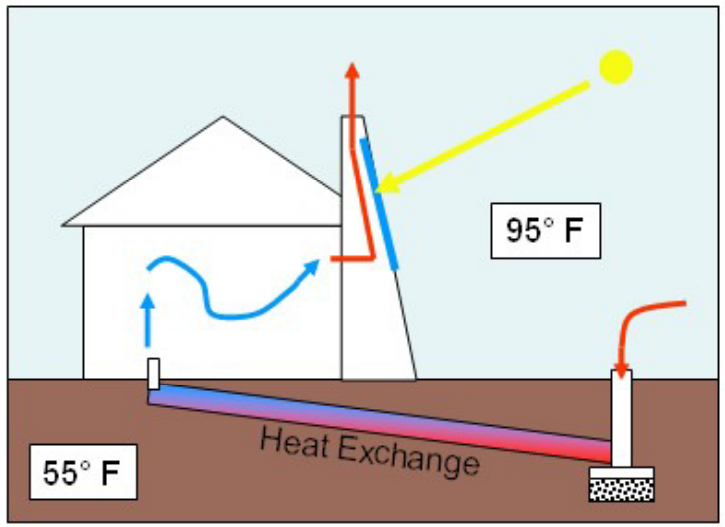
•Daily and annual temperature fluctuations decrease with the increase in depth below the ground surface.

•At a depth of about 4 m below ground, the temperature inside the earth remains nearly constant round the year and is nearly equal to the annual average temperature of the place.

•A tunnel in the form of a pipe or otherwise embedded at a depth of about 4 m 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 and warmed in winter and this air can be used for cooling in summer and heating in winter.





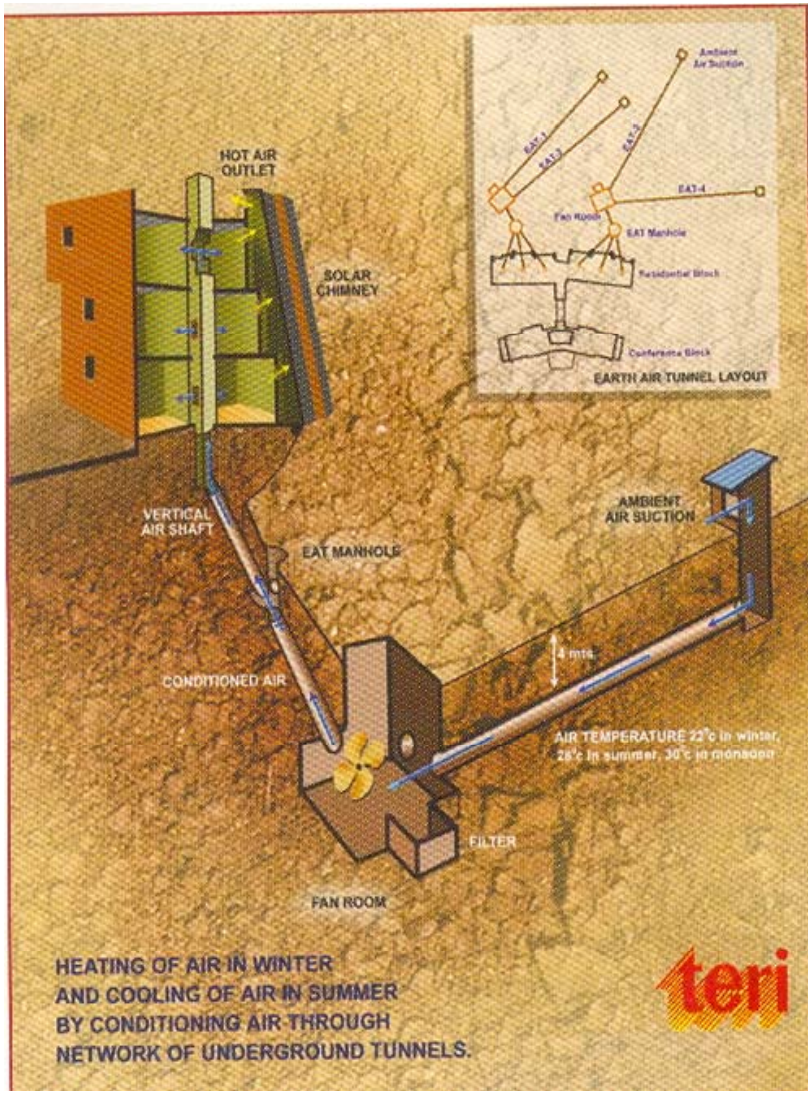
•This technique has been used in the composite climate of **Gurgaon** in **RETREAT building**.

•The living quarters (the south block of RETREAT) are maintained at comfortable temperatures (approx. 20-30 degree Celsius) round the year by the earth air tunnel system, supplemented, when-ever required, with a system of absorption chillers powered by liquefied natural gas during monsoons and with an air washer during dry summer.

•However, the cooler air underground needs to be circulated in the living space. Each room in the south block has a 'solar chimney; warm air rises and escapes through the chimney, which creates an air current for the cooler air from the underground tunnels to replace the warm air.

•Two blowers installed in the tunnels speed up the process.

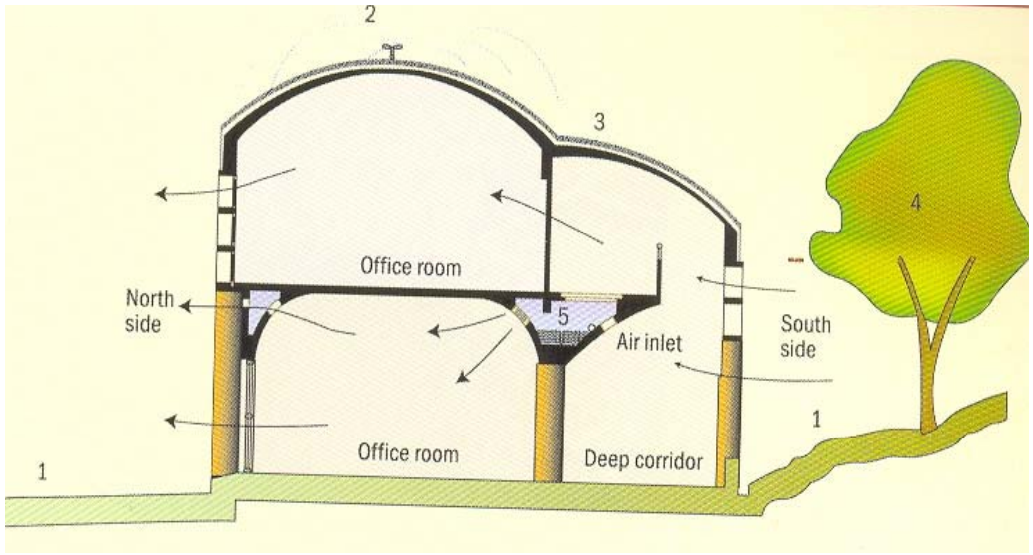
•The same mechanism supplies warm air from the tunnel during winter.



PASSIVE SPACE CONDITIONING
USING EARTH AIR TUNNEL SYSTEM

EVAPORATIVE COOLING

- Evaporative cooling lowers indoor air temperature by evaporating water.
- It is effective in hot and dry climate where the atmospheric humidity is low.
- In evaporative cooling, the sensible heat of air is used to evaporate water, thereby cooling the air, which, in turn, cools the living space of the building.
- Increase in contact between water and air increases the rate of evaporation.
- The presence of a water body such as a pond, lake, and sea near the building or a fountain in a courtyard can provide a cooling effect.



- The most commonly used system is a desert cooler, which comprises water, evaporative pads, a fan, and pump.

1. **Ground cover**
2. **Water sprinkler**
3. **Insulated roof**
4. **Shading trees**
5. **Water trough**

A TYPICAL SECTION SHOWING PASSIVE SOLAR FEATURES OF **WALMI BUILDING,BHOPAL**

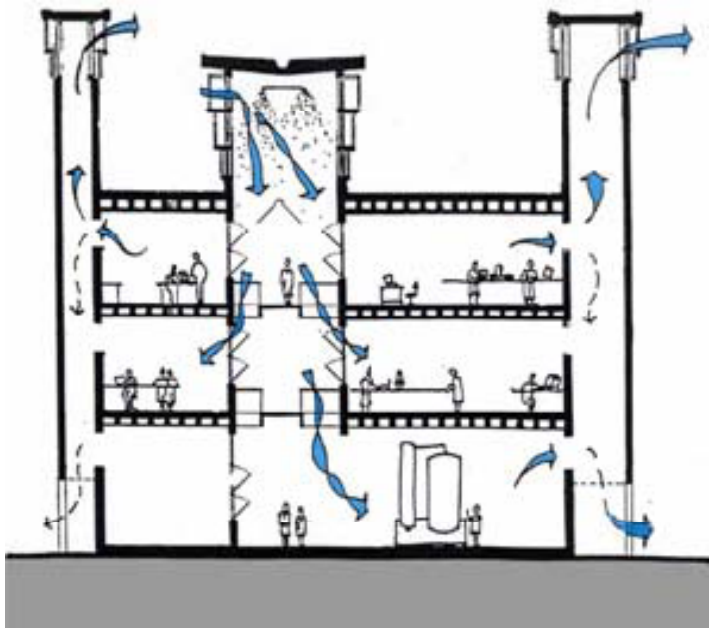
PASSIVE DOWN DRAUGHT COOLING

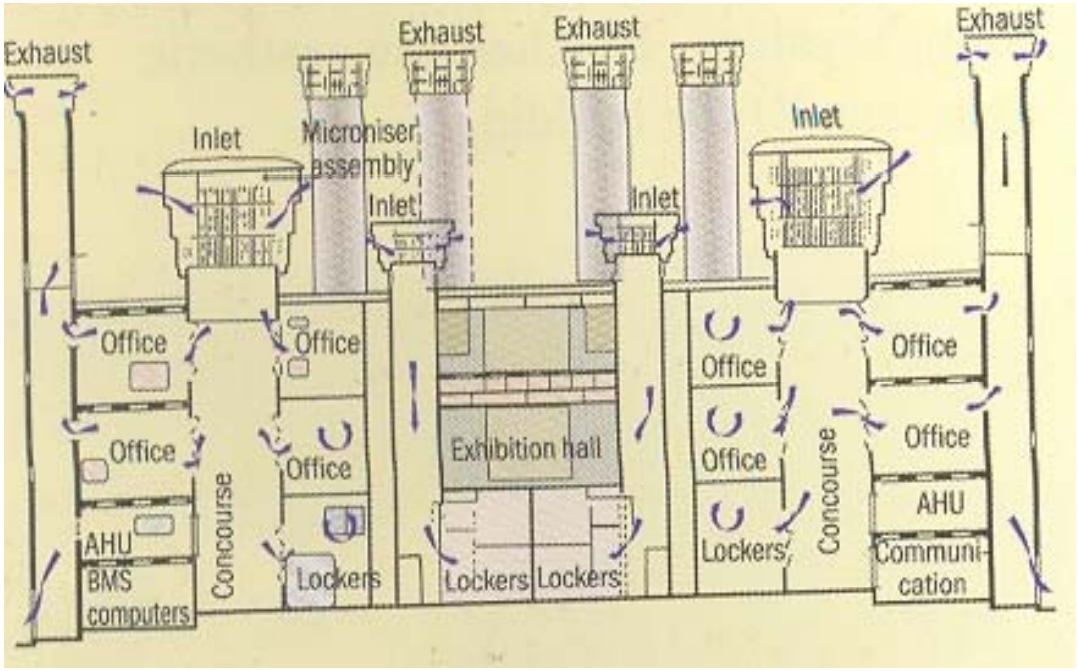
•Evaporative cooling has been used for many centuries in parts of the middle east, notably Iran and turkey.

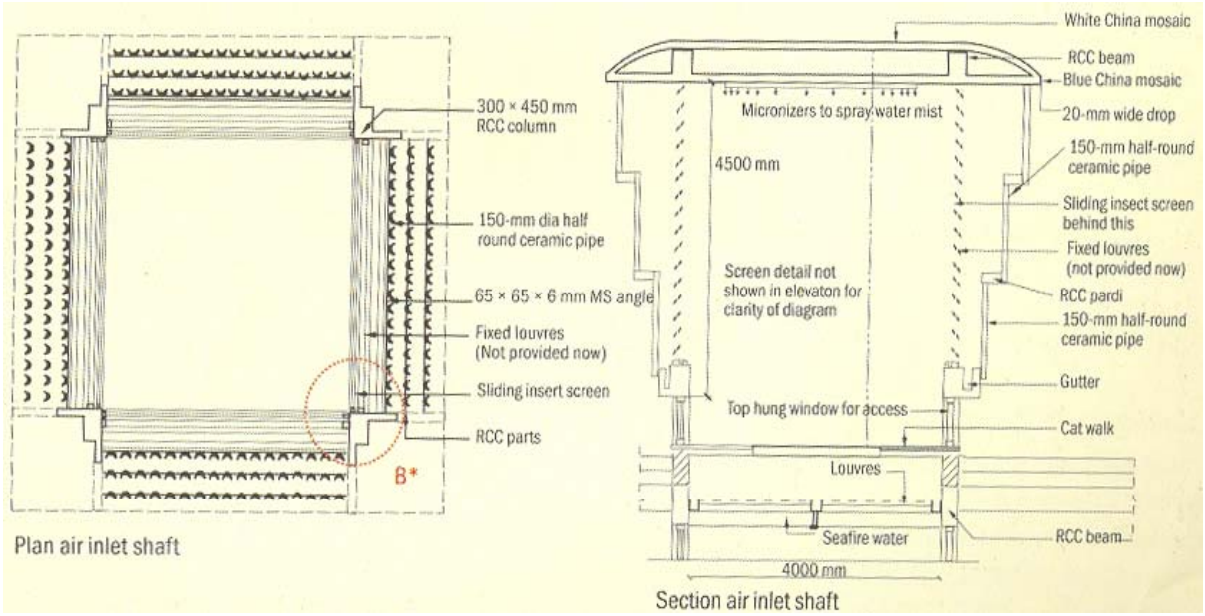
•In this system, wind catchers guide outside air over water-filled pots, inducing evaporation and causing a significant drop in temperature before the air enters the interior.

•Such wind catchers become primary elements of the architectural form also.

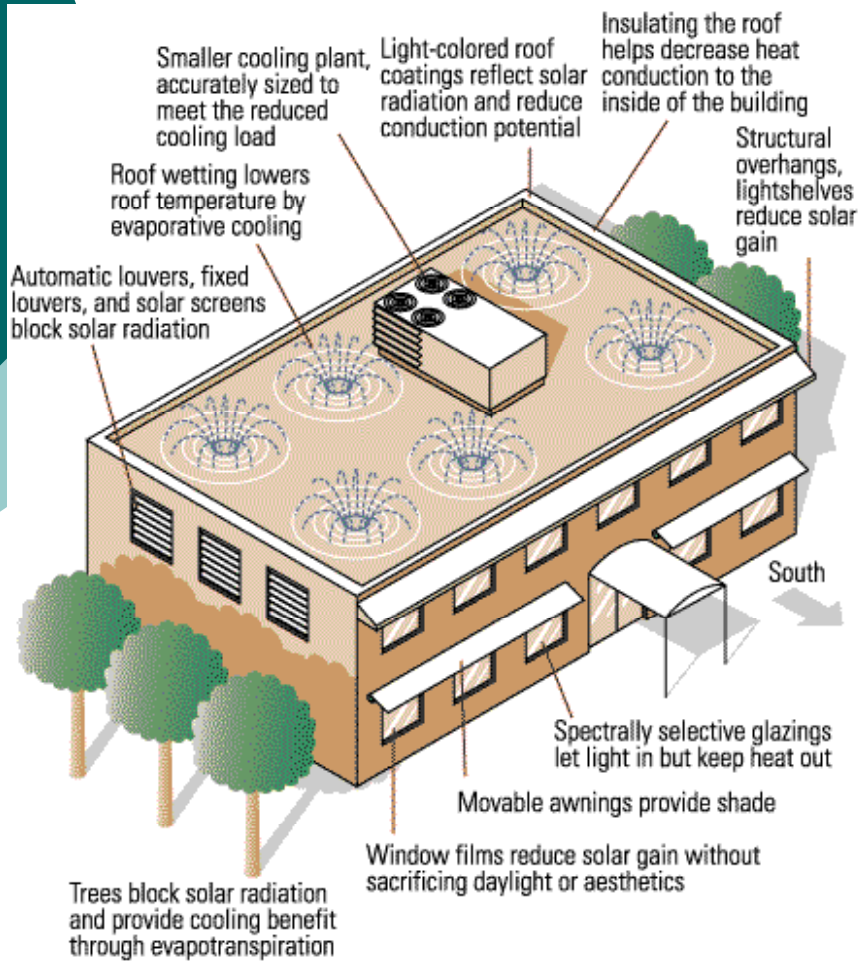
•Passive downdraught evaporative cooling is particularly effective in hot and dry climates. It has been used to effectively cool the **Torrent Research Centre** in **Ahmedabad**.







DETAILS OF THE PASSIVE DOWN DRAUGHT COOLING INLETS



ROOF SPRAYS

EARTH SHELTERED BUILDINGS