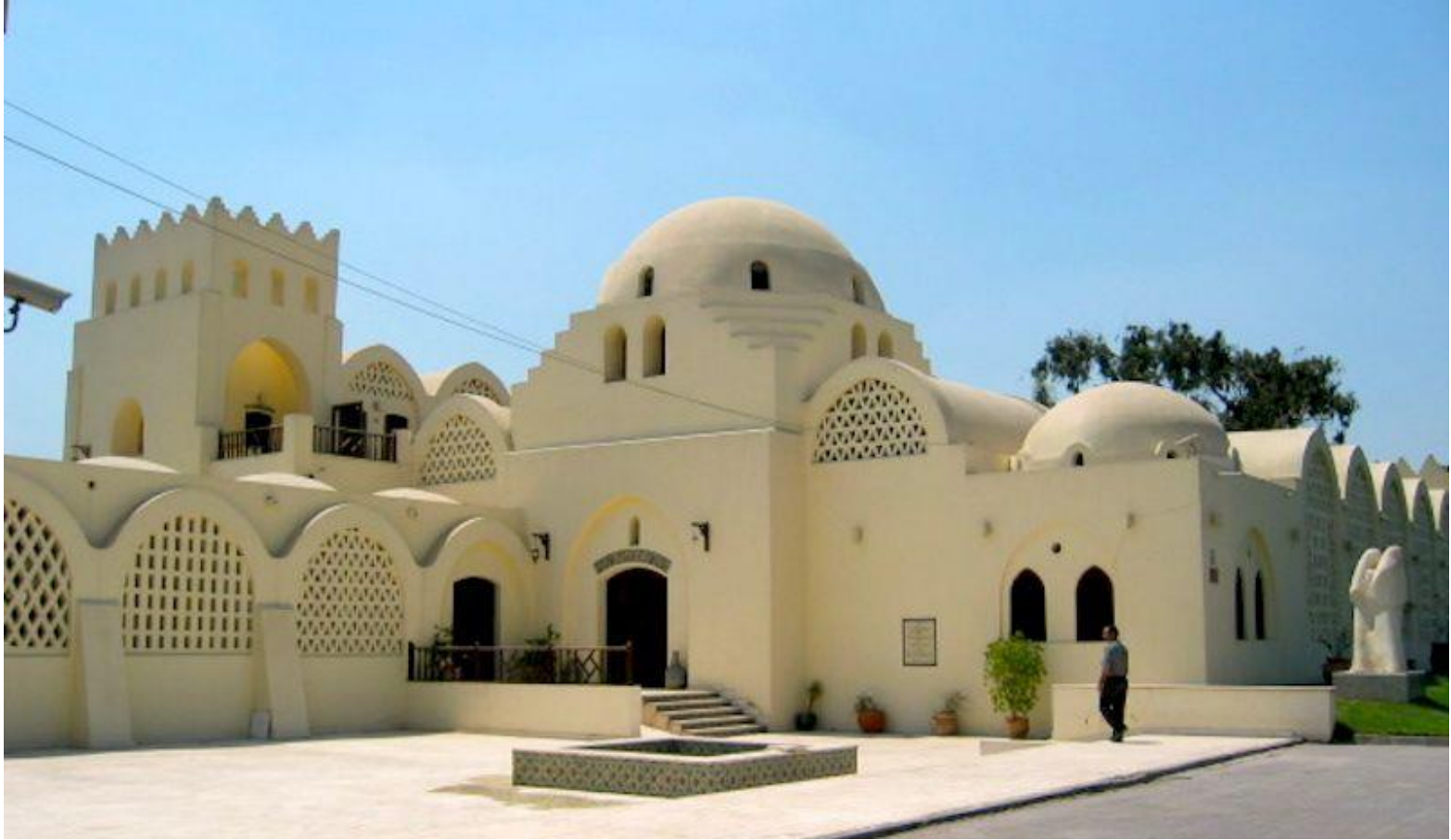




Lecture 13: Passive Cooling

10.1 Introduction

10.2 Historical and Indigenous use of passive cooling

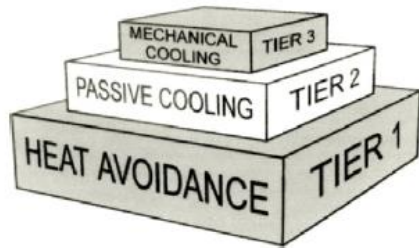


Figure 10.1 Sustainable cooling is achieved by the three-tier design approach. This chapter covers tier two.



Figure 10.2d The wind towers in Dubai, United Arab Emirates, are designed to catch the wind from any direction. These substantial wind towers evolved from the one shown in Fig. 1.2d. (Photograph by Mostafa Howeedy.)

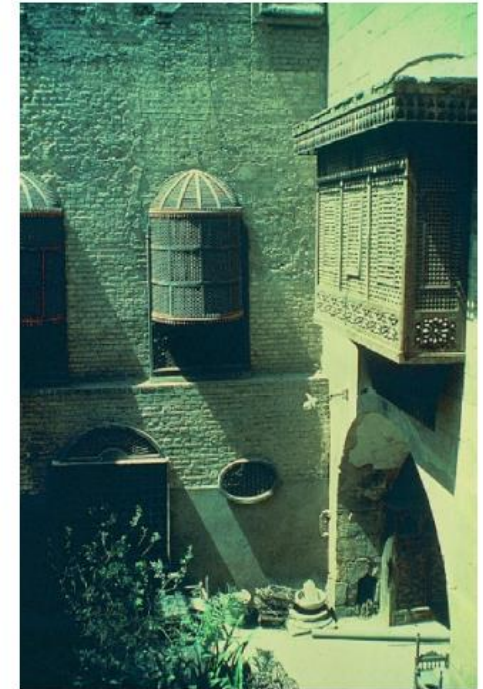


Figure 10.2f A *mashrabiya* is a screened bay window popular in the Middle East. It shades, ventilates, and provides evaporative cooling. Cairo, Egypt. (Photograph by Mostafa Howeedy.)

10.2 Historical and Indigenous use of passive cooling

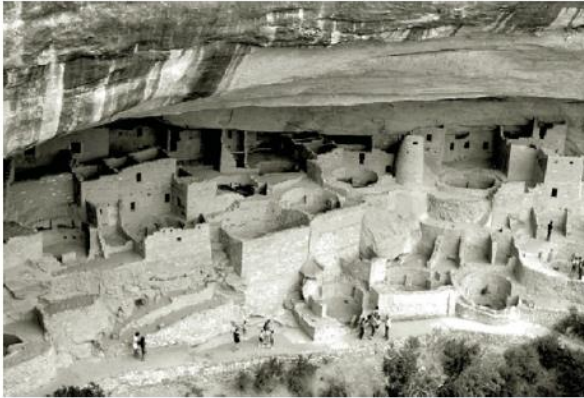


Figure 10.2j The cliff dwellings at Mesa Verde, Colorado, benefit from the heat-sink capacity of the stone walls and rock cliff.



Figure 10.2k The Navajo hogan, with its thick earthen walls, provides comfort in the hot and dry Southwest.



Figure 10.2g Many traditional courtyard houses have all of their windows and doors facing the courtyard in large part for thermal comfort. The courtyard stays relatively cool because it is self-shading most of the day and because it is protected from hot winds. Further comfort comes from transpiration from plants and evaporation from fountains. Marrakesh, Morocco.

10.2 Historical and Indigenous use of passive cooling



Figure 10.2n Ventilation is maximized by movable wall panels in traditional Japanese houses. (Courtesy of the Japan National Tourist Organization.)



Figure 10.2o The movable wall panels open onto the *engawa* (veranda), which is protected by a large overhang. Also note the large gable vent. Japanese Garden, Portland, Oregon.



Figure 10.2p This Gulf Coast house incorporated many cooling concepts appropriate for hot and humid climates. Note the large shaded porch, ventilating dormers, large windows, and ventilation under the house.



Figure 10.2q The breezy passage of the dogtrot house was a favorite for both man and beast during the hot and humid summers.

10.2 Historical and Indigenous use of passive cooling

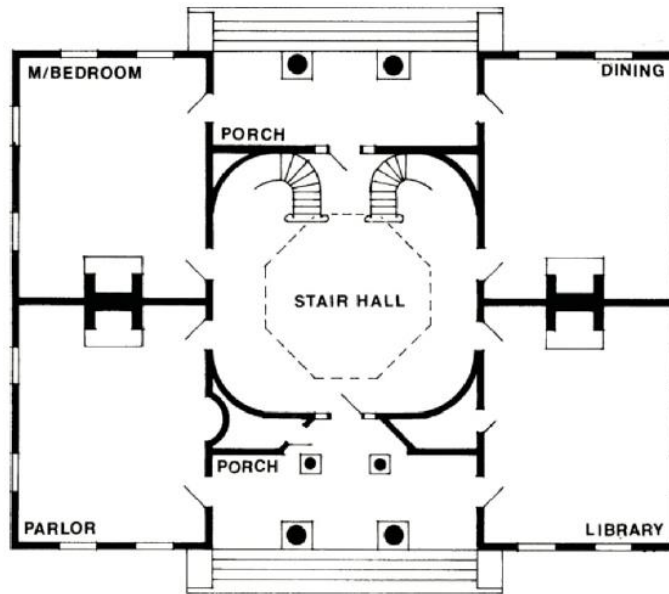


Figure 10.2t A strong stack effect is created by the octagonal belvedere over the open stair hall of the Waverly plantation. All interior doors have transoms. From *Mississippi Houses: Yesterday Toward Tomorrow*, by Robert Ford (copyright).



Figure 10.2u The Governor's Mansion in Colonial Williamsburg, Virginia, is well suited for a temperate climate.

- 10.3 Passive Cooling Systems
- 10.4 Comfort Ventilation Versus Night-flush Cooling
- 10.5 Basic Principles Of Airflow

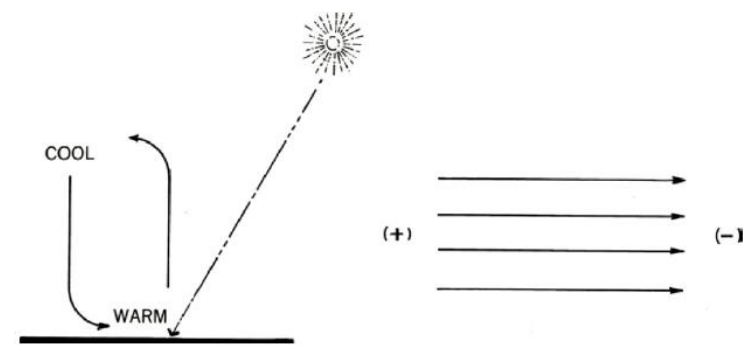


Figure 10.5a Air flows because of either natural convection or pressure differentials.

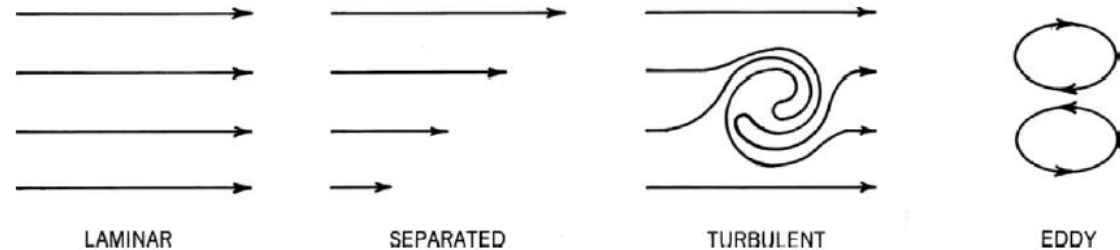


Figure 10.5b The four different kinds of airflow are shown. (After Art Bowen, 1981.)

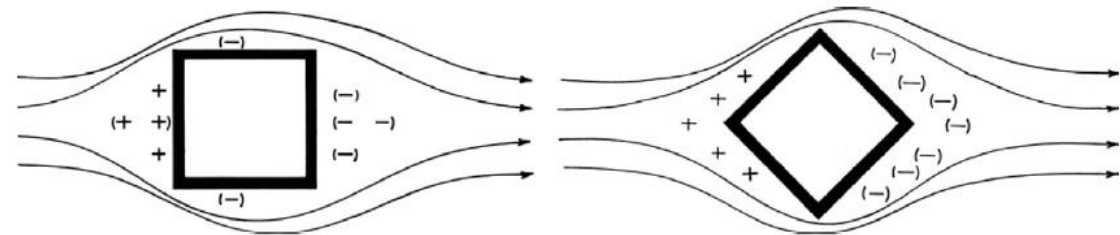


Figure 10.5c Air flowing around a building will cause uneven positive and negative pressure areas to develop. (After Art Bowen, 1981.)

10.5 Basic Principles Of Airflow

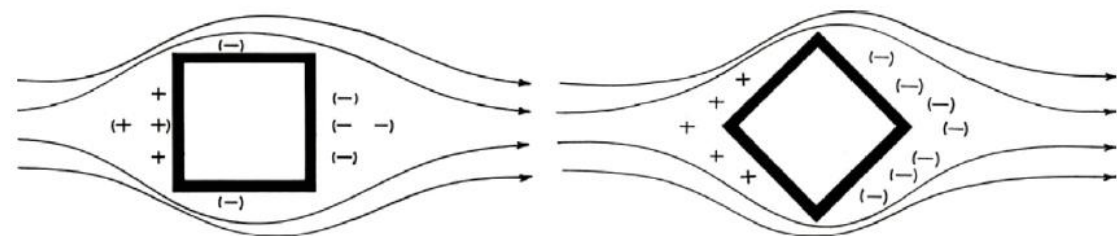


Figure 10.5c Air flowing around a building will cause uneven positive and negative pressure areas to develop. (After Art Bowen, 1981.)

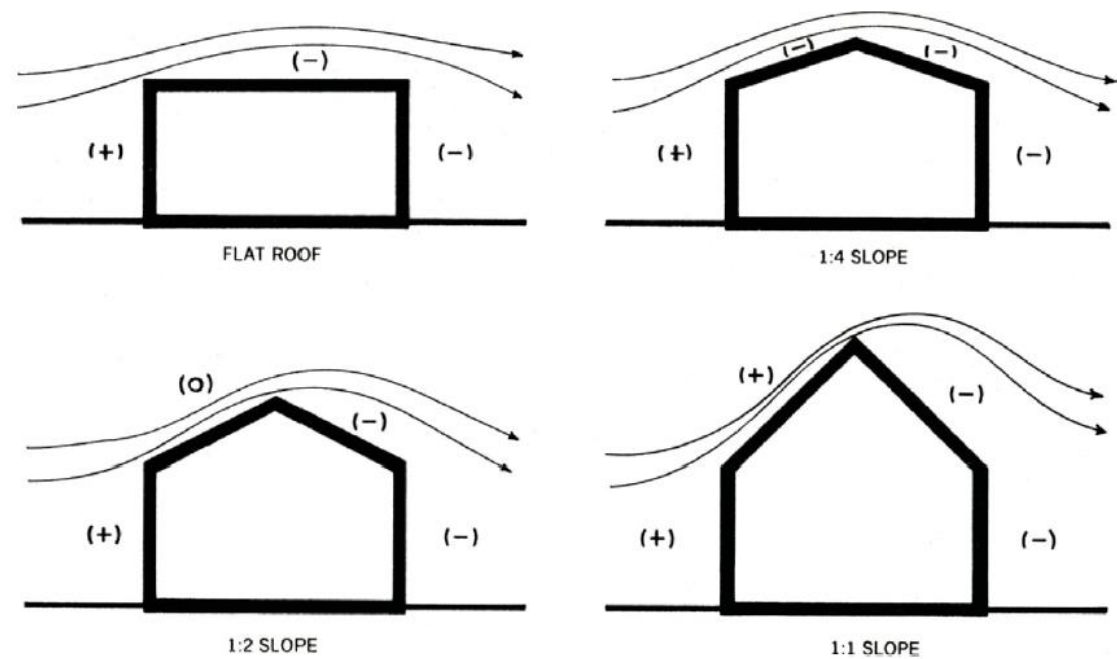


Figure 10.5d The pressure on the leeward side of a roof is always negative, but on the windward side it depends on the slope of the roof. (After Art Bowen, 1981).

10.5 Basic Principles Of Airflow

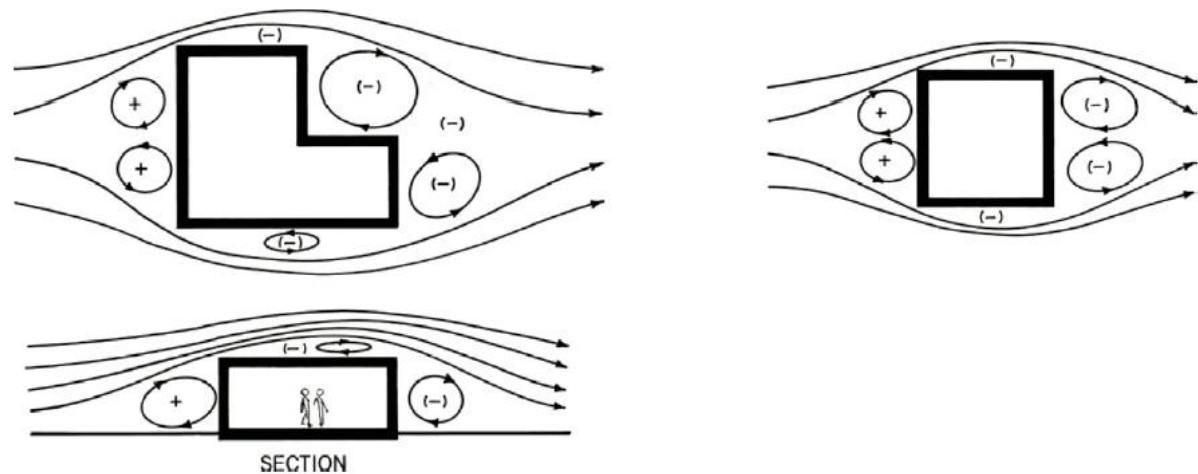


Figure 10.5e Turbulence and eddy currents occur in the high- and low-pressure areas around a building. For simplicity, turbulent air is not shown in any of the diagrams (After Art Bowen, 1981).

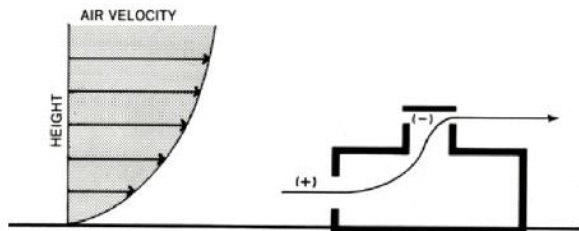


Figure 10.5j Because the air velocity increases rapidly with height above grade, the air has less static pressure at the roof than on the ground (the Bernoulli effect).

10.5 Basic Principles Of Airflow

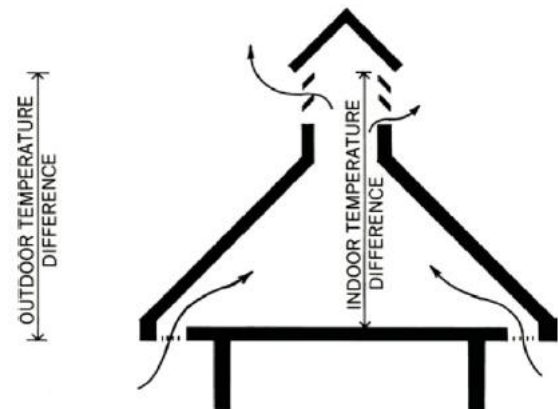


Figure 10.5k The stack effect will exhaust hot air only if the indoor-temperature difference is greater than the outdoor-temperature difference between the vertical openings.

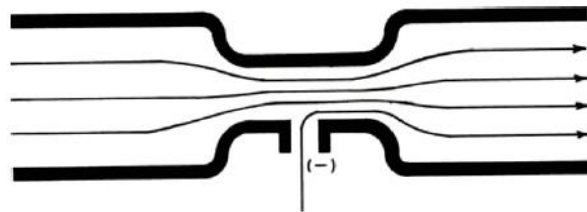


Figure 10.5f The venturi tube illustrates the Bernoulli effect: As the velocity of air increases, its static pressure decreases. Thus, an opening at the constriction would suck in air.

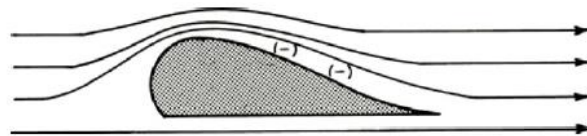


Figure 10.5g An airplane wing is like half of a venturi tube. In this case, the negative pressure is also called lift.

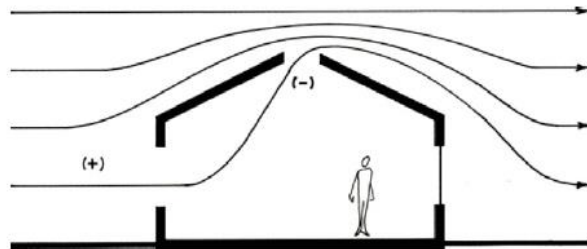


Figure 10.5h The venturi effect causes air to be exhausted through roof openings at or near the ridge.

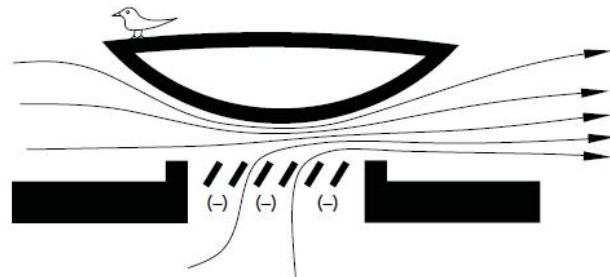


Figure 10.5i Venturi passive ventilators with adjustable louvers are used at the Strasbourg, France, airfreight terminal. Architects: Jockers Architekten, 2001.

10.5 Basic Principles Of Airflow

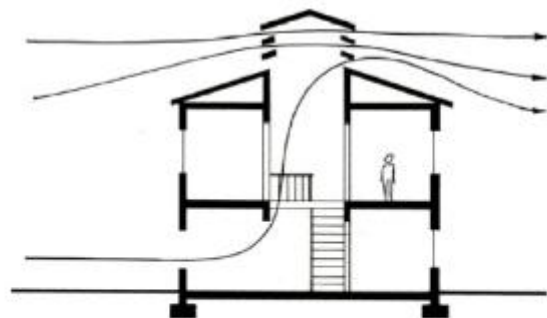
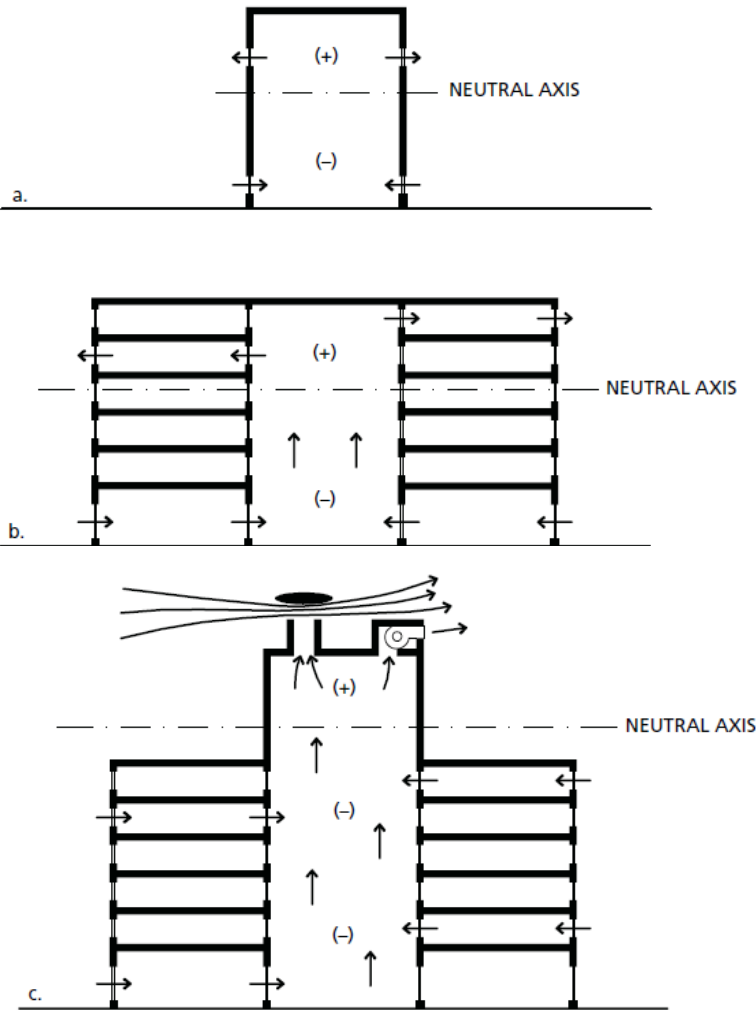


Figure 10.5l The central stair and geometry of this design allow effective vertical ventilation by the combined action of stratification, the stack effect, and both the Bernoulli and venturi effects.

Figure 10.5m The stack effect causes negative pressure in the lower part of a space, positive pressure in the upper part, and zero pressure in between (top drawing). If this space were the atrium of a multistory building, the hot air would enter the upper floors (middle drawing). To avoid this problem, the neutral axis must be raised by increasing the height of the atrium, using wind, and/or exhaust fans (bottom drawing).



10.6 Airflow Through Buildings

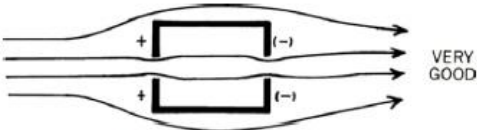


Figure 10.6d Cross ventilation between windows on opposite walls is the ideal condition.

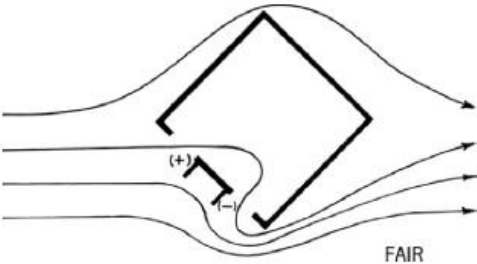


Figure 10.6g Fin walls can significantly increase ventilation through windows on the same wall. (After Art Bowen, 1981.)

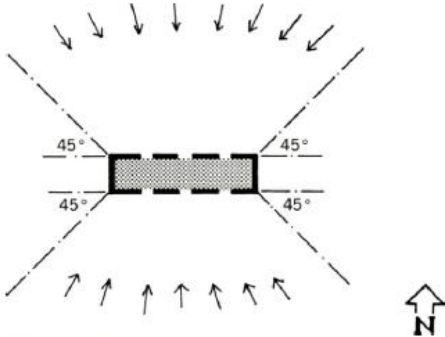


Figure 10.6b Acceptable wind directions for the orientation that is best for summer shade and winter sun.

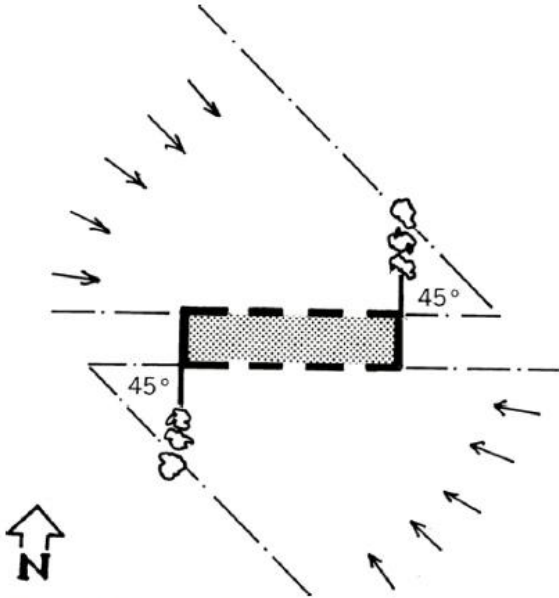


Figure 10.6c Deflecting walls and vegetation can be used to change air-flow direction so that the optimum solar orientation can be maintained.

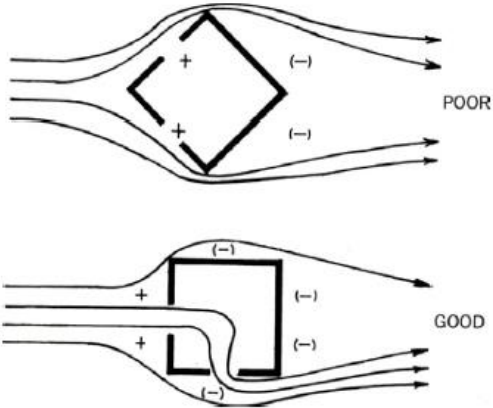


Figure 10.6e Ventilation from windows on adjacent sides can be poor or good, depending on wind direction.

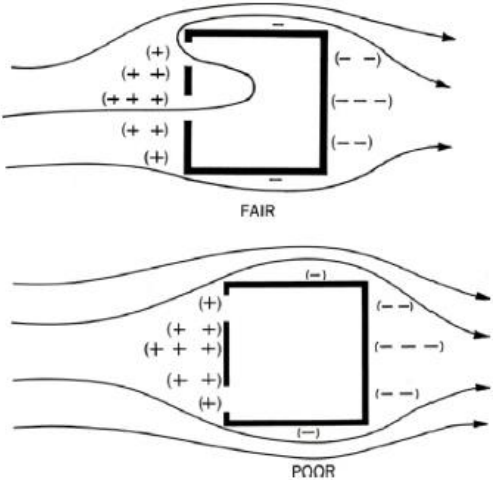


Figure 10.6f Some ventilation is possible in the asymmetric placement of windows because the relative pressure is greater at the center than at the sides of the windward wall. (After Art Bowen, 1981.)

10.6 Airflow Through Buildings

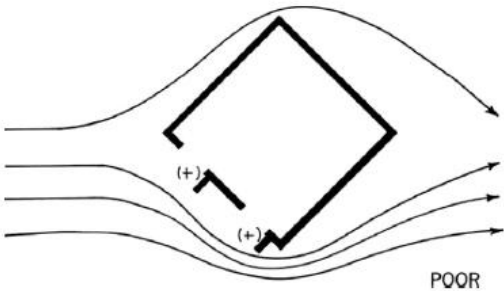


Figure 10.6h Poor ventilation results from fin walls placed on the same side of each window or when two fins are used on each window.

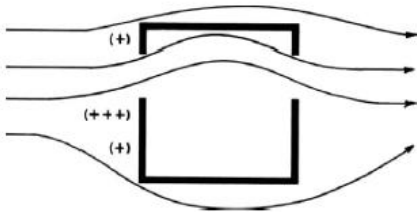


Figure 10.6i The greater positive pressure on one side of the window deflects the airstream in the wrong direction. Much of the room remains unventilated.

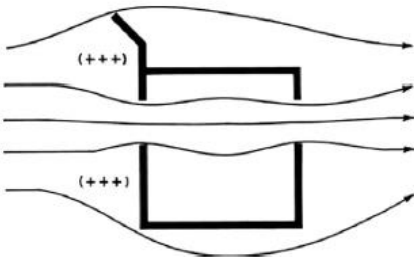


Figure 10.6j A fin wall can be used to direct the airstream through the center of the room, as seen in this plan view.

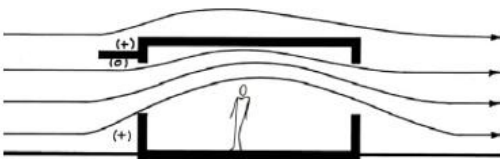


Figure 10.6k The solid horizontal overhang causes the air to deflect upward. (After Art Bowen, 1981.)

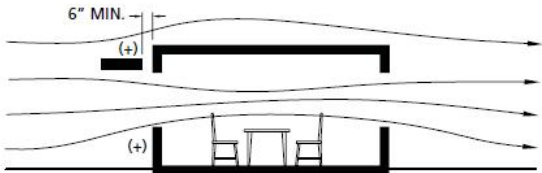


Figure 10.6l A louvered overhang or a gap in the overhang will permit the airstream to straighten out.

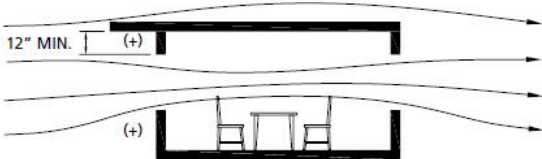


Figure 10.6m A solid horizontal overhang placed high above the window will also straighten out the airstream. (After Art Bowen, 1981.)

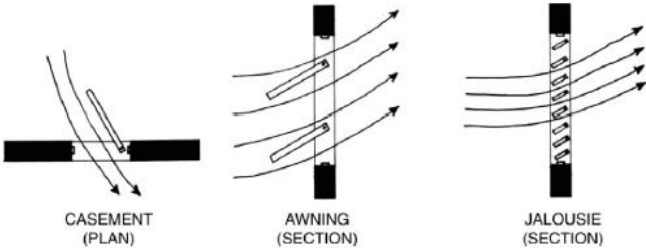


Figure 10.6n All but double-hung and sliding windows have a strong effect on the direction of the airstream.

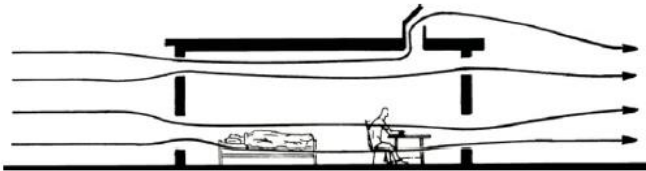


Figure 10.6o For comfort ventilation, openings should be at the level of the occupants. High openings vent the hot air collecting near the ceiling and are most useful for night-flush cooling. (After Art Bowen, 1981.)