**CLIMATE**

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**EGR3413 COURSE TEXT, CH 5:**

\[
\text{WIND} = s(\Delta P_{\text{RESF}}) = s(\text{LATITUDE}) \\
= s(\text{TERRAIN}) \\
= s(\Delta T_{\text{TEMP}}) \\

\]

\[
\star \text{ MICROCLIMATES} \\
\rightarrow \text{A LOCALIZED VARIATION IN CLIMATE} \\
= s(\text{ELEVATION}) \\
= s(\text{GEOGRAPHY}) = s(\text{PROXIMITY/EXPLOITATION TO SUN AND WATER}) \\
= s(\text{GEOLOGY}) \\
\rightarrow \text{EA., SOIL: COLOR, WATER CONTENT, HEAT-CAPACITY} \\
= s(\text{VEGETATION}) \\
= s(\text{BUILDING DENSITY}) \text{ WHICH CREATE:} \begin{cases} \bullet \text{HUMIDITY} \\
\bullet \text{SHAPE} \\
\bullet \text{WIND BLOCKS} \end{cases}
\]
CLIMATE ANOMALIES

Even more radical and localized variation in climate than a micro climate

[×] CALENDAR BEACHES CAN BE 30°F DIFFERENT THAN DESERT AREAS ONLY 10 MILES INLAND

Hot air in desert rises, drawing a convection current in of air over ocean which drags in a cold fog.

CLIMATE REGIONS
US/Canada has 17.

CLIMATE CASE STUDIES

“DEGREE-DAY” (DD)

It's not a day!

For any one day

\[
DD = T_{ave} - 65°F
\]

If + DD Cooling

If - DD Heating

* EX1: Today \( T_{ave} = 62°F \) over 24 hours!

\[
DD = 62°F - 65°F = -3°F
\]

Today has 3 heating degree days.

The units are strange.
PHOTOCOPIED HANDOUT OF COURSE TEXT

- OUR PA CLIMATE
- ARIZONA
- SOUTH FLORIDA

DESIGN STRATEGIES

- I MISSED MOST IMPORTANT THINGS
CLIMATE REGION 3

REFERENCE CITY: INDIANAPOLIS, INDIANA

The Climate

This climate of the Midwest is similar to that of regions 1 and 2, but it is somewhat milder in winter. Cold winds, however, are still an important concern. The mean annual snowfall ranges from 12 to 60 in. (30–150 cm). There is some potential for solar energy in the winter since the sun shines more than 40 percent of the daylight hours.

Significant cooling loads are common since high summer temperatures often coincide with high humidity. Winds are an asset during the summer.

The annual precipitation is about 39 in. (98 cm) and occurs fairly uniformly throughout the year.

Climatic Design Priorities*

1st  Keep heat in and cold temperatures out in the winter. (I)
2nd  Protect from the cold winter winds. (II)
3rd  Let the winter sun in. (III)

*These climatic design priorities are for envelope-dominated building types only. See Section 5.9 for a list of design strategies appropriate for achieving each of these priorities. Use the Roman numerals to find the relevant lists.

Note: For an explanation of these Climatic Data Tables, see Section 5.6. Much of the material in the Climate Data Tables comes from the book Regional Guidelines for Building Passive Energy Conserving Homes by the AIA Research Corporation.

Lower priority

4th  Keep hot temperatures out during the summer. (VIII)
5th  Protect from the summer sun. (IV)
6th  Use natural ventilation for summer cooling. (V)
CLIMATIC DATA TABLE FOR REGION 3

BASIC CLIMATIC CONDITION

<table>
<thead>
<tr>
<th>Month</th>
<th>Comfortable period</th>
<th>too hot</th>
<th>too cold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-Feb</td>
<td>14</td>
<td></td>
<td>20</td>
</tr>
<tr>
<td>Mar-Apr</td>
<td></td>
<td></td>
<td>66</td>
</tr>
</tbody>
</table>

TEMPERATURE

- range of comfortable temp.
- afternoon maximum temperature
- average daily temperature
- morning minimum temperature

RELATIVE HUMIDITY

- average morning humidity
- average afternoon humidity
- range of comfortable humidity

WIND SPEED

- mean daily wind speed
- wind speed for effective natural ventilation

for wind direction see the wind roses in Figs. 5.6d to h

SUNSHINE

- average % of daylight hours
- annual sunshine = 55%
- peak solar radiation in January horiz. ft² = 500 btu/day
  vert. ft² = 600 btu/day

DEGREE-DAYS

- annual heating degree-days = 5650
- cooling degree-days = 928
CLIMATE REGION 11
REFERENCE CITY: PHOENIX, ARIZONA

The Climate

The climate of the Southwest desert regions is characterized by extremely hot and dry summers and moderately cold winters. The skies are clear most of the year, with annual sunshine of about 85 percent.

Since summers are extremely hot and dry, the diurnal temperature range is very large; consequently, nights are quite cool. The humidity is below the comfort range much of the year. Summer overheating is the main concern for the designer.

The annual precipitation of about 7 in. (18 cm) is quite low and occurs throughout the year. April, May, and June are the driest months, while August is the wettest, with 1 in. (2.5 cm) of rain.

Climatic Design Priorities*

1st  Keep hot temperatures out during the summer. (VII)
2nd  Protect from the summer sun. (IV)
3rd  Use evaporative cooling in the summer. (IX)
4th  Use thermal mass to reduce day-to-night temperature swings during the summer. (VII)

Lower priority

5th  Keep the heat in and the cool temperatures out during the winter. (I)
6th  Let the winter sun in. (III)
7th  Use natural ventilation to cool in the spring and fall. (VI)

* These climatic design priorities are for envelope-dominated building types only. See Section 5.9 for a specific list of design strategies appropriate for achieving each of these priorities. Use the Roman numerals to find the relevant lists.

Note: For an explanation of these Climatic Data Tables, see Section 5.6. Much of the material in the Climatic Data Tables comes from the book "Regional Guidelines for Building Passive Energy Conerving Homes" by the AIA Research Corporation.
CLIMATE REGION 16
REFERENCE CITY: MIAMI, FLORIDA

The Climate

The climate of southern Florida has long, hot summers and no winters. When the slightly high temperatures are combined with high humidity, uncomfortable summers are the result. However, in spring, fall, and winter, the climate is quite pleasant. Ocean winds add significantly to year-round comfort.

Annual precipitation is quite high, at about 58 in. (145 cm) and much of the rain falls during the summer months.

Climatic Design Priorities*

1st  Open the building to the outdoors since temperatures are comfortable much of the year. (XI)
2nd  Protect from the summer sun. (IV)
3rd  Allow natural ventilation to both cool and remove excess moisture most of the year. (VI)
4th  Avoid creating additional humidity. (X)

Lower priority

5th  Keep the hot temperatures out during the summer. (VIII)
6th  Keep the heat in and the cool temperatures out during the winter. (I)

*These climatic design priorities are for envelope-dominated building types only. See Section 5.9 for a list of design strategies appropriate for achieving each of these priorities. Use the Roman numerals to find the relevant lists.

Note: For an explanation of these Climatic Data Tables, see Section 5.6. Much of the material in the Climate Data Tables comes from the book Regional Guidelines for Building Passive Energy Conserving Homes by the AIA Research Corporation.
5.9 Design Strategies

The following climate-related design strategies are appropriate ways of achieving the design priorities listed in the Climatic Data Tables (above). More detailed information is found in the chapters shown in parentheses.

Winter

1. Keep the heat in and the cold temperatures out during the winter. (Fig. 5.9a)
   a. Avoid building on cold northern slopes. (Chapter 11)
   b. Build on the middle of slopes to avoid both the pools of cold air at the bottom and the high winds at the top of hills. (Chapter 11)
   c. Use a compact design with a minimum surface area-to-volume ratio. For example, use two- instead of one-story buildings. (Chapter 15)
   d. Build attached or clustered buildings to minimize the number of exposed walls. (Chapter 15)
   e. Use earth sheltering in the form of underground or bermed structures. (Chapter 15)
   f. Place buffer spaces that have lower temperature requirements (closets, storage rooms, stairs, garages, gymnasia, heavy work areas, etc.) along the north wall. Place a sunspace buffer room on the south wall. (Chapters 7 and 15)
   g. Use temperature zoning by both space and time since some spaces can be kept cooler than others at all times or at certain times. For example, bedrooms can be kept cooler during the day, and living rooms can be kept cooler at night when everyone is asleep. (Chapter 16)
   h. Minimize the window area on all orientations except south. (Chapters 7 and 15)
   i. Use double or triple glazing, low-e coatings, and movable insulation on windows. (Chapter 15)
   j. Use plentiful insulation in walls, on roofs, under floors, over crawl spaces, on foundation walls, and around slab edges. (Chapter 15)
   k. Insulation should be a continuous envelope to prevent heat bridges. Avoid structural elements that are exposed on the exterior, since they pierce the insulation. Avoid fireplaces and other masonry elements that penetrate the insulation layer. (Chapter 15)
   l. Place doors on fireplaces to prevent heated room air from escaping through the chimney. Supply fireplaces and stoves with outdoor combustion air. (Chapter 16)

2. Protect from the cold winter winds (Fig. 5.9b)
   a. Avoid windy locations, such as hilltops. (Chapter 11)
   b. Use evergreen vegetation to create windbreaks. (Chapter 11)
   c. Use garden walls to protect the building and especially entrances from cold winds. (Chapter 11)
   d. In very windy areas, keep buildings close to the ground (one story).
   e. Use compact designs to minimize the surface area exposed to the wind. (Chapter 15)
   f. Use streamlined shapes with rounded corners to both deflect the wind and minimize the surface area-to-volume ratio.
   g. Cluster buildings for mutual wind protection. (Chapter 11)
   h. Use long sloping roofs, as in the New England saltbox houses, to deflect the wind over the building and to create sheltered zones on the sunny side.
   i. Place garages and other utility spaces on the winter windward side. This is usually the north, northwest, and northeast side of the building.
   j. Use sun spaces and glazed-in porches as windbreaks.
   k. Use earth sheltering or build in hollows. Also, the wind can be deflected by earth berms.

Figure 5.9a Use attached buildings to reduce the exposed wall area. Use compact building forms and two-story plans. Use at least double glazing. Always use low-e glazing, and consider using movable night insulation. (Drawings from Regional Guidelines for Building Passive Energy Conserving Homes by the AIA Research Corporation.)
Figure 5.9b Build in wind-protected areas such as the side of a hill. Plant or build barriers against the wind. Evergreen trees are effective wind barriers. (Drawings from Regional Guidelines for Building Passive Energy Conserving Homes by the AIA Research Corporation.)

Figure 5.9c Orient building with the long side facing south. Avoid trees or other structures on the south side. Place most windows on the south facade. Use mainly vertical glazing. Use south-facing clerestory windows or dormers to bring the sun farther into the interior. (Drawings from Regional Guidelines for Building Passive Energy Conserving Homes by the AIA Research Corporation.)
air to penetrate throughout the building.
k. Use direct-gain Trombe walls and sunspaces for effective passive solar heating.
l. Use thermal mass on the interior to absorb and store solar radiation.
m. Use light-colored patios, pavements, or land surfaces to reflect additional sunlight through windows.
n. Use specular reflectors (polished aluminum) to reflect additional sunlight through windows.
o. Use active solar collectors for domestic hot water, swimming-pool heating, space heating, and process heat for industry. (Chapter 8)
p. If there is little or no summer overheating, use dark colors on exterior walls (especially the south wall).
q. Create sunny but wind-protected outdoor spaces on the south side of the building. (Chapter 11)

Summer

IV. Protect from the summer sun (covered in Chapter 9 unless noted otherwise) (Fig. 5.9d).
a. Avoid building on east and especially west slopes, North slopes are best if solar heating is not required in the winter, while south slopes are best if solar heating is desirable in the winter. (Chapter 11)
b. Use plants for shading. Evergreen trees can be used on the east, west, and north sides of a building. Deciduous plants are most appropriate for shading the southeast, the southwest, and the roof. Unless carefully placed, deciduous plants on the south side of a building might do more harm in the winter than good in the summer. The exception is a very hot climate with a very mild winter. (Chapter 11)
c. Avoid light-colored ground covers around the building to minimize reflected light entering windows unless daylighting is an important strategy. Living ground covers are best because they do not heat the air while they absorb solar radiation.
d. Have neighboring buildings shade each other. Tall buildings with narrow alleys between them work best. (Chapter 11)
e. Avoid reflections from adjacent structures that have white walls and/or reflective glazing.
f. Build attached houses or clusters to minimize the number of exposed walls. (Chapter 15)
g. Use free-standing or wing walls to shade the east, west, and north walls.
h. Use the form of the building to shade itself (e.g., cantilevered floors, balconies, courtyards).
i. Avoid east and especially west windows if at all possible. Minimize the size and number of any east and west windows that are necessary. Project windows on east and west facades so that they face in a northerly or southerly direction.
j. Use only vertical glazing. Any horizontal or sloped glazing (skylights) should be shaded on the outside during the summer. Only skylights on steep northern roofs do not require exterior shading.
k. Use exterior shading devices on all windows except north windows in cool climates.
l. Shade not only windows but also east and especially west walls. In very hot climates, also shade the south wall.
m. Use a double or second roof (ice house roof), with the space between the roofs well ventilated. Use a parasol roof.
n. Use shaded outdoor spaces, such as porches and carports.

Figure 5.9d Orient the short side of the building to the east and west and avoid windows on these facades if possible. Use overhangs, balconies, and porches to shade both windows and walls. Use large overhanging roofs and porticoes to shade both windows and walls. (Drawings from Regional Guidelines for Building Passive Energy Conserving Homes by the AIA Research Corporation.)
to protect the south, east, and especially west facades.

o. Use open rather than solid shading devices to prevent trapping hot air next to the windows.

p. Use vines on trellises for shading. (Chapters 9 and 11)

q. Use movable shading devices that can retract to allow full winter sun penetration and more daylight on cloudy summer days.

r. Use highly reflective building surface (white is best). The roof and west wall are the most critical.

s. Use interior shading devices in addition to exterior shading devices.

t. Use “selective glazing” to reduce heat gain but still allow views and daylighting.

u. Place outdoor courtyards, which are intended for summer use, on the north side of the building. The east side is the next best choice. (Chapter 11)

V. Use natural ventilation for summer cooling (covered in Chapter 10 unless noted otherwise) (Fig. 5.9e).

a. Night ventilation that is used to cool the building in preparation for the next day is called “night flush cooling” and is described under priority VII below.

b. Natural ventilation that cools people by passing air over their skin is called “comfort ventilation.”

c. Site and orient the building to capture the prevailing winds. (Chapters 10 and 11)

d. Direct and channel winds toward the building by means of landscaping and landforms. (Chapter 11)

e. Keep buildings far enough apart to allow full access to the desirable winds. (Chapter 11)

f. In mild climates where winters are not very cold and summer temperatures are not extremely high, use a non-compact shape for maximum cross-ventilation.

g. Elevate the main living space since wind velocity increases with the height above ground.

h. Use high ceilings, two-story spaces, and open stairwells for vertical air movement and for the benefits of stratification.

i. Provide cross-ventilation by using large windows on both the windward and leeward sides of the building.

j. Use fin walls to direct air through the windows.

k. Use a combination of high and low openings to take advantage of the stack effect.

l. Use roof openings to vent both the attic and the whole building. Use openings, such as monitors, cupolas, dormers, roof turrets, ridge vents, gable vents, and soffit vents.

m. Use porches to create cool outdoor spaces and to protect open windows from sun and rain.

n. Use a double or parapet roof with sufficient clearance to allow the wind to ventilate the hot air collecting between the two roofs. (Chapter 9)

o. Use high-quality operable windows with good seals to allow summer ventilation while preventing winter infiltration. (Chapter 15)

p. Use an open floor plan for maximum air flow. Minimize the use of partitions.

q. Keep transoms and doors open between rooms.

r. Use a solar chimney to move air vertically through a building on calm, sunny days.

s. Use operable windows or movable panels in garden walls to maximize the summer ventilation of a site while allowing protection against the winter winds.

vi. Allow natural ventilation to both cool and remove excess moisture in the summer (covered in Chapter 10 unless otherwise noted). (Fig. 5.9f)

a. All the strategies from priority V above also apply here.

b. Elevate the main living floor above the high humidity found near the ground.

Figure 5.9e Provide many large but shaded windows for ventilation. Provide both high and low openings. Provide large openings to vent attic spaces. (Drawings from Regional Guidelines for Building Passive Energy Conserving Homes by the AIA Research Corporation.)
c. Use plants sparsely. Minimize low trees, shrubbery, and ground covers to enable air to circulate through the site to remove moisture. Use only trees that have a high canopy. (Chapter 11)
d. Avoid deep basements that cannot be ventilated well.

VII. Use thermal mass to reduce day-to-night temperature swings in the summer (covered in Chapter 10 unless noted otherwise). (Fig. 5.9g)
a. This cooling strategy is also known as "night flush cooling" because the thermal mass is usually cooled with night ventilation. See Chapter 10 for a description of this strategy.
b. Use massive construction materials since they have a high heat capacity. Use materials such as brick, concrete, stone, and adobe. (Chapter 15)
c. Place insulation on the outside of the thermal mass. (Chapter 15)
d. If massive materials are also to be used on the outside, sandwich the insulation between the inside and outside walls. (Chapter 15)
e. Use earth or rock in direct contact with the uninsulated walls. (Chapters 10 and 15)
f. Keep daytime hot air out of the building by closing all openings.
g. Open the building at night to allow cool air to enter. Use the strategies of natural ventilation, listed above in priority V, to maximize the night cooling of the thermal mass.
h. Use water as a thermal mass because of its very high heat capacity. Use containers that maximize heat transfer into and out of the water. (Chapter 7)
i. Use radiant or evaporative cooling to reduce temperature drop in the thermal mass at night.
j. Use mechanical equipment at night when it is most efficient to create a heat sink. By cooling the building at night, the cool thermal mass can soak up heat the next day. (Chapter 16)
k. Use earth sheltering to maximize the benefits of mass. (Chapters 10 and 15)
VIII. Keep hot temperatures out during the summer (Fig. 5.9h).

a. Use compact designs to minimize the surface-area-to-volume ratio. (Chapter 15)

b. Build attached houses to minimize the number of exposed walls. (Chapters 11 and 15)

c. Use vegetation and shade structures to maintain cool ambient air around the building and to prevent reflecting sunlight into the windows. (Chapter 11)

d. Use earth sheltering in the form of underground or bermed structures. (Chapter 15)

e. Use plenty of insulation in the building envelope. (Chapter 15)

f. Use few and small windows to keep heat out.

g. Use exterior window shutters. In hot climates use double glazing, and in very hot climates also use movable insulation over windows during the day when a space is unoccupied (e.g., a bedroom). (Chapter 15)

h. Isolate sources of heat in a separate room, wing, or building (e.g., kitchen).

i. Zone building so that certain spaces are cooled only while occupied. (Chapter 16)

j. Use light-colored roofs and walls to reflect the sun’s heat.

IX. Use evaporative cooling in the summer (covered in Chapter 10 unless otherwise noted) (Fig. 5.9i).

a. Locate pools or fountains in the building, in a courtyard, or in the path of incoming winds.

b. Use transpiration by plants to cool the air both indoors and outdoors.

c. Spray water on roof, walls, and patios to cool these surfaces.

d. Pass incoming air through a curtain of water or a wet fabric.

e. Use a roof pond or another “indirect evaporative cooling” system.

f. Use an “evaporative cooler.” This simple and inexpensive mechanical device uses very little electrical energy.

Avoid creating additional humidity during the summer (Fig. 5.9j).

a. Do not use evaporative cooling strategies in humid climates.

b. Use underground or drip rather than spray irrigation.

c. Avoid pools and fountains.

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Figure 5.9h Use compact, well-insulated, and white-painted buildings. Use attached housing units to minimize the exposed wall area. Have buildings shade each other. Avoid reflecting sun into windows. (Drawings from Regional Guidelines for Building Passive Energy Conserving Homes by the AIA Research Corporation.)

Figure 5.9i Use fountains, pools, and plants for evaporative cooling. Use courtyards to prevent cooled air from blowing away. Use energy-conserving evaporative coolers. (Drawings from Regional Guidelines for Building Passive Energy Conserving Homes by the AIA Research Corporation.)
d. Keep the area around the building dry by providing the proper drainage of land. Channel runoff water from the roof and paved areas away from the site.

e. Use permeable paving materials to prevent puddles on the surface.

f. Minimize plants, especially indoors. Use plants that add little water to the air by transpiration. Such plants are usually native to dry climates. Use trees that have a high canopy.

g. Shade plants and pools of water both indoors and out because the heat of the sun greatly increases the rate of transpiration and evaporation.

h. Use exhaust fans in kitchens, bathrooms, laundry rooms, etc., to remove excess moisture.

Open the building to the outdoors since temperatures are comfortable much of the year (Fig. 5.9k).

a. Create outdoor spaces with different orientations for use at different times of the year. For example, use outdoor spaces on the south side in the winter and on the north side in the summer.

b. Create outdoor living areas that are sheltered from the hot summer sun and cool winter winds.

c. Use noncompact building designs for maximum contact with the outdoors. Use an articulated building with many extensions or wings to create outdoor living spaces.

d. Use large areas of operable windows, doors, and even movable walls to increase contact with the outdoors.

e. Create pavilion-like buildings that have few interior partitions and minimal exterior walls.