NESEA – Orientation, Site, Climate

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www.civil.uwaterloo.ca/beg
BEG
Building Engineering Group

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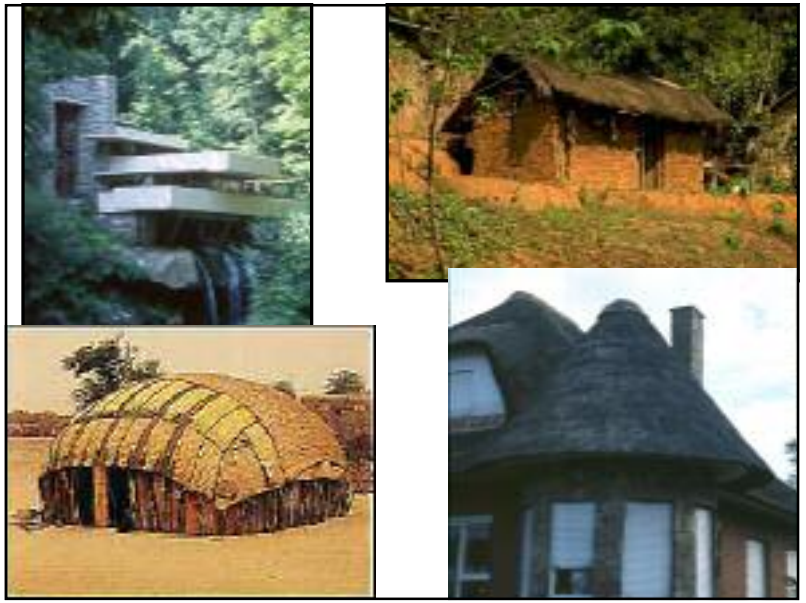
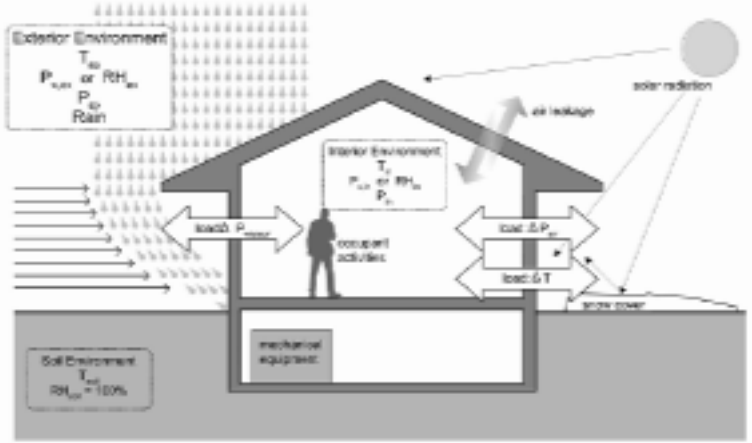


Where are these?

Why such differences? Art?

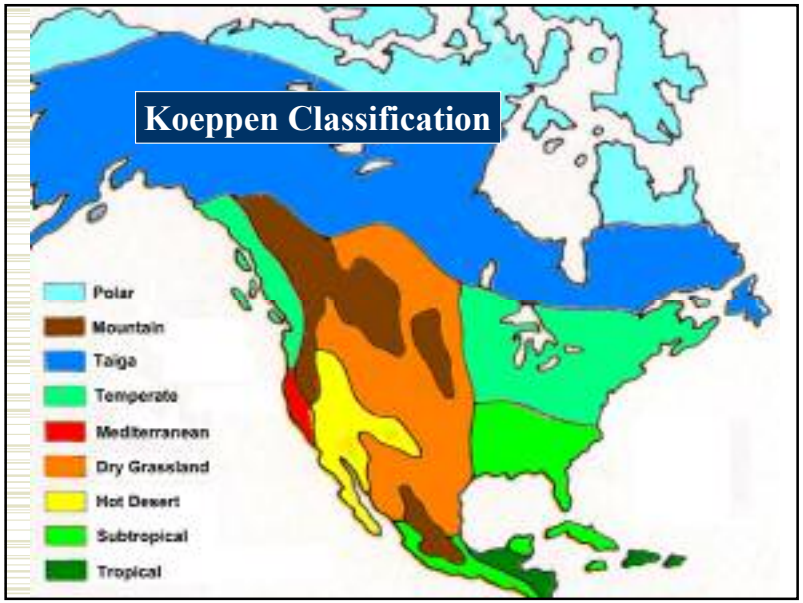
- We usually create buildings to provide an interior environment
- Hence, must be aware of exterior environment
- Many factors affect comfort, durability, energy
  - Shape,
  - Size,
  - Orientation,
  - Glazing use

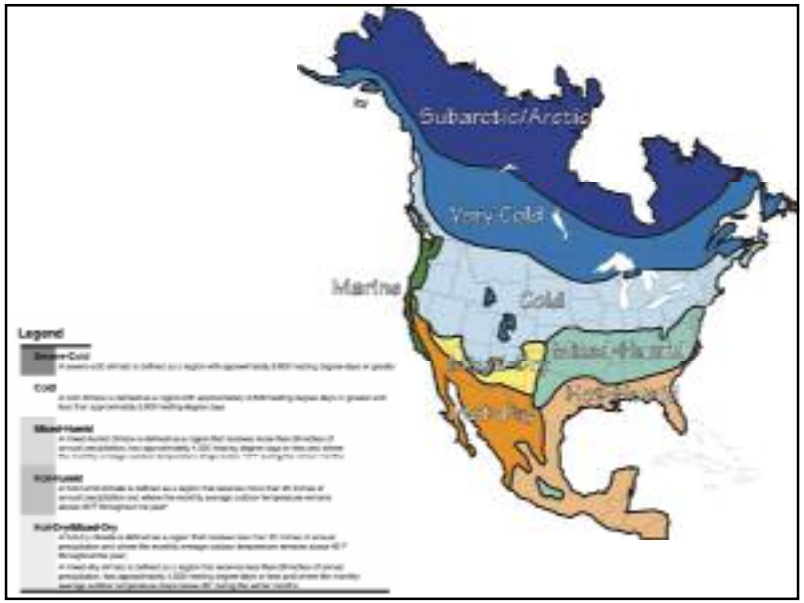
The role of the building enclosure

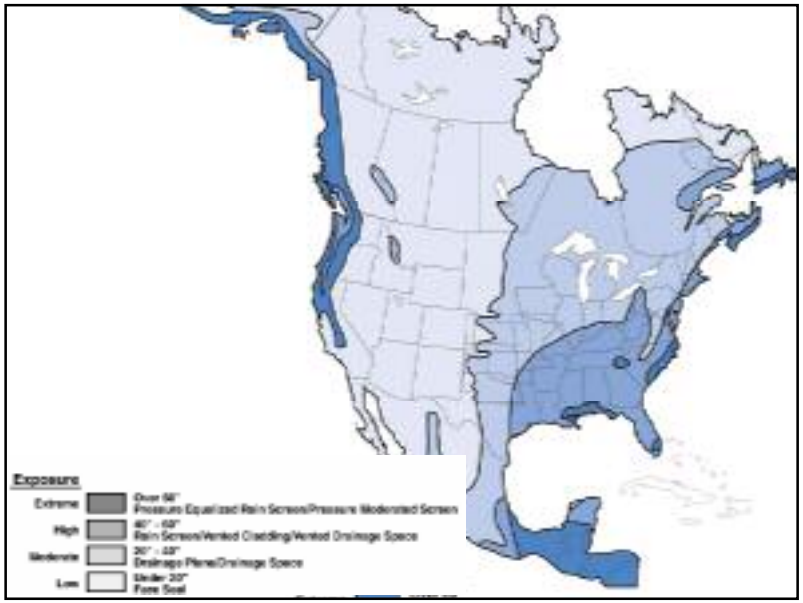


Climate Parameters

- Start with Climate
- Basic:
  - Temperature
  - Humidity
  - Sun
  - Rain
  - Wind







Climate Zone

- Vernacular experience indicates the type of buildings that are appropriate
  - Vernacular cant help us much with large buildings
- Primary Determinants for Buildings
  1. Temperature (summer and winter)
  2. Humidity (mostly summer)
  3. Rain (peak and annual)
  4. Wind (esp. winter and summer)

Climate Zone

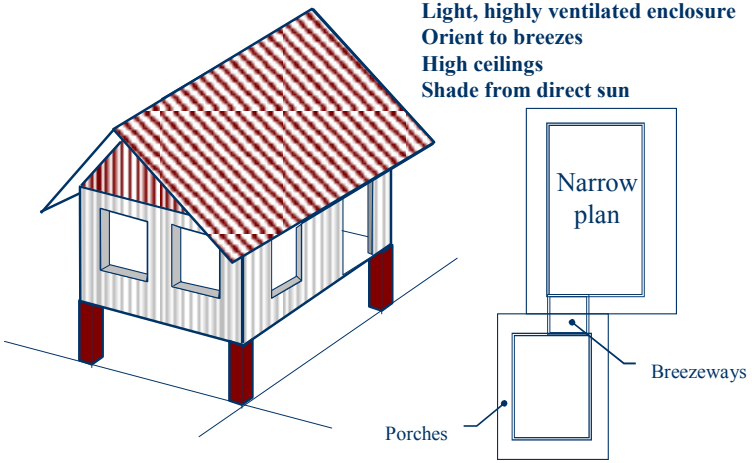
Climate Zones:

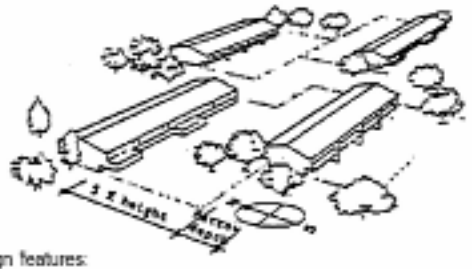
- Hot-Humid
- Hot-Arid
- Mixed
- Cold-Humid
- Cold-Dry

- Different strategies are used for each

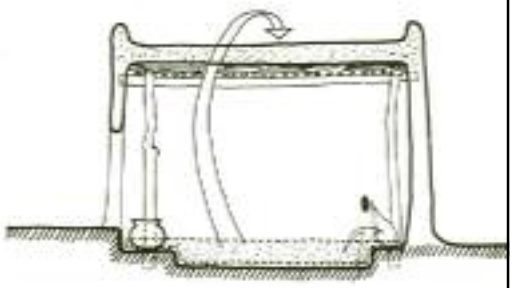
Hot-Humid

Light, highly ventilated enclosure
Orient to breezes
High ceilings
Shade from direct sun



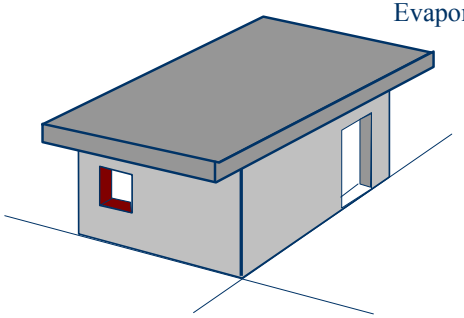


Main design features:
1. Main habitable rooms facing north - south
2. Wide spacing between dwellings to ensure good air movement
3. Narrow depth of dwelling to allow good air movement in all rooms
4. Overhanging roof to the north and south to provide protection from sun and rain and glare from the bright overcast sky
5. Trees to provide shade in the east and west walls without blocking air movement



Arid Climate (Hot and Cold)

High mass - moderate temperature
Few or shaded windows
Overhangs for solar shade
Evaporative cooling / solar chimney

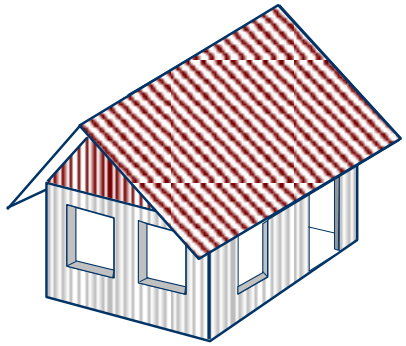


Towns:Narrow Streets

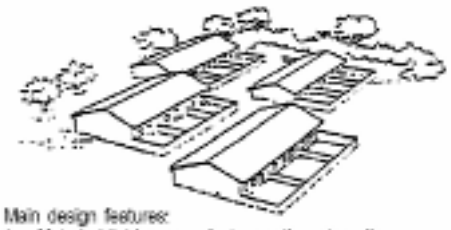
Stocky Plan

Main design features:
1. Compact planning with minimal external surface area
2. Windows of habitable rooms orientated to the north and south
3. Most windows facing onto patios, rather than the exterior of the group
4. Shaded pedestrian circulation
5. Small patios to provide sheltered private outdoor living space
6. Very limited planting

Cool-Moist



Collect sun in winter
Shade sun in summer
Shelter from rain
Shelter from winter wind



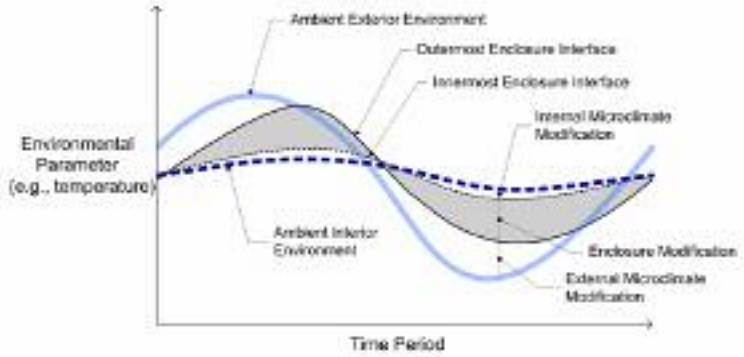
Main design features:

1. Main habitable rooms facing north and south
2. Controlled space between dwellings for air movement in the humid season
3. Planting and layout provide protection from hot - dry and cold winds
4. Walls to provide some shade to external spaces
5. Medium depth of building to allow temporary cross ventilation in the humid season

Climate Modification

- Building & Site (overhangs, trees…)
  - Creates microclimate
- Building Enclosure (walls, windows, roof…)
  - Separates climates
  - Passive modification
- Building Environmental Systems (HVAC…)
  - Use energy to change climate
  - Active modification

Climate Modification



Site/Microclimate

- SUN - heating or shade
- WIND – protection, cooling or ventilation
- TOPOGRAPHY - hill top versus valley
- PLANTING - sun, rain, wind protection
- Ponds, reflective snow, etc
- Orientation

MATRIX OF REGIONAL BIOCLIMATIC, SITE USE, AND SITE DESIGN FACTORS

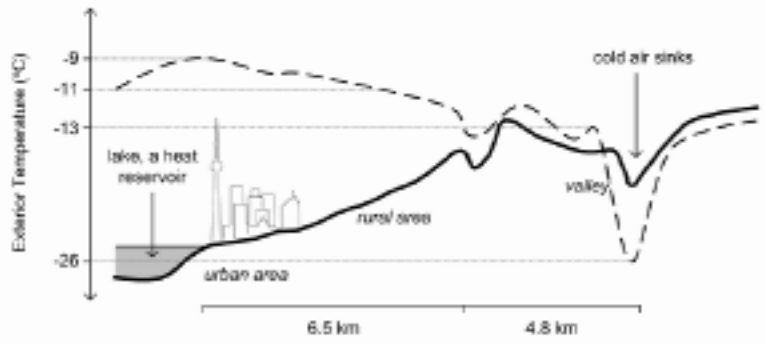
Use Type	Cold	Temperate	Hot	Hot-Humid
Orientation				
L to W Ratio				
BTUs/ S. F.				
Plants				
Grading				
Drainage				
Pavement				
Clearing				
Air Movem't				
Circulation				
Other...				

From: DOE Sustainable Technology Manual

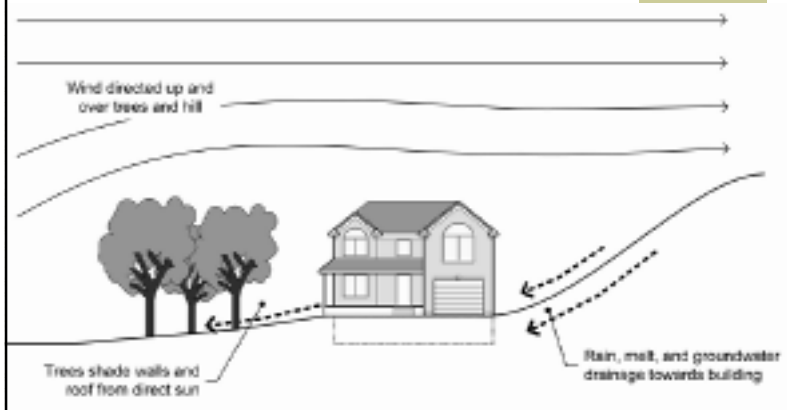
"Virtual" Enclosures

- Space can be formed by more than walls
- Climate can be modified by more than walls
- Multiple levels of control
  - climate
  - site
  - micro-climate
  - enclosure

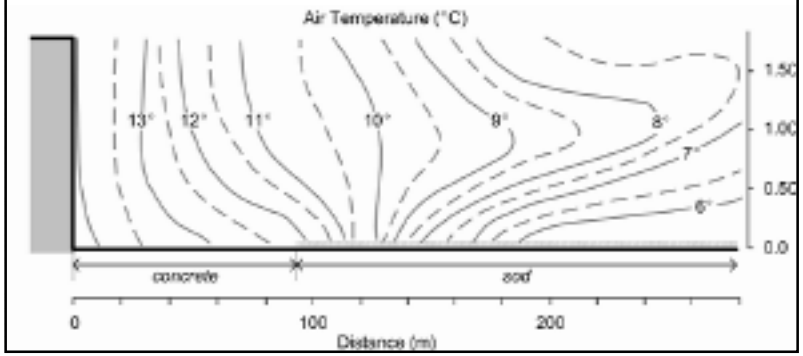
Regional microclimate



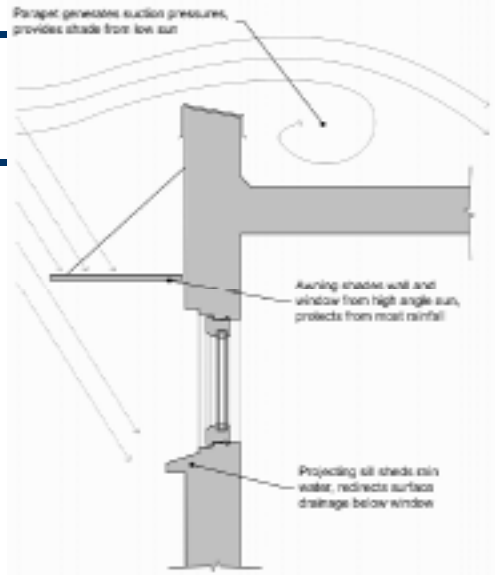
Site-specific microclimate



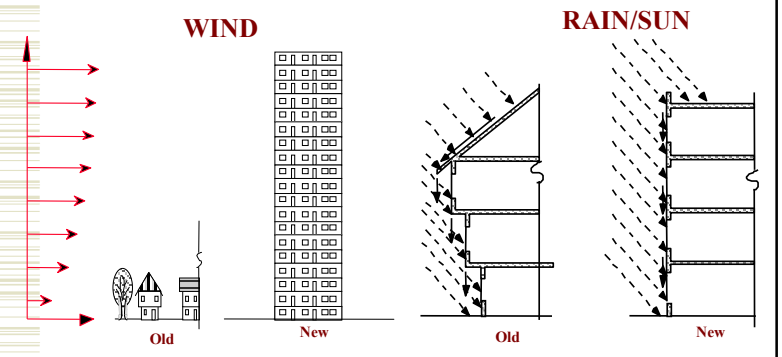
Building Microclimate



Building Microclimate

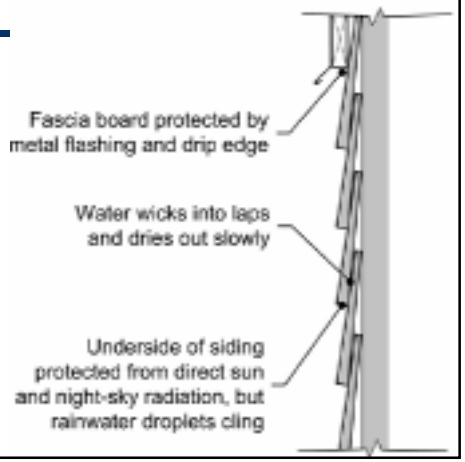


Gradients

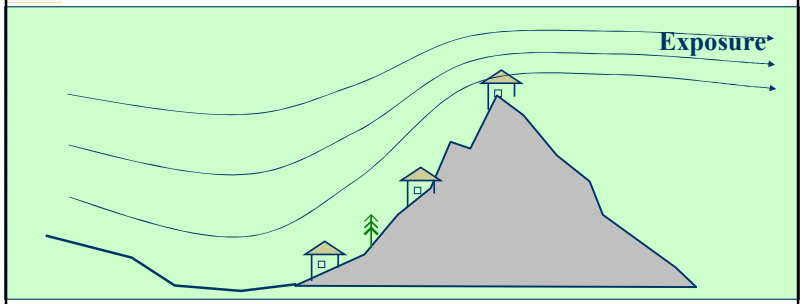


Overhangs - Surface - Drainage - Shelter

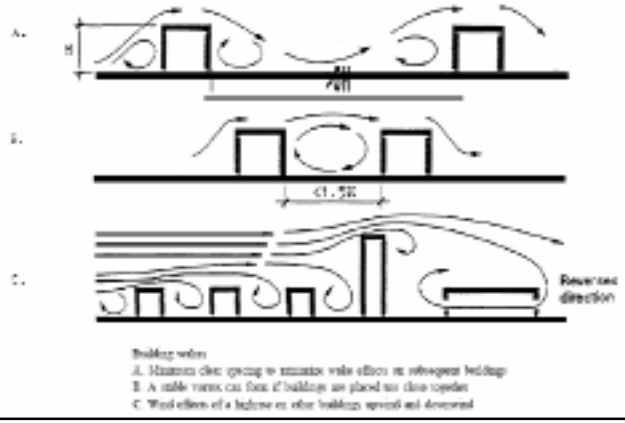
Nano-climate



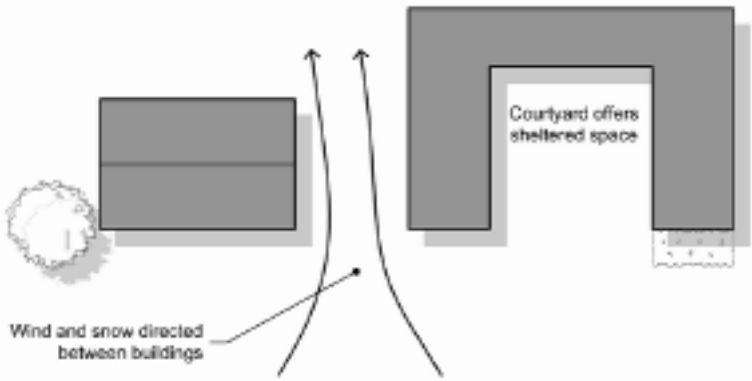
Wind – cooling, driving rain



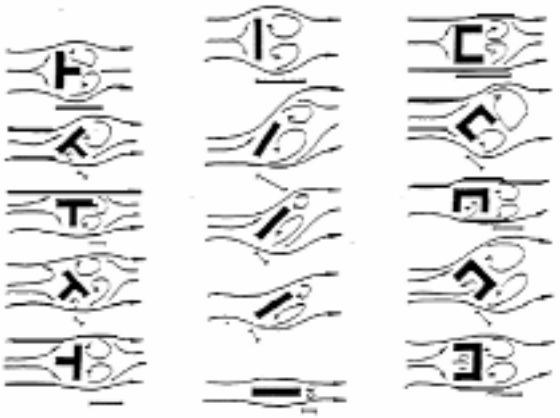
Wind



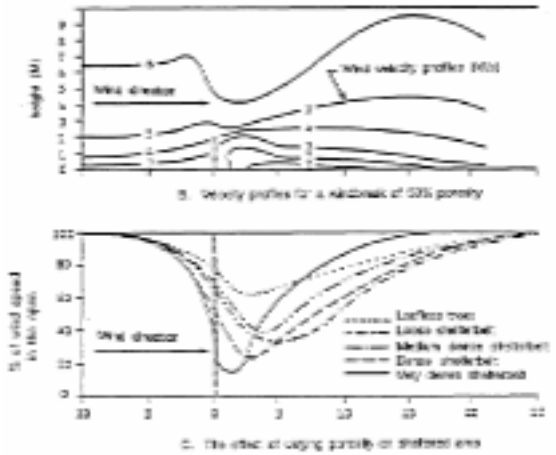
Building Specific Microclimate



Wind Channeling



Wind breaks



Size: Surface Area to Floor Area

- Size matters

1 - 12' storey

FA: 100 x 250 = 25000
SA: = 33400

Ratio 0.75:1

10 - 12' storeys

FA: 120 x120 = 144000
SA: = 72 000

Ratio 2:1

1 - 10' storey

FA: 30x 50 = 1500
SA: = 3100

Ratio 0.48:1

The higher the ratio, the less the enclosure & climate impact performance

Size

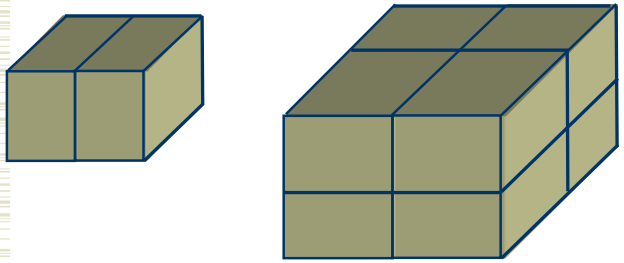
- Large floor area to enclosure area means
  - Less interaction with climate
  - Dominated by interior
- Smaller buildings and homes are enclosure dominated
  - Climate and enclosure critical

Internal Gains

- Increase in gains = heat loss less important
  - Commercial, assembly buildings have larger cooling problems
- Energy efficiency reduces this waste heat
  - Requires more insulation to reduce heating needs in cold weather
- Solar is a key gain to manage

Grouping buildings

- Grouping reduces heat loss/gain through shared walls

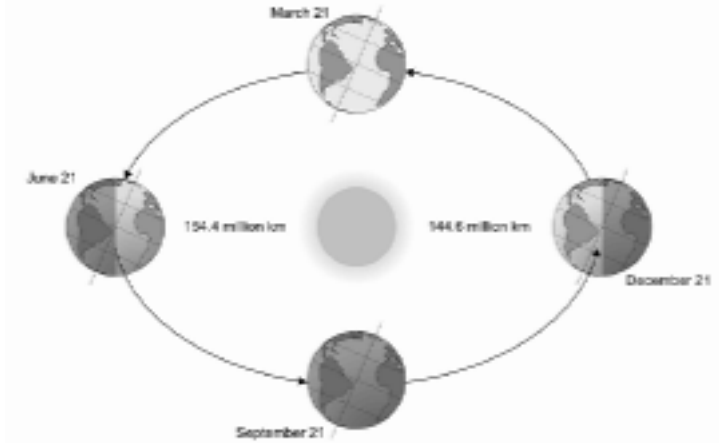


Grouping buildings

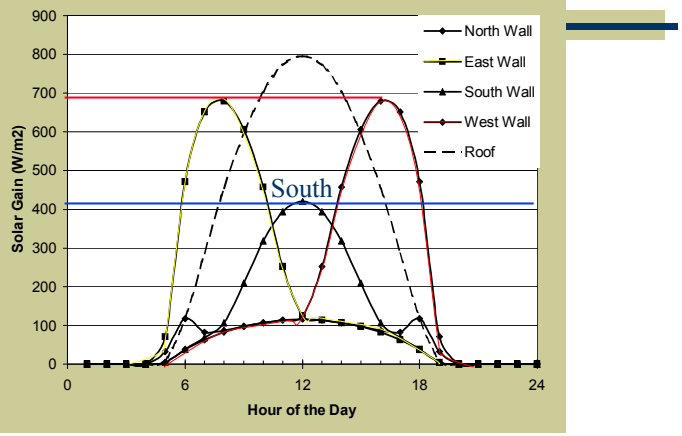
City planning has a large impact on the micro-climate

Large open solar absorbing and rain rejecting surfaces

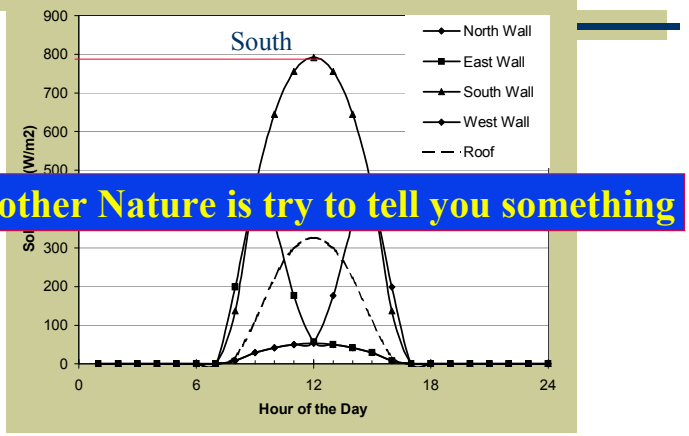
Sun is predictable



Solar Gains - July 21 @45 N



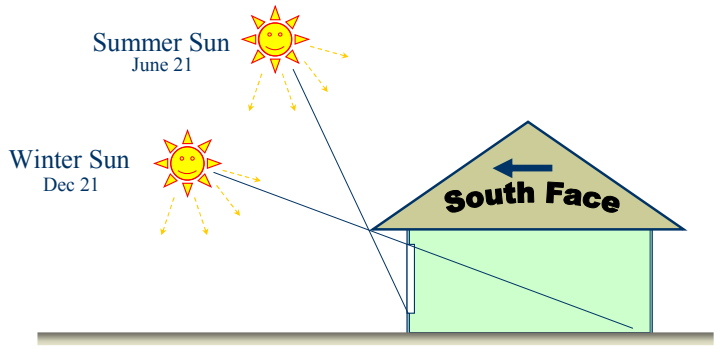
Solar Gains - Jan 21 @ 45 N



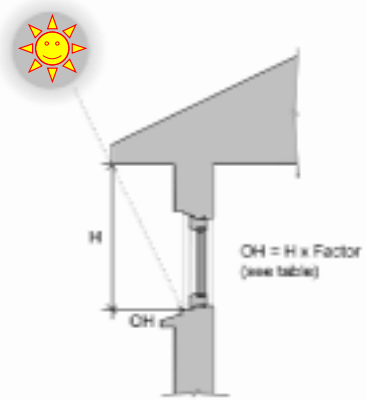
Mother Nature is try to tell you something

Solar Control - Shading

At high noon

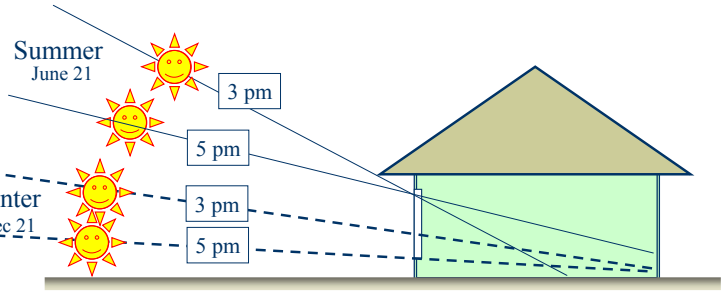


South Shading

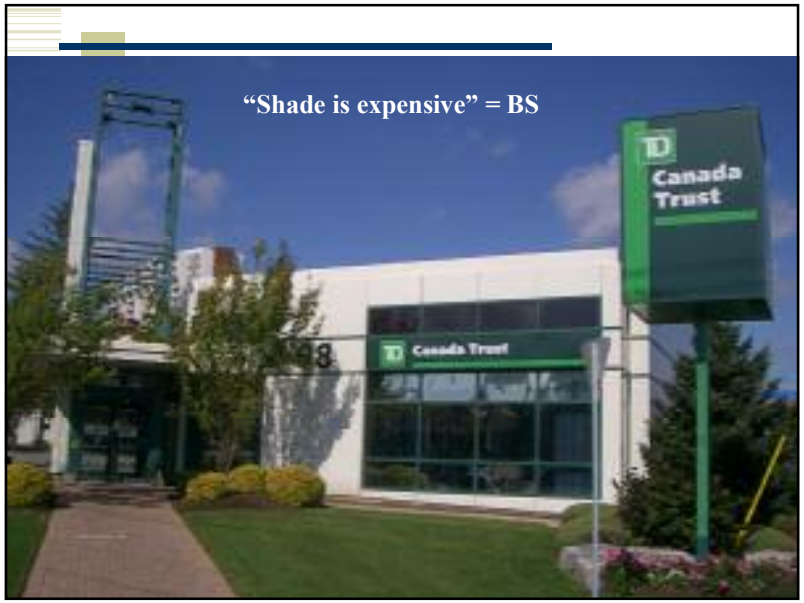


Degrees Latitude	June 21 Only	May 10 to Aug 1
28	0.09	0.18
32	0.16	0.25
36	0.22	0.33
40	0.29	0.40
44	0.37	0.50
48	0.45	0.59

East-West Shading



Overhanging Shade



Overhangs

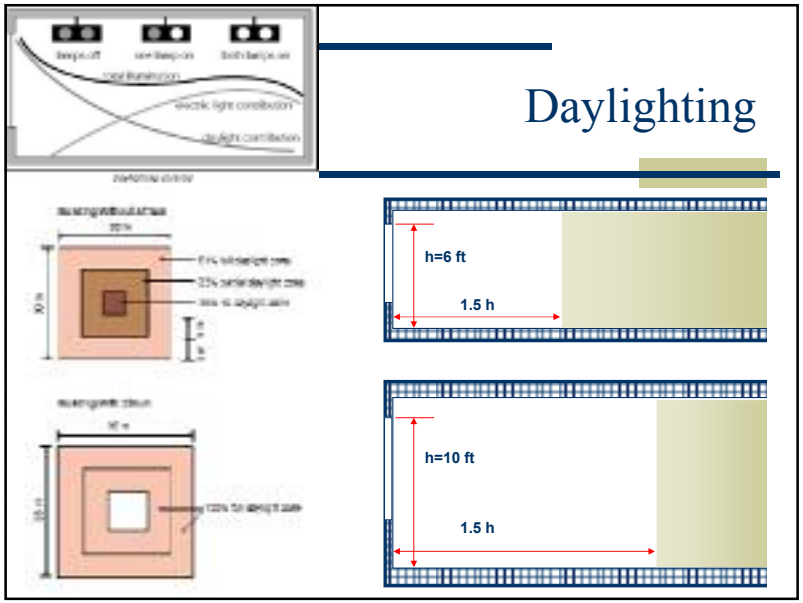
- "Are too expensive"?

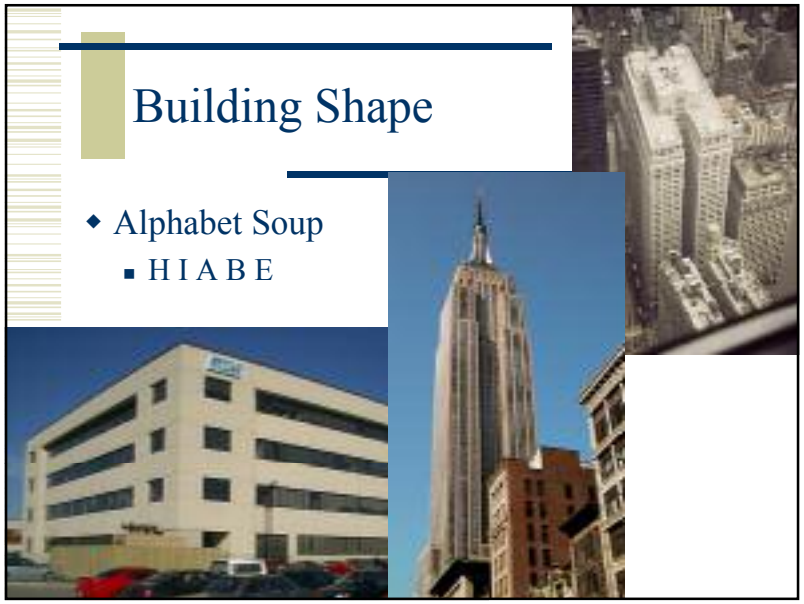
Anaheim, California

- "Plantings are a rural solution"??


Orientation, shape
e.g., Real Goods, Arkin Tilt

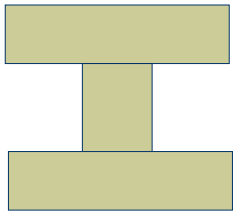

Daylighting glare control
Solar heating/cooling
Night ventilation


Daylighting
h=6 ft
1.5 h
h=10 ft
1.5 h


Building Shape
Alphabet Soup
H I A B E

Expanded Plans

- Better daylight, easier ventilation
- but more enclosure heat loss and gain and air leaks so still need better enclosure



Trade offs

- Large rectangular buildings have a reduced surface to volume ratio
  - Equals lower heat loss and gain
- Complex building shapes increase surface area
  - Heat loss and gain increase
  - Require better insulation and solar control

Structure

- Structure may provide thermal mass
  - Encourage interaction with the interior
    - (no carpets, exposed ceiling)
    - Allow inside temperature to swing
    - The better insulation the greater the mass effect
- Thermal mass allows one to
  - Shift peak loads
  - Collect solar heat or air cool for later

Website

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- Building Science Textbook at
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