Building Shape

Shape affects the efficiency of the envelope which can be defined as the ratio (A/E ratio) of the floor area to the building envelope area (for a specified usable floor space).
Envelope Efficiency

- Square footprint is more efficient than rectangular shape
Multistory buildings are more efficient that single story buildings. i.e. Building envelope design is more critical for single story buildings.
Effect of shape (of footprint) on efficiency of building envelope

Circle/square with symmetry about the two principal axes are the most efficient shapes
Orientation

In temperate climate, such as the US, orientation significantly affects microclimate, so that each side of a building has its own unique set of conditions.

Examples:

- South facing building envelope are much warmer than those facing north.
- Southern exposures can develop summer surface temperatures of 120-140°F even in mild climates. Has adverse effect on material, durability, sealant, coatings, etc.
- Southern exposure can be warm and dry in winter while the north side is damp and shady.
- Southern exposure walls will experience more cycles of freeze-thaw than the north wall because of the longer range of temp, fluct, see graph.

- See figure 2.22 in text
Winter Solstice
22 December, 40° North

- south slope 45°
- south vertical
- east slope 45°
- east vertical
- horizontal

north-facing slopes steeper than 22.5° receive no direct radiation on this data.
Vertinal Equinox
21 March, 40° North

Incident Energy (cal/cm² min)

east slope 45°
east vertical

horizontal
south slope 45°
south vertical

north slope 45°
north vertical
(NO DIRECT RADIATION)
Figure 3.3  Amount of solar radiation incident upon sloping surfaces as a function of time of day at latitude 40° N for the winter and summer solstice and the vernal and autumnal equinox. (From Gates, Man and His Environment: Climate.)
Elevation generally causes a decrease in temperature and an increase in wind speed.

Wind turbulence is lowest at the bottom of a hill and highest at the top.

Wooded areas reduce wind speed.

High-rise areas (downtown) create their own air flow pattern because of shape and temp differences between the sunny and shady sides.

Wind speed is affected by the surrounding bldgs.
The slope of a surface affects the amount of radiant heat absorbed, see graph.

Solar radiation on a H surface can elevate the temp 80-90°F above air temp.

At night, H surfaces lose heat by radiation cooling - a drop 20 below the air temp.

As a result, large variation in temp which affects thermal expansion/contraction ---> size and spacing of movement points. (Daytime solar heating/Nighttime radiation cooling)

As the air temp drops in the morning the RH near the surface rises and dew may form on the cool surfaces.
Fenestration

The area of **windows and doors** has a significant effect on the response of bldg envelope.

2. Thermal response (day-lighting) solar gain and the need for shading control.
3. Condensation/icing.
4. Air infiltrating ---> level of RH indoor.
5. Structural considerations - control joints and wall flexibility, see figure.
6. Sealant design

Typically a window/total area varies from 0 - 0.4 for single glazing and from 0 - 0.6 for double glazing. For window treatment and window setting, effects on aesthetics, see figures on next slide
Different Window Settings

(a) Surface Mounted
(b) Accentuated
(c) Deep Set and Narrow

Effect of Window Treatment on Structural Emphasis
(a) Vertical Emphasis
(b) Horizontal Emphasis
(c) Neutral Emphasis of Punched Windows

Effect of Openings on Wall Flexibility
(a) Decreasing Openings with Increased Shear
(b) Staggered Openings
(c) Uniformed Punched Windows
(d) Use of Window Strips to Separate Walls
(e) Use of Window Strips to Create Solid Cantilever Walls
(f) Offset Window Pattern
Joints and Sealants

**Joints** - to accommodate bldg movement due to:
- Dimensional changes (thermal/moisture)
- Structural loads (wind/earthquakes)
- Support settlement
- Long term deformation (creep)

**Sealants** - to provide air and moisture barriers
Joint Design - design considerations:

2. Type (butt, lap, fillet)
3. Location
4. Sealant type
5. Size (joint thickness)
6. Shape

Based on application
Joints and Sealants - continued

Joint Types

1. **Butt it** - most common for walls of control joints
   - W
   - W
   - W
   - W
   - Hourglass
   - Rect.
   - Square
   - Tape
   - Rods

2. **Fillet it** - between walls intersecting
   - 
   - 
   - 

3. **Lap it** - framing, glass, flashing
Joints and Sealants- continued

Locations of movement joints

1. At intersections
2. At corners
3. At openings
4. At intervals (spacing) in long walls –
   range 10’ ---> 40’
Sizing Movement Joints

\[ J = J_t + J_m + J_c \]

- \( J_t \): Joint thickness
- \( J_m \): Width to accommodate thermal movement
- \( J_c \): Width to accommodate construction tolerances
- \( J_c \): Width to accommodate moisture movement
Calculating Moisture Movement

- Shrinkage
  - Concrete/masonry
    - Reversible
      - Ignore
    - Irreversible

- Expansion
  - Clay brick
    - Irreversible (permanent)
  - Consider in joint design
Moisture Movement

<table>
<thead>
<tr>
<th>Material</th>
<th>Coefficient</th>
<th>Type of movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concrete, gravel aggregate</td>
<td>(-0.0003) to (-0.0008)</td>
<td>Shrinkage</td>
</tr>
<tr>
<td>Concrete, limestone aggregate</td>
<td>(-0.0003) to (-0.0004)</td>
<td>Shrinkage</td>
</tr>
<tr>
<td>Concrete, lightweight aggregate</td>
<td>(-0.0003) to (-0.0009)</td>
<td>Shrinkage</td>
</tr>
<tr>
<td>Concrete block, dense aggregate</td>
<td>(-0.0002) to (-0.0006)</td>
<td>Shrinkage</td>
</tr>
<tr>
<td>Concrete block, lightweight aggregate</td>
<td>(-0.0002) to (-0.0006)</td>
<td>Shrinkage</td>
</tr>
<tr>
<td>Face brick, clay</td>
<td>(+0.0002) to (+0.0007)</td>
<td>Expansion</td>
</tr>
</tbody>
</table>
Joints and Sealants- continued

Calculation of Thermal Movement

\[ M_t = C_t \Delta T L \]

- Coeff. of thermal expansion (T. 9.1)
- Diff. surface temp. bet. summer & winter
  - Usually = 200° F
  - Panel length or jct spacing in inches (typical 10-15)
Estimate of Joint Thickness
Joints and Sealants - continued

Sealant Stresses

- Extension
- Compression
- Longitudinal Shear
- Transverse Shear
Sealant Properties

2. Elasticity (movement capability)
3. Hardness
4. Substrate compatibility
5. Resistance to ultraviolet
6. Chalking
7. Dirt pickup
Sealant types and rating

**Sealant types** - polymer based:

2. Polysulfide
3. Wrethane
4. Silicone

For characteristics of different types: advantages and disadvantages refer to table 9.6 & 9.7 in text.

**Sealant rating** - based on % deformability:

7. High performance sealants +/- 50%, +100, -50%
8. Normal rating +/-25%