Principles of Building Enclosure Design

Three Primary Causes of Failure:

Design

Materials

Construction / Installation

Design

“Theory of the Enclosure”
* Proper sizing of elements
* Proper sizing of connections
* Consideration of expansion
* Waterproofing details
* Conveying details through adequate contract documents
* Accurate representation of Design intent to give contractors the chance of success.

Materials

Selection of appropriate material
* Ensuring material compatibility
* Consideration of the environment
* Intrinsic material weakness
* Quality control
* Chemistry compatibility

Installation / Construction

• “Implementation of the Design”
• Material substitutions
  * Improper installation
• Details
  * Poor workmanship
  * Poor quality control

Basic Principles

Physics

HEAT
Hot to Cold
Control Heat transfer

AIR
High to Low Pressure
Control passage of air into and out of the building enclosure

MOISTURE
Liquid water
Control and Disposal

VAPOR
High to Low Pressure
Diffusion - Permeability
Drying Capacity
Moisture Migration – Bulk Water

How is bulk water managed?
- Deflection
- Drainage
- Storage
- Barrier

Moisture Migration – Vapor

Vapor Pressure (or Partial Vapor Pressure)
- Pressure exerted by the water molecules in a mixture
- Vapor Pressure seeks equilibrium (High to Low)
- Vapor Pressure differential determines direction of vapor flow and may be opposite of air flow.

Saturation Vapor Pressure
- Vapor Pressure of air mass at dew point temperature

Moisture Migration – Air

Relative humidity (RH):
- RH = amount of water in air/max water air can hold
- RH = partial vapor pressure/saturation vapor pressure of an air mass at a prescribed temperature
- As the temperature of air increase so does its ability to hold more moisture, therefore RH is reduced
- Condensation occurs at 100% RH or Dew Point Temperature
Heat Flow

**Conduction (Thermal Bridges)**

**Radiation (Sun)**

**Convection (Air)**

Heat Flow - Conduction

- **Conduction** – the flow of heat through materials by direct contact

  Heat transfer to low heat materials

- **Radiation** – The process of heat emitting as particles or waves.
Heat Flow - Radiation

Heat Flow

- Convection – the transfer of heat through the circulation of air.

Heat Flow - Convection

Air Flow

Air flows from areas of high air pressure to areas of low air pressure, resulting in either wetting or drying.

Air pressure differences:
- Wind Effect
- Stack Effect
- Mechanical Effects

Air Flow – Mechanical Effect

When the volume of outside makeup air for the building mechanical system does not equal the volume of exhausted air.

+\(^{ve}\) pressure vs. -\(^{ve}\) pressure
Air Flow – Stack Effect
When temperature changes result in stack effects and expansion of cavity air.

Air Flow – Wind Effect
Sometimes from wind – limited source of air pressure differences as it is usually temporary and changes direction.

Control Strategies
- Air Barriers
- Vapor Barriers
- Waterproofing
- Cladding and Wall Systems
- Roof System Design

Performance Strategies
- Barrier
- Drainage
- Pressure equalization
- Redundancy
- Maintenance

High Performance Design
Green building is also known as a sustainable or high performance building.

Sustainability / Durability
- Sustainable Material Choice
- Design for Maintenance operations
- Safety of access at roofs and facade
- Durable Systems, with Redundancy
- Site specific design
- Environment specific design
- Take Responsibility for Design and Construction