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1. Introduction

**Definition**

The building envelope is the *enclosure*, *barrier*, and *separator* of the *outdoor* environment and the desired *indoor* environment. It is also the protector from the undesired outdoor threats of danger.
Human Requirements for Buildings

- Sensitivity to thermal changes and air movements
- Sensitivity to vibrations and noise
- Problems of vision, within a building and looking out from a building
- Social aspects and location
- Safety
Requirements for a Barrier

1. Durability
2. Strength
3. Rigidity
4. Control of heat flow (insulation)
5. Control of air flow (air barrier)
6. Control of vapor flow (vapor)
7. Control of rain penetration
8. Control of solar and other radiation
9. Control of sound transmission
10. Control of fire protection
11. Aesthetically pleasing
12. Economical requirements
Envelope as a Barrier between the outside and the Inside

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Classifications - Walls

- **Permeable** such as brick veneer
- **Impermeable** such as glass

- **Single-wythe**
  - Stone, brick, block masonry/concrete
  - Glass/metal framing

- **Multi-wythe**
  - Brick veneer (skin) with metal stud backup
  - Brick veneer (skin) with block backup
  - Stone cladding (skin) with block backup
Types of Building Envelopes

- There is a variety of types of building envelopes depending on building plan, use and location.
- In the North east of the US most of the walls are cavity walls because of the high demand of thermal resistance and water penetration.
Wall Types

Use of a variety of materials for building envelope

Brick with its rich colors and textures offers attractive and durable material for building envelopes
Wall Types - Continue

- Brick Veneer
- Note the light and dark brown colors of the brick
Wall Types - Continue

- Glazed brick offers attractive and durable cladding of buildings

- Glazed concrete blocks. Note the different patterns and colors
Stone cladding is popular for high-rise buildings. Surface is polished and therefore impermeable. Has high resistance to rain penetration.
Loadbearing stone masonry walls. This goes back to the beginning of the century with massive gravity wall construction.
Wall Types - Continue

- Stucco is commonly used for housing and residential construction. Metal lath is used to provide resistance to shrinkage cracking.

- Drivette system & EFIS. A heavy duty stucco with a rough durable surface.
Wall Types - Continue

- Glass block. Note the confined effect of the steel frame.
- Wood cladding. Note the flashing at the window top.
Wall Types- Continue

- A variety of building envelope materials can be noted. Note that the brick is painted.

- A combination of cladding- brick, block, stucco & vinyl
Design Considerations

1. **Architectural**
   - Building layout and shape
   - Efficiency
   - Fenestration (windows/lighting)
   - Detailing

2. **Structural**
   - Loads
   - Resistance/material
   - Serviceability
   - Strength
   - Relative moments
   - Control/Joints

1. **Environmental**
   - Thermal
   - Moisture/air
   - Sound
   - Fire

2. **Mechanical**
   - Heat
   - Ventilation
   - Air-conditioning
Adequate Design

Should provide a building with the following features:

- Structurally sound
- Functional
- Initial low cost
- Low maintenance cost
- Aesthetically pleasing
Components of Building Skin

- **Material** (brick, block, concrete, stone, glass, wood, stucco)
- **Windows** - type, size and distribution
- **Movement joints** - to accommodate thermal and moisture expansion
Building Problems

(Mainly related to inadequate performance of building envelope)

“Building problems are like pregnancies; if you want to prevent them it helps to know the cause.”

- Diagnostic (forensic) engineering
- Remedial Action
  - Restoration
  - Rehabilitation
  - Repair
  - Retrofit
- Factors
  - Function/expected performance
  - Time
  - Budget
Inadequate Performance “Problems”

1. Spalling
2. Cracking
3. Rain penetration
4. Moisture problems
5. Efflorescence
6. Deficient thermal resistance
   - High energy cost
7. Collapse

Causes
- Deficiency in design
- Deficiency in construction
- Deficiency in maintenance