Building Envelope

Nolan Day
WR Meadows
The American Association of Home Inspectors found mold in 38% of the homes they inspected.

Per the E.P.A:
- 70-90% of our lives are spent indoors.

Moisture

MOLD
GOOD
BAD
UGLY

- Structural and Architectural Damage
- Health Concerns
  - Productivity
  - Illness
  - Death
- Energy Costs
  - Resale
  - Marketibility
Overview

Building Envelope
What is an Air Barrier System?

An Air Barrier System is a system of building components within the building envelope designed and installed in such a manner as to stop the flow of air into and through the building envelope system.

Why use Air Barrier Systems?

The U. S. Government now requires them on federal building projects.
The U.S. Department of Energy has determined that 40% of a buildings energy consumption to heat and/or cool the building is due to air leakage.
The use of Air Barrier systems result in:

- Reduced building energy consumption
- Reduced building heating and cooling costs
- Reduced fossil fuel consumption
- Reduced pollution emissions
- Reduction of the Greenhouse Effect
- Improved indoor air quality
- Reduced building envelope system problems

The U.S. Department of Energy has instituted a program of goals to reduce building energy consumption by 25% by the year 2010 and by 50% by the year 2020.
Cross-cutting Issues Related to Building Envelope

Heat Transfer through Building Envelope

- U-factor
- R-values
- Thermal Mass
- Heat Capacity
Heat Transfer through Building Envelope

- U-factor
- R-values
- Thermal Mass
- Heat Capacity
Flashing Details Are Very Important

Heat Transfer through Building Envelope

- U-factor
- R-values
- Thermal Mass
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Heat Transfer through Building Envelope

- U-factor
- R-values
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![Diagram showing temperature variations over time with annotations for trans-lag and damping.](image-url)
Heat Transfer through Building Envelope

- U-factor
- R-values
- Thermal Mass
- Heat Capacity

Minimum R-values from ASHRAE 90.1

<table>
<thead>
<tr>
<th>Climate Region</th>
<th>Hot and Dry</th>
<th>Hot and Humid</th>
<th>Temperate and Humid</th>
<th>Cold and Dry</th>
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<tr>
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<td>(Boston)</td>
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<td>Walls, Below Grade</td>
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<td>R-7.5@12 in</td>
<td>R-7.5@12 in</td>
<td>R-10@36 in</td>
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Note: "ci" means continuous insulation, "NR" means no requirement.
### Recommended R-values for schools

<table>
<thead>
<tr>
<th>Climate Region</th>
<th>Hot and Dry</th>
<th>Hot and Humid</th>
<th>Temperate and Humid</th>
<th>Cool and Humid</th>
<th>Cold and Humid</th>
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<tbody>
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<td>R-13+3.8 ci</td>
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<td>R-13+7.5 ci</td>
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<table>
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<tr>
<td>Mass</td>
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<td>R-8.3 ci</td>
<td>R-8.3 ci</td>
<td>R-10.4 ci</td>
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<td>Steel Joist</td>
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<td>R-30</td>
<td>R-30</td>
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<table>
<thead>
<tr>
<th>Slab-On-Ground Floors</th>
<th>R-10@24 in.</th>
<th>R-10@24 in.</th>
<th>R-10@36 in.</th>
<th>R-10@36 in.</th>
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</thead>
<tbody>
<tr>
<td>Unheated</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Heat</td>
<td>R-7.6@12 in.</td>
<td>R-7.6@12 in.</td>
<td>R-10@36 in.</td>
<td>R-10@36 in.</td>
</tr>
</tbody>
</table>

Note: "ci" means continuous insulation. "NR" means no requirement.
Moisture Control

- Vapor migration occurs from the warm humid side to the cool dry side of the construction where it can condense and lead to mold growth.
- Install vapor barriers on the warm, moist side of framed walls, doors and roofs:
  - Outside of the assembly in humid climates.
  - Inside the assembly for non-humid climates.
- Provide adequate ventilation in attics, crawl space, wall cavities (only in extreme climates).

Air Infiltration

Strategies for reducing infiltration:

- Continuous air barrier on roof and walls.
- Windows/doors with low rates of infiltration.
- Weatherstripping.
- Using air lock entries in cold climates.
Air Infiltration

- Vestibule doors should be at least 7 feet from the school’s main entrance.
- Vestibule doors should have self-closing devices.

Insulation Recommendations – Wood Framed Walls

- Install a minimum of R-13 cavity insulation in all climates.
- In the Cool and Humid, Cold and Humid, and Cool and Dry climates, also install R-7.5 insulating sheathing.
Insulation Recommendations – Metal-Framed Walls

- Install a minimum of R-13 cavity insulation in all climates.
- In the Hot and Humid and Hot and Dry climates, also install R-3.8 continuous insulating sheathing. In the other climates, use R-7.5 continuous insulating sheathing.

Insulation Recommendations – Mass Walls

- Install R-7.6 continuous insulation in the Hot and Dry and Hot and Humid climates.
- Upgrade this to R-9.5 in the Temperate and Humid climate, to R-13.3 in the Cool and Humid and Cool and Dry climates, and to R-15.2 in the Cold and Humid climate.
- Higher levels of insulation may be appropriate depending on local climate.
Insulation Recommendations – Mass Walls

Building Envelope

THE HYDROLOGIC CYCLE AND MOISTURE MIGRATION
### Laws of Physics

**Vapor Pressure, as a Function of Temperature & Relative Humidity**

<table>
<thead>
<tr>
<th>Relative Humidity</th>
<th>100</th>
<th>90</th>
<th>80</th>
<th>70</th>
<th>60</th>
<th>50</th>
<th>40</th>
<th>30</th>
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<tr>
<td>100</td>
<td>0.948</td>
<td>0.854</td>
<td>0.798</td>
<td>0.663</td>
<td>0.569</td>
<td>0.474</td>
<td>0.379</td>
<td>0.284</td>
<td>0.189</td>
<td>0.085</td>
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<tr>
<td>90</td>
<td>0.639</td>
<td>0.621</td>
<td>0.551</td>
<td>0.482</td>
<td>0.414</td>
<td>0.344</td>
<td>0.275</td>
<td>0.209</td>
<td>0.138</td>
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<tr>
<td>80</td>
<td>0.506</td>
<td>0.455</td>
<td>0.405</td>
<td>0.357</td>
<td>0.303</td>
<td>0.263</td>
<td>0.202</td>
<td>0.152</td>
<td>0.101</td>
<td>0.051</td>
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<td>75</td>
<td>0.429</td>
<td>0.386</td>
<td>0.343</td>
<td>0.300</td>
<td>0.258</td>
<td>0.214</td>
<td>0.172</td>
<td>0.129</td>
<td>0.086</td>
<td>0.043</td>
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<tr>
<td>70</td>
<td>0.362</td>
<td>0.326</td>
<td>0.290</td>
<td>0.253</td>
<td>0.217</td>
<td>0.181</td>
<td>0.145</td>
<td>0.108</td>
<td>0.072</td>
<td>0.036</td>
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<tr>
<td>65</td>
<td>0.305</td>
<td>0.274</td>
<td>0.244</td>
<td>0.213</td>
<td>0.183</td>
<td>0.152</td>
<td>0.122</td>
<td>0.091</td>
<td>0.061</td>
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<tr>
<td>60</td>
<td>0.256</td>
<td>0.230</td>
<td>0.205</td>
<td>0.179</td>
<td>0.153</td>
<td>0.128</td>
<td>0.102</td>
<td>0.077</td>
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<td>55</td>
<td>0.214</td>
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<td>50</td>
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**Note:** The values represent vapor pressure in millimeters of mercury (mmHg).
BUILDING EXTERIOR WALLS 30 YEARS AGO

VENEER (PROTECTIVE LAYER)
CAVITY (DRAINAGE LAYER)
INSULATION (INSULATION LAYER)
DAMPPROOFING (DRAINAGE PLANE)
CMU (STRUCTURAL LAYER)

RIGID INSULATION AND DAMPROOFING PROVIDE A PRETTY GOOD AIR BARRIER AND VAPOR RETARDER SYSTEM
CMU WILL NOT DEGRADE WHEN SUBJECTED TO FAIRLY HIGH MOISTURE LEVELS
MOISTURE WILL MIGRATE OUT OF CMU AS QUICKLY AS IT IS ABSORBED INTO IT

INTERIOR
HEATED AND COOLED ENVIRONMENT

DEW POINT RANGE
Building Envelope Systems Today

VENIER (PROTECTIVE LAYER)
CAVITY (DRAINAGE LAYER)
MOISTURE BARRIER (DRAINAGE PLANE)
INSULATION (INSULATION LAYER)
LGMF & GWB (STRUCTURAL LAYER)
VAPOB BARRIER (VAPOBAR LAYER)

BRICK VENIER IS A "RESERVOIR" CLADDING MATERIAL. IT WILL HOLD MOISTURE AND WHEN HEATED BY SOLAR RADIATION, WILL CREATE EXTREME TEMPERATURES AND VAPOB PRESSURE LEVELS IN THE CAVITY SPACE.

GWB IS NOT PROTECTED FROM MOISTURE INTRUSION IN ITS GASEOUS FORM.

GWB ABSORBS AND RETAINS MOISTURE AND WILL DEGRADE OR DETERORATE UNDER FAIRLY LOW MOISTURE CONTNENT LEVELS AS WELL AS HOST MICROBIAL GROWTH.

LGMF SYSTEMS WITH GWB AND VAPOBAR BARRIERS CREATE CHAMBERS FROM WHICH VAPOB CANNOT BE EASILY VENTED. LGMF MEMBERS WILL CORRODE WHEN EXPOSED TO HIGH RH LEVELS.

INTERIOR
HEATED, COOLED AND HUMIDITY CONTROLLED ENVIRONMENT

DEW POINT RANGE
Epoxy Injection Ports should be spaced appropriately.
Example of what can happen when air flow relocates a building envelope system’s dew point into the veneer layer.
### Air And Vapor Barriers
- Metal
- Glass
- Modified bituminous self adhering membrane
- Modified bituminous torch grade membrane
- Foil back urethane insulation: 1” or thicker
- Foil back gypsum board: 1/2” or thicker
- Certain asphalt impregnated fiber board
- Certain fluid applied membranes
- Sealants ( Caulking )
- Plastic
- Certain trowel applied modified asphalt emulsions
- Certain urethane insulation materials
- Certain foam insulation

### Materials that do not meet the requirements to be an Air Barrier
- Plywood sheathing: Less than 3/8” thick
- Reinforced non perforated polyolefin
- Tempered hardboard
- Asphalt saturated felt paper: 15# and 30#
- Plain fiberboard
- Spunbonded olefin film
- Vermiculite insulation
- Concrete masonry units

### Air Barriers
- Plywood sheathing: 3/8” or thicker
- Smooth surface roofing membrane
- Cement board: 1/2” or thicker
- Extruded Polystyrene: 1 1/2” or thicker
- Gypsum board ( Use moisture resistant board )
- Concrete
- Phenolic insulation board: 15/16” or thicker
- Flakewood board
- Particle board
- Expanded polystyrene
- Glass fiber rigid insulation board
- Asphalt impregnated fiberboard
- Glasswool insulation
- Cellulose insulation
- Brick
Wall order of assembly

• Air barriers must be installed on the warm side of the insulation. This way, any moisture that forms will occur on the outside of the air barrier. The moisture will be reabsorbed into the exterior atmosphere or drained away through flashings and/or floor slabs.

• Thermal insulation must be in direct contact with air barrier membrane, installed tight. Direct contact between insulation and the air barrier prevents the generations of convective air currents that can lead to water vapor and condensation problems.

Wall order of assembly

• In hot and humid, air flow retarders should be installed on the exterior of the building, and building assemblies should protect the outside wall surface from getting wet. Any moisture should be allowed to drain away or dry toward the interior, using permeable interior wall finishes and avoiding wall coverings.
Problems Related To Slab Moisture

DUSTING - water trowled into surface
SCALING - high permeability in surface
BLISTERING - premature finishing discolor
CURLING - differential drying/curing
CRACKING - excess water & evaporation

Subgrade preparation

Excess water leaves through top & bottom
Granular fill
Subgrade preparation

Excess water can’t leave through bottom of slab

Vapor barrier under slab

Water cure can lead to:

Slab Curl
Consider Durability

- **ASTM E 1993**
  “Standard Specification for Bituminous Water Vapor Retarders used in Contact with Soil or Granular Fill under Concrete Slabs.”
INSTALLATION TIMING IS CRITICAL
COMPLETE SECOND COURSE PANEL POSITIONING ON ADDITIONAL COURSES.

3. WHEN TRIMMING, LAY PANELS FLAT AND CUT LONGITUDINALLY WITH FLUTES, OR SWAB CROSS-CUT FLUTES WITH WATER BEFORE HANDLING.

8. PROTECT PANELS AGAINST PRECIPITATION AND CONSTRUCTION DAMAGE AT ALL TIMES BEFORE AND DURING BACKFILL.

MADE IN U.S.A.