North Carolina State Buildings Efficiency Conference

Building Envelope

Sponsored by:

State Energy Office and State Construction Office
NC Department of Administration

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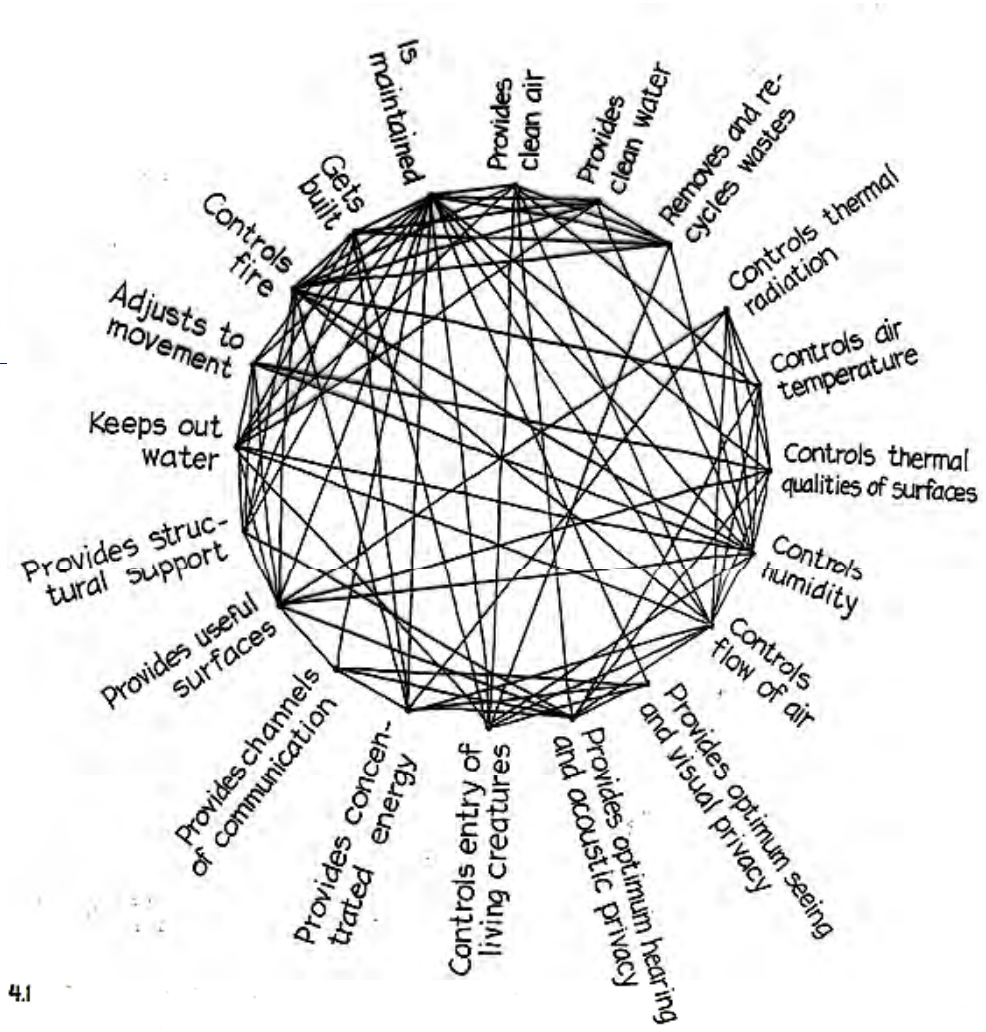
Question for Today

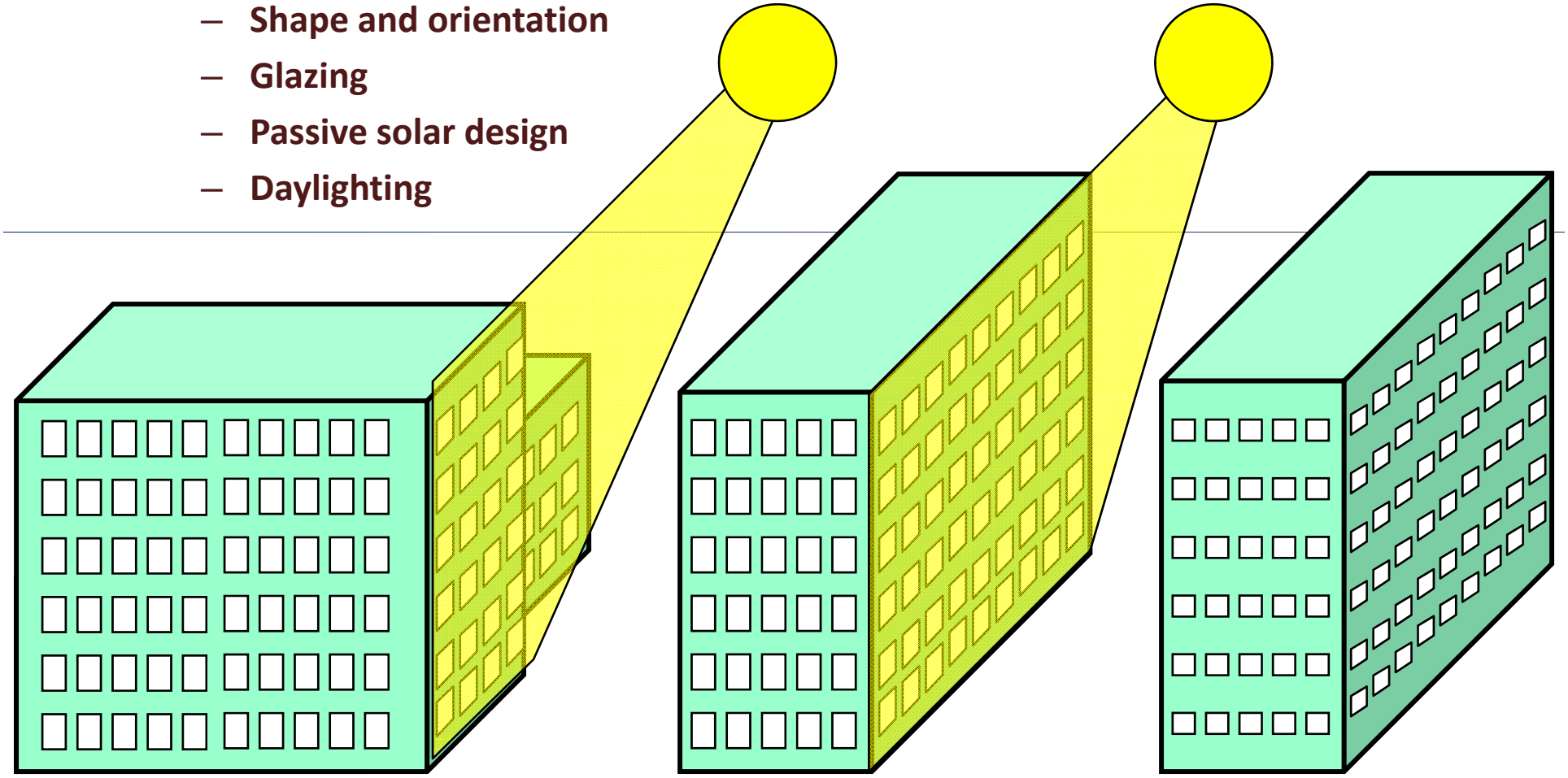
Given the mandates of Senate Bill 668, how do you design the building envelope to optimize energy efficiency?

What are the functions of the Building Envelope?



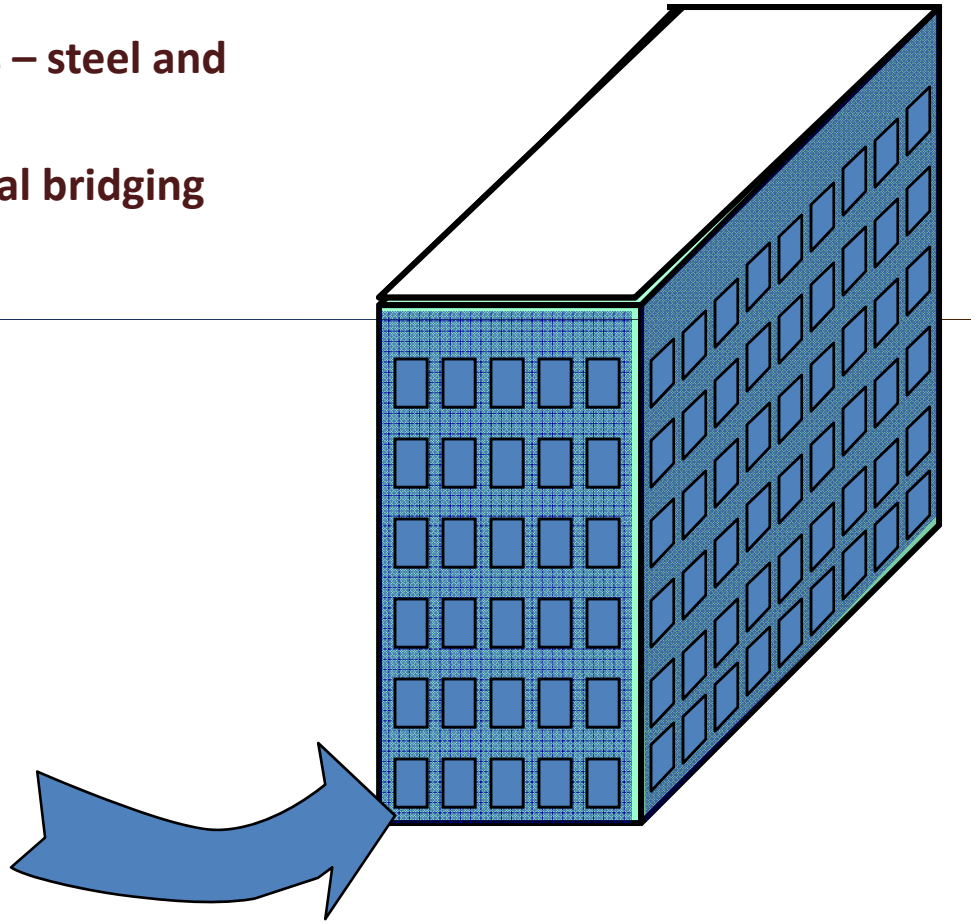
Building Envelope – Key Targets

- **Building design**
  - Shape and orientation
  - Glazing
  - Passive solar design
  - Daylighting

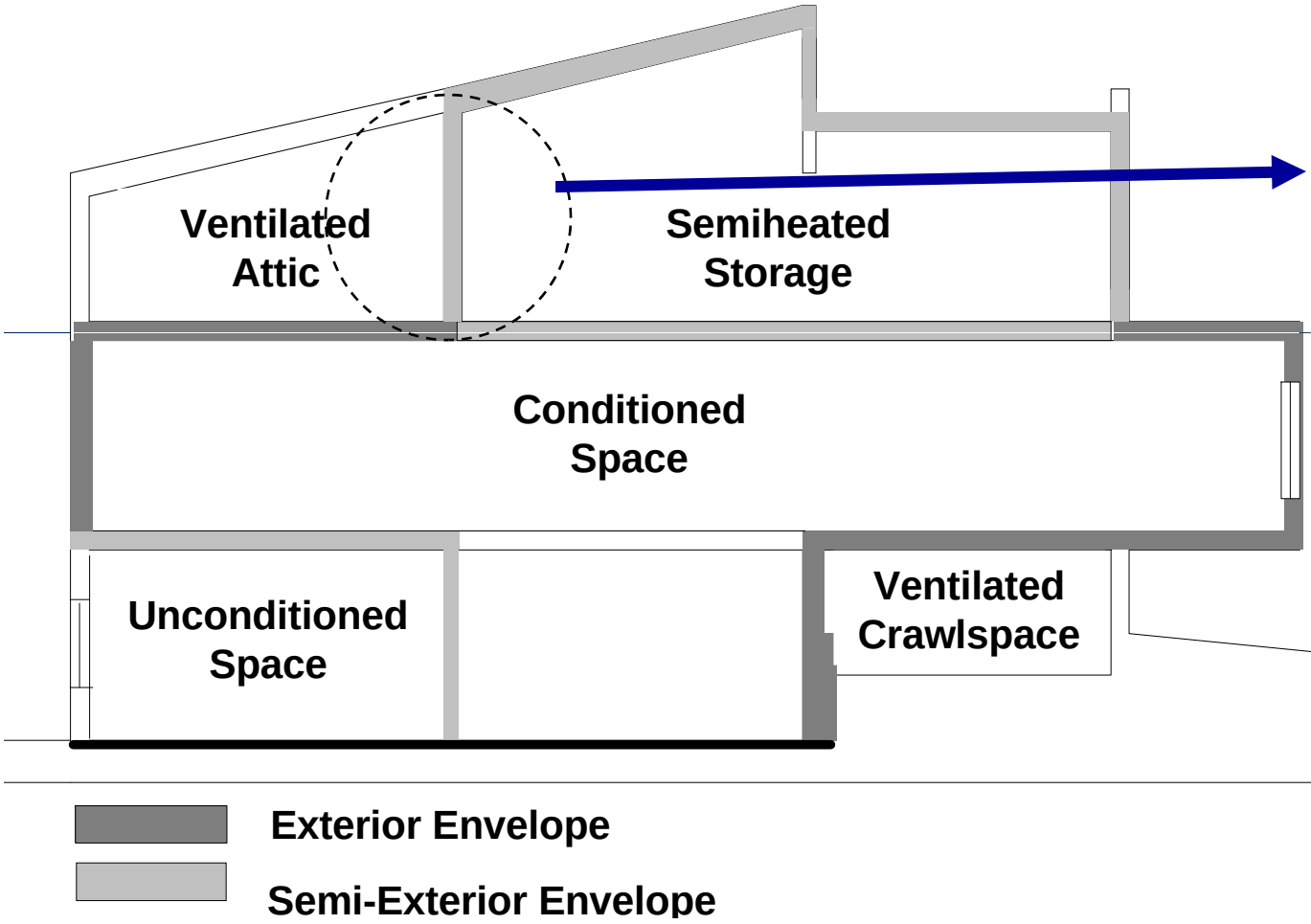


Building Envelope – Key Targets

- **Building structure and finishes**
  - Typically highly conductive materials – steel and concrete
  - Insulate on exterior to reduce thermal bridging
  - Reflective finishes reduce solar gains
- **Insulation**
  - Reduces conductive losses
  - R-values
  - Installation
- **Fenestration (glazing)**
  - Quantity and orientation
  - U-factor
  - Solar Heat Gain Coefficient
  - Shading features
- **Air leakage/ ventilation control**



Defining the Building Envelope

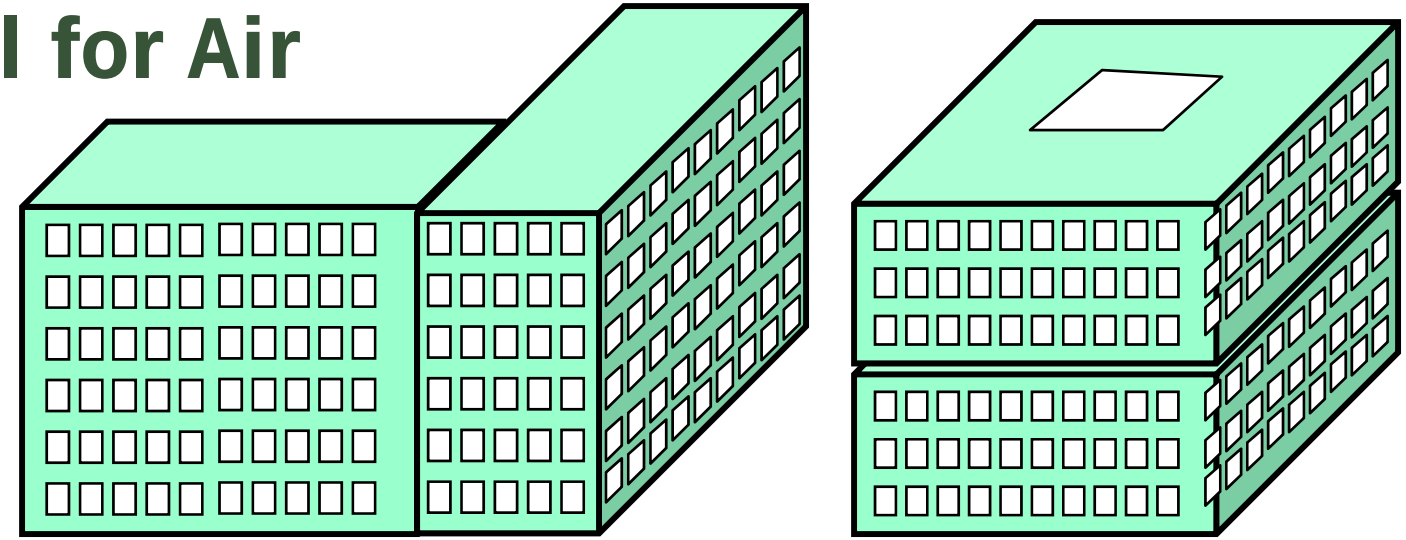


To be effective, insulation must be in contact with an air barrier material, such as drywall or other sheet material, with penetrations and edges sealed

Building Shape

- Fit the site and program
- Aesthetics
- Exposure to Environment

- Surface to Volume Ratio
- Potential for Air Leakage



Glazing Area Percentage

- Daylighting potential
- Connection to exterior/ Views
- Aesthetics

- Heat gain and loss
- Comfort
- HVAC size
- Maintenance

Operable Windows?

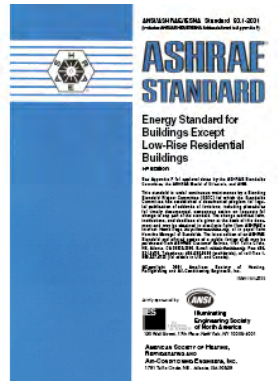
- Natural ventilation
- "Manual" economizer
- Perceived control

- Comfort control
- Humidity control
- HVAC balancing
- Other issues

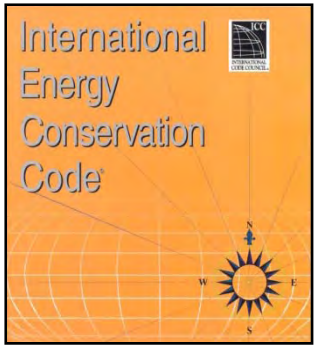
Insulation

- Not a major issue?
- Pretty much standardized
- Comfort
- Heat loss and gain
- Maintenance/ condensation

Two Sets of Requirements – multiple pathways to compliance



- **Chapter 5: Commercial Energy Efficiency**
  - **ASHRAE 90.1-2004 in the North Carolina energy code**
  - **IECC 2006 – with local amendments**



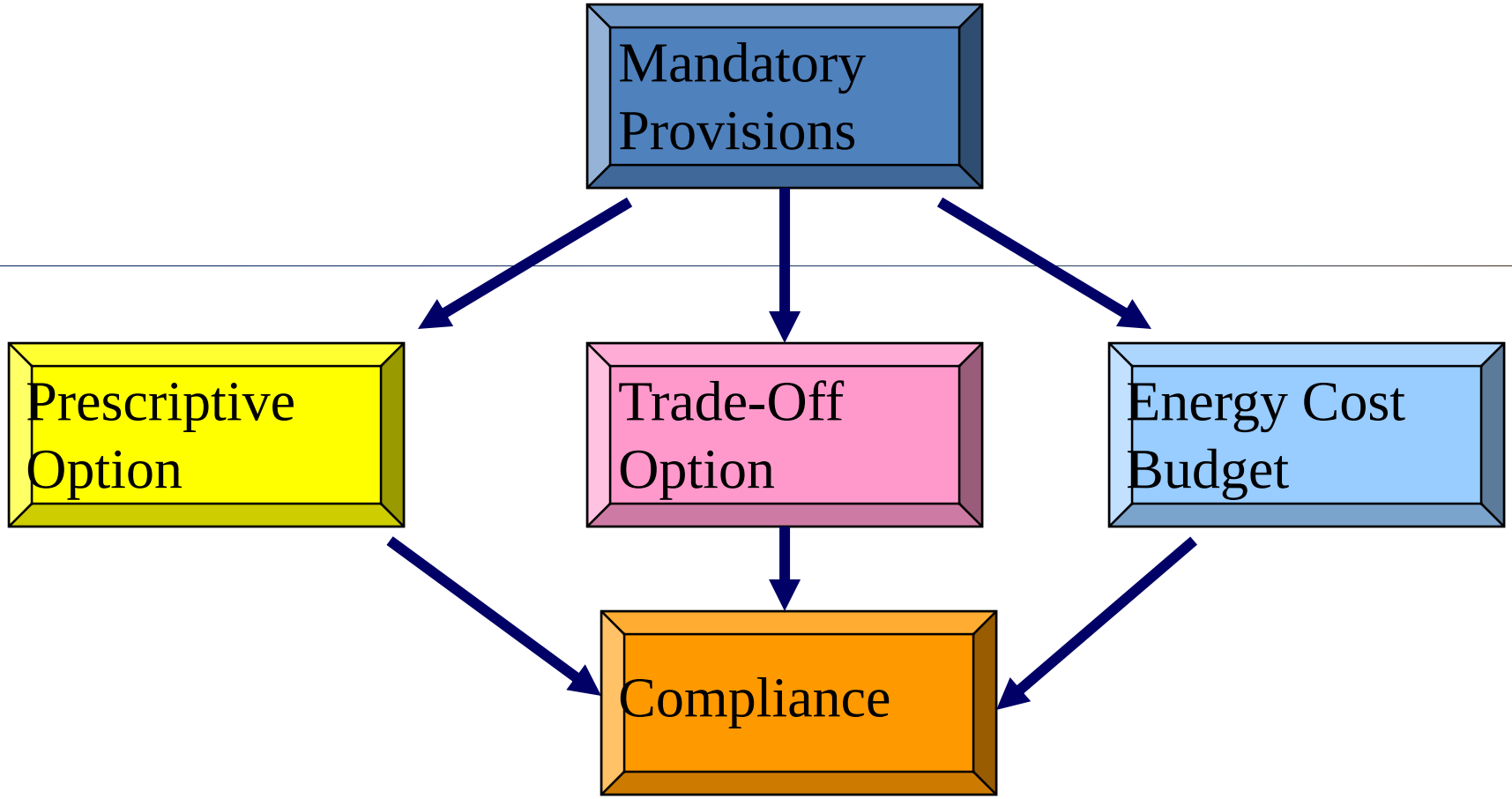
Organization of ASHRAE Standard 90.1-2004

1 Purpose
2 Scope
3 Definitions
4 Administration and Enforcement
5 Building Envelope
6 Heating, Ventilating, and Air-Conditioning
7 Service Water Heating
8 Power
9 Lighting
10 Other Equipment
11 Energy Cost Budget Method
12 Normative References

High Rise Residential – Which Energy Code?

Section 5
Envelope Compliance Methods

Section 5.2



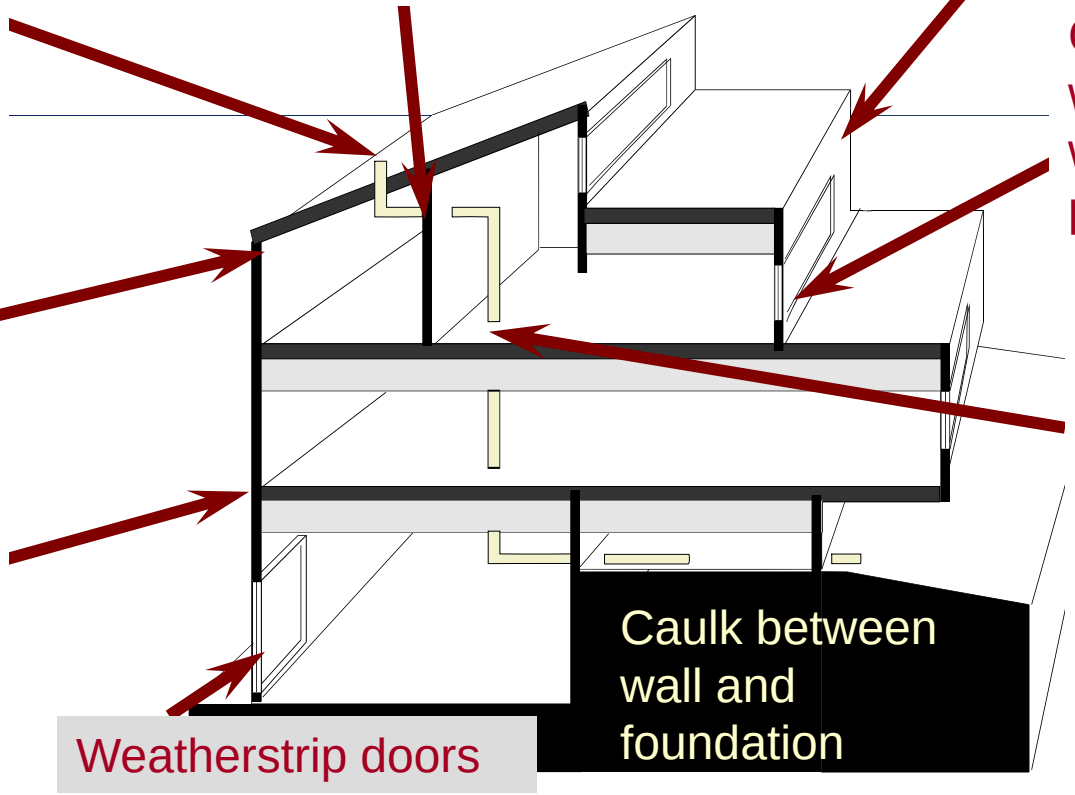
Section 5
Envelope Mandatory Provisions

Section 5.4

- **Air leakage**
  - **Building envelope sealing**
  - **Fenestration (windows and exterior glass)**
    - **NFRC 400***
      - 1.0 cfm/ft^2
      - 0.4 cfm/ft^2
  - **Loading Docks**
- **Vestibules**

* *NFRC = National Fenestration Rating Council*

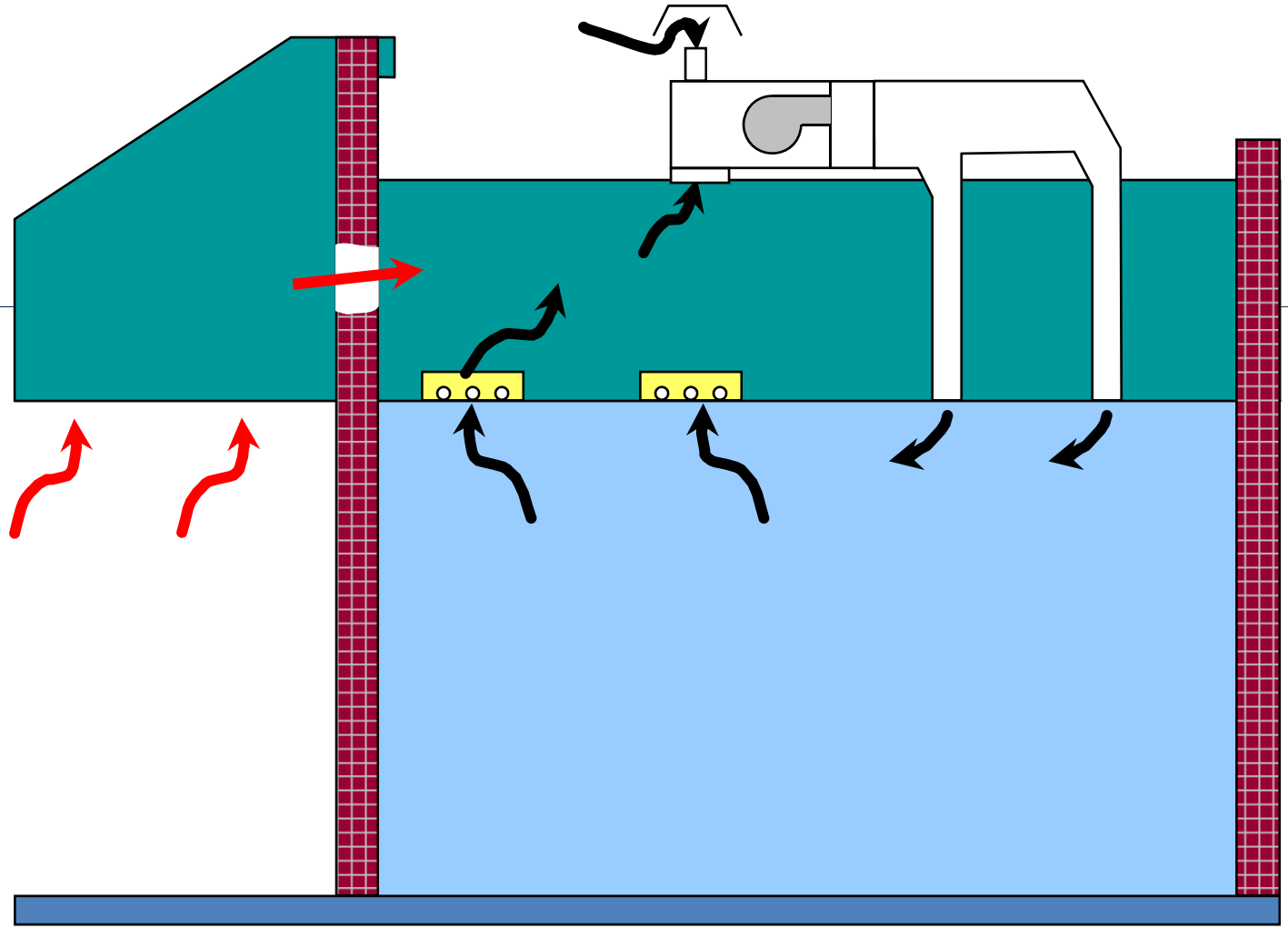
502.3 Basic Requirement: Air Leakage - Building Envelope Sealing



Major Air Leakage Sites

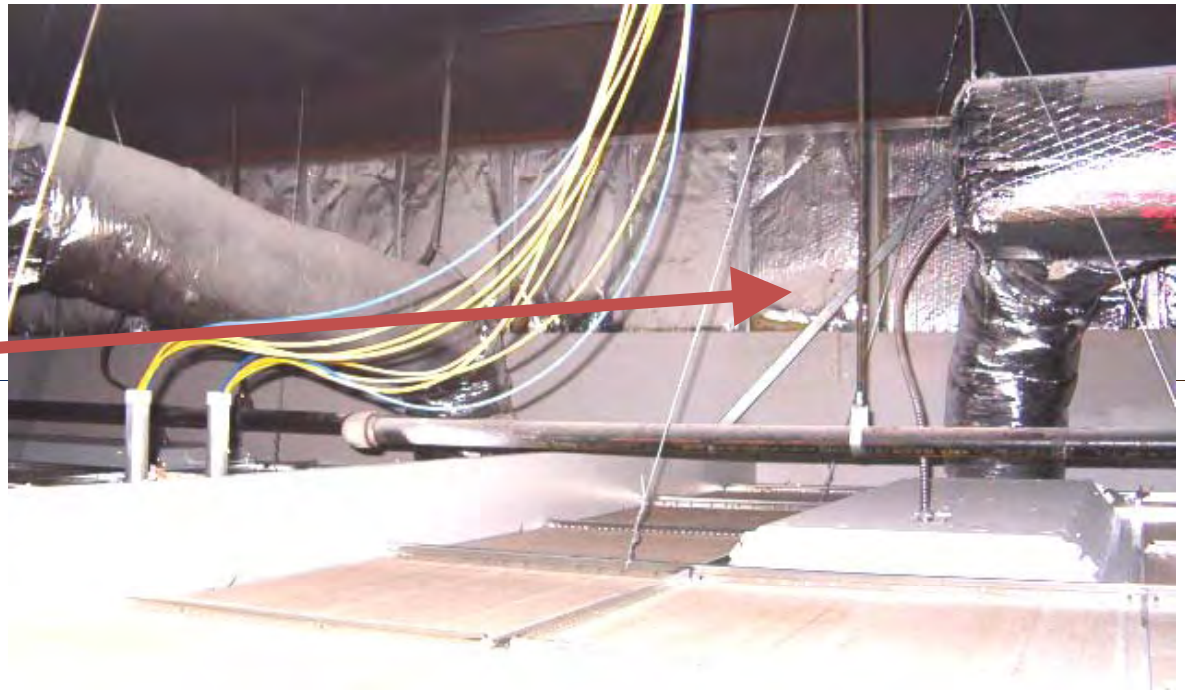
- Cavities above
  - suspended ceilings
- Plenum return spaces
  - (Highly depressurized)
- Ventilated walls
- Equipment tunnels and
  - chases
- Mechanical rooms and mezzanines
- Unconditioned adjacent space
  - (Storage, warehouse, plant, etc.)
- Exhaust and ventilation fans, plus
  - wind and stack effect, are major
  - driving forces

Return Plenum Problems - Canopy



Is Air Barrier Continuous?

- Brand-new NC building
- Drywall left off of exterior wall above dropped ceiling
- Building uses above-ceiling area as return



- When HVAC operates, entire wall cavity goes to a negative pressure, increasing air leakage, effectively reducing insulation value, and potentially causing moisture problems

Limiting Air Leakage Pathways

Materials and connections must:

- stop air flow
- withstand jobsite abuses
- withstand forces of wind and pressure

Penetrations must be sealed

- plumbing, wiring, communications
- ductwork
- windows and doors

Functional penetrations, such as air intakes for exhaust fans, must be dampered

Vestibules (5 Stories or more, with exceptions)

Section 5 – Envelope -- Vestibules

Required at *building entrances*

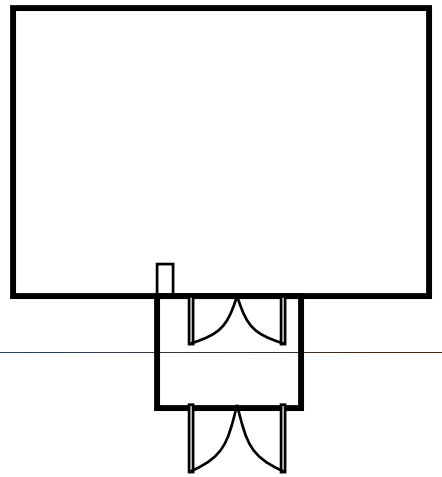
Self closing doors

Exceptions:

a. *Building entrances* **with revolving** *doors*.

b. *Doors* **not used as a** *building entrance.*

c. *Doors* **opening directly from a** *dwelling unit*.



d. *Building entrances* **in buildings located in climate zone 1 or 2.**

e. *Building entrances* **in buildings located in climate zone 3 or 4 that are less than four stories above grade and less than 10,000 ft² in area.**

f. *Building entrances* **in buildings located in climate zone 5, 6, 7, or 8 that are less than 1,000 ft² in area.**

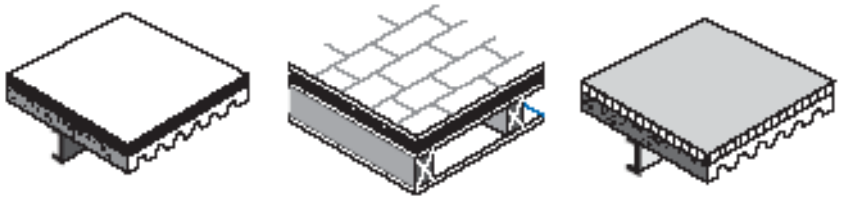
g. *Doors* **that open directly from a** *space* **that is less than 3,000 ft² in area and is separate from the** *building entrance*.

Common R-values – Resistance to Conductive Heat Flow

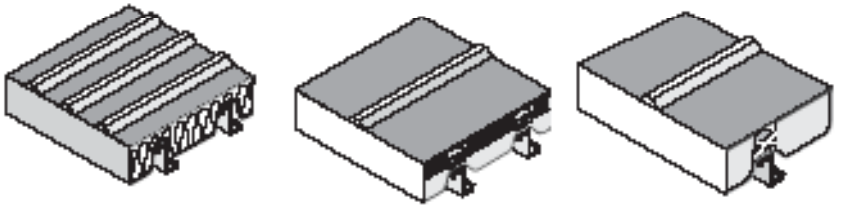
Concrete	0.2 per inch
½” Drywall	0.5
Double-paned glass	1.8
Low-e glass	about 3.0
Fiberglass insulation	3 to 4 per inch
Cellulose insulation	3.7 per inch
Expanded polystyrene	4 per inch
Extruded polystyrene	5 per inch
Icynene foam	3.6 to 3.7 per inch
Polyurethane foam	6.7 to 7.0 per inch

Roof Insulation (5.5.3.1)

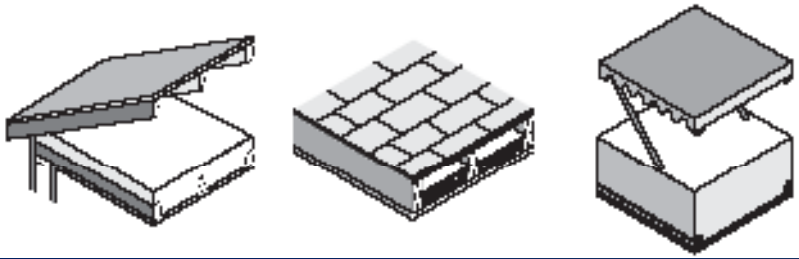
3 classes of roof construction



Insulation above



Metal buildings



Attic + Other

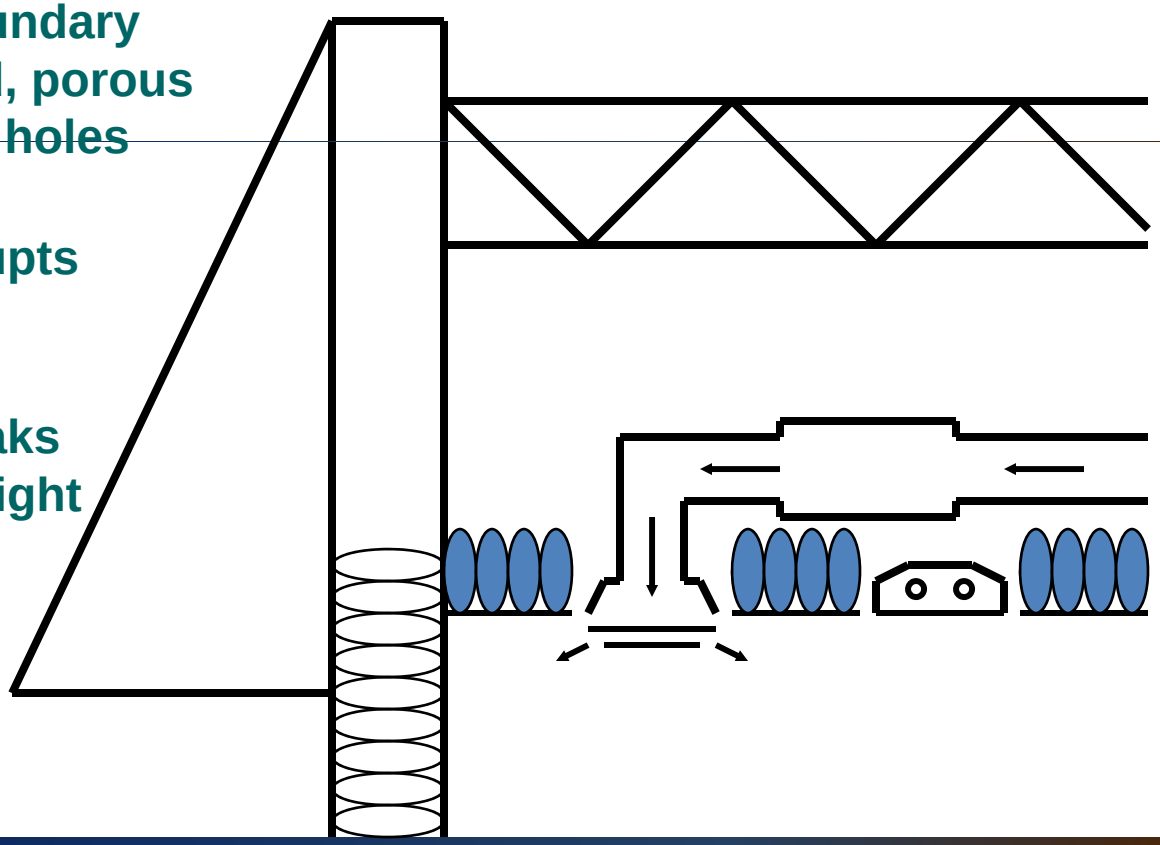
Building Envelope Example: Roofs

Insulation not counted on top of suspended ceiling

- **Poor Design:**

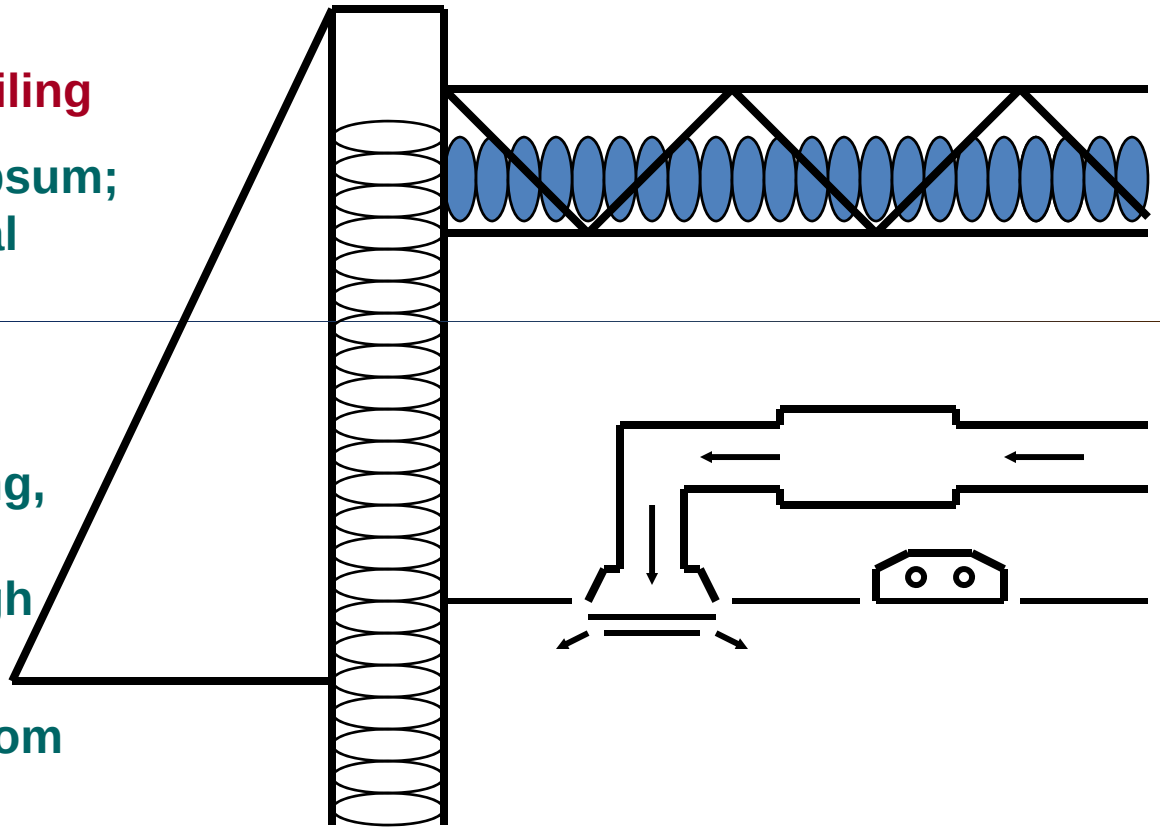
  Batts over suspended ceiling tiles

  - Poor pressure boundary caused by tile grid, porous tiles, lighting vent holes
  - Poor durability - maintenance disrupts batts, exposure to fiberglass dust
  - Many thermal breaks due to ductwork, light fixtures, grid, and support wires



Building Envelope Example: Roofs

- **Okay Design:**
  Insulation above hard ceiling
  - Example: taped gypsum; similar to residential construction
  - Ductwork is inside but must limit and seal HVAC, plumbing, and electrical penetrations through pressure boundary
  - Thermal bridging from metal roof trusses

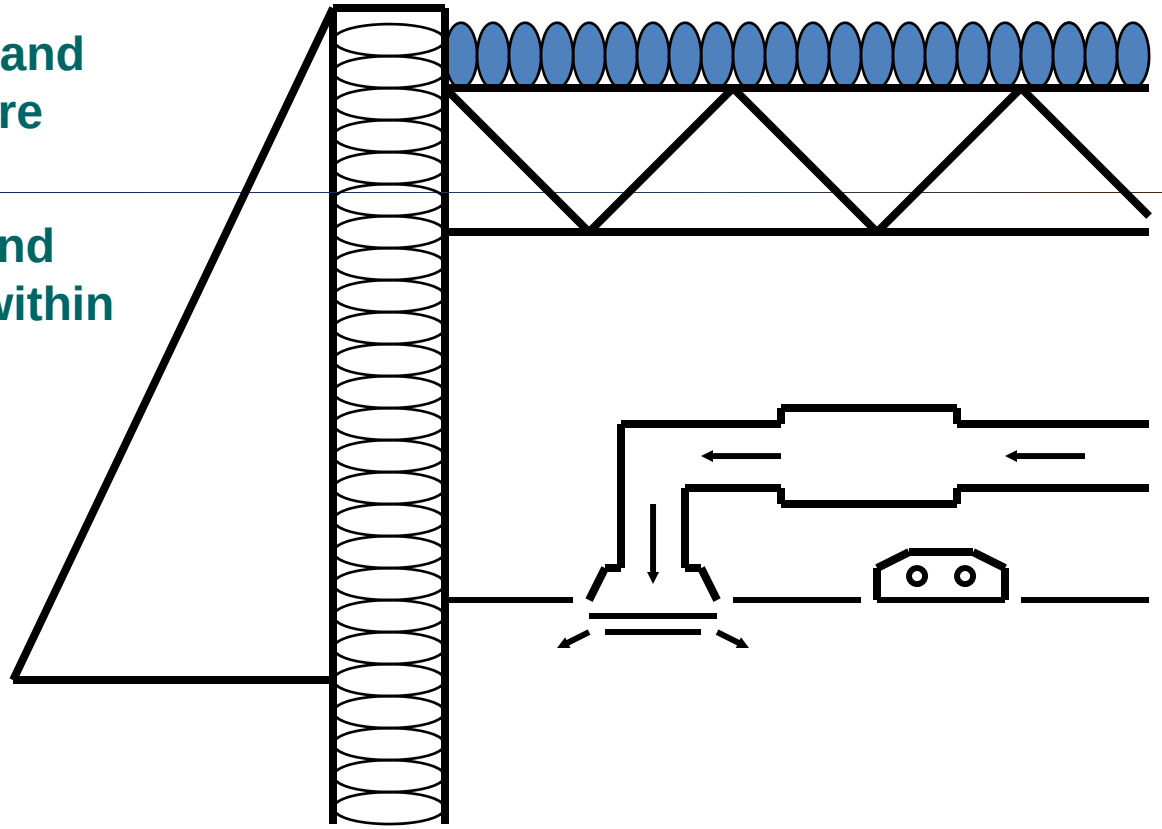


Building Envelope Example: Roofs

- **Best Design:**

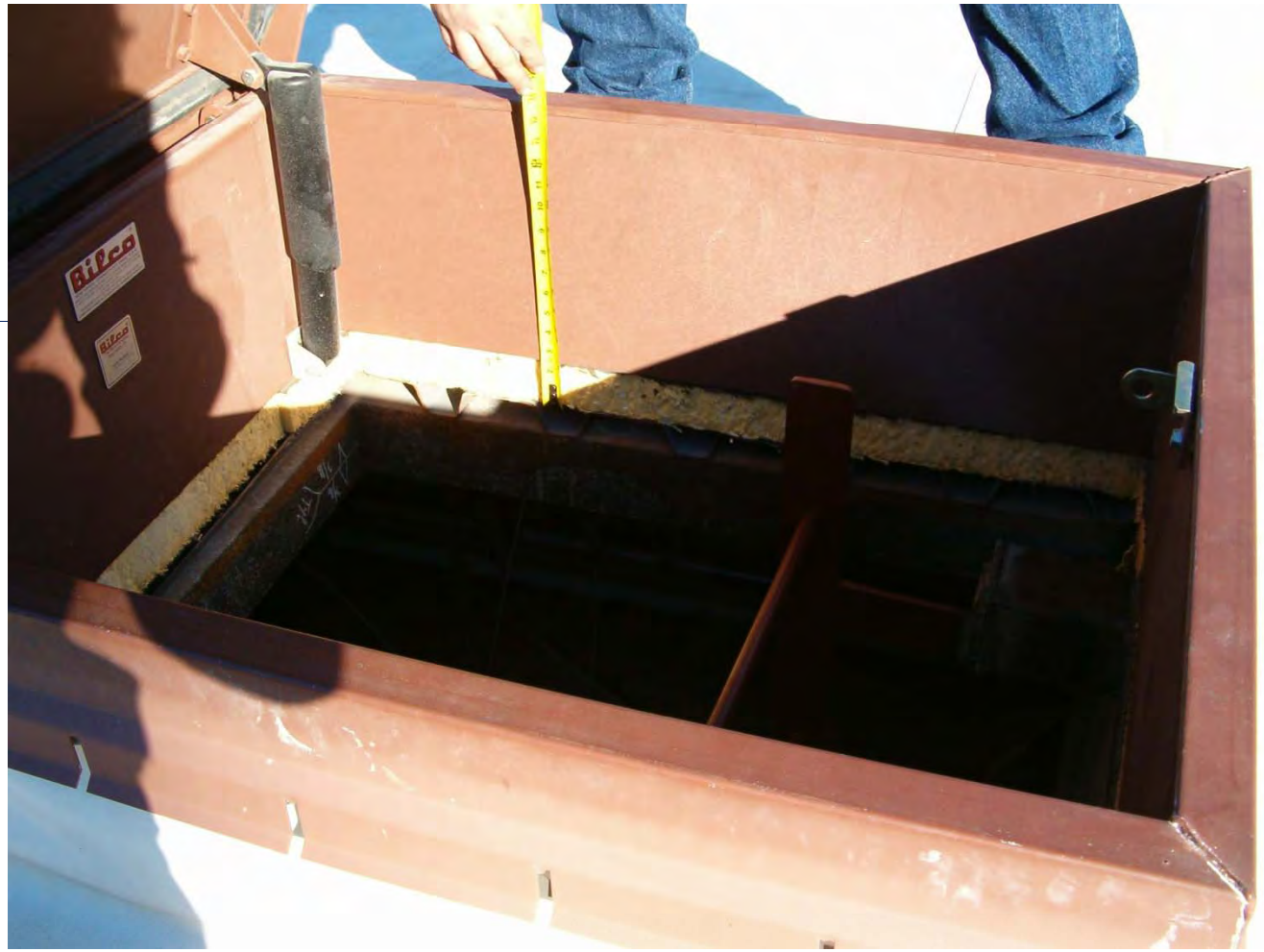
  Rigid insulation above roof deck

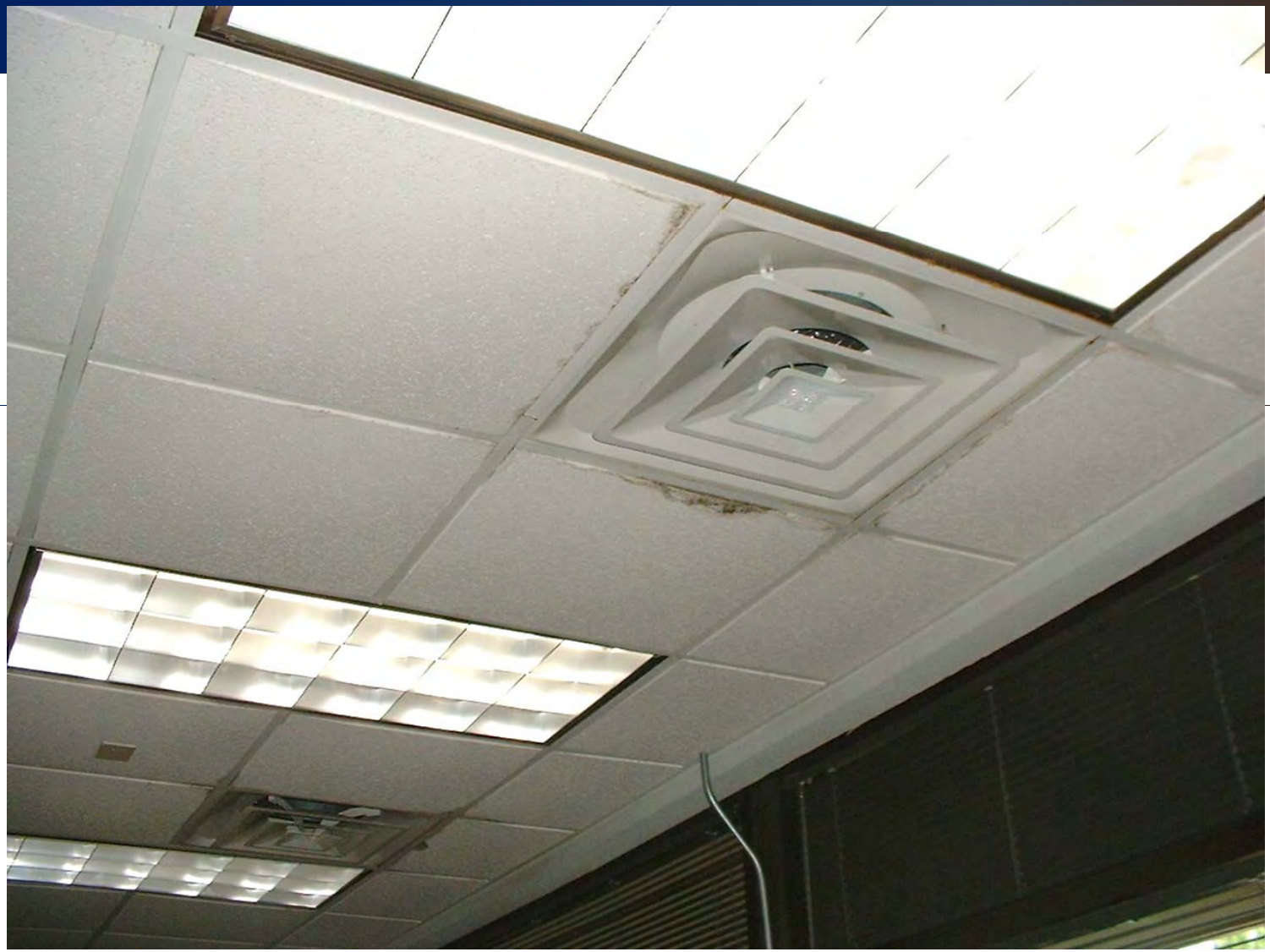
  - No thermal breaks and continuous pressure boundary
  - HVAC equipment and ductwork located within conditioned space
  - Good durability



What's Under the Membrane?

R-30?





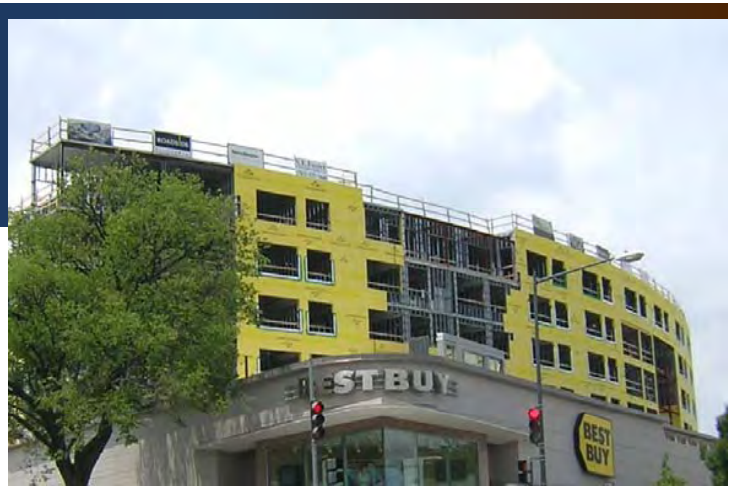

Betsy Terrett
104


Owens Corning
Fiberglas
Insulation
ation R19

Attic Insulation Alternative?

Foam (Icynene) Under-Roof

Above-Grade Wall Insulation



5 Classes of wall construction

Mass

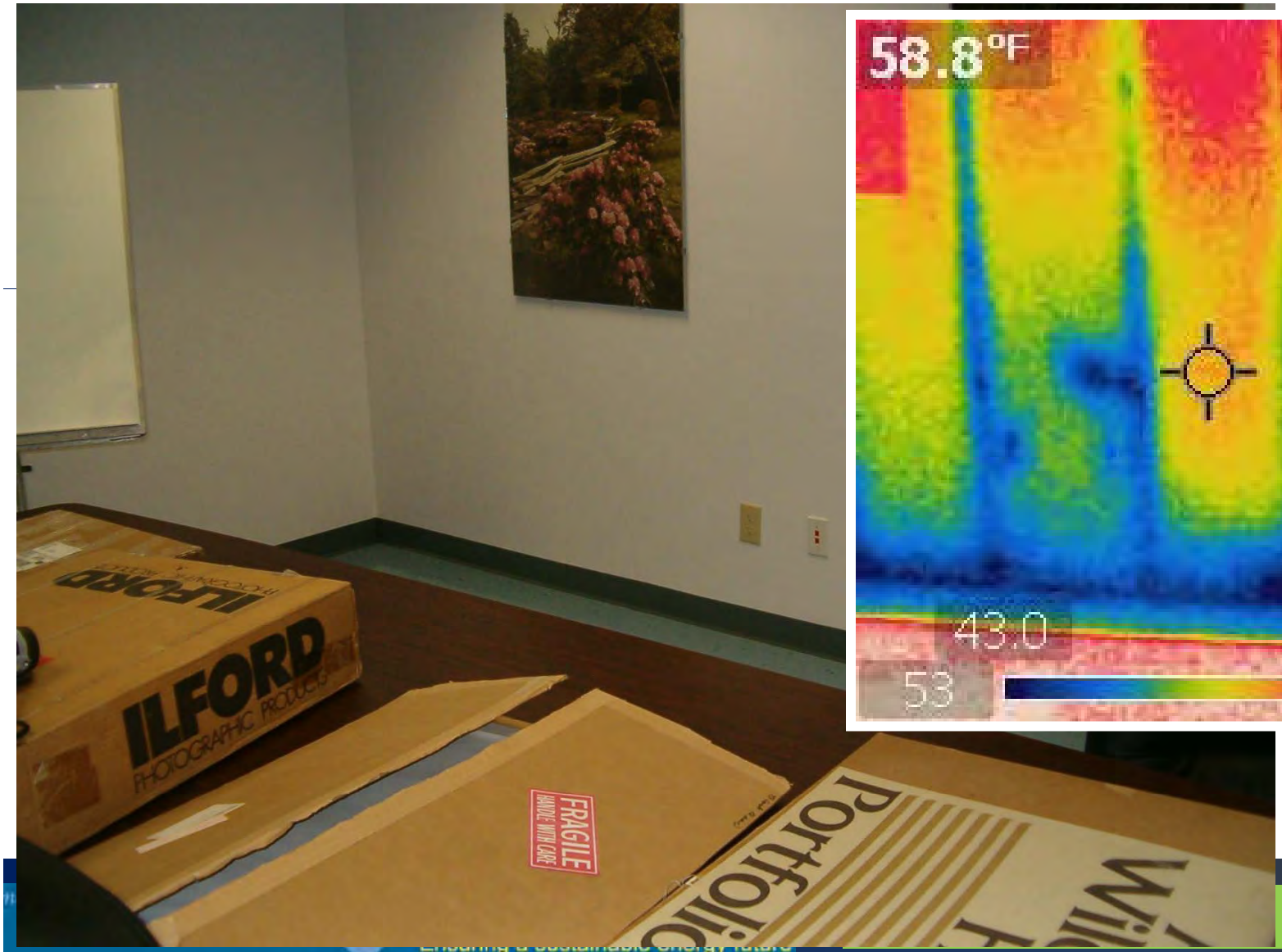
Metal Building

Metal Stud

Wood Stud

Below Grade

Steel Framed Walls

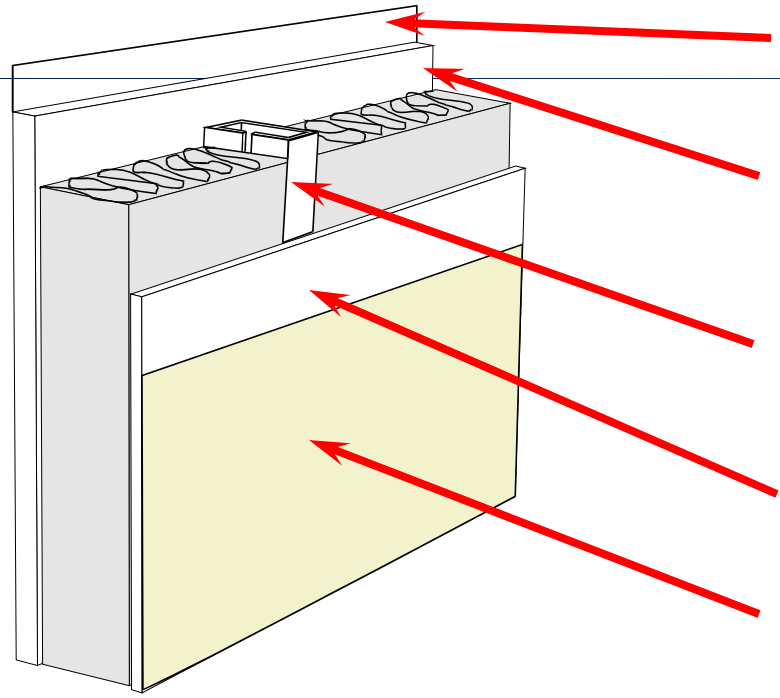


Office

Steel Framing and Insulation

Metal Framing Effects

- **Thermal bridging effect of metal framing must be accounted for in calculating U-factors**

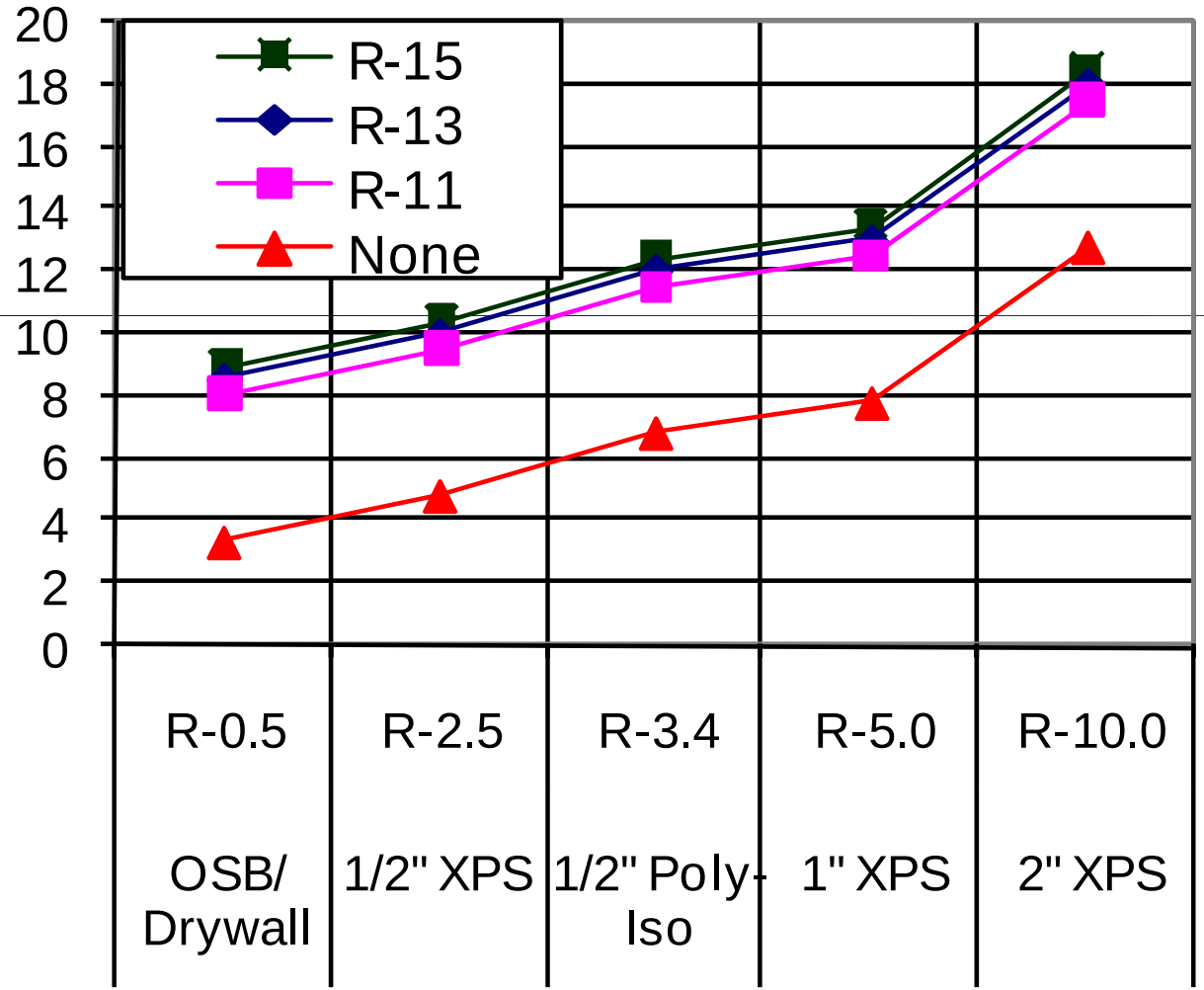


- Outside Air Film
- 1- inch Exterior sheathing (R-3.8) with Stucco
- 2 x 4 Metal Studs with R-13 in the Cavity
- 1/2 in. Gypsum Board
- Inside Air Film

U-factors for Metal Stud Walls

Nominal R-value	Effective R-value	U-factor	Continuous Insulated Sheathing		
			1/2" EPS R-2.0	5/8" Poly-Iso R-4.0	1" XPS R-5.0
2 x 4 Metal Framing at 16 inches on Center (3.5 in cavity depth)					
None	(0.0)	0.352	0.207	0.146	0.128
R-11	(5.5)	0.132	0.105	0.087	0.080
R-13	(6.0)	0.124	0.100	0.083	0.077
R-15	(6.4)	0.118	0.096	0.080	0.074
2 x 4 Metal Framing at 24 inches on Center (3.5 in cavity depth)					
R-11	(6.6)	0.116	0.094	0.079	0.073
R-13	(7.2)	0.108	0.089	0.075	0.070
R-15	(7.8)	0.102	0.084	0.072	0.067

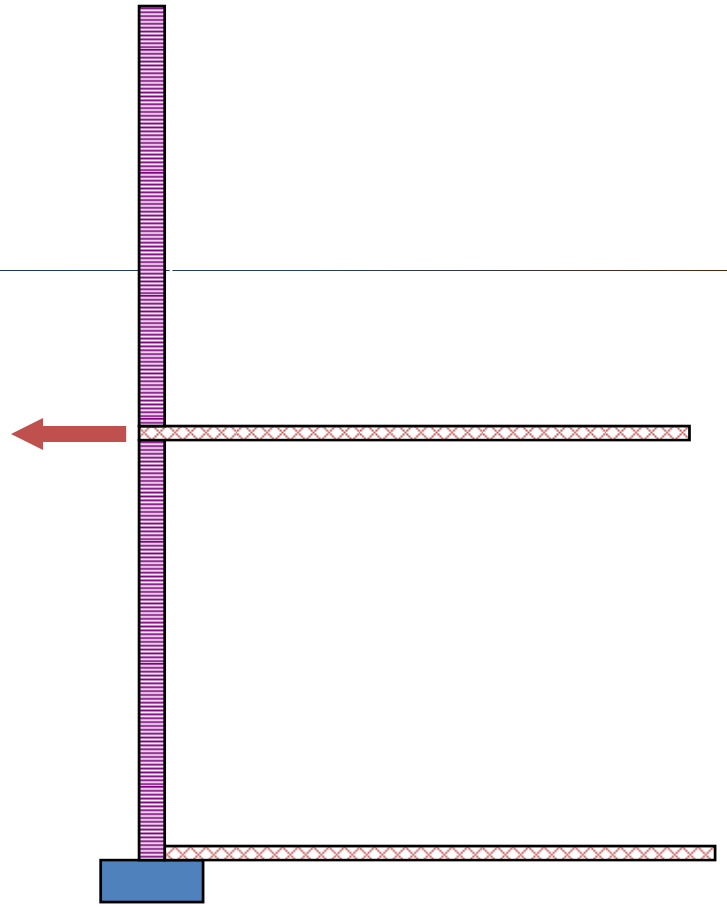
Effective R-value of 2x4 Metal Framed Walls (16” o.c.)



Effective R-Value of 2x4 Metal Framed Wall with R-13 Batt Insulation	
Sheathing	**R-value**
OSB/ Drywall	8.1
1/2" XPS	9.5
1/2" Poly-Iso	11.5
1" XPS	12.5
2" XPS	17.5

Above Grade Floors – Is the Insulation Missing?

- Continuous insulation is the key
- 1” of foam is vital for exposed slab edges
- Heat loss will be more than just 4” of missing insulation
- Trace other potential discontinuities in wall insulation system

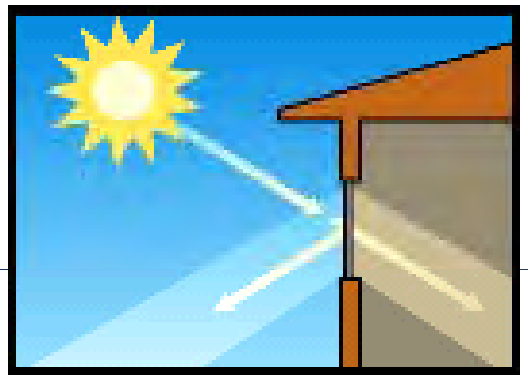


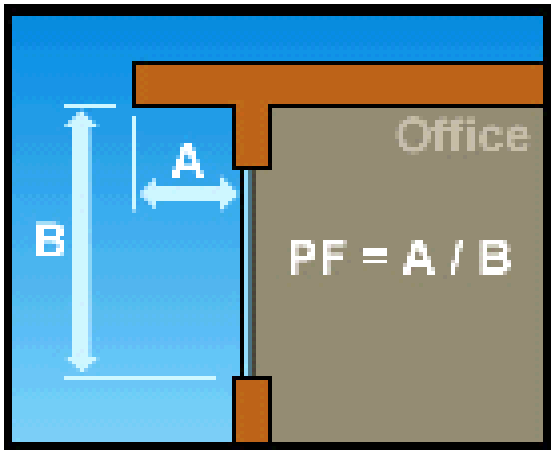
Make Insulation Continuous

- Block walls -- should be insulated; insulating cores very ineffective
- Floors over unheated spaces, such as parking areas, need insulation
- For discontinuities in walls, such as offset areas for stairwells, elevators, and other spaces, the exterior envelope must be determined. The envelope requires both insulation and air sealing.

Windows - SHGC

- **Solar Heat Gain Coefficient**
  - Requirements dependent on projection factor
  - National Fenestration Rating Council (NFRC) tested
  - Default SHGC range diagrams
  - SHGC = SC x .87

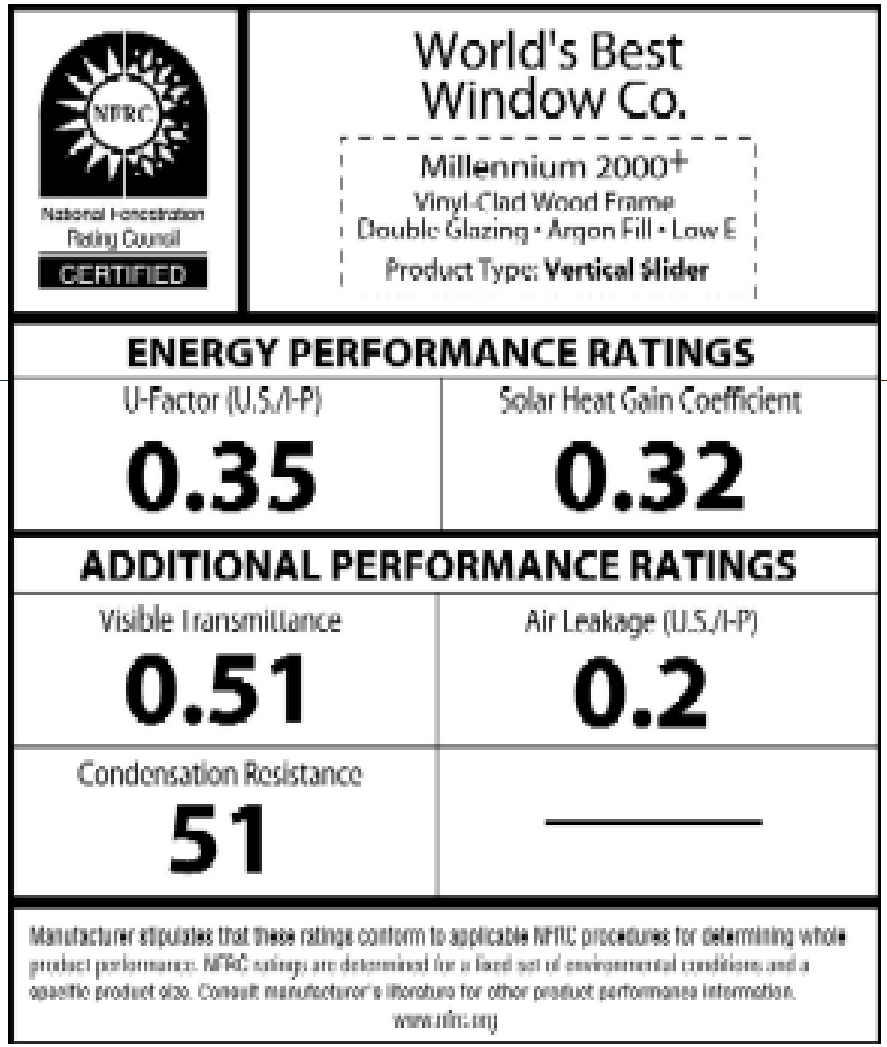




Fenestration Performance

Section 5.8.2

- **NFRC Rating for all Manufactured Fenestration**
  - **U-factor**
  - **SHGC**
  - **Air Leakage**



National Fenestration Rating Council
CERTIFIED

World's Best Window Co.

Millennium 2000+
Vinyl-Clad Wood Frame
Double Glazing • Argon Fill • Low E
Product Type: **Vertical Slider**

ENERGY PERFORMANCE RATINGS

U-Factor (U.S./I-P)	Solar Heat Gain Coefficient
0.35	**0.32**

ADDITIONAL PERFORMANCE RATINGS

Visible Transmittance	Air Leakage (U.S./I-P)
0.51	**0.2**
Condensation Resistance	
51	———

Manufacturer stipulates that these ratings conform to applicable NFRC procedures for determining whole product performance. NFRC ratings are determined for a fixed set of environmental conditions and a specific product size. Consult manufacturer's literature for other product performance information.
www.nfrc.org

Skylights

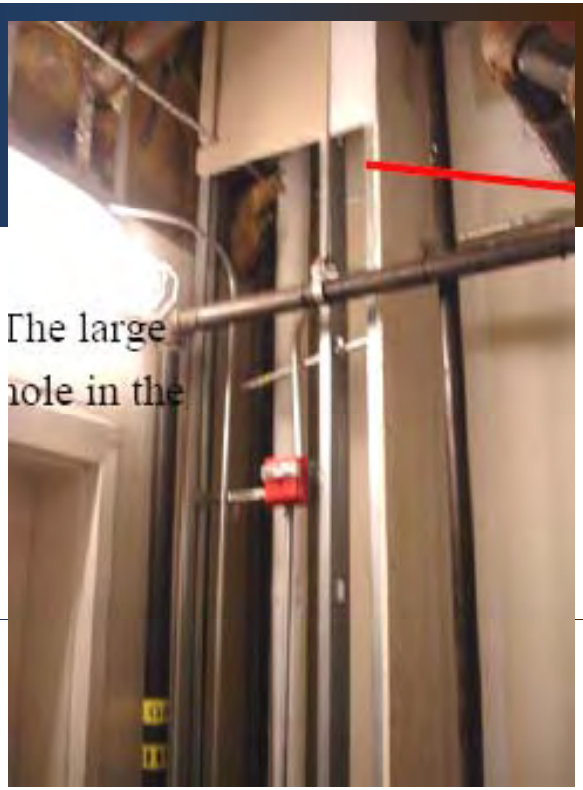
- **Restricted to ≤ 3% of roof area**
  - **Requirements based on**
    - **U-value (NFRC tested) or**
    - **Default U-value table**

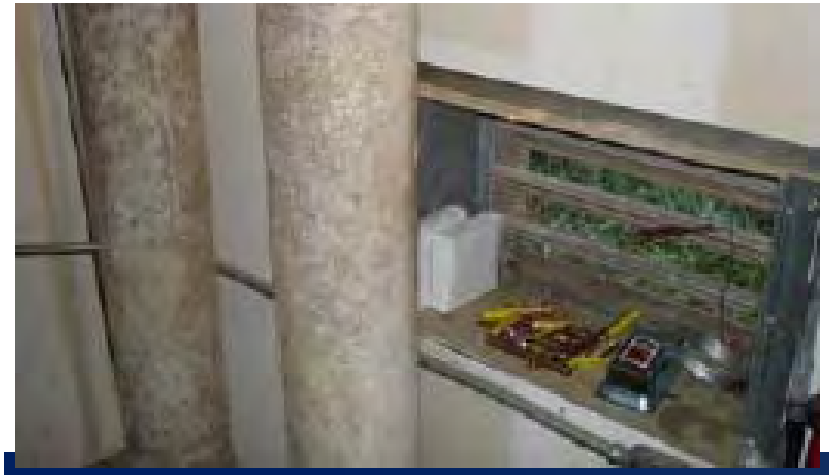
Integrated Design Process

- Site Considerations
- Reduce Loads
- Size Systems Properly for Reduced Loads
- Incorporate Efficient Equipment and Systems
- Refine System Integration

ASHRAE Advanced Energy Guidelines as a Model

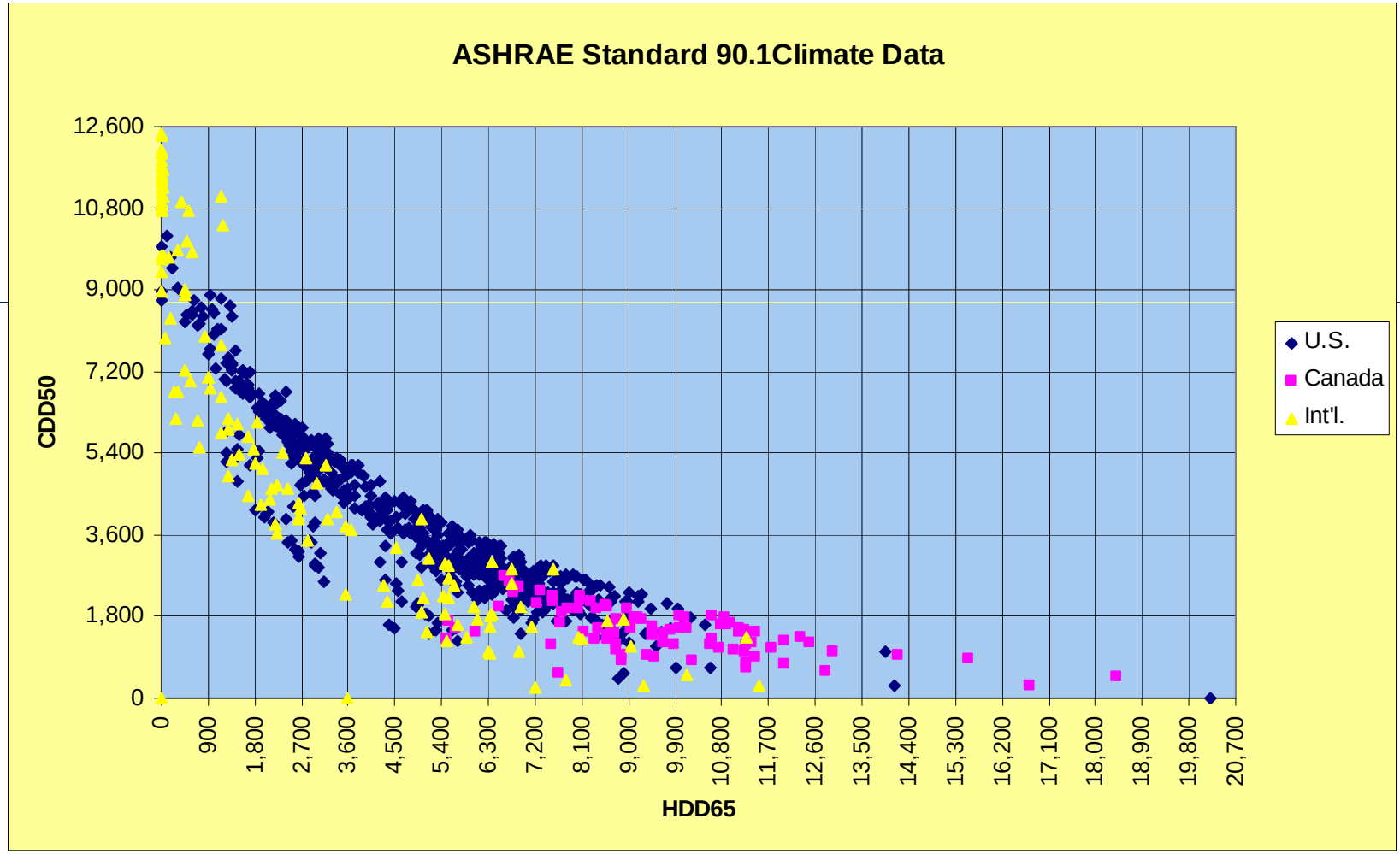
The Major Unknown: Post Occupancy





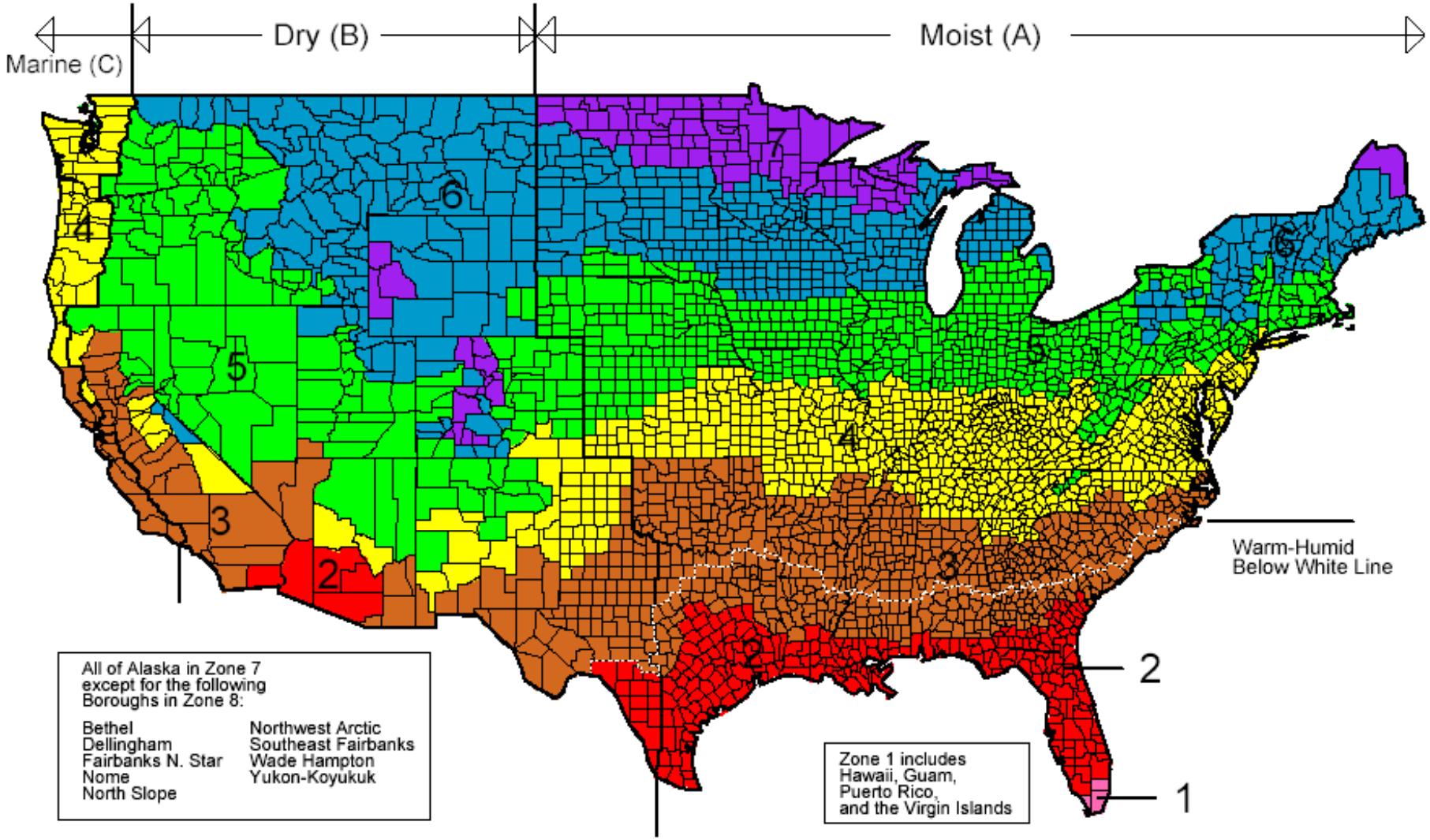
Non-Code Compliant

Climate


ASHRAE Standard 90.1Climate Data
CDD50
12,600
10,800
9,000
7,200
5,400
3,600
1,800
0
HDD65
0
900
1,800
2,700
3,600
4,500
5,400
6,300
7,200
8,100
9,000
9,900
10,800
11,700
12,600
13,500
14,400
15,300
16,200
17,100
18,000
18,900
19,800
20,700
U.S.
Canada
Int'l.

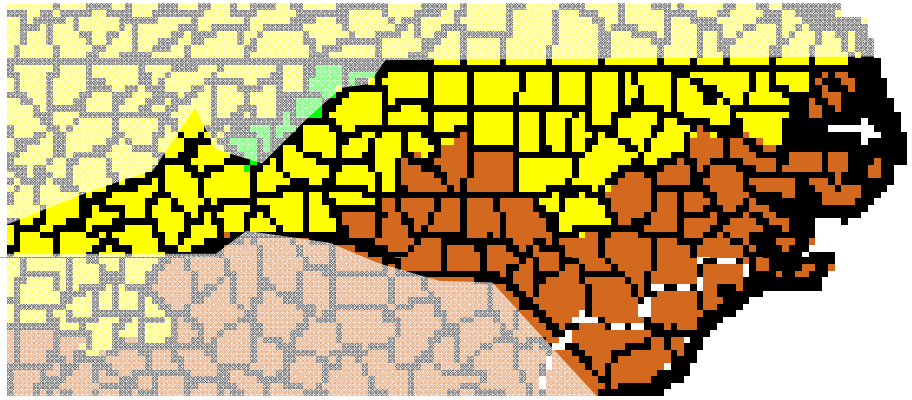
2009 IECC Climate Zones:

Zones 4 and Below Don't Require Wall Vapor Barriers
(Only NW Mountains need one)

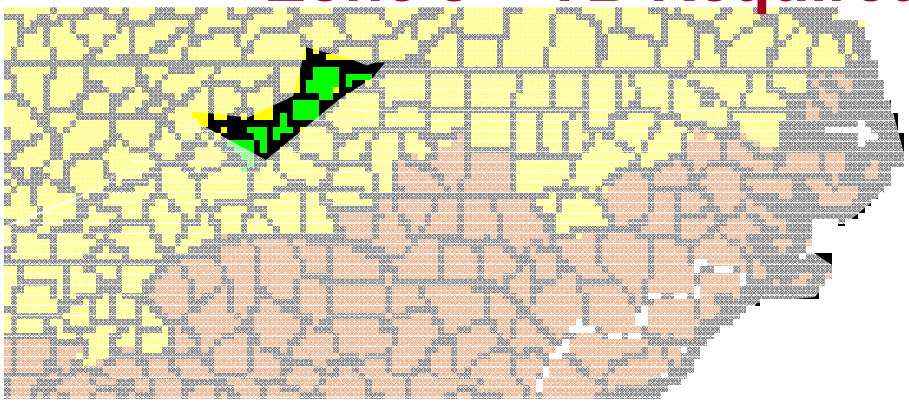


2009 NC Energy Code Climate Zones

Zone 3&4 – No VB



Zone 5 – VB Required



Section 5 – Prescriptive Requirements

Section 5.5

- **Nonresidential**
  - Commercial
- **Residential**
  - Not one and two-family
  - Typically over 3 stories
  - Hotels and dormitories
- **Semi-Heated**

ASHRAE 90.1-2004			
Nonresidential	**Zone 3**	**Zone 4**	**Zone 5**
Floors			
Mass	R-6.3 c.i.	R-6.3 c.i.	R-8.5 c.i.
Steel Joist	R-19	R-19	R-19
Wood Framed and Other	R-19	R-19	R-30
Slab-On-Grade Floors			
Unheated	NR	NR	NR
Heated	R-7.5, 12 in.	R-7.5, 24 in.	R-10, 36 in.
Opaque Doors			
Swinging	U-0.700	U-0.700	U-0.700
Non-Swinging	U-1.450	U-1.450	U-1.450

Residential	**Zone 3**	**Zone 4**	**Zone 5**
Floors			
Mass	R-8.3 c.i.	R-8.3 c.i.	R-10 c.i.
Steel Joist	R-19	R-30	R-30
Wood Framed and Other	R-30	R-30	R-30
Slab-On-Grade Floors			
Unheated	NR	NR	NR
Heated	R-7.5, 24 in.	R-10, 36 in.	R-10, 36 in.
Opaque Doors			
Swinging	U-0.700	U-0.700	U-0.700
Non-Swinging	U-1.450	U-0.500	U-0.500

ASHRAE 90.1 Fenestration Requirements for Climate Zones 3 and 4

ASHRAE 90.1-2004 (Chapter 5)			
Fenestration Values for Climate Zone 3			
Window-Wall Ratio	**Nonresidential**	**Residential**	**Semiheated**
0-10.0%	U_{fixed}-0.57, $SHGC_{all}$-0.39	U_{fixed}-0.57, $SHGC_{all}$-0.39	U_{fixed}-1.22, $SHGC_{all}$- NR
	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-1.27, $SHGC_{north}$- NR
10.1-20.0%	U_{fixed}-0.57, $SHGC_{all}$-0.25	U_{fixed}-0.57, $SHGC_{all}$-0.39	U_{fixed}-1.22, $SHGC_{all}$- NR
	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-1.27, $SHGC_{north}$- NR
20.1-30.0%	U_{fixed}-0.57, $SHGC_{all}$-0.25	U_{fixed}-0.57, $SHGC_{all}$-0.25	U_{fixed}-1.22, $SHGC_{all}$- NR
	U_{oper}-0.67, $SHGC_{north}$-0.39	U_{oper}-0.67, $SHGC_{north}$-0.39	U_{oper}-1.27, $SHGC_{north}$- NR
30.1-40.0%	U_{fixed}-0.57, $SHGC_{all}$-0.25	U_{fixed}-0.57, $SHGC_{all}$-0.25	U_{fixed}-1.22, $SHGC_{all}$- NR
	U_{oper}-0.67, $SHGC_{north}$-0.39	U_{oper}-0.67, $SHGC_{north}$-0.39	U_{oper}-1.27, $SHGC_{north}$- NR
40.1-50.0%	U_{fixed}-0.46, $SHGC_{all}$-0.19	U_{fixed}-0.46, $SHGC_{all}$-0.19	U_{fixed}-0.98, $SHGC_{all}$- NR
	U_{oper}-0.47, $SHGC_{north}$-0.26	U_{oper}-0.47, $SHGC_{north}$-0.26	U_{oper}-1.02, $SHGC_{north}$- NR

U_{fixed} = U-value of fixed windows; U_{oper} = U-value of operable windows

$SHGC_{all}$ = Solar Heat Gain Coefficient of all windows

$SHGC_{north}$ = Solar Heat Gain Coefficient of north windows

Fenestration Values for Climate Zone 4			
Window-Wall Ratio	**Nonresidential**	**Residential**	**Semiheated**
0-10.0%	U_{fixed}-0.57, $SHGC_{all}$-0.39	U_{fixed}-0.57, $SHGC_{all}$-0.39	U_{fixed}-1.22, $SHGC_{all}$- NR
	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-1.27, $SHGC_{north}$- NR
10.1-20.0%	U_{fixed}-0.57, $SHGC_{all}$-0.39	U_{fixed}-0.57, $SHGC_{all}$-0.39	U_{fixed}-1.22, $SHGC_{all}$- NR
	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-1.27, $SHGC_{north}$- NR
20.1-30.0%	U_{fixed}-0.57, $SHGC_{all}$-0.39	U_{fixed}-0.57, $SHGC_{all}$-0.39	U_{fixed}-1.22, $SHGC_{all}$- NR
	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-1.27, $SHGC_{north}$- NR
30.1-40.0%	U_{fixed}-0.57, $SHGC_{all}$-0.39	U_{fixed}-0.57, $SHGC_{all}$-0.39	U_{fixed}-1.22, $SHGC_{all}$- NR
	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-0.67, $SHGC_{north}$-0.49	U_{oper}-1.27, $SHGC_{north}$- NR
40.1-50.0%	U_{fixed}-0.46, $SHGC_{all}$-0.25	U_{fixed}-0.46, $SHGC_{all}$-0.25	U_{fixed}-0.98, $SHGC_{all}$- NR
	U_{oper}-0.47, $SHGC_{north}$-0.36	U_{oper}-0.47, $SHGC_{north}$-0.36	U_{oper}-1.02, $SHGC_{north}$- NR

nstruction Office

ASHRAE 90.1: Advanced Design Guide – Office Building

	ASHRAE 90.1 2004	Advanced Design Guide
Roof	**Zone 4**	**Zone 4**
Insulation Entirely above Deck	R-15 c.i.*	R-20 c.i.*
Metal Building	R-19.0	R-13 + 19
Attic and Other	R-30.0	R-38
Walls, Above Grade		
Mass	R-5.7 c.i.	R-11.4 c.i.
Metal Building	R-13	R-13
Steel Framed	R-13	R-13+R-7.5
Wood Framed and Other	R-13	R-13
Below Grade Wall	NR	NR
Floors		
Mass	R-8.3 c.i.	R-8.3 c.i.
Steel Joist	R-30	R-30
Wood Framed and Other	R-30	R-30

ASHRAE 90.1: Advanced Design Guide – Office Building

Fenestration Values for Climate Zone 4		
Window-Wall Ratio	**ASHRAE 90.1 2004**	**Advanced Design Guide**
0-10.0%	U_{fixed}-0.57, $SHGC_{all}$-0.39	Up to 40% of wall area
	U_{oper}-0.67, $SHGC_{north}$-0.49	U-0.42
10.1-	U_{fixed}-0.57, $SHGC_{all}$-0.39	SHGC - 0.46
	U_{oper}-0.67, $SHGC_{north}$-0.49	Area of north glass * SHGCn +
20.1-	U_{fixed}-0.57, $SHGC_{all}$-0.39	Area of south glass * SHGCs >
	U_{oper}-0.67, $SHGC_{north}$-0.49	Area of east glass * SHGCe +
30.1-	U_{fixed}-0.57, $SHGC_{all}$-0.39	Area of west glass * SHGCw
	U_{oper}-0.67, $SHGC_{north}$-0.49	South, east, west has overhang
40.1-	U_{fixed}-0.46, $SHGC_{all}$-0.25	
	U_{oper}-0.47, $SHGC_{north}$-0.36	

ASHRAE 90.1: Advanced Design Guide – Office Building

Interior Lighting	ASHRAE 90.1 2004	Advanced Design Guide
	1.30 Watts/. Sq ft	0.90 Watts/ sq ft
		90 lumen/ watt linear fluorescent
		Dimmable fixture within 12 ft of N/S window wall or within 8 ft of skylight edge
		Auto-off in all unoccupied rooms
		Reflectance of 80% on ceilings, 70% on walls and vertical partition

ASHRAE 90.1: Advanced Design Guide – Office Building

Cooling	ASHRAE 90.1 2004	Advanced Design Guide
0-65 kBtuh	10 SEER	13 SEER
65-135 kBtuh	10.3 EER/ 11.2 IPLV	11 EER/ 11.4 IPLV
135-240 kBtuh	9.7 EER/ 11.2 IPLV	10.8 EER/ 11.2 IPLV
> 240 kBtuh	9.5 EER/ 11.2 IPLV	10 EER/ 10.4 IPLV
Furnaces		
All sizes	80% AFUE	80% AFUE
Heat pumps		
0-65 kBtuh	10 SEER/ 6.8 HSPF	13 SEER/ 7.7 HSPF
65-135 kBtuh	10.1 EER	10.6 EER/ 11 IPLV
>135 kBtuh	9.3 EER/ 9.2 IPLV (>240)	10.1 EER/ 11 IPLV
Other	Economizers -- depend	Economizers > 54 kBtuh
	Ventilation controls	Motorized control with
	optional	CO_2 sensors
	Sealed ducts	Sealed ducts
		81% gas instantaneous water htr
		EF > 99%

Integrated Design: Assess the Site

- ❑ Evaluate centrality to the community
- ❑ Evaluate access to public transportation
- ❑ Identify on-site energy opportunities
- ❑ Identify best building orientation

Identify on-site energy opportunities

- Integrated design begins with site assessment and selection
- Site selection is an opportunity to obtain free energy resources

Reduce loads on energy-using systems

- Reduce Internal Loads
  - More efficient equipment, appliances and lighting
- Reduce heat gain/loss through the building envelope: many options, see next slides
- Reduce Thermal Loads:
  - Utilize Passive Solar Design, Thermal Storage
- Refine building to suit local conditions
  - Operable Windows, cross ventilation

Reduce Heat Gain/Loss

- Control Solar Gain to reduce cooling load through windows
  - Use beneficial building form and orientation
  - Minimize windows east and west, maximize windows north and south
  - Use glazing with low solar heat gain coefficient (SHGC)
  - Provide external shade glazing to reduce solar heat gain and glare
  - Use vegetation on S/E/W to control solar heat gain and glare

Reduce Heat Gain/Loss

- Reduce Solar Gain through opaque surfaces to reduce cooling load
  - Increase Insulation of opaque areas
  - Increase Roof surface reflectance and emittance
  - Shade building surfaces with deciduous and coniferous trees as appropriate for surface orientation

Reduce Heat Gain/Loss

- Reduce Conductive Heat Gain and Loss through building envelope
  - Increase Insulation on roof, walls, floors, slabs and doors and decrease window U factor
- Reduce air infiltration
  - Provide continuous air barrier
- Reduce Heat Gain or Loss from ventilation exhaust air
  - Use energy recovery to precondition outdoor air

Key Points to Check

- **Envelope**
  - Insulation values correct? Proper installation?
  - Fenestration -- % glass
  - Fenestration – U-factor and SHGC (on plans and in field)
  - Air sealing details
- **HVAC**
  - Programmable controls?
  - Economizer?
  - Duct and pipe insulation?
  - Ducts sealed?

Key Inspection Points (cont.)

- **HVAC (continued)**
  - No simultaneous heating and cooling (except where allowed for reheat)
  - Complex systems
    - Fan power
    - Temperature reset
    - Zoning
    - Reheat limitation
    - Etc.

Key Inspection Points (cont.)

- **Lighting**
  - If most lamps are not T-8 fluorescent or more efficient lamps, need to check
  - Check controls -- occupancy and daylighting controls
  - Exit signs
  - Exterior lighting efficiency and controls

Questions?

Roof Insulation Requirements:
ASHRAE 90.1-2004 (Chapter 5, section 501 of new code)

Table 5.5-3 ASHRAE 90.1-2004

	Nonresidential	Residential	Semiheated
ASHRAE 90.1-2004 (Chapter 5)			
Nonresidential			
Roof	**Zone 3**	**Zone 4**	**Zone 5**
Insulation Entirely above Deck	R-15 c.i.*	R-15 c.i.*	R-15 c.i.*
Metal Building	R-19.0	R-19.0	R-19.0
Attic and Other	R-30.0	R-30.0	R-30.0
Residential			
Roof	**Zone 3**	**Zone 4**	**Zone 5**
Insulation Entirely above Deck	R-15.0 c.i.	R-15.0 c.i.	R-15.0 c.i.
Metal Building	R-19.0	R-19.0	R-19.0
Attic and Other	R-38.0	R-38.0	R-38.0
Semiheated			
Roof	**Zone 3**	**Zone 4**	**Zone 5**
Insulation Entirely above Deck	R-4.0 c.i.	R-4.0 c.i.	R-5.0 c.i.
Metal Building	R-10.0	R-10.0	R-10.0
Attic and Other	R-13.0	R-13.0	R-19.0

* c.i. = continuous insulation -- typically foam

Commercial Wall Insulation Requirements: IECC 2006 (Chapter 5 of new code)

	Climate Zone		
Walls, Above Grade	**3**	**4**	**5**
Mass	R-5.7 c.i.	R-5.7 c.i.	R-7.6 c.i.
Metal building	R-13	R-13	R-13+R-13
Metal framed	R-13	R-13	R-13+R-3.8 c.i.
Wood framed and other	R-13	R-13	R-13
Walls, Below Grade	NR	NR	NR

Walls for Metal Buildings:
R-13 Single insulation layer: The first layer of R-13 insulation batts is installed continuously perpendicular to the girts and is compressed as the metal skin is attached to the girts.
R-13 + R-13 Double insulation layer: The first layer of R-13 insulation batts is installed continuously perpendicular to the girts, and is compressed as the metal skin is attached to the girts. The second layer of R-13 insulation batts is installed within the framing cavity.

Roof Insulation Requirements:
IECC 2006

	Climate Zone		
Roofs	**3**	**4**	**5**
Insulation entirely above deck	R-15, c.i.	R-15, c.i.	R-20, c.i.
Metal buildings (with R-5 thermal blocks)	R-19	R-19	R-19
Attic and other	R-30	R-30	R-30

Roofs for Metal Buildings:

~~R-19 + R-10 Filled cavity roof -- Thermal blocks are a minimum, R-5 of rigid~~ insulation, which extends 1 in. beyond the width of the purlin on each side, perpendicular to the purlin. This construction is R-10 insulation batts draped perpendicularly over the purlins, with enough looseness to allow R-19 batt to be laid above it, parallel to the purlins. Thermal blocks are then placed above the purlin/batt, and the roof deck is secured to the purlins. In the metal building industry, this is known as the "sag and bag" insulation system.

R-19: Standing seam with single insulation layer. Thermal blocks are a minimum R-5 of rigid insulation, which extends 1 in. beyond the width of the purlin on each side, perpendicular to the purlin. This construction R-19 insulation batts draped perpendicularly over the purlins. Thermal blocks are then placed above the purlin/batt, and the roof deck is secured to the purlins.

Building Envelope Example: Roofs

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4 Building Envelope Considerations

- Materials
- Building Assemblies
- Process Design
- Performance

ASHRAE Advanced Energy Guidelines as a Model

Materials

- Building Skin
- Insulation
- Radiant Technologies
- Moisture Control Materials

Building Assemblies

- Wall Systems
- Rain Screens
- Roof/Attic Systems

- Energy Services/Supply
- Envelope Component Integration
- Advanced Panel/Prefabrication
- Intelligent Envelope Systems

Process and Design

- Daylight and Passive Solar
- Modular Coordination
- Natural Ventilation

- Recycling/Reuse Processes
- Regional Design

Performance

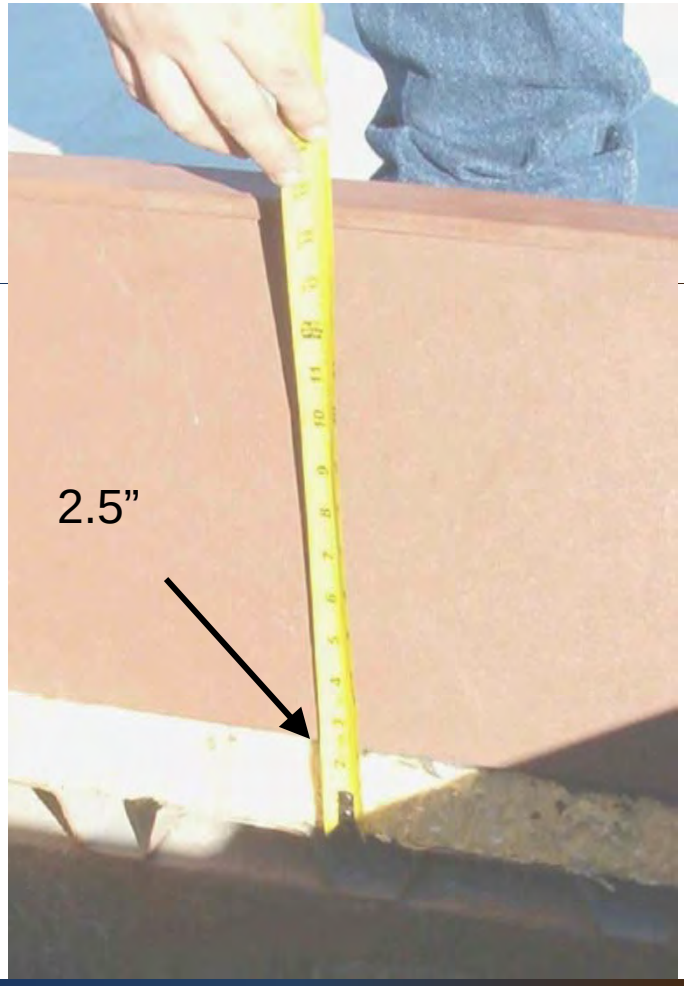
- Performance Modeling/Testing
- Performance Monitoring/Testing
- Performance Rating Criteria

Outline from here

- ASHRAE 90.1 Design Guides
- Orientation impact on energy use
- Insulation measures impact on energy use
- Glazing measures impact on energy use
- Air sealing/ ventilation control impact on energy use
- Impact of package of measures with energy management system/ lighting controls

Inspection is Critically Important!

- Insulation specification was R-30 foam on roof deck according to the plans (and HVAC design)
- The 2.5 inches found installed in the field would only provide about R-15



Cool Roof (SRI - solar reflectance index)

- Solar reflectance and emittance values from a lab accredited by the Cool Roof Rating Council
  - Insert chart

Commercial Wall Requirements:
ASHRAE 90.1-2004 (Chapter 5, Section 501 of new code)

Nonresidential	Zone 3	Zone 4	Zone 5
Walls, Above Grade			
Mass	R-5.7 c.i.	R-5.7 c.i.	R-7.5 c.i.
Metal Building	R-13	R-13	R-13
Steel Framed	R-13	R-13	R-13 + R-4 c.i.
Wood Framed and Other	R-13	R-13	R-13
Below Grade Wall	NR	NR	NR
Residential			
Walls, Above Grade			
Mass	R-7.3 c.i.	R-10 c.i.	R-11 c.i.
Metal Building	R-13	R-13	R-13 + R-13 c.i.
Steel Framed	R-13 + R-4 c.i.	R-13 + R-7 c.i.	R-13 + R-7 c.i.
Wood Framed and Other	R-13	R-13	R-13
Below Grade Wall	NR	NR	NR
Semiheated			
Walls, Above Grade			
Mass	NR	NR	NR
Metal Building	R-6	R-10	R-11.0
Steel Framed	NR	R-13	R-13.0
Wood Framed and Other	R-13	R-13	R-13.0
Below Grade Wall	NR	NR	NR

Commercial Wall Insulation Requirements: IECC 2006 (Chapter 5 of new code)

	Climate Zone		
Walls, Above Grade	**3**	**4**	**5**
Mass	R-5.7 c.i.	R-5.7 c.i.	R-7.6 c.i.
Metal building	R-13	R-13	R-13+R-13
Metal framed	R-13	R-13	R-13+R-3.8 c.i.
Wood framed and other	R-13	R-13	R-13
Walls, Below Grade	NR	NR	NR

Walls for Metal Buildings:
R-13 Single insulation layer: The first layer of R-13 insulation batts is installed continuously perpendicular to the girts and is compressed as the metal skin is attached to the girts.
R-13 + R-13 Double insulation layer: The first layer of R-13 insulation batts is installed continuously perpendicular to the girts, and is compressed as the metal skin is attached to the girts. The second layer of R-13 insulation batts is installed within the framing cavity.

Typical? Non-Compliant!

How about now?

Commercial Floor Requirements:
ASHRAE 90.1-2004 (Chapter 5, Section 501 of new code)

ASHRAE 90.1-2004			
Nonresidential	**Zone 3**	**Zone 4**	**Zone 5**
Floors			
Mass	R-6.3 c.i.	R-6.3 c.i.	R-8.5 c.i.
Steel Joist	R-19	R-19	R-19
Wood Framed and Other	R-19	R-19	R-30
Slab-On-Grade Floors			
Unheated	NR	NR	NR
Heated	R-7.5, 12 in.	R-7.5, 24 in.	R-10, 36 in.
Opaque Doors			
Swinging	U-0.700	U-0.700	U-0.700
Non-Swinging	U-1.450	U-1.450	U-1.450

Residential	**Zone 3**	**Zone 4**	**Zone 5**
Floors			
Mass	R-8.3 c.i.	R-8.3 c.i.	R-10 c.i.
Steel Joist	R-19	R-30	R-30
Wood Framed and Other	R-30	R-30	R-30
Slab-On-Grade Floors			
Unheated	NR	NR	NR
Heated	R-7.5, 24 in.	R-10, 36 in.	R-10, 36 in.
Opaque Doors			
Swinging	U-0.700	U-0.700	U-0.700
Non-Swinging	U-1.450	U-0.500	U-0.500

Commercial Floor Requirements:
IECC 2006 (Chapter 5 of new code)

Floors	Zone 3	Zone 4	Zone 5
Mass	R-5 c.i.	R-10 c.i.	R-10 c.i.
Joist / Framing	R-19	R-19	R-19
Slab-on-Grade Floors			
Unheated slabs	NR	NR	
Heated slabs	R-7.5 (12 in vert)	R-7.5 (12 in vert)	R-7.5 (24 in vert)