Updating Your Masonry Details

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Directory, Industry Development & Technical Services

team

UNION MASONRY CRAFTWORKERS
CONTRACTORS & CONSULTANTS

MASONRY DESIGN, CONSTRUCTION, AND TROUBLESHOOTING

HAMILTON PARKER COMPANY

FRIDAY, APRIL 15, 2016

team

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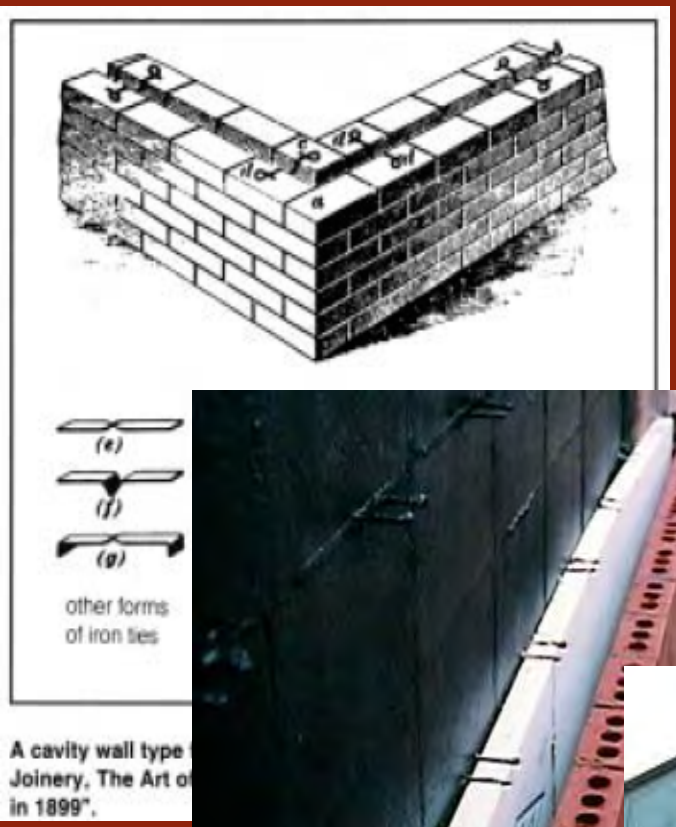
Introduction / Learning Objectives

- Energy Efficiency and Effect on Detailing
- Water Penetration Resistance
  - Rain Screen Walls
- Movement and Dissimilar Materials
- The Flexibility of Brick

Change


(e)
(f)
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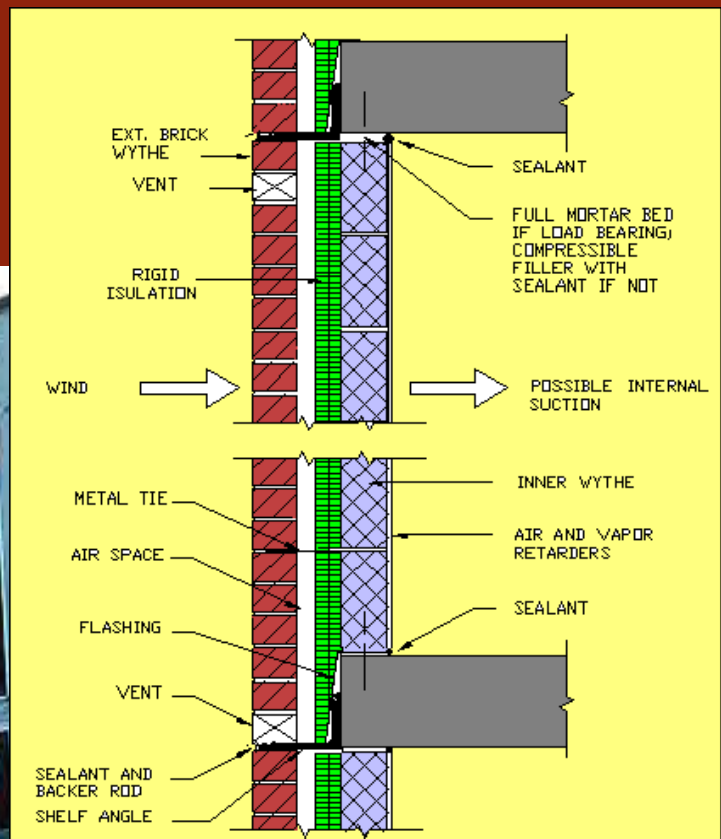
other forms
of iron ties
A cavity wall type
Joinery, The Art o
in 1899".


EXT. BRICK
WYTHE
VENT
RIGID
ISULATION
WIND
SEALANT
FULL MORTAR BED
IF LOAD BEARING,
COMPRESSIBLE
FILLER WITH
SEALANT IF NOT
POSSIBLE INTERNAL
SUCTION
METAL TIE
AIR SPACE
FLASHING
VENT
SEALANT AND
BACKER ROD
SHELF ANGLE
INNER WYTHE
AIR AND VAPOR
RETARDERS
SEALANT

Increasing Insulation Requirements

ASHRAE 90.1 Prescriptive Insulation Requirements
Steel-Framed, Above-Grade Walls

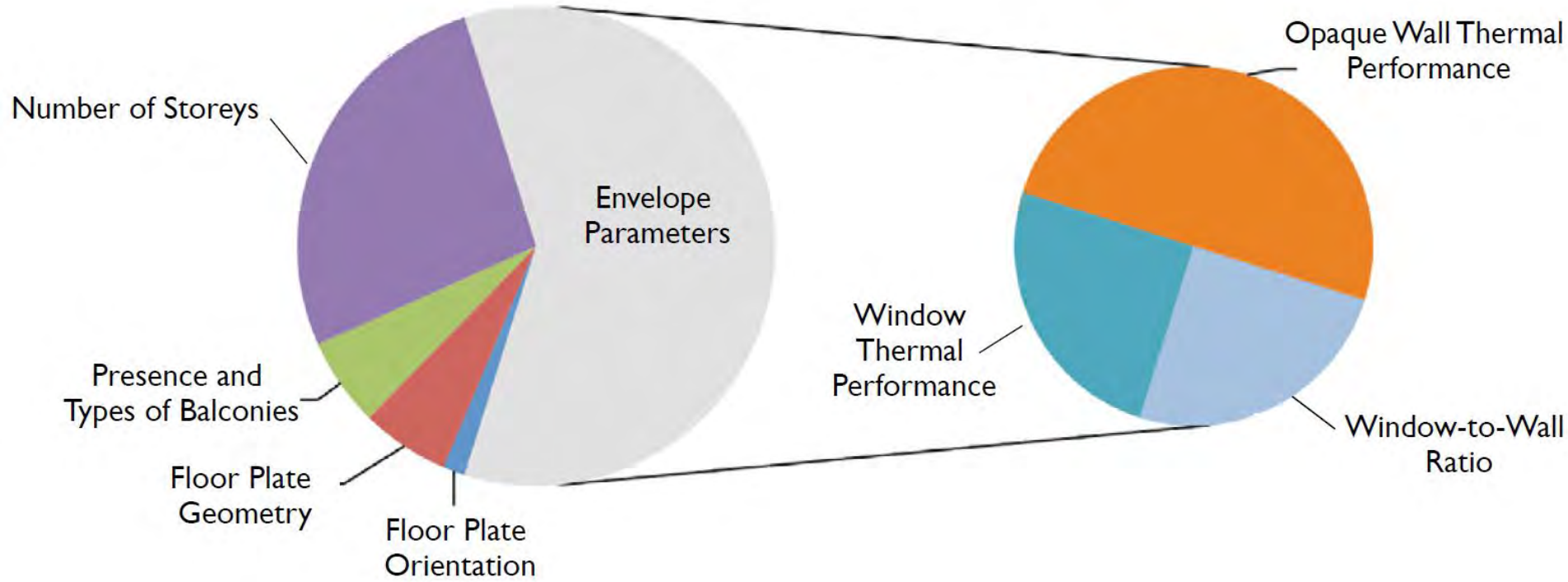
Climate Zone	Min. R-Value, **Non-Residential**			
	2004	**2007**	**2010**	**2013**
1	R-13.0	R-13.0	R-13.0	R-13.0
2	R-13.0	R-13.0	R-13 + R-3.8 c.i.	R-13 + R-3.8 c.i.
3	R-13.0	R-13 + R-3.8 c.i.	R-13 + R-5.0 c.i.	R-13 + R-5.0 c.i.
4	R-13.0	R-13 + R-7.5 c.i.	R-13 + R-7.5 c.i.	R-13 + R-7.5 c.i.
5	R-13 + R-3.8 c.i.	R-13 + R-7.5 c.i.	R-13 + R-10.0 c.i.	R-13 + R-10.0 c.i.
6	R-13 + R-3.8 c.i.	R-13 + R-7.5 c.i.	R-13 + R-12.5 c.i.	R-13 + R-12.5 c.i.
7	R-13 + R-7.5 c.i.	R-13 + R-7.5 c.i.	R-13 + R-12.5 c.i.	R-13 + R-12.5 c.i.
8	R-13 + R-7.5 c.i.	R-13 + R-7.5 c.i.	R-13 + R-18.8 c.i.	R-13 + R-18.8 c.i.

c.i. = continuous insulation, uninterrupted by structural members

Importance of the Building Envelope

- What has the biggest impact on building loads?
  - Form of building (massing)
  - Height of Building
  - Orientation
  - Performance of opaque wall For heating climates
  - Window Performance
  - Window-to-Wall ratio (WWR)

Relative Impact of Architectural Features on Heating Loads



"Impact of Architectural Form on the Potential Energy Performance of Multi-Unit Residential Buildings", Canada Mortgage and Housing Corporation, Nov. 2014

Energy Efficiency with Masonry

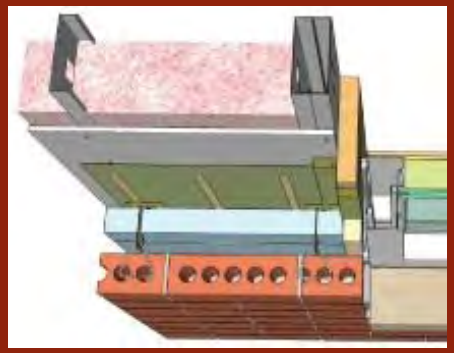
- Insulating Masonry Walls
- Thermal Mass
- Passive Heating and Cooling techniques
- Air Barriers
- Minimize Thermal Bridging

Insulation Strategies with Masonry

- Interior

- Cavity

Hybrid



Exterior

Thermal Performance of Cavity Walls

- Provides room for Continuous Insulation
- Provides thermal mass reducing insulation reqt's
- Leaves drainage space

- There are limitations on insulation in cavity wall systems

Thermal Performance

- 12” brick & block* cavity wall w/ 2” air space
  - w/ 1” XPS insulation **9.5**
- 14” brick & block* cavity wall w/ 4” air space
  - w/ 2” XPS insulation **14.5**
- 16” brick & block cavity wall w/ 4” air space
  - w/ 2” XPS insulation **13.7**

Does not include thermal mass!

* Lightweight CMU

Typical R-values of Brick Walls

- 14” brick & block* cavity wall w/ 4” air space
  - w/ 3” XPS insulation **19.5**
- 16” brick & block* cavity wall w/ 4” air space
  - w/ 3” polyiso insulation **26.3**

Does not include thermal mass!

* Lightweight CMU

Energy Codes and Continuous Insulation

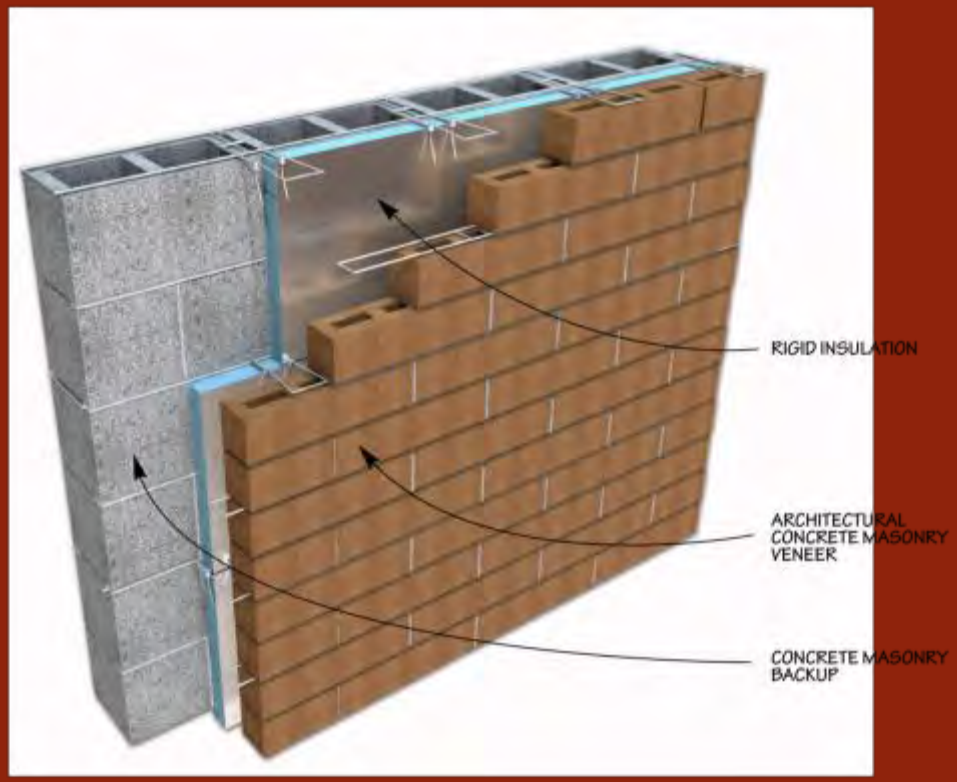
- What is Continuous Insulation?

> ***continuous insulation (c.i.):*** insulation that is continuous across all structural members without thermal bridges other than fasteners and service openings. It is installed on the interior or exterior or is integral to any opaque surface of the building envelope.

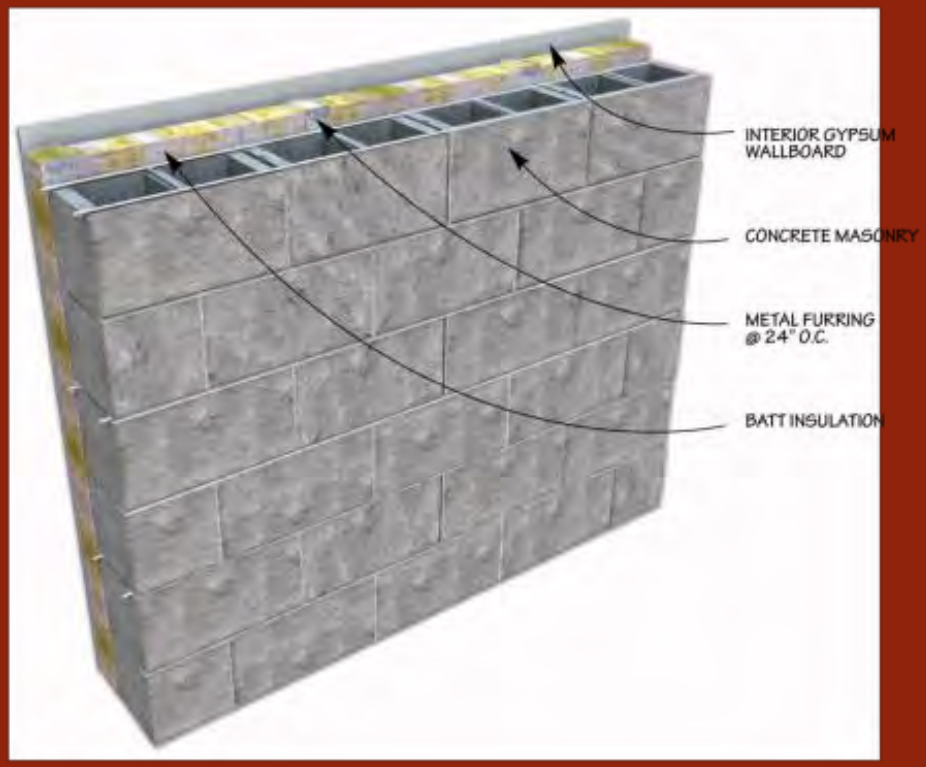
- First of all, all walls don't NEED to have continuous insulation, it's only REQUIRED when using the Prescriptive R-value tables
- Still a GOOD IDEA to have insulation that is continuous though

Continuous Insulation

- This

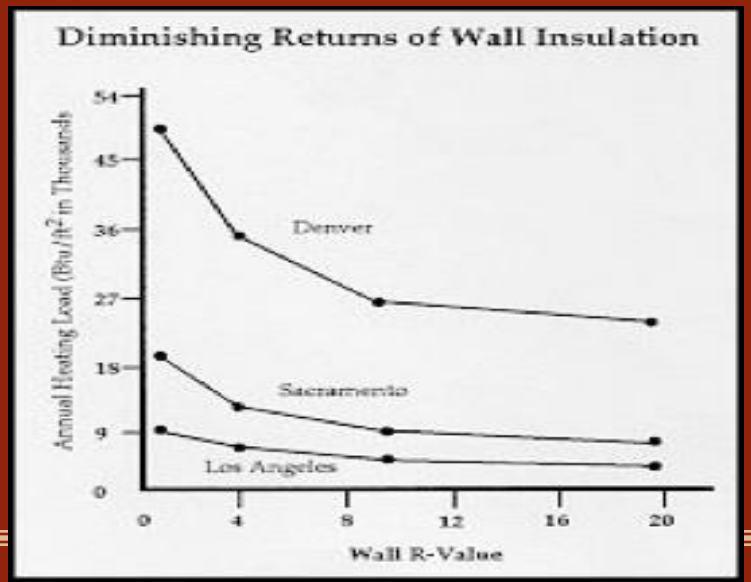


- Not This



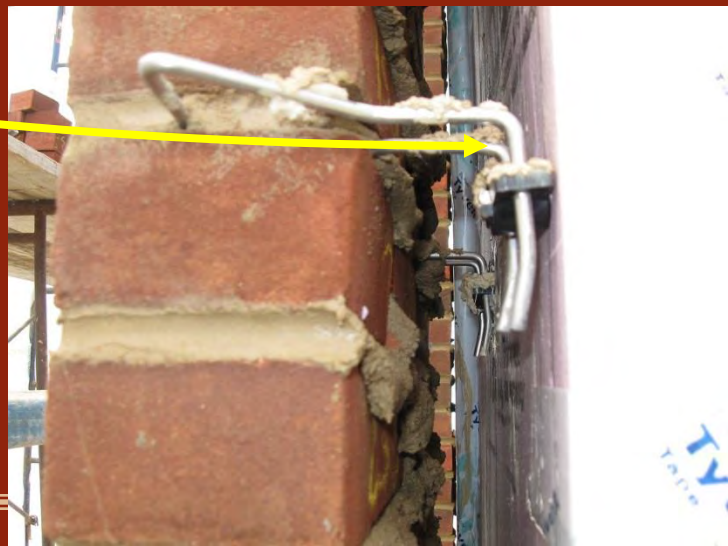
Limits on Insulation Thickness

- Maximum cavity thickness
  - 4 ½" max. dictated by code, but thicker cavities can be designed; a wall tie analysis is conducted
  - Minimum 1" air space for moisture resistance
- Insulation has a point of diminishing return



Wider Air Spaces & Detailing

- Maximum air space is 4 1/2 in. according to TMS 402
- Detailed wall tie analysis
  - Compression dictates (not tension)
  - Largest impact is offset in adjustable tie



Limits on Insulation

Table 3.5: Cost and Performance Comparison of Adding More Insulation to Steel Stud Assemblies to go from an "Effective" R-value of R-15.6 to R-20

Building Type	Incremental Construction Cost	Energy Cost Savings	Payback (years)
Commercial Office	$ 94,825	$ 1,116	85
High-Rise MURB	$ 153,222	$ 2,542	60
Hotel	$ 64,650	$ 543	119
Large Institutional	$ 150,375	$ 1,833	82
Non-Food Retail	$ 24,192	$ 461	53
Recreation Centre	$ 28,400	$ 263	108
Secondary School	$ 36,325	$ 306	119

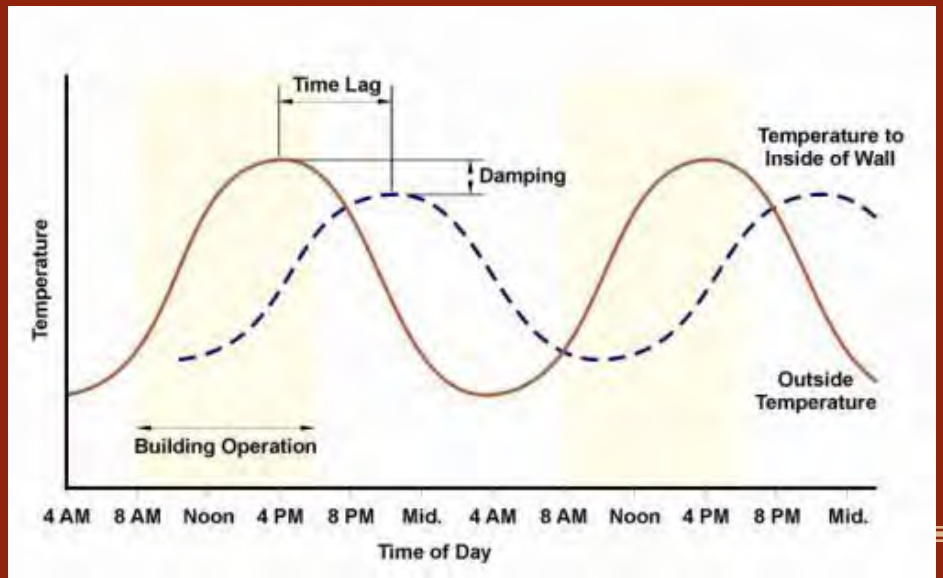
The costs for adding more insulation is quite high when compared to the energy savings.

Building Envelope Thermal Bridging Guide, BC Hydro, Morrison Herschfield, Vancouver, 2014

Central Michigan University Graduate Housing
5 ½” wide cavity; 4” spray foam insulation

Thermal Mass

- Thermal Lag
  - Materials with high thermal mass take longer to heat or cool
- Dampening Effect
  - Steady-state calculations may overstate heat flows of masonry walls by up to 60%



Thermal Mass Effects (Prescriptive)

- Lower levels of insulation are required for a mass-type wall system

From ASHRAE 90.1 - 2007

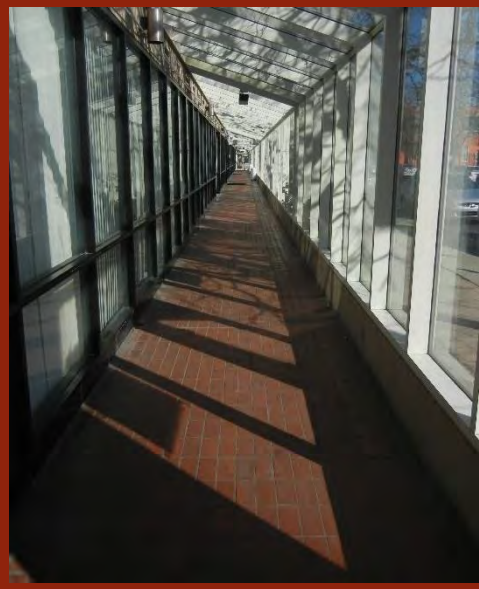
TABLE 5.5-5 Building Envelope Requirements for Climate Zone 5 (A, B, C)*

Opaque Elements	Nonresidential		Residential		S
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum
Roofs					
Insulation Entirely above Deck	U-0.048	R-20.0 c.i.	U-0.048	R-20.0 c.i.	U-0.119
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-0.097
Attic and Other	U-0.027	R-38.0	U-0.027	R-38.0	U-0.053
Walls, Above-Grade					
Mass	U-0.090	R-11.4 c.i.	U-0.080	R-13.3 c.i.	U-0.151[a]
Metal Building	U-0.113	R-13.0	U-0.057	R-13.0 + R-13.0	U-0.123
Steel-Framed	U-0.064	R-13.0 + R-7.5 c.i.	U-0.064	R-13.0 + R-7.5 c.i.	U-0.124
Wood-Framed and Other	U-0.064	R-13.0 + R-3.8 c.i.	U-0.051	R-13.0 + R-7.5 c.i.	U-0.089

40% difference

Passive Heating and Cooling Strategies

- East-West elongated floor plan
- (Appropriately) Glazed South wall
- Overhangs/projections to block out the summer sun
- Thermal storage media exposed to radiation penetrating South wall
  - Direct Gain (interior thermal mass)
  - Thermal Storage Wall Systems
- Biomimicry



Lanchester Library, Coventry University

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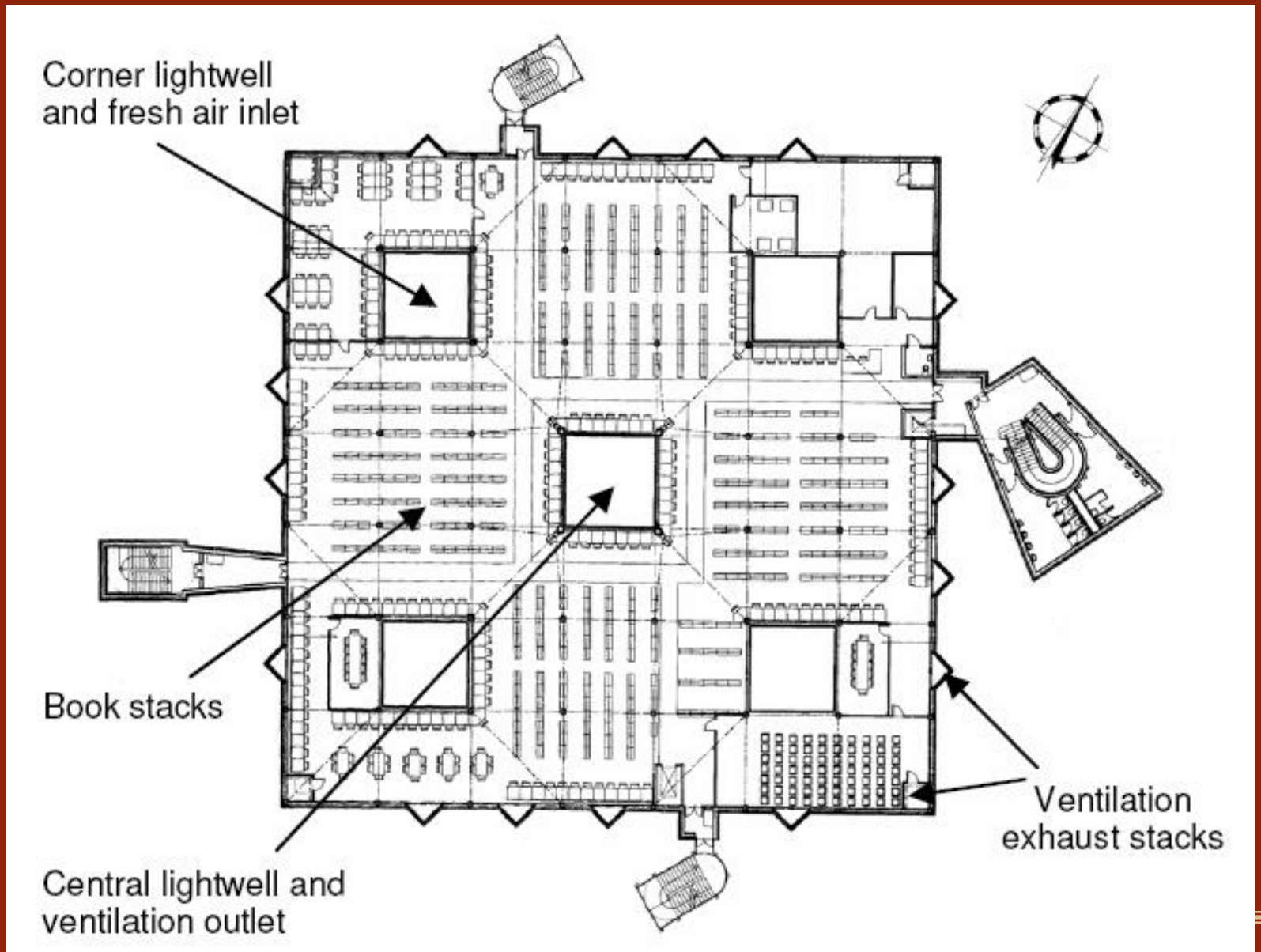

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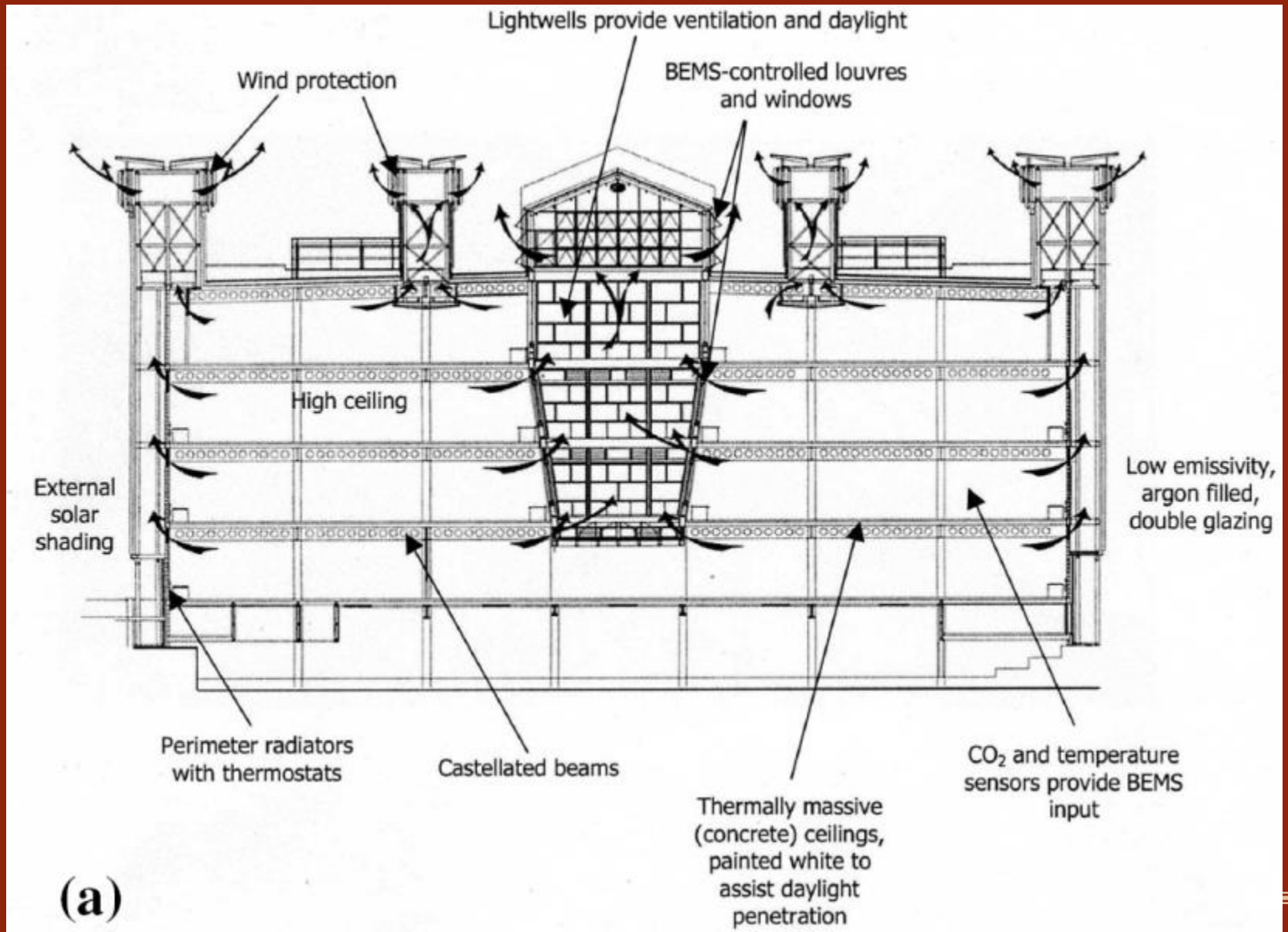

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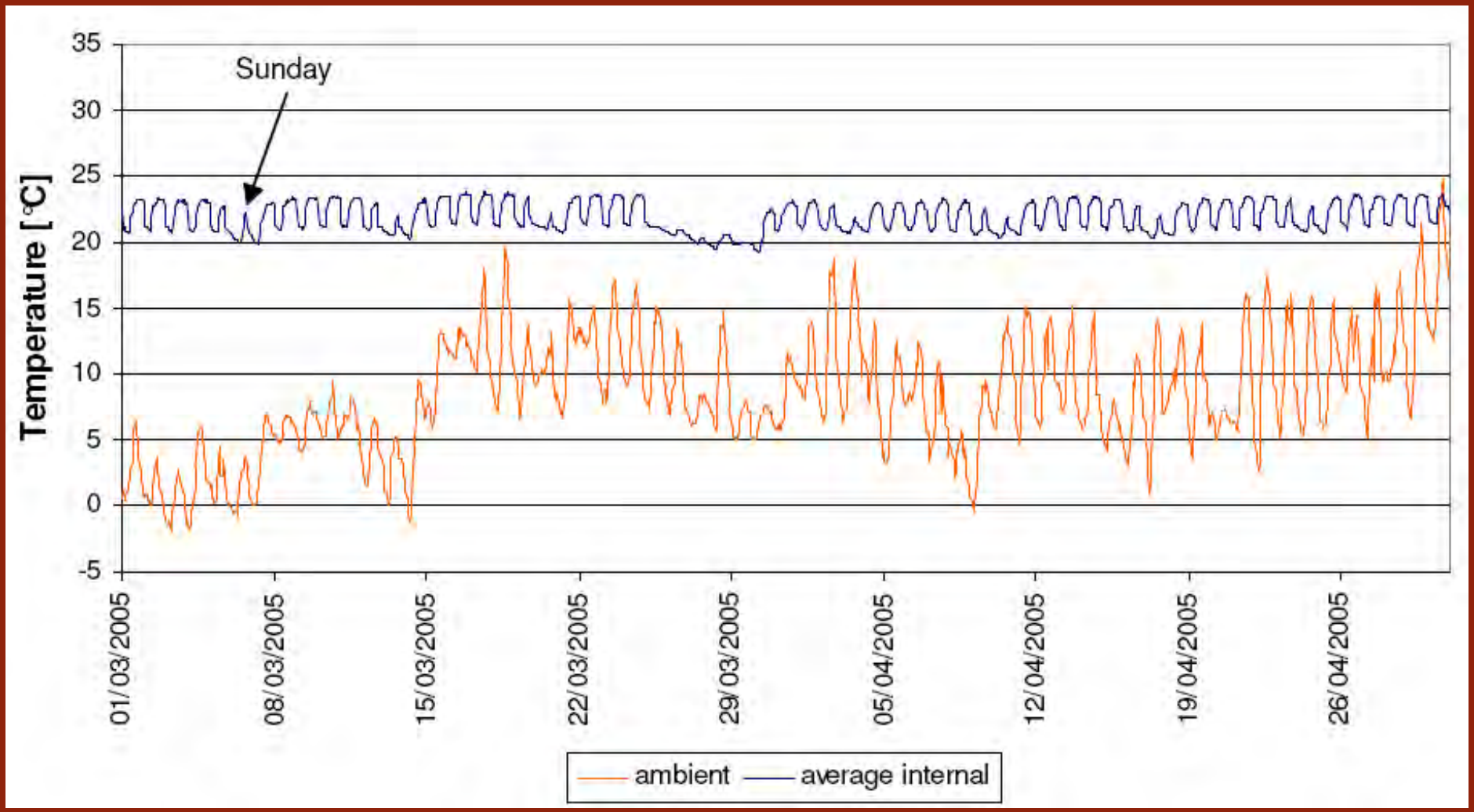
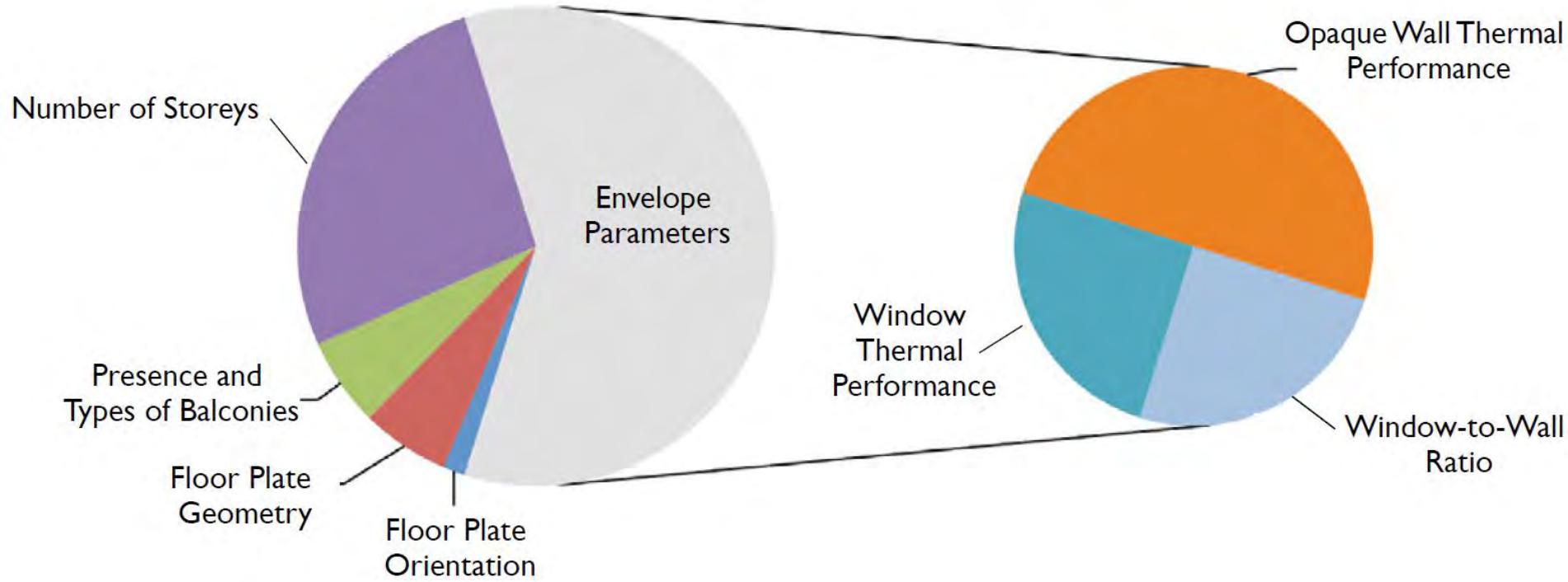


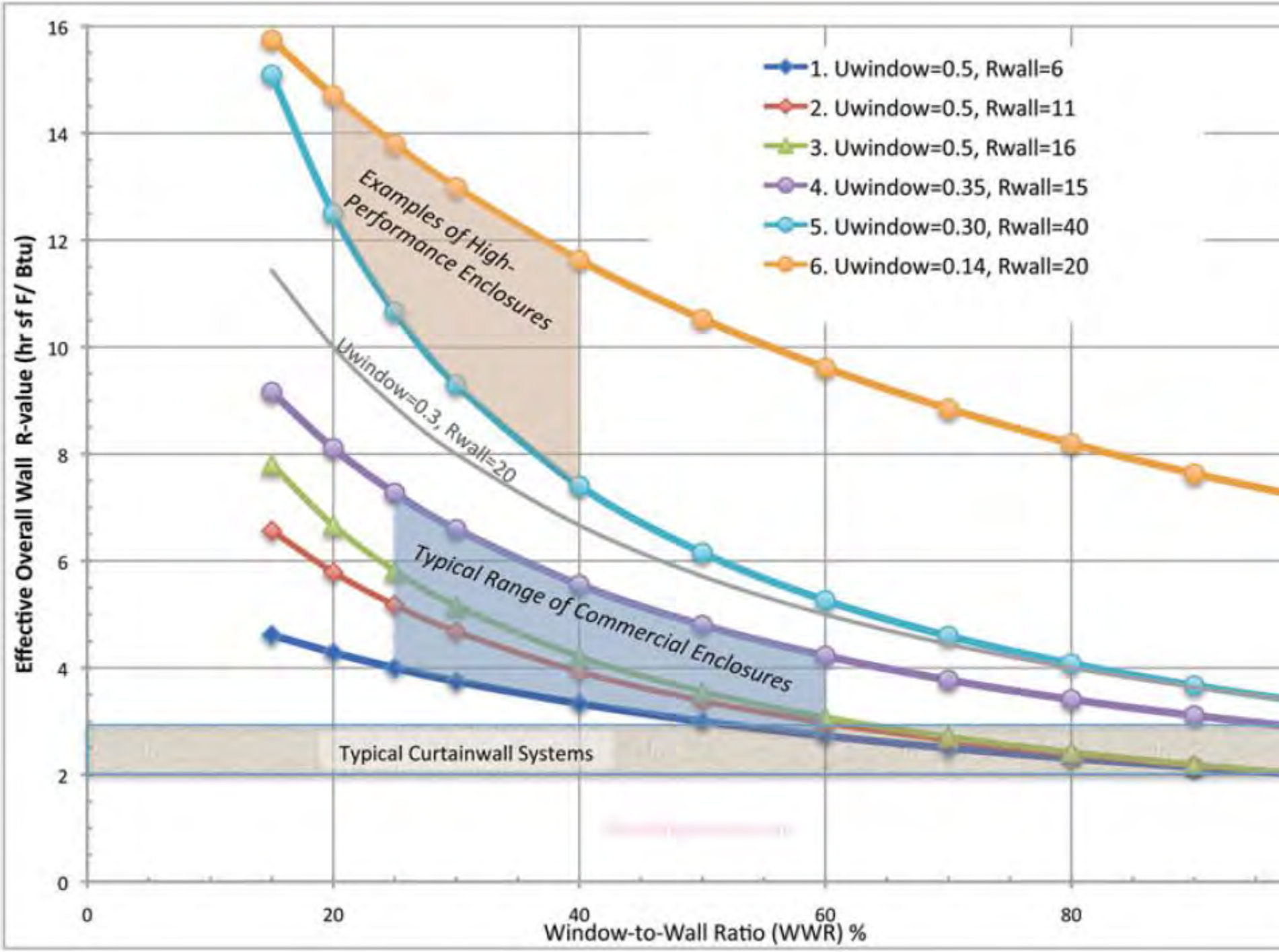
Relative Impact of Architectural Features on Heating Loads

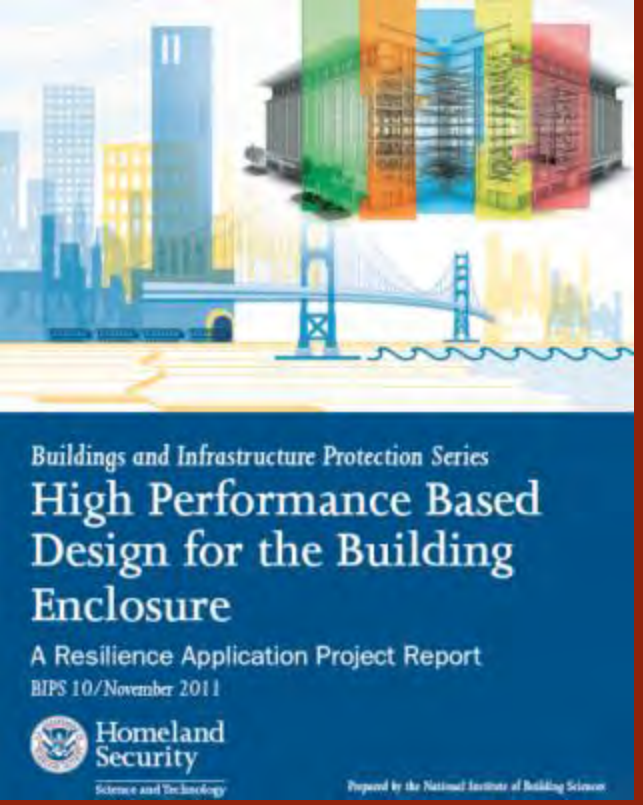


"Impact of Architectural Form on the Potential Energy Performance of Multi-Unit Residential Buildings", Canada Mortgage and Housing Corporation, Nov. 2014

Energy Efficiency

- Windows and Daylighting
  - Important for views, but…
  - Too much glass ➡ issues with heat gain / glare
  - Poor insulator
- *From LEEDUser.com*
  - 40% window-to-wall ratio is appropriate
  - Anything within 30" of floor has no daylight benefit


1. Uwindow=0.5, Rwall=6
2. Uwindow=0.5, Rwall=11
3. Uwindow=0.5, Rwall=16
4. Uwindow=0.35, Rwall=15
5. Uwindow=0.30, Rwall=40
6. Uwindow=0.14, Rwall=20
Examples of High-Performance Enclosures
Uwindow=0.3, Rwall=20
Typical Range of Commercial Enclosures
Typical Curtainwall Systems
Effective Overall Wall R-value (hr sf F/ Btu)
Window-to-Wall Ratio (WWR) %
0
2
4
6
8
10
12
14
16
0
20
40
60
80



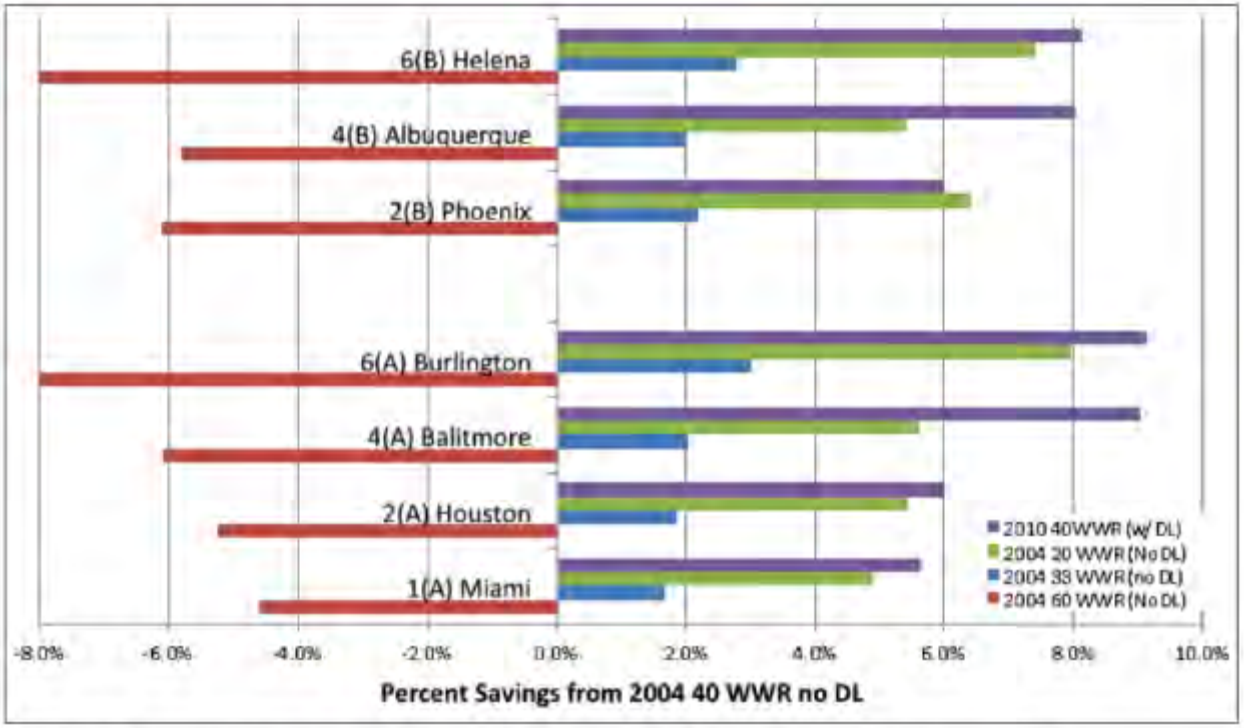
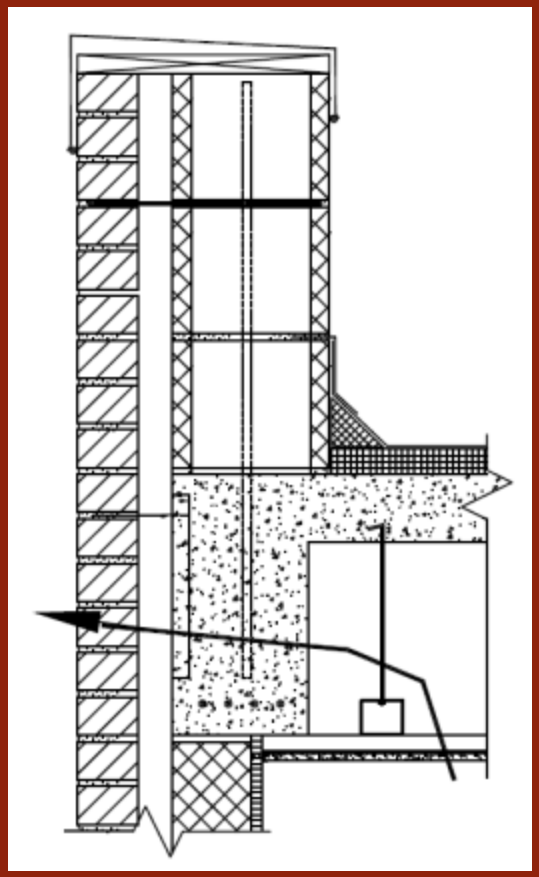


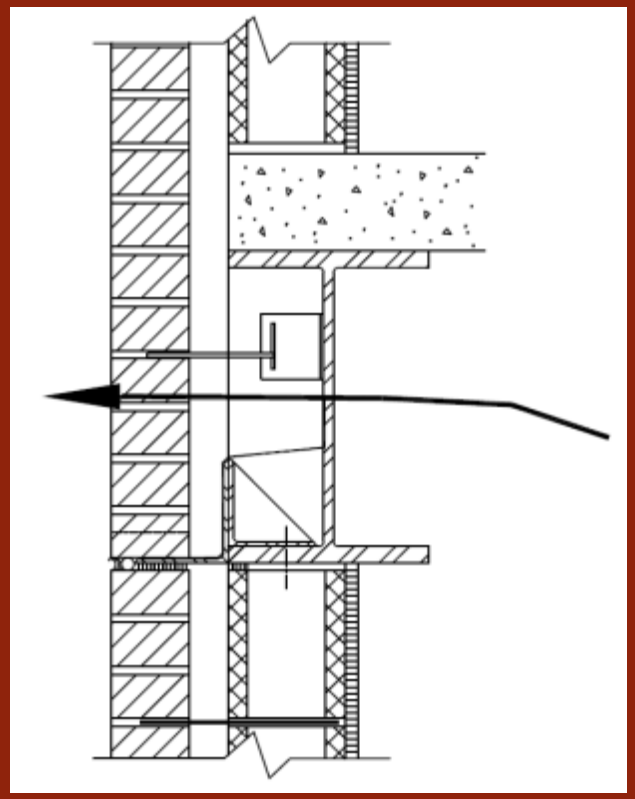
Figure B-32: Bar graph of Source Percent Savings for different window-to-wall ratios from 90.1-2004 (no daylighting)

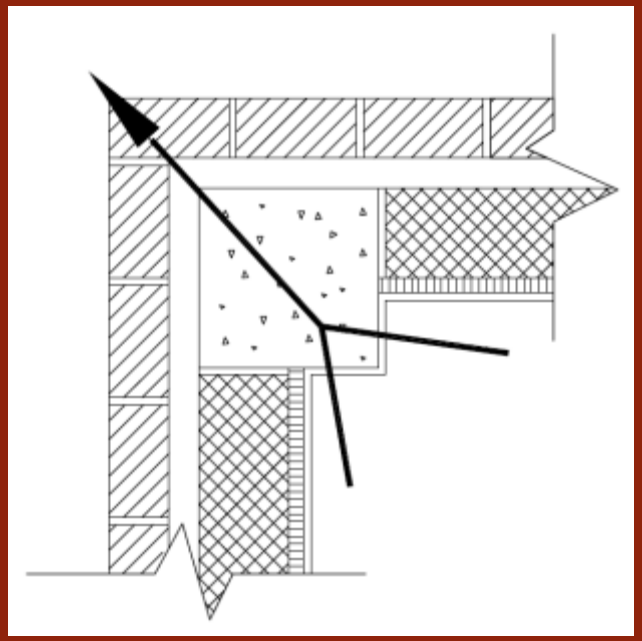
One implication of these results is that designers should be careful about increasing WWR when using daylighting, for the increased WWR is likely to partially or completely offset the energy or cost savings from daylighting. If WWR is increased substantially over a non-daylighting base case, the resultant design with high WWR and daylighting might use more energy than the base case.

Energy Efficiency and Thermal Bridges

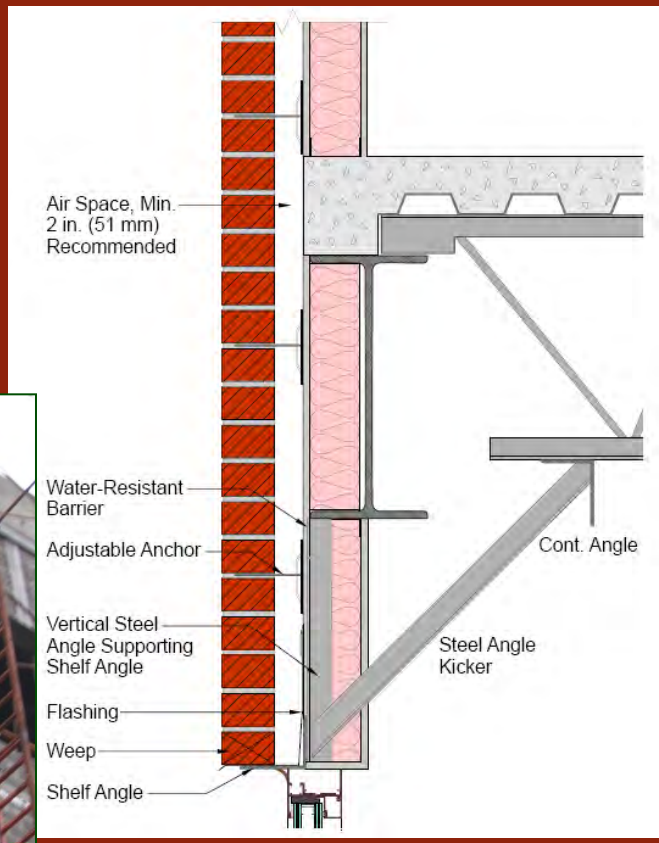
- Consider areas where insulation is not continuous



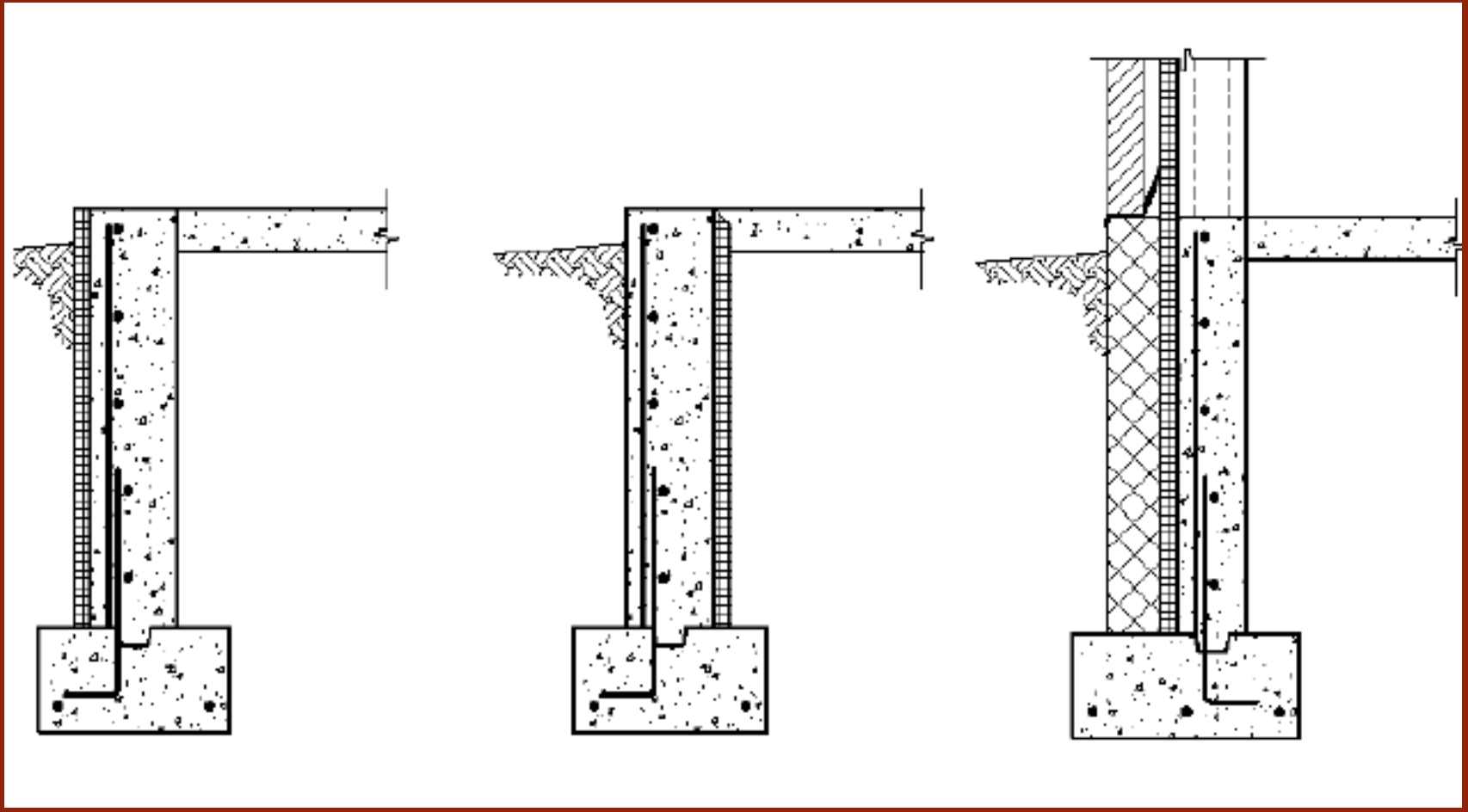




Thermal Bridges to Avoid

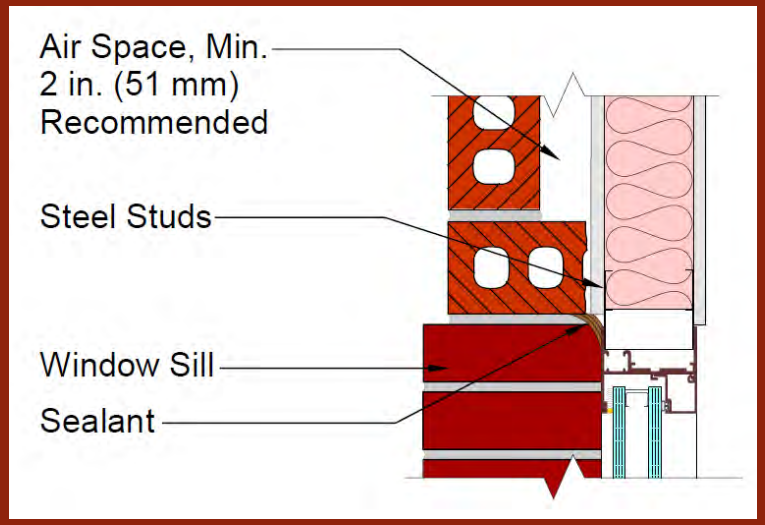


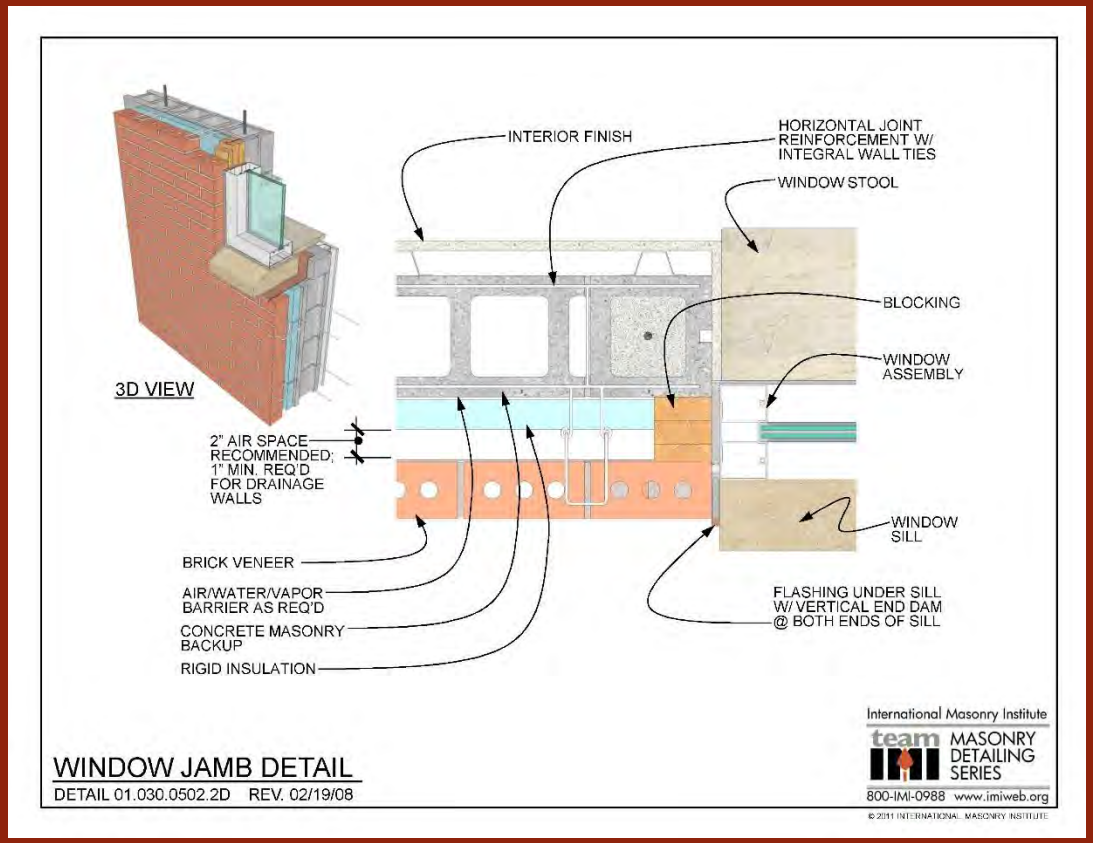
Foundation Insulation



Window Return and Thermal Bridging

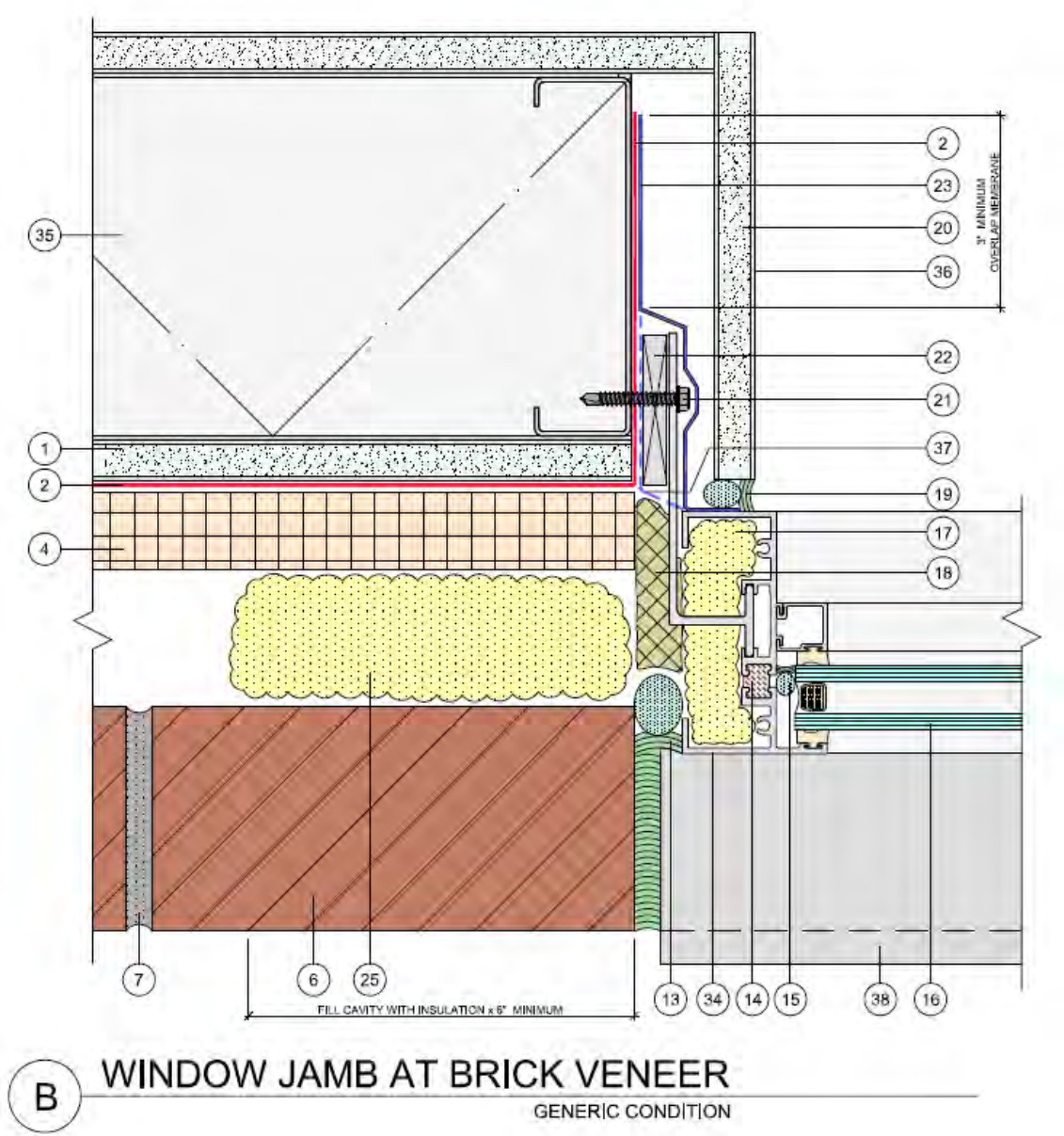
- Continuous Insulation/Thermal Bridging





Window Return and Thermal Bridging

- Detail from Whole Building Design Guide
- Could you build it?!?



Shelf Angles and Thermal Bridging

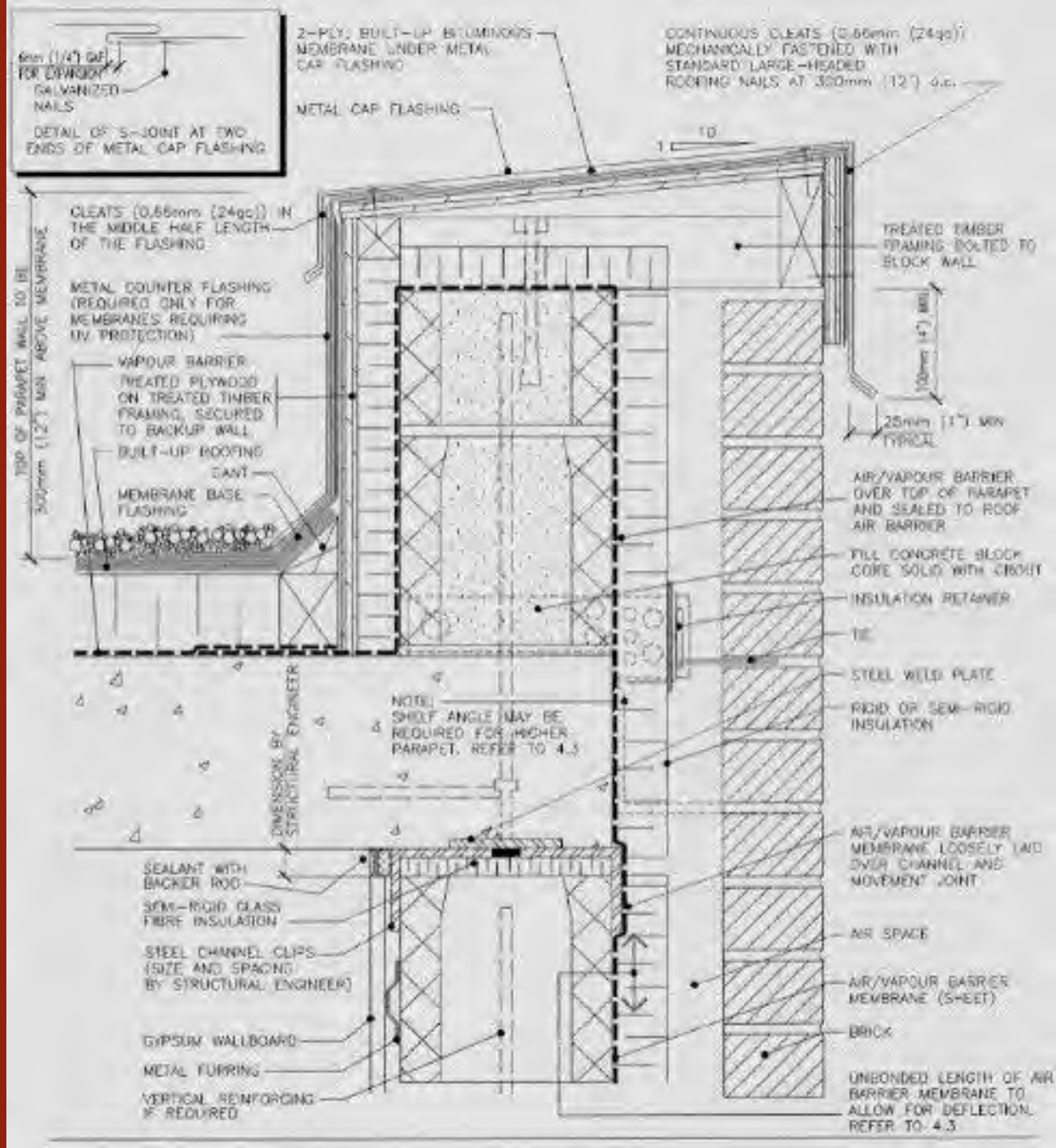
- Studies show a 20% to 30% reduction in R-value of wall at shelf angle locations

Shelf Angles and Thermal Bridging

- Clip System
- Insulation behind angle
- Minimize steel connection

Parapets

- Consider:
  - Thermal bridging
  - Air Barrier



Fire Issues

- Brick and Block don't burn
- Always consider Compartmentation

Limits on (certain types) of Insulation

- Newer editions of the IBC have set limits on the use of foam plastic insulation in wall systems
- NFPA 285
- Now what?

NFPA 285 TESTING REQUIREMENTS IN THE INTERNATIONAL BUILDING CODE (IBC)

Material	Code Section	First Appearance in the IBC
Water-resistive barrier (WRB)	1403.5	2012
Metal composite materials (MCM)	1407.10	2003
High-pressure laminates (HPL)	1409.10	2012
Foam plastic insulation	2603.5	2000
Fiber-reinforced polymers	2612.6	2009

NFPA 285

- Designing with current IBC requirements in place:
  - Use foam plastic insulation that has been tested according to NFPA 285 using all listed materials
  - Use other than foam plastic insulation, i.e. mineral wool fiber insulation
  - Provide information to AHJ showing alternate compliance

NFPA 285 & Detailing

- Follow details from manufacturer
- Window head is tricky spot
- Mostly ignored

285 for a steel stud or block-backed cavity with 4" nominal exterior brick veneer. Mineral wool fire safing (min. 1" thick) is required in the header of all openings. Attachment may be achieved with impaling pins welded to the underside of the header lintel or similar method. Floor-line firestopping is also required in the stud cavity at each

Continued Problems with Water Penetration

- Water entry into interior
- Efflorescence
- Mold
- Spalling
- Corrosion
- Reduced insulating capacity
- Staining

Keys to Providing Water Penetration Resistance

- Quality Materials
- Good Construction
- Proper detailing
- Maintenance

Rain Penetration Control

Rain Screen Walls

- History
- A design approach – not a product

Open-jointed barn technique, Norway

Alice Cook House, Cornell University, New York

Why Rain Screen Walls?

- Approximately 80 percent of post-construction claims against architects are for water leakage. Reason:
  - Improper design and/or construction
  - Lack of pertinent knowledge
  - Use of outdated practices

Rain Screen Theory

- Practical solution to rain penetration
- Design exterior rainproof finishing (brick veneer) so open that no super-pressure can be created
- Provide air space behind the exterior finishing, but with connection to the outside air
- Surges of air pressure created by gusts of wind will be equalized on both sides of the finishing

Birkeland, Curtain Walls, 1962

When Should Rain Screen Walls be Used?

- Areas of high precipitation in combination with high wind
- In heating dominated climates, or where the building may be under negative pressure a majority of the time
- Low maintenance wall
- A better wall – energy, moisture

Rain Screen Walls
Benefits

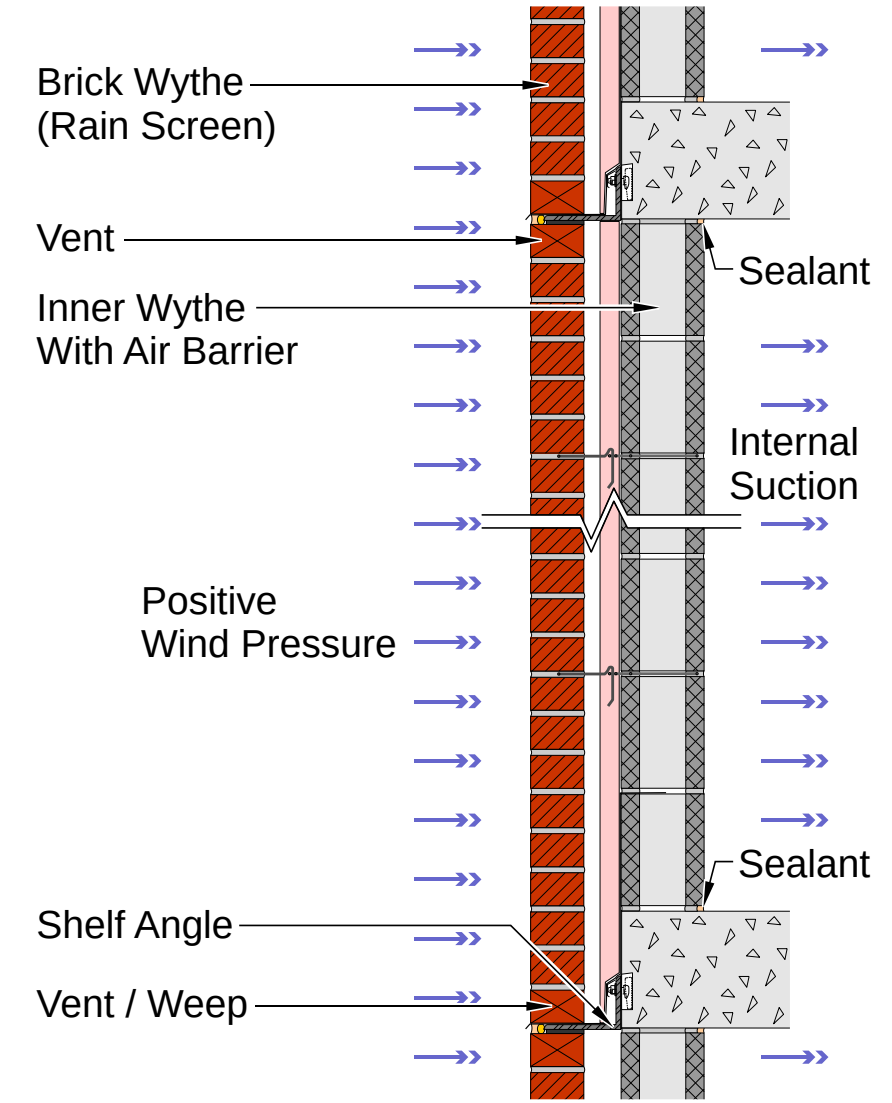
- Helps neutralize forces that drive/draw air and water into the wall
- Building elements protected by screen
- Wall dries quickly
- Effective in any climate
- Energy performance
- Forgiving: Defaults to drainage wall

Disadvantages

- More analysis – maybe
- Air tightness of backup is critical
- Lack of familiarity among trades, design community
- Careful design – not an off-the-shelf product
- Cost

How Walls Leak -- Air

- Air flow/movement from:
  - Wind
  - Stack effect
  - Fan pressures
- Diffuse flow through material
- Channel flow through openings



Air Movement

Cavity and Rain Screen Walls Requirements

- 2 to 4 ½ inch clear cavity
- Moisture / Air / Vapor Barrier
- Flashing and weep holes
- Vents (for rain screens)

Moisture Resistance Layers

Weather Resistive Barrier

- Bulk Water ⇨ W.R.B.
- Air Diffusion ⇨ V.R.
- Air Leakage ⇨ A.B.

Vapor Retarder

Air Barrier

Flashing Detail

Good Flashing

Bad Flashing

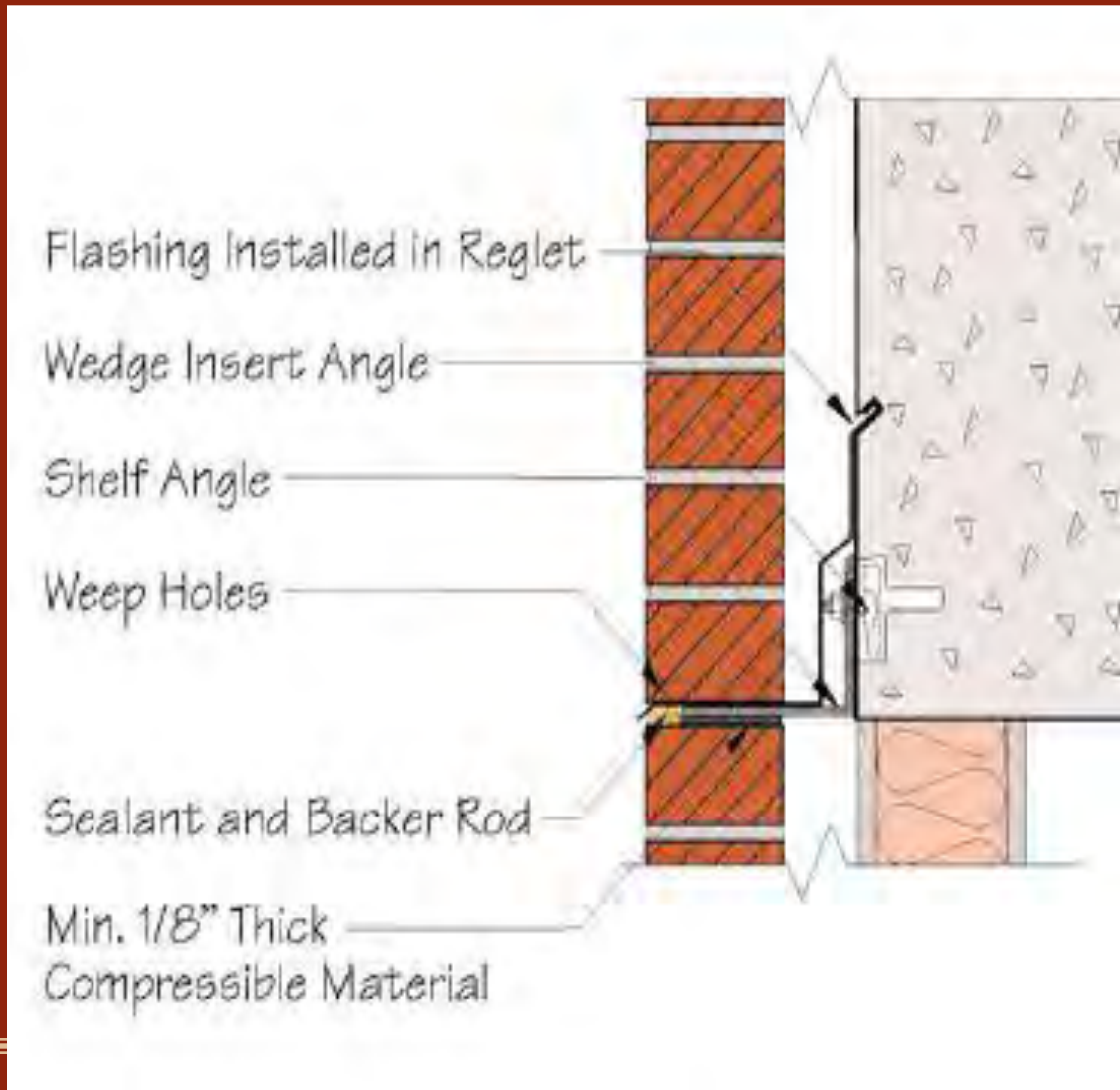
More Desirable Weeps

Less Desirable Weeps

Vents for Rain Screen Walls

- Alternating open head joints in the bottom course of brick or no more than 24” o.c.
- Top of the wall is also ventilated with a protected wall vent
- Vents at top and bottom not at same vertical location

Drip Edges


Flashing Installed in Reglet
Wedge Insert Angle
Shelf Angle
Weep Holes
Sealant and Backer Rod
Min. 1/8" Thick
Compressible Material

Differential Movement / Cracking

- Differential Movement
- Restraint
- Settlement
- Elastic Deformations
- Creep

Types of Movement

TABLE 1
Types of Movement of Building Materials

Building Material	Thermal	Reversible Moisture	Irreversible Moisture	Elastic Deformation	Creep
Brick Masonry	X	–	X	X	X
Concrete Masonry	X	X	–	X	X
Concrete	X	X	–	X	X
Steel	X	–	–	X	–
Wood	X	X	–	X	X

Movement Joints

- Expansion Joint - Brick Masonry

- Control Joint - Concrete Masonry

- Building Expansion Joint - Structures

Expansion Joint Spacing

- $w = (0.0005 + 0.0000036\ \Delta T)\ L$

Coefficient of moisture expansion

Coefficient of thermal expansion

  – Where: w = size of expansion joint

    ΔT = temp. change (usually 100 °F)

    L = length of wall

- Rule of thumb ≈ every 25’

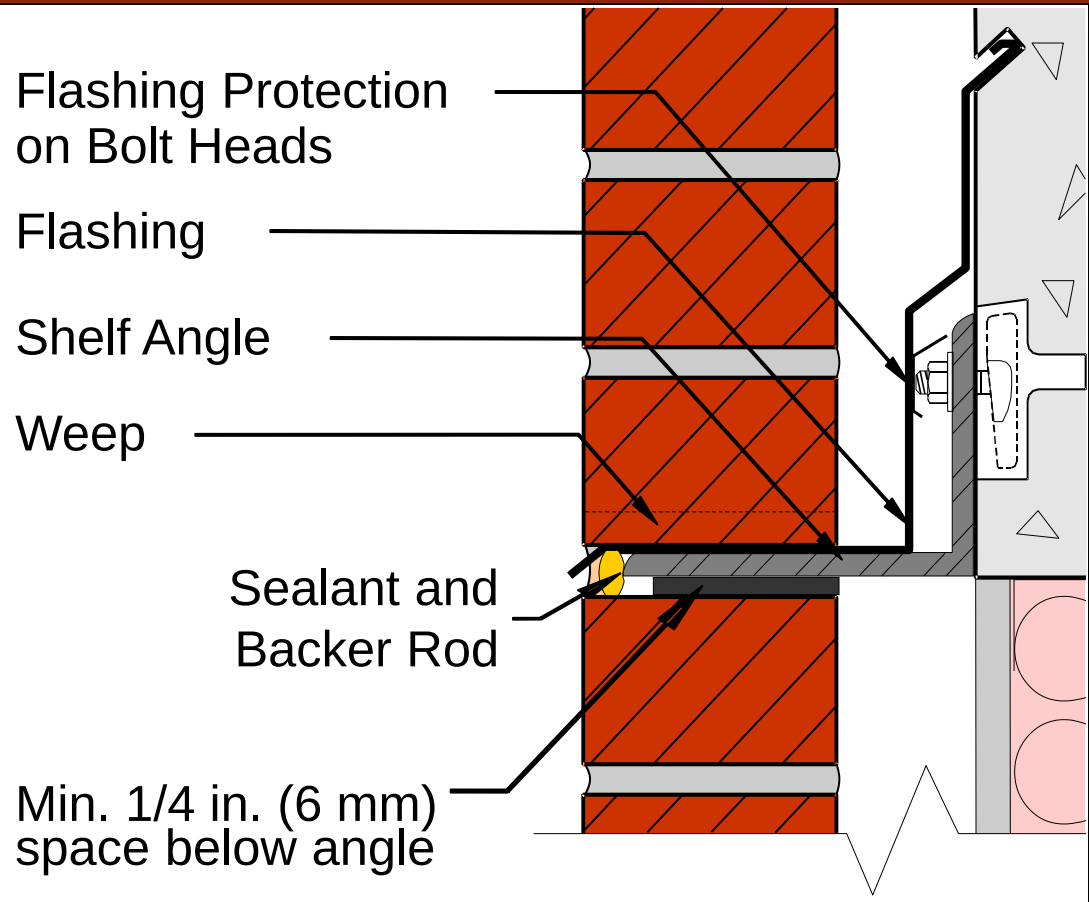
Expansion Joint Placement

Horizontal Expansion Joints

- Shelf Angles
  - NOT Relieving Angles

Standard Shelf Angle Detail

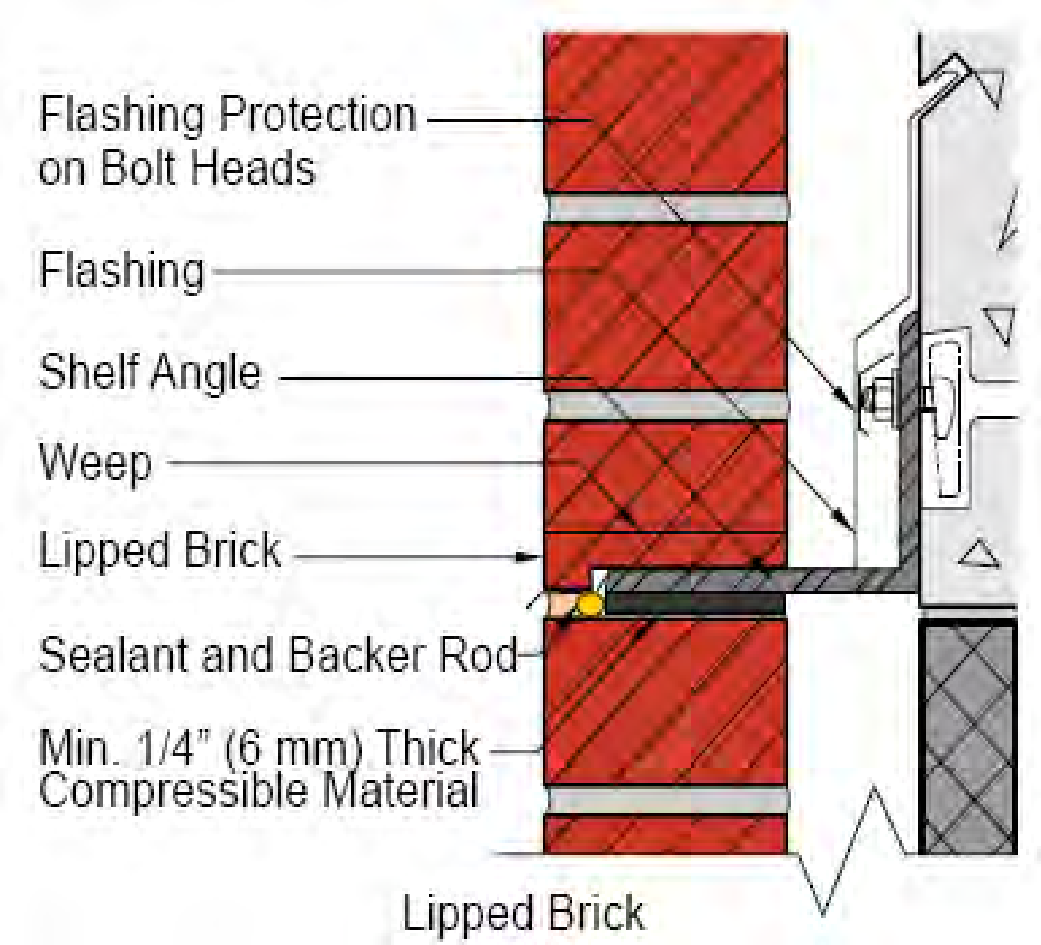
- Code R'qment
  - 30' high max.
  - 38' at gable
  - often at every floor
- Minimum ¼" gap beneath angle



Horizontal Expansion Joint at Shelf Angle

Shelf Angle with Lip Brick

- Lipped Brick reduces apparent size of EJ
- Complicates flashing



Shelf Angles and Multi-story Buildings

Block backing –
no limit on brick veneer

Wood frame backing –
limits on brick veneer

Shelf Angles and Wood Frames

- Attachment?

Brick Veneer and Wood Frame

Growth of Brick / Shrinkage of Wood Frame

Podium Construction

- 1st story concrete or concrete masonry

Alternative Design Procedures

- TMS 402 Section 12.2.1 Alternative Design
  - Doesn't use prescriptive requirements

12.2.1 *Alternative design of anchored masonry veneer*

The alternative design of anchored veneer, which is permitted under Section 1.3, shall satisfy the following conditions:

(a) Loads shall be distributed through the veneer to the anchors and the backing using principles of mechanics.

(b) Out-of-plane deflection of the backing shall be limited to maintain veneer stability.

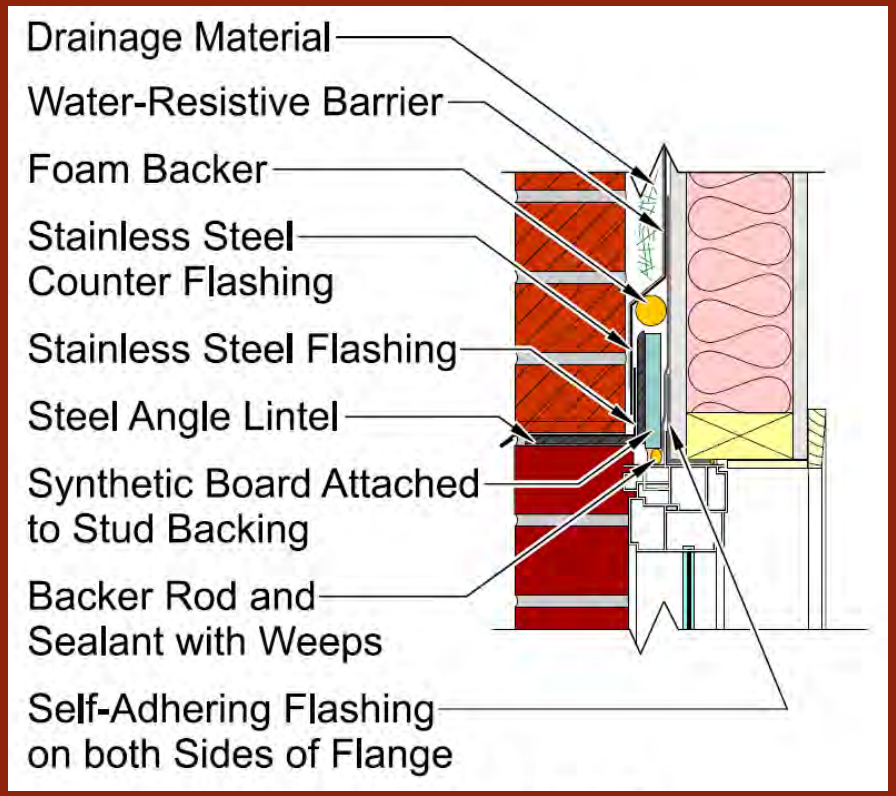
(c) The veneer is not subject to the flexural tensile stress provisions of Section 8.2 or the nominal flexural tensile strength provisions of Section 9.1.9.2.

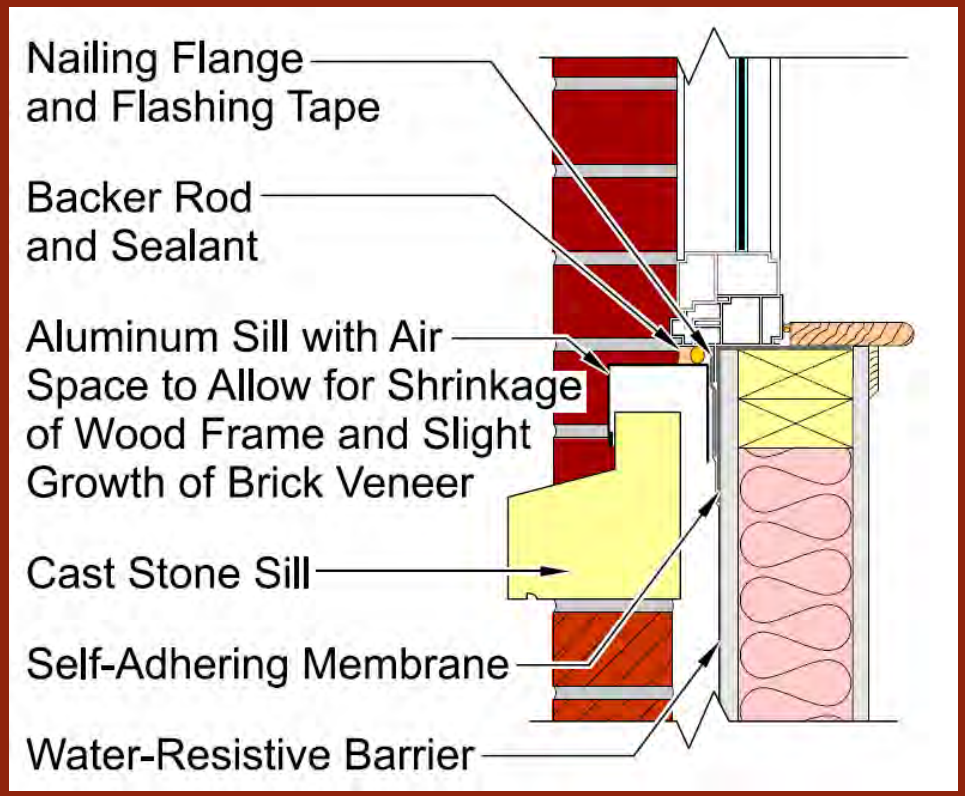
(d) The provisions of Section 12.1, Section 12.2.2.9, and Section 12.2.2.10 shall apply.

Differential Movement

- Minimizing Wood Frame Movement
  - Minimize top and sole wood plates as much as possible
  - Specify wood plates with lower moisture
  - Specify engineered wood floor joist systems
  - Specify metal hangers to support floor joists
  - Require lumber to be stored properly at the job site
  - Require dry-in of the wood frame as soon as possible
  - Enclose openings as late in the construction process as possible

Detailing


Drainage Material
Water-Resistive Barrier
Foam Backer
Stainless Steel Counter Flashing
Stainless Steel Flashing
Steel Angle Lintel
Synthetic Board Attached to Stud Backing
Backer Rod and Sealant with Weeps
Self-Adhering Flashing on both Sides of Flange


Nailing Flange and Flashing Tape
Backer Rod and Sealant
Aluminum Sill with Air Space to Allow for Shrinkage of Wood Frame and Slight Growth of Brick Veneer
Cast Stone Sill
Self-Adhering Membrane
Water-Resistive Barrier

The Flexibility of Brick

University of Texas, Brownsville
URS

Yale Health Center, New Haven, CT
Mack Scogin Merrill Elam Architects

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The Concave House, Liaoning Province, China
Tao Lei Architect Studio

Contact Theatre, England, Alan Short Architects

Kieran Timberlake Associates

Alice Cook House, Ithaca, NY

97 Crooke Avenue, New York, NY
Dattner Architects

Chau Chak Building, University of Technology, Sydney

Todd Ritchie
England

Brick Industry Association

www.gobrick.com