The Building Envelope IS the HVAC System

Presented by

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LEED® AP
May 15, 2014 BCBEC

Building Design and HVAC

- ***"...the modern architect has produced the most flagrantly uneconomic and uncomfortable buildings ... inhibited only with the aid of the most expensive devices of heating and refrigeration ... glass-sheathed buildings without any contact with fresh air, sunlight or view."***
- *Louis Mumford, architectural critic and social commentator,* ***1960***

- ***Air conditioning is the most poisoned "gift" inherited from the Industrial Revolution. It leads to the following excuse: "Whatever the lack of intelligent environmental design, there will always be a bunch of engineers and industrialists to offer their services and their products to fix the shortcomings." It opens wide the door to an enormous waste of energy, irresponsible costs, and unhealthy environments.***
- *EccaCoil 2004*

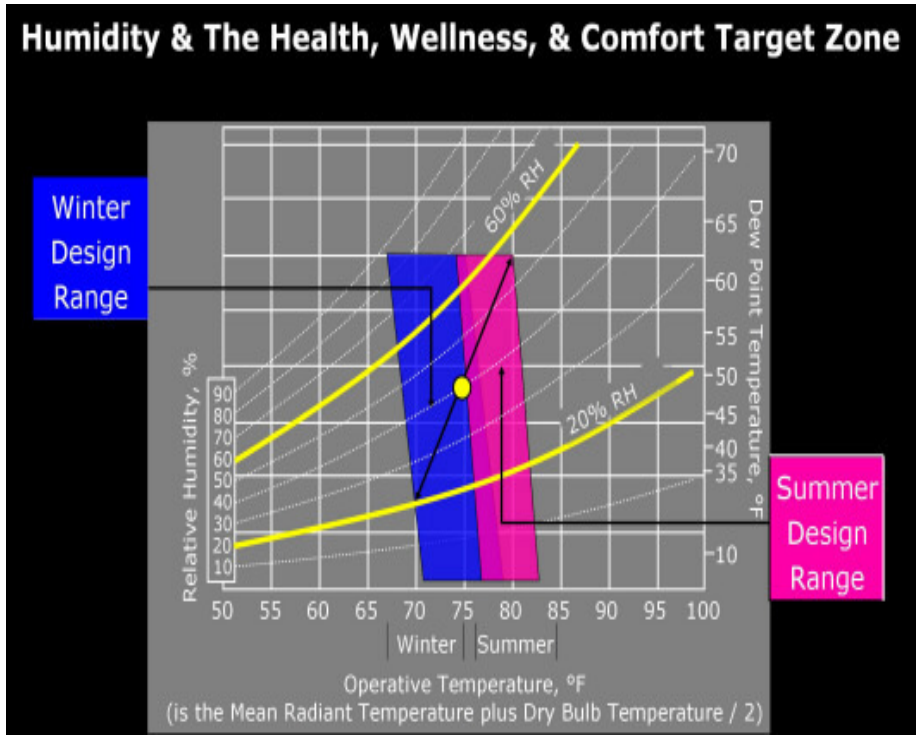
Human Comfort

- **10%-15% humidity/perspiration**
- **35%-40% convection/air movement**
- **50% radiant heat exchange**

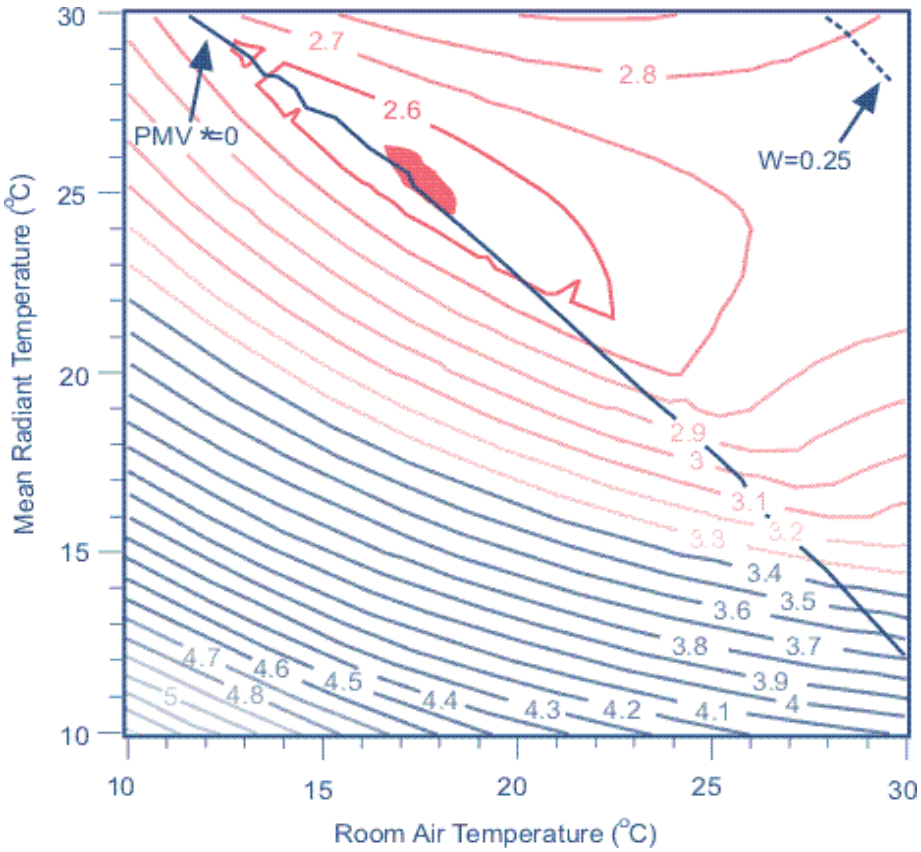
- *In a low velocity air environment at moderate humidity,* ***Resultant Temperature =***

  Mean Radiant Temperature + Air Temperature / 2

Human Comfort Range



Robert Bean Graphic, used with permission

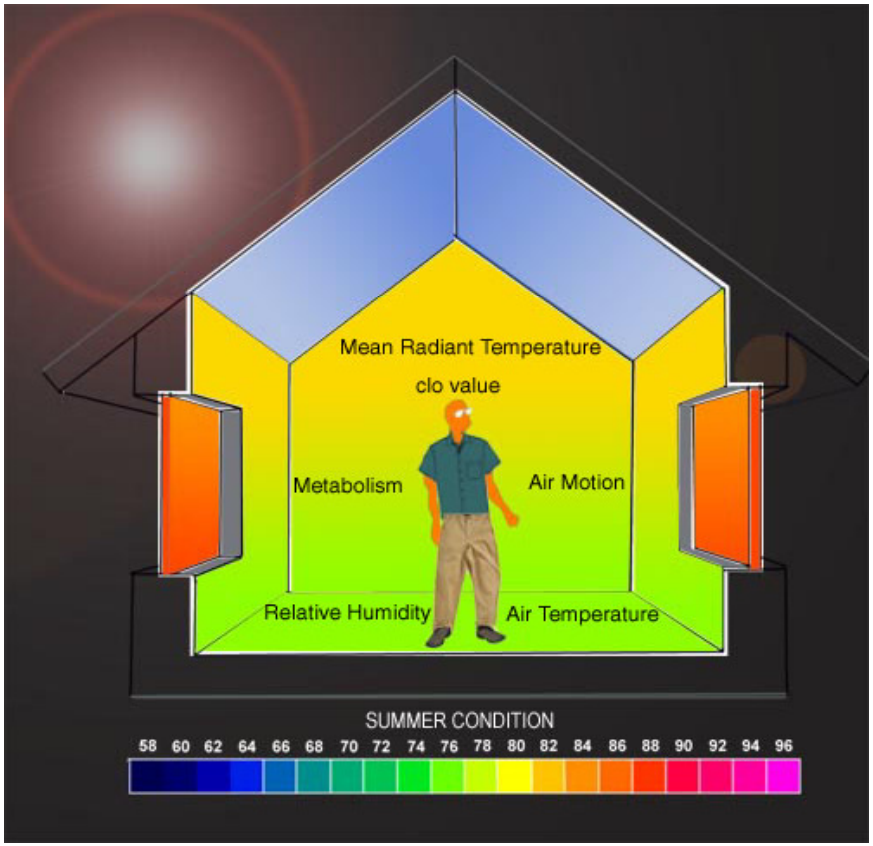


Graphic via LowEx, Isawa et al, 2002

OPERATIVE TEMPERATURE !
ASHRAE-55 STANDARD

HVAC Calculations

- Is Mean Radiant Temperature (MRT) accounted for?
  - **Window surfaces**
  - **Walls**
  - **Floors**
  - **Equipment**



ASHRAE 90.1 REQUIREMENTS

ASHRAE/IES 90.1:

- **Load Calculations:** Heating and cooling system design loads for the purpose of sizing systems and equipment shall be determined in accordance with generally accepted engineering standards and handbooks acceptable to the adopting authority (for example, *ASHRAE Handbook – Fundamentals).*

- **Thermal Comfort:**

  That condition of mind which expresses satisfaction with the thermal environment and is assessed by subjective evaluation."

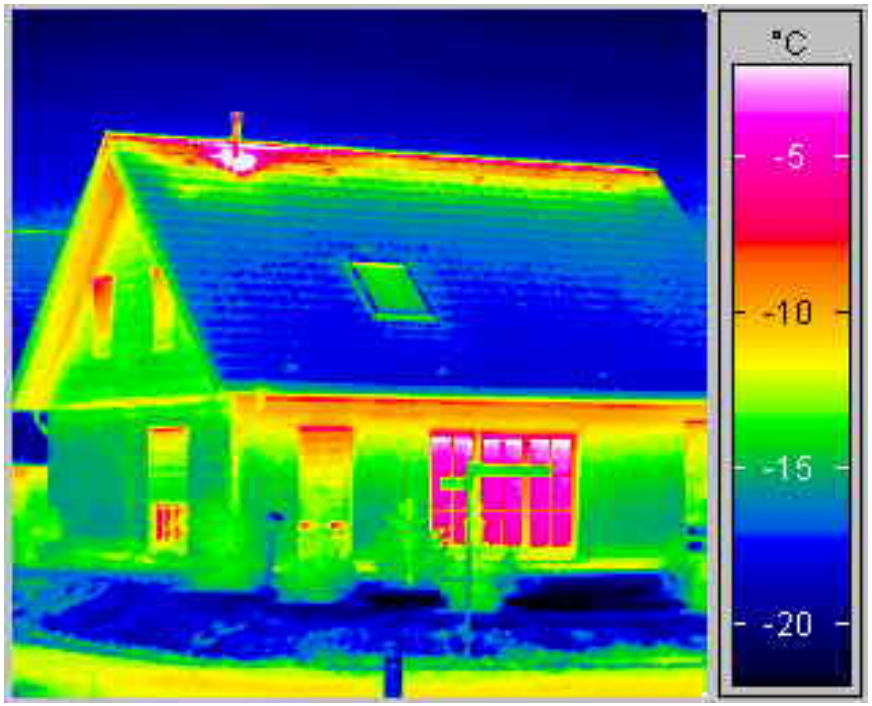
  ASHRAE-55 Standard for Thermal Comfort

ASHRAE 90.1 REQUIREMENTS

- **Overall** thermal performance, not just insulation value
- Window to wall ratio effects
- Thermal bridging calculations ***required***
- Detailed lighting loads calculations
- Detailed equipment loads calculations
- Must use ASHRAE 62 Standard for Ventilation Loads

Overall Thermal Performance

- Insulation plus degradation due to thermal bridging.
- Window to opaque wall ratio
- Skylites to opaque roof ratio



Overall Thermal Performance

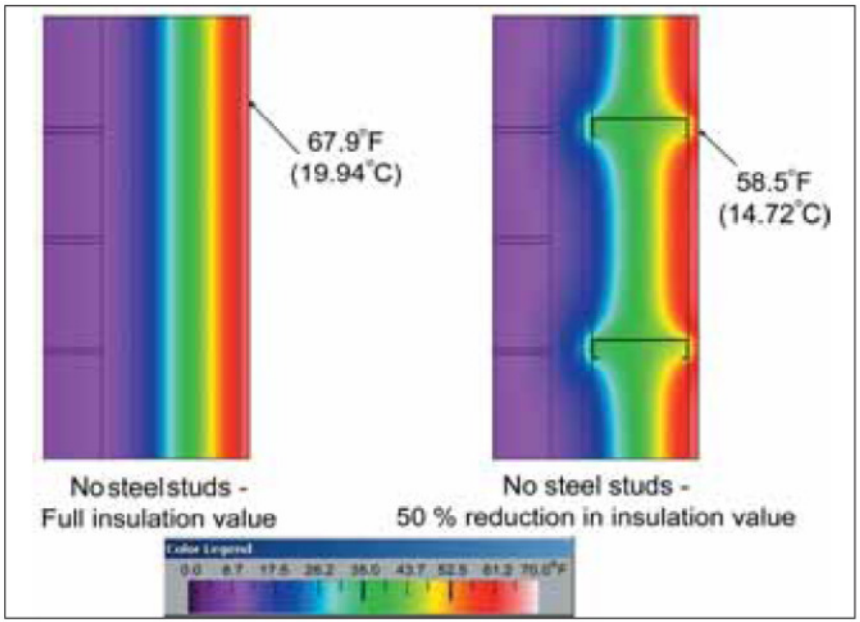


Figure 4 - Computer simulation results showing effects of thermal bridging through steel framing.

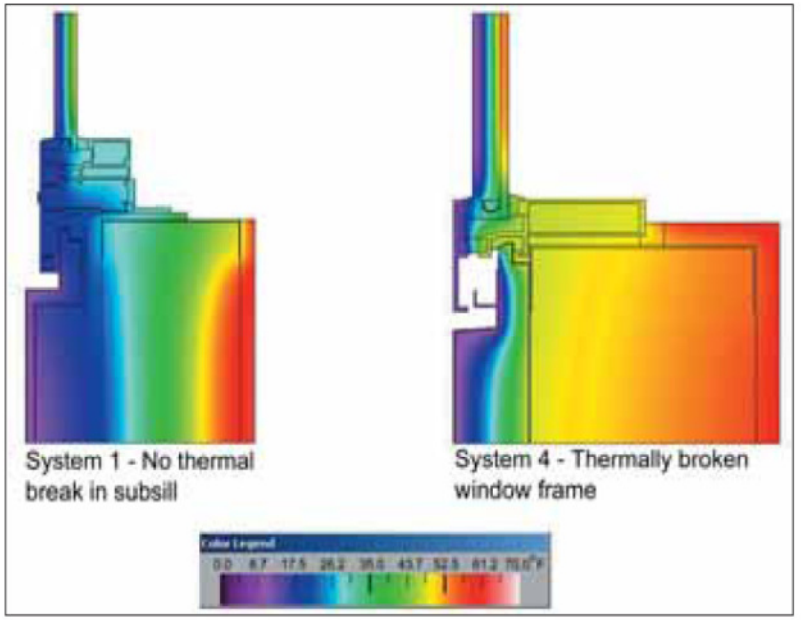


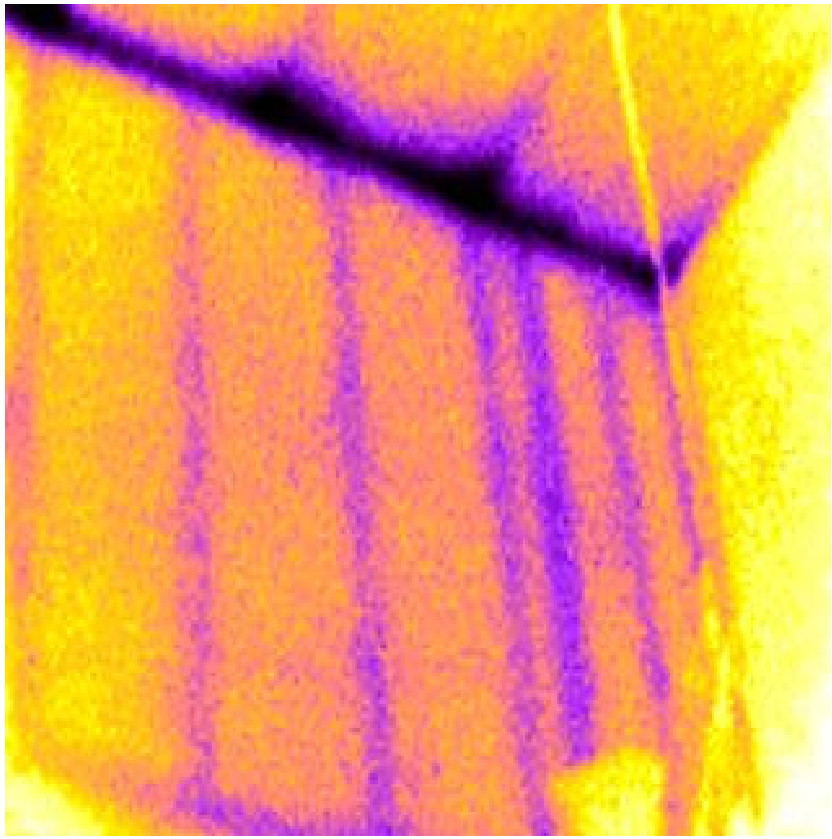
Figure 6 - Computer simulation results showing the effects of thermally broken window frames.

Illustrations from Journal of Building Enclosure Design, Summer 2007

*Thermal Bridging will **degrade** insulation value by 25% to 100% depending on detailing*

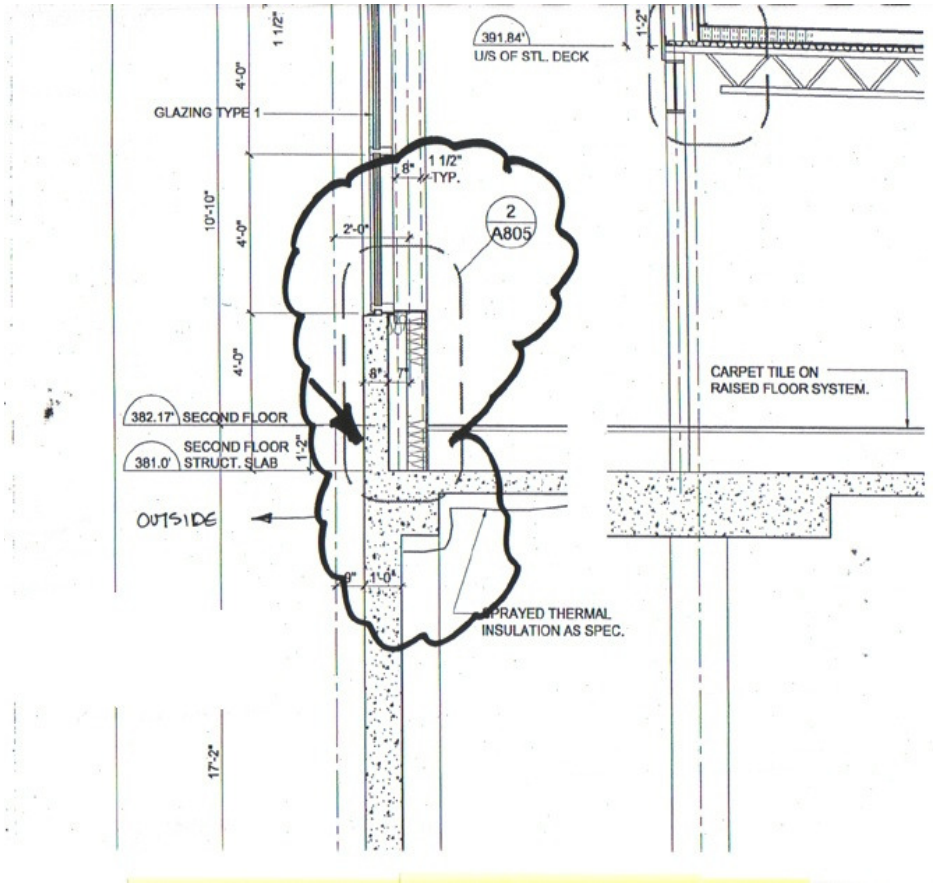
What's Thermal Bridging?

- Degrades insulation value by an average of 15%-25% (wood frame) and up to 100% for metal framed wall system.
- **R-28 Insulation = R-20 overall for wood structure**
- **R-28 Insulation = R-14 for steel stud/frame structure**



Thermal Bridging

- Saves detailing and construction costs, but…
- Add HVAC costs and on-going energy costs, ***forever***…



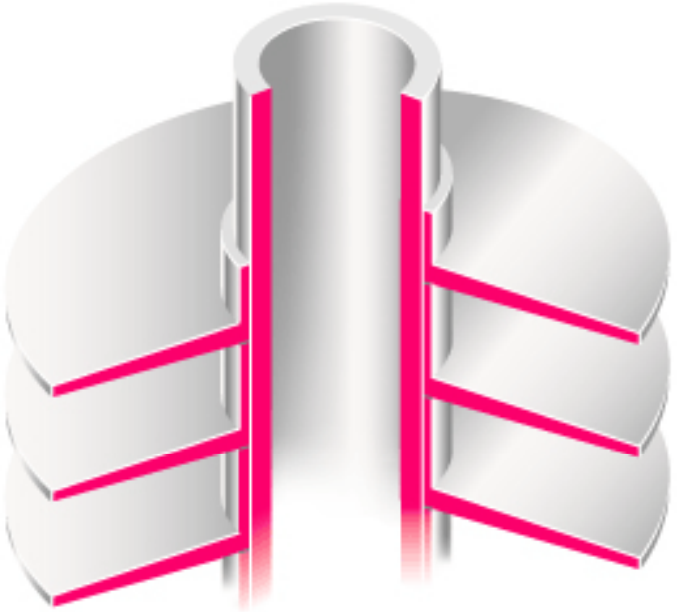
Cast in place exterior wall with floor slab

Thermal Bridging

- **From Detail on last slide:**
- Outdoor temperature at time of check = 35F (2C)
- Underfloor Supply Air temperature = 72F (22C) at main plenum discharge
- **Actual SAT near perimeter was 66F (19C) !**

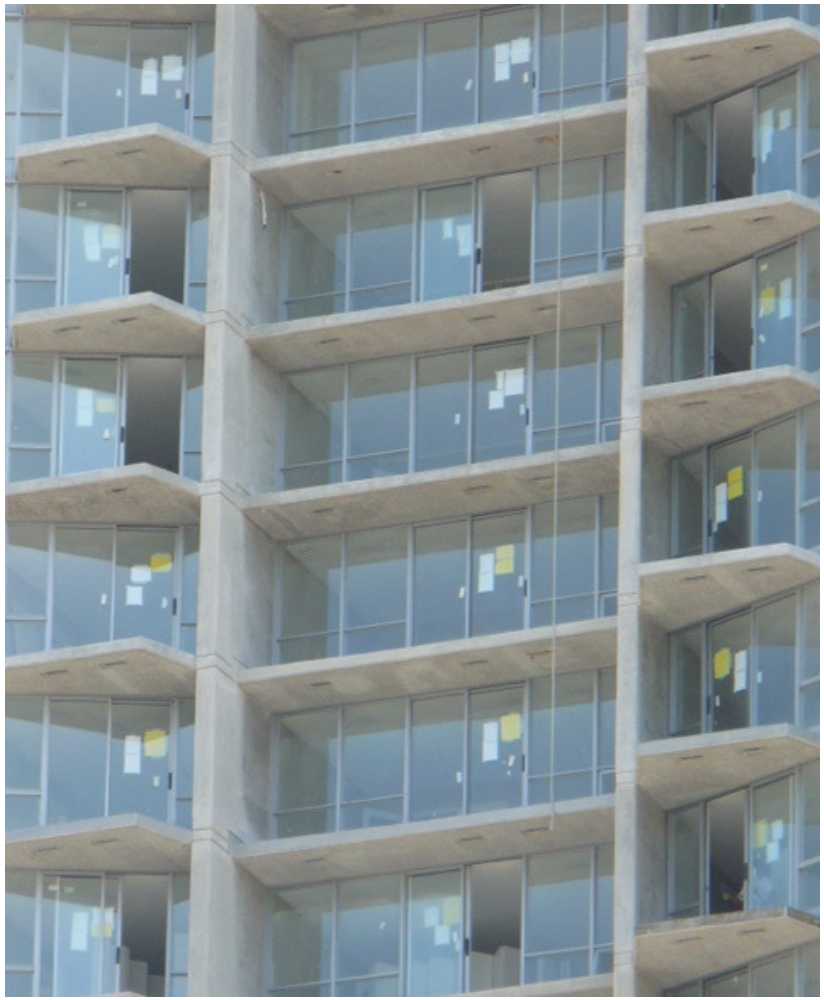
HEADLINES: *HVAC Designer blamed for lack of heating at perimeter!*

Thermal Bridging



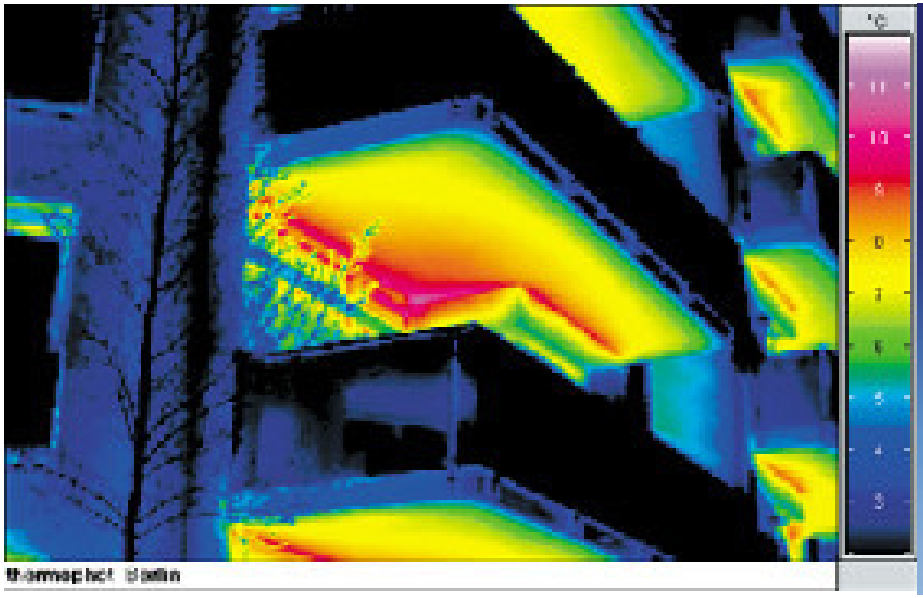
Graphic from Spirax/Sarco Ltd

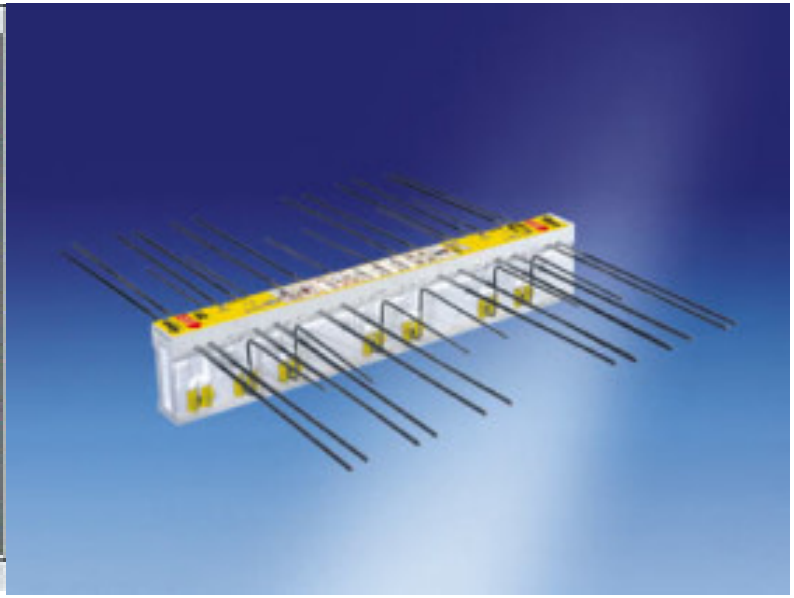
High-Rise Condos = efficient heat transfer design! ***FOREVER !!***



Geoff McDonell Photo

Thermal Bridging

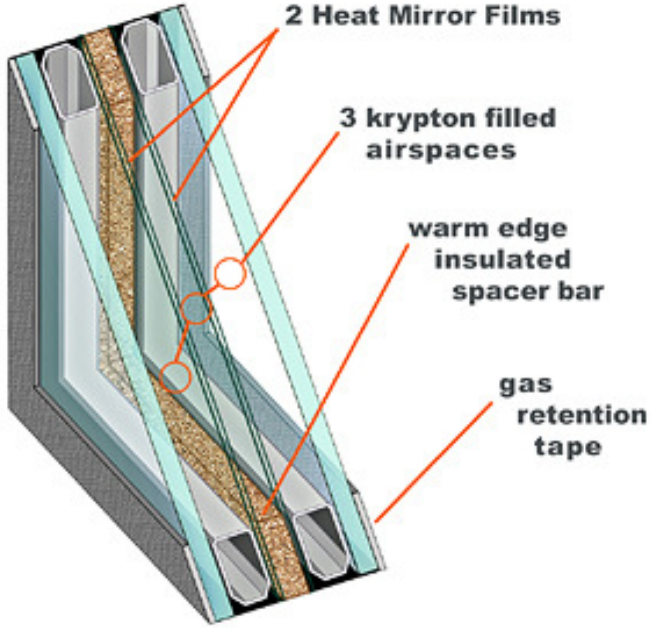


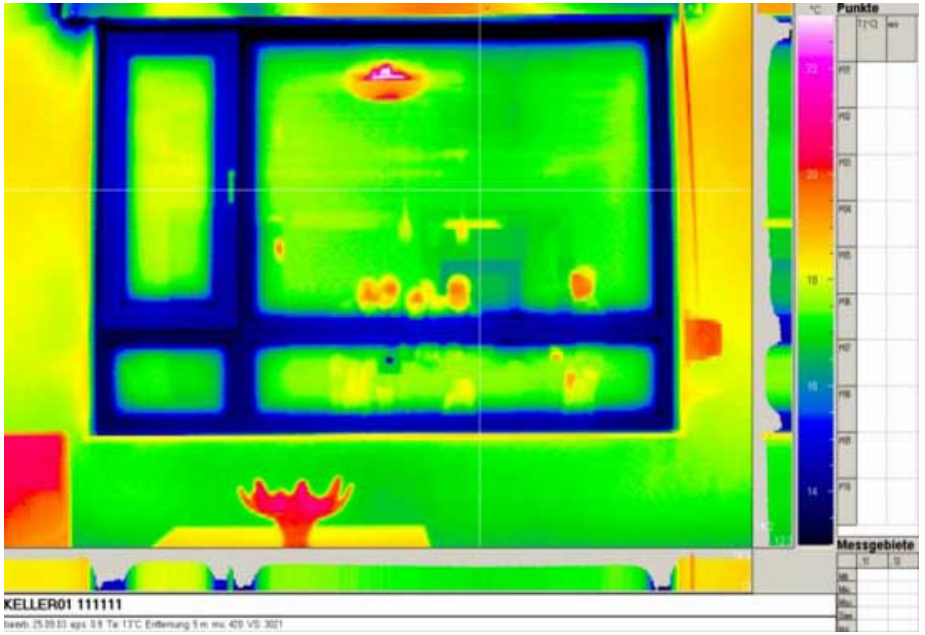


Schoeck Company (UK)
Thermal bridging detail for balconies.

Overall Thermal Performance

- “Overall” wall thermal performance includes ratio of windows to opaque walls.
- Higher window to opaque wall ratio means very high window thermal performance to equalize “overall” thermal performance.

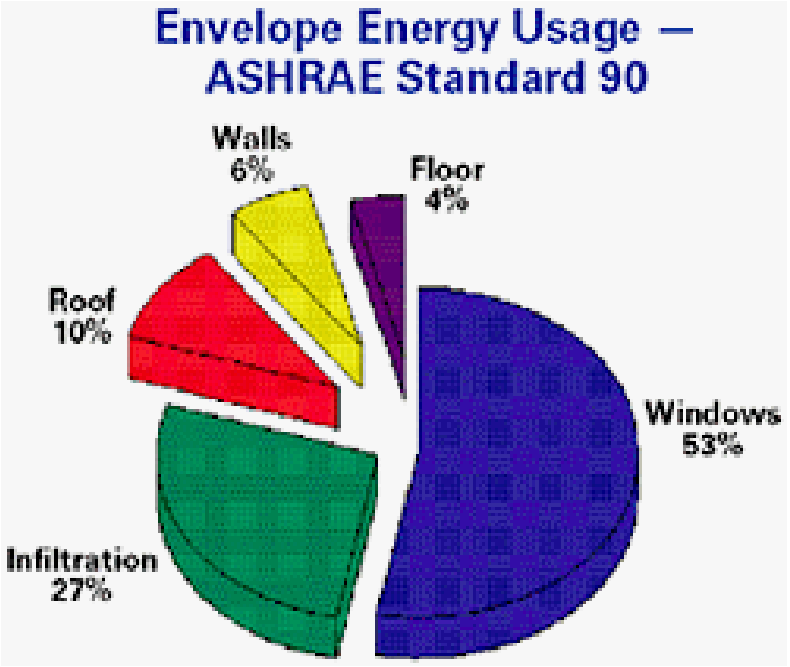




Overall Thermal Performance

Glass and Windows:

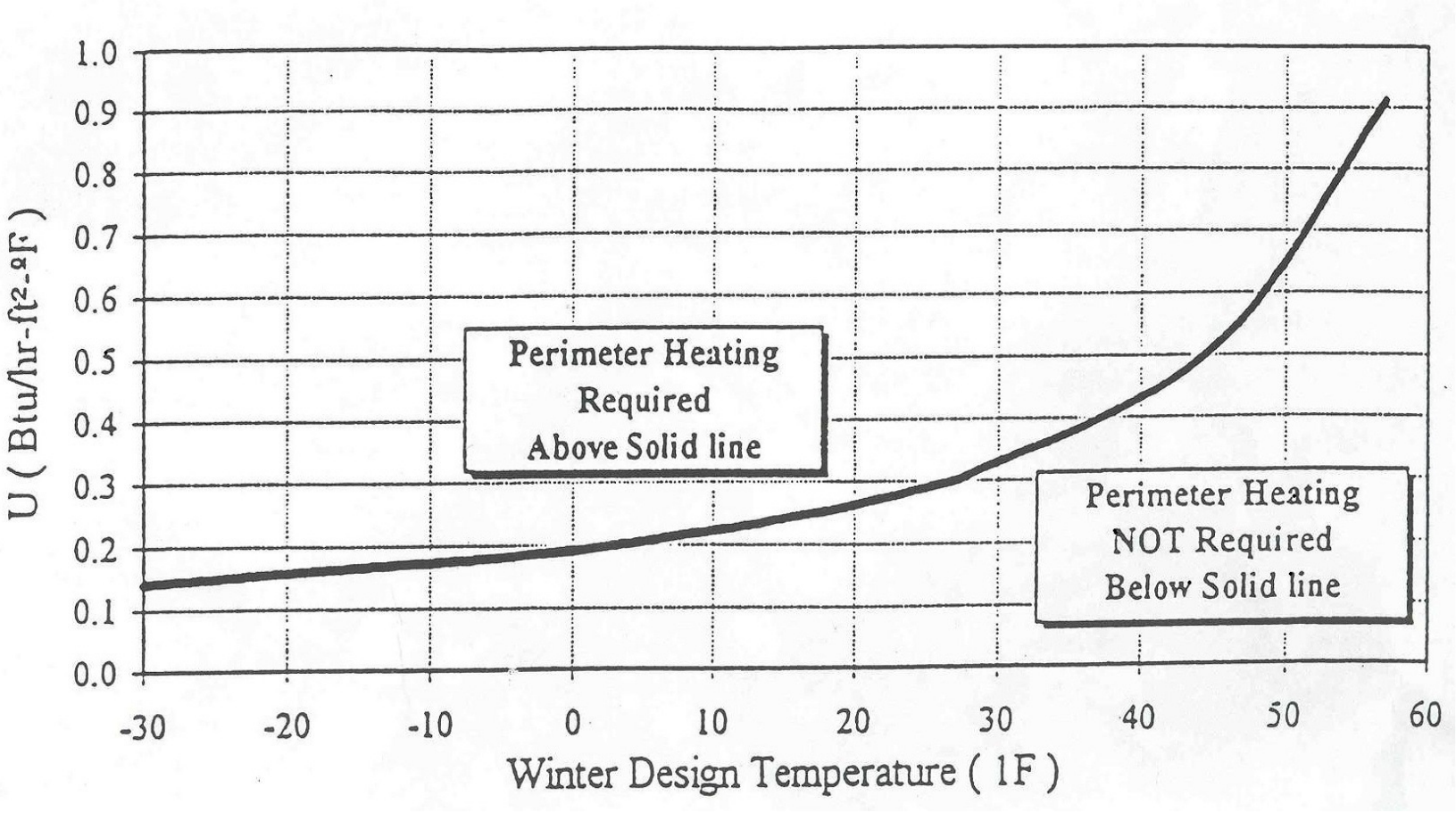
- Centre of glass U Value/R-Value
- Thermal bridging of framing
- Calculate “overall R-Value/U Value”



Free Software !!

Lawrence Berkeley Labs downloads at:
http://windows.lbl.gov/

Glazing Performance



Quick Window Performance Selector

(source: Don Holte, Visionwall 1990)

Overall Thermal Performance

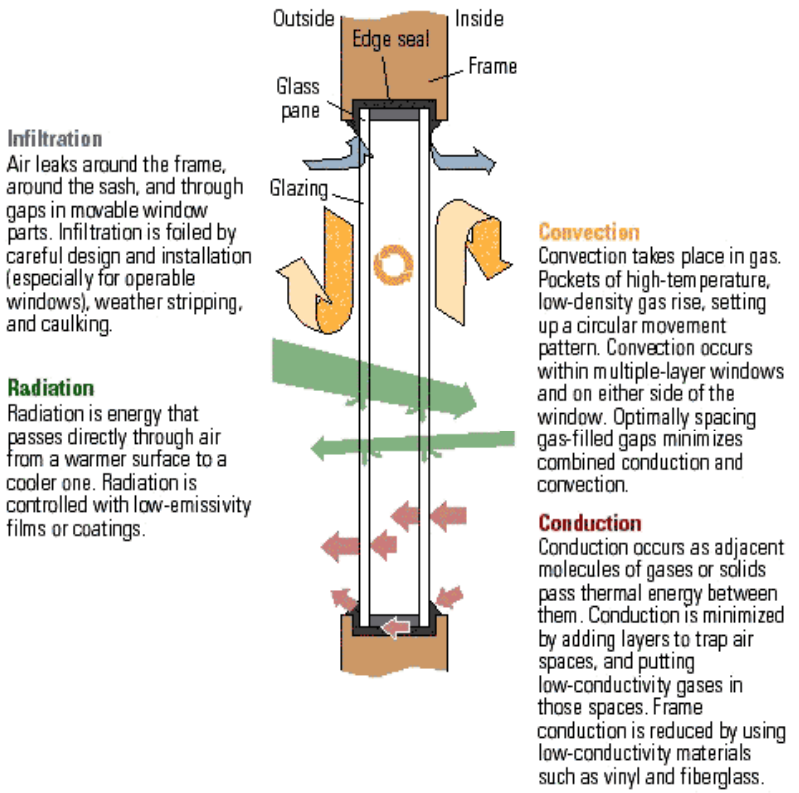
Windows and Glass:

- Solar heat gain coefficient (SHGC)
- Shading Coefficient (SC)
- Visible light transmittance (VLT)
- Centre of glass vs. overall performance

LBL Window 5.2 free download at:
http://windows.lbl.gov/software/window/window.html

Glazing Performance

- Low-e coatings
- Gas fills – Argon, Krypton
- Multiple air spaces
- Frame construction
- Installation detailing

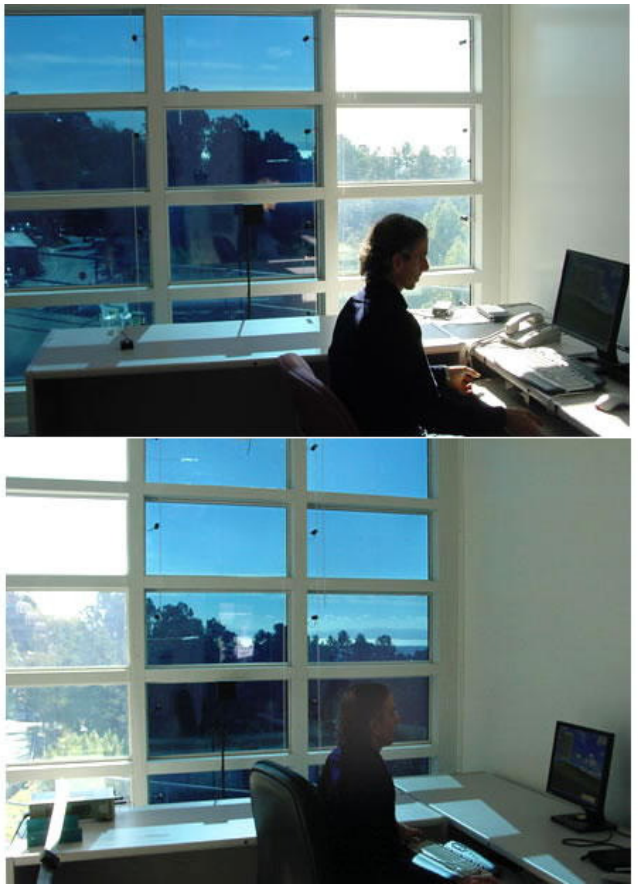


Key Issue: Inside surface temperature of glass > 64F in wintertime, < 78F in summer

Glazing Solar Performance

Important for:

- Reduced summer heat gains at perimeter
- Glare control year round
- Daylighting
- Passive solar gain in Winter
- Mean Radiant Temperature



SageGlass Inc.

Glazing Solar Performance

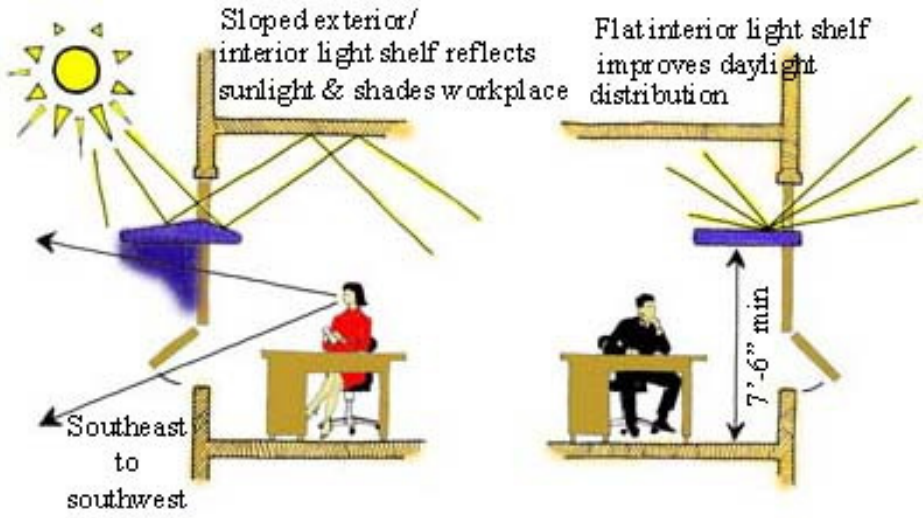
Glass treatments:

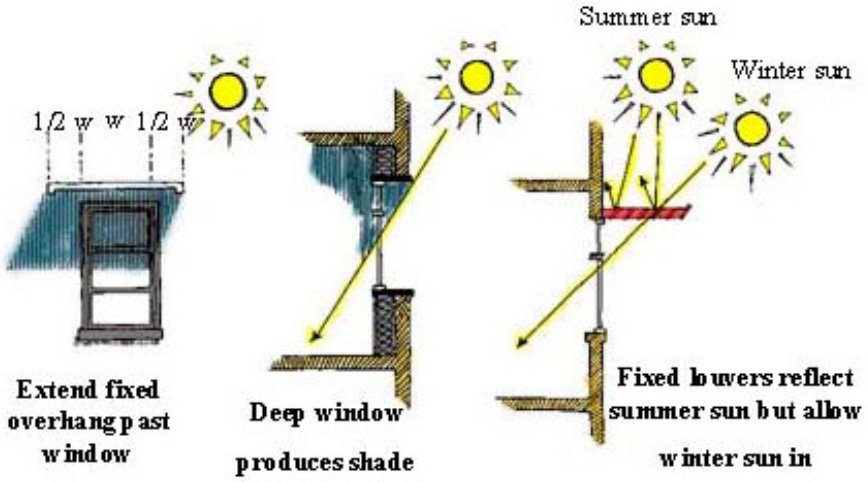
- Exterior sunshades
- Building Shapes
- Fritting

Geoff McDonell photos

Glazing Solar Performance

Maximize “daylighting” while reducing solar heat gain





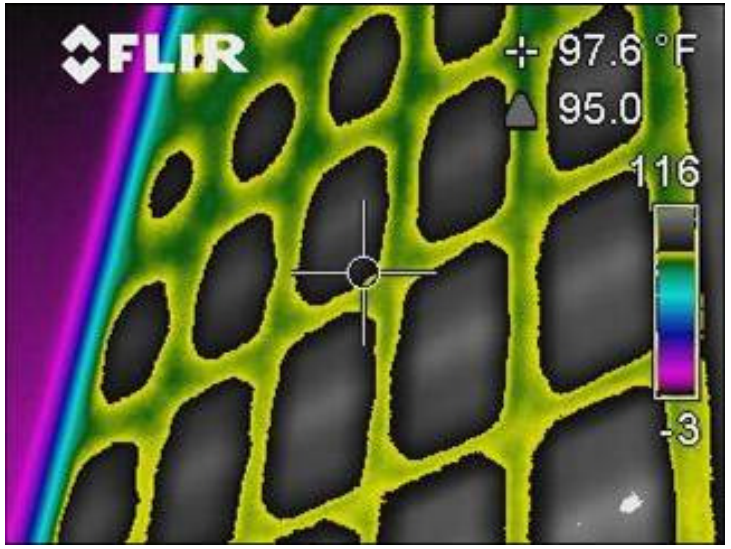
Calculate exterior shading for the warmest day of the year, ***NOT*** for June 21st. !!

Glazing Solar Performance

Dark tinted glass for solar control absorbs heat, ***BUT*** warms up the inside glass surface to over 90F (32C)

Warm inner glass = Radiant heating panel at 35 Btuh/SF!

(Fine in winter, bad in summer!)



Photos via Vladimir Mikler

Glazing Solar Performance

Visionwall 4-element windows:

- Visible Light Transmittance (VLT) of **9%** !!
- SHGC = **0.15** !!

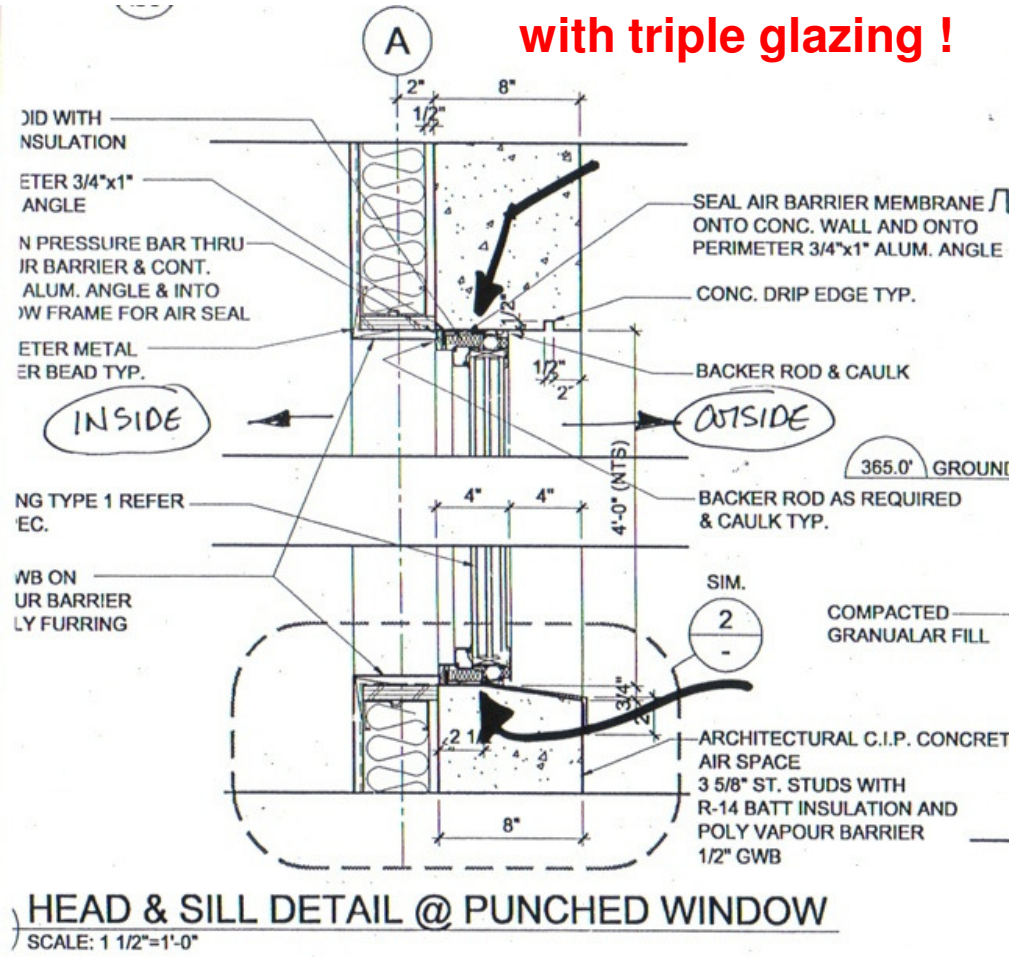
Surrey Gateway Centre

Glazing Thermal Performance

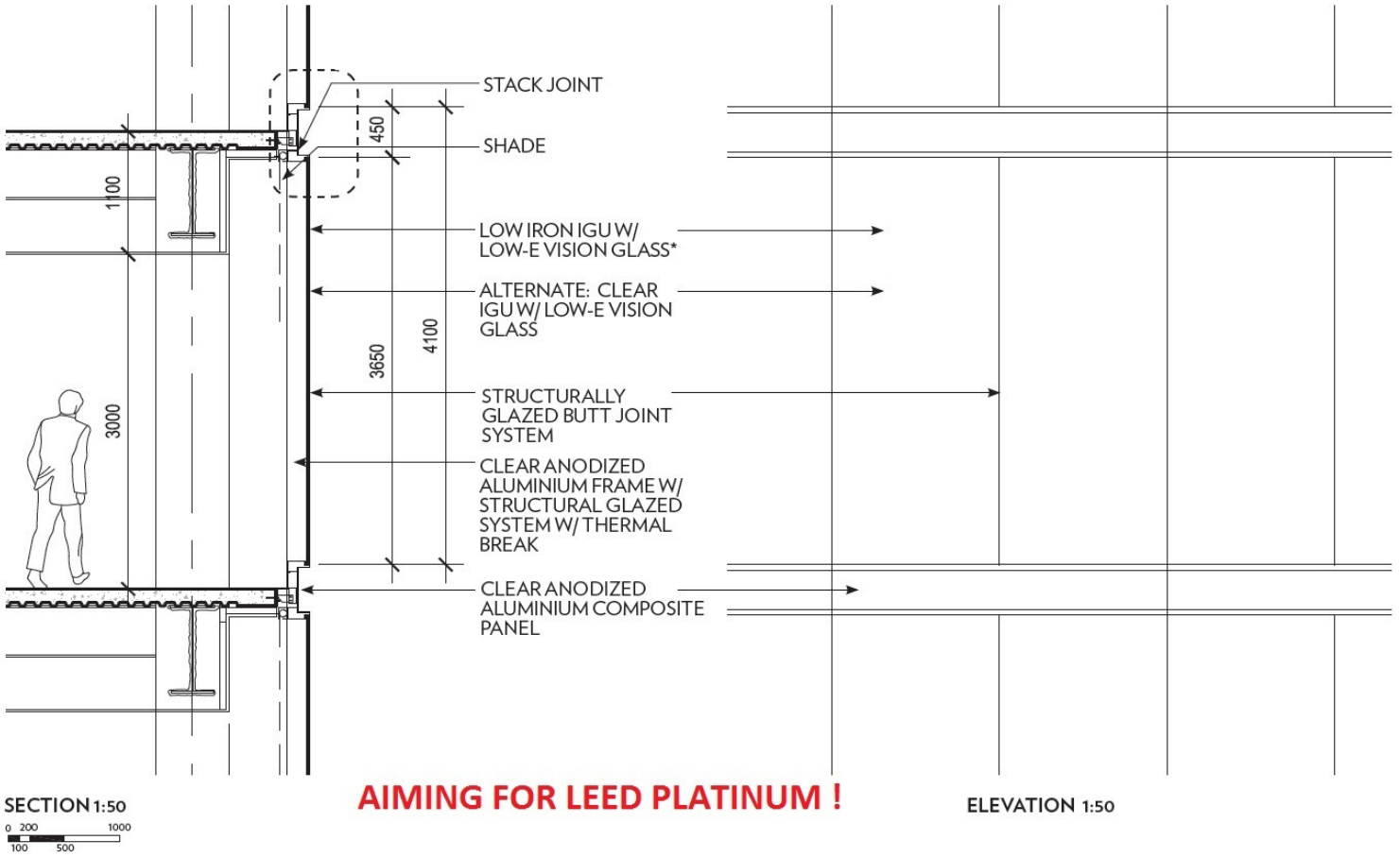
High performance window and frame wasted in this detail

Actual performance equivalent to double glazing in solid alum. frame

Kawneer 7500 frames with triple glazing !



Glazing Performance Circa 2014



Landed on my Desk a couple months ago….89% W-W Ratio

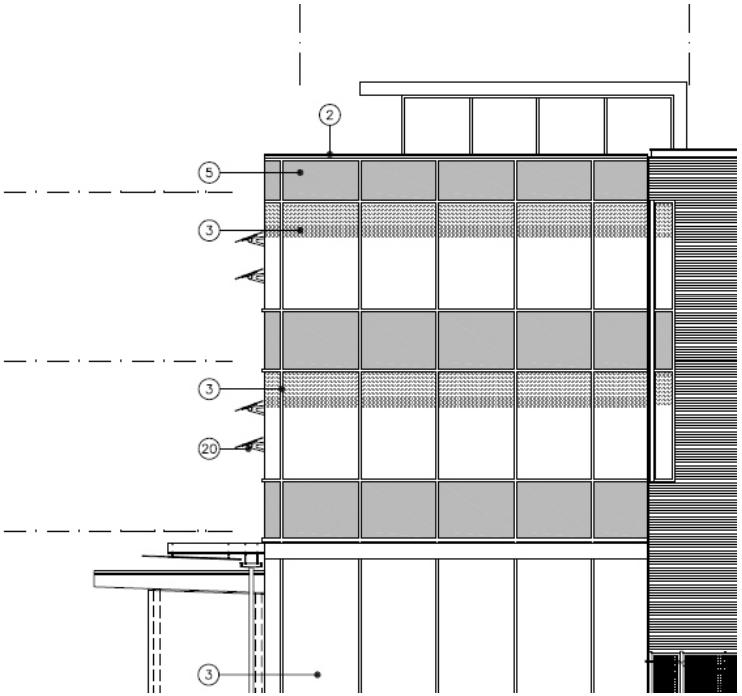
Case Study: City of North Vancouver Library

Challenges:

- Extensive east, south, and west glazing
- High expectations from Staff
- Construction management and sequential tendering
- Many, many changes during design and construction
- Integration to Lonsdale Energy Plant
- Getting along with the neighbours

Case Study: City of North Vancouver Library

Energy Targets vs Value Engineering and Design Changes



TP-5 Curtain Wall Tender as issued 1 month *after* Mechanical Tender Package

Change to Curtain Wall long after the fact - think there might be energy and comfort issues?

Case Study: City of North Vancouver Library

Passive Solar and Daylighting Design

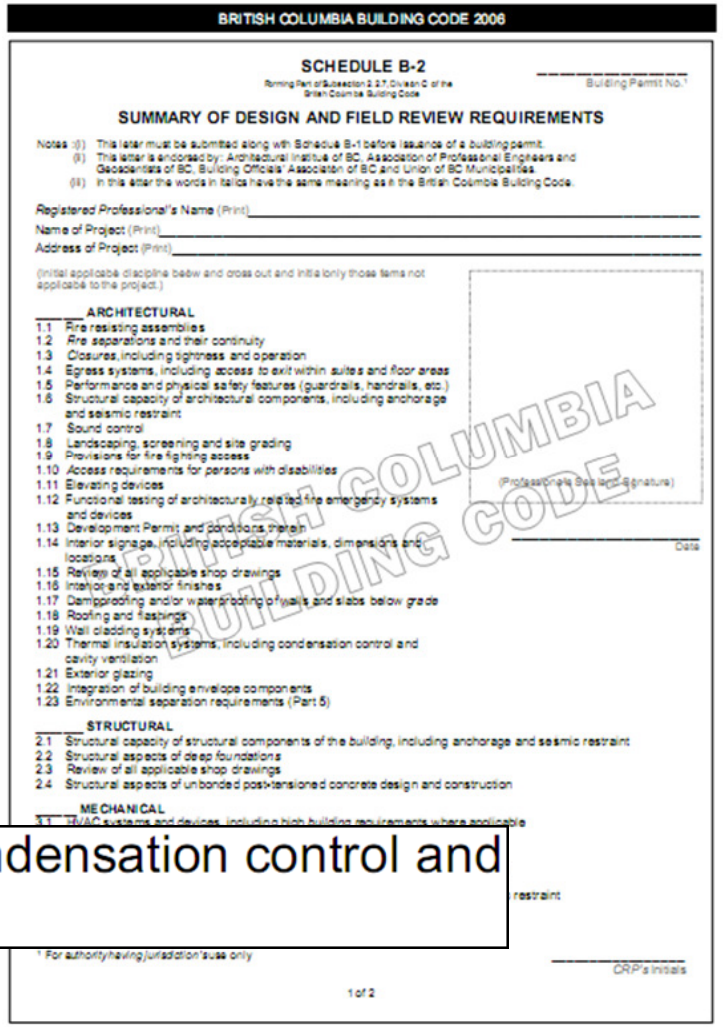
TOO much direct sunlight!

Great passive solar performance on cold days

January 20, 2009 photo
(Geoff McDonell Photo)

British Columbia Buildings

- Average energy intensity of Office buildings in BC = 302 kwh/sq.m./year (NRCan Data - 2006)
- European Building Codes require MAXIMUM 60 kwh/sq.m./year for Offices
- Architecture 2030 Challenge



BRITISH COLUMBIA BUILDING CODE 2006

SCHEDULE B-2

Forming Part of Subsection 2.2.7. Division C of the British Columbia Building Code

Building Permit No.[1]

SUMMARY OF DESIGN AND FIELD REVIEW REQUIREMENTS

Notes (i) This letter must be submitted along with Schedule B-1 before issuance of a building permit.
(ii) This letter is endorsed by: Architectural Institute of BC, Association of Professional Engineers and Geoscientists of BC, Building Officials' Association of BC and Union of BC Municipalities.
(iii) In this letter the words in italics have the same meaning as in the British Columbia Building Code.

Registered Professional's Name (Print)

Name of Project (Print)

Address of Project (Print)

(Initial applicable discipline below and cross out and initial only those items not applicable to the project.)

(Professional Seal and Signature)

Date

_____ ARCHITECTURAL
1.1 Fire resisting assemblies
1.2 *Fire separations* and their continuity
1.3 *Closures*, including tightness and operation
1.4 Egress systems, including *access to exit* within *suites* and *floor areas*
1.5 Performance and physical safety features (guardrails, handrails, etc.)
1.6 Structural capacity of architectural components, including anchorage and seismic restraint
1.7 Sound control
1.8 Landscaping, screening and site grading
1.9 Provisions for fire fighting access
1.10 *Access* requirements for *persons with disabilities*
1.11 Elevating devices
1.12 Functional testing of architecturally related fire emergency systems and devices
1.13 Development Permit and conditions therein
1.14 Interior signage, including acceptable materials, dimensions and locations
1.15 Review of all applicable shop drawings
1.16 Interior and exterior finishes
1.17 Damproofing and/or waterproofing of walls and slabs below *grade*
1.18 Roofing and flashings
1.19 Wall cladding systems
1.20 Thermal insulation systems, including condensation control and cavity ventilation
1.21 Exterior glazing
1.22 Integration of building envelope components
1.23 Environmental separation requirements (Part 5)

_____ STRUCTURAL
2.1 Structural capacity of structural components of the building, including anchorage and seismic restraint
2.2 Structural aspects of deep foundations
2.3 Review of all applicable shop drawings
2.4 Structural aspects of unbonded post-tensioned concrete design and construction

_____ MECHANICAL
3.1 HVAC systems and devices, including high building requirements where applicable

restraint

[1] For *authority having jurisdiction* use only

_____
CRP's initials

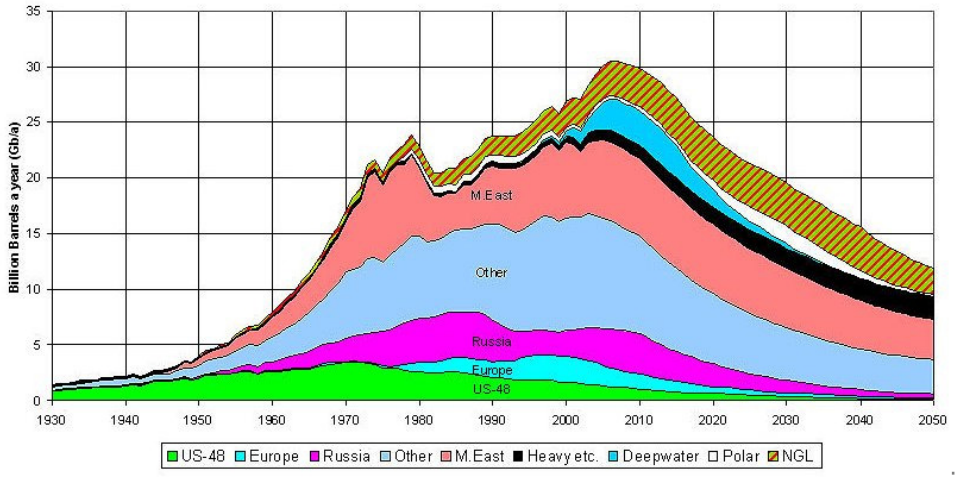
1 of 2

ARCHITECTURAL

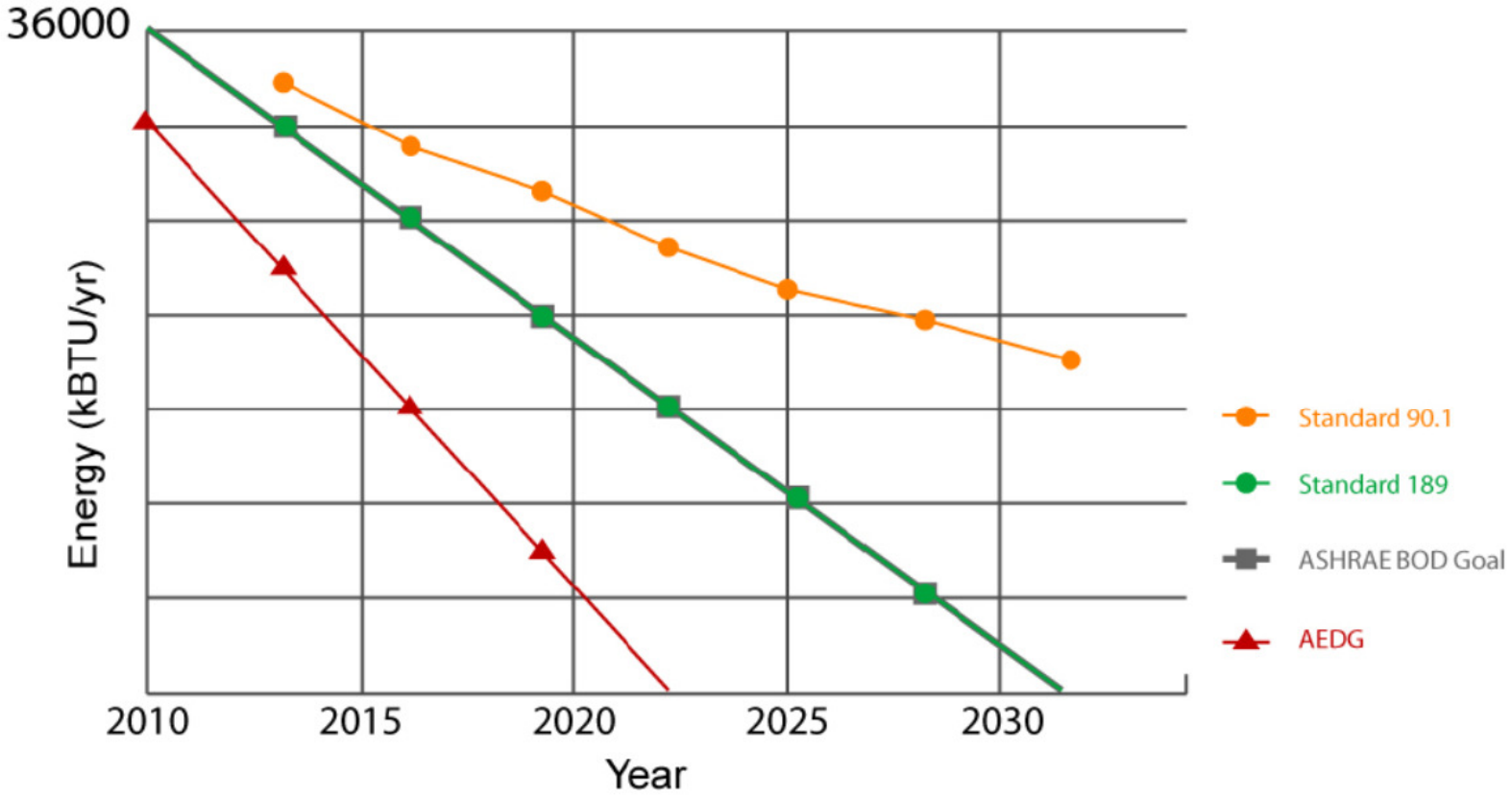
1.20 Thermal insulation systems, including condensation control and cavity ventilation

Next Steps

- Drivers: Energy costs and type
- Passivhaus building design
- “Minergie” building systems solutions
- Net Zero Energy Buildings
- More stringent Energy Codes – energy intensity regulations, building labelling.
- More availability of renewable energy devices/sources



Energy Codes



Improvements in standards, Advanced Energy Design Guides, and the ASHRAE Board of Director's goals.

Building Envelope Performance

Who "Commissions" the Building Envelope?

Building Envelope Commissioning Guidelines:

- **CAN/CGSB 149-GP-2MP:** Manual for Thermographic Analysis of Building Enclosures;
- **ASTM C1060:** Standard Practice for Thermographic Inspection of Insulation Installations in Envelope Cavities of Frame Buildings;
- **ANSI-ASHRAE 101:** Application of Infrared Sensing Devices to the Assessment of Building Heat Loss Characteristics;
- **ASTM E1186:** Standard Practice for Air Leakage Site Detection in Building Envelopes and Air Barrier Systems;
- **ASTM E779:** Standard Test Method for Determining Air Leakage Rate by Fan Pressurization.
- **NIBS Guideline 3-2012** Building Enclosure Commissioning Process BECx
- **ASTM E2813 – 12** Standard Practice for Building Enclosure Commissioning

The Top Ten List

Geoff's Top Ten List of Things the HVAC Designer Needs to Know about the Building Envelope:

1. How is the window specified and what quality control is in place to ensure its performance?
2. How is the solar gain addressed around the perimeter?
3. Have the electrical engineer and lighting designer been included in resolving window sizes and locations to optimize daylighting while reducing solar gain?
4. Are the HVAC Calculations using "overall" roof and opaque wall U-values (R values) that have been corrected for thermal bridging?
5. Are you using "overall" window thermal performance in the HVAC Calculations and Energy Modeling?

The Top Ten List

6. How thermally efficient are the envelope details, and have thermal bridges been eliminated or reduced to be as low as practical?

7. How has the envelope air infiltration been specified, and how will it be tested and enforced?

8. Are the building shell colours appropriate for the local climate? (light reflective coloured finishes in hot climates / darker colors in heating dominated climates).

9. Have the Architect, Owner and Facilities Maintenance representatives signed off and accepted the building envelope performance criteria, and has it been tied to the energy performance goals of the building?

10. Is the building design working ***with*** the local climate, or ***against*** it?

The point is to design the building envelope as the primary indoor comfort system *FIRST*, before applying "active" HVAC and lighting systems.

Thank You

"You can't change the world; you can only change the way you think."

Albert Einstein