John Straube, Ph.D., P.Eng

Roxul Building Science

Thermal Control:
Insulation & Thermal Bridges

presented by www.buildingscience.com

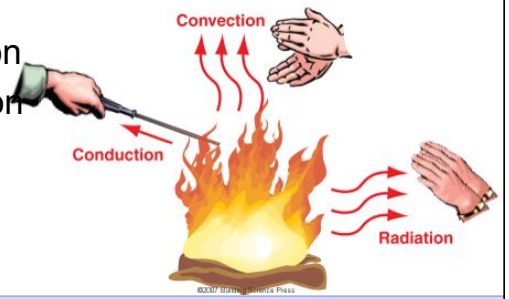
Why Control Heat flow?

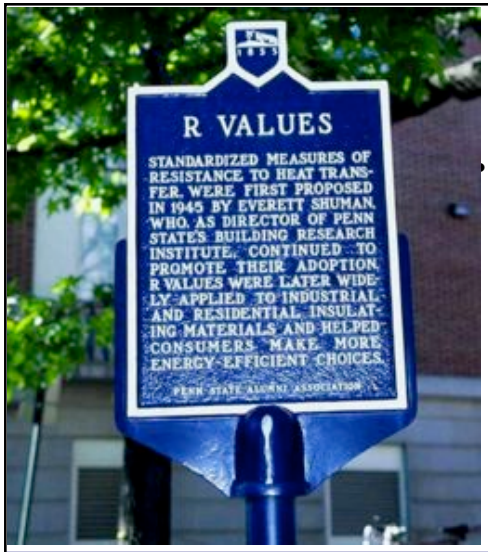
1. Occupant Comfort
2. Control surface and interstitial condensation
3. Save energy, reduce operating cost & pollution
4. Save distribution & heating plant costs (capital)
5. Increase architectural options
6. Decrease load diversity
7. Meet codes and specs

How to Control Heat Flow?

Modes of heat transfer:

- Radiation
- Convection
- Conduction





R Values

- An effective property including all heat flow modes

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Trends in materials

- Low density materials insulate better!
- High density materials are structural
- Past – relied on high density (but **thick**) structural materials to control heat, air, and moisture flow
  - Wood R 1.000 /inch
  - Clay Straw R 0.700 /inch
  - Old brick R 0.180 / inch
  - Concrete R 0.070 /inch
  - Steel R 0.004 / inch
  - Aluminum R 0.001 / inch

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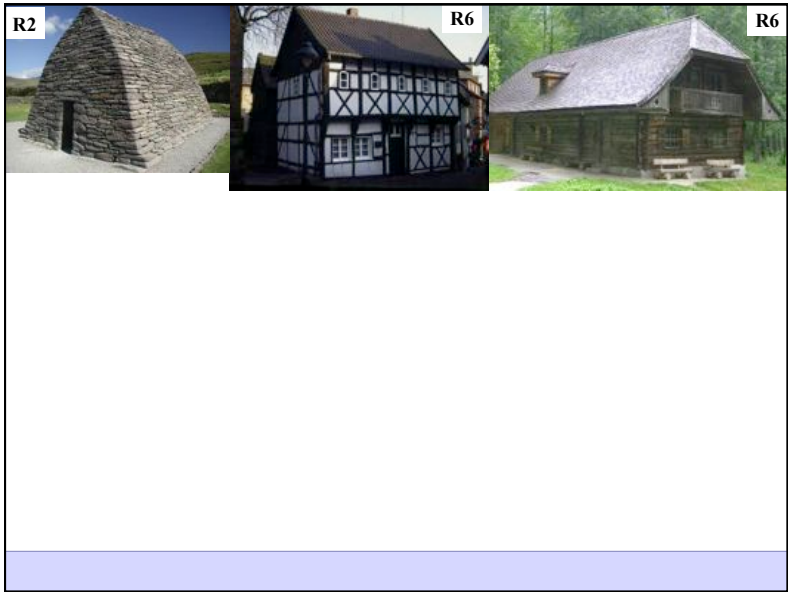
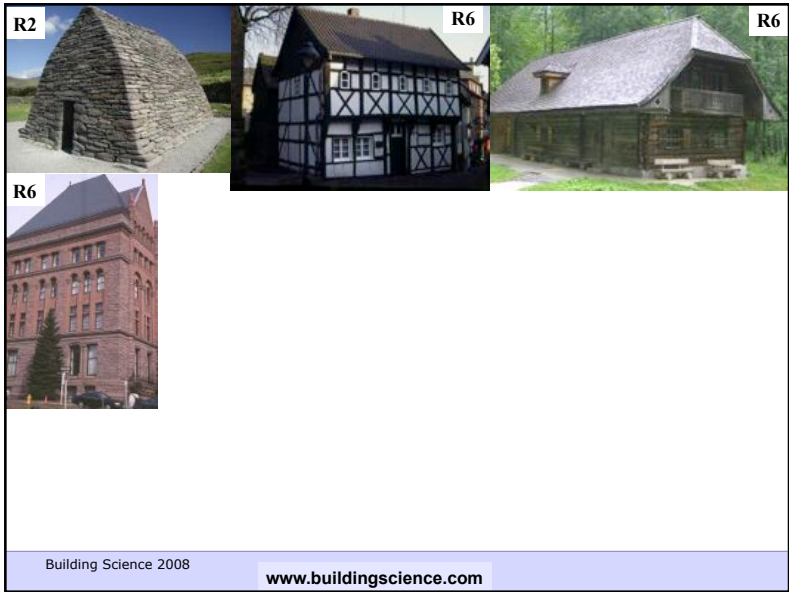
on - History


R2
R6
R6


R2
R6
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R6
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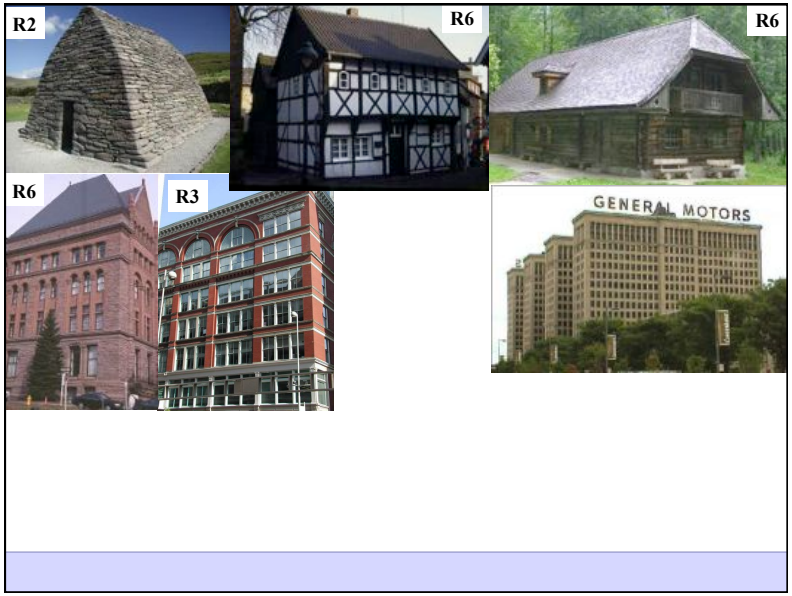
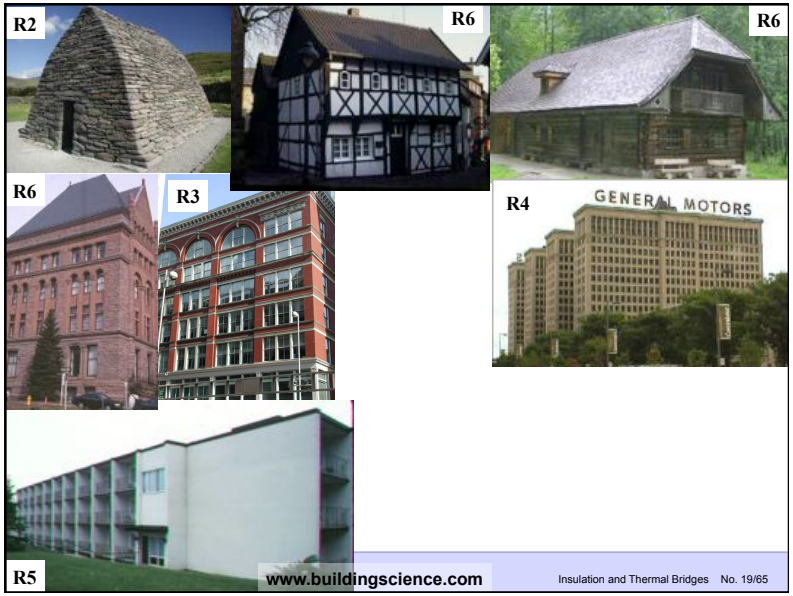

R2
R6
R6
R6
R3
GENERAL MOTORS


R2
R6
R6
R6
R3
R4
GENERAL MOTORS
R5
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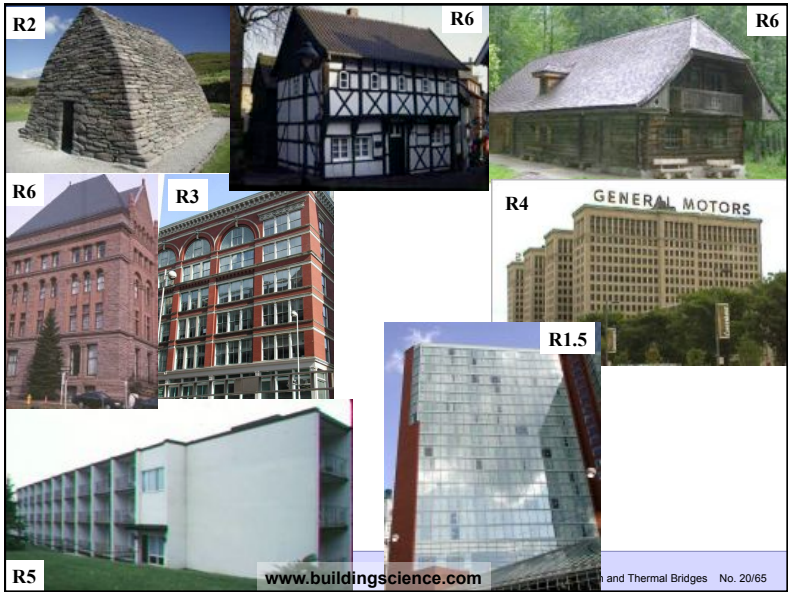

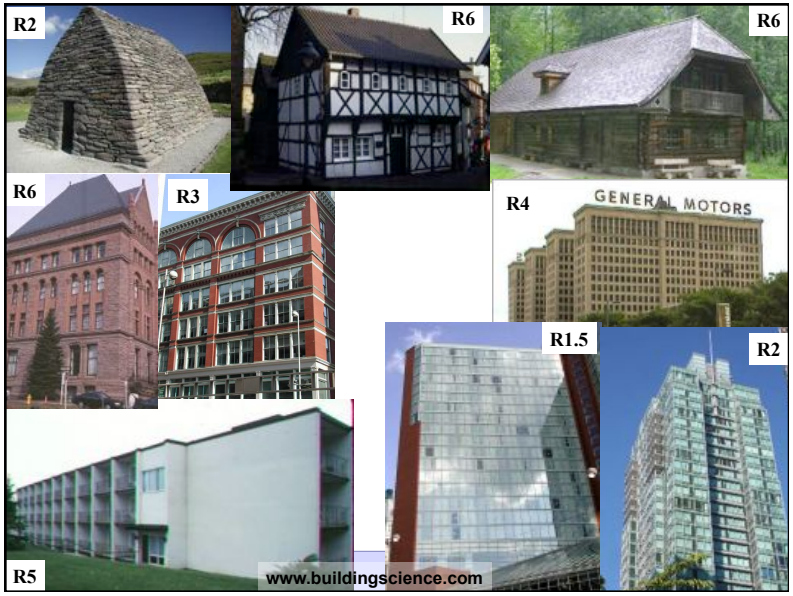

Changing Needs

- Now and tomorrow
  - – Better heat flow control required
  - – More environmental concerns re: energy
  - – More demanding comfort standards
  - – Building materials & finishes are less resistant to condensation (& mold)

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Insulation

- A brief survey . . .

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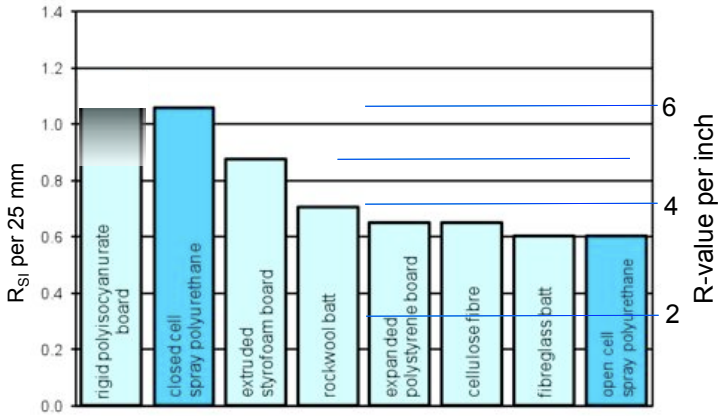

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Fibers

- Mineral Fiber Insulation (vs organic fibers)
  - glass fiber
  - rock fiber } rockwool
  - slag fiber
- Glass vs rockwool
  - melts at a much lower temperature
  - has thinner fibers so can use lower density
  - Lower density usually means more air permeance, less strength, and low volume (less cost and energy) shipping

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Blown/spray fibrous insulation

- Can use cellulose, glass, rockwool
- Net or adhesive holds sprayed fiber in cavity
- fills space and around obstructions
- help control convection
- Need to control settling

- Are NOT vapour barriers

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Blown Cellulose

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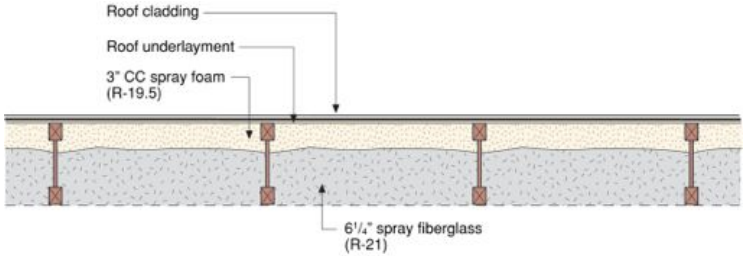
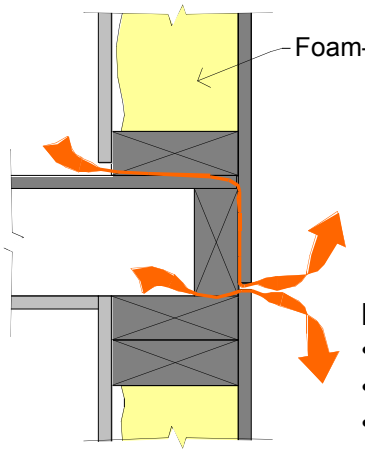
Can act as thermal (fire) control layer over foam

R40+ roof, fire protection



Cold Climate (Zone 5/6) Solution



Air Sealing Framed Walls with Foam: foam the details!

Most air leakage at
- rim joist
- windows
- penetrations
- bath rooms

Rigid Boards (sheathing)

- Expanded Polystyrene (EPS)
  - R-value of 3.6 to 4.2
- Extruded Polystyrene (XPS)
  - higher R-value, usually 5/inch or higher
  - usually more strength
- Polyisocyanurate (PIC)
  - Highest temp resistance. Long term R6
- all have fire “issues”

Mineral Fiber Sheathing

- Semi-rigid MFI (mineral fiber insulation)
- Rockwool and Fiberglass
  - Air permeable
  - Vapor permeable
  - Allows drainage (provides gap)
- R values of 4 to 4.4/inch

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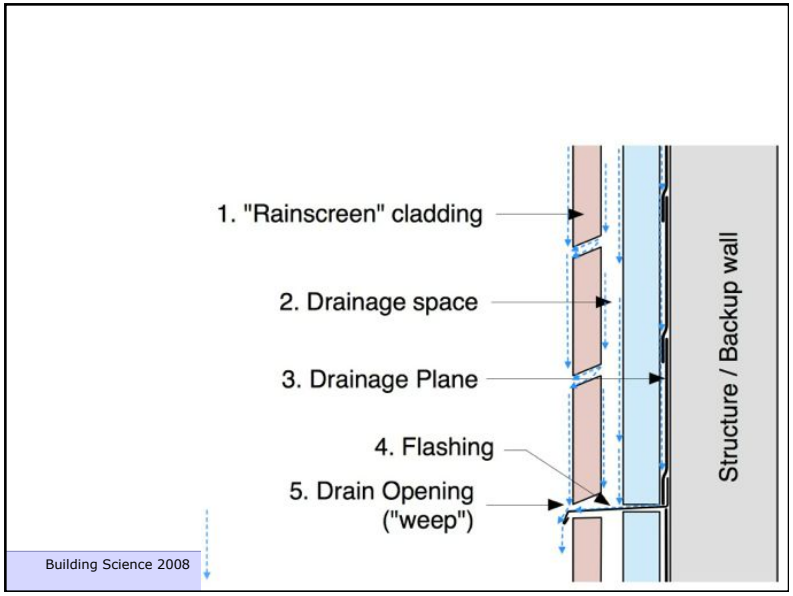

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Spray Foam

- Primarily polyurethane foam
- open cell (CO_2 blown) e.g., Icynene
  - about R3.7/inch (R13/3.5", R20/5.5")
  - moderate to high vapour permeance (>10 perms)
  - Airtight <0.01 lps/m^2 @ 75 Pa
- closed cell (gas blown)
  - R6+/inch
  - 1 - 2 US perms (don't need vapour barrier)
  - Airtight <0.01 lps/m^2 @ 75 Pa

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Spray Foam

- Open cell
  - Most high vapor permeance
  - controls convection / wind washing
- Closed cell
  - air barrier and part vapor barrier
  - excellent air seal in difficult areas!
  - Beware: adhesion and movement/shrinkage cracks
- Both Expensive
- Neither solve air leakage outside of stud cavity

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Great for sealing/insulating difficult complex details

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- **Complete air-vapour-water barrier solution**
- **Requires transition membranes**

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How much insulation?

- Regardless of type, use *more*
- Comfort & moisture –
  - **True** R5-10 is usually enough, but …..
- For energy / environment
  - As much as practical
- Practical constraints likely the limit
  - How much space available in studs?
  - Exterior sheathing of 1.5”/4”
- Increased insulation should reduce HVAC capital as well as operating!

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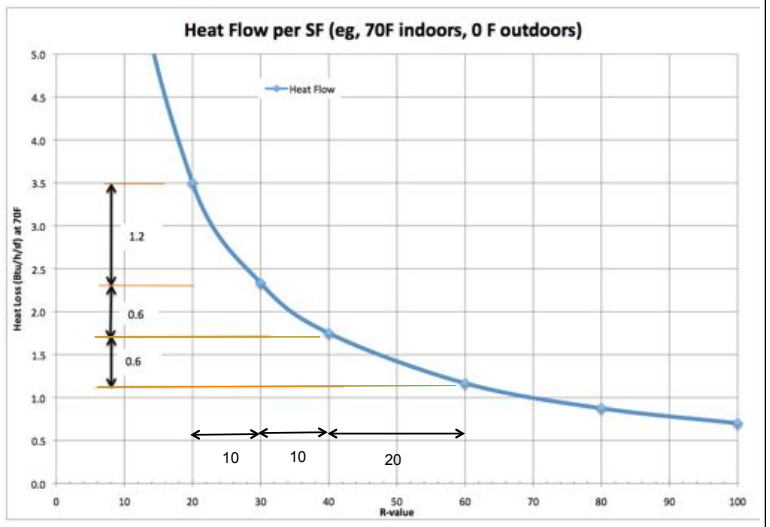

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Insulation and Thermal Bridges No. 48/65

But there are Complications

- Add up the R-values of the layers to get the total R-value of the assembly
- **BUT** the actual thermal resistance of an assembly is affected by
  - **Air Leakage**
  - **Thermal Bridges**
  - **Thermal Mass**

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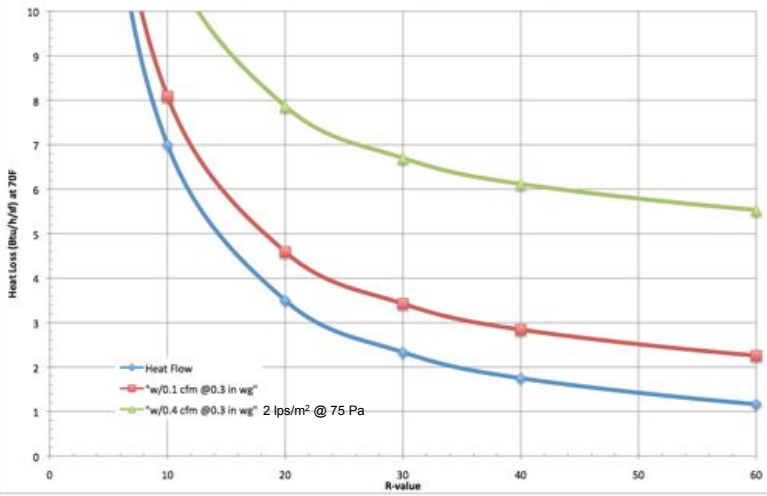
Insulation and Thermal Bridges No. 49/65



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It's More Than Insulation!

- Thermal bridges provide shortcut for heat through insulation
- Heat passes through the structural members
- Common offenders
  - Floor and balcony slabs
  - Shear walls
  - Window frames
  - Steel studs

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Insulation and Thermal Bridges No. 60/65

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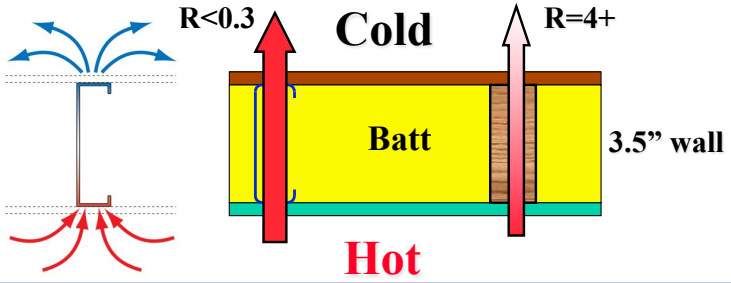
Insulation and Thermal Bridges No. 62/65

Thermal Bridging

- **Steel is 400 times more conductive than wood**
- **Steel studs are about 40 times thinner**



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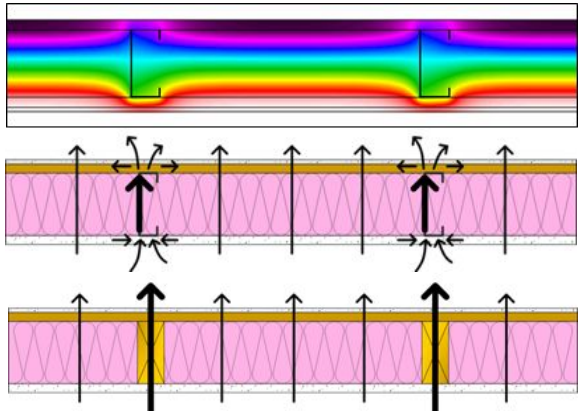
Insulation and Thermal Bridges No. 64/65

Wood vs Steel



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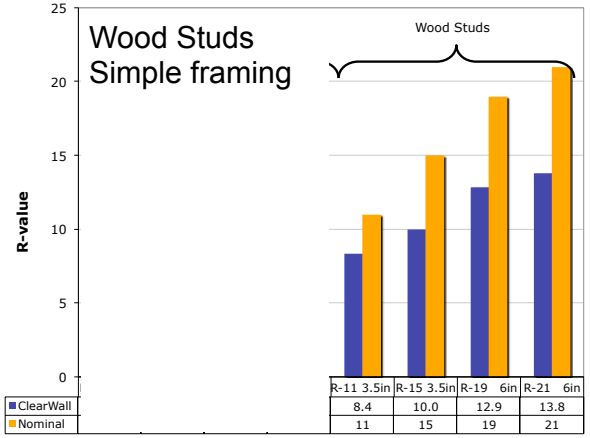
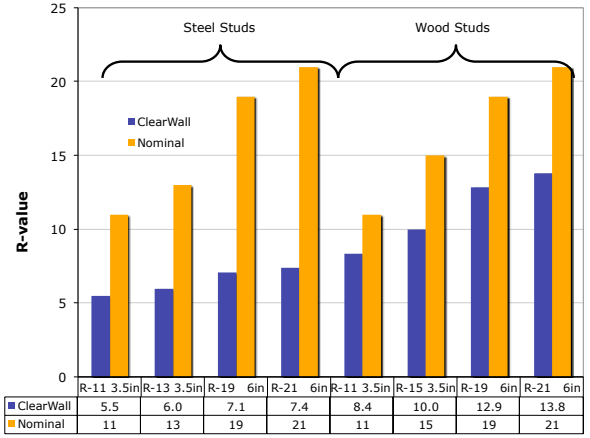
Insulation and Thermal Bridges No. 65/65

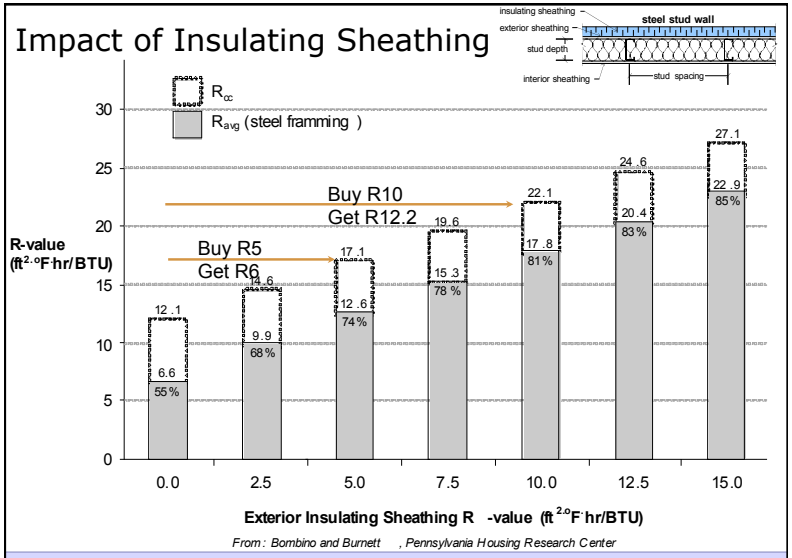
ASHRAE 90.1 "Clear Wall" best case



ASHRAE 90.1 "Clear Wall" best case

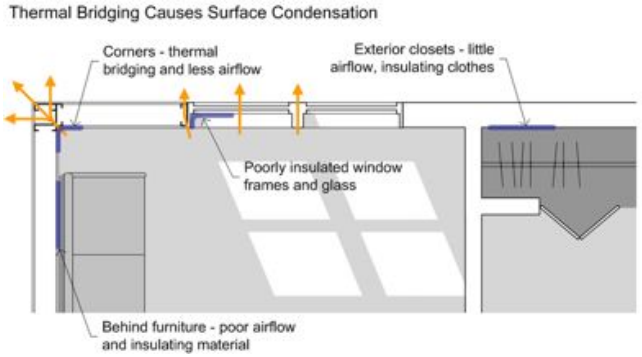


Impact of Insulating Sheathing



From: Bombino and Burnett , Pennsylvania Housing Research Center

Thermal Bridging: Common Problems



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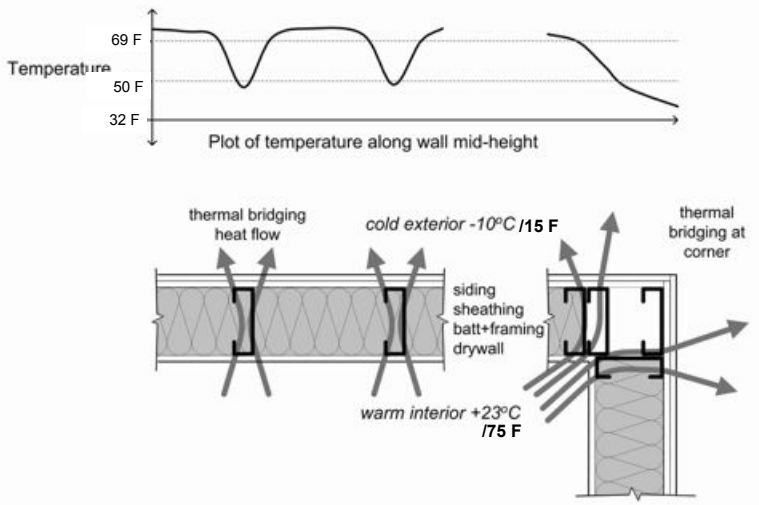
Cold surfaces where R<5



High RH / Low R

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Thermal Bridge Examples

- Balcony, etc
- Exposed slab edge,

Solving Thermal Bridging

- Exterior insulation can solve most thermal bridges
  - Inside works, but hard to cover structural penetrations
- Lower interior RH to stop condensation

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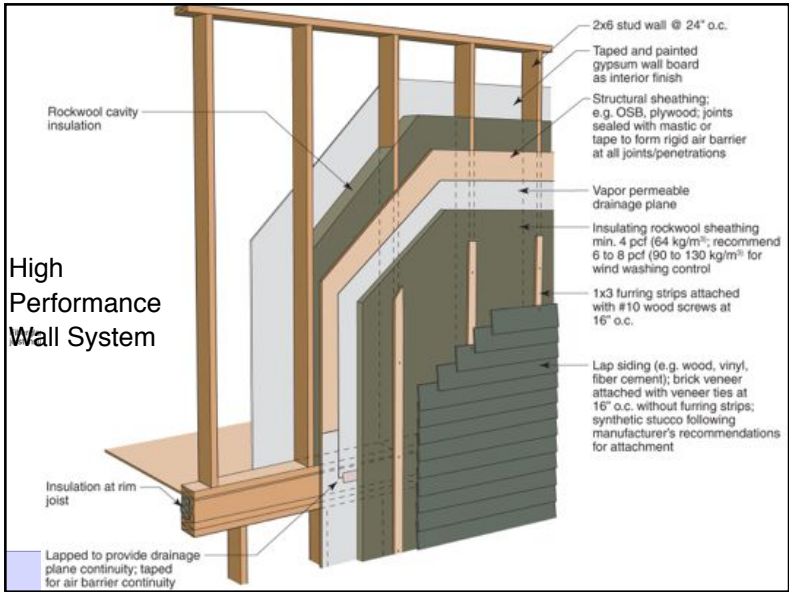
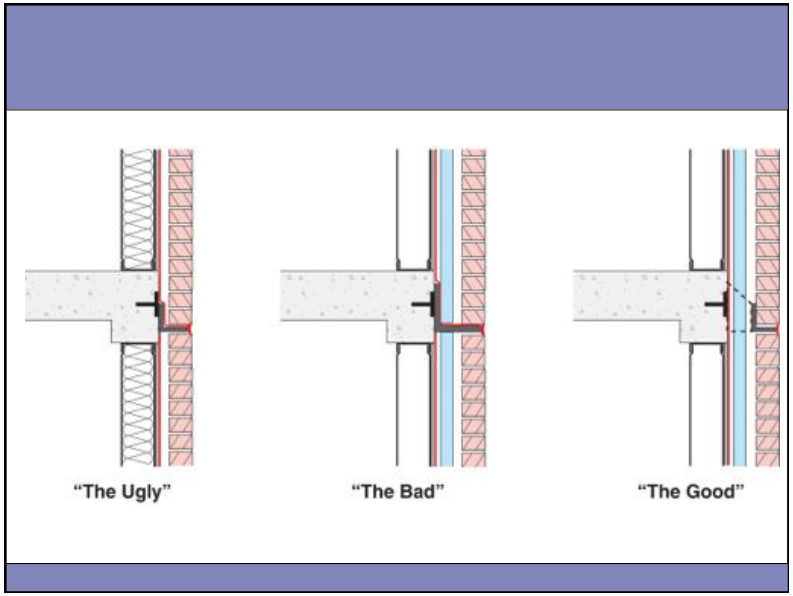
Insulation and Thermal Bridges No. 76/65



High Performance Wall System



Summary: Heat flow control

- A *continuous* layer of only R5-10 is key
  - Exterior is easiest to get continuous
  - Should provide much more for energy efficiency
- Heat flow control is not just about R-value!
  - Control of airflow
  - Thermal bridging must be managed
  - Thermal mass can play a role
  - Solar Gain can dominate
    - Window area, shading, low SHGC windows
    - Overhangs, light colors for walls and roofs

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Insulation and Thermal Bridges No. 81/65