Buildings, Enclosures, and The *Royal Building System*

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Overview of Presentation

- Buildings
  - what are they and why build them
- Building enclosures
  - their components
  - their functions
- The Royal Building System
  - how it fills the needs
  - how it compares functionally
  - RBS strengths and advantages

Building and Enclosure Function

- *New building systems require fresh thinking*
- **Process of development**
  - **define need**
  - **propose solution**
  - **confirm it works**
  - **design and work out details**

Building Function

- **What do buildings do?**

  - “Durability, Convenience, and Beauty”

  - **Vitruvius 70 BC**

  - “Provide space for human use & occupancy”

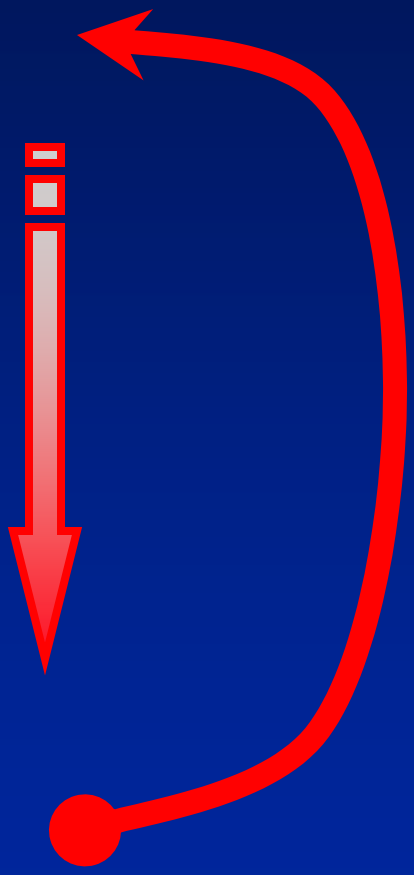
  - **Straube 1994**

Buildings

- *"Provide space for human use & occupancy"*
- **Usually control the interior environment**
  - **1. By passive means e.g. caves (the enclosure)**
  - **2. By active means e.g., fire (services, HVAC)**

Building Lifecycle

- Conception
  - why? fill a need
- Design
  - define what
- Construction
  - how to build
- Operation Maintenance & Repair
  - Owner's and Operators Manual
- Conversion Reuse
- Demolition & Recycling of materials/sub-systems

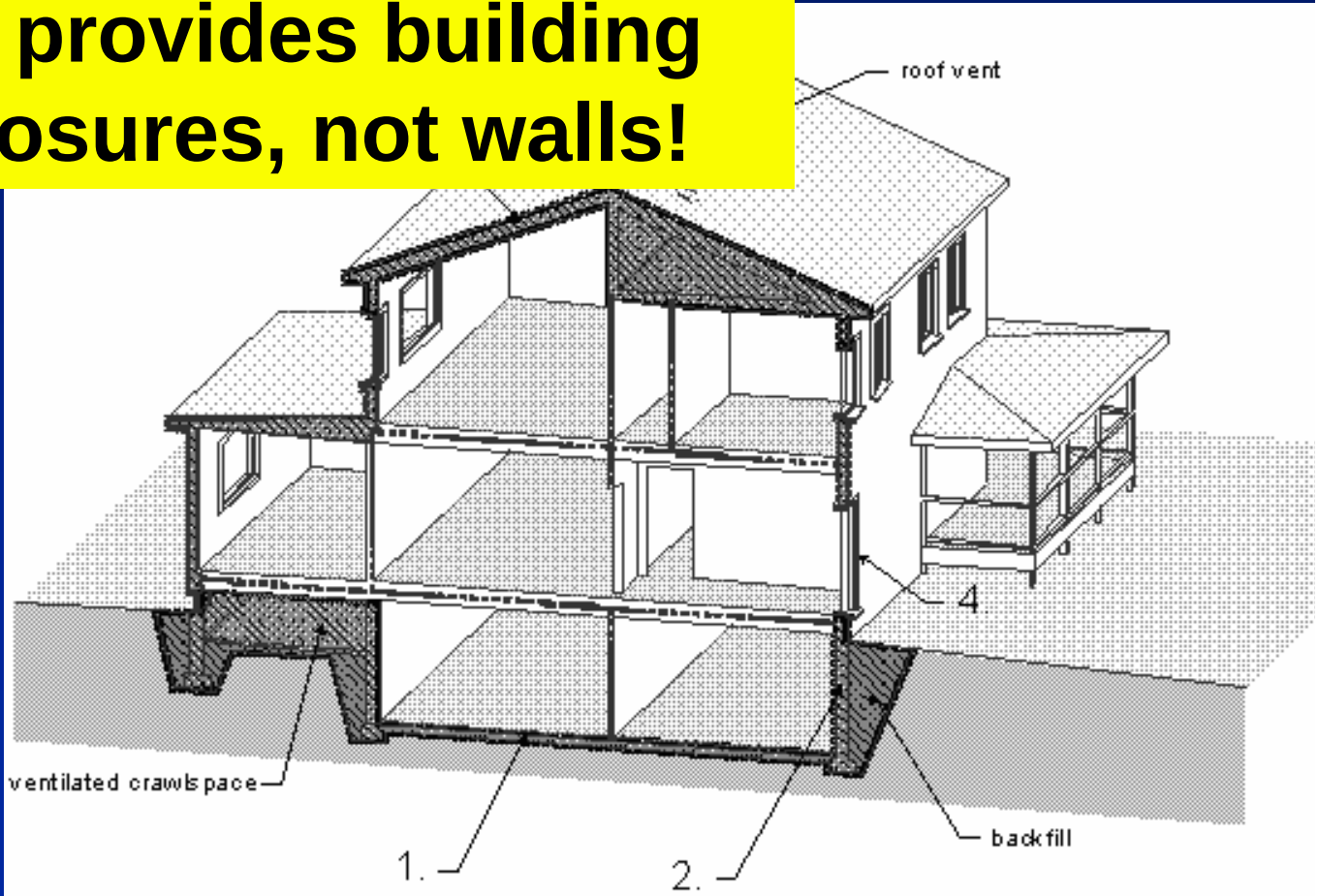


Building Enclosure

- Separates interior and exterior environment
- Critical building component (function, aesthetics)

RBS provides building enclosures, not walls!

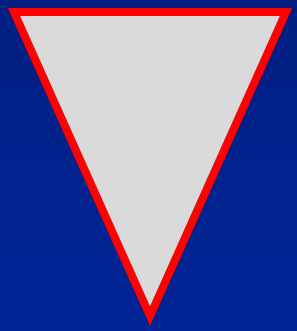
- roof
- wall,
- window,
- door,
- basement,
- slab etc.



Building Enclosure

- What does the building enclosure do?

- Basic Building Enclosure Functions
  - Support
  - Control
  - Finish
  - Distribute (sometimes)



Hierarchy of need

Building Enclosure Functions

- Basic Functions
  - Support
  - Control
  - Finish
  - Distribute (sometimes)

Lateral (Wind Earthquake)
Gravity (dead, snow)
Rheological (temp, moisture)
Impact
Wear / Abrasion

Support - resist and transfer physical forces from inside and out

Building Enclosure Functions

- Basic Functions
  - Support
  - Control
  - Finish
  - Distribute (sometimes)

Control:
- Heat
- Air
- Vapour
- Rain
- Sound
- Fire
- Insects
- Access

Control - Mass and Energy Flows

Building Enclosure Functions

- Basic Functions
  - Support
  - Control
  - Finish
  - Distribute (sometimes)

Finish:
- Colour
- Texture
- Reflectance
- Pattern
- Speculance

Finish - interior and exterior surfaces for people

Building Enclosure Functions

- Basic Functions
  - Support
  - Control
  - Finish
  - Distribute (sometimes)

Electricity
Communications
Plumbing
Air ducts
Gas lines
Roof drains

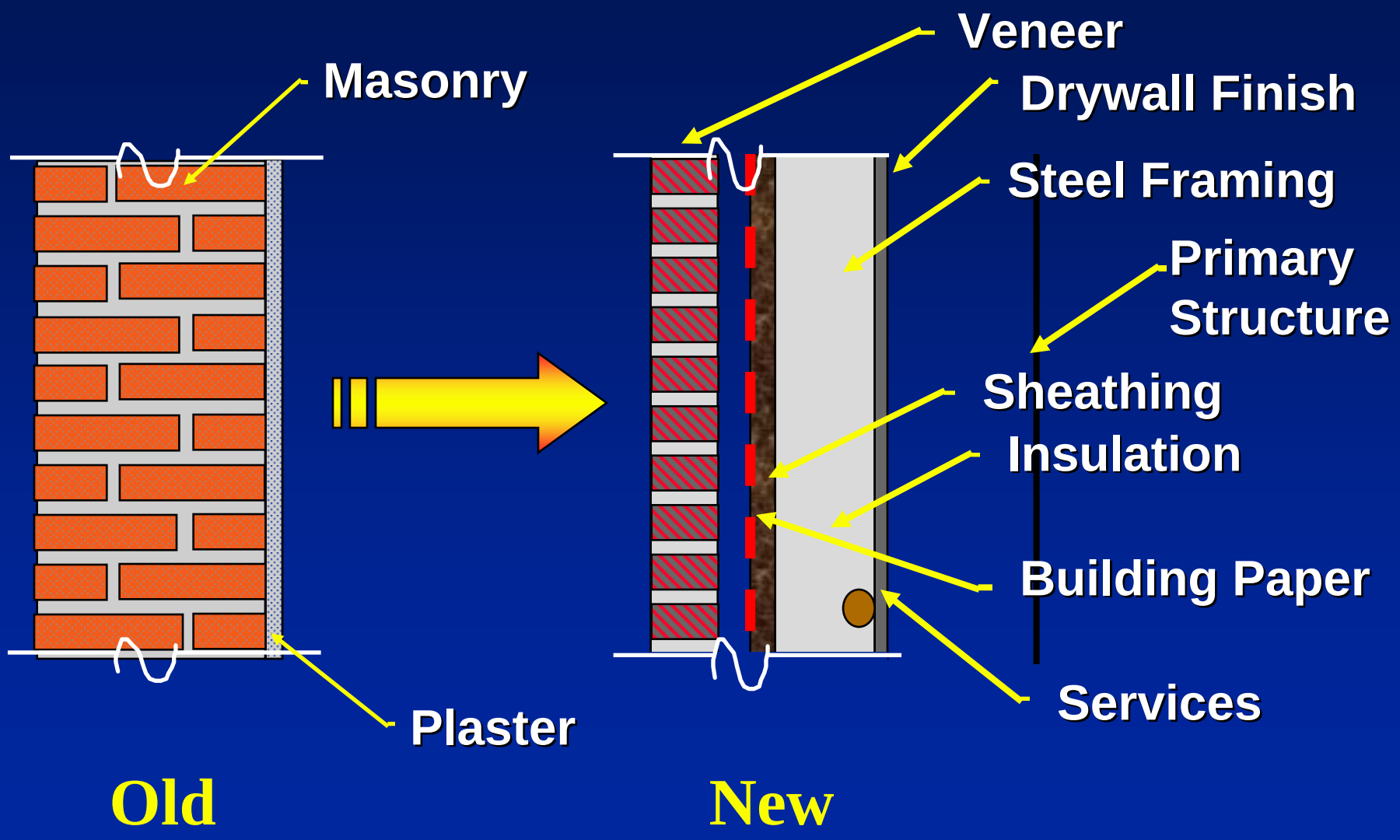
Distribute Services - a building function imposed on the enclosure

Who Cares?

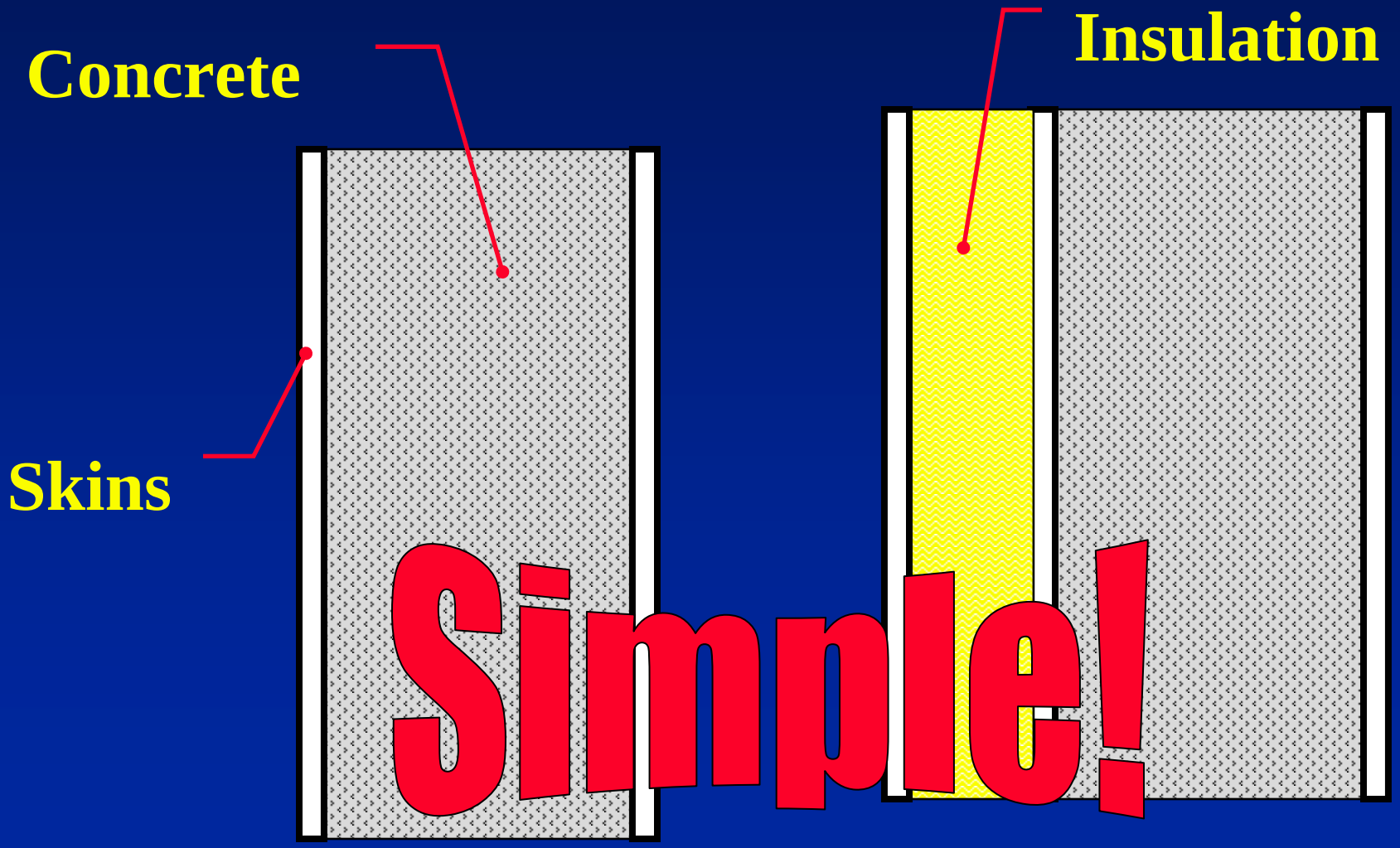
Who Cares?

- Architect - “brick, painted drywall inside”
- HVAC Engineer = “R19”
- Structural Engineer = “Wood Stud”
- Reality:
  The Enclosure is a System.
- RBS is a system, whose benefits arise when seen as a system

Building Enclosures: Change



The Royal Building System

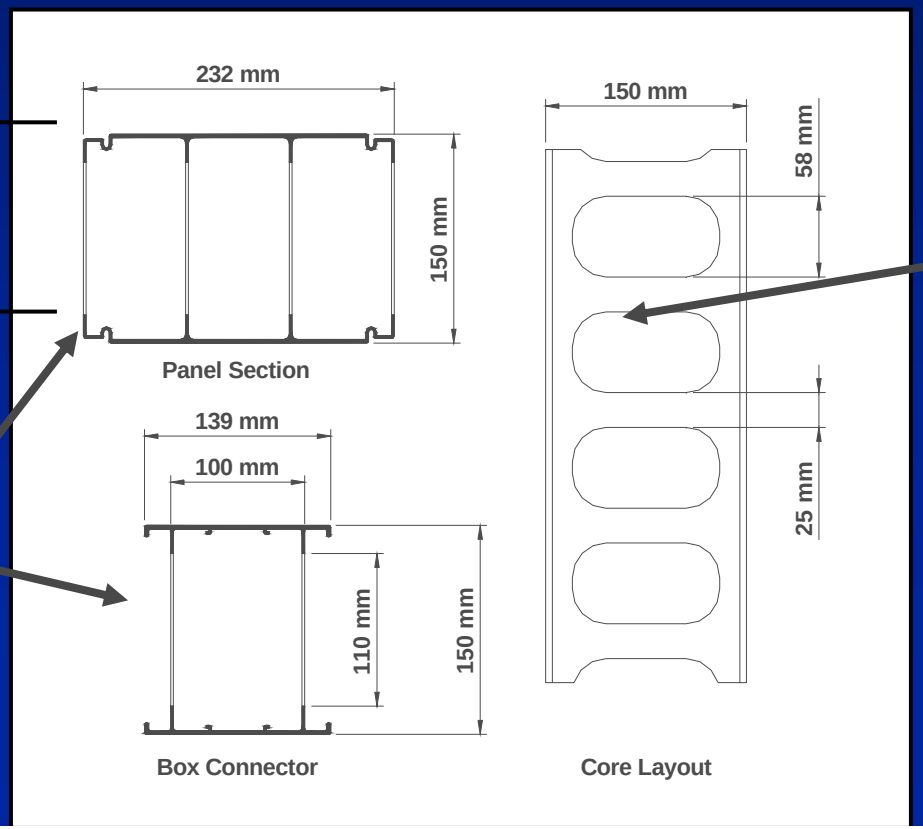


RBS Wall System

- Extruded polymer components
- 3 Sizes: 100 mm, 150 mm, 200 mm
- f_u = 40 MPa, E = 3600 MPa

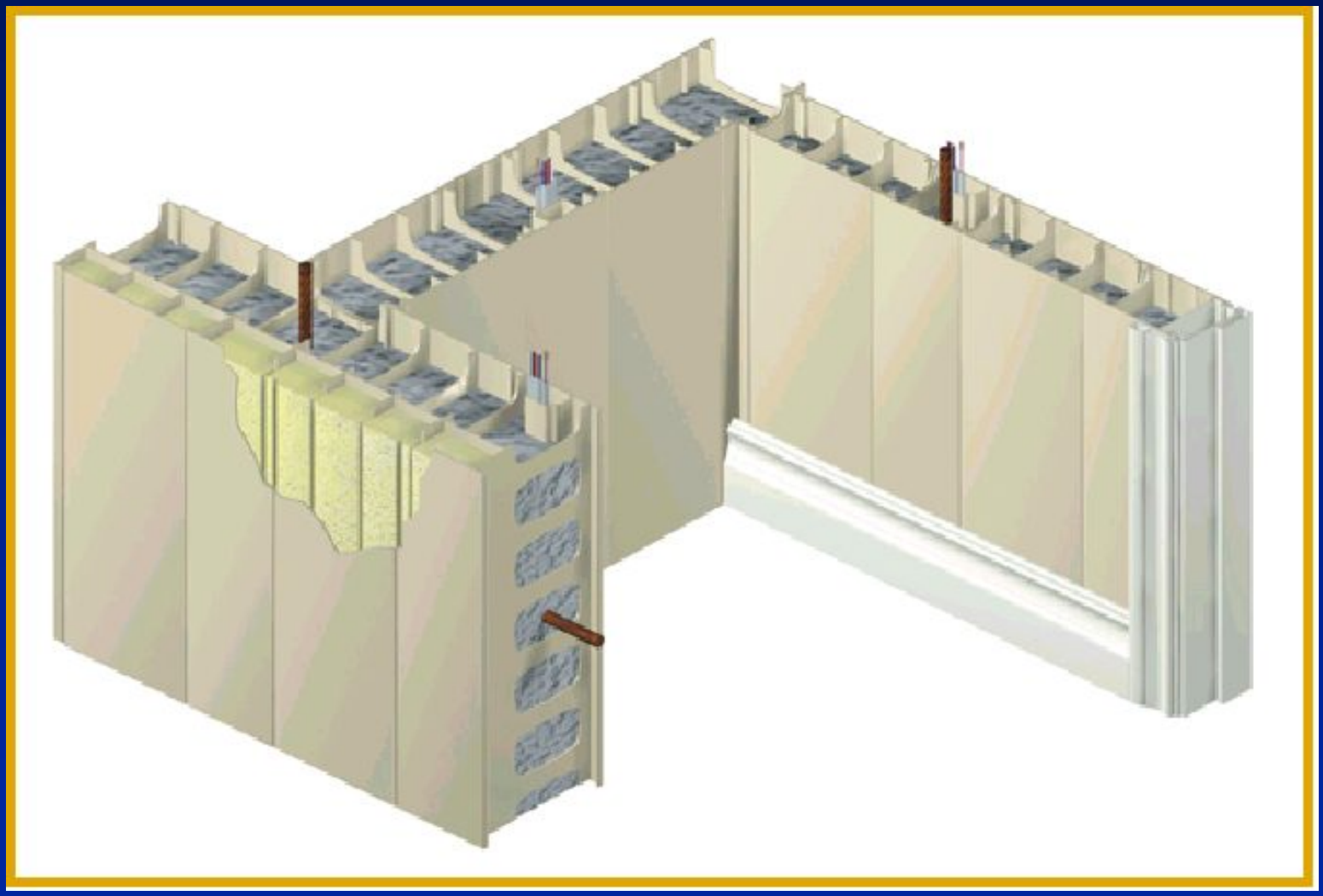
Thickness

Specimen Cross-sections



Side view showing core layout

System Schematic

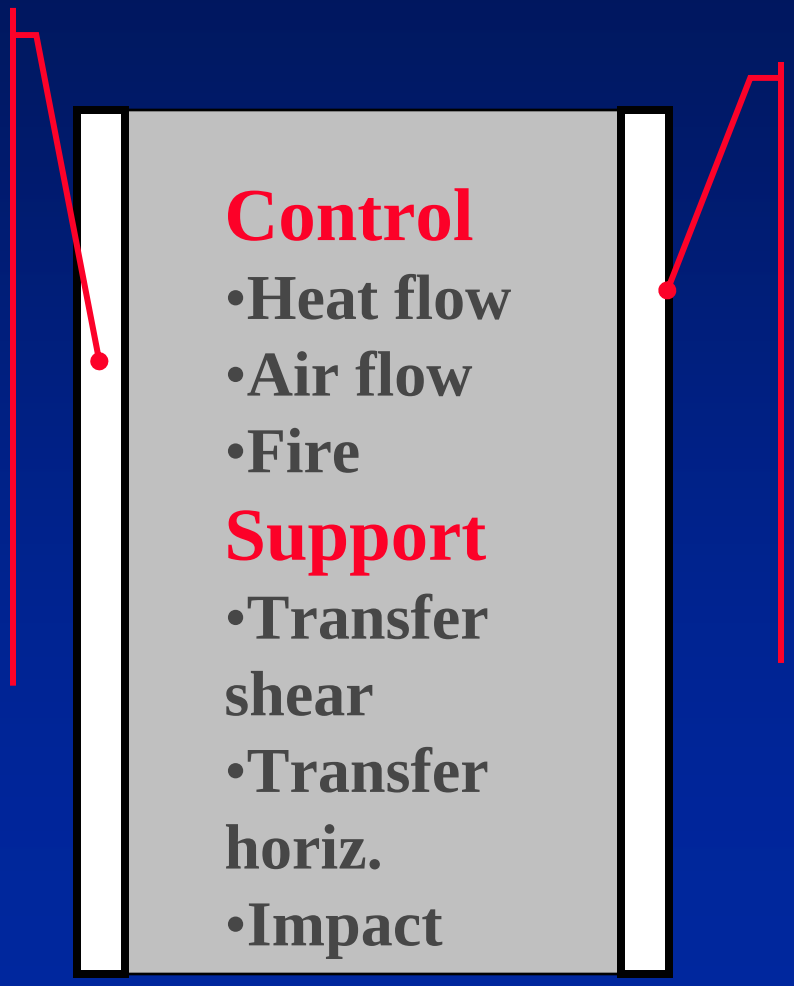


The Simplicity of RBS

Control
- Rain control
- Vapour control

Finish

Support
- Formwork
- Abrasion
- Reinforcing



Control
- Vapour control

Finish

Support
- Formwork
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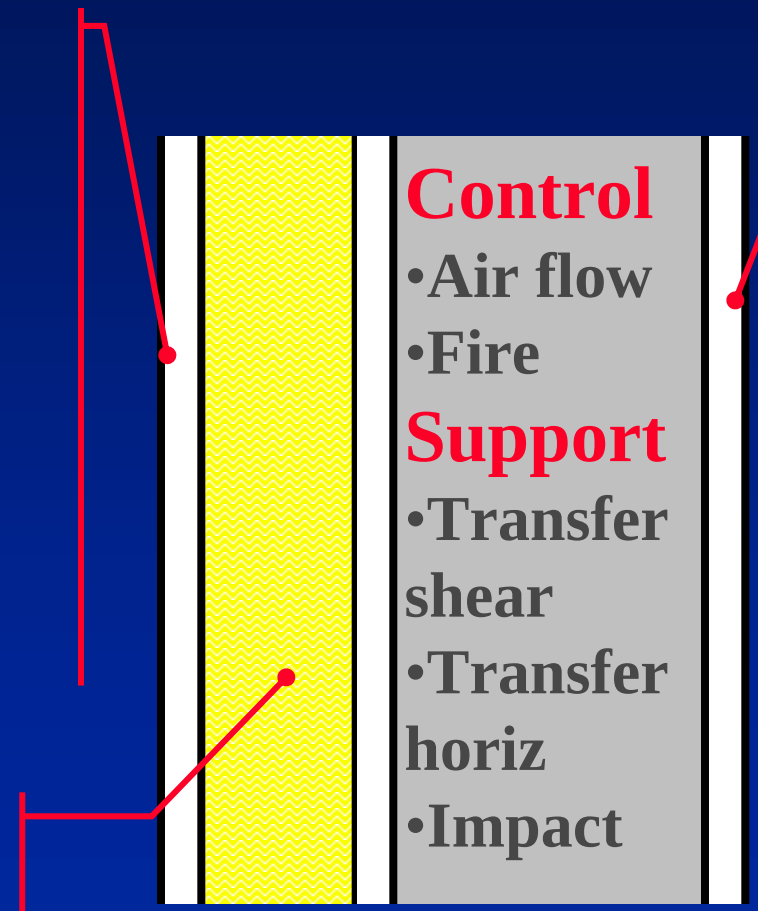
- Reinforcing

The Simplicity of RBS

Control
- Rain control
- Vapour control

Finish

Support
- Formwork
- Abrasion
- Reinforcing?



Control
- Vapour control

Finish

Support
- Formwork
- Abrasion
- Reinforcing

Control
- heat flow

Special Topics

- **Support: disaster resistance (tornadoes, hurricanes, earthquakes, blast) requires:**
  - **high load capacity,**
  - **ductility,**
  - **distributed structure**
- **Control: moisture control is critical to durability**
  - **rot**
  - **corrosion**
  - **mould**

Flexure Testing

- Four Point Bending
- Span 2000 mm, loaded at quarter points

Typical Column Behaviour

Disasters and mistakes

Control: Heat Flow

- **Thermal Resistance**
  - **R-value**
  - **Thermal Bridging**
- **Airtightness**
  - **about 30 - 50% of energy loss**
- **Mass**
  - **smooths peaks and valleys**
  - **takes advantage of heat within (sun, equipment)**

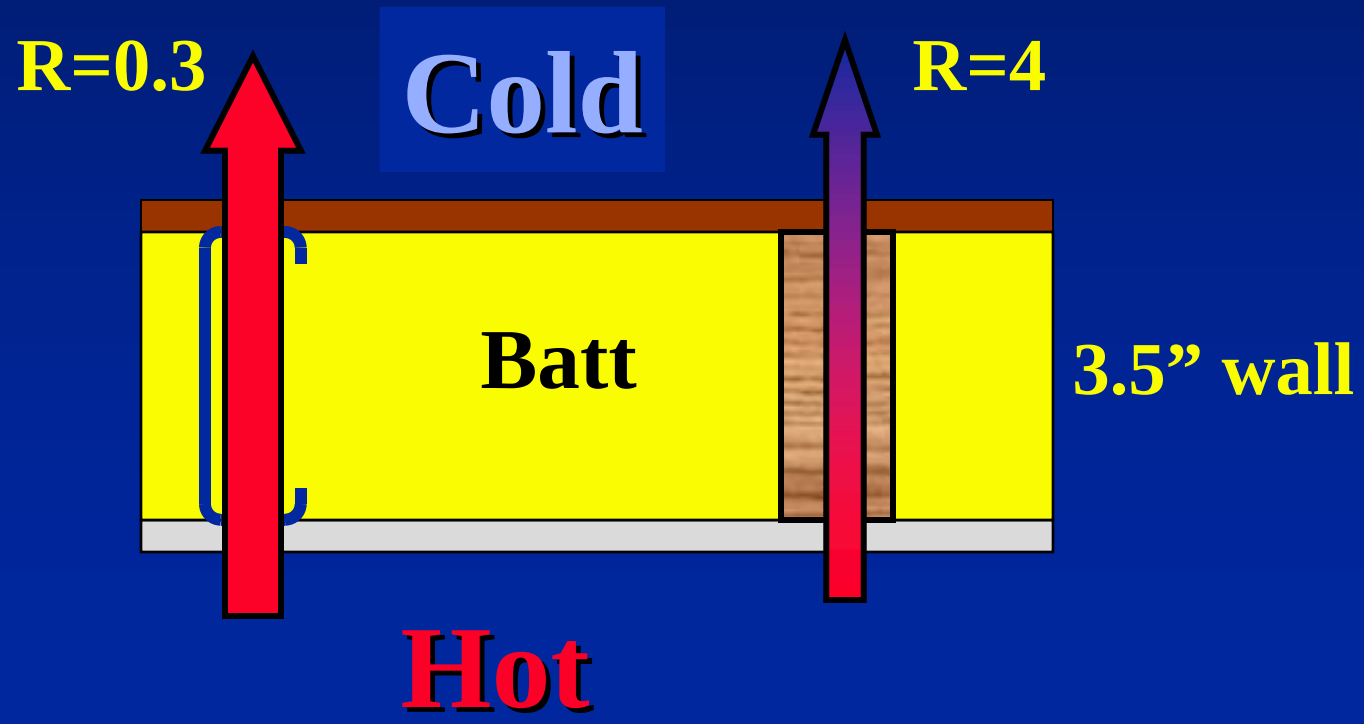
Heat flow matters

- Cold climates
- Hot climates
- Cold storage

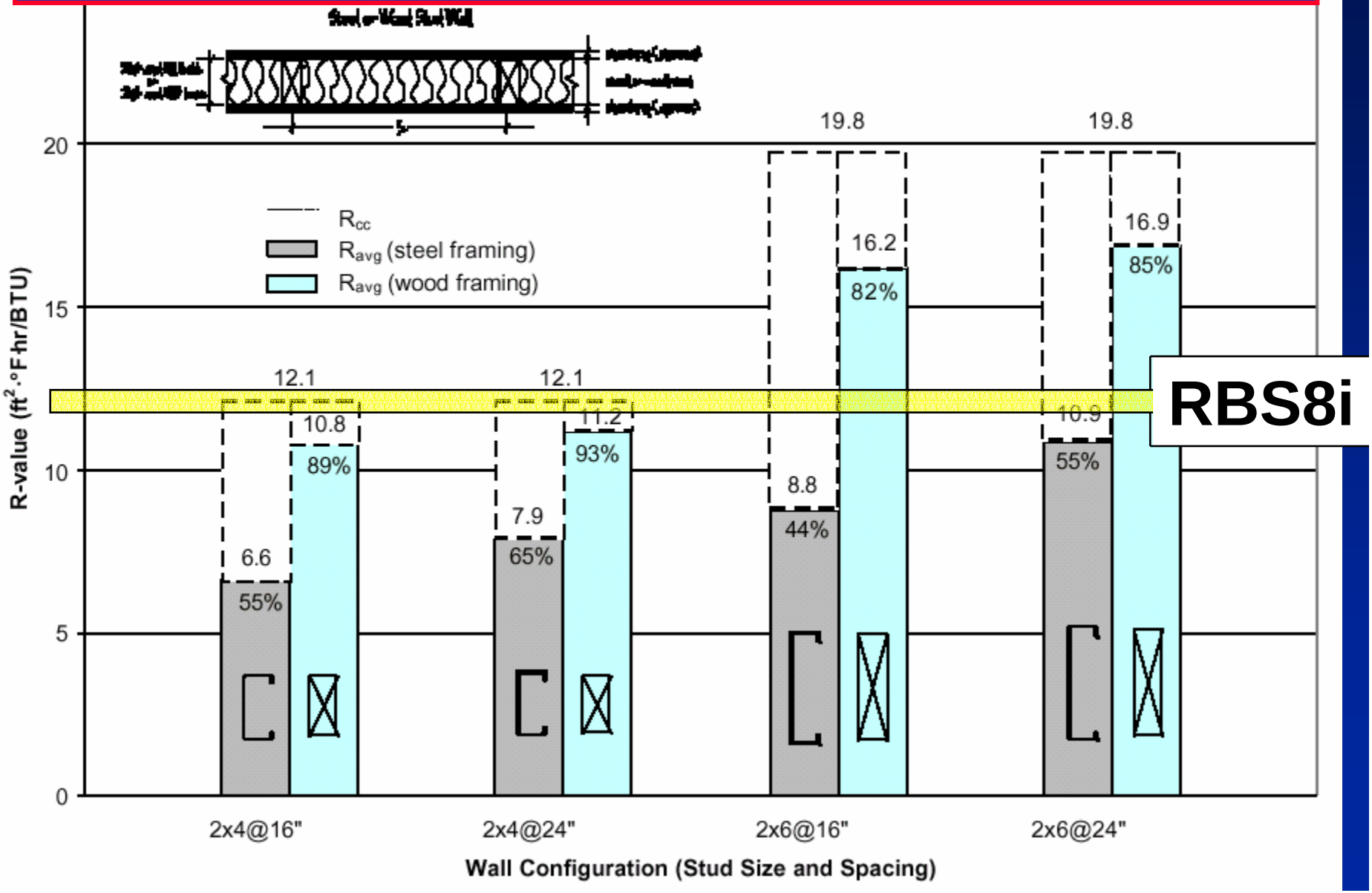

A5
C1-003
WEST
Genie S-40

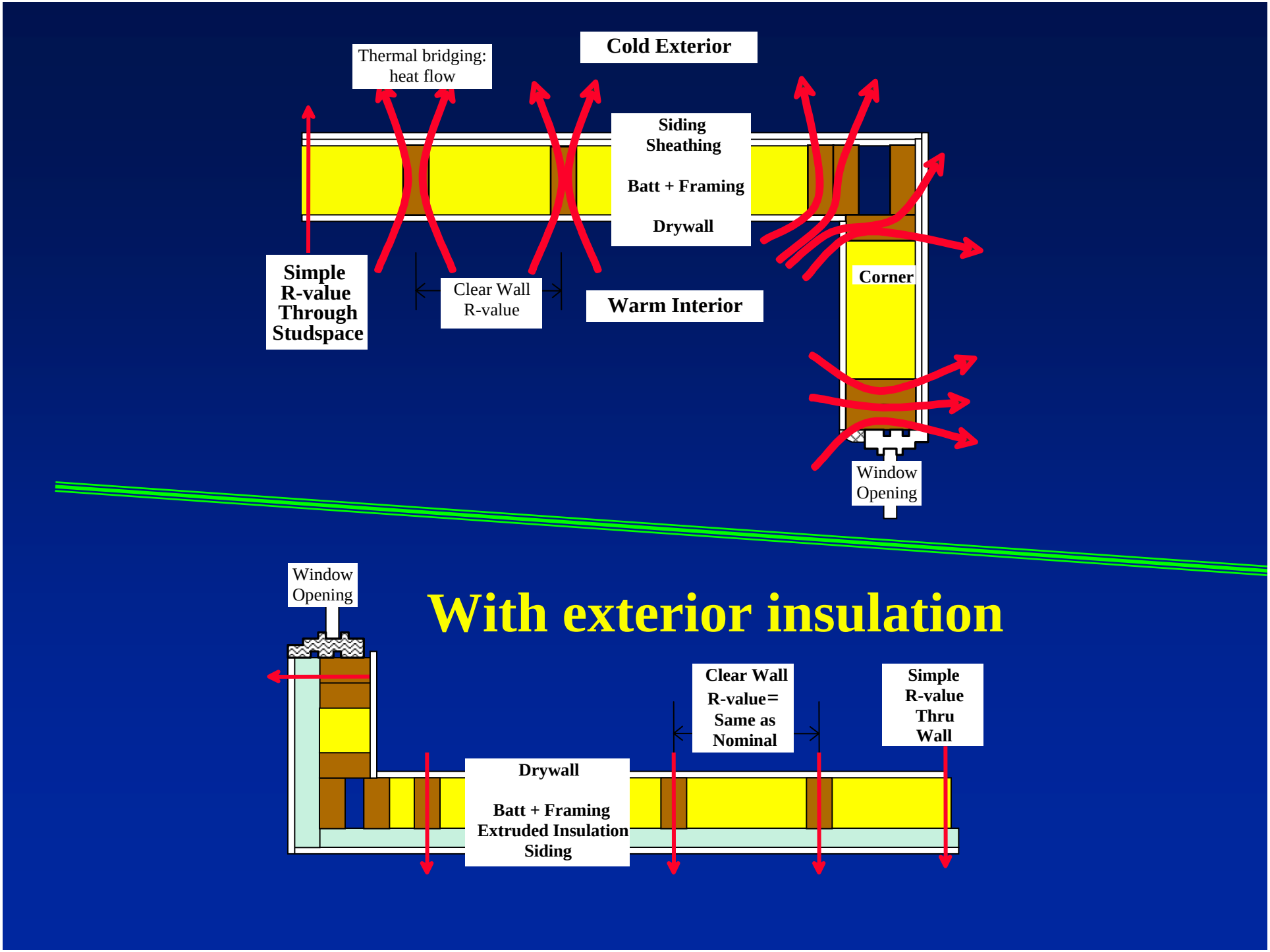
Thermal Bridging

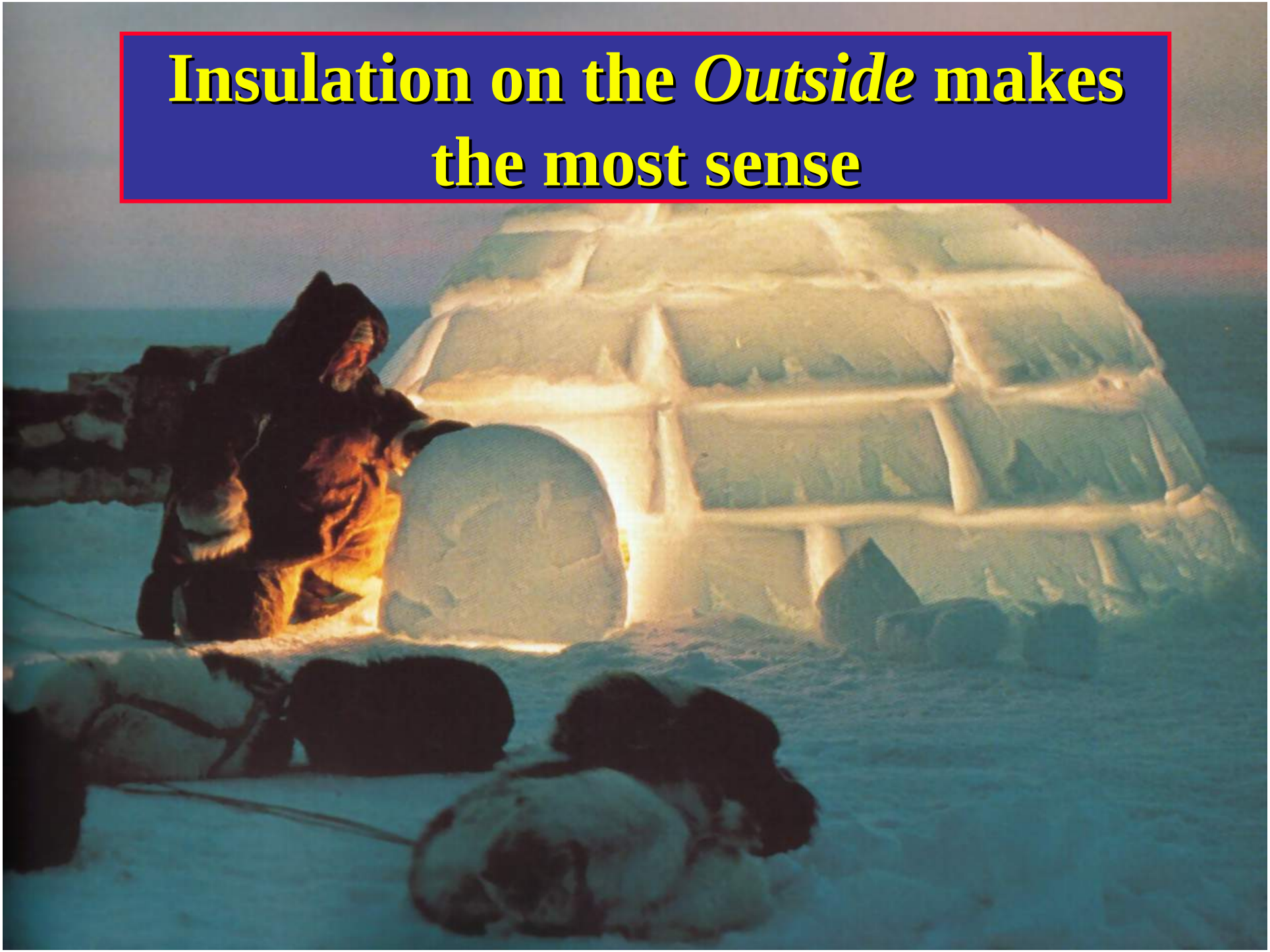
- Steel is 400 times more conductive than wood
- Wood studs cover 15-20% of walls



R-value Comparison




Thermal bridging: heat flow
Cold Exterior
Siding
Sheathing
Batt + Framing
Drywall
Simple R-value Through Studspace
Clear Wall R-value
Warm Interior
Corner
Window Opening
Window Opening
With exterior insulation
Clear Wall R-value= Same as Nominal
Simple R-value Thru Wall
Drywall
Batt + Framing
Extruded Insulation
Siding

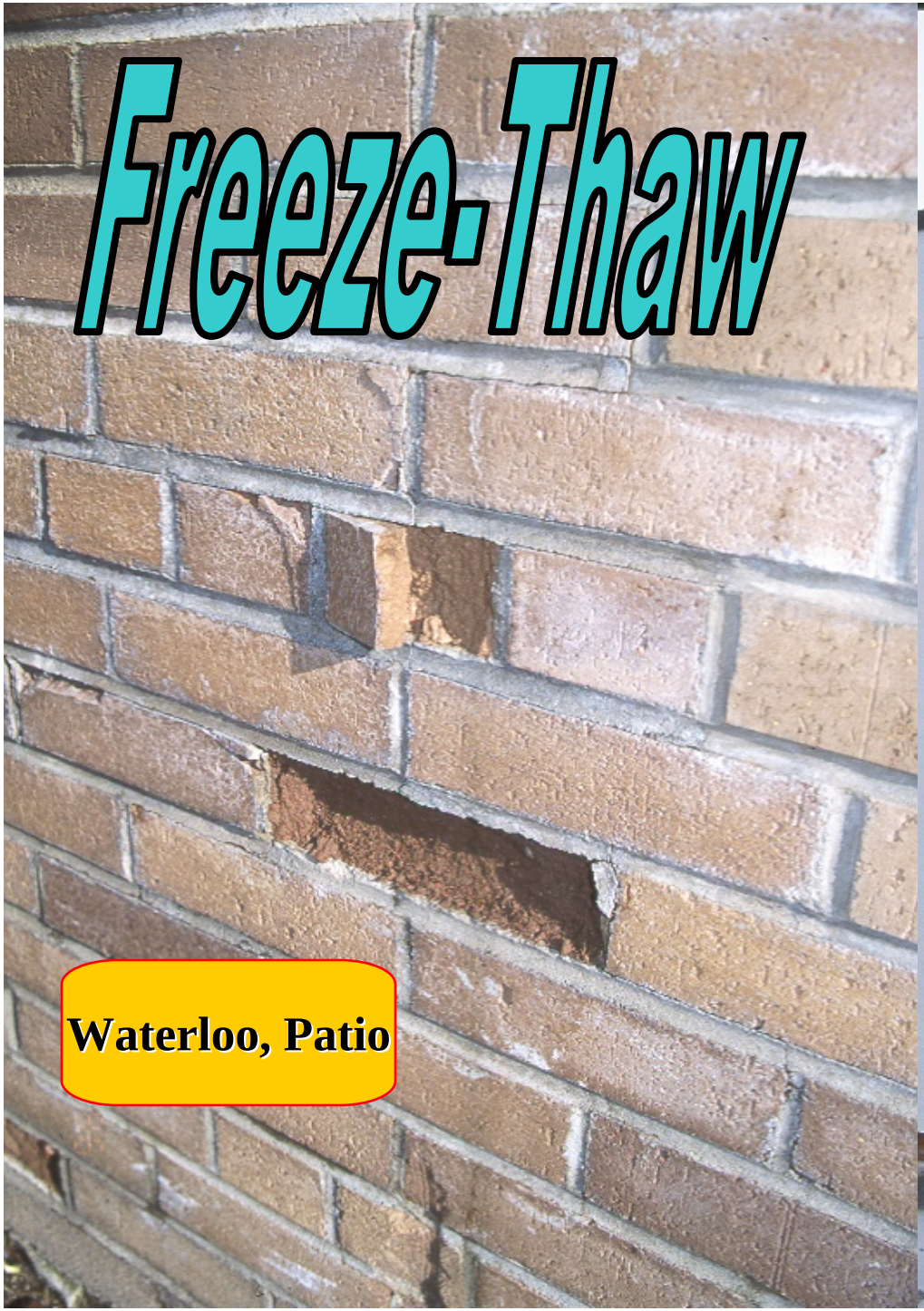

Insulation on the *Outside* makes the most sense

RBS Advantages

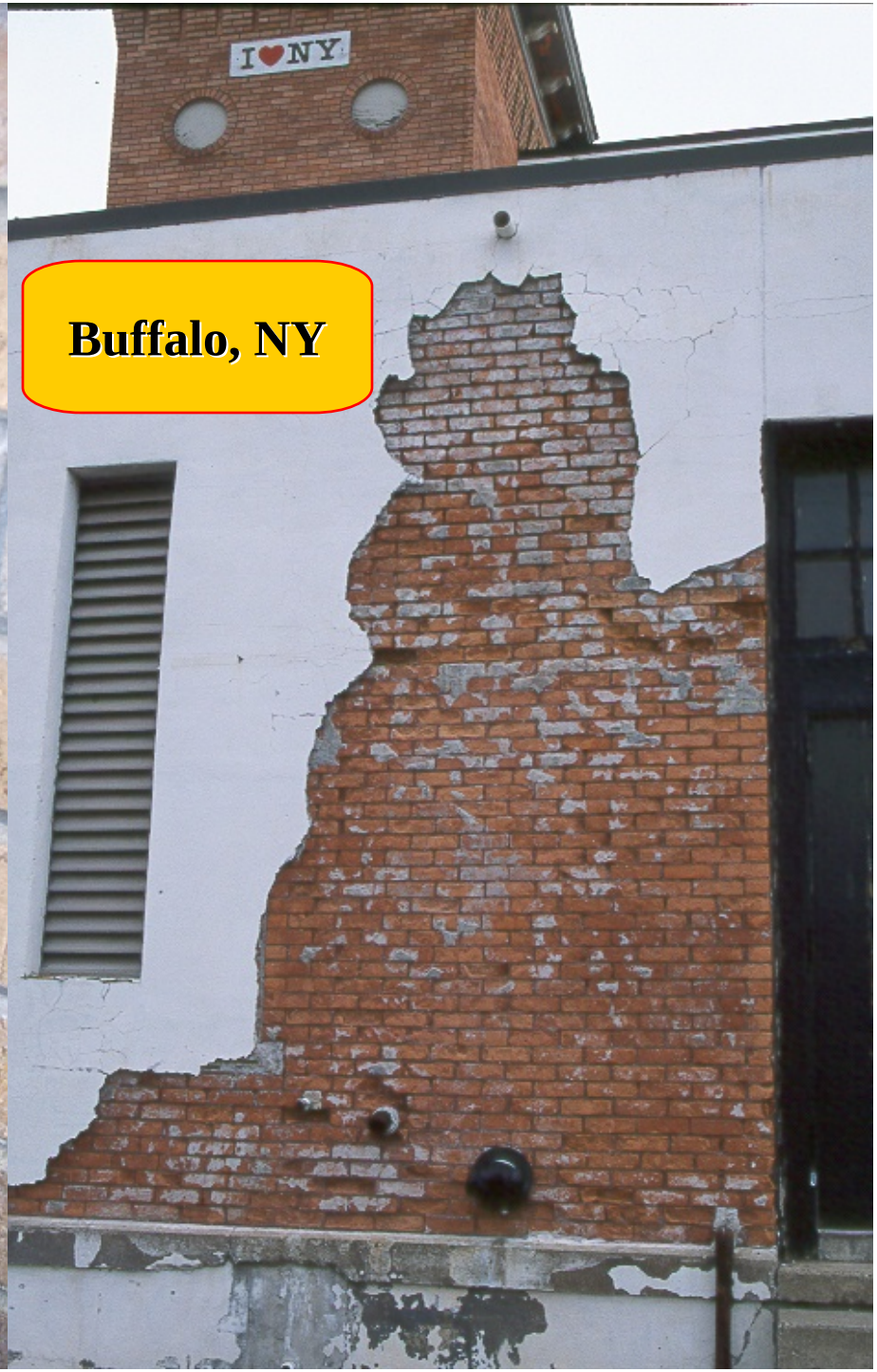
- Complete insulation coverage
- Moisture resistance
  - Key RBS advantage
  - agriculture
  - car wash
- Disaster tolerance (control + support)
  - Flood – hurricances, etc
  - Impact – flying 2x4, forklift

Fungal Growth

Freeze-Thaw



Waterloo, Patio



Buffalo, NY

Decay

Corrosion


Florida Pier
DANGEROUS
CONDITIONS
Brampton
Parking Garage
Structural Steel
Waterloo

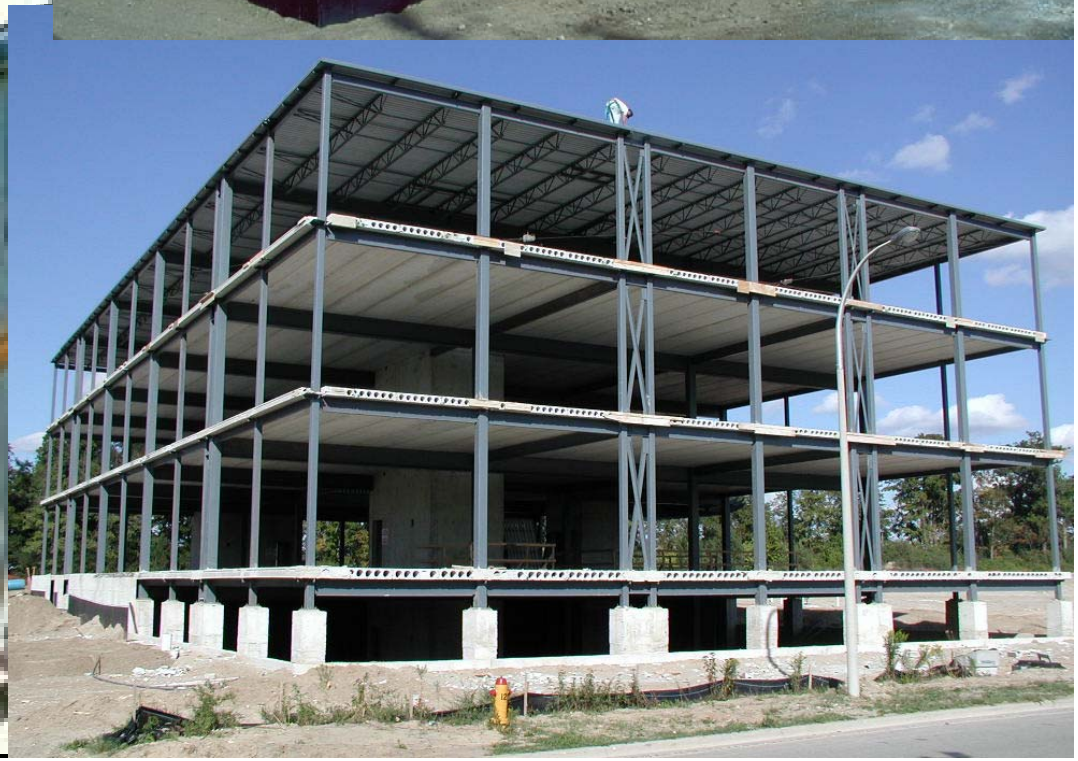
Mold concerns

- **Mold is a growing concern**

A brief comparison of enclosure wall systems

Commercial construction

Steel and Wood Framing



Wood and Steel Framed

- Advantages
  - Low-cost, available labour, no cranes
  - Lightweight? (foundation, earthquake loads)
  - Fast construction, weather insensitive
  - flexible design on site, little lead time

Wood and Steel Framed

- **Disadvantages**
  - **moisture damage susceptible (rot, corrosion)**
  - **impact damage from inside, maybe outside**
  - **fire (?)**
  - **low load capacity**
  - **low disaster resistance**
  - **low thermal mass + high thermal bridging**

Masonry

Single Wythe Masonry

Single Wythe Concrete Masonry

- Advantages
  - moisture resistant
  - fire resistant
  - high axial strength
  - can be disaster resistant -- usually not
  - thermal mass
  - flexible design on site, little lead time

Single Wythe Concrete Masonry

- **Disadvantages**
  - **on-site time and labour is high**
  - **Labour is scarce**
  - **requires scaffolds, cranes**
  - **poor insulation**
  - **rain penetration problems**

Masonry – walls not enclosures

Insulation?
Cladding?

Multi-wythe Masonry

Multi-wythe Masonry

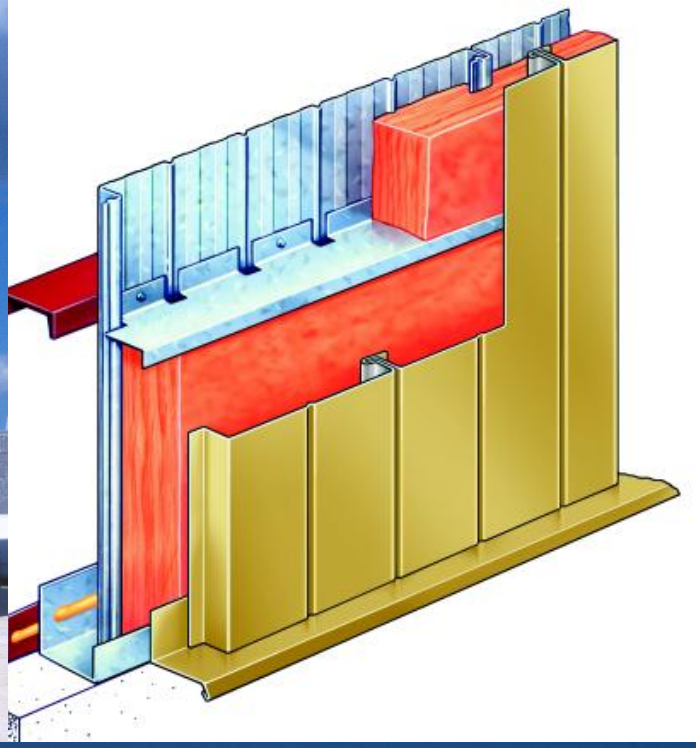
- Advantages
  - moisture resistant - can be very durable
  - fire resistant
  - high axial strength
  - can be disaster resistant -- usually not
  - well-insulated thermal mass inside of insulation
  - flexible on site design, little lead times
- Disadvantages
  - on-site time and labour is high, scaffolds, cranes
  - very high initial cost

Precast Panels non-bearing

Precast Sandwich Panels

- Advantages
  - moisture resistant - can be very durable
  - fire resistant
  - high strength
  - can be disaster resistant -- usually not tied together
  - well insulated- thermal mass inside of insulation
  - on-site time and labour is low
- Disadvantages
  - long lead times
  - inflexible in-office and on-site design
  - very high initial cost

Metal Building Systems



Metal Building Systems

- Advantages
  - low cost
  - lightweight? (foundation, earthquake loads)
- Disadvantages
  - moisture damage susceptible (corrosion)
  - impact damage from inside and outside
  - fire (?)
  - low disaster resistance, impact resistance
  - low thermal mass + high thermal bridging

RBS

- Advantages
  - moisture resistant, chemical resistant
  - disaster and impact resistant
  - fast construction, low labour on site, low lead time
  - lightweight to transport, massive in service
  - finish integral with product, colours, patterns
  - well insulated (RBS 8i)

RBS for ICI Buildings

The Delivery Process

- RBS advantages
  - Technical advantages
  - Delivery process advantages
  - Capital cost advantage
  - Operating cost advantage
- Each participant optimize for their benefit, e.g.
  - designers: minimize risk, effort
  - contractor: maximize project profit

The Delivery Process

- System benefit ≠ Sub-system benefit
  - e.g. engineer chooses precast panels -- little design or inspection required from him/her
  - benefit of lower HVAC costs does not save steel stud wall contractor money
  - savings in coordination costs of windows, structure, etc. not usually prices
  - save steel structure at perimeter
- Performance advantages go to owner
- Construction advantages to builder

Conclusions

- **RBS is an ENCLOSURE not a WALL**
- **Must consider walls as a system**
  - **support**
  - **control**
  - **finish**
- **Speedy construction**
- **Design flexibility**
- **Quality finish**
- **Durable, low energy**